THE KINGSTON STEAM PLANT

A REPORT ON THE PLANNING, DESIGN, CONSTRUCTION, COSTS, AND FIRST POWER OPERATIONS

TECHNICAL REPORT No. 34

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TENNESSEE VALLEY AUTHORITY
Knoxville, Tenn., July 2, 1964

MR. L. J. VAN MOL, *General Manager,*
Tennessee Valley Authority, Knoxville, Tenn.

DEAR MR. VAN MOL: The accompanying report covers the planning, design, construction, costs, and first power operations of the Kingston Steam Plant. It has been prepared by the Office of Engineering Design and Construction staff with contributions from a large number of persons from other TVA divisions, and forms a companion volume to the previously issued technical reports on the Johnsonville and Colbert Steam Plants.

Kingston Steam Plant is the fifth steam electric project to be planned, designed, and constructed by TVA. It is the fourth of eight TVA steam plants under construction in the 1950's, preceded by Johnsonville, Widows Creek, and Shawnee and followed by Colbert, John Sevier, Gallatin, and Paradise. These new plants were in the forefront of advances in steam plant technology and have commanded a wide interest among engineers, constructors, and electric power suppliers in this country and throughout the world. At the time of completion, Kingston Steam Plant was the largest known steam-electric plant in the world, and still ranks with the great installations of its kind.

The report is recommended for publication as a public document.

Very truly yours,

G. P. Palo
Manager of Engineering
Design and Construction

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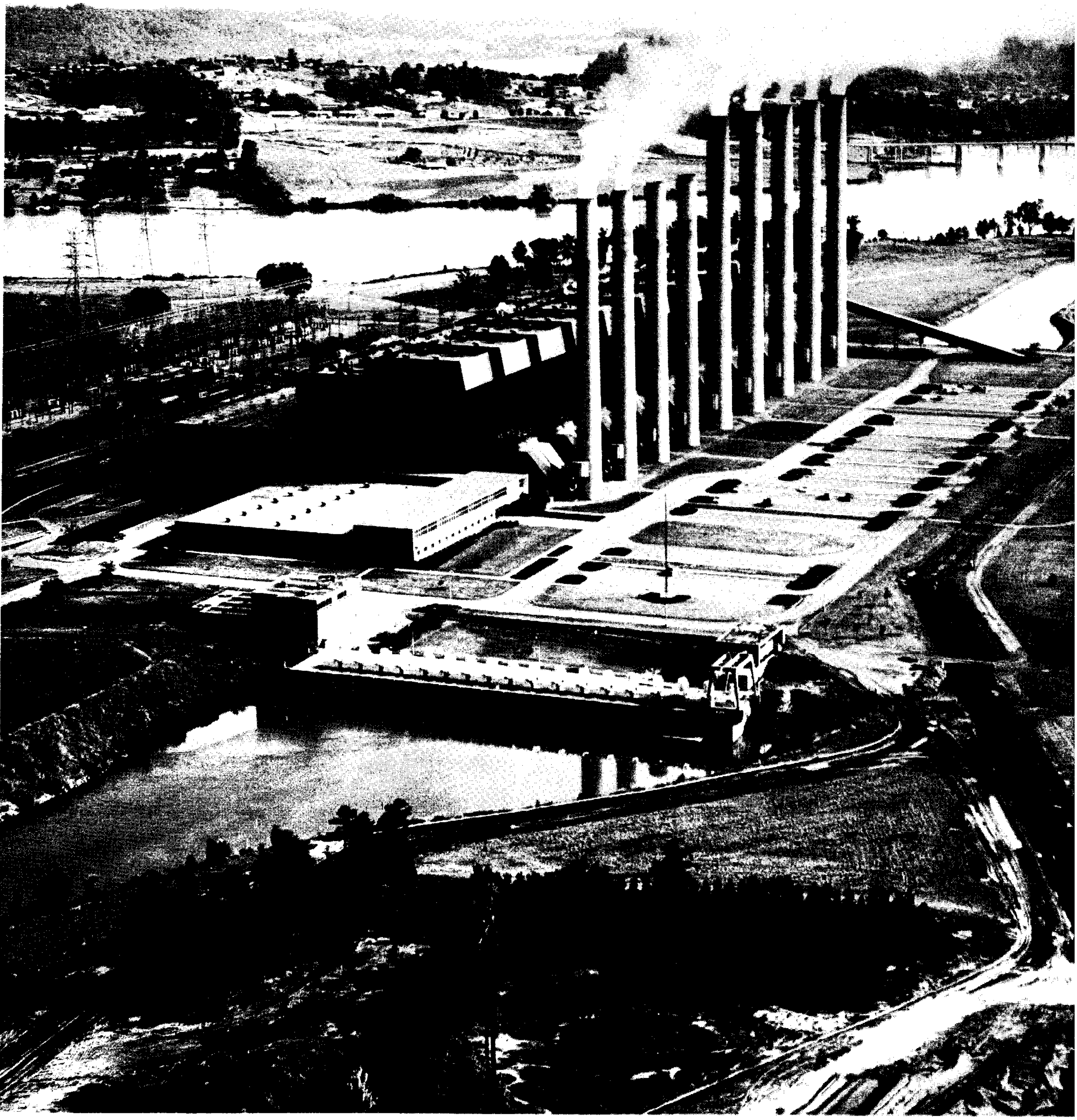
ABBREVIATIONS

acre-feet	ac.-ft
alternating current	a-c
Aluminum Company of America	ALCOA
American Association of State Highway Officials	AASHO
American Concrete Institute	ACI
American Institute of Steel Construction	AISC
American Railway Engineers Association	AREA
American Society of Civil Engineers	ASCE
American Society of Mechanical Engineers	ASME
American Society for Testing Materials	ASTM
American Standards Association	ASA
American Welders Society	AWS
American wire gage	Awg
amperes	amp
Arnold Engineering Development Center	AEDC
Atomic Energy Commission	AEC
biochemical oxygen demand	BOD
Birmingham wire gage	Bwg
British thermal units	Btu
brake horsepower	bhp
cubic feet	cu ft
cubic feet per minute	cfm
cubic feet per second	cfs
cubic yards	cu yd
cycles per second	cps
degrees Centigrade	°C
degrees Fahrenheit	°F
diameter	diam
direct current	d-c
feet board measure	fbm
feet per second	fps
feet per minute	fpm
feet, foot	ft
footcandle	ft-c
forced draft	FD
gallons per hour	gph
gallons per minute	gpm
horsepower	hp
inch	in.
induced draft	ID
inside diameter	id
Institute of Electrical and Electronics Engineers	IEEE
iron pipe size	IPS
key branch exchange	Key-BX
kilovolts	kv
kilovolt-amperes	kva
kilowatts	kw
kilowatt-hours	kwh
kilowatt-year	kw-yr
mean sea level	MSL
megawatts	mw
megavolt-amperes	mva
milliamperes	ma
millivolts	mv
National Electric Manufacturers Association	NEMA
Net positive suction head	NPSH
outside diameter	od
parts per billion	ppb
parts per million	ppm
phase	ph
power factor	pf
pounds	lb
pounds per hour	pph
pounds per square foot	psf
pounds per square inch	psi
pounds per square inch absolute	psia
pounds per square inch gage	psig
private automatic exchange	PAX
private branch exchange	PBX
revolutions per minute	rpm
root mean square	rms
short circuit ratio	scr
square feet	sq ft
thousand circular mils	mcm
tons per hour	tph
tons per square foot	tsf
total dynamic head	tdh
volts	v
watts	w

NOTE: Where applicable, abbreviations apply to both singular and plural usage.

XIX



XIX

The Kingston Steam Plant

THE KINGSTON STEAM PLANT

CHAPTER 1

INTRODUCTION

Kingston Steam Plant is located at the base of a peninsula formed by the Clinch and Emory River embayments of Watts Bar Lake about 2.7 miles above the confluence of the Clinch and Tennessee Rivers. The plant derives its name from Kingston, a small town of colorful history lying two miles to the south, which enjoys the distinction of being the capital of the State of Tennessee for one day, September 21, 1807. An access road about one mile long leads to the plant from U. S. Highway No. 70.

The Kingston Steam Plant is the fifth steam-electric power plant to be constructed by TVA. The first of these, the Watts Bar plant, was built as part of an emergency power program of the World War II period. In 1949, some four years after the completion of the Watts Bar Plant, construction started on the first of nine large steam-electric projects to be built over a span of 17 years. This program included, successively: Johnsonville, Widows Creek, Shawnee, Kingston, Colbert, John Sevier, Gallatin, Paradise, and Bull Run.

In 1950 the Korean conflict forced an expansion of the national defense program. Again, as in World War II, Congress turned to TVA as it made plans to strengthen the national preparedness program. Production of atomic defense material became vital, and additional electric generating capacity was needed for the atomic energy installation at Oak Ridge. To supply the urgently needed power, Congress appropriated funds on January 6, 1951, for the first four units of Kingston Steam Plant.

As the Korean conflict continued, AEC accelerated its expansion plans at Oak Ridge to reach maximum production levels. Keeping pace, TVA stepped up its construction schedules and Congress appropriated funds for five additional Kingston units. The chronology of appropriation acts is summarized at the end of this chapter, page 12.

On-site construction of the Kingston Steam Plant began April 30, 1951, and the final unit was placed in commercial operation December 2, 1955. The entire net output of Kingston has continued to flow into Oak Ridge. As each unit was completed and placed in commercial operation, another block of available energy was added to the Oak Ridge resources, as follows:

Unit No.	Capability, kw	Commercial operation
1	150,000	2- 8-54
2	150,000	4-29-54
3	150,000	6-11-54
4	150,000	7-27-54
5	200,000	1-18-55
6	200,000	3- 3-55
7	200,000	5- 6-55
8	200,000	8- 3-55
9	200,000	12- 2-55

Until 1963, Kingston, with a total plant capability of 1,600,000 kw, was the largest known steam plant in the world.

Figure 1 shows the geographical location of Kingston Steam Plant. Figure 2 shows the site location and plant layout. A decided asset of this location is the particular adaptability for handling the condenser cooling water. Coming into the plant through an intake on the Emory River, the cooling water is discharged into the Clinch River on the other side of the peninsula but four miles downstream from the intake. This arrangement positively prevents any possibility of recirculation of condenser discharge water through the system.

The final over-all cost of the plant is $198,199,849.95, or 124 dollars per kw. This equals the lowest unit cost of TVA's major steam plants built since Watts Bar. Included in the over-all figure are the costs of land, land rights, structures, improvements, equipment, transmission plant, and intersite communication equipment. The transmission plant, including the transformer yard and switchyard equipment, alone totals $8,460,774.28.

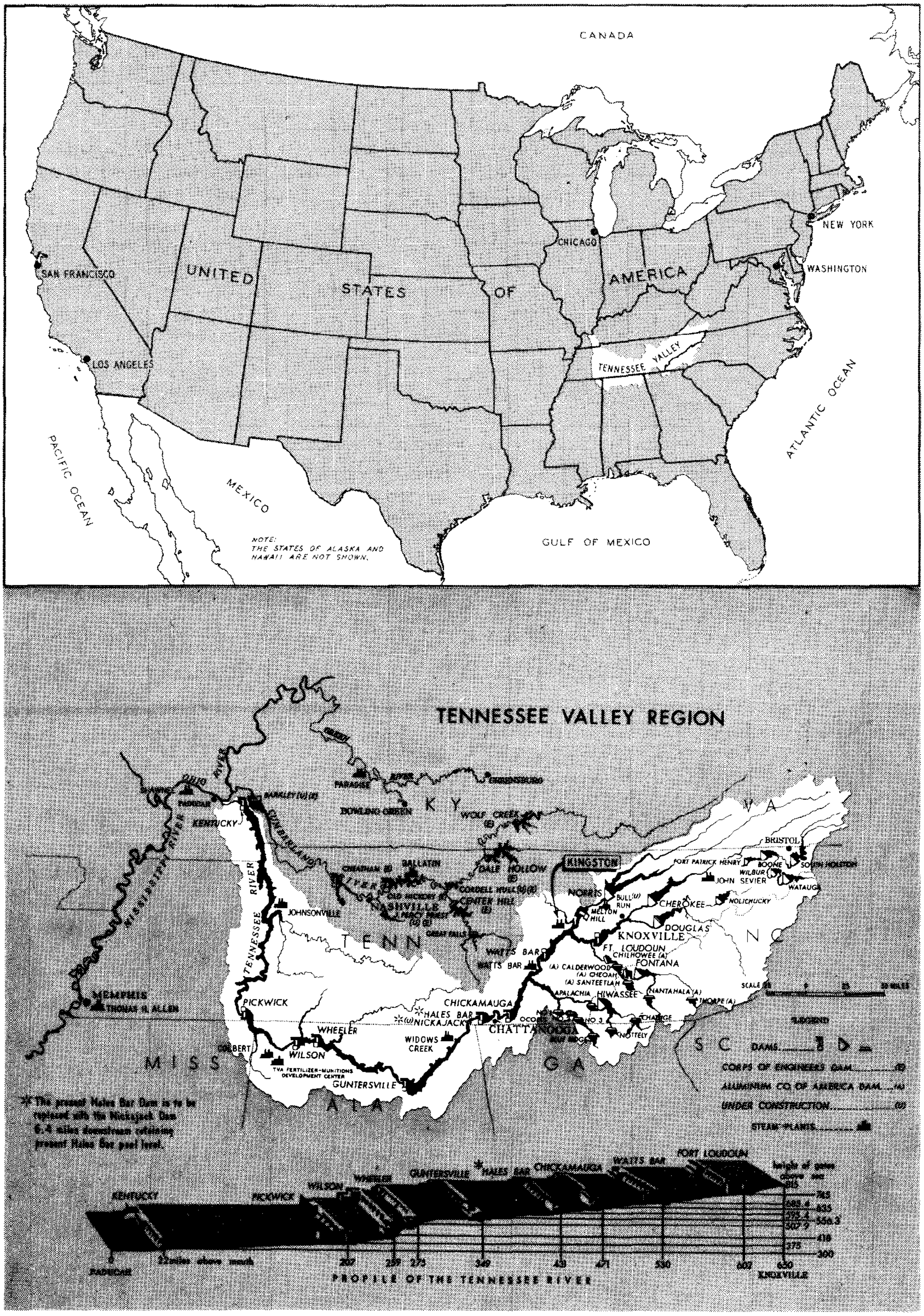


FIGURE 1.—*Geographical location of the Tennessee Valley.*

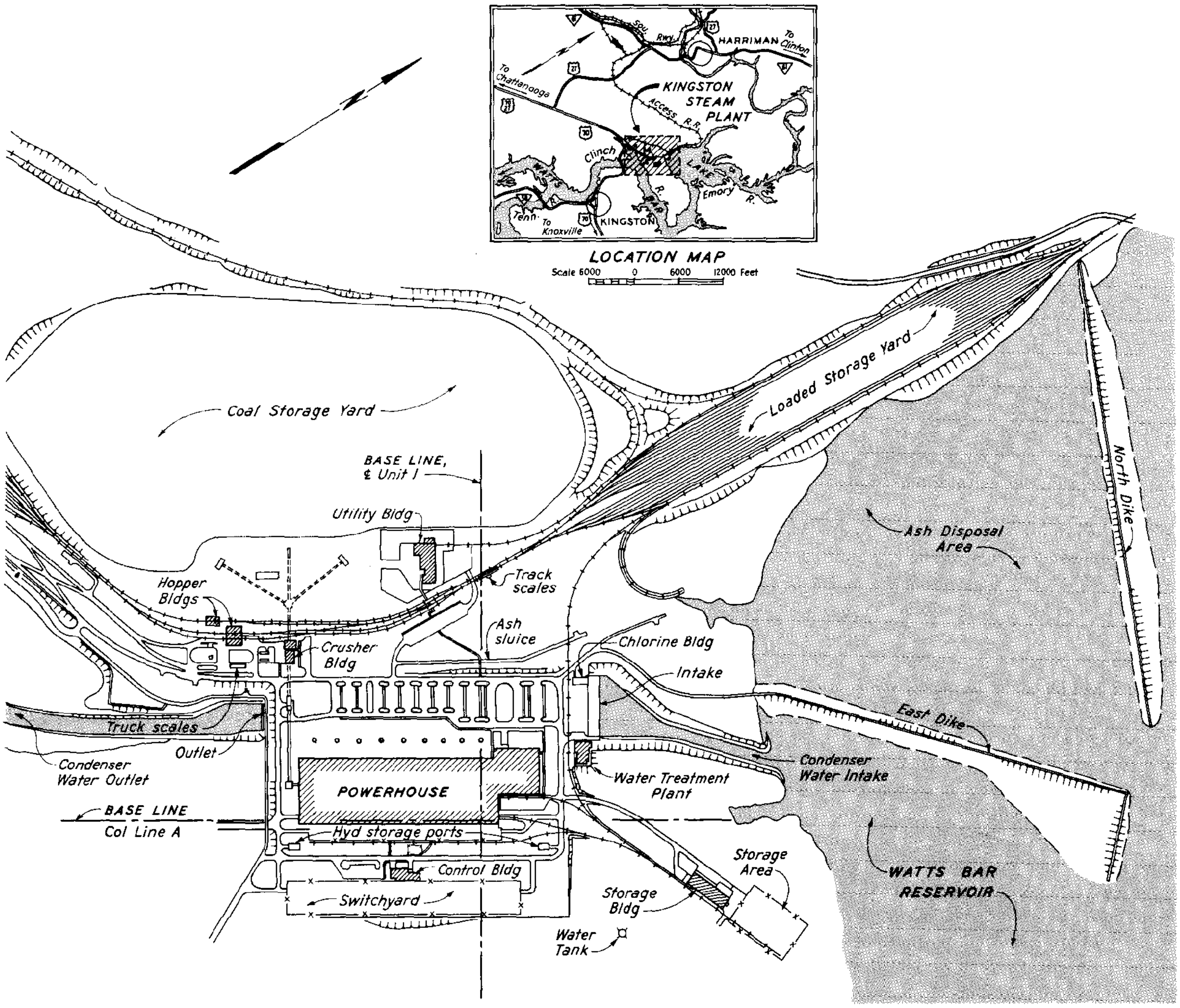


FIGURE 2.—*General project layout and location map of the Kingston Steam Plant.*

The Kingston report presents a record of the more important facts concerning the planning, design, construction, costs, and initial operations of units 1-9. It contains, as exhibits, a group of selected drawings and a complete list of project drawings. The report summarizes the basic office and field reports available for reference at the office of Manager of Engineering Design and Construction, TVA, Knoxville, Tennessee.

TVA AND POWER

TVA is a corporate agency of the United States Government established by Act of Congress in 1933 to develop the Tennessee River and to assist in the development of other resources of the Tennessee Valley and adjoining areas. TVA's objective is to help achieve the unified development of the region's resources in order to strengthen the regional and national economy and the national defense. Its specific purposes include:

1. Effective water control on the Tennessee River, and substantial assistance to flood control on the lower Ohio and Mississippi Rivers.
2. Navigation on the Tennessee River, linking the region to the Nation's 9000-mile system of inland waterways.
3. Widespread and abundant use of electric power.
4. Greater opportunities for agriculture, industry, and forestry production.
5. Development and introduction of more efficient soil fertilizers.

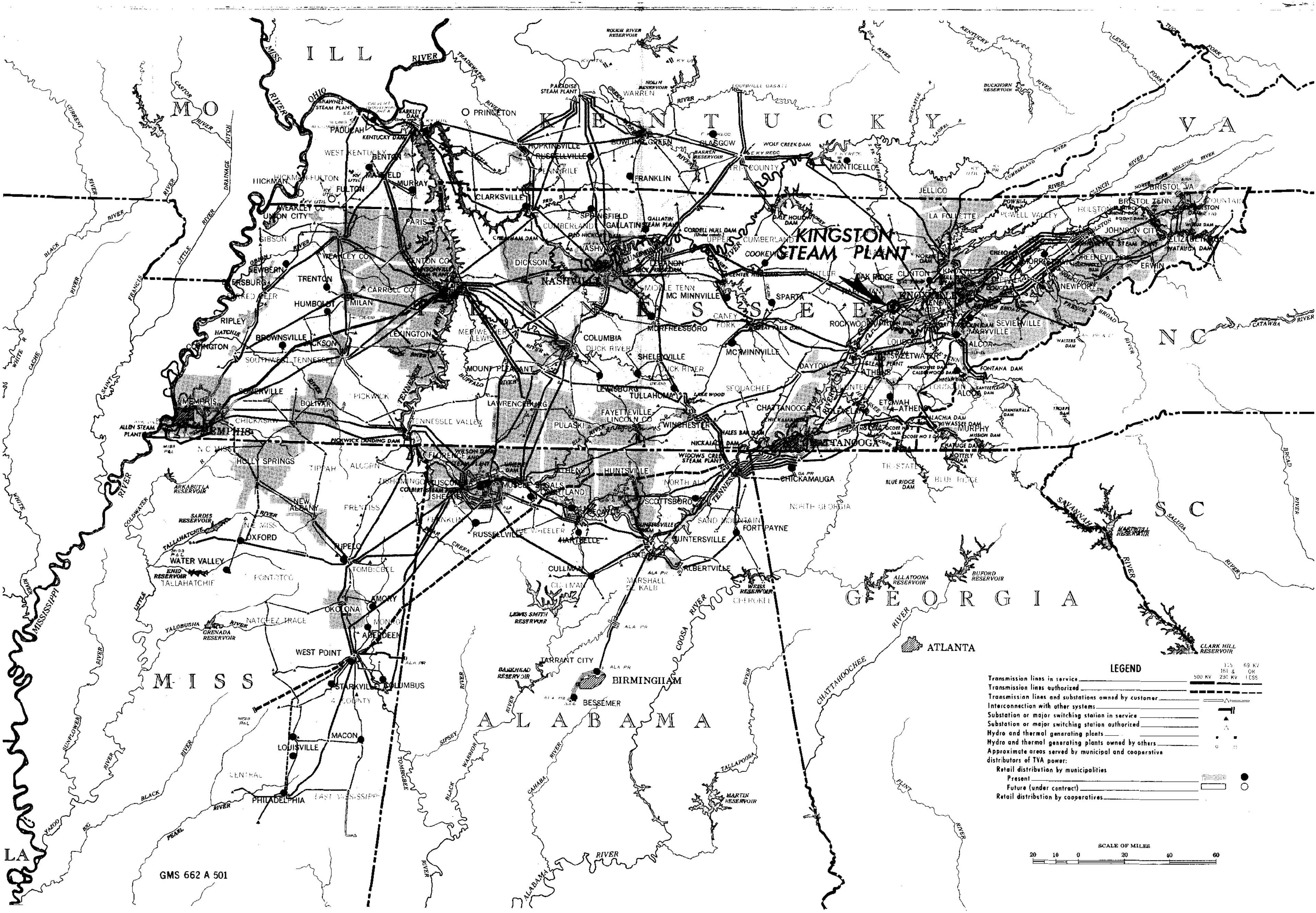


FIGURE 3.—*The TVA power system in 1965.*

TABLE 1.—*Scheduled additions and modifications to June 30, 1966.*

Name	Unit number	Scheduled data of commercial operation	Rated capacity kw	System capacity kw
Thomas H. Allen (steam)[1]	1-3	Jan. 1965	750,000	14,175,615
Widows Creek (steam)	8	Feb. 1965	500,000	14,675,615
Colbert (steam)	5	Sept. 1965	500,000	15,175,615
Barkley (hydro)[2]	1	Nov. 1965	32,500	15,208,115
Barkley (hydro)[2]	2	Nov. 1965	32,500	15,240,615
Barkley (hydro)[2]	3	Jan. 1966	32,500	15,273,115
Barkley (hydro)[2]	4	May 1966	32,500	15,305,615
Bull Run (steam)	1	May 1966	900,000	16,205,615 (16,662,815)[3]

1. Leased by TVA from City of Memphis.
2. U. S. Corps of Engineers project.
3. Total capacity includes steam plant and hydro unit modifications not tabulated.

When TVA was created, the Wilson Steam Plant of 64,000-kw capacity was acquired with other Government properties. By the end of 1939, other steam plants acquired or leased from utilities operating in the region brought system steam plant capacity to 224,000 kw. Hydro was then 635,000 kw. The need for additional steam-electric plants first arose from studies to increase system efficiency by supplementing fluctuating hydroelectric power. The eruption of World War II made added power capacity an emergency matter. The emergency program included Watts Bar, first TVA-built steam plant, constructed along with 11 hydro projects to guarantee the supply of power so urgently needed for war industries, including the then-secret atomic energy plant at Oak Ridge. By mid-1945, steam plant capacity was 456,000 kw and hydro 2,057,000 kw.

After the war, power demands continued to rise in TVA's service area and it became increasingly apparent that the hydroelectric potential of the Tennessee and Cumberland Valleys could not meet the needs of industrial, commercial, domestic, and Federal users. In 1949 TVA began construction of the big Johnsonville Steam Plant. Then, spurred by sharply increased power needs during the Korean struggle and subsequent increasing demands of its service area, TVA built a series of large, modern steam plants. The ninth—Bull Run—will go into operation in 1966.

The year 1964 concluded with a total installed system capacity of 13,425,615 kw, of which 9,334,000 kw is steam-electric. Scheduled additions and modifications would bring the net system capacity to 16,662,815 kw by the middle of 1966 in accordance with the program shown in table 1.

The system will then include, in all, 27 major and 2 minor hydroelectric plants constructed or acquired by TVA, 6 Corps of Engineers hydroelectric plants, 12 hydroelectric plants constructed by ALCOA (Aluminum Company of America), 10 TVA steam-electric plants, and one steam plant leased from the city of Memphis. The entire system serving an area of some 80,000 square miles is interconnected with a grid of high voltage transmission lines and is operated as one integral system (fig. 3).

Responsibility for supplying electricity to the ultimate consumer in the region is shared by TVA, as wholesaler, and 158 local electric systems which retail the power to some 1,800,000 residential, farm, commercial, and industrial customers. Long-term power contracts between TVA and these local systems —105 municipalities, 51 rural electric cooperatives, and 2 privately owned utilities—provide a basis for the distribution of power which adds strength to both the distribution agencies and TVA. As part of its power system, TVA interchanges power with adjacent systems and distributes the power generated at the Corps of Engineers dams on the Cumberland River by arrangement with the Southeastern Power Administration. Furthermore, the ALCOA hydro plants on the Little Tennessee River are operated as part of the TVA system. ALCOA operates its plants at TVA's direction, for which TVA delivers to ALCOA a uniform amount of power. Tables 2 and 3 list the principal features and generating capacities of the hydro and steam projects respectively.

LEGISLATIVE HISTORY

Units 1-4

On December 1, 1950, the President of the United States submitted to Congress a proposed second supplemental appropriation for fiscal year 1951 in the amount of $84,000,000 for the Tennessee Valley Authority.[1] The proposed appropriation included $25,000,000 for beginning construction of a new steam electric plant in the eastern part of the TVA system near Kingston, Tennessee.[2] The steam plant was to consist of four units having a total capacity of 540,000 kw.

Hearings on the TVA supplemental request were held before a Subcommittee of the House Committee

1. H. Doc. No. 727, 81st Cong., 2nd sess., Dec. 1, 1950.
2. Hearings before Subcommittees of the House Committee on Appropriations, 81st Cong., 2nd sess., on Second Supplemental Appropriation Bill for 1951, p. 225.

TABLE 2.—*Principal features of water*

PROJECT	OWNER	DATE OF FIRST COM-MERCIAL USE	RIVER	DAM AND APPURTENANCES: MAX.[a] HEIGHT (FEET)	OVERALL CREST LENGTH (FEET)	MAX.[b] SPILLWAY CAPACITY (CFS)	VOLUME OF CONCRETE (CU. YDS.)	VOLUME[c] EARTH AND/OR ROCK FILL (CU. YDS.)	POWER: RATED CAPACITY (KW)	LOCK: SIZE (FEET)	LOCK: MAX. LIFT (FEET)
TENNESSEE RIVER BASIN											
Kentucky	TVA		Tennessee	206	8422	1,050,000	1,356,000	5,582,000	160,000	110x600	75
Pickwick Landing	TVA		Tennessee	113	7715	650,000	679,100	3,081,000	216,000	110x600	63
Wilson	TVA		Tennessee	137	4535	671,000	1,729,400	0	598,000	110x600 60x300 60x292	100 100[s]
Wheeler	TVA	1936	Tennessee	72	6342	542,000	1,100,000	0	356,400	60x400 110x600	52
Guntersville	TVA	1939	Tennessee	94	3979	478,000	308,600	874,900	97,200	60x360 110x600	45
Nickajack[w]	TVA	1967	Tennessee	83	3700	500,000	530,700	378,000	97,200	110x800 110x600	42
Hales Bar[w]	TVA	1913	Tennessee	112	2315	224,000	—	—	99,700	60x265	41
Chickamauga	TVA	1940	Tennessee	129	5800	470,000	506,400	2,793,500	108,000	60x360	53
Watts Bar	TVA	1942	Tennessee	112	2960	560,000	480,200	1,210,000	150,000	60x360	70
Fort Loudoun	TVA	1943	Tennessee	122	4190	390,000	586,700	3,594,000	128,000	60x360	80
Apalachia	TVA	1943	Hiwassee	150	1308	136,000	237,800[i]	0	75,000	none	
Hiwassee	TVA	1940	Hiwassee	307	1376	112,000[k]	800,600	0	117,100[r]	"	
Chatuge	TVA	1942[m]	Hiwassee	144	2850	11,500	25,700	2,348,400	10,000	"	
Ocoee No. 1	TVA	1912	Ocoee	135	840	45,000[n]	160,000	0	18,000	"	
Ocoee No. 2	TVA	1913	Ocoee	30	450	—	0	0	21,000	"	
Ocoee No. 3	TVA	1943	Ocoee	110	612	95,000	82,500[j]	82,000	27,000	"	
Blue Ridge	TVA	1931	Toccoa	167	1000	55,000	—	1,500,000	20,000	"	
Nottely	TVA	1942[m]	Nottely	184	2300	11,500	21,700	1,552,300	15,000	"	
Melton Hill	TVA	1963[u]	Clinch	103	1020	122,000	250,000	0	72,000	75x400	60
Norris	TVA	1936	Clinch	265	1860	93,400[k]	1,002,300	181,700	100,800	none	
Chilhowee	ALCOA	1957	Little Tenn	91	1373	182,000[k]	91,500	307,000	50,000	"	
Calderwood	ALCOA	1930	Little Tenn	232	916	260,000	—	0	121,500	"	
Cheoah	ALCOA	1919	Little Tenn	225	750	200,000	—	0	110,000	"	
Fontana	TVA	1945	Little Tenn	480	2365	134,300[k]	2,815,500	760,600	202,500	"	
Santeetlah	ALCOA	1928	Cheoah	212	1054	76,100	—	0	45,000	"	
Nantahala	ALCOA	1942	Nantahala	250	1042	59,000	—	1,829,000	43,200	"	
Thorpe	ALCOA	1941	Tuckasegee	150	900	56,000	—	1,060,000	21,600	"	
Douglas	TVA	1943	French Broad	202	1705	342,000[k]	556,400[i]	127,900[i]	112,000	"	
Nolichucky	TVA	1913	Nolichucky	—	—	—	—	—	10,640	"	
Cherokee	TVA	1942	Holston	175	6760	286,000[k]	694,200	3,304,100	120,000	"	
Fort Patrick Henry	TVA	1953	S Fork Holston	95	737	141,000	72,500	30,400	36,000	"	
Boone	TVA	1953	S Fork Holston	160	1532	137,000	198,400	714,000	75,000	"	
South Holston	TVA	1951	S Fork Holston	285	1600	116,200[k,q]	97,500	5,897,400[i]	35,000	"	
Wilbur	TVA	1912	Watauga	77	375	34,000	—	—	10,700	"	
Watauga	TVA	1949	Watauga	318	900	73,200[k,q]	80,400	3,497,800	50,000	"	
CUMBERLAND RIVER BASIN											
Great Falls	TVA	1916	Caney Fork	92	800	150,000[n]	—	—	31,860	"	
Barkley	C of E	1965	Cumberland	155	10,020	620,000	—	—	130,000	110x800	73
Center Hill	C of E	1950	Caney Fork	250	2,160	458,000	993,800	2,616,500	135,000	"	
Cheatham	C of E	1959	Cumberland	75	980	—	195,860	94,500	36,000	110x800	30
Dale Hollow	C of E	1948	Obey	200	1,717	166,000	581,710	—	54,000	none	
Old Hickory	C of E	1957	Cumberland	98	3,750	226,000	339,500	366,550	100,000	84x400	60
Wolf Creek	C of E	1951	Cumberland	258	5,736	541,000	1,421,000	9,397,000	270,000	none	

a. From deepest excavation on or near base line to roadway or deck.

b. At top of gates level. (See exceptions--n,q.)

c. Includes riprap.

d. From full pool level to minimum expected pool level.

e. At full pool elevation, including islands.

f. Except during drawdown in advance of floods at main-river plants.

g. Head at maximum power storage level of tributary storage projects and average head at tributary run-of river and main-river projects.

h. "Full Pool Elevation" is the normal level to which the reservoirs may be filled. Where storage space is available above this level, additional filling may be made as needed for flood control.

i. Apalachia - An additional 219,600 cubic yards concrete in tunnel.
Ocoee No. 3 - An additional 28,500 cubic yards concrete in tunnel.
Douglas - An additional 3,800 cubic yards concrete in saddle dams and dike. An additional 797,200 cubic yards fill in saddle dams and dike.
South Holston - An additional 205,300 cubic yards fill in saddle dam.

j. At remote powerhouse.

k. Includes capacity of discharge conduits.

control projects—TVA integrated system.

RESERVOIR DATA AND OPERATING LEVELS											
AREA AT FULL POOL EL.[h] (ACRES)	TOTAL VOLUME BELOW TOP OF GATES (ACRE-FEET)	USEFUL[d] CONTROLLED STORAGE (ACRE-FEET)	LENGTH[e] OF SHORE LINE (MILES)	BACKWATER LENGTH (MILES)	FULL POOL EL.[h]	TOP OF GATES (EL.)	MINIMUM[f] EXPECTED POOL LEVEL (EL.)	AVERAGE TAILWATER LEVEL (EL.)	HEAD[g] (FEET)	COST[t]	PROJECT
											TENNESSEE RIVER BASIN
158,300	6,002,600	4,010,800	2,380	184.3	359	375	354	310	47	$117,383,684	Kentucky
42,800	1,091,400	418,400	496	52.7	414	418	408	362	50	45,656,873	Pickwick Landing
15,930	650,000	53,000	154	15.5	507.5	507.88	504.5	414	92	100,374,379	Wilson
67,100	1,150,400	347,500	1,063	74.1	556	556.28	550	507	48	87,453,214	Wheeler
69,100	1,018,700	162,900	962	82.1	595	595.44	593	557	37	52,888,000	Guntersville
10,900[v]	254,600[v]	21,200[v]	192[v]	46.3[v]	634	635	632	596	34	73,200,000	Nickajack[w]
6,420	154,200	12,370	162	39.9	634	635	632	596	35	33,441,200	Hales Bar[w]
34,500	705,300	329,400	810	58.9	682.5	685.44	675	634	45	41,327,285	Chickamauga
38,600	1,132,000	377,600	783	72.4	741	745	735	682	56	35,813,215	Watts Bar
14,600	386,500	109,300	360	55	813	815	807	740	70	42,333,040	Fort Loudoun
1,123	58,700	8,700	31	9.8	1280	1280	1272	840[j]	380[net]	23,703,332	Apalachia
6,120	438,000	364,700	180	22	1524.5	1526.5	1415	1275	254	24,330,515	Hiwassee
6,950	247,800	229,300	132	13	1927	1928	1860	1804	126	9,113,893	Chatuge
1,900	91,300	33,100	18	7.5	837.65	837.65	816.9	724	113	3,100,423	Ocoee No. 1
—	—	silted	—	—	1115	1115	—	843[j]	252	2,974,484	Ocoee No. 2
604	8,700[o]	5,850[o]	24	7	1435	1435	1413	1119[j]	313	8,866,480	Ocoee No. 3
3,290	200,800	186,300	60	10	1690	1691	1590	1543	147	5,536,485	Blue Ridge
4,180	184,400	171,300	106	20	1780	1780	1690	1612	174.5	8,095,778	Nottely
5,720	124,900	26,000	144	44	795	796	790	742	51	36,065,992	Melton Hill
34,200	2,567,000	2,281,000	800	72 Clinch 56 Powell	1020	1034	930	826	194	33,509,027	Norris
1,690	49,250	6,564	30	8.9	874	874	870	812	60[net]	—	Chilhowee
536	41,160	1,570		8	1087.46	1087.46	1084.46	869[j]	209[net]	—	Calderwood
595	35,030	1,850	—	10	1276.51	1276.51	1273.51	1087	187[net]	—	Cheoah
10,530	1,444,300	1,157,300	248	29	1708	1710	1525	1276	429	78,365,496	Fontana
2,863	156,250	133,300	85	7.5	1939.92	1939.92	1863	1275[j]	597[net]	—	Santeetlah
1,605	138,730	126,000	—	4.6	3012.16	3012.16	2881	2007[j]	944[net]	—	Nantahala
1,462	70,810	67,100	—	4.5	3491.75	3491.75	3415	2284.4[p]	1200	—	Thorpe
30,600	1,514,100	1,419,700	555	43.1	1000	1002	920	873	129	46,465,826	Douglas
797	9,850	—	—	—	1245.9	1245.9	—	—	68	1,867,624	Nolichucky
30,200	1,565,400	1,473,100	463	59	1073	1075	980	925	149	36,387,160	Cherokee
893	27,100	4,300	36.9	10.3	1263	1263	1258	1195	75	12,288,233	Fort Patrick Henry
4,520	196,700	150,000	130	17.3 S Fork Holston 15.3 Watauga	1385	1385	1330	1264	123	27,677,012	Boone
7,580	744,000	625,200		24.3	1729	1742	1616	1490	239	31,400,985	South Holston
72	—	327	3	1.75	1650	1650	1645	1585	62	2,491,529	Wilbur
6,430	678,800	627,200	106	16.7	1959	1975	1815	1650	309	32,508,729	Watauga
											CUMBERLAND RIVER BASIN
2,270	54,500	49,400	120	22	805.16	805.16	762.16	655[j]	150	6,354,220	Great Falls
62,100	2,248,000	1,555,000	—	118	359	376	346	313	44	—	Barkley
23,060	2,092,000	1,254,000	—	64	685	685	618	486	170	—	Center Hill
7,450	104,000	20,000	—	67.5	385	386	382	363	22	—	Cheatham
30,990	1,706,000	849,000	—	51	663	663	631	512	143	—	Dale Hollow
22,500	545,000	100,000	—	97.3	445	447	442	398	45	—	Old Hickory
63,530	6,089,000	4,236,000	—	101	760	760	673	561	177	—	Wolf Creek

m. Closure date; storage project initially.

n. Ocoee No. 1 - At headwater elevation 834.6.
Great Falls - At headwater elevation 812.

o. 1953 data.

p. Center line of nozzle.

q. Surcharged pool for *maximum design flood.*

r. Unit 2 is a reversible pump-turbine.

s. Two-lift auxiliary lock.

t. For completed projects cost, including switchyard, is from 6-30-65 financial statement which reflects *all additions, reclassifications,* and retirements except Guntersville which includes estimated cost of $16,505,000 for new lock now in final clean-up stage of construction.

u. Lock operation; first unit operation in 1964.

v. Includes amount presently shown for Hales Bar.

w. Hales Bar Dam will be replaced by Nickajack Dam six miles downstream. Nickajack Reservoir will include the present Hales Bar Reservoir.

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TABLE 3.—*TVA steam*

NAME	LOCATION	UNITS	UNIT NAMEPLATE CAPACITY KW	TOTAL NAMEPLATE CAPACITY KW	UNIT CAPABILITY KW	TOTAL CAPABILITY KW	STEAM PRESSURE-THROTTLE LB/SQ IN.	STEAM TEMP-°F THROTTLE/ REHEAT	SPEED RPM
MAJOR STEAM PLANTS BUILT BY TVA									
Bull Run	On Clinch River between Knoxville and Oak Ridge, Tenn.	1 h	900,000	900,000	900,000	900,000	3500	1000/1000	3600/1800[f]
Colbert	On Pickwick Landing Lake 12 mi SW of Wilson Dam, Ala.	1-4 5 h	180,000 500,000	1,220,000	200,000 500,000	1,300,000	1800 2400	1050/1050 1050/1000	3600 3600/3600[f]
Gallatin	On Cumberland River 5 mi SE of Gallatin, Tenn.	1-2 3-4	250,000 275,000	1,050,000	250,000 275,000	1,050,000	2000 2000	1050/1050 1050/1050	3600 3600
John Sevier	On Holston River 3 mi SE of Rogersville, Tenn.	1-4	180,000	720,000	200,000	800,000	1800	1050/1050	3600
Johnsonville	On Kentucky Lake 12 mi W of Waverly, Tenn.	1-6 7-10	112,500 150,000	1,275,000	125,000 150,000	1,350,000	1450 2000	1000 1050/1000	4 @ 1800 6 @ 3600
Kingston	On Watts Bar Lake 2 mi NE of Kingston, Tenn.	1-4 5-9	135,000 180,000	1,440,000	150,000 200,000	1,600,000	1800 1800	1000/1000 1050/1050	3600 3600
Paradise	On Green River near Paradise, Ky.	1-2 3	650,000 1,130,000	2,430,000	650,000 1,130,000	2,430,000	2400 3500	1050/1000 1000/1000	3600/1800[f]
Shawnee	On Ohio River 10 mi NW of Paducah, Ky.	1-10	135,000	1,350,000	150,000	1,500,000	1800	1000/1000	3600
Watts Bar	2/3 mi below Watts Bar Dam, 7 mi SE of Spring City, Tenn.	A-B-C-D	60,000	240,000	66,667	266,667	850	900	1800
Widows Creek	On Guntersville Lake 5 mi SW of Bridgeport, Ala.	1-4 5-6 7 8 h	112,500 112,500 500,000 500,000	1,675,000	125,000 125,000 500,000 500,000	1,750,000	1450 1800 2400 2400	1000 1000/1000 1050/1000 1050/1000	3600 3600 3600/1800[f] 3600/3600[f]
LEASED BY TVA[d]									
Thomas H. Allen	Memphis, Tenn.	3	250,000	750,000	272,000	816,000	2400	1050/1050	3600

a. TVA-built plants have one boiler to each unit. All are reheat type except Watts Bar, units 1-6 Johnsonville, and units 1-4 Widows Creek.

b. Actual construction costs or estimates including switchyards as included in budget programs submitted to Congress January 1965. Estimates for present construction include interest during construction.

c. Unit 5 is in trial operation pending acceptance for commerical operation.

d. Leased from City of Memphis, Light, Gas and Water Division, January 1, 1965.

plant data.

GENERATOR VOLTAGE KV	BOILER[a] CAPACITY/ UNIT--LB STEAM/HR	APPROX COAL[e] CONSUMP-TION/UNIT --TONS/HR	NET PLANT HEAT RATE BTU/KWH	CONDENSER COOLING WATER/UNIT --GAL/MIN	CONSTRUC-TION STARTED	FIRST UNIT IN COMMERCIAL OPERATION[g]	LAST UNIT ON LINE ACTUAL SCHEDULED	ACTUAL OR ESTIMATED COST[b]	NAME
									MAJOR STEAM PLANTS BUILT BY TVA
24.0	6,400,000	316	8391	397,500	4- 2-62	5- -66	5- -66	139,400,000	Bull Run
20.0	1,280,000	76	9299	142,500	10-15-51	1-18-55	11- 4-55	99,104,000	Colbert
24.0	3,900,000	188	8846	295,000	1- 4-60	c	c	65,709,000	
24.0	1,650,000	99.5	9294	144,200	5-11-53	11- 8-56	8- 9-59	137,915,000	Gallatin
24.0	1,960,000	111.5	9165	152,000	8- 7-56				
20.0	1,280,000	70	9267	113,500	10-14-52	7-12-55	10-31-57	105,953,000	John Sevier
4 • 13.8	1,000,000	54	4 • 10,222 2 • 10,152	105,500	5-12-49	10-27-51	2-22-53	94,284,000	Johnsonville
6 • 18.0	1,100,000	62	9317	99,000	7- 2-56	11-30-58	8-20-59	75,705,000	
18.0	1,000,000	58	9367	90,000	4-30-51	2-8- 54	7-27-54		Kingston
20.0	1,280,000	76.5	9288	121,400	-	1-18-55	12- 2-55	198,200,000	
24.0	4,900,000	306	8767	226,200	11- 2-59	5-19-63	11- 1-63	178,510,000	Paradise
	8,000,000				10- -65	10- -69	10- -69	133,500,000	
18.0	1,000,000	58	9398	107,600	1- 6-51	4- 9-53	10-12-56	213,536,000	Shawnee
13.8	600,000	26	11,404	70,200	8- 8-40	2-15-42	4- 8-45	19,821,000	Watts Bar
18.0	1,000,000	51	10,096	107,600	3-29-50	7- 1-52	1 -23-53	93,826,000	Widows Creek
18.0	850,000	49	9442	92,500		6- 3-54	7-17-54		
24.0	3,850,000	208	8835	227,000	3- 3-58	2- 1-61	2- 1-61	71,506,000	
24.0	3,850,000	226	8766	250,000	10-12-60	2- 7-65	2- 7-65	61,647,000	
									LEASED BY TVA[d]
24.0	2,000,000	j	8825	127,000	9- -56	5-22-59			Thomas H. Allen

e. Based on coal specified in boiler specifications.

f. Cross-compound unit.

g. Actual or scheduled.

h. Under construction.

j. Also equipped to burn gas.

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on Appropriations on December 7, 1950.[3] At this hearing, TVA officials stated that the international situation and the effect that this situation was having upon delivery dates of power-generating equipment were increasing the amount of time required to get new generating units into operation, and that this addition to the TVA power system was needed so that TVA would not be caught short in meeting the electric requirements in the Tennessee Valley area in 1953. TVA officials pointed out that the location of the plant in the eastern part of the TVA system would help make it possible for TVA to serve expanding loads that were taking place throughout this area in industrial plants related to national defense.

The House Committee on Appropriations submitted its report on the Second Supplemental Appropriation Bill, 1951, on December 15, 1950.[4] The Committee recommended an appropriation of $22,500,000 for the start of the Kingston Steam Plant, $2,500,000 less than the amount requested. The reduction was based on testimony that the funds requested in the estimate allowed for an anticipated cost increase of between 7 and 10 percent.[5] The House accepted the recommendation of the Committee on the Kingston Steam Plant and passed the bill on December 15, 1950.[6]

Hearings on the TVA portion of the Second Supplemental Appropriation Bill, 1951, were held before the Senate Committee on Appropriations on December 18, 1950.[7] TVA officials stated that the anticipated extra-ordinary load developments due largely to national defense, required that the Kingston Steam Plant be started immediately in order that TVA could meet the power load requirements in 1953. TVA also asked the Senate Committee to restore the $2,500,000 reduction made by the House, since the very tight schedule for this plant made it highly desirable that the greatest possible proportion of total necessary funds be obligated at the earliest date. Moreover, the TVA officials pointed out that any reduction in the 1951 funds would have to be added in 1952, since the estimated total cost of the plant would not be changed.

The Senate Committee on Appropriations submitted its report on the Second Supplemental Appropriation Bill, 1951, on December 20, 1950.[8] The Committee recommended that the Senate restore the $2,500,000 reduction made by the House in the Kingston Steam Plant appropriation request. The Senate restored the cut and passed the bill on December 21, 1950.[9]

A House-Senate conference committee was appointed to consider the differences in the Second Supplemental Appropriation Bill, 1951, as passed by the House and as passed by the Senate. The conference committee agreed on an appropriation of $24,500,000 for starting the Kingston Steam Plant.[10] Both the House and the Senate agreed to this amount.[11] The President of the United States signed the Second Supplemental Appropriation Bill, 1951, on January 6, 1951.[12]

Units 5 and 6

In its budget submission for fiscal year 1953, TVA requested $62,528,000 for beginning construction of 8 additional steam units and 4 additional hydro units.[13] Included in this request was $15,000,000 for adding units 5 and 6 at the Kingston Steam Plant.[14]

The TVA budget for 1953 was included in the Independent Offices Appropriation Bill, 1953. Hearings on the TVA portion of this bill were held before a Subcommittee of the House Committee on Appropriations on February 14, 1952.[15] In its justification of the 12 additional power units which included Kingston Steam Plant units 5 and 6, TVA pointed out that these new installations were being prepared in order to increase the assured capacity of the system to about 7,600,000 kilowatts by the end of 1955.[16]

The House Appropriations Committee submitted its report on the Independent Offices Appropriation Bill, 1953, on March 14, 1952.[17] The amount the Committee recommended for TVA included $15,000,000 for starting units 5 and 6 at the Kingston Steam Plant, and this provision was included in the bill as passed by the House on March 21, 1952.[18]

The Subcommittee of the Senate Committee on Appropriations held hearings on the TVA budget for fiscal year 1953 on April 25, 1952.[19] The Committee submitted its report on May 28, 1952, and the amount recommended for TVA included $15,000,000 for Kingston Steam Plant units 5 and 6.[20] The Senate passed the Independent Offices Appropriation Bill, 1953, on June 3, 1952,[21] and the bill as passed contained the appropriation for Kingston Steam Plant, units 5 and 6.

A House-Senate Conference Committee was appointed to consider differences in the Independent Offices Appropriations Bill, 1953, as passed by the two legislative bodies. In the report, the Committee made no reference to Kingston Steam Plant, units 5 and 6, since both the House and the Senate were

3. *Ibid.*, pp. 224-244.
4. H. Rept. No. 3193, 81st Cong., 2d sess., Dec. 15, 1950.
5. *Ibid.*, pp. 16-17.
6. *Congressional Record*, 96:16815-16841.
7. Hearings before the Senate Committee on Appropriations, 81st Cong., 2d sess., on Second Supplemental Appropriation Bill, 1951, pp. 215-241.
8. S. Rept. No. 2684, 81st Cong., 2d sess., Dec. 20, 1950, pp. 6-7, 9.
9. *Congressional Record*, 96: 17050, 17059-17067.
10. H. Rept. No. 3240, 81st Cong., 2d sess., Jan 1, 1951, pp. 2-4.
11. *Congressional Record*, 96: 17246-17254, 17276-17281, 17283-17284.
12. Public Law 911, 81st Cong.
13. *The Budget of the United States*, 1953, pp. 194-206.
14. *Ibid.*, pp. 194-195.
15. Hearings before the Subcommittee of the House Committee on Appropriations, 82nd Cong., 2d sess., on Independent Offices Appropriations for 1953, part 3, pp. 1325-1409.
16. *Ibid.*, pp. 1336-1337.
17. H. Rept. No. 1517, 82d Cong., 2d sess., March 14, 1952.
18. *Congressional Record*, 98:2563-2582, 2649-2682, 2697-2740.
19. Hearings before the Subcommittee of the Senate Committee on Appropriations, 82d Cong., 2d sess., on Independent Offices Appropriations, 1953, pp. 411-450.
20. S. Rept. No. 1603, 82d Cong., 2d sess., May 28, 1952.
21. *Congressional Record*, 98:6543-6544, 6547-6585.

in agreement on this item.[22] The conference report was agreed to by the House and by the Senate on July 2, 1952.[23]

The Independent Offices Appropriation Bill, 1953, was signed by the President on July 5, 1952.[24] The Act included $15,000,000 for starting units 5 and 6 at the Kingston Steam Plant.

Units 7 and 8

On May 28, 1952, the President of the United States transmitted a proposed supplemental appropriation for fiscal year 1953 in the amount of $150,000,000 for the Tennessee Valley Authority.[25] The proposed supplemental appropriation was to provide funds for commencing construction of steam electrical generating plants, transmission lines, and other facilities necessary to furnish power for certain of the proposed expanded facilities of the Atomic Energy Commission.[26] The proposed supplemental included $20,000,000 for starting units 7 and 8 at Kingston Steam Plant.[27]

Hearings on the TVA portion of the Supplemental Appropriations Bill for 1953 were held by a Subcommittee of the House Committee on Appropriations on June 16, 1952.[28] The committee in its report recommended the full amount that the President had requested for TVA.[29] The House, however, reduced the amount for TVA from $150,000,000 to $85,000,000, but did not specify where the cut was to be made.[30]

TVA presented its testimony before the Senate Committee on Appropriations on July 1, 1952, and asked for restoration of the $65,000,000 cut by the House.[31] The Senate Committee on Appropriations recommended restoration of the House reduction.[32] The Senate debated and passed the Second Supplemental Appropriation Act, 1953, on July 3, 1952, after having adopted an amendment to increase the TVA appropriation from $85,000,000, as passed by the House, to $150,000,000.[33]

A Conference Committee was appointed from the House and the Senate to consider differences in the Supplemental Appropriation Bill, 1953. The Conference Committee agreed to provide $150,000,000 for TVA instead of $85,000,000 as proposed by the House.[34] Although there were other items in disagreement, these did not relate to TVA.[35] Both the House and the Senate adopted the Conference Committee's report on July 7, 1952.[36]

The bill was signed by the President on July 15, 1952.[37] The Act provided supplemental appropriations of $150,000,000 for TVA for fiscal year 1953,[38] and this amount included $20,000,000 for starting Kingston Steam Plant units 7 and 8.

Unit 9

TVA requested $9,000,000 for beginning construction of Kingston Steam Plant, unit 9, in its budget submission for fiscal year 1954.[39] TVA's budget was submitted to the Congress as part of the Budget of the United States for fiscal year 1954 by President Harry S. Truman on January 9, 1953.

On January 20, the administration of President Dwight D. Eisenhower came into office. Shortly thereafter, the new administration ordered all departments and agencies to make a special review of their 1954 budget request.[40] TVA made such a review; and although it made a reduction in its appropriation financed budget, it made no change in the amount of funds requested for Kingston Steam Plant, unit 9.[41]

Hearings on the TVA budget for 1954 were held by a Subcommittee of the House Committee on Appropriations on March 12 and 27, April 1, and May 14, 18, 25, and 28, 1953.[42] During the hearings, TVA officials pointed out that the Kingston Steam Plant, unit 9, was one of the four units that TVA proposed to begin in 1954 in order to take care of future power requirements which were expected to grow at the rate of at least 750,000 kilowatts a year.[43]

On June 11, 1953, the House Committee on Appropriations reported the Second Independent Offices Appropriation Bill, 1954.[44] The committee recommended the appropriation of $9,000,000 for the start of Kingston Steam Plant, unit 9.[45] The House debated the bill on June 16 and 17, 1954,[46] and rejected an amendment to delete TVA's appropriations for Kingston Steam Plant, unit 9.[47] The appropriation bill was passed by the House on June 18, 1953.[48]

Hearings on the TVA budget for 1954 were held before a subcommittee of the Senate Committee on

22. H. Rept. No. 2443, 82d Cong., 2d sess., July 2, 1952.
23. *Congressional Record*, 98:8207-8212, 8367-8378, 9019-9028, 9161-9163.
24. Public Law 455, 82d Cong.
25. H. Doc. No. 476, 82d Cong., 2d sess., May 29, 1952.
26. *Ibid.*, p. 3.
27. Letter to Hon. Albert Thomas, Chairman, Subcommittee on Independent Offices, Committee on Appropriations, House of Representatives, from Chairman of the Board, TVA, June 10, 1952.
28. Hearings before Subcommittees of the House Committee on Appropriations, 82d Cong., 2d sess., on the Supplemental Appropriations Bill for 1953, pp. 75-96.
29. H. Rept. No. 2316, 82d Cong., 2d sess., June 26, 1952, pp. 25, 29.
30. *Congressional Record*, 98:8390-8431, 8526-8580.
31. Hearings before the Senate Committee on Appropriations, 82d Cong., 2d sess., on Supplemental Appropriation Bill, 1953, pp. 372-385.
32. S. Rept. No. 2076, 82d Cong., 2d sess., July 2, 1952, pp. 6, 18.
33. *Congressional Record*, 98:9249-9254, 9264-9297.
34. H. Rept. No. 2494, 82d Cong., 2d sess., July 5, 1952, pp. 1-2, 8.
35. *Cf.* H. Rept. No. 2498, 82d Cong., 2d sess., July 5, 1952, and H. Rept. No. 2499, 82d Cong., 2d sess., July 7, 1952.
36. *Congressional Record*, 98:9746-9750, 9774-9783, 9801-9805, 9813-9815, 9831-9834, 9843.
37. Public Law 547, 82d Cong.
38. *Ibid.*, p. 9.
39. *The Budget of the United States*, 1954, pp. 177-191.
40. Letter to the Chairman of the Board, TVA, from Joseph M. Dodge, Director, Bureau of the Budget, February 3, 1953.
41. Letter to Joseph M. Dodge, Director of the Bureau of the Budget, from General Manager, TVA, March 6, 1953.
42. Hearings before the Subcommittee of the House Committee on Appropriations, 83d Cong., 1st sess., on Second Independent Offices Appropriations for 1954, Part 1, pp. 1-242, and on Independent Offices Appropriations for 1954, Part 3, pp. 1238-1328.
43. *Ibid.*, pp. 55-58.
44. H. Rept. No. 550, 83d Cong., 1st sess., June 11, 1953.
45. *Ibid.*, pp. 5-7.
46. *Congressional Record*, 99:6862-6901, 6909-6962.
47. *Ibid.*, 99:6916-6926.
48. *Ibid.*, 99:7043-7044.

Appropriations on June 22 and 26, 1953.[49] On July 8, 1953, the Committee submitted its report which made no change in House appropriation for Kingston Steam Plant, unit 9.[50] On July 10, 1953, the Senate passed the Second Independent Offices Appropriation Bill, 1954, with amendments.[51] These amendments did not concern the Kingston Steam Plant, unit 9.

A House-Senate Conference Committee was appointed to consider differences in the Second Independent Offices Appropriation Bill, 1954, as passed by the House and by the Senate. In its report, the Committee made no reference to the Kingston Steam Plant, unit 9, since both the House and the Senate were in agreement on this item.[52] On July 20, 1953, both the Senate and the House adopted the conference report.[53]

The bill was signed by the President on July 27, 1953.[54] This act made available to TVA $9,000,000 for the start of construction of Kingston Steam Plant, unit 9, in fiscal year 1954.

49. Hearings before the Subcommittee of the Senate Committee on Appropriations, 83d Cong., 1st sess., on Second Independent Offices Appropriations for 1954, pp. 81-149, 253-365, 408-487.
50. S. Rept. No. 502, 83d Cong., 1st sess., July 8, 1953, pp. 4-5, 9.
51. *Congressional Record,* 99:8742-8784.
52. H. Rept. No. 882, 83d Cong., 1st sess., July 18, 1953.

Summary

The following tabulation lists the legislative acts that authorized TVA to begin construction of Kingston Steam Plant units 1-9. The appropriation acts listed provided only the initial funds to begin construction of the units specified. Funds for completing the units were provided in subsequent appropriation acts.

53. *Congressional Record,* 99:9481-9482, 9516-9519.
54. Public Law 149, 83d Cong.

Units	Law	Congress	Name of Act	Date
1-4	PL 911	81st, 2d sess.	Second Supplemental Appropriation Act, 1951	Jan. 6, 1951
5-6	PL 455	82d, 2d sess.	Independent Offices Appropriation Act, 1953	July 5, 1952
7-8	PL 547	82d, 2d sess.	Supplemental Appropriation Act, 1953	July 15, 1952
9	PL 149	83d, 1st sess.	Second Independent Offices Appropriation Act, 1954	July 27, 1953

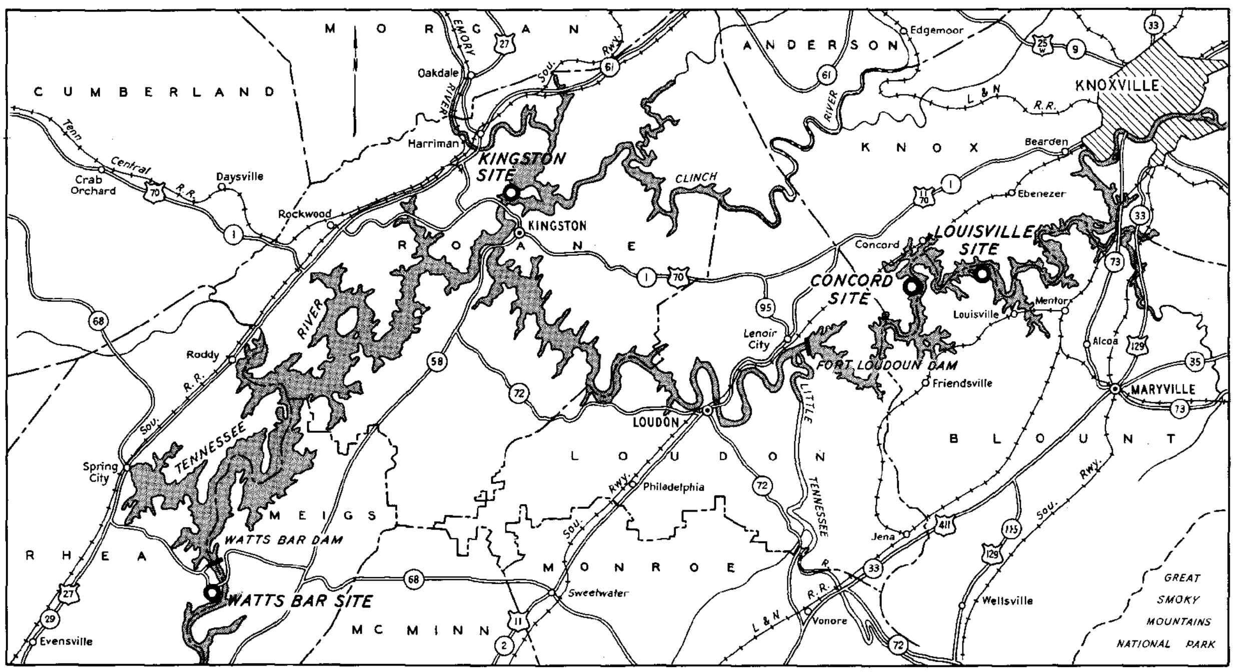

FIGURE 4.—*Alternate steam plant sites studied prior to selection of the Kingston site.*

CHAPTER 2

PLANNING

This chapter on planning describes factors that led to the selection of the Kingston site for a steam-electric plant over several other sites which were studied and compared. All are discussed in the following text.

NEED FOR PLANT, GENERAL LOCATION, SIZE

The Government's program for defense mobilization in the early 1950's, superimposed on the normal growth of the system load, resulted in a rapid increase in the power demands on the TVA system during the Korean conflict. This made it imperative to develop additional power, which could be obtained most expeditiously and economically by adding steam-generating facilities to the system.

The nature of the defense load to be supplied required the construction of two plants, one in the northwestern part and one in the eastern part of the service area. In the eastern area, a general location near Oak Ridge was indicated because of the heavy power demand of the Atomic Energy Commission.

The initial planning studies were made for a plant to contain four units of 150,000-kw capability each, feasible of expansion to six 150,000-kw units. After the design of the first four units was under way, new estimates of load growth indicated that greater capacity was needed. Consequently, the layout of the plant was changed to include four 150,000-kw units and five 200,000-kw units, an ultimate installation of 1,600,000-kw capability.

SITES CONSIDERED

Certain basic requirements for a steam plant site are necessary for operating efficiency and low cost of energy. Generally, these requirements include suitable topographic conditions; foundations that permit safe and economical design; an ample supply of cooling water for condensers; an adequate supply of fuel that can be brought to the site by existing facilities at a reasonable cost; and a location from which power can be delivered to the system without excessive transmission costs and losses.

In the area near Oak Ridge, topographic and cooling water requirements effectively limit the available sites to those on the shores of TVA lakes. The availability of fuel by existing transportation facilities further limited the site selection. The following locations were studied in considerable detail:

1. A site immediately downstream from the present Watts Bar Steam Plant on the right bank of Chickamauga Lake approximately at river mile 528.
2. A site near Concord, Tenn., on the right bank of Fort Loudoun Reservoir approximately at river mile 615.
3. A site near Louisville, Tenn., on the left bank of Fort Loudoun Reservoir near river mile 623.
4. A site near Kingston, Tenn., on a peninsula in Watts Bar Reservoir formed by the confluence of the Emory and the Clinch Rivers.

The locations of these sites are shown in figure 4.

SELECTION OF THE SITE

The Louisville site was eliminated when coal procurement studies indicated that freight rates would be higher than to the other sites. The choice between the three remaining sites was made after a comparison of the costs of plant features that would differ because of site conditions as discussed in the following paragraphs.

Land

Land appraisals showed that the Kingston site would be more expensive than either the Concord or Watts Bar sites. Both of the latter sites were being used entirely for agricultural purposes, but part of the Kingston site had been subdivided and several residences had been constructed. An additional expense would be caused by the necessity to relocate the water supply line for the town of Kingston.

At the Kingston site, additional land would have to be purchased for the access railroad and interchange yard. On the other hand, a plant at Watts Bar would make some use of the access railroad and the interchange yard that serve the existing plant. At Concord only a small expenditure would be necessary for a railroad right-of-way.

Highway access

Access by highway to all the sites would be relatively easy. However, the cost of providing highway access to the three sites would differ considerably. The Watts Bar access road would be the lowest in cost because only a small amount of grading would be required. The Concord access road would require

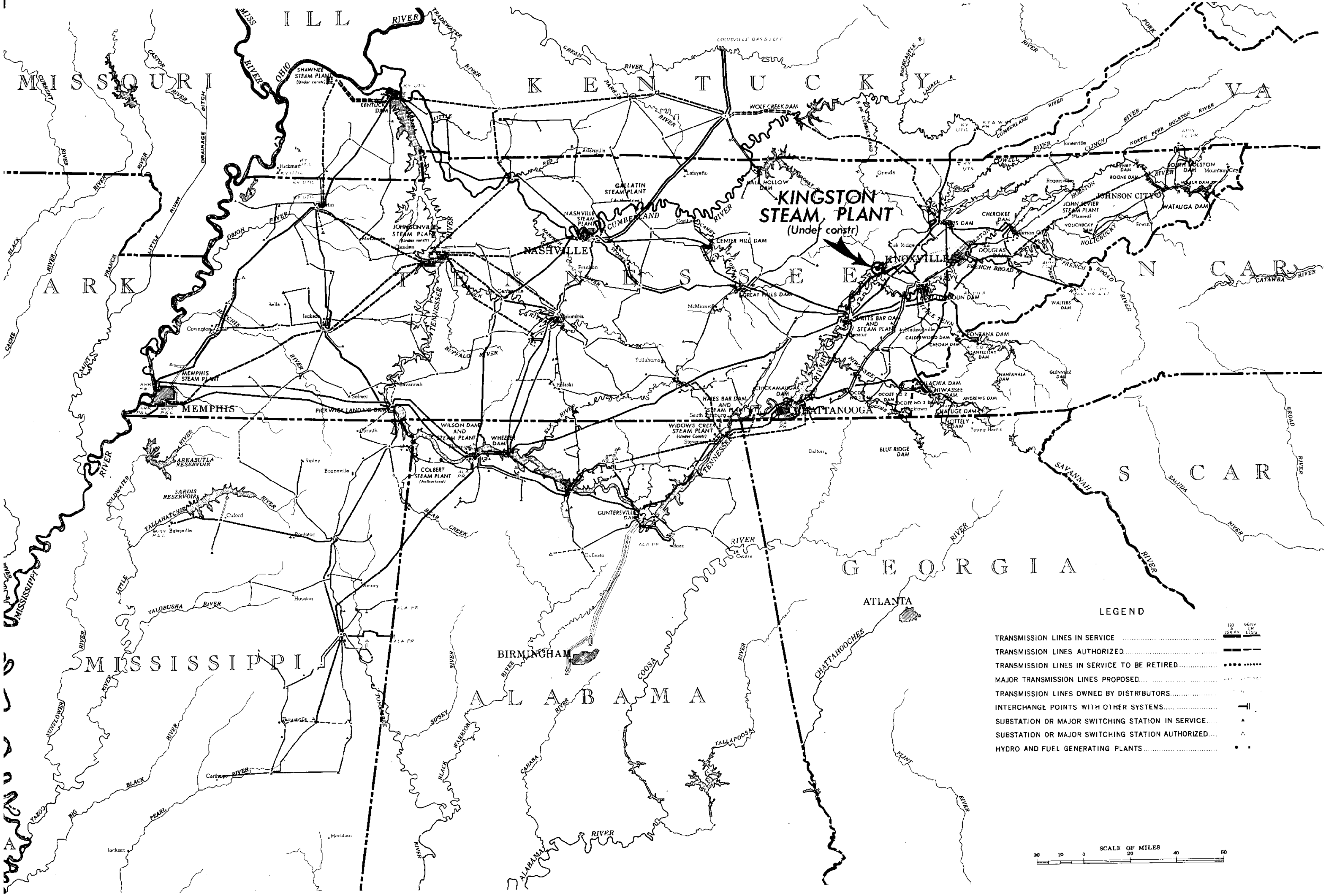

FIGURE 5.—*The TVA power system, June 1951.*

a long and relatively expensive fill to locate it above flood level. Under the plan used for the site comparisons, the Kingston access road also would be relatively expensive, for it would require a grade separation at a railroad crossing.

Railroad access

For the purpose of site comparison, maximum grades on the access railroads had been set at 1.5 percent for loaded cars and 2 percent for empties. Since the existing access railroad at Watts Bar reaches a maximum grade of 4 percent, the expense of reducing grades to a maximum of 2 percent was taken into account. Enlargement of the existing interchange yard south of Spring City would also be necessary.

Rail access to the Concord site would require about 2 miles of new railroad as well as an interchange yard. The terrain in the area is comparatively gentle, and any location proposed would have easy access grades and curves.

The Kingston site would require the construction of about 6.5 miles of spur railroad and suitable interchange yards at the railhead. Consequently, the cost of rail facilities would be more than twice as much as that for either of the other two sites.

Navigation facilities

Barge access could be readily provided at each of the three sites. All of them are located so as to provide sufficient space for maneuvering tows without interference. There would be no need at any of the sites to construct an artificial harbor, though more shoreline improvement would be necessary at Kingston than at either Watts Bar or Concord.

Plant foundations

Preliminary foundation explorations were conducted to determine the approximate surface of bedrock and to obtain a general idea of the geologic formations involved.

The top of rock at the Concord site ranges from elevations 762 to 786. The bedrock is a limestone that is extremely soluble and cavernous and would require a substantial amount of foundation treatment. It was estimated that the extra concrete required to treat the cavernous foundation would exceed 70,000 cu yd. The normal minimum level of Fort Loudoun Reservoir is elevation 807, some 40 feet above the average bottom elevation of the powerhouse excavation. Although the overburden at the site seemed tight during core drilling operations, it was probable that during the construction period the excavated powerhouse area would be subjected to considerable rapid inflow from numerous solution channels in the bedrock.

At the Watts Bar site, explorations revealed a bedrock of shale containing numerous thin beds of sandstone. After removal of the weathered top layers, it would make an excellent foundation. The foundation costs at this site were estimated to be the least expensive of the three sites.

Over most of the Kingston site the depth of the overburden was only about 5 or 6 feet. Beneath the overburden was found the same shale formation as at Watts Bar. At Kingston, the shale was interspersed with beds of limestone and siltstone in place of sandstone. Even though practically all the powerhouse excavation would be in rock, the cost of excavation at Kingston was estimated to be much less than at Concord because it was anticipated that more than 80 percent of the rock could be removed with power machinery. A few solution channels present in the scattered limestone beds would require foundation treatment. Despite the fact that the bottom of the basement slab would be 16 feet below the normal minimum pool level of Watts Bar Reservoir, little difficulty in dewatering the excavation was anticipated because of the relatively impermeable bedrock.

Excavation costs for a plant at the Kingston site were estimated to be somewhat higher than those for the Watts Bar site, chiefly on account of the larger amount of rock to be excavated. However, these costs for both Watts Bar and Kingston would be much lower than those estimated for the Concord site.

Transmission line costs and losses

Of the three sites investigated, Concord would require the lowest capital investment in transmission lines and would have the smallest losses. A map of the transmission network of May 1951 is shown in figure 5. Table 4 compares estimated transmission costs and losses expected for each of the sites. Costs shown do not include overheads or contingency allowances.

TABLE 4.—*Comparison of transmission line costs and losses.*

Site	Number of units	Direct cost	Losses	
			Kw	Kwh/yr
Watts Bar	2	$ 8,594,000	9,000	25,000,000
	4	13,952,000	21,000	60,000,000
	6	20,052,000	34,000	105,000,000
Kingston	2	6,048,000	2,800	7,500,000
	4	12,368,000	7,800	22,000,000
	6	17,096,000	11,000	35,000,000
Concord	2	6,176,000	3,000	8,000,000
	4	10,288,000	7,000	20,000,000
	6	14,424,000	11,000	35,000,000

Cost of fuel

Preliminary negotiations with officials of the railroads serving the different sites developed the freight rates listed in table 5. Taking into account these figures and the estimated cost of coal at the mines, table 5 shows the cost of coal per ton delivered to each site.

TABLE 5.—*Cost of coal per ton delivered.*

Site	Railroad	Freight rates/Ton Min.	Freight rates/Ton Max.	Freight rates/Ton Used	Cost of coal/Ton At mine	Cost of coal/Ton Delivered
Kingston	Tenn Central CNO&TP	$0.72 1.38	$0.72 1.78	$0.90	$3.35	$4.25
Concord	Southern	1.38	1.99	1.70	3.50	5.20
Watts Bar	CNO&TP	1.20	1.81	1.33	3.50	4.83

TABLE 6.—*Comparison of estimated costs.*

	Watts Bar Site	Concord Site	Kingston Site
Capital cost:[1]			
Generating Plant			
Land	$ 140,000	$ 253,000	$ 505,000
Access facilities	359,000	519,000	1,070,000
Plant foundations	253,000	2,197,000	339,000
Condensing water facilities	845,000	731,000	709,000
Grading—Plant	231,000	77,000	188,000
—Coal storage yard	340,000	206,000	160,000
Rail yards	655,000	776,000	834,000
Subtotal	2,823,000	4,759,000	3,805,000
Transmission plant			
Switchyard	4,039,000	4,183,000	4,039,000
Transmission lines	15,347,000	11,317,000	13,605,000
Subtotal	19,386,000	15,500,000	17,644,000
Total capital cost	$22,209,000	$20,259,000	$21,449,000
Annual cost:[2]			
Generating plant	$ 84,700	$ 141,200	$ 114,700
Transmission plant	709,500	568,000	645,800
Transmission losses[3]	267,000	89,000	99,000
Fuel[4]	7,900,000	8,500,000	7,250,000
Total annual cost	$ 8,961,200	$ 9,298,200	$ 8,109,500

1. Includes only items that vary with site conditions. Amounts indicated are direct costs plus an allowance of 10 percent for contingencies.
2. Fixed charges assumed to be 2 percent interest and depreciation on a sinking-fund basis.
3. Based on $7 per kilowatt-year and 2 mills per kilowatt-hour.
4. Based on an annual consumption of 1,700,000 tons of coal.

The freight rate used in the site comparison is a composite of the two lowest rates, for it was anticipated that more than one source of coal would be required to supply plant demands. It is apparent that, with respect to fuel costs, the Kingston site had a great advantage over the other two sites.

Comparative costs

Table 6 summarizes the estimated capital and annual costs for the principal items that vary with site conditions and locations. The comparative estimates are based on initial installations of four generating units with provisions made for future expansion. The comparison of total annual costs shows the Kingston site to be the most economical by a substantial margin. This conclusion would not have been altered appreciably if larger installations had been considered, primarily because of the preponderant influence of fuel costs upon site economy.

PRELIMINARY STUDIES OF THE KINGSTON SITE

Geology of the Kingston site

Physiography—The Kingston site is located on the neck of a peninsula formed when the impoundment of Watts Bar Reservoir flooded the courses of the Clinch and Emory Rivers. It lies in the Ridge and Valley province of the Appalachian Highlands about 4 miles from the Cumberland Escarpment.

A pattern of longitudinal, parallel, even-topped ridges separated by broad valleys is the topographic expression of the geologic structure of the locality. Various formations crop out at the surface in narrow, linear belts trending northeast and southwest. As one traverses the area from the southeast to the northwest, he can see each formation repeated several times. Apparently, the strata, which originally were nearly horizontal, have been compressed, folded tightly, overturned to the northwest, and finally broken along the axes of the folds by forces acting from the southeast. The tops of the various structures were then removed by erosion, the softer limestones and shales wearing away faster than the harder sandstone and cherty limestones, leaving the harder strata projecting as ridges.

Scope of exploration—In the exploration of the site, 41 holes totaling 1775.8 feet in depth were drilled on an irregular pattern. These holes, as summarized in the following tabulation, were sufficient to indicate the amount of overburden, the depth of weathering, and the character of the underlying bedrock.

	Elevation			
Hole Number	Surface	Top of Rock	Bottom of Serious Weathering	Bottom of Hole
A-22+00	767.2	767.2	748.6	714.5
A-26+00	785.7	785.7	761.7	756.3
A-30+00	796.1	794.6	762.3	756.7
C-12+00	751.2	750.4	746.2	741.9
C-14+00	767.0	765.7	748.0	739.7
C-16+00	753.2	750.7	750.7	713.2
C-18+00	750	748.8	748.8	739.0
C-20+00	765.0	764.5	764.5	733.5
C-22+00	763.3	763.3	742.8	710.2
E-12+00	755.7	755.7	729.3	710.7
E-14+00	764.3	762.8	752.1	709.3
E-16+00	772.9	771.7	771.7	735.8
E-18+00	756.2	755.6	755.6	739.9
E-20+00	763.4	763.4	748.4	710.4
E-22+00	773.1	773.1	763.1	709.1
E-26+00	776.4	776.4	757.2	710.4
E-30+00	785.5	784.0	769.5	711.2
G-12+00	759.6	759.6	743.6	738.6
G-14+00	766.4	766.4	754.2	740.2
G-16+00	772.9	772.9	733.1	710.9
G-18+00	770.2	768.4	743.4	710.4
G-20+00	765.5	763.7	755.8	710.5
G-22+00	764.7	763.2	753.7	714.7
H-14+00	756.2	756.2	734.2	714.7
H-16+00	758.5	756.9	736.4	708.5
H-18+00	762.4	761.2	741.8	709.4
H-20+00	753.1	752.1	748.1	708.1
H-22+00	766.5	765.5	750.9	708.5
L-16+00	736.6	733.1	711.1	710.6
L-18+00	745.7	745.7	735.2	728.7
N-18+00	758.1	758.1	753.1	731.1
R- 6+00	790.5	776.1	776.1	758.9
R-20+00	750.6	750.6	734.2	700.6
T- 6+00	828.8	782.7	782.7	758.2
T-20+00	760.4	759.4	748.1	710.4
V- 4+00	831.5	798.6	773.8	771.5
V- 6+00	848.4	787.4	760.4	758.4
V- 8+00	835.1	802.7	792.9	769.5
EE-22+00	750.7	747.9	737.8	732.7
EE-26+00	760.1	758.9	747.1	736.3
EE-30+00	779.2	779.2	766.2	760.2

A test trench 250 feet long and a test pit were excavated to sound rock in order to examine the top of rock and determine the permeability of the overlying material. Additional information was obtained by examining road cuts in the vicinity where the same formation occurs as at the steam plant The locations of the drill holes, test trench, and test pit are shown in figure 6.

Stratigraphy—Three formations are exposed in the peninsula, although only one crops out in the plant site. The Rome formation composes Pine Ridge to the west, the Conasauga formation crops out in the neck of the peninsula where the steam plant was constructed, and the Copper Ridge dolomite forms the high knob on the head of the peninsula. Very little overburden, either residual or alluvial, was present on the steam plant site.

The Conasauga formation is chiefly composed of a blue-gray shale containing many lenses of limestone, conglomerate, and siltstone. The proportion of shale to the other ingredients is about 4 to 1. The lenses of limestone range in thickness from about 1 inch to several feet.

Structure—The controlling structural feature of the locality is a large thrust fault located northwest of the site. Along this fault, older rocks moved from the southeast over the underlying younger rocks. This movement resulted in contorting and shearing the weaker shales underlying the site so that the dips of the strata vary from vertical to 10 degrees from horizontal. All dips are toward the southeast and average between 45 and 50 degrees.

Weathering—Both the shale and the limestone of the Conasauga formation are susceptible to weathering. However, the disintegration processes are different. After the shale has weathered enough to accumulate a mantle of decayed rock from 5 to 35 feet deep, the action is arrested and the bedrock is protected against further weathering. Weathering of the limestone takes place along bedding planes, especially where they are nearly vertical, and solution channels may extend to great depths.

One of the most noteworthy features of the site was a large sinkhole at the contact between the Conasauga shale and the Copper Ridge dolomite. Erosion from the drainage into the sinkhole created a large topographic depression in the shale. It was certain, however, that the subsurface cavity extended into the dolomite and not into the shale.

Foundation conditions—Even in an unweathered state the shale was easily excavated by power machinery, the only resistance being that offered by scattered lenses of limestone, conglomerate, and siltstone. It was necessary to drill and dynamite some of these lenses. Geologic examination led to the conclusion that the rock, where fresh and unweathered, was capable of supporting any contemplated load. With the exception of lenses of limestone, the foundation is relatively impervious to the percolation of ground water or reservoir water.

Water supply

Quality—Condenser cooling water is taken from the Emory River embayment of Watts Bar Reservoir (fig. 144, Appendix D, page 289). This reach of the river was being polluted by the discharge of paper

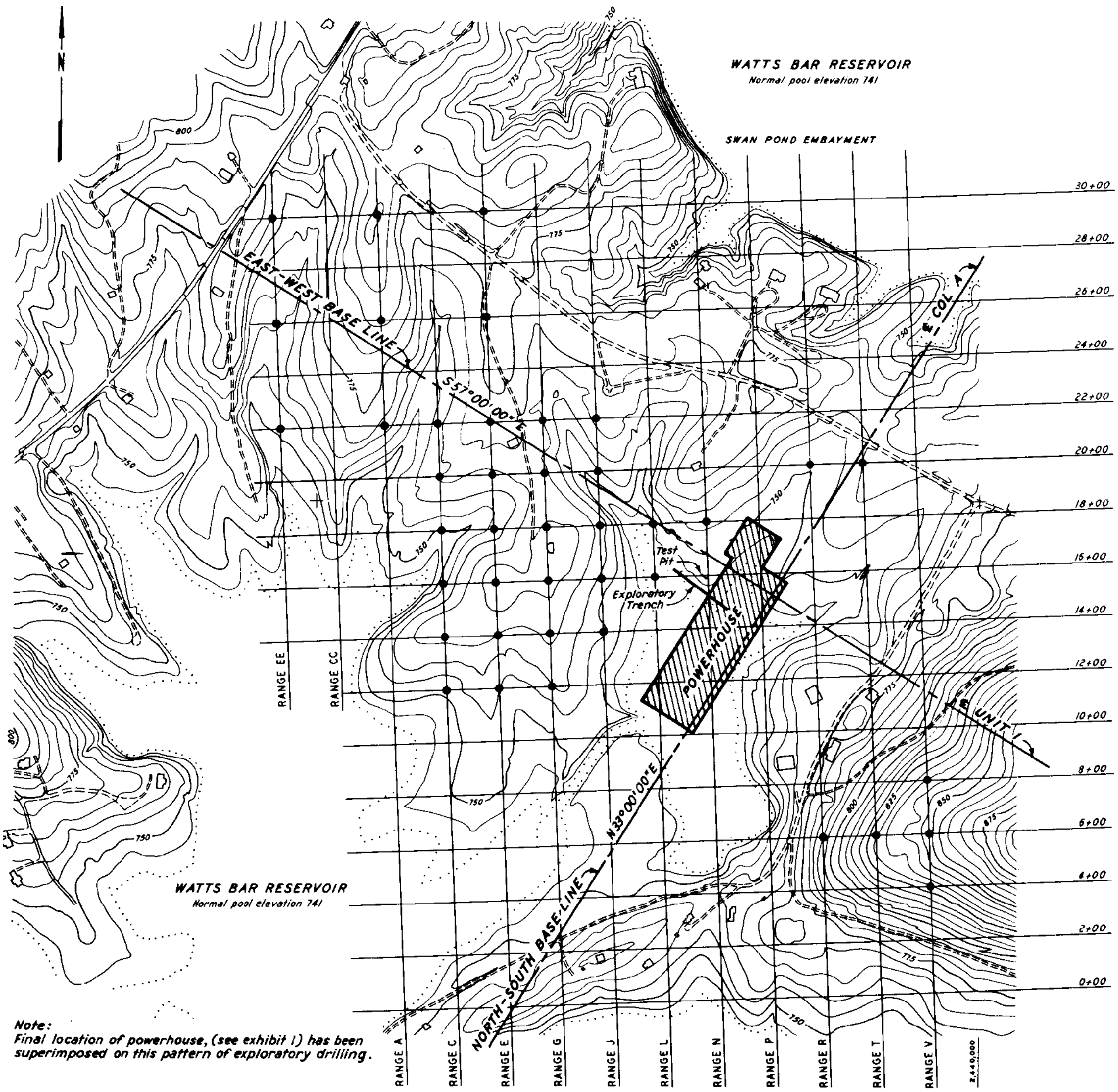

FIGURE 6.—*Location of core drilling for foundation exploration with summary of core logs. The final location of the powerhouse is superimposed for reference.*

mill wastes (a practice since corrected) from a plant at Harriman, Tenn. The wastes gave the water a dark color and a strong taste that make it objectionable for drinking purposes. Because there was some doubt as to whether the water would be suitable for boiler feed water and condenser water purposes, TVA consulted officials of the paper company and the city of Harriman about their experience in using it.

The paper company reported no unusual operating difficulties as a result of using the river water. It was pointed out that the waste, when discharged, is only slightly alkaline; that the black color is caused by the reaction of tannic acid on iron salts in the water; and that a chemical called "lignin," of which various compounds are used to prevent caustic embrittlements, is a principal component of the wastes.

The Harriman Utility Board reported that fibrous material occasionally blocked boiler tubes in small installations even though the paper company had barged the greater part of such material below the mouth of the Clinch River. However, it was thought that the condenser tubes of the steam plant would not be affected because of the relatively low temperatures and the high velocity of the water passing through the condensers.

The total hardness of the Emory River water ranges from 12 to 38 parts per million; whereas, the total hardness of the Clinch River water ranges from 92 to 112 parts per million. Although the Clinch River water is not very hard, relatively speaking, it is hard enough to require treatment before use as boiler feedwater.

Temperature—A considerable amount of data concerning temperature-depth relationships in this arm of the Watts Bar Reservoir was accumulated between 1944 and 1948. Temperature readings were taken at elevations 700, 715, and 730 at a station located at mile 2 on the Emory River by the use of a bathythermograph. These readings were plotted on charts directly below hydrographs showing the discharges of the Emory River and releases from Norris Reservoir during the same period of time. Similar readings were made at a station at the U. S. Highway No. 70 bridge at Kingston on the Clinch River and plotted below the releases from Norris Reservoir. Although the temperatures were not observed continuously, they were observed frequently enough so that a representative chart could be developed from temperatures at all seasons.

Analyses of these and other data revealed that water released from Norris Dam, some 75 miles upstream, is quite cold because of the great depth of Norris Reservoir. Although the water warms up considerably by the time it reaches the head of Watts Bar Reservoir, it is colder than either the water from the Emory River or from the Tennessee River during most of the year. Consequently, the water in Watts Bar Reservoir near the steam plant site becomes stratified. The cold Clinch River water fills the bottom of the reservoir, and the warmer water from the Emory and, at certain times, the Tennessee flows at the surface. When the releases from Norris are quite large, the cold water from the Clinch River flows up the Emory River beyond Harriman. When releases are curtailed the flow is reversed, and the cold water drains out of the Emory River arm of the reservoir.

Investigations of these conditions and the fact that the water temperatures in the Swan Pond embayment remain high during the warmer months of the year, led to the proposal to dredge a deep canal from the Emory to the intake building. They also led to the proposal to construct a skimmer wall across the intake canal and an underwater dam on the Clinch River below the mouth of the Emory.

Preliminary project layout

The preliminary plan for development of the site provided for an initial installation of four 150,000-kw units and possible expansion to six 150,000-kw units.

The location of the powerhouse was chosen so that it would be entirely on shale, out of the vicinity of the sinkhole mentioned earlier. The transmission lines were to be conducted over the top of the hill in the peninsula. Condenser cooling water was to be drawn from the Swan Pond embayment and discharged into the Clinch River at a point about four miles downstream from the intake. The intake building would have been constructed east of the switchyard at the end of a canal some 1600 feet long. It was expected that dredging probably would be necessary in the embayment from the Emory River to the entrance to the intake canal.

The access railroad from South Harriman would have approached the site from the north along the shore of the Swan Pond embayment. The storage yards and connecting tracks formed a loop which enclosed the plant and coal storage area.

There appeared to be little need to provide initially for receiving barge shipments of coal. However, the possibility of transferring coal shipments from rail cars to barges at this location for shipment to other steam plants appeared to justify provision for future barge-loading facilities on the Clinch River side of the plant.

Plant operation

Output—It was expected that the Kingston Steam Plant would operate on baseload and at a high capacity factor. The type of power load which was to be served by the project, and the fact that hydro capacity in the area can be used effectively to carry peak loads, indicates that this will be the normal type of operation. Estimated average annual output of the 4-unit plant was in the order of 4.0 billion kwh at station switchboard after allowing for station service. Total gross generation was estimated to be 4.2 billion kwh.

Coal requirements

The average annual coal requirement for the 4-unit plant was estimated to be about 1,700,000 tons, based on a gross generation of 4.2 billion kwh. The probable maximum rate of coal use would be about 5800 tons per day, 170,000 tons per month, and 1,900,000 tons per year. These estimates were approximate because of the variation in the thermal content of the various coals that would be used.

The manufacturer's guarantee anticipated that the heat rate for normal plant conditions would be about 9350 Btu per net kwh, which is equivalent to 0.75 lb of coal per kwh for 12,500-Btu coal. For the economic studies, a more conservative heat rate of 10,000 Btu per net kwh was used. Assuming that the average heat content would be 12,500 Btu per lb, the average rate of coal consumption would be 0.80 lb per kwh.

Available fuels

Sources—The plant is located in a coal-producing area of District No. 8 and most of the fuel was expected to come from mines within 15 to 70 miles of the plant.

It was believed that the most likely sources of coal would be the mines of the Cumberland Plateau near Monterey, Tenn., served by the Tennessee Central Railroad, and those between Oakdale, Tenn., and Stearns, Ky., served by the Cincinnati, New Orleans, and Texas Pacific Railroad. Also, it was thought that mines of the Cumberland Mountain area between Lake City, Tenn., and Harlan, Ky., and those of southwestern Virginia would furnish some coal; but these mines are increasingly distant and transportation costs are higher. The Louisville and Nashville Railroad serves this area.

Several years of operation have demonstrated that a very high proportion of the coal used can be obtained from truck mines within 25 miles of the plant.

Quality—Representative analyses of some of the coal used by the plant were made from mine or face samples, which usually do not contain shale or other foreign matter found in shipped coal. Consequently, the thermal values were somewhat higher and the percentage of ash content somewhat lower than would be obtained from coal that would be delivered to the plant.

Cost—Table 7 contains coal costs and freight rates, average thermal values, and costs (expressed in cents per million Btu of coal) from several districts in northern Tennessee and southern Kentucky from which coal can be purchased economically. The costs are based on 1951 rates and the heat values on the average of a large number of samples of coal. Although future coal prices and freight rates may vary from those given in the table, the same relationship probably will continue to exist between the costs for the various districts. It was apparent from these data that the coals from the Cumberland Plateau, in

TABLE 7.—*Cost of coal.*

Coal District No.	Field	Shipping Point	Railroad	Cost Per Ton			Average Btu/Lb	Cost (Cents Per Million Btu)
				Coal at Mine	Freight	Total		
8	Northeastern Tennessee Southern Group No. 7	Lake City	Southern	$3.50	$1.38	$4.88	13,730	17.8
8	Northeastern Tennessee Southern Group No. 8	LaFollette	Southern	3.50	1.57	5.07	13,780	18.4
8	Northeastern Tennessee Southern Group No. 9	Jellico	Southern	3.50	1.63	5.13	13,500	19.0
8	Southeastern Kentucky Southern Group No. 9	Jellico	Southern	3.50	1.78	5.28	13,500	19.5
8	Northern Tennessee Southern Groups Nos. 15 and 21 include O&W R.R., Brimstone R.R., Tennessee R.R., and Emory River R.R.	Oneida	CNO&TP	3.50	1.33	4.83	13,530	17.8
8	Southern Kentucky	Stearns	Ky. & Tenn.	3.50	1.73	5.23	13,140	19.9
8	Southern Kentucky Southern Group No. 17	Stearns and Sloans Valley	CNO&TP	3.50	1.73	5.23	13,300	19.7
8	Middle Tennessee Tennessee Central Groups Nos. 1 and 2	Monterey	Tennessee Central	3.35	0.72	4.07	13,200	15.4
13	Southeastern Tennessee	Dayton and Soddy (Rathburn)	CNO&TP	3.50	1.66	5.16	13,200	19.5

NOTES: Freight rates are taken from memorandum of John I. Snyder to C. E. Blee, November 9, 1950.
Coal costs are taken from memorandum of C. E. Blee to John I. Synder, November 15, 1950.
Btu values are computed from an average of 18 to 28 samples listed in the following:
U. S. Department of Interior, Bureau of Mines, Technical Paper 652, "Analyses of Kentucky Coals."
U. S. Department of Interior, Bureau of Mines, Technical Paper 671, "Analyses of Tennessee Coals (Incl. Georgia)."
Btu values shown in the above tabulation are for at-the-mine samples. An average value of 12,500 Btu per pound was used in the economic studies for coal delivered to the plant.

the areas served by the Tennessee Central and Cincinnati, New Orleans, and Texas Pacific Railroads, and from the vicinity of Lake City and LaFollette, Tennessee, would be the most economical for use by the steam plant.

Estimated project cost

On the basis of the preliminary study, it was estimated that the initial 4-unit plant at Kingston would cost $85,000,000, of which $80,000,000 would be for the generating plant and $5,000,000 for transformer and switchyard facilities. Costs of major items are shown in table 8.

TABLE 8.—*Kingston Steam Plant—summary of preliminary cost estimate.*

Steam production plant:	
Land and land rights	$ 615,000
Structures and improvements	12,232,000
Boiler plant equipment	23,447,000
Turbogenerator units	16,319,000
Accessory electrical equipment	4,560,000
Miscellaneous power plant equipment	1,110,000
Division of Reservoir Properties building	35,000
Carrier current equipment	96,000
Subtotal	58,414,000
General expense and contingencies	21,586,000
Total steam production plant	80,000,000
Transmission plant:	
Switchyard	3,672,000
General expense and contingencies	1,328,000
Total transmission plant	5,000,000
Total Kingston Steam Plant	$85,000,000

ADOPTED GENERAL PLAN

Project layout

After the completion of the preliminary studies, additional work was directed toward developing the most practical and economical arrangement of plant structures and facilities. The arrangement used for the preliminary studies had one serious defect—it could not be expanded beyond six 150,000-kw units.

The selected general plan (exhibit 1) provided for an initial installation of four units, each to have a capability of 150,000 kw, with provision for the addition of five 200,000-kw units. Therefore, the total capability of the completed plant is 1,600,000 kw.

The boiler room is located on the west side and the turbine room on the east side of the plant. The service bay and office wing are at the north end of the powerhouse. The main floor of the plant was set at elevation 765. As in the preliminary layout, the transmission lines lead out over the hill in the tip of the peninsula.

The locations of the railroad interchange yards and the access track are essentially the same as that in the preliminary layout. However, the arrangement of the full and empty car storage yards was altered in order to provide more space for future expansion. The selected arrangement allowed the expansion not only of the powerhouse but also of the rail yards and the coal storage yard.

The condenser water supply is obtained from the Swan Pond embayment and discharged into the Clinch River, much as in the preliminary plan. The conduits parallel the west wall of the powerhouse, entering and leaving the plant between the stack foundations. A distance of four miles, measured along the natural river channel, separates the intake and discharge points. This will prevent recirculation of the warmer discharged water through the condenser cooling system.

Two features not contemplated in the preliminary layout were incorporated in the completed plant in an effort to obtain the coolest possible water for the condensers. They were a skimmer wall and an underwater dam. A dike was constructed across a portion of Swan Pond, from the intake channel to the Emory River, in such a way as to form a canal between the two points. At the end adjacent to the Emory River a wall was constructed across the canal. The upper portion of the wall is solid, but the lower portion contains openings located so that the lower, colder water can pass from the Emory River into the intake channel. After the plant began operation there were periods when the skimmer wall did not function as planned because the level of the cold Clinch River underflow dropped too low. It was estimated that the cold water furnished only 17 to 36 percent of the total condensing water supply, depending on the amount of discharge from Norris Dam some three days beforehand. After considerable research with a hydraulic model of the embayment, it was concluded that a submerged dike or dam built across the Clinch River downstream from the mouth of the Emory River would increase the amount of cold water available to the condensers. Such an obstruction would increase the depth of the cold water, thus diverting more of it up the Emory River. The dam was constructed at mile 3.9 on the Clinch River (fig. 2, chapter 1, page 3) of limestone rock dumped from barges. Its crest was set at elevation 722 to provide for navigation clearance at extreme low water. As constructed, it would retain approximately a three-day supply of cold water, thus smoothing out the effect of weekend shutdowns at Norris. It apparently has increased the percentage of cold water used by the condensers to 80-90 percent of the total.

Estimated cost

The estimated cost of the selected plan of development for the 4-unit installation, excluding the submerged dam, was the same as that estimated for the preliminary plan, $85,000,000. However, there were slight differences in detail. Of the total amount, $79,600,000 was for generating plant and $5,400,000 was for transformer and switchyard facilities.

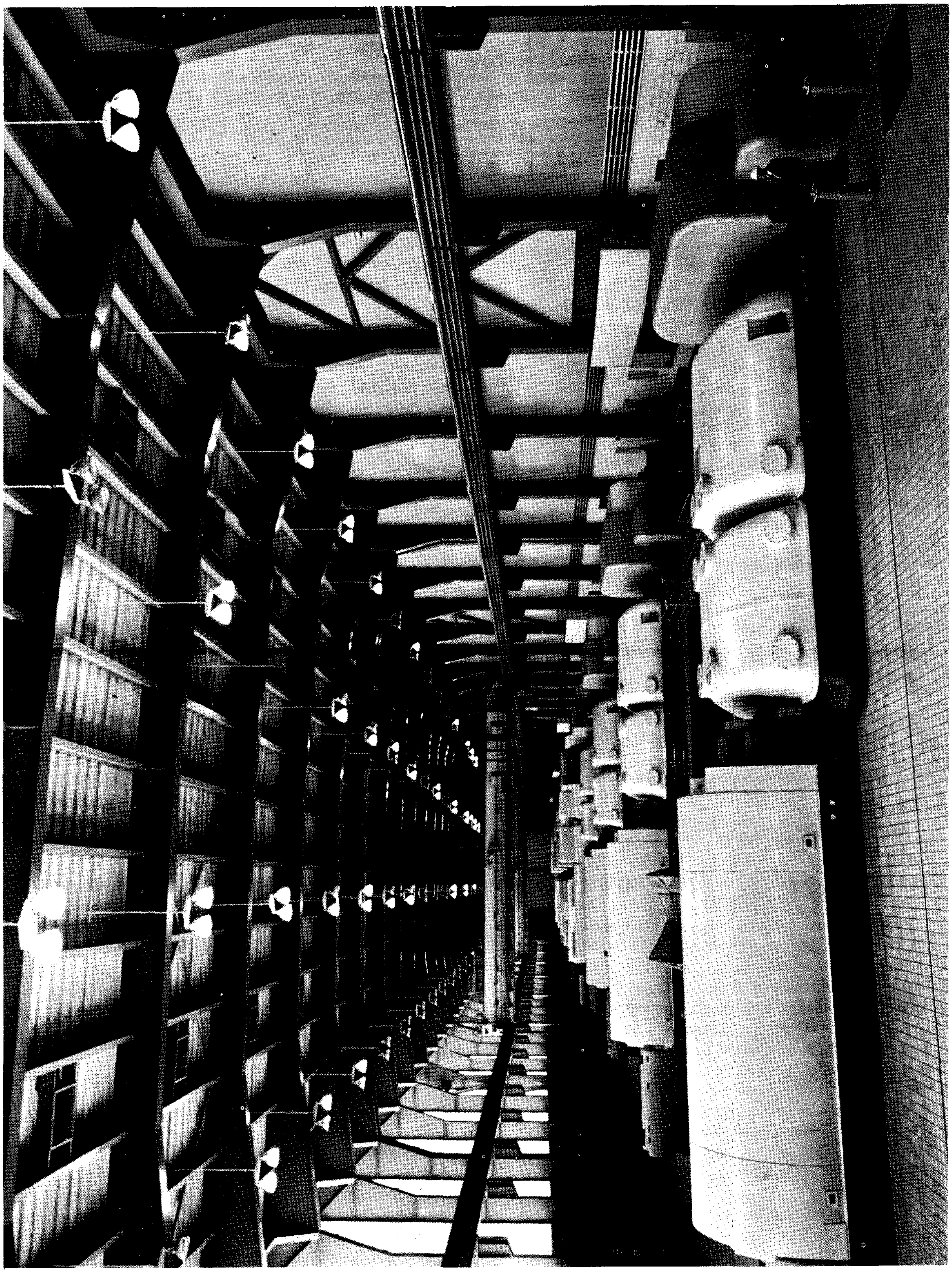

FIGURE 7.—*Turbogenerator room from visitor's balcony. Units 1-4, each with a capability of 150,000 kw, appear in the foreground; units 5-9, 200,000-kw capability, are seen to the rear. Two 90-ton overhead cranes serve the 900-foot-long room.*

CHAPTER 3

DESIGN

The Kingston Steam Plant was designed originally for a maximum installation of ten 150,000-kw units, and auxiliary facilities were arranged on this basis. A later decision was made that the final layout should include four 150,000-kw and five 200,000-kw units. With minor adjustments the space originally planned was sufficient for this layout.

The placing of the powerhouse and the auxiliary structures on the steam plant site was complicated by the functional inter-relationships of the many and varied facilities together with their space requirements. For such a major plant, these considerations presented a wide range of problems. The project layout as finally adopted is shown in figure 6.

The plant is located on a peninsula of Watts Bar Reservoir formed by the Clinch and Emory Rivers' embayments and is about 1.7 miles downstream from the mouth of the Emory embayment. Advantage was taken of this favorable topographic position to widely separate the condenser cooling water intake and discharge openings by taking water from the Emory River side and discharging it into the Clinch River embayment south of the plant.

The coal unloading and storage operations were located at the greatest practicable distance from the transformer yard and switchyard to prevent short circuiting of the equipment due to coal dust. The office areas were located at the northeast end of the powerhouse, and the nine stacks were placed on separate foundations adjacent to the boiler room.

The initial ash-disposal area was located north of the powerhouse and has a capacity of 90 unit-years. A future area with a capacity of 380 unit-years is provided north of the initial area.

Other major considerations which helped determine the character of the plant layout and its final location were the amount of earth and rock to be moved and access to the highway and railroad lines.

A large part of the plant area is over shale formation. Along the eastern side adjoining the shale is a belt of limestone some 500 feet in width. On the plane of contact between the shale and limestone at a location approximately 800 feet south of unit 1 and 300 feet east of the north-south baseline there was a large sinkhole. This hole was filled with a filter material of graded crushed rock and covered with clay before leveling the area to final grade.

Access highway

The access highway, 0.9 mile long, meets U. S. Highway 70 about 0.6 mile west of the Clinch River Bridge crossing. It extends between Watts Bar Lake and the railroad empty car storage yard to the plant entrance. Its location provides the most satisfactorily direct access from the plant to the state highway system. See exhibit 1 and location map in figure 6.

For purposes of economy and appearance, the access road was designed integrally with the railroad yard. In order to carry the anticipated traffic, which included a large number of coal trucks, a graded width of 40 feet was adopted upon which was built a 22-foot pavement and stabilized crushed stone shoulders. The pavement consists of a 6-inch stabilized stone subbase, 5 inches of penetration macadam base, and a 70-pound double-bituminous surface treatment. On the lakeside the embankment slopes are exposed to wave action throughout most of the length of the road. To the extent that sufficient spoil was available from powerhouse excavation, the exposed embankment slope was constructed to 1 on 8. For the remainder of the embankment the slope is 1 on 2 and is protected with rock riprap where exposed to wave action.

The minimum elevation of the highway is 755, about the same as the design flood. The likelihood of its being flooded, however, is so remote that additional raising did not appear justified, especially since access above the design flood is provided by railroad.

Access railroad

The Kingston plant is located on the edge of extensive coal fields which are served by three railroads: Tennessee Central, Southern, and Louisville and Nashville, which converge at Harriman about five miles from the plant site. In view of the existing facilities it appeared likely that the principal coal supply would move from the mines to the vicinity of

Harriman by rail. Movement of coal from the Harriman area to the plant by the alternate methods of rail, water, belt conveyor, and a combination of conveyor and rail was studied. The most favorable methods were found to be all-rail or all-conveyor with rail being most economical. This was true even though it was necessary to build a temporary construction railroad. Consequently, it was decided to construct the access railroad instead of a conveyor system from the railhead to the plant.

Since the most favorable freight rates were available via the Tennessee Central Railway, the initial connection was made to that railway, but the access line was so located as to permit a later connection to the Southern line. Upon authorization of units 4 to 8, the Southern Railway tie-in was eventually made.

The length of the access railroad from the plant to the Tennessee Central line is 5.2 miles and from the plant to the Southern yard at Emory Gap is 5.9 miles (see exhibit 1). The ruling grade toward the plant is 1.00 percent, compensated for curvature at the rate of 0.04 percent per degree. Studies using maximum grades of 0.8, 1.0, 1.25, and 1.65 percent showed that relative to initial cost, maintenance, and operation, the 1.0 percent inbound grade was most economical.

The portion of the line extending from the Caney Creek interchange yard to the grade summit lies on the maximum grade continuously for 6000 feet. Under normal conditions, about 25 cars, each loaded with 50 tons of coal, can be hauled up this grade by one 120-ton locomotive.

The ruling return grade for empty cars is 1.70 percent, which permits a 120-ton locomotive to haul about 50 empty cars. Since the grade summit is relatively near the Caney Creek interchange yard, a side track (or doubling track) was placed at the summit, which allows an inbound locomotive to leave its loads on this track, return to the interchange, pick up another string of loads, return to the summit, and haul a double load to the plant area. The return grade of 1.70 percent permits returning this "double" train of empty cars to the interchange yard.

The access railroad from Caney Creek interchange yard to the plant required the construction of a grade separation structure across U. S. Highway 27 at a point about two miles north of the intersection with U. S. Highway 70. The bridge consists of single-track, ballast-deck, plate-girder spans arranged as a 3-span continuous unit with concrete piers and abutments. The foundations of the piers rest on shale and sandstone, and the abutments are supported on steel H-piles. The design live load is E-72, AREA, 1948 edition.

The extension of the access railroad to connect with the Southern Railway Company's interchange yard at Emory Gap also required the construction of a bridge. This was across the relocation of Tennessee State Highway 61, which connects Harriman and Rockwood. The bridge consists of a single-track, ballast-deck, and plate-girder spans with concrete piers and abutments. The railroad alignment is on a 9-degree 30-minute curve. Four spans were required for the ultimate construction of a 4-lane highway. The design live load is E-72, AREA, 1948 edition. The piers have rock foundations and the abutments have steel H-pile foundations.

Right-of-way for the access railroad was purchased in fee and is, in general, 100 feet wide. It is fenced from the connections to the Southern and Tennessee Central Railways to the reservation boundary except for a short distance where a parallel road and urban property made a fence objectionable.

The location adopted made it necessary to relocate 2.34 miles of county road and 0.7 mile of state-maintained highway and to install automatic flashing light and bell warning signals at three grade crossings. Contracts setting forth the standards, specifications, and other agreements relating to the road relocations and grade crossings were negotiated with Roane County and the Tennessee Highway Department. TVA assumed responsibility for maintenance of the crossing signals and the state or county assumed ownership and maintenance of their respective relocated roads upon their completion, and TVA conveyed the new right-of-way to them.

CHRONOLOGY OF THE KINGSTON STEAM PLANT

Authorized unit	Date steam admitted	Commercial operation
January 6, 1951:		
1	1-26-54	2-8-54
2	4-23-54	4-29-54
3	6- 4-54	6-11-54
4	7-22-54	7-27-54
July 5, 1952:		
5	11-25-54	1-18-55
6	2- 2-55	3-3-55
July 15, 1952:		
7	4-17-55	5-6-55
8	7- 7-55	8-3-55
July 27, 1953:		
9	11-24-55	12-2-55

POWERHOUSE STRUCTURE

The first four Kingston turbogenerators are identical to those installed in the Shawnee Steam Plant near Paducah, Ky., and the corresponding steam generators, although not the same manufacture, have the same rated capacities and equivalent space requirements. Therefore, the layout and design, generally, for units 1-4 and the office building are virtually the same as for Shawnee. This saved considerable design time and money. Kingston units 5-9, although larger than 1-4, were conveniently adapted later to the established bay spacings of units 1-4 by increasing the center-to-center-of-units dimension.

Since the powerhouse foundation was to be set on bedrock and grading quantities kept to a minimum, it was necessary to set the basement floor at elevation 725 and the generator room floor at elevation 765, ten feet above maximum design flood. These elevations also satisfied the requirements for the flow of cooling water through the condensers.

POWERHOUSE SUBSTRUCTURE

The powerhouse substructure rests in its entirety on a shale formation having thin interbedded layers of limestone. Based on load-bearing tests on this formation, a modulus of elasticity for the material was set at 175,000 psi with a maximum foundation pressure of 5 tons per sq ft considered a safe value.

The substructure itself is essentially a reinforced concrete box containing the nine units. The entire substructure is about 895 feet long and 280 feet wide, with the finished basement floor 40 feet below the generator room floor at ground level. Expansion and contraction joints, as well as construction joints, are used in the foundation slab and walls to minimize the effect of volume change and to facilitate construction.

Metal seals are used in all joints to prevent the entrance of seepage from the lake or from ground water, double seals are used in all vertical joints up to elevation 750, normal design flood level.

Along the east and west walls a sand and gravel fill was placed below elevation 725 to facilitate drainage of water toward the open end of the powerhouse during the construction period and to prevent the possibility of excessive uplift pressures on the base slabs before the stabilizing dead load was in place.

Backfill

The earth backfill around the powerhouse supports the foundations for the main transformers along the east side of the building and for the fans and ductwork to the stacks along the west side. This important equipment is connected with the powerhouse and can be damaged if any part settles appreciably relative to the building. Accordingly, care was taken in selecting good backfill of clay from limestone residuum for the east and north sides. The material was placed in 6-inch layers and thoroughly compacted. On the south and west sides decomposed shale was used because of its easy availability, and steel piles were driven through this material to bedrock for firm support of the fan and ductwork foundations.

Design data

1. Lake stages (elevation mean sea level)

Minimum	Probable maximum	Maximum design assumption
735	750	755

2. Uplift:
Full hydrostatic head acting on entire area under consideration. Factor of safety against floating = 1.05 for maximum uplift with minimum downward loads.

3. Principal design cases:
Case I — Dry fill pressures on outside walls, combined with dead load of structure plus the live loads placed to give maximum stresses.
Case II — Hydrostatic uplift and saturated fill pressures corresponding to water surface elevation 750, combined with dead load of structure plus the live loads placed to give maximum stresses.
Case III — Hydrostatic uplift and saturated fill pressures corresponding to water surface at elevation 755, combined with dead load of structure plus the live loads placed to give maximum stresses.

4. Allowable stresses:
Concrete, f'_c = 3000 psi
Normal f_c = 0.4 f'_c
Reinforcement
Normal f_s = 8000 psi for powerhouse pressure conduits
Normal f_s = 18,000 psi elsewhere
Cases I and II, normal stresses
Case III, normal stresses increased 25 percent
Cases I and II combined with temperature effect, normal stresses increased 25 percent
Case III combined with temperature effect, normal stresses increased 57 percent

5. Foundation stresses:
Allowable compression, 5 tons per sq ft
Allowable tension, none

6. Earth pressure:
Weight of fill, 120 lb per cu ft
Angle of internal friction, 32 degrees
Friction angle on walls, 16 degrees
Surcharge, 200 psf except for special loadings

7. Temperature and shrinkage stresses:
Change in length based on 10-degree rise and 35-degree temperature drop

8. Weight of concrete: 145 lb per cu ft

Base slab

Structural slab—The concrete basement slab is divided by painted or cork-filled joints into a series of blocks which are keyed to each other to prevent differential settlement or uplift. Due to the uncertain characteristics of the foundation material and the low assumed modulus of elasticity of the shale, each block was designed as a spread footing under column loads and its depth was determined accordingly. Interior blocks vary in depth from 9 to 11.5 feet except at the distilled water wells, station sumps, and waterways. The total weight of the concrete basement slab plus the dead loads carried by the columns is sufficient to overcome the buoyancy during maximum high water levels.

Fill slab—It was necessary that a large amount of piping and electrical conduit be embedded in the base slab. Much of the drain piping and most of the electrical conduit could not be precisely located or procured in time for embedment in the structural slab. To meet this condition, the structural slab was stopped 2 feet below the finished floor and provisions made to place a concrete fill slab later when all embedded conduit and piping were assembled. Other features which affected the fill slab and could not be determined at an early date were the ash sluice piping and the concrete foundations for mechanical equipment. The top surface of the fill slab contains wire mesh to control shrinkage cracks and was held 3 inches below the finished floor elevation. The final cement finish, which is sloped to interior drains or gutters at exterior walls, was not placed until all equipment was installed and the danger from damage due to moving and mounting the equipment was substantially past.

Basement walls

The basement walls are reinforced concrete and support the superstructure walls, the steel columns, the main operating floor at elevation 765, and the intermediate floor at elevation 744. These walls are the counterfort type which allow very little deflection of the vertical stem of the wall. The vertical stem supports building columns, retains the fill, and is itself supported horizontally by counterforts extending about 20 feet into the fill. The base is continuous and is from 6 to 8 feet thick, the toe extends into the powerhouse and forms part of the basement slab. Vertical contraction joints divide the walls into blocks of varying lengths up to a maximum of 110 feet.

The east wall supports the heavy steel columns for the turbogenerator room. Pilasters are provided on the inside of this wall under the columns and in line with the counterforts, thus adding to its stiffness. A continuous concrete rectangular cable tunnel is placed directly on top of the east wall counterforts.

Wherever a brick wall rests on top of a basement wall and crosses a contraction joint, the top portion of the joint was treated as a construction joint and a heavy band of reinforcing steel running through the joint was used. This reinforcement is to prevent the joint from opening up and cracking the brick wall above.

The walls are designed to be stable without support from the floors framing into them. This design facilitated construction by allowing backfilling to take place before the steel framing and superstructure floors were erected.

Distilled water storage wells

Compartments for storing distilled water were formed in the concrete structure beneath the basement floor in the heater bay. The capacity of each storage compartment or well is adequate to store the entire volume of feedwater for the boiler of one unit. The wells for units 1-4 each have a capacity of approximately 56,000 gallons and those for units 5-9, a capacity of approximately 75,000 gallons.

In order to protect the hot distilled water from contamination, the bottom and sides of the wells are sealed with a heavy application of asphaltic compound backed up with a 1-inch cement mortar coat over a layer of porous concrete which is drained to a special sump. Thus, if water leaks out through the asphaltic seal or comes through the surrounding concrete toward the inside of the well, it is prevented from entering the well by drainage through the porous concrete layer. On the inside of the well the asphaltic seal is held in place and protected by a layer of carbon brick.

FOUNDATIONS FOR THE TURBOGENERATORS

Choice of heavy reinforced concrete frames for turbogenerator foundations was based on the advantages afforded by the resulting great mass and rigidity. This type of construction greatly reduces distortion, deflection, and vibration which occur in foundations of a less rigid type. The outline of the foundation for units 1-4 is shown in exhibit 17.

In the design of the foundation the recommendations given in the General Electric publication "Turbine-Generator Foundations," No. GET-1749, were followed (fig. 8).

POWERHOUSE SUPERSTRUCTURE

The powerhouse comprises two main structural units, the boiler room and the turbogenerator room, with an attached service bay and office wing. The building is oriented with the long axis in a north-south direction and covers about eight acres in area.

The boiler room is approximately 870 feet long, 138 feet wide, and over 100 feet high—about the height of a 10-story building. It houses nine steam generators, four double-unit control rooms, one single-unit control room, coal bunkers, conveyors, feedwater heating equipment, and forced-draft fans.

The turbogenerator room is approximately 900 feet long, 115 feet wide, and approximately one-half the height of the boiler room. It houses the nine

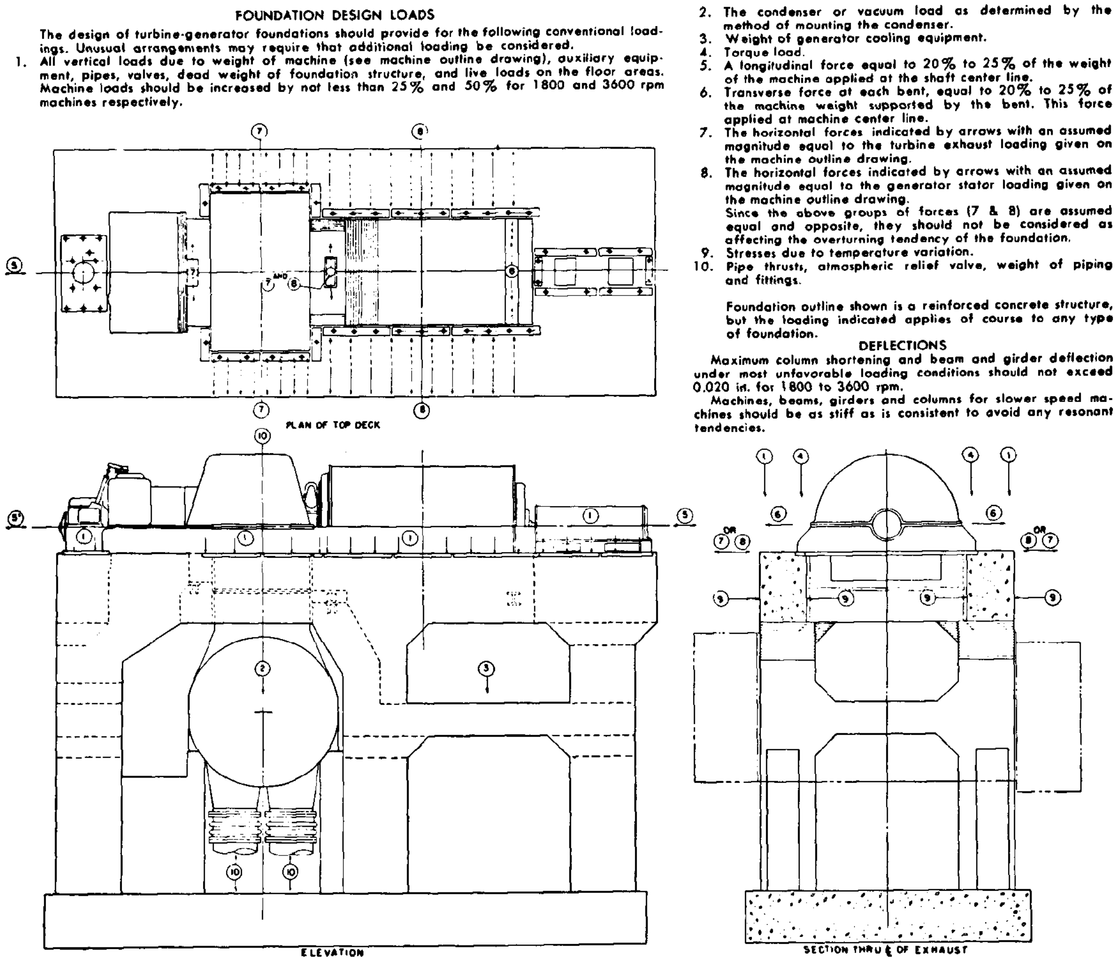

FIGURE 8.—*Massive concrete foundations carry the large static and dynamic loads of the turbogenerators independent of the powerhouse structure. Their design was based on this typical General Electric foundation loading diagram.*

turbogenerators, the two 90-ton overhead traveling cranes, and an erection bay for the disassembling and repair of transformers and turbogenerators. Transverse sections through the powerhouse are shown in figures 9 and 10, and plans of the three lower floors are shown in exhibits 26, 27, 29, 30, 31, and 32. A plan of the operating floor for the 9-unit plant is shown in exhibit 28.

Architecture

The architectural design followed that of the Johnsonville and Widows Creek Steam Plants in the use of insulated metal wall panels for enclosure walls above a 14-foot-high brick base.

Because the plant is close to and plainly visible from a principal highway, and because of the numerous tourists and technical groups expected as visitors, it is desirable that the structure present the most attractive and interesting appearance consistent with economic factors. The aluminum-faced wall panels as used at Johnsonville and Widows Creek were not available at the time the Kingston plant was constructed, so asbestos-covered steel sheets with a maroon surface coating were selected. This proved to be a satisfactory material. The dark wall mass contrasting with the gray brick base, the gray brick and glass wall of the turbogenerator bay, the office wing with its expanse of aluminum windows and yellow enameled panels, and the towering stacks result in a pleasing and effective color design.

The roof is of precast lightweight concrete channel slabs, with 2 inches of rigid insulation, covered with 20-year smooth-surface built-up roofing. The smooth-surface type was selected to facilitate removal of fly ash deposits.

Another important architectural feature results from the use of free-standing concrete smoke stacks

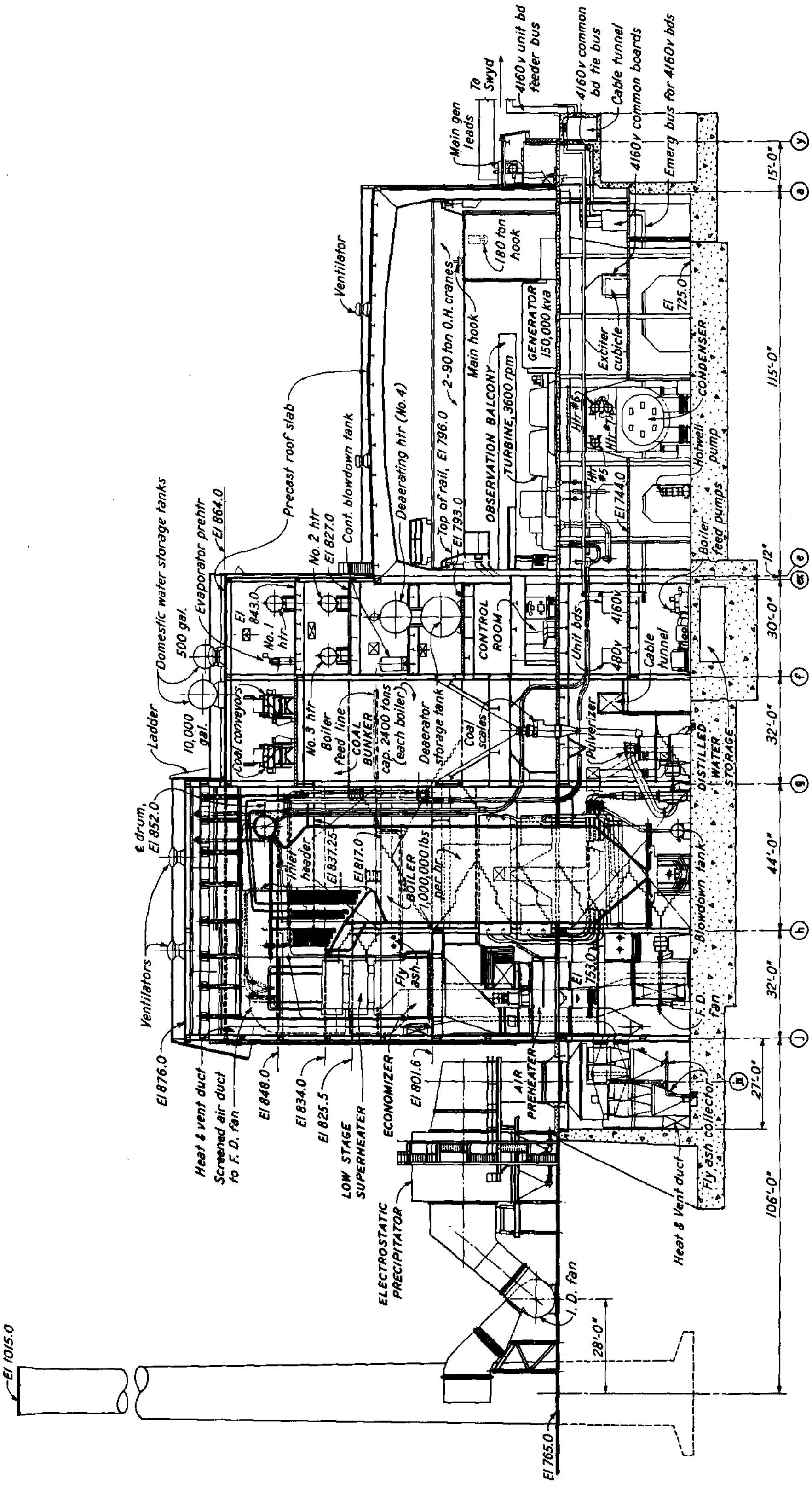

FIGURE 9.—*Transverse section of powerhouse showing general equipment arrangement for units 1 to 4.*

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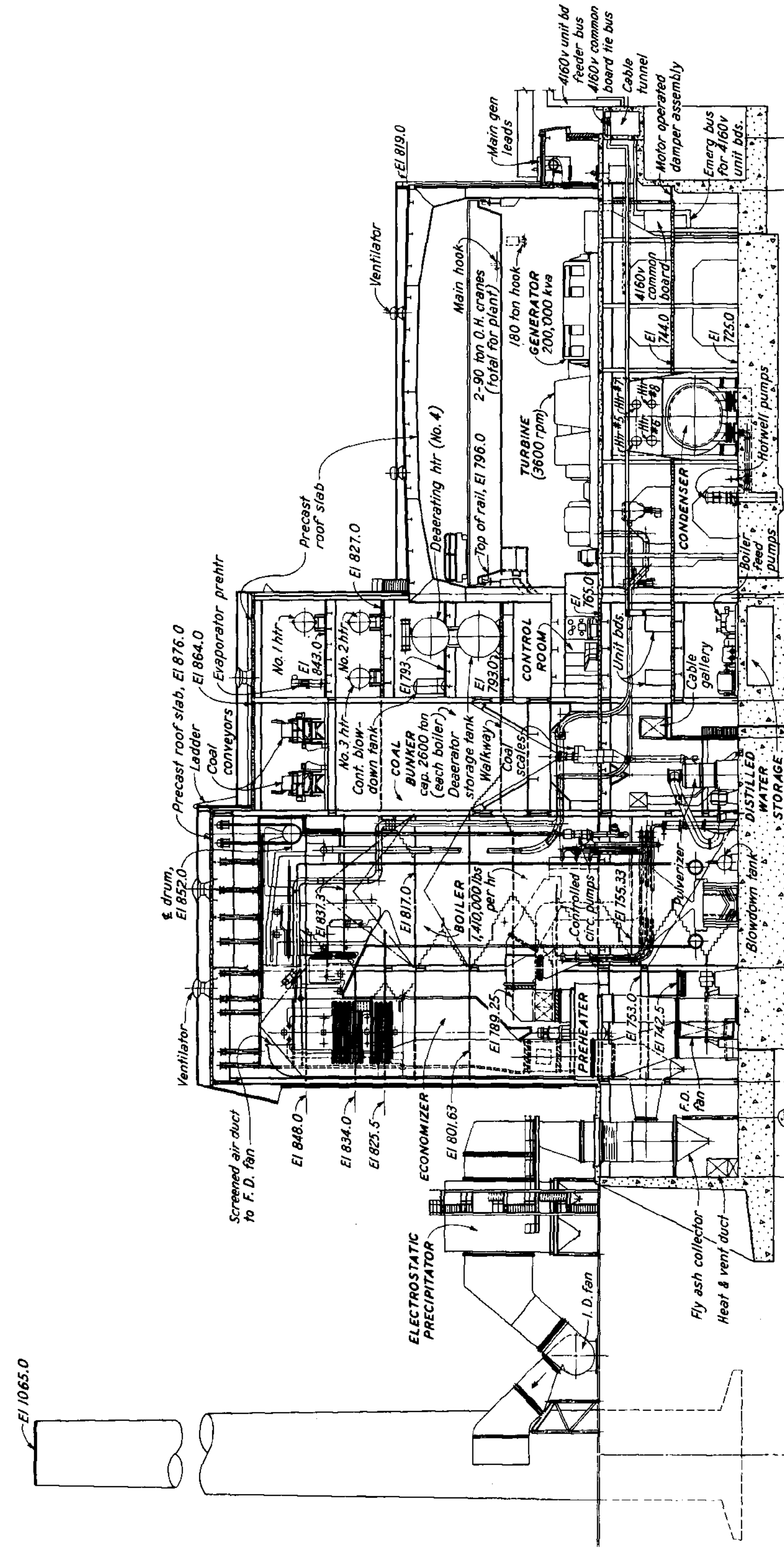


Figure 10.—Transverse section of powerhouse showing general equipment arrangement for units 5 to 9.

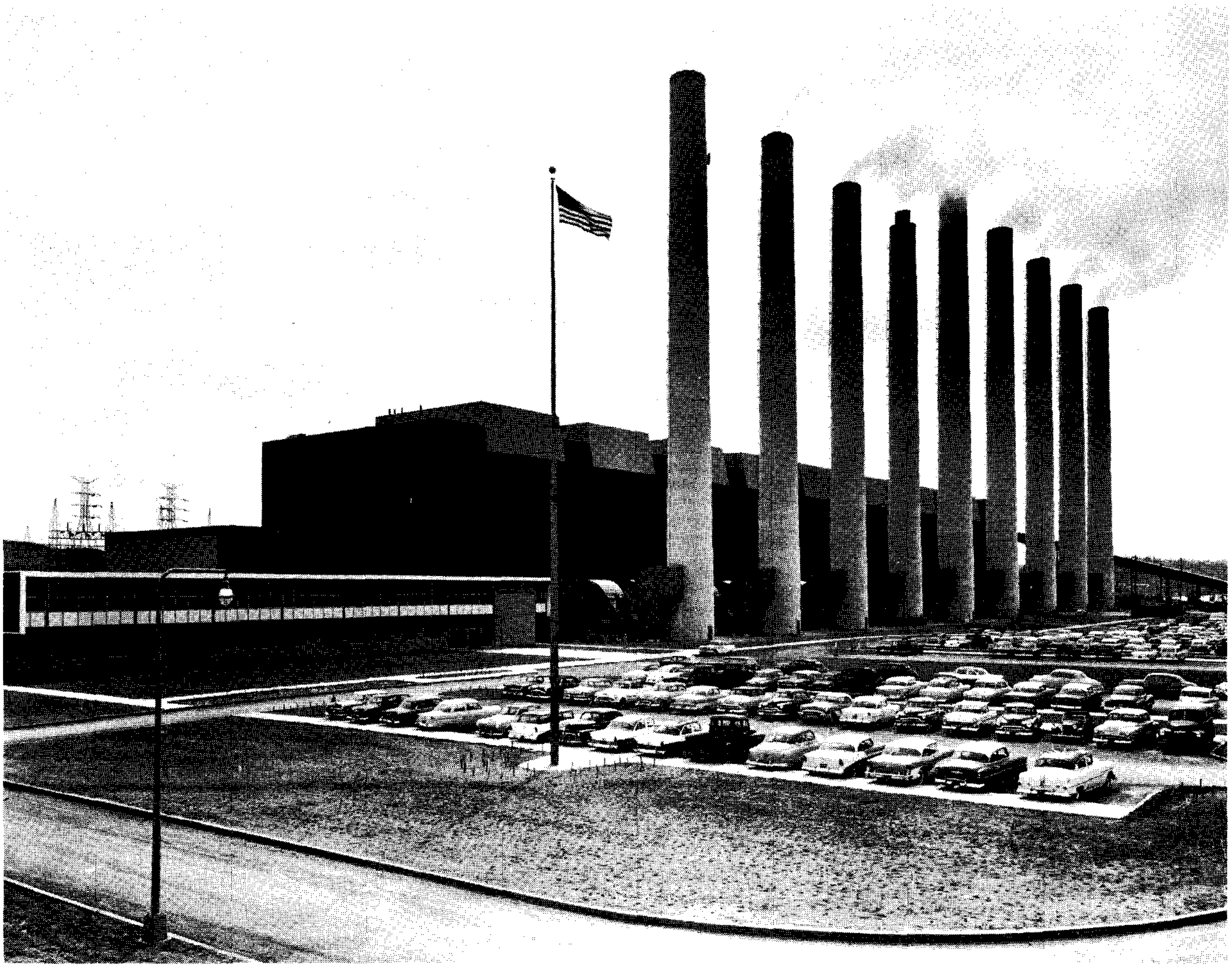


FIGURE 11.—*Kingston powerhouse looking south. The dark wall mass of the maroon, steel-paneled boiler bay contrasts with the gray brick and glass exterior of the office wing and the concrete stacks.*

in contrast to the steel, roof-supported stacks of the Johnsonville and Widows Creek Steam Plants. Four of the stacks are 250 feet high while the remaining five are 300 feet (fig. 11). From the approach road the massive stacks stand like giant columns in front of the powerhouse.

A consideration of some influence on the general planning was provision for reception of visitors. As the largest known steam-electric generating plant in the world, when constructed, a large number of public visitors were anticipated. Thus, the main entrance and visitors' reception facilities were arranged to accommodate the public with a minimum of interference with plant operation. The facilities include a visitor's overlook balcony in the turbine room, with a connecting corridor along the boiler room providing easy access and a general view of these two parts of the plant.

Exterior—The insulated metal wall panels consist of an asphalt- and asbestos-coated steel face sheet crimped into V-beam corrugations and backed up with 16-gauge zinc-coated steel sheet. The 1½-inch space between the sheets is filled with Fiberglas insulation. The panels form an economical enclosing wall and can be erected quickly.

In order to provide a more substantial base to withstand hard usage of normal plant operation, as well as to better balance the exterior design, the base story of the boiler room wall is of masonry construction. It is 14 feet high, faced with buff-gray face brick in pleasing contrast to the maroon metal-panelled walls above. The extensive wall area is unbroken except for a vertical row of aluminum ventilating windows lighting stair landings at each end of the boiler room, and a continuous horizontal aluminum ventilating hood extending the length of the southeast side of the building.

A well-defined separation is introduced between the masonry wall of the turbine room and the high mass of the adjacent boiler room. The turbine room end walls are buff-gray brick matching the base of the boiler room, relieved only by the exposed dark blue-green steel work and the large rolling steel doors at the access track entrances. The side of the turbine room is of glass block panels set in metal frames and topped by a continuous steel roof spandrel. The view of this facade is somewhat obscured by the adjoining transformer yard.

Interior—The steel frame is exposed on the inside of the boiler room and the ceiling is formed by the underside of the gray precast concrete roof slabs. There are intermediate floors of reinforced concrete supporting heavy equipment and of steel grating for walkways and open areas. The various levels are served by electric freight and service elevators, steel stairways, and ship ladders. The walls at the operating floor level are buff unglazed facing tile above which the wall is formed by the inside surface of the insulated steel wall panels. The floor is buff-gray quarry tile.

In the hydro plants the interior colors were selected to create a feeling of warmth, while in the steam plants the heat generated called for the use of "cool" colors. The gray-buff of tile walls and floors, blue-green for exposed structural steel and wall panels, and boiler insulation of gray-green, accented by the brick-red of the hollow metal doors and the bright red of the steam lines, tended to accomplish this purpose.

Five unit control room enclosures are housed in the boiler room with large plate glass windows set in aluminum frames projecting as bay windows into the turbogenerator room. One of these control areas is between each pair of turbogenerators from 1 through 8 and one serves unit 9 alone. The projecting bay windows provide the operators with a full view of the units on each side of the window. The control rooms are finished with gray marbleized rubber tile floors and gray-buff facing tile walls. Aluminum grid ceilings are used in two of these rooms and plastic grids in the other three, each concealing cold cathode light tubes providing uniformly distributed illumination.

Special attention was given to the design of the rigid steel frame of the turbogenerator room and the column brackets supporting the crane girders. These are major elements in the interior design and exert a strong influence on the character of the interior. The room is impressive in its size, having ample space for the nine turbogenerators uniformly spaced down its 900-foot length and for the two overhead traveling cranes (fig. 7, page 22). Daylight entering through the high wall panels of directional glass blocks is diffused throughout the room. A horizontal panel of ventilating louvers formed of heavy extruded aluminum vanes separates the 10-foot-high glazed tile wall from the steel panelling above. The expanse of the wall adjoining the heater bay is broken by the plate glass and aluminum framed windows of the unit control rooms.

The turbogenerators and traveling cranes are painted in yellow and harmonizing shades of light and dark blue-green to accentuate the principal elements of the machines and to give them a sense of unity and function.

The visitors balcony projecting into the room at the north end about 14 feet above the operating floor is a continuation of the visitors corridor and provides an uninterrupted view for the full length of the room. The balcony front is of patented aluminum panels and trim. The soffit is finished with sand finish plaster.

Structural steel

The powerhouse supporting frame is steel riveted construction except the turbine room frames and bracing portals which are welded. TVA standard design specifications supplemented by AISC specifications were used throughout. Except for the boiler suspension steel and elevator machinery supports, where a maximum allowable stress of 16,000 and 12,000 psi, respectively, were used, the framing in general was designed for a maximum allowable stress of 18,000 psi.

Turbine room framing—It was found that a considerable saving could be made in the turbine room steelwork (exhibit 18) by the installation of a 15-ton monorail hoist just below roof steel, between transverse frames in the erection bay, for untanking the main transformers. This permitted lowering the overhead traveling crane and thus reduced the height of the structure. The top of the crane rail is 31 feet above the operating floor.

The main framing consists of welded rigid transverse frames with longitudinal girders and beams extending between the frames. In the units 1-4 area the frames are spaced on 27-foot 6-inch centers. Three bays are used to contain one unit. In the units 5-9 area four bays are required per unit, three of them being 24 feet wide and one, the aisle bay between units, being 30 feet wide. The clear span between faces of columns is 110.5 feet. The rigid frames are welded construction and are composed of a horizontal member and two haunched column sections. These members are made up of solid web and flange plates, proportioned to suit the moment and shear loads. The horizontal member is 44 inches deep at the center, and the straight sections of the columns are 54 inches deep. The maximum thickness of metal was limited to 2½ inches. The frames were designed with fixed bases to take all lateral and vertical loads. Wind loads on the turbine room and lateral forces from the overhead crane were transmitted, at suitable points, into transverse braced bays in the boiler room framing.

The crane runway girders are supported on heavy plate brackets which are built as an integral part of the columns.

Boiler room framing—The boiler room structure across its width consists of one heater bay adjacent to the turbine room, a bunker bay, and two boiler bays. The building below the main operating floor is extended laterally for an additional bay to accommodate the fly-ash collectors in the basement. The roof of the heater and bunker bays and the aisle bays between units is 149 feet above the basement floor. The height of the roof over the boiler bays is 161 feet above the basement floor. The longitudinal spacing of the columns in the boiler room is the same as the spacing of the rigid frames in the turbine room. Except for heavy loading conditions on the boiler suspension girders and bunker framing where built-up girders were required, the framing is the conventional type, and standard rolled sections and riveted connections are used.

Expansion and bracing—For expansion purposes in the longitudinal direction, the powerhouse is provided with an expansion joint every two units by using a double row of columns spaced 3 feet apart. Expansion allowance was based on a temperature variation of $\pm$ 60 degrees. Wind loading on bracing was assumed as 30 psf. Longitudinal bracing is provided on each column line in the aisle bays between units. For unit 9 the bracing is in the end bay of the building. In the transverse direction the bracing is located in the column lines on each side of the boiler.

Coal bunkers—The coal bunkers are rectangular-bin type with multiple hopper bottoms which connect to the coal valves and scale above the pulverizers. Each 32-foot-wide bunker serves one boiler unit. The bunkers for the first four units are built in pairs, with a common partition wall separating the bunkers for each unit. The total length for two units is 137.5 feet. This provides for some capacity in the area of the common bay between pairs of units. The capacity of the bunker for each of these units is 2400 tons. For units 5-9 the bunkers are 72 feet long and have a capacity of 2600 tons per unit. The bunkers for these units do not extend into the common bay between units. However, chutes are provided underneath the tripper slots in these bays to allow for continuous operation of the trippers while passing from one bunker to another. The depth of all bunkers, measured from the conveyor floor at elevation 843 to the outlet on the hopper bottoms, is 66 feet. The bunkers are built up of steel plates with suitable stiffeners and are supported on wide-flange beams and built-up girders which are integrally built. At points inaccessible for normal riveting, rivet bolts were used.

Boiler walkways—Walkways of steel grating are provided in the boiler room at various elevations for access to the equipment. These walkways are supported from the building steel by posts, brackets, or hangers.

Penthouse and stairs—Framed penthouses are located on the boiler room roof for housing the elevator hoists and equipment and the stairways to the roof. A system of stairs and walkways serves all levels of the powerhouse. In general, stair widths are 3½ feet. In the turbine room, above elevation 744, the stair treads and platforms are cast aluminum with steel riser plates. The remainder of the stairs in the turbine room and all the stairs in the boiler room have grating treads with open risers.

Electrical leads housings, cable trays and racks—The main housings are made up of asbestos-cement sheets on a skeleton frame of aluminum angles. Station service leads housings are all aluminum construction. Cable trays are asbestos cement supported on light structural framing.

Concrete floor and roof slabs

Precast slabs of lightweight concrete were used for the turbine room roof, the boiler room roof, and the exposed deck over the fly ash collector bay, since they were considered to be the most economical support for a dependable watertight surface. This surface is composed of a watertight membrane placed over a concrete fill with the precast slabs acting as forms for the concrete fill as well as for carrying the load. The deck being at grade is covered with a protective layer of crushed stone.

The remainder of the slabs were cast-in-place floor sections. Depending on the type of surface required, the thickness of finish varies and is placed after all equipment is in position and other interior work completed.

For design purposes the floors poured on steel beams are considered as freely supported with shrinkage reinforcement added for a condition of no restraint.

Turbine room cranes and miscellaneous handling equipment

Turbine room cranes—There are two single-trolley, overhead traveling cranes in the turbine room for erection, dismantling, and maintenance of the turbogenerators, handling of transformers, and other uses. Since the generator stator, weighing approximately 172 tons, was the heaviest anticipated lift, the combined capacity of the cranes was set at 180 tons, and each crane trolley was equipped with a 90-ton main hoist arrangement. When using the two cranes together, a special lifting beam is employed. Heavy lifts of up to 90 tons are handled by the main hoist of one crane. Each crane trolley is also equipped with a 25-ton auxiliary hoist arrangement, and all lifts of 25 tons or less are handled by the auxiliary hook. The general arrangement of the cranes is shown in exhibit 18. Additional details of the cranes are noted in the "Statistical Summary," Appendix B.

Miscellaneous handling equipment—To facilitate the handling and maintenance of equipment in the turbine and boiler rooms which could not be handled by the turbine room cranes, a variety of smaller handling equipment was provided. This equipment is also listed in Appendix B.

Included in this equipment is a 15-ton-capacity electric-driven trolley-type untanking hoist to operate on a trolley beam framed into the roof structure of the turbine room just above the center line of the incoming railroad track. Its vertical hook movement and trolley travel motions are controlled from a push-button station mounted on the turbine room side wall at a convenient height above the floor. This hoist is used for the dismantling and reassembly of transformer parts that cannot be handled by the turbine room overhead cranes because of their limited high hook position.

Reinforced concrete chimneys

The location, size, and orientation of the plant, as well as the surrounding topography, all affect the chimney height which was determined as 250 feet for units 1-4 and 300 feet for units 5-9. All chimneys are located on a center line about 80 feet west of the powerhouse west wall. In the area between the chimneys and the powerhouse are the fans and duct-work required to carry the exhaust gases to the chimneys. Electrostatic precipitators were added later. A detailed description of the installation is covered in Appendix E.

Construction is reinforced concrete with a brick lining above ground where the hot gases enter the stack. The chimneys were built under contract with The Rust Engineering Company of New York City in accordance with the American Concrete Institute Specifications 505-36T, "Design and Construction of Reinforced Concrete Chimneys." The foundation extends 41 feet below grade to the shale and limestone bedrock. For the taller stacks this foundation consists of a cylindrical concrete shell or pedestal with an inside diameter of 19 feet and shell thickness of 3.25 feet resting on a 43.5-foot solid octagonal concrete base slab 6 feet thick. This foundation was designed for a maximum pressure on the bedrock of 5 tsf. The chimney above ground was designed for a horizontal wind load of 25 psf of projected area. This load is carried entirely by the concrete shell with no ties between it and the lining. A ventilated air space of at least 5 inches separates the two. Constructed of a hard-burned brick and reinforced by wrought iron bands, spaced 5 feet on centers, the lining, being of the same height as the shell, is self-supporting and rests on the foundation at grade elevation. The inside diameter of the lining tapers from 19 feet at the bottom to 16.5 feet at the top, making the exit velocity of the gas flow for normal full-load rating approximately 50 fps.

Each chimney is equipped with lightning rods, safety ladder, painter's trolley, flue parts, gas baffle, ash sluice, and other miscellaneous devices. A microwave antenna is located on the unit 1 stack.

The unit 4 stack, after being in operation for some time, was equipped with an experimental nozzle of 10-foot outlet diameter to increase the gas velocities from 50 to about 100 fps in an attempt to jet the flue gases to a higher elevation. After a considerable period of operation, the nozzle was removed since the increased draft system loss due to the nozzle imposed a considerable load restriction on unit 4 as compared with the other generating units. The jetting effect of the nozzle proved to have little effect on the dispersal of the effluent.

POWERHOUSE MECHANICAL FEATURES

MAJOR EQUIPMENT

Turbogenerators units 1-4

This section discusses the turbines (fig. 9). For the generators, see "Powerhouse Electrical Features," page 61. These units were purchased approximately one year after the Widows Creek units 1-4 were ordered. During this period there was a definite trend in the industry to reheat-type units and larger 3600-rpm machines. A study of the requirements for Kingston indicated that at the current prices for fuel and equipment the reheat-type unit would afford the most economical installation.

The machines were purchased for steam conditions of 1800 psig and 1000°F at the throttle and 1000°F reheat. The Widows Creek units 1-4 throttle conditions are 1450 psig and 1000°F with no reheat. The expected improvement in plant heat rate due to these changes in steam condition was approximately 4.5 percent for the addition of reheat and 1.5 percent for increasing throttle pressure, or a total of 6.0 percent.

The machines were supplied by the Westinghouse Electric Corp.

Guaranteed performance of units:

Generator output, kw	Turbine heat rate, Btu per kwh
33,750	9,593
67,500	8,575
101,250	8,198
135,000	7,998
150,000	7,947

Performance is based on extraction for feedwater heating, 2 percent evaporated makeup, and 2-inch Hg absolute exhaust pressure.

A turbine acceptance test was made on unit 2 in June 1954. The results of the test failed to meet the guaranteed heat rate by 2.3 percent at rated load and 2.1 percent at the capability rating. It was assumed that these results were typical of the first four units at this plant as well as the ten similar units at the Shawnee Steam Plant. However, to serve as a check on these results a similar test was performed on Shawnee unit 8 during March 1955. The results of that test confirmed the first test.

The poor economy of these units led the manufacturer to redesign and rebuild Shawnee unit 1 in an effort to meet the guarantee. The rebuilt unit was retested during January 1956. A definite improvement resulted from the modifications; but the unit still did not meet its guarantee by 1.4 percent at rated capacity and 1.7 percent at the capability rating. Further tests were performed on Kingston unit 2 during April and May 1959 after the last two rows of stationary blading and the last row of rotating blades of each of the three low-pressure ends were replaced with the new thinner-type blades. The final calculations (including the effect of the new low pressure blading, shielding of low pressure extraction piping and heaters, and increased cooling steam flow) indicated that the unit failed to meet the guaranteed heat rate by 0.11 percent at rated capacity and 0.30 percent at the capability rating. The guaranteed capability was exceeded by 6.2 percent.

Turbine—The units are the three-cylinder, tandem-compound, triple-flow exhaust, condensing, reheat type. Rated capacity is 135,000 kw, and maximum guaranteed capability is 150,000 kw at 2½-inch Hg absolute exhaust pressure. The high-pressure (HP) turbine is the combination impulse and reaction type. The steam path consists of a single-row, large-diameter impulse wheel followed by twenty reaction stages. The steam exhausted from the HP turbine is reheated and returned to the intermediate pressure (IP) turbine through two separately mounted interceptor valves. The steam then expands through 15 reaction stages and exhausts into a chamber where approximately two-thirds is piped through two crossunder pipes to the double-flow low-pressure (LP) turbine. The remainder of the steam passes straight through the single-flow LP section. There are eight reaction stages in each of the three LP sections which discharge through a common exhaust into the condenser neck.

The unit is provided with two steam chests, one located on each side of the HP turbine casing. Each steam chest contains four plug-type governing valves operated in the proper sequence by a lift bar activated in turn by an oil-operated servomotor for each chest.

The shape of the cylinders and their methods of support are designed to obtain free but symmetrical movements resulting from thermal changes and thereby reducing the possibility of distortion. The outer casing of the HP turbine is an alloy steel casting split horizontally in the center plane to form a base and cover. Reaction blading in the inner casing is composed of two separate elements so adjusted as to maintain proper relative position to the turbine axis under all load conditions.

The IP turbine consists of an inner and outer casing. The outer casing cover is made in three sections, the HP part being made of cast alloy steel and the LP part of cast iron. The base is a combination of cast and fabricated sections. The stationary reaction blading in the inner casing is composed of four separate elements.

The LP outer casing base is fabricated, while the cover is cast iron. The stationary blading is carried in a single, cast blade ring.

The base and cover of both the HP and IP turbines are bolted together by large stud bolts.

All three rotors or spindles are machined from solid forgings of alloy steel. Flange-type rigid couplings are used to join the three turbine and generator rotors. The solid rotating element thus formed is fixed in position by the turbine thrust bearing.

Rotating impulse blades are the three-in-one type in which three individual blades are secured by welding and finished as a single unit. These units are each secured to the turbine rotor by two straight pins. Rotating and stationary reaction blading made of special alloy steel highly resistant to erosion is secured in machined "T-root" grooves. Shrouding is secured to the blade tenons by riveting. Radial clearance seal strips of thin-section chrome iron alloy are provided to prevent steam leakage past the ends of the blading. The last row of rotating blading is attached to the rotor by a side-entry buttress-type thread. The inlet edges of the last rows of blading are protected against erosion by means of renewable Stellite strips silver-soldered to the blades.

At the points where the shaft passes through the casing, a combination of metallic labyrinth packing and water seals are used to prevent leakage. Six water packing glands—three circulating-type and three noncirculating-type—are used.

The HP and IP turbine rotors are each machined to form a 2-stage balance piston (or dummy piston) which is designed to balance the thrust of the blading and thus minimize the thrust which must be carried by the thrust bearing. The steam leakage past the balance piston is returned to the turbine casing or piped to extraction heaters. Pressure breakdown is accomplished in the balance pistons by radial labyrinth seals.

Turbine control and governor mechanism—In normal operation the speed or load of the turbines is controlled by the main governor. The governor controls the positioning of the steam inlet or governing valves through two servomotors as mentioned previously. The auxiliary oil governor is hydraulically connected to the governing control oil system through a check valve. Should the turbine speed reach 3630 rpm or more, the auxiliary governor takes control of the governing valves until the turbine speed returns to 3630 rpm or less, at which time control is automatically returned to the main governor. The main and auxiliary governors and main and governing oil pumps are located in a single housing mounted on the turbine No. 1 bearing pedestal.

The main governor is equipped with both hand- and motor-operated speed changers. Remote control of the speed-changer motor is provided by a switch located on the main control board. Load limit is determined by an oil pressure regulating valve which limits load by controlling the maximum opening of the steam chest valves. The governor is the oil pressure, transformer-type and can be divided into four parts:

1. The governor impeller, mounted on the turbine shaft and supplied with a limited amount of high-pressure oil from the main pump, maintains a pressure which varies as the square of the speed, thus giving a positive governing medium.
2. The governor transformer magnifies the relatively small pressure changes delivered by the governor impeller into large pressure changes which are utilized to actuate the relay of the servomotor.
3. The servomotors, which are mounted on the steam chests, operate the governing (steam inlet) valves.
4. The main oil pump supplies all oil requirements when the turbine is operating at normal speed.

Safety devices included in the control system are: an overspeed trip mechanism, trips for low oil pressure and low vacuum, a remote solenoid trip, and a manually operated trip. Each of these mechanisms operates to stop the turbine by immediately closing throttle valves, interceptor valves, and governing valves, whether actuated by an operator or an appropriate emergency condition.

Connected into the trip circuit is an oil-operated air pilot valve which operates to close check valves in the number 2 and number 4 extraction lines whenever the throttle valves are tripped.

The overspeed trip is entirely separate from and independent of the main governor. It functions to protect the turbine from overspeed and is usually adjusted to operate when the turbine speed reaches 10 percent above normal. Each of the other safety devices operates through the overspeed mechanism to trip the turbine.

Turbine supervisory instruments provided are: a cylinder-expansion meter, a rotor-position meter, a shaft-vibration meter, a spindle-eccentricity meter, and speed and load indicators.

Turbine bearings and lubrication system—Each unit has seven main journal bearings of the split-sleeve type, parted in the horizontal plane, lined with tin-based babbitt, and pressure lubricated from the turbine oil system. The thrust bearing is the Kingsbury leveling-plate type which automatically distributes the load equally among the several shoes. The thrust of the rotor is transmitted to the shoes by means of a steel collar machined integrally with the HP turbine rotor. The thrust bearing cage assembly positions the turbine rotor axially within the cylinder and can be moved by means of adjusting screws. The entire thrust bearing assembly can be dismantled without removing the rotor. The bearing is flooded with oil from the main bearing supply line at all times.

The turbine oil system has three principal parts: the high-pressure oil system, the lubrication system, and the control system. The high-pressure oil system, i.e., oil discharged from the main oil pump, is used to operate the oil ejector which supplies the main oil pump impeller suction. This ejector (or hydraulic jet pump) takes oil from the reservoir and supplies it under positive pressure to the main oil pump suction. The high-pressure oil system is also used to operate the throttle valves and the steam chest servomotors, to supply oil to the bearings, and as a control medium for governing and safety devices. Oil supplied to the lubrication system after passing through an adjustable orifice separates, part passing through filters to supply the exciter gear sprays, the remainder passing through the oil cooler to the main bearings, thrust bearing, and turning gear. A relief valve in the bearing oil line is set to maintain a pressure of 10-20 psi.

During starting and stopping periods, oil is supplied by an auxiliary oil pump located at the oil reservoir. Controls on this pump are arranged so that it starts automatically whenever the bearing oil pressure drops to 7.5 psi. It is driven by a 60-hp a-c motor. There are two additional auxiliary oil pumps —one driven by a 15-hp a-c motor, and the other by a 15-hp d-c motor. The a-c motor-driven pump starts when the bearing oil pressure drops to 5.5 psi while the d-c motor-driven pumps start on a decrease in pressure to 3.5 psi. These pumps do not have sufficient pressure for lubrication during startup but supply lubricating oil when operating on turning gear. There are two raw-water-cooled oil coolers, either of which will normally cool the oil to the desired temperature.

Turbogenerator turning device—A turning motor is connected by gear train to the turbine rotor to rotate it at low speed while the machine is out of operation. The turning device has speeds of 6.5 or 30 rpm and is mounted on the coupling housing cover between the LP turbine and generator rotors.

Turbogenerators units 5-9

This section discusses the turbines (fig. 10). For the generators, see "Powerhouse Electrical Features," page 61. Shortly before purchase of these units a study was made to determine the most economical size and type of turbines for installation in the TVA system. Results of the study indicated that larger units than the first four would be more economical. These larger units of 200,000-kw capability were purchased from the General Electric Company.

Steam conditions are as follows: throttle temperature, 1050°F; throttle pressure, 1800 psig; reheat temperature, 1050°F; and exhaust pressure, 2-inch Hg absolute.

Guaranteed performance of units:

Generator output kw	Turbine heat rate, Btu per kwh
54,509	8,868
93,417	8,272
130,771	7,994
171,155	7,841
200,435	7,793

Performance is based on extraction for feedwater heating, 2 percent evaporated makeup, and 2-inch Hg absolute exhaust pressure. At Colbert Steam Plant, units 1-4 are identical to Kingston's units 5-9. Acceptance tests on Colbert units 2 and 4 are significant for the Kingston units. The results of the Colbert unit 2 tests indicated that the machine failed to meet its guaranteed economy by 0.6 and 0.4 percent at rated load of 180,000 kw and capability load of 200,000 kw, respectively. However, the results of the tests were challenged by the manufacturer on a basis of suspected deposits of carryover in the steam path. Therefore, Colbert unit 4 was operated normally for a period of about six months, after which it was dismantled, inspected, and thoroughly cleaned. Soon after restarting the unit, the tests were made. Results of these tests indicated that the unit met the guarantee at the capability rating but failed to meet the guarantee at rated load by 0.1 percent. At lower loads the deficiency in heat rate economy varied upward to about 1 percent at 25 percent load.

Turbine—The units are the tandem-compound, triple-flow exhaust, condensing, reheat-type. Rated capacity is 180,000 kw, and maximum guaranteed capability is 200,000 kw at 2½-inch Hg absolute exhaust pressure. Operating speed is 3600 rpm. Each unit consists of a HP section (combining high-pressure and reheat steam paths), a single-flow IP section, and a triple flow LP section. The high-pressure steam path consists of a single row, large-diameter wheel followed by eight single-row stages. The steam is then reheated to 1050°F and is admitted to the reheat steam path to pass through three single-row stages. The steam then passes through two crossunder pipes and enters the IP turbine where it passes through six stages. The steam exhaust from this section splits so that approximately one-third goes directly through one of the LP sections while two-thirds passes through two steel crossover pipes to the center of the remaining two LP sections. The HP shell is cast-steel, double-wall type, with an integral steam chest. The IP section is of a similar type. The LP section is fabricated steel.

The turbine spindle is made from alloy-steel forgings in three sections solidly coupled together. These are the HP, IP-LP single flow, and LP double-flow. All stage wheels are machined integrally with the shaft, and the wheels are machined to receive the dovetails of the buckets. The buckets are machined from chrome-iron alloy bar stock. Steel shroud bands are used to tie the outer ends of the buckets together. On last-stage wheels, where tip speed is high, Stellite shields are attached to the leading edge of the outer portion of each bucket as an additional safeguard against erosion due to moisture. Nozzle partitions are machined from chrome-iron alloy and are incorporated into the diaphragm by either a welding or "cast-in" process.

At the points where the shaft passes through the casing, labyrinth-type steam seal packing is used to prevent steam leakage into the powerhouse and air leakage into the condenser. A steam-seal regulator is provided to properly maintain seal pressures. In addition, a gland-steam condenser receives the steam from the lowest pressure packing. The pressure in the condenser is maintained slightly below atmospheric by a centrifugal exhauster.

Steam leakage along the shaft at the bores of the diaphragms is held to a minimum by metal packing rings fitted into the diaphragms. The rings are segmented, each supported by a flat spring. The springs hold the segments in place and maintain a small clearance between the packing rings and the shafts. The segmented spring-backed ring will provide additional clearance if the rotor should become distorted as a result of some transient operation condition. Segments of the ring will spring back at each revolution to prevent serious damage to the ring or heavy rubbing of the shaft. This reduces the possibility of local heating which also might damage the shaft.

Turbine control and governor mechanism—The inlet steam from the boiler is admitted to the turbine through two emergency stop valves, then through the two control-valve chests, and through the control valves to turbine nozzles. There are no conventional gate-type shutoff valves at the boiler superheater header or ahead of the stop valves.

The normal governing devices function through hydraulic relays to operate the controlling valves which are the poppet-type with venturi seats. The various normal governing devices which may operate the control valves are: the speed governor (rotating pilot-valve type) and its motor-operated synchronizing device, or the starting handwheel and (motor-operated) load limit.

The pre-emergency device functions similarly to the normal governing devices in case of abnormal operating conditions. It operates intercept valves at high speed.

The emergency devices may either operate the control valves, main or reheat stop valves, or the intercept valves, or any combination. The various emergency devices are: an oil-tripped overspeed emergency governor (operates control valves, main and reheat stop valves, and intercept valves); a hand trip (operates main stop valves); a solenoid trip (operates main and reheat stop valves, control valves, and intercept valves), and a low-vacuum trip (operates main and reheat stop valves, control valves, and intercept valves).

The operating governor is the centrifugal type, driven through the worm gear on the turbine shaft. When the turbine is running at or near rated speed, with the generator disconnected from the line, its speed is held constant automatically by the operating mechanism. The speed may be varied between limits by a synchronizing device which is remotely controlled from the main control room. This device is used also to synchronize the generator with the system during startup.

When starting the unit the hand control provides a means of manually opening and closing the control valves through the hydraulic operating mechanism in the same manner as if operated by the operating governor. This control also provides a load-limit device which restricts the opening of the control valves to some predetermined position. It does not, however, prevent the operating governor from closing the control valves should a large drop in load make this necessary. The load limit may also be controlled remotely from the unit control room.

There is a testing device at each stop valve, intercept valve, and reheat stop valve to enable the operator to close the valves while the unit is in service to assure that valves are always operative.

The emergency governor is an unbalanced ring which is held concentric with the shaft by a spring. When the speed reaches 110-111 percent of the synchronous speed, the centrifugal force of the ring overcomes the force of the spring and the ring snaps to an eccentric position, thereby operating the emergency trip for the control, intercept, and reheat stop valves and the main stop valve emergency trip. The emergency governor can be made to trip at normal speed by admitting oil through the oil trip valve.

The device to control the intercept valves is termed the pre-emergency governor. Its speed-sensitive element is the pilot-valve type, operating through hydraulic elements to position the intercept valves. This device holds the intercept valves wide open at all speeds below 101 percent. At 101 percent it starts to close them and at 105 percent has them completely closed. The purpose is to quickly shut off steam from the reheater in case the generator loses its load. This action, along with the rapid closing of the high-pressure control valves under action of the speed governor, will keep the speed of the turbine below the trip point of the emergency governor.

Two reheat stop valves provide an additional safeguard against overspeed produced by steam entrapped in the reheater. These valves are located in the hot reheat lines as close as possible to the reheat valves. They are the single-seated swing-gate type designed with unbalanced disc which is able to open against a pressure differential of 25 psi maximum. The valves are closed by the overspeed governor as well as the other emergency trip devices.

Turbine supervisory instruments include a shell and differential expansion recorder, vibration amplitude recorder, speed and camshaft position recorder, and eccentricity recorder.

Turbine bearings and lubrication systems—The lubricating system for each turbine is complete and self-contained, consisting of a supply tank, pumps, a cooler, gages, and piping. The pumps deliver high-pressure oil which is used in the hydraulic mechanism to operate the controlling valves. A flow of low-pressure oil is delivered to the bearing header from which branches lead to the bearings and other parts to be lubricated. The pressure oil system consists of a main oil pump, oil-driven booster pump, auxiliary oil pump, turning gear pump, and emergency direct-current bearing pump.

The main oil pump which supplies oil to the hydraulic mechanism and bearings is a centrifugal pump mounted on the turbine shaft. It is supplied with oil at about 15-20 psig by the oil driven booster pump located in the oil tank. Oil discharging from the main pump at about 200 psig is piped back to the oil tank where it passes through the oil turbine which drives the booster pump. In passing through the oil turbine the oil pressure is reduced from about 200 psig to about 40 psig to provide the power to drive the booster pump. The oil then passes through the oil cooler and bearings.

The turbogenerator unit has eight main bearings of the spherical-seat, self-aligning, pressure-lubricated type, having linings of babbitt metal. The thrust bearing is the Kingsbury segmental-shoe type. It is located on both sides of the number 3 journal bearing. It absorbs the axial thrust of both the turbine and generator rotors which are joined by a solid coupling.

Turbogenerator turning device—A turning motor to rotate the turbogenerator rotor at 2-3 rpm is mounted over the turbine middle bearing standard. The drive is transmitted through a silent chain and reducing gear train to the turbine shaft. The turning gear has two general functions: first, as a turning device which keeps the turbogenerator shaft rolling slowly and continuously during periods when temperature change is taking place and, second, as a jacking device which can turn the rotor small amounts at intervals for inspection.

Steam generators

The steam generators for units 1-4, supplied by Combustion Engineering, Incorporated, are reheat units of radiant-type, natural circulation, dry-bottom furnaces, with a continuous rating of 1,020,000 pph steam and a 4-hour peak rating of 1,120,000 pph. Figure 12 shows a cross section of these steam gen-

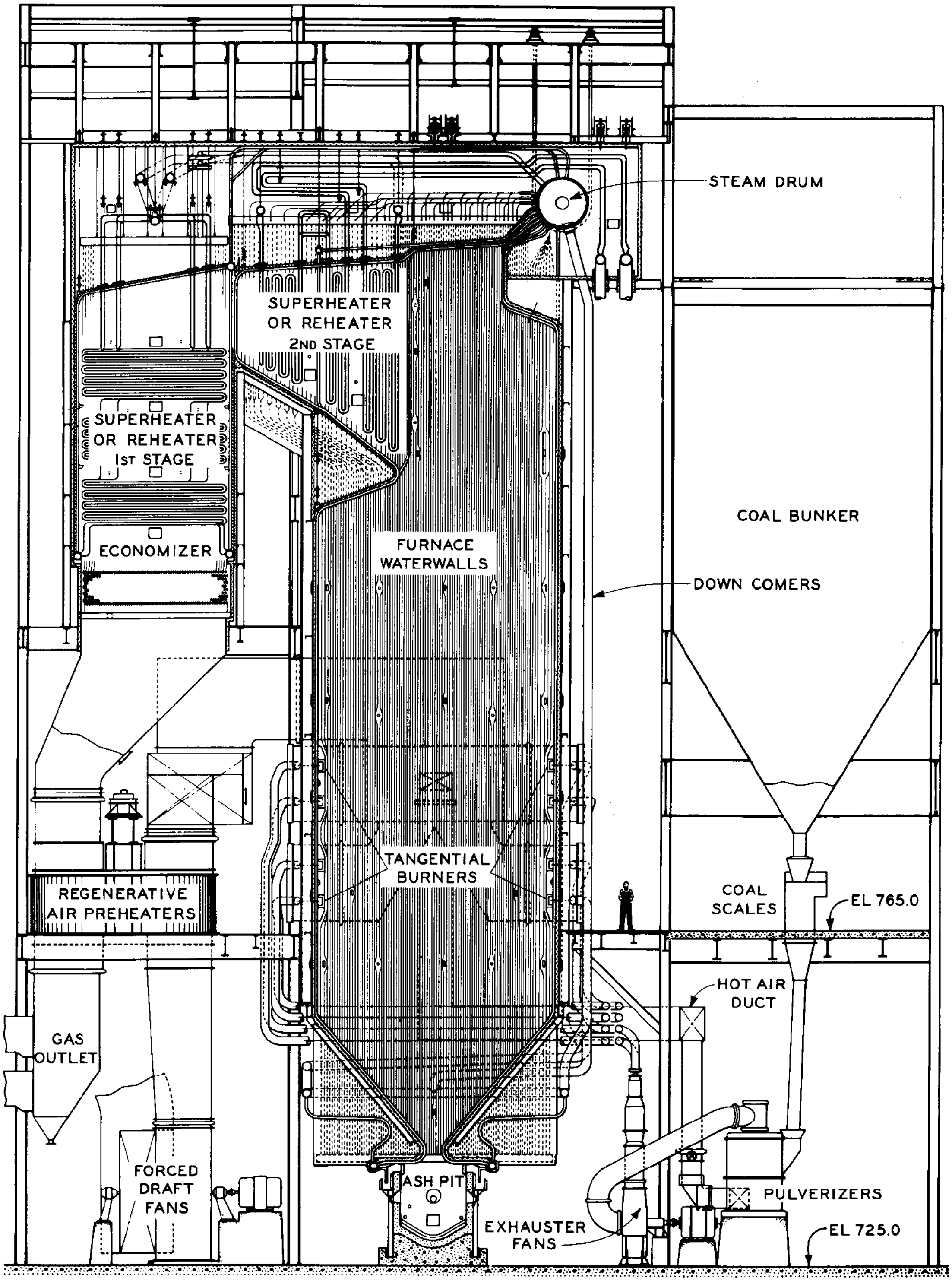


FIGURE 12.—*Section through steam generator representative of units 1-4 is about 12 stories high and is capable of producing 1,000,000 pounds of steam per hour. The boiler portion of the generator consists of a wall of water tubes covering the inner faces of the combustion chamber, with natural circulation of water.*

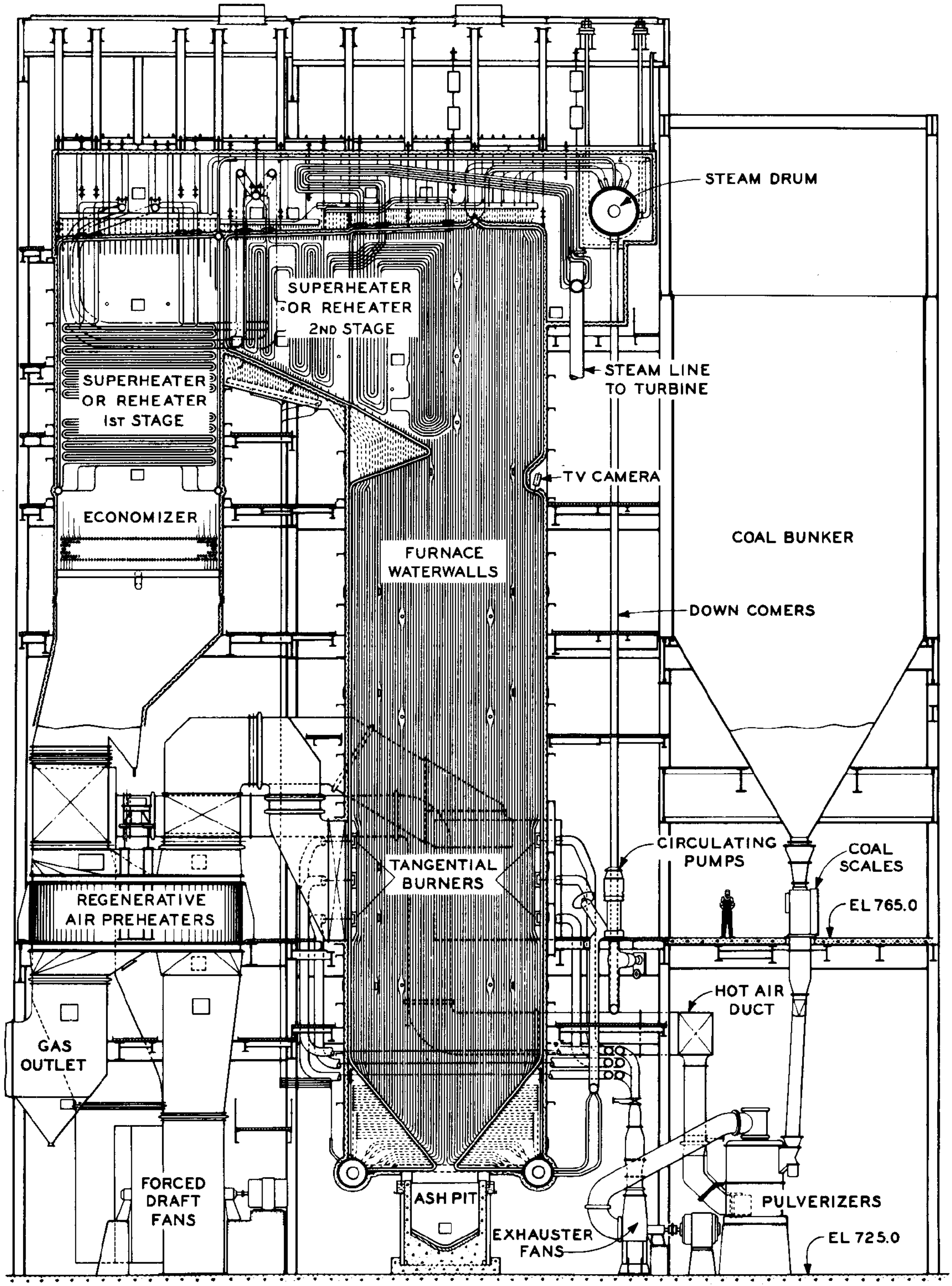


FIGURE 13.—*Section through steam generator representative of units 5-9. This unit, capable of producing 1,410,000 pounds of steam per hour, is also about 12 stories high, generally similar to those of units 1-4 except that the generators are twin construction for each unit with controlled circulation of water.*

erators. The reheater has a continuous rating of 870,000 pph steam and a 4-hour peak rating of 956,000 pph. The steam conditions at the superheater outlet are 1825 psig and 1003°F to give a throttle condition of 1800 psig at 1000°F. The design pressure of the boiler and superheater is 2025 and the economizer is 2086 psig. Reheat steam conditions entering the reheater are 425 psig at 640°F and leaving are 404 psig at 1003°F.

The steam generators for units 5-9 (fig. 13), also supplied by Combustion Engineering, Incorporated, are reheat units with twin dry-bottom furnaces and have a continuous rating of 1,280,000 pph steam and a 4-hour peak rating of 1,410,000 pph. The steam conditions at the superheater outlet are 1840 psig and 1053°F. to give a throttle condition of 1800 psig at 1050°F. The design pressure of the boiler and superheater is 2060 and the economizer is 2100 psig. Reheat steam conditions entering the reheater are 378 psig at 668°F and leaving are 356 psig at 1053°F. The furnace, superheater, and reheater tube spacing and gas velocity designs were specified to be liberal to reduce slagging and keep unit availability as high as possible (fig. 12).

Because of the extremely large dimensions of furnace width and depth necessary for the desired capacity of units 5-9 boilers, it was decided to use the twin furnace controlled circulation design. The boiler unit consists of two separate but identical furnaces with primary stages of superheater surfaces, reheater surfaces, and economizer surfaces. One furnace is designated as the superheater furnace, the other as the reheater furnace. Water walls of both furnaces are connected to a common drum. The four controlled circulating pumps (fig. 14) are mounted on the downcomer pipes suspended from the drum. To provide a seal and to moderate conditions of pressure and temperature for these pumps, a combination injection and bleed-off arrangement is provided. Boiler feedwater at approximately 65 psi higher than the circulating pump discharge pressure is delivered to these pumps through one injection water pump per unit (fig. 15).

Superheaters and controls—The superheaters are the continuous tube-pendant type and consist of two single-pass elements with heating surface sized to maintain the outlet steam temperature from full load down to one-half load. The heating surface installed on each of units 1-4 is 82,285 sq ft and that of units 5-9 is 125,000 sq ft.

Superheat temperature control is by means of desuperheaters installed between the primary and secondary elements. Boiler feedwater is used as a desuperheating medium. The superheater tubes are carried over the roof of the furnace and terminate in an outlet header. This arrangement provides sufficient flexibility to accommodate the vertical expansion of the main steam line.

Reheaters and controls—The reheaters are the continuous tube-pendant type and consist of one single-pass element with heating surface on units 1-4 sized to maintain outlet steam temperature from full load down to 662,000 pph. The reheater outlet temperature is maintained at 924°F at half load. The heating surface on units 5-9 is sized to maintain outlet steam temperature from full load down to 1,116,000 pph. The reheater outlet temperature is maintained as high as possible consistent with superheater and reheater economy. Reheater heating surface is 18,893 sq ft for units 1-4 and 25,300 for units 5-9. Reheat temperature control is by means of desuperheater sections installed in the reheat return line just before entering the boiler. Boiler feedwater is used here also as a desuperheating medium. Tilting burners are also used as desuperheat control.

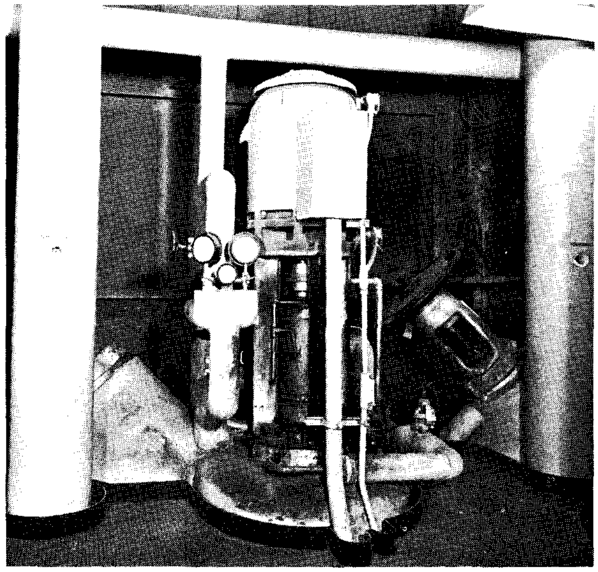


FIGURE 14.—*Boiler circulating water pumps serve each steam generator for units 5-9; steam generators for units 1-4 have natural circulation.*

Economizers—The economizers are the horizontal, continuous-tube, counterflow-type and are located at the rear of the boiler below the low-stage superheater and just ahead of the gas duct to the air preheater. Units 1-4 contain 26,000 sq ft of heating surface each, and units 5-9 contain 30,450 sq ft each.

Pulverizers—The pulverizers, four per unit for units 1-4 and six per unit for units 5-9, were furnished under the boiler contract and have a capacity of 35,600-pph coal at 50 grindability and 7 percent moisture. The pulverizers are driven by 350-hp, 4000-v, fan-cooled electric motors. These motors also drive the mill exhausters which are the straight-blade type with single-bearing overhung wheel. The fan blades are renewable, and renewable liners are provided in the fan scroll. Coal feeders are mounted directly on the side of the pulverizers. The coal pipes

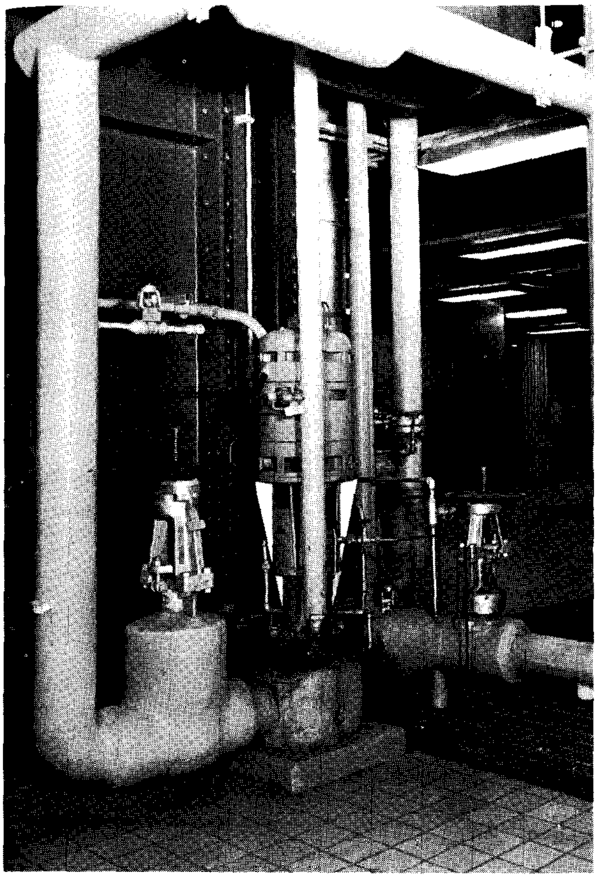


FIGURE 15.—*Injection water pumps moderate pressure and temperature for the boiler circulating water pumps.*

between the pulverizer exhausters and the burners are cast iron, 11-inch od for units 1-4 and 12-inch od for units 5-9. There are four pipes per pulverizer with individual shutoff valves just above the exhauster. To obtain uniform distribution of the coal in the pipes, a riffle type distributor is provided at each exhauster outlet. Orifices are also provided in the coal pipes to equalize the friction.

Air preheaters—There are two regenerative-type air preheaters per unit. On units 1-4 they are designed for a corrected gas temperature leaving the heater of 310°F with an entering air temperature of 80°F. The heating element is 44 inches high and the casing is designed for an additional 8 inches of element in case it is found from operating experience that the exit gas temperature can be lowered without fouling of the cold end of the elements due to cooling the gas to below the dew-point. On units 5-9, heaters are designed for a corrected gas temperature leaving the heater of 300°F with an entering air temperature of 80°F. The heating element is 48 inches high.

Dual-nozzle cleaning devices were provided for cleaning the preheater elements with steam at 550 psi. The steam nozzle is operated automatically from the soot blower sequential control panel while washing of the preheater is by hand control, using water only or water and steam as may be required.

Burners and ignition torches—Each pulverizer supplies four burners. On units 1-4 there are four burners in each corner of the furnace while for the twin furnace units 5-9, there are three burners in each furnace corner. The burners are the adjustable, tangential type, and are provided with air-mixing chambers, adjustable air dampers, and connections for the coal pipes (fig. 16). Provision for future burning of natural gas was made in the burners. Each burner was provided with an automatic oil lighter and, in addition, one oil burner per corner was provided for use in starting up the boiler and raising the temperature to the point where one pulverizer can be operated continuously. The burners use oil at 100 psig and are the hand-operated, air-atomizing type.

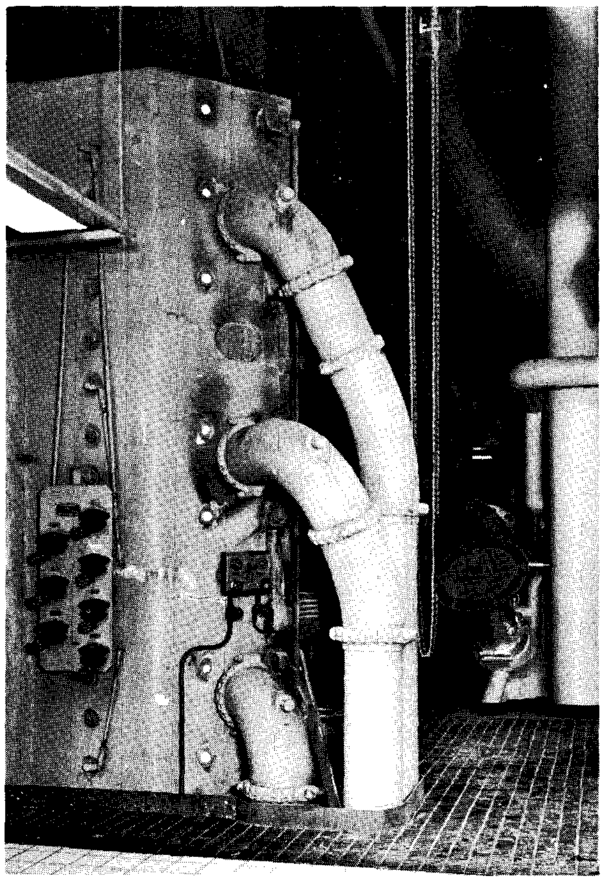


FIGURE 16.—*Sixteen adjustable, tangential-type coal burners were provided for each steam generator, units 1-4; 24 each for units 5-9.*

Ductwork—All ductwork required for operation of the steam generators was designed for minimum pressure drop consistent with first cost. The air preheaters were provided with bypass ducts for use during startup and low-load operation to prevent condensation and buildup on the cold end. These ducts have dampers which can be operated from the unit control room. Multiple-leaf, louver-type dampers were installed as required to segregate either set of fans, preheaters, and fly ash collectors for maintenance. Hoppers with 6-inch drains were provided in the ductwork under the air preheaters to catch water and ash when washing the heaters.

Soot blowers—Steam soot blowers were furnished under the boiler contract. Initially, in addition to equipment for cleaning the air preheaters, six long retractable blowers were provided for each of units 1-4 located in the superheater area of the unit. Operation proved that these were not sufficient and two more blowers were added. There are six half-tracts in the primary superheat section, with provisions for addition of twelve more if ever needed. There are 36 wall blowers installed in the furnace and provisions for 4 rotary-type blowers in the economizer.

For units 5-9, in addition to equipment for cleaning the air preheaters, 10 long retractable blowers were installed in the secondary superheater and reheater area and eight half-tracts installed in the primary superheater area. Provisions are made for four more long retractable blowers. There are 24 wall blowers installed in the furnace walls and four rotary-type blowers in the economizer. All blowers are controlled from automatic sequential panels in the unit control rooms.

Safety valves—Spring-loaded pop safety valves were provided for the steam generators in accordance with the requirements of the ASME Boiler Code. Units 1-4 have four 2½-inch valves on the boiler drum and one 3-inch valve on the superheater outlet header. These valves have a total relieving capacity of 1,211,900 pph. The reheat inlet header is fitted with two 4-inch valves. Total relieving capacity of all reheat valves is 1,446,200 pph.

Units 5-9 have five 2½-inch valves on the boiler drum and two 2½-inch valves on the superheater outlet header. These valves have a total relieving capacity of 1,606,700 pph. The reheat inlet pipes are fitted with six 4-inch valves and the outlet header is

TABLE 9.—*Refractory and insulation thickness for steam generators—units 1-4.*

Location	Refractory			Insulation		
	Special shapes, inches	Castable 50 pounds, inches	Castable 110 pounds, inches	Minimum 1200°F block, inches	Low temperature block, inches	Cement, inches
Furnace						
Front, rear, and side tube walls	—	2⅝	—	1	—	⅝
Deflection arches	—	—	2½	—	—	—
Front roof	2½	—	1	—	—	—
Rear roof	4½	—	1	—	—	—
Superheater and economizer						
Side fin tube walls	—	2⅝	—	1	1½	⅝
Front and rear tube walls	6	—	—	3	2	—
Sloping floor tubes	3½	—	—	3	2	—

TABLE 10.—*Refractory and insulation thickness for steam generators—units 5-9.*

Location	Refractory					Insulation	
	Special shapes, inches	Flat tile, inches	Suspended tile, inches	Super No. 3000 inches[1]	50 pounds castable, inches	Block, inches	Cement, inches
Furnace							
Front, rear, and side tube walls	—	—	—	1	—	4	½
Deflection arch	—	—	—	1	—	—	—
Bottom tubes	—	—	—	1	—	—	—
Roof	—	—	—	1	—	—	—
Floor under superheater	2	—	—	—	—	4	—
Sides at superheater	—	2½	—	—	—	6	½
Primary superheater							
Front fin tube wall	—	—	—	1	—	4	½
Rear fin tube wall	—	—	—	1	—	4	½
Side fin tube wall	—	—	—	1	—	4	½
Economizer							
Front, side, and rear walls	—	—	2½	—	1	3½	1¼

1. Embedded in expanded metal that is welded to the tube. Thickness is from center line of tube.

fitted with two 4-inch valves. Total relieving capacity of all reheat valves is 1,414,200 pph. In addition to the spring-loaded safety valves, each superheater outlet header on all units is fitted with a 2½-inch, solenoid-operated power-control valve to take minor load swings and prevent operation of the spring-loaded valves whenever possible.

Insulation and refractories—All insulation and refractory material for the steam generators was furnished under the boiler contract and applied by TVA's insulation and refractory contractors. The type and thickness of insulation and refractory for the steam generators were selected to keep heat losses due to radiation within ABMA Standards and are as shown in tables 9 and 10. The entire walls and roof of the units were covered with a 12-gage welded steel casing, stiffened and reinforced where necessary. Air and gas ducts and miscellaneous piping with the steam generators were insulated in accordance with tables 11 and 12.

Table 11.—***Insulation thickness for air and gas ducts and piping—units 1-4.***

Location	Blanket, inches	Block: High temperature, inches	Segmented block: High temperature, inches	Segmented block: Low temperature, inches	Hard finish cement, inches	Canvas, ounces
Sides of economizer	4	—	—	—	½	—
Ductwork						
Economizer to air heater	3½	—	—	—	½	—
Air heater to windboxes	2½	—	—	—	½	—
Hot air to pulverizers	2½	—	—	—	½	—
Equipment						
Air heater	3½	—	—	—	½	—
Enclosures						
Roof housing	—	4	—	—	½	—
Deflection arch housing	—	4	—	—	½	—
Tubes, pipes, headers, etc.						
Exposed downtake pipe	—	—	1½	2	—	8
Superheater connecting pipe including desuperheater	—	—	1½	2½	—	8
Exposed downtake tubes, grouped	3	—	—	—	½	—
Exposed economizer headers and connecting pipe	—	—	—	2½	—	8
Exposed soot blower pipe	—	—	—	2	—	8
High temperature superheater elements under roof housing	—	2	—	—	½	—

Table 12.—***Insulation thickness for air and gas ducts and piping—units 5-9.***

Location	Mineral wool block, inches	Block: Medium temperature, inches	Block: Low temperature, inches	Segmented block: High temperature, inches	Segmented block: Low temperature, inches	Cement, inches	Canvas, ounces
Ductwork							
Economizer to air heater	3	—	—	—	—	½	—
Air heater to windbox	2	—	—	—	—	½	—
Hot air to mills	2	—	—	—	—	½	—
Bypass duct	2	—	—	—	—	½	—
Equipment							
Air heaters	3	—	—	—	—	½	—
Enclosures							
Deflection arch	—	3	—	—	—	½	—
Roof	—	4	—	—	—	½	—
Bottom	—	3	—	—	—	½	—
Tubes, pipes, headers, etc.							
Drum shells and heads	—	1½	2	—	—	½	—
Final stage superheater and reheater headers and elements	—	2	—	—	—	½	—
Exposed downtake pipe	—	—	—	1½	2	—	8
Desuperheater shells and pipe	—	—	—	1½	2	—	8
Soot blower pipe	—	—	—	—	2	—	8

Coal scales and valves

To indicate the quantity of coal burned, four totally enclosed, dustproof, automatic coal scales of 500-lb-per-dump capacity were provided for units 1-4 and six scales per unit for units 5-9. They are located on the operating floor level. The scales each have an hourly capacity of 30 tons with an accuracy of ¼ of 1 percent. All parts of the scales in contact with the coal are stainless steel except the rubber conveyor belts. The outer housings are 11-gauge enameled steel, welded to be dust tight.

Timing devices are provided to sound an alarm in case the scale fails to complete a weighing within its set time due to plugging of the supply chute. Paddle-type alarm switches are provided in the coal-scale discharge hopper to sound an alarm in case the scale fails to keep the hopper filled.

In addition to the weighing counters mounted on the scales, electrically-operated, 6-figure remote counters are also provided in the unit control room. Bypass arrangements are built into the scales to assure continuous supply in emergency. Ventilation of the scales is provided by the dust-collecting systems.

Stainless-steel, clamshell coal valves are provided at the scale inlets to isolate for maintenance. Filler pieces between these valves and the scales are removable to allow emergency emptying of the coal bunker if necessary.

Draft system

The draft system consists of motor-driven constant-speed fans and individual ducts from the forced-draft fans to the air preheaters and from the air preheaters to the fly ash collectors and thence through the induced-draft fans to the stack. There are two fans of each type per unit.

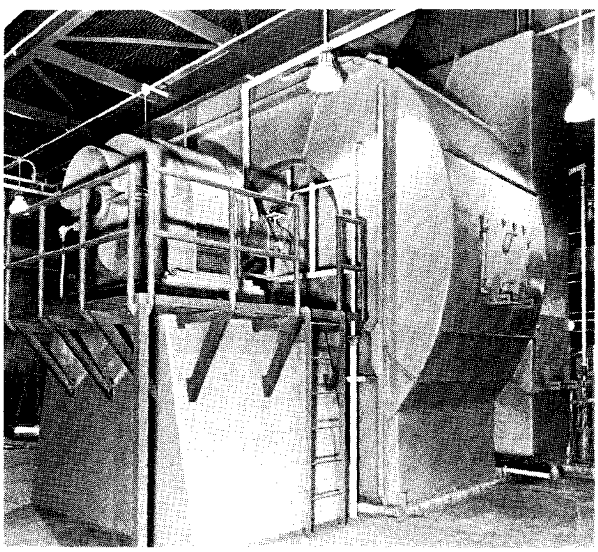


FIGURE 17.—*Forced draft fans, two for each unit, are located on the basement floor west of the boilers and supply air to the preheaters, pulling it through ducts from the top of the boiler bay.*

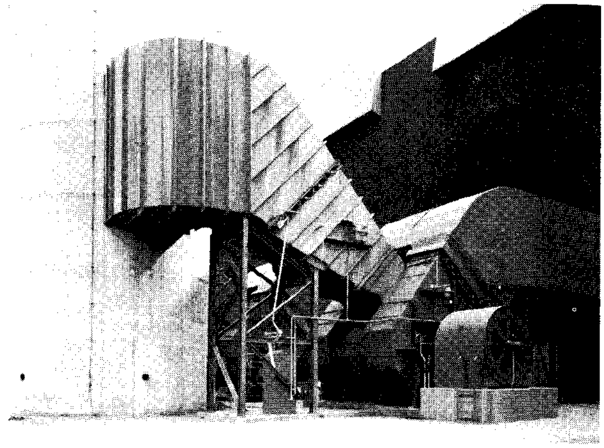


FIGURE 18.—*Double-inlet induced draft fans, two for each unit, are located at ground level, one on either side of each chimney.*

Forced-draft fans—For units 1-4 these fans were specified for 200,000-cfm air at 140°F and 11.5-inch water pressure at test block. For units 5-9 the capacity specified was 270,000 cfm at 140°F and 13 inches of water at test block. The fans for all units are single width, single inlet, driven by 3-ph, 4000-v Westinghouse motors (fig. 17). Volume and pressure controls are by means of inlet vanes.

Induced-draft fans—For units 1-4 these fans were specified for 290,000 cfm gas at 320°F against 20.5 inches of water at test block. For units 5-9 the capacity specified was 400,000 cfm at 320°F and 20 inches of water at test block. The fans for all units are driven by 4000-v motors (fig. 18). Volume and pressure control is by means of louver-type dampers in the fan inlet boxes. Shutoff dampers were provided at the end of the evase section on the fan outlet. Wear plates, ½-inch thick, are installed in the inlet boxes and the scroll of the fans, and 3/16-inch tabs are provided for the floats of the fan wheels.

Fly ash collectors Mechanical fly ash collectors are used and there was a provision for installation of electrostatic precipitators if necessary. (The electrostatic precipitators were added after completion of the project, see Appendix E). The cones are located just above the basement floor between the air preheaters and the induced-draft fans. There are two collectors per unit designed for a maximum normal gas flow of 239,000 cfm at 305°F with 3-inch water pressure drop for units 1-4. Collectors for units 5-9 are designed for a maximum normal gas flow of 310,000 cfm at 295°F with 3-inch water pressure drop.

Ductwork—Because of the arrangement of the plant the forced-draft fans, located in the basement, have intake ducts which originate just under the roof of the boiler room. Thus advantage is taken of the preheating of the air as it rises around the boilers by placing the suction inlet of these ducts near the roof. These ducts are 10-gauge steel plate reinforced by 5-inch corrugated ribbing, spaced to withstand an internal pressure of minus 20.5 inches of water for units 1-4 and 20 inches for units 5-9.

The air ducts are not insulated while the gas ducts have a 1½-inch cover of 85-percent magnesia block plastered over with a ½-inch coat of asbestos cement. Outside the building the gas ducts are covered with 2 inches of 85 percent magnesia block and a ½-inch finish coat of asbestos cement, one layer of 15-pound perforated asbesto felt, and a weatherproof finish of two ⅛-inch layers of Johns-Manville "Airtite."

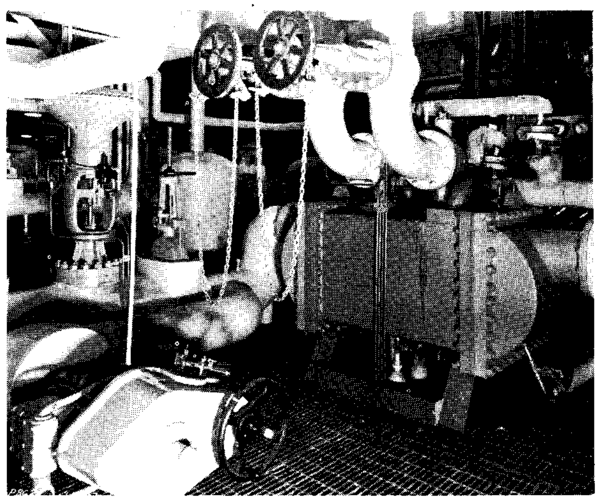


FIGURE 20.—*Venturi-type steam jet ejector, one per unit, for ejecting air from the condenser on start-up.*

Condensing equipment

As a result of the exhaustive study made for the Johnsonville Steam Plant relative to the type of condensers to be specified and because conditions for the Kingston plant were so similar, the same type of condenser was selected. This was a single-pass type with 75°F chosen as the circulating water design temperature to provide 28-inch Hg vacuum at full load.

Condensers—The condensers are the divided water-box type with two separate inlet and discharge connections on each condenser (fig. 19). Therefore, either half can be isolated and inspected or repaired while the other half is in operation. The condenser shells are welded-steel plate with water boxes of fabricated steel designed for 25-psig operating pressure. Tube sheets are Muntz metal.

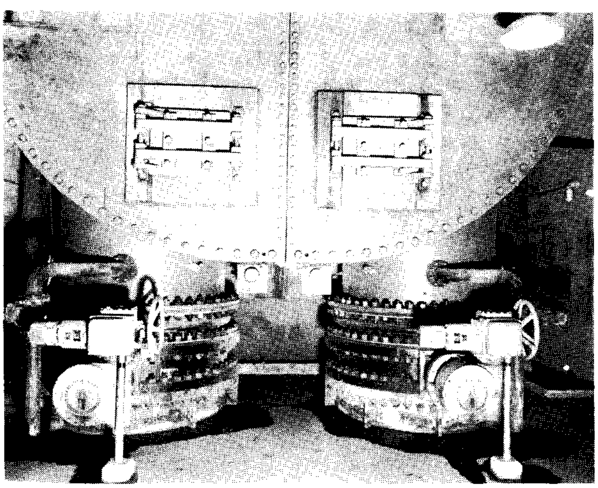


FIGURE 19.—*The condensers are the divided water-box-type, one for each unit, similar to the unit 9 condenser shown.*

The condenser hotwells are the deaerating-type and have a storage capacity sufficient to allow about 3 minutes full-load operation.

Air removal equipment—The air, together with other noncondensable gases, is removed from the system by a steam jet air ejector (fig. 20) for which steam is supplied from the main steam line. The steam pressure is reduced by a hand-operated control valve to an operating pressure of 300 psig. This steam, together with vapors and gases from the condenser, passes through an intercondenser and aftercondenser, where the steam is condensed and the noncondensables are discharged to the atmosphere. A separate single-stage priming ejector is provided for starting. Capacity of this ejector is such that about 15-20 minutes is required to reduce the pressure in the exhaust space to 15-inch Hg.

Condensate and feedwater systems

The feedwater cycle heating is similar to that used at the Johnsonville and the Widows Creek Steam Plants. The cycles used are shown in figure 21 for units 1-4 and figure 22 for units 5-9, and include three high-pressure heaters and a deaerator. Units 5-9 each have a fourth low-pressure heater.

Closed feedwater heaters—All the closed feedwater heaters are the horizontal-type. The high-pressure heaters are located on upper floor levels in the heater bay made to accommodate the deaerating feedwater heater and storage tank (fig. 23). The low-pressure heaters are installed in the condenser neck (fig. 24).

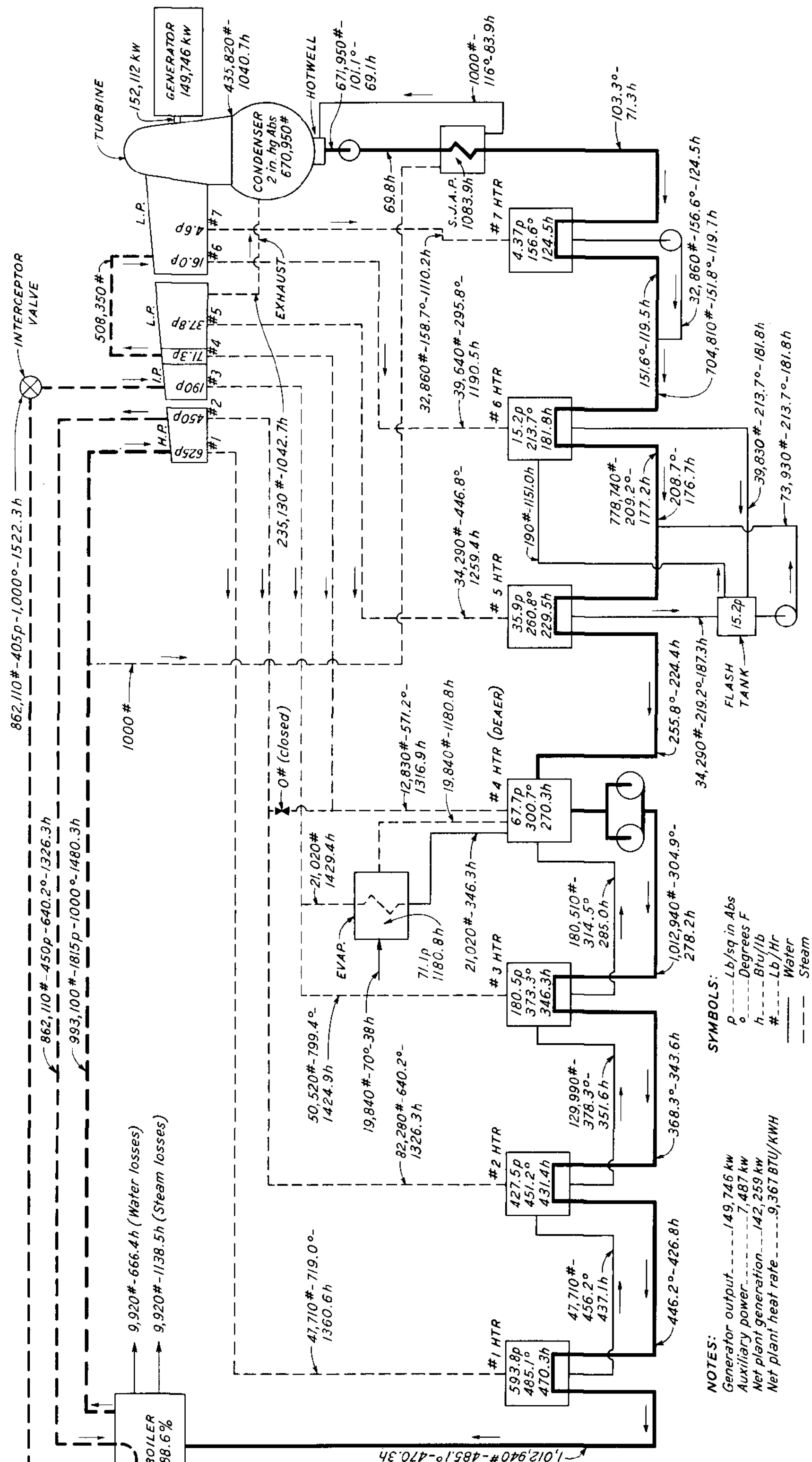


Figure 21.—*Guaranteed performance of units 1-4 is specified in accordance with design heat balance diagram shown, which indicates a generator output of 149,746 kw at 2 inches of mercury absolute exhaust pressure and 2 percent evaporated makeup.*

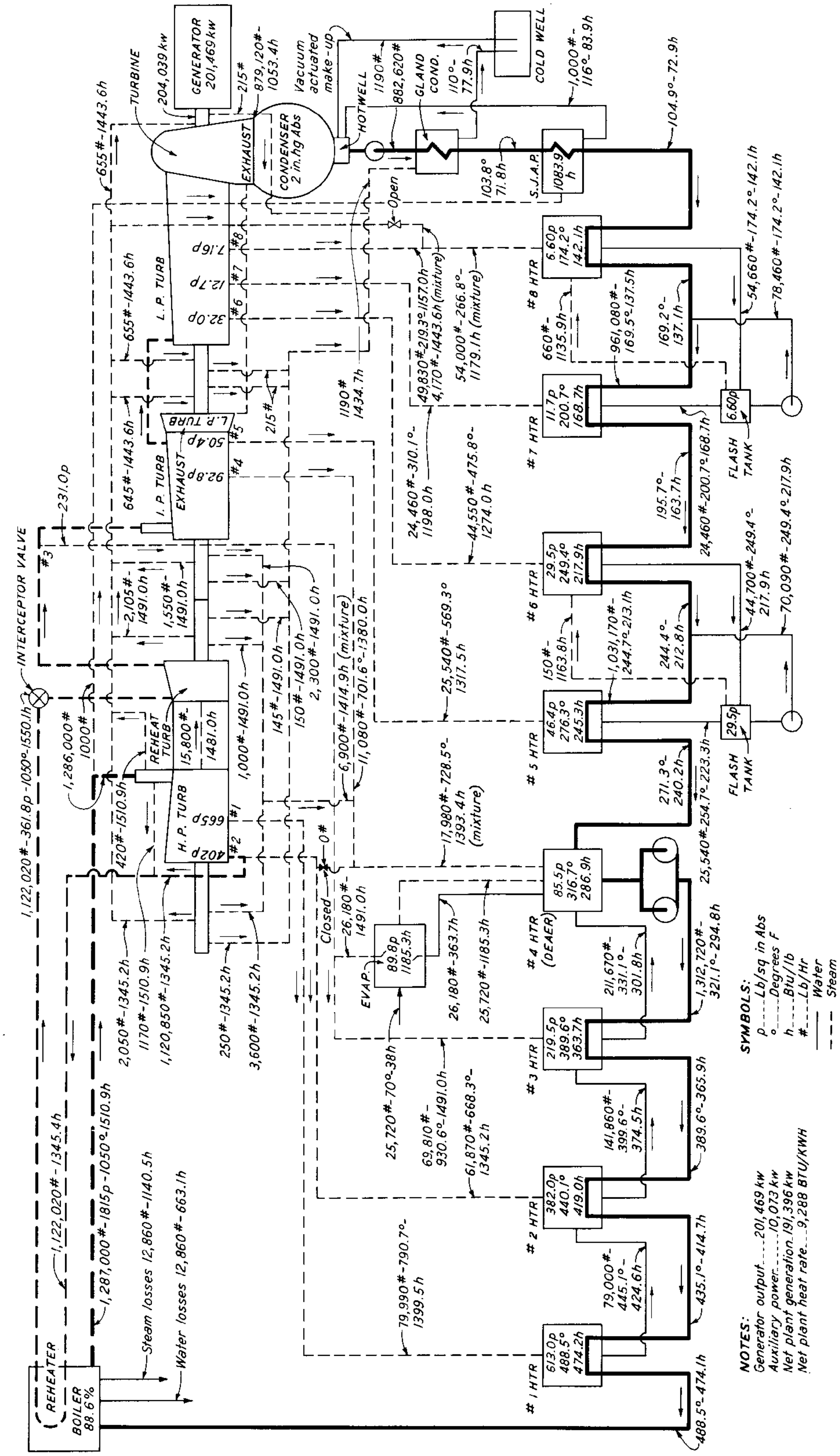


Figure 22.—*Guaranteed performance of units 5-9 is specified in accordance with design heat balance diagram, above, which indicates a generator output of 201,469 kw at 2 inches of mercury absolute exhaust pressure and 2 percent evaporated makeup.*

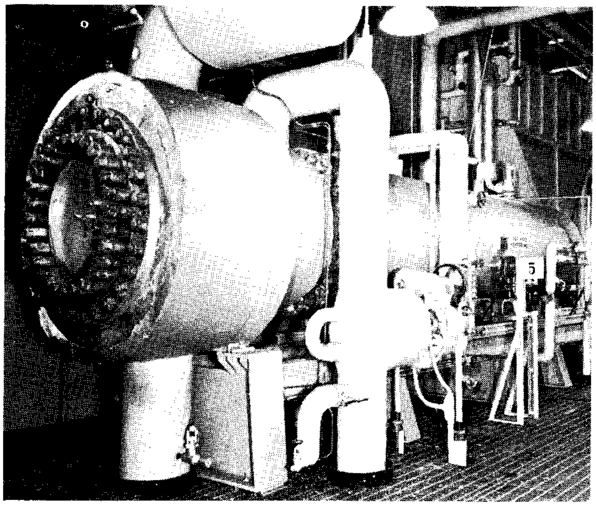


FIGURE 23.—*High-pressure horizontal closed feedwater heaters, three for each of the nine units, with internal sub-coolers.*

On all units the three high-pressure heaters and the low-pressure heater adjacent (in the cycle) to the deaerator have internal subcoolers designed to reduce the drain temperatures to within 10°F of the incoming feedwater. This was more than justified in improved heat rate, and in addition, reduced the flashing in the drain lines, thereby eliminating to some extent a troublesome maintenance item. On the feedwater side all closed heaters are designed for a total temperature difference of 5°F with the exception of No. 1 for all units and No. 3 for units 5-9 which are designed for no temperature differential.

Each of the high-pressure heaters drains to the next lower pressure heater, and the No. 3 heater drains to the deaerating heater. The level in each heater internal drain cooler is maintained by an air-operated throttling control valve in the drain line from the respective heater. Each No. 5 heater drains through an air-operated control valve to a flash tank, which also functions as a suction reservoir for the No. 6 heater drain pump. The flash tank is

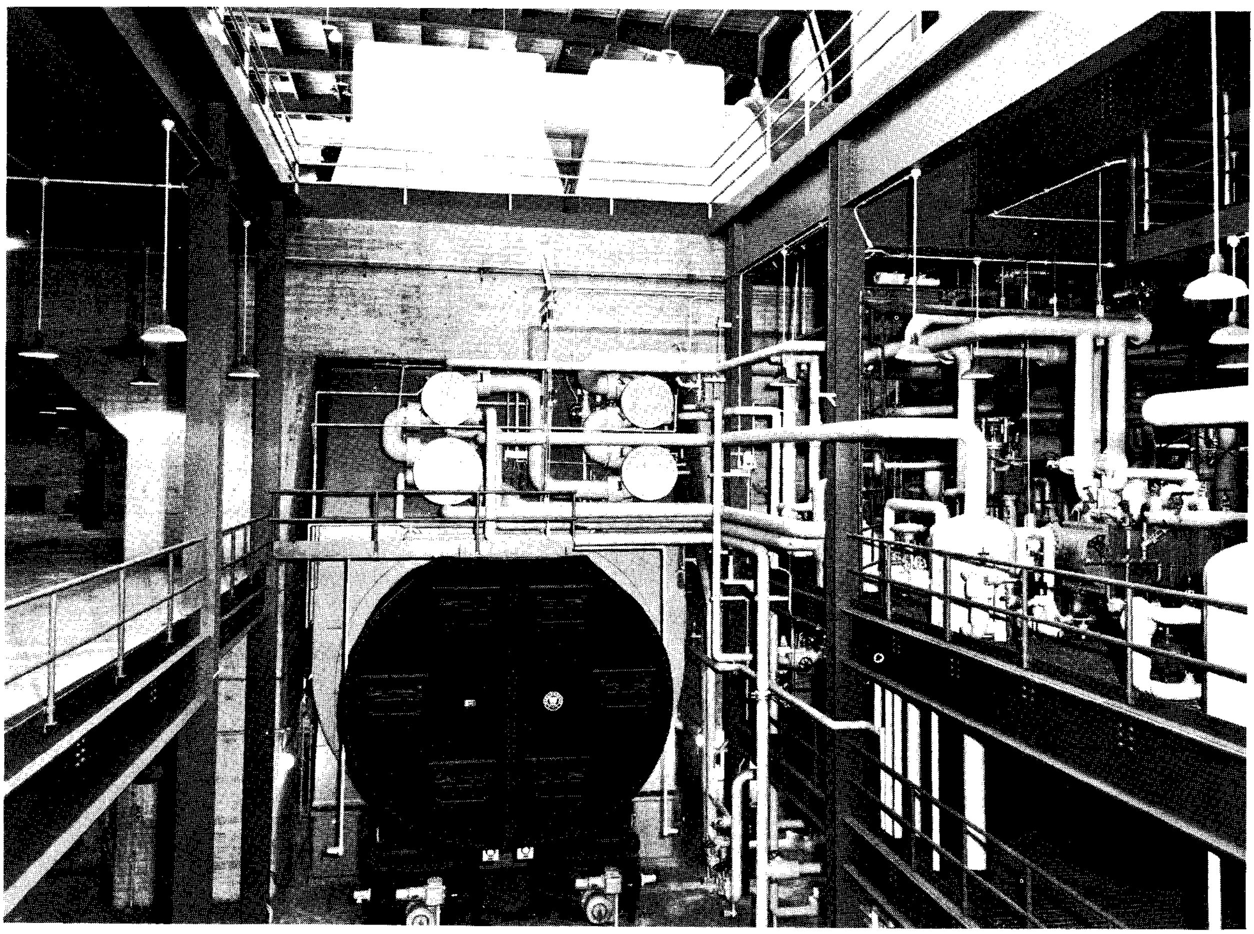


FIGURE 24.—*Unit 6 turbogenerator, its low-pressure feedwater heaters and condenser. At right, steam jet air ejector.*

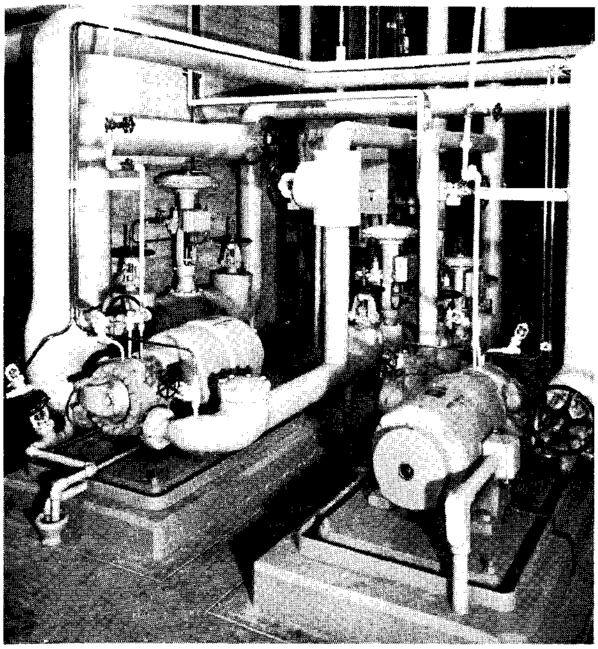


FIGURE 25.—*Nos. 6 and 7 heater drain pumps, unit 1. These pumps return drainage to the condensate system at Nos. 5 and 6 heater inlets respectively (see diagram figure 21, page 46).*

vented through an unrestricted line to the No. 6 heater, thus operating the same pressure. The No. 6 heater drains directly to the same flash tank. Thermodynamically, this arrangement is the same as draining the No. 5 directly to the No. 6 heater. A close-coupled drain pump takes water from the flash tank and discharges it into the condensate system at the No. 5 heater inlet. The water level in the flash tank is maintained by an air-operated control valve at the pump discharge.

On units 1-4 the No. 7 heater drains directly to a pump-suction tank. A close-coupled pump drains this tank into the condensate system at the No. 6 heater. The water level in the tank is maintained by an air-operated control valve at the pump discharge. Figure 25 shows the heater drain pumps for unit 1.

On units 5-9 the drain system for the Nos. 7 and 8 heaters is arranged similarly to the system for the Nos. 5 and 6 heaters; i. e., the No. 7 heater drains through a control valve to a flash tank which operates at No. 8 heater pressure, the No. 8 heater drains directly to the flash tank, and a drain pump discharges the suction from this tank to the condensate system at the No. 7 heater inlet. The No. 2 heater drain is arranged to bypass to the deaerator during unit startup. An arrangement at the suction of the low-pressure drain pumps provides automatic bypassing of the drains from the low-pressure heaters to the condenser during emergency conditions.

Deaerating feedwater heaters—The deaerating heaters (fig. 26) consist of a horizontal shell for heating and deaerating purposes mounted upon a horizontal storage tank. The shells of these tanks are made of copper-bearing steel plate. To provide protection against the corrosive effects of the non-condensable gases, 1/16 inch of thickness was added in the deaerator section over and above the thickness required for strength alone.

The deaerating heater is the nonstorage tray type with a vent condenser. The trays and distributing system are made of fabricated stainless steel. The deaerating heater operates on the counterflow principle; i. e., water leaving the tray section comes in direct contact with steam at its highest pressure. This principle ensures that the heater will deliver water at the temperature corresponding to maximum operating steam pressure.

A downcomer pipe is provided between the heater and the storage tank, which has a net storage volume of approximately 210,000 pounds for units 1-4 and 265,000 pounds for units 5-9 (or about 12 minutes storage at full load), so that deaerated water from the heater will be supplied adjacent to and directed into the boiler feedwater pump suction connection.

In the heater numbering system the deaerating heater is designated as the No. 4 heater. At low

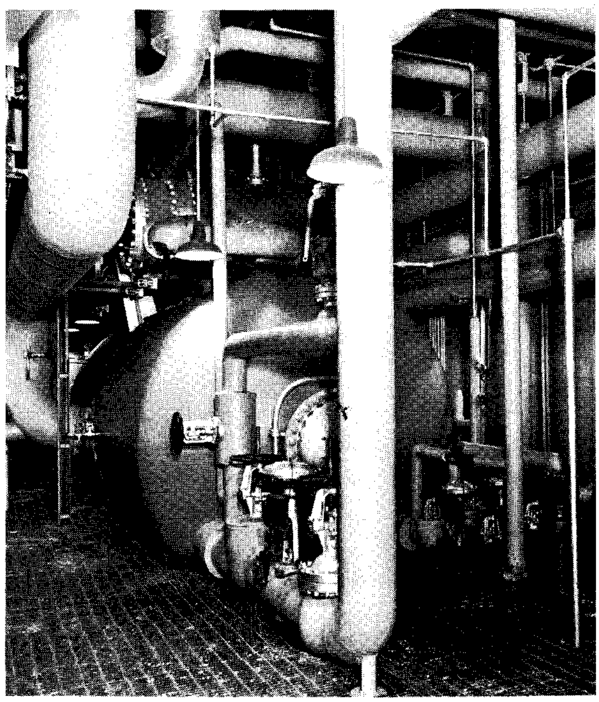


FIGURE 26.—*Deaerating heater No. 4—unit 7. The deaerators—included in the feedwater cycle to provide corrosion protection—consist of tray-type deaerating feedwater heaters, storage tanks, and vent condensers.*

loads, such that the extraction steam pressure would cause the operating pressure of this heater to be below 5 psig, supplementary steam is supplied from the No. 2 extraction line. In case of control failure on further decrease in load, the heater shell is provided with a vacuum breaker to prevent a vacuum being imposed on this equipment.

Evaporators—Evaporators are horizontal U-tube type consisting of a horizontal shell containing the heating element and vapor purifier. The cylindrical shell has dished heads with the heating element inserted through one end. The heating element is a bundle of straight tubes rolled and expanded into a steel tube sheet at each end. The tube bundle is held together by tie rods and support plates. The bundle may be easily removed from the evaporator shell. The steam supply line connects to the bonnet or header which is through-bolted to the tube sheet and end plate. A vapor purifier is provided which effectively removes solids entrained in the vapor from the evaporating surface and returns them to the evaporator shell. The purifier vapor then flows from the evaporator to the unit deaerating feedwater heater (heater No. 4 in the feedwater cycle).

A separate direct-contact preheater, which deaerates and heats the make-up water to evaporator vapor temperature, supplies make-up water to the evaporator. Steam is supplied to the preheater from the evaporator shell.

Evaporators for units 5-9 are horizontal, single-effect, straight-tube type (fig. 27). The evaporator consists of a horizontal shell which contains the heating element and vapor purifier. The cylindrical shell has a dished head at one end and a flat shell cover at the other. The steam inlet is piped through the flat head and internally to the rear tube header. The tubes are expanded into the rear tube header and the shell cover. The tube bundle and shell cover can be removed from the shell as a unit. A centrifugal-type separator removes solids from the vapor.

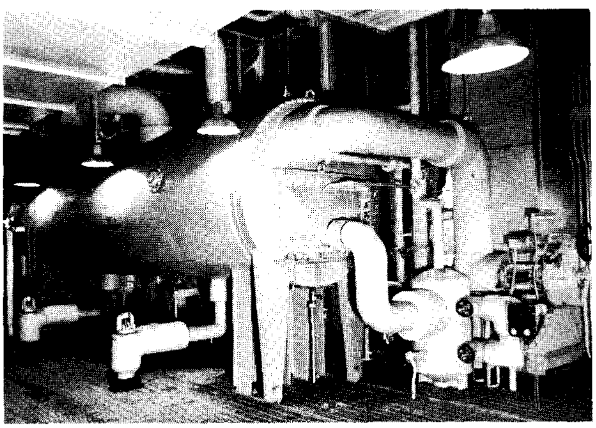


FIGURE 27.—*Unit 5 evaporator. Units 1-4 have evaporative capacities of 20,000 pph; units 5-9, 26,000 pph.*

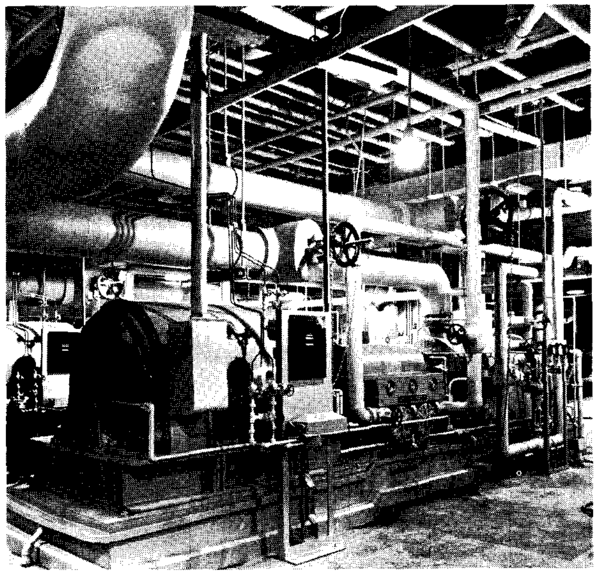


FIGURE 28.—*Boiler feedwater pump—unit 2. There are three pumps per unit—one a spare. Pumps for units 1-4 are rated 1102 gpm at a tdh of 6075 feet; units 5-9 are rated 1445 gpm at a tdh of 6305 feet.*

Boiler feedwater pumps—Three electric-motor-driven boiler feedwater pumps (fig. 28) are provided for each unit. Two of these pumps are capable of supplying water to the boiler under maximum load conditions; the third pump acts as a standby. The motor drive is very reliable and a less expensive installation than a steam-turbine drive. To ensure high reliability for the all-motor-driven installation, two of the motors are supplied from separate auxiliary power sources. The standby pump can be connected to either of the power sources.

Studies were made for the Johnsonville units to compare constant-speed pump operation and attendant feedwater regulator versus variable-speed pump drive, incorporating motor and fluid coupling. Final evaluation indicated that the variable-speed drive offered only a slight financial benefit. However, the reduced pump speed under normal operating conditions reduces maintenance and allows longer pump life and lower feedwater system operating pressure. These results were applied to the design of the Kingston plant.

The pumps are the horizontal-barrel type. The pump casing is forged steel and cylindrical in form to withstand the high pressure and eliminate distortion from high temperatures. The rotor is assembled and inserted into the outer barrel as a single unit. The pump shaft bearings are the self-aligning journal-type. Combined with the outboard bearing is a Kingsbury thrust bearing. A rotary oil pump is located on the outboard end of the pump shaft and supplies pressure lubrication to the pump and motor bearings.

All impellers are single-suction enclosed-type. The pumps for units 1-4 are hydraulically balanced by arranging the impellers in equal and opposite groups. The pumps for units 5-9 are hydraulically balanced by a combination balancing disc and drum which automatically compensate for the pump thrust at all capacities by controlling the leakage between the balancing disc faces in a radial plane and through a constant annular gap. The balancing disc is mounted to the shaft adjacent to the last-stage impeller. The leakage through the balancing device is returned to the deaerator storage tank. The balancing device is accessible for inspection or removal without disturbing the main bolting of the pump heads.

To protect the pumps under low-load or no-load conditions, there is a bypass control system. A line from each pump discharge connects to a common header which connects to the deaerator storage tank. The system operates by automatically opening an air-operated valve in the bypass line when the flow through a pump reaches a predetermined minimum as determined by a flowmeter in the discharge from each pump. When a pump is to be maintained in standby service it is continuously kept warm by a small amount of water circulated through the pump from the discharge of an operating pump. This circulating water passes through the pump and enters the suction header.

Condensate pumps—Each condenser is provided with two hotwell pumps purchased as a part of the condenser contract. The pumps are multistage centrifugal with vertical shaft (fig. 29). The capacity of one pump is sufficient to remove all the condensate at maximum overload; the second pump serves as a spare. Should the condensate level in the hotwell rise to a predetermined maximum the spare pump is started automatically.

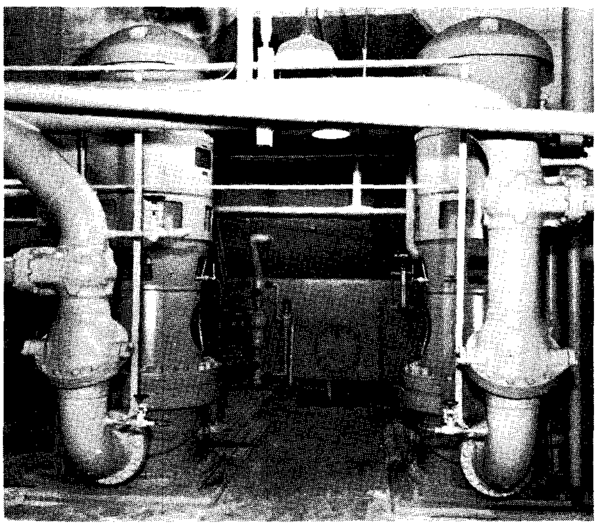


FIGURE 29.—*Unit 6 hotwell pumps. Two pumps are furnished for each condenser. Pumps for units 1-4 have a capacity of 1700 gpm at 370-foot head; pumps for units 5-9 are rated 2250- gpm, 470-foot head.*

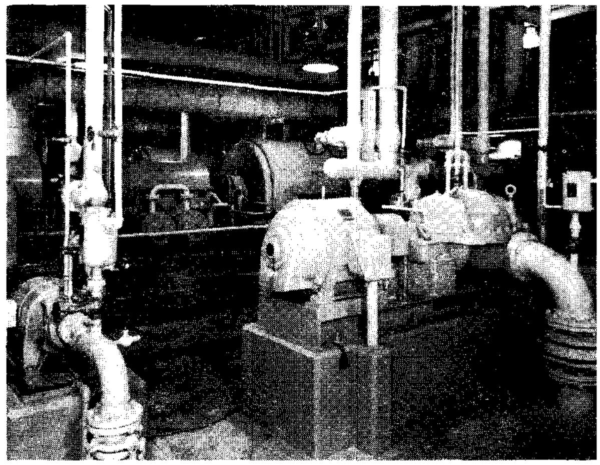


FIGURE 30.—*The distilled water pumps, one per unit, are located over the distilled water wells in the boiler bay basement. At left, unit 1 gland seal water pump.*

AUXILIARY EQUIPMENT AND PIPING SYSTEMS

The equipment and piping are quite similar to that of the Johnsonville Steam Plant (TVA Technical Report No. 31). For this reason, only a brief description is given of each of the various systems except where the equipment or piping is significantly different due to changes in design conditions.

Boiler feedwater system

This system circulates boiler feedwater from the distilled water storage wells and is diagrammed in exhibits 43 and 44. Lines to and from the distilled water pump, vacuum-operated makeup to condenser hotwell, automatic bypass to coldwell, and drains from connecting headers from all distilled water pumps are shown in exhibits 45 and 46. Drains from the condensate drain tank may be seen in exhibits 49 and 50, and drains from the boiler and the start-up heat exchanger are shown in exhibit 51. The suction line to the gland seal water pump and the drain from the gland seal water storage tank are shown in exhibits 60 and 61.

Gland seal water system

This system supplies distilled water for sealing packings on the turbines for units 1-4 and for sealing glands on various pumps as shown in exhibit 60. Figure 30 shows both the distilled water pump and the gland seal water pump. Exhibit 61 shows the gland seal system for units 5-9.

Vacuum-priming system

The vacuum-priming system was installed to remove air from the condenser outlet water boxes and to prime the distilled water and the gland seal water pumps. This system is shown in exhibits 58 and 59.

Raw water system

Raw water is taken from the river without treatment other than screening and intermittent chlorination dosage to prevent the growth of algae. All raw water for the powerhouse is supplied by the condenser circulating pumps through intake conduits and service pumps located in the powerhouse basement. Figure 31 and exhibits 68 and 69 show this system. Raw water is used for condenser cooling, fire protection, cooling and lubricating of other equipment, ash sluicing, general flushing-down, and cleaning services (exhibits 75, 76, 77, and 78). The yard raw water distribution system is supplied from the powerhouse system through three 10-inch pipes, one of which runs through the service bay and supplies raw water for air-conditioning equipment and fire protection system. The yard system furnishes water for fire protection and miscellaneous uses in the yard and the other buildings throughout the plant (exhibit 79).

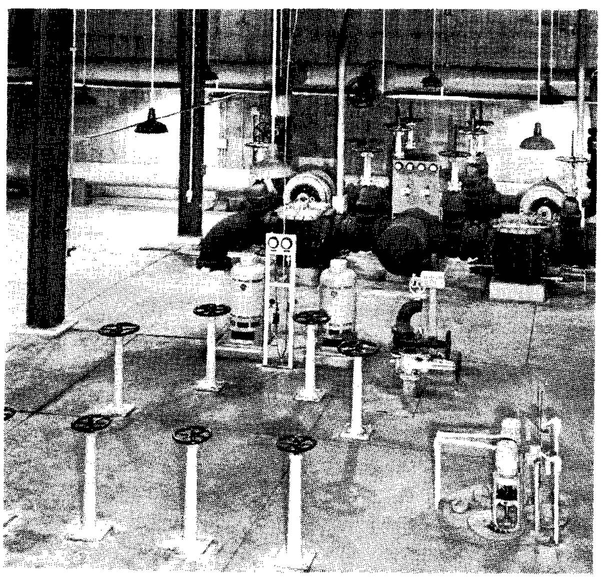


FIGURE 31.—*Station sump pumps (foreground) and raw water pumps, valves, and strainers between units 7 and 8.*

Compressed-air systems

There are two complete compressed-air systems designated as "Station Service Air" and "Control Air."

Five horizontal, 2-stage, motor-driven compressors supply the air for station service; two of these compressors with their accessory equipment are located in the basement at the north end of the powerhouse, a third in the utility building, and the other two in the basement of the powerhouse between units 8 and 9. This system is shown in exhibits 72 and 73.

A complete air compressor installation and piping system was provided to supply oil-free compressed air to all pneumatically operated instruments and controls throughout the powerhouse (exhibits 70 and 71). Reference to the control air diagrams and to the statistical summary will show the control air system and equipment as installed, together with pertinent data on capacities, and operating pressures.

Feedwater treatment systems

A primary system involves treatment of all water used in the feedwater system by filtering and softening to two parts per million hardness by a zeolite softening system. See "Water Treatment Plant," page 94, for details.

A diagram of the secondary system as given in exhibits 54 and 55 shows the piping connections for introducing the following chemicals:

1. Sodium hydroxide and morpholine are mixed and fed continuously into the discharge of the deaerator. Feed rates are adjusted to maintain a pH of between 8.8 and 9.1 in the condensate. The morpholine evaporates with the water and passes through the complete boiler and turbine system, condensing wherever the steam does to again protect all parts of the system by maintaining a high pH. The sodium hydroxide is not carried over but remains as a sludge in the boiler drum.

2. Hydrazine hydrate is also fed into the discharge of the deaerator. Its purpose is to react with any free oxygen which may have passed through the deaerator. The end products of this reaction are water and nitrogen.

3. Sodium phosphate is fed intermittently into the boiler drum to react with any hardness radicals which may be present to form a soft sludge instead of a hard scale.

The equipment consists of mixing and measuring tanks, solution storage tanks, and high-pressure low-capacity chemical feed pumps. This same equipment is used also to introduce miscellaneous auxiliary chemicals into the boiler during initial startup.

There are two feeding stations. The one for units 1-4 is located in the northeast corner of the turbine room basement north of unit 1. The one for units 5-9 is located between units 4 and 5 on the east wall of the basement. The chemical dissolving tanks are located on the elevation 744 floor directly above.

The use of the boiler feedwater dosed with both sodium hydroxide and morpholine in the boiler feedwater suction and used in the desuperheaters or attemporators allows solids from the reaction of the caustic to enter the steam cycle. Tests at one or two units in each of the TVA plants indicated that the use of morpholine only in the feedwater will provide sufficient carry-over to the steam cycle to prevent solids contamination in the steam. Sodium hydroxide is used also for pH control but is now fed directly to the boiler drum by mixing it with the sodium phosphate instead of introducing it into the boiler feedwater. This method of internal treatment was adopted for all units. No changes were required in any of the mixing, storing, or feeding equipment.

Ash handling systems

Two separate systems are provided for ash removal. There is a bottom ash system which uses Hydroejectors to remove ash from the dry-bottom furnace and pyrites from the pulverizers. This system has a capacity of 50 tph. The fly ash system removes the fine ash from the mechanical collectors, the economizer section of the boilers, the dead spaces in the lower part of the furnace, and the boiler roof spaces. This Hydrovactor system has a capacity of 20 tph (exhibit 91).

Water for the ash sluice water systems is taken from the discharge culverts of the condenser circulating water system. The bottom ash sluice water system supplies water for the Jetpulsion pump, the high-pressure water jet of the pyrites system, and the boiler ash hopper nozzles. This system also supplies water through a reducing valve at 100 psi for operation of the vertical gates on the boiler ash hoppers. All valves in the system are manually operated except the shutoff valves for the sluice water pump discharge, pyrites, Hydrovactors, and the Hydroejectors. These are motor operated.

The fly ash sluice water system supplies water to the high-pressure water jet and also for removing dust from the coal bunker dust collectors. The fly ash sluice water system can also be used during emergency periods to supply water to the raw water service system and to the high-pressure fire-protection system. The flow diagrams for these systems are shown in exhibits 56 and 57.

Fire-protection system

In addition to the normal fire hose outlets shown in exhibit 84, a special fire-protection system is provided by connections to the ends of the fly ash sluice water header through pressure-reducing stations at each end of the boiler room basement. These stations have a capacity of 2000 gpm each and provide water for a header under the operating floor of the heater bay which serves four risers from the basement to the roof. Each riser is provided with two 2½-inch hose valves on the boiler and turbine room roofs and on each floor except the deaerator level.

Hose carts, equipped with 250 feet of 2½-inch hose, adjustable fog nozzles, and playpipes, are located on the operating floor and the basement floor at or near the risers; on the other floors, where outlets occur, one hose cart is located at each end of the building. The roofs are provided with 250-foot hoses, nozzles, and playpipes stored in weatherproof boxes adjacent to the hose valve outlets.

The turbine oil tanks, the seal oil tanks, and the area under the head end of the turbine are provided with permanently installed fog spray systems. The water for these systems is supplied from the fire control header through individual piston-operated check valves actuated by solenoid valves. Remote-control push-button stations activate the solenoids. Strategically located fire detectors sound an alarm if fire occurs.

Sampling systems

An important factor in chemical control involves sampling water and steam at various points in the cycle. The sampling points are of three kinds: steam condensate, boiler water, and miscellaneous. The steam condensate samples consist of saturated and superheated steam, evaporator vapor condensate, condensate from condenser, and feedwater at the outlet of the deaerator storage tank before the introduction of chemicals and at the boiler feed pump suction after the introduction of chemicals. The boiler water samples consist of blowdown from the steam drum, water wall headers, and the evaporator. The miscellaneous group, composed of continuous blowdown tank vapor condensate, condensate entering the deaerator, and the No. 3 heater drain, are not connected at the sampling stations and are used only during special tests.

The sampling stations were located as close as possible to the points of sampling and on floors accessible with a sampling cart. Each sampling station consists of one or more cooling coils, a drain basin, and the necessary valves for controlling flow of the sample and the cooling water. In addition, the saturated steam and the evaporator vapor condensate sampling stations are provided with conductivity recorder cells on the outlet of the cooling coils. The sampling station for the boiler feedwater at the boiler feed pumps has a pH recorder cell on the outlet of the cooling coil. In these three sampling stations the cooling water to the coils is controlled by a temperature regulating valve.

Condenser circulating water piping

Water flows up into the separate condenser water boxes through 54-inch-diam connections for units 1-4 and 60-inch connections for units 5-9, through the fill slab over the intake culvert (exhibit 68). The connections are fitted with motor-operated butterfly valves and rubber expansion joints (fig. 19, page 45) and have 4-inch bypass valves and connections around the valves. The water leaves the condenser water boxes through similar connections into the discharge culvert, the motor-operated butterfly valves being used for throttling flow. Each condenser connection is equipped with drains and five instrument taps for recording temperatures and pressures. Permanently installed U-tube manometers are located across the inlet and outlet water boxes to determine pressure drop through the condenser.

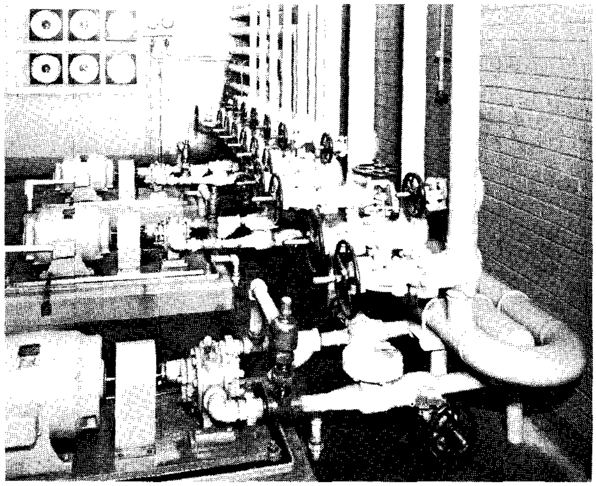


FIGURE 32.—*Fuel oil pumps provide oil used for initial firing of the steam generators prior to the introduction of pulverized coal.*

Oil systems

Lubricating oil—The four 4463-gallon turbine oil tanks for units 1-4, together with their continuous circulating equipment, are located on the elevation 744 floor adjacent to their respective turbine foundations. The five 5410-gallon tanks for units 5-9 are located on the basement floor.

The equipment for the lubricating oil system, other than the tanks, consists of portable and stationary purifiers, transfer pumps, two dirty-oil storage tanks equipped with electric heaters, two clean-oil tanks, and the piping system shown in exhibits 62 and 63. This equipment is located in the oil purification room at the north end of the turbine room on the elevation 744 floor. The lubricating oil storage room adjacent to the oil purification room contains one clean and one dirty-oil storage tank, having capacities of 4150 gallons, and clean and dirty-oil storage tanks each having a capacity of 2000 gallons.

Insulating oil—Approximately 225,000 gallons of oil are used in the transformers, oil circuit breakers, and neutral reactors located in the transformer yard and switchyard for the 9-unit plant. To condition this oil a purifiication system is installed (exhibits 66 and 67).

The dirty and clean insulating oil pumps and the insulating oil purifier are located in the oil purification room. The purifier is a stationary unit with a capacity of 1200 gph with or without the filter press. The dirty and clean insulating oil pumps are rated at 200 gpm at 30- and 75-psi discharge pressure, respectively.

There is one clean oil, one dirty transformer oil, and one dirty circuit breaker oil storage tank, each having a capacity of 12,500 gallons. These tanks are buried adjacent to the north end of the turbine room.

Fuel oil—The purpose of the fuel oil system is to provide oil for starting up the steam generating units and for ignition of the coal burners (exhibits 64 and 65). The oil is stored in four 12,500-gallon underground tanks adjacent to the insulating oil tanks. Three fuel oil pumps, each rated at 25 gpm against 240-psi pressure, are located in a room adjacent to the oil purification room (fig. 32).

From the distribution panel at each boiler, fuel oil and air are fed to the burners used during startup. Fuel oil to the main oil burners is maintained at approximately 200-pound pressure by a back pressure valve which relieves excess pressure through the 3-inch return header to the storage tanks. Air for atomizing and purging oil is fed from the station service air system at approximately 85-psi pressure. The flow of oil and air to the burners is controlled by hand.

The oil-ignition system for the burners consists of electrically ignited pilot torches, a control panel for each pilot torch, compressed-air supply, and a remote control station to permit operation of the torches either locally or from the control room.

Vacuum-cleaning system

A central system of vacuum cleaning is installed in the powerhouse. The two vacuum units each consist of a centrifugal-type vacuum producer, a primary separator of the centrifugal-type capable of separating 95 percent of the dust and dirt, and a secondary separator of the centrifugal filter bag combination-type capable of separating 99 percent of the dust and dirt. This equipment is centrally located in the boiler bay between units 2 and 3 and units 5 and 6 on the elevation 725 floor. A piping system connects this equipment to outlets installed at convenient locations throughout the powerhouse and service bay.

Station drainage

All powerhouse drains are discharged into the condenser cooling water discharge culverts, the yard drainage system, or the station sumps. There are five 9000-gallon station sumps, one located between each pair of turbines for units 1-8 and a separate one for unit 9. Each sump is emptied by two vertical, turbine-type, float-operated, 2000-gpm pumps located on the basement floor (fig. 31, page 52) and arranged to discharge into either of its unit discharge culverts.

For emergency service there is a portable gasoline-engine-driven pump, rated at 1425 gpm at 84-foot head. This pump is mounted on rubber-tired wheels and can be moved to any location where needed.

Unit piping systems

This plant was designed on a unit basis, and a contract was executed supplying shop fabrication, field erection, and testing the unit piping systems in their entirety. Piping and plumbing other than unit systems were designed, procured, and erected by TVA. Flow diagrams of the principal piping systems are shown in exhibits 39 and 40.

The unit piping systems are welded throughout with the exception of connections to certain equipment and valves where flanges were used to facilitate maintenance. Part of this piping is shown in figure 23, page 48. Backing rings of the same material as the pipe were used on all joints larger than 2½ inches.

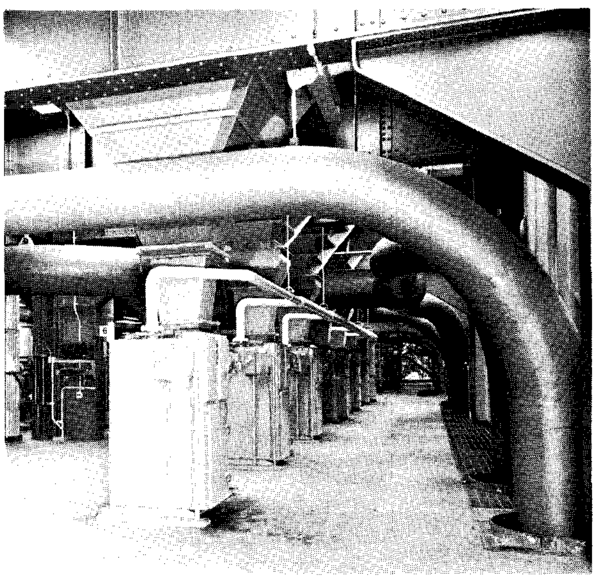


FIGURE 33.—*Unit 6 main steam lines, with an outside diameter of 17 inches and a wall thickness of 2.50 inches, are designed to carry steam at 1053°F under 1945 psi pressure. Coal scales are shown beneath the pipes.*

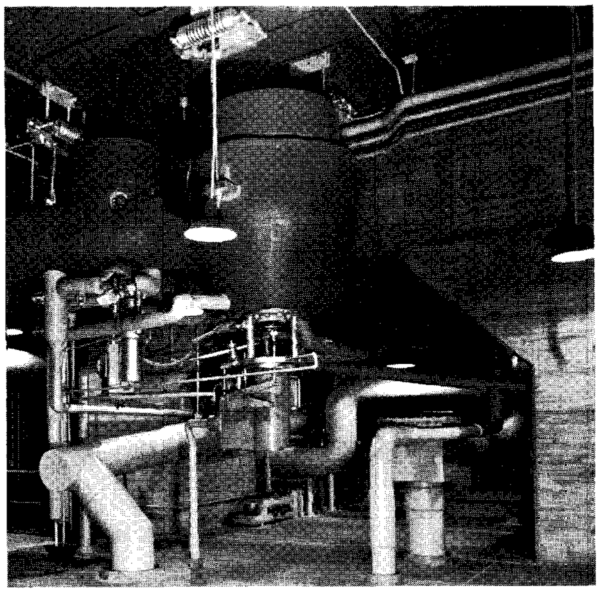


FIGURE 34.—*Reheat steam lines and interceptor valve—unit 6. The reheat steam lines to and from the turbines operate at 362 and 402 psi at 1053°F and 668°F respectively.*

Main steam—Piping for units 1-4 was designed for 1920 psig at 1003°F with throttle inlet at 1800 psig at 1000°F. The material specified was chromium-molybdenum steel containing 1¼ percent chrome and 0.5 percent molybdenum, the composition conforming to ASTM Specifications A158-50T, symbol P-11. The pipe was turned and bored from solid forged billets. A further qualification as a safety measure against graphitization was that the steel be silicon-killed, with any aluminum used to be limited to 0.50 pound maximum per ton of steel. The carbon was also limited to 0.10 percent maximum.

The steam line leaving the superheater has an outside diameter of 16.25 inches with a wall thickness of 2.375 inches and branches into two lines, each having an outside diameter of 13.50 inches and a wall thickness of 2 inches, as shown in exhibits 41 and 42.

Piping for units 5-9 was designed for 1945-psig pressure at 1053°F for throttle inlet conditions of 1815 psig at 1050°F. Views of the main steam and reheat steam piping are shown in figures 33 and 34. This piping was also forged and bored from solid billets but was specified to ASTM Specifications A335-52T, Symbol P-22, which is 2¼ percent chrome and 1 percent molybdenum. The same additional qualifications as for units 1-4 were specified. The steam line leaving the superheater header has an outside diameter of 17 inches with a wall thickness of 2.50 inches and branches into two lines, each having an outside diameter of 15.25 inches and a wall thickness of 2.375 inches. These lines are shown in exhibits 41 and 42.

Reheat steam—The operating conditions of the reheat piping to and from the turbine are 447 and 485 psig at 1003°F and 665°F respectively for units 1-4, and 362 and 402 psig at 1053°F and 668°F respectively for units 5-9. The material for the reheat steam piping to the turbine is alloy steel. For units 1-4 the pipe is 1¼ percent chrome and ½ percent molybdenum in accordance with ASTM Specifications A158-50T, symbol P-11, seamless pipe extruded from plate. The steam line leaving the reheat outlet header is 20-inch od schedule 80, and branches into two 16-inch od schedule 80 lines. For units 5-9 this pipe is 2¼ percent chrome, 1 percent molybdenum, in accordance with ASTM Specifications A155-52T, rolled and welded from plate. The steam line leaving the reheat outlet header has an outside diameter of 24 inches with a wall thickness of 1.00 inch and branches into two lines, each having an outside diameter of 18 inches and a wall thickness of 0.75 inch. The piping from the turbine to the reheat section is carbon steel ASTM Specifications A106, grade B. The reheat steam lines were equipped with emergency governor oil-operated swing trip valves in the lines before the intercept valves for safety purposes. Model tests were also performed on both the hot and cold reheat steam lines.

Extraction steam—This piping was designed to supply steam for boiler feedwater heating and evaporating makeup water with a minimum pressure loss and a minimum use of pressure controls, the flow depending upon heat transfer in the heaters and the load on the turbine.

Steam is extracted from the turbine at the sixteenth, twenty-first (high-pressure exhaust), thirtieth, thirty-sixth, thirty-eighth, fortieth, and forty-secondth stages for units 1-4 and the sixth, ninth (high-pressure exhaust), thirteenth, sixteenth, eighteenth, nineteenth, twenty-first, and twenty-secondth stages for units 5-9. Heaters 1 through 7 on units 1-4 and 1 through 8 on units 5-9 are supplied with steam from the extraction points listed above in the order of listing (exhibits 47 and 48).

All extraction steam pressures and temperatures, with the exception for Nos. 1 and 3 extractions of units 5-9, are within the allowable range for carbon steel, and pipe conforming to ASTM Specifications A106, grade B, was used. The pipe used for the exceptions noted above was alloy steel, 1¼ percent chrome, ½ percent molybdenum, conforming to ASTM Specifications A335-52T, symbol P-11.

The 6-inch piping to No. 1 heater on all units is schedule 80. Piping 10 inches in size and smaller for the other heaters is schedule 40, while piping larger than 10 inches in diam has ⅜-inch wall thickness.

After startup of units 1-4 the extraction temperature to No. 1 heater was found to be much higher than calculated and above the range of design for the heater. To remedy this condition the turbine manufacturer furnished a desuperheater for installation in this line after the steam leaves the turbine. Water for the desuperheater was supplied through a diaphragm-operated temperature control valve from the boiler feedwater pump discharge line.

Boiler feedwater—The pump discharge piping was designed in accordance with the "ASME Boiler Construction Code" and the "American Standard Code for Pressure Piping" where piping was within their respective jurisdictions.

The normal water temperatures leaving the No. 1 heaters are 491°F and 497°F for units 1-4 and 5-9, respectively. Boiler feedwater regulators were not installed and the flow is regulated by a 3-element control system through the fluid drive units of the boiler feed pumps. Scoop tubes vary the speed drives. This control is supplemented while starting and at low loads by use of a 3-inch motor-operated globe valve, with a parabolic throttling disc, to bypass the motor-operated gate valve in the feed line to the boilers. This valve can be operated either from the unit control room or locally. The flow diagrams are shown in exhibits 43 and 44. The pumps have a diaphragm control valve and pressure-reducing orifice to maintain enough flow at low loads to protect the pumps. Balancing drum leakoff lines and emergency leakoff lines are piped to the deaerator storage tank, and there are connections to drain the system to the distilled water storage tank.

The high-pressure heaters are equipped with a bypass line through a motor-operated 3-way valve to allow them to be removed from service if necessary without shutting down the unit.

Condensate—The units 5-9 condensate from the condenser hotwell is pumped through the gland steam condenser (fig. 35) and then through the steam jet

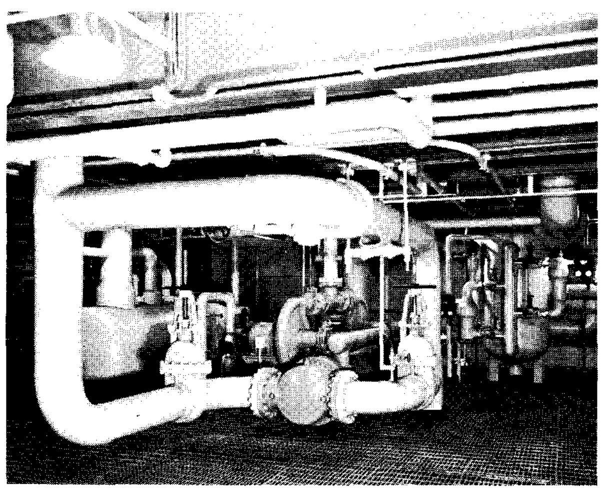


FIGURE 35.—*Unit 7 gland steam condenser and condensate piping. The condenser receives the condensate from the condenser hotwell.*

air pump. The units 1-4 condensate is pumped directly to the steam-jet air pump. It then passes through the low-pressure heaters to the deaerator. These heaters are also equipped with a bypass through a motor-operated 3-way valve (exhibits 45 and 46).

Miscellaneous piping at turbine—This piping system covers the leakoff piping and the drain piping for startup and normal operation of the turbine (exhibits 51, 52, and 53). All startup and warming lines subject to be operating below atmospheric pressure during startup are piped to the condenser. Drains for use after startup are trapped and piped to the condensate drain tank. Contaminated drains are piped to waste.

Heater drains and vents—This piping system includes the drains and vents from the high- and low-pressure heaters, deaerator, evaporator, evaporator preheater, and related equipment (exhibits 49 and 50).

The drains from each high-pressure heater are cascaded to the next lower pressure heater through diaphragm-operated valves activated by level controllers on their respective heaters, finally flashing into the deaerator. At low loads the drains from No. 2 heater are discharged through a diaphragm-operated valve directly into the deaerator. The shells of these heaters have relief valves which discharge to the atmosphere through the powerhouse roof. The air-removal vents are connected to the deaerator. Each vent is equipped with a V-port-type globe valve for throttling.

The evaporator preheater drains by gravity into the evaporator. The evaporator coil-drain is flashed to the deaerator through a diaphragm-operated valve which is actuated by a controller on the evaporator level control reservoir. Relief valves on the evaporator and deaerator are discharged to atmosphere.

On all units the drains from the No. 5 heater are flashed into the No. 6 heater flash tank through a diaphragm-operated valve; the drains from the No. 6 heater flow by gravity to this flash tank, and the tank is vented back to the heater to utilize the flashing steam; the drains are then piped to the Nos. 5 and 6 heater drain pump which discharges through a diaphragm-operated valve into the condensate system at the channel of No. 5 heater. On units 1-4 the No. 7 heater drains by gravity to its level control reservoir, then to the No. 7 heater drain pump which discharges through its diaphragm-operated valve to the channel of the No. 6 heater. On units 5-9, heaters Nos. 7 and 8, piping is similar to that of heaters 5 and 6 and discharge to the channel of the No. 7 heater. Air-removal vents of these heaters are connected to the condenser through individual V-port globe valves. Air-removal vents on the deaerator and evaporator preheater are discharged to atmosphere.

Diaphragm control valves are actuated pneumatically from torque-tube-type controllers located on the heater shells or the level control reservoirs.

Miscellaneous traps, drains, vents, etc.—Each boiler has a continuous blowdown system. Water is taken from the boiler drum and discharged into the continuous blowdown tank through a manually operated flow-control valve. The flashed steam is vented to the deaerator and the condensate is discharged into the condenser discharge culvert vent through a diaphragm-operated valve actuated by a level controller on the continuous blowdown tank. The bottom blowdown system is connected through tandem-type blowdown valves to a tank located in the boiler room basement. This tank also collects miscellaneous drains from the boiler and vents them through the roof. It is fitted with manually operated drain valves arranged to drain to the distilled water well or to waste as the operation dictates (exhibits 51 and 53).

To maintain a flow through the superheater and main steam line during startup, drain lines from the superheater header and the main steam lines are connected to a heat exchanger located on the basement floor. Discharge from the heat exchanger may be routed either to the distilled water well or to waste.

A condensate drain tank is located in the basement of the turbine room and is fitted with a loop-seal overflow connection to the distilled water well and a vent to the atmosphere through the boiler room roof. The discharge from this tank is normally pumped to the condensate system between the No. 5 heater and the deaerator or it may be bypassed to the cold wells. Drains from each of the extraction lines below the turbine are trapped and discharged to the condensate drain tank heating system returns and miscellaneous noncontaminated drains are also discharged into this tank.

Plumbing

Each unit control room is equipped with toilet facilities, a water cooler, and a kitchen unit consisting of a sink, electric surface units, an electric refrigerator, and storage cabinets.

Two toilet rooms for use of the operating personnel are located on the elevation 827 floor. Electric water coolers are installed at various locations throughout the powerhouse. Two service sinks are provided on each floor of the heater bay except at elevations 809 and 843 (exhibit 81).

Two 100-gallon and one 30-gallon capacity electric water heaters located on the elevation 744 floor supply all the hot water requirements for the plumbing system in the powerhouse. Because of the long distances of the various outlets from the water heaters and the intermittent use, it was necessary to install circulating water pumps. An immersion thermostat, installed in the return line near the water heater, starts the pump whenever the water temperature falls 10 degrees below the desired temperature.

Elevators

There are five elevators to serve the powerhouse. Operators' elevators are located between units 2 and 3 and units 6 and 7, utility elevators between units 4 and 5 and units 8 and 9, and a freight elevator at the unit 1 end of the powerhouse.

Operators' elevators—The two operators' elevators are identical automatic electric traction types having a rated live-load capacity of 1500 pounds (exclusive of car, cables, and equipment) at a rated speed of 300 fpm. Travel extends from the basement floor at elevation 725 to elevation 843, a total lift of 118 feet, serving seven landings and openings which are located at elevations 725, 744, 765, 793, 809, 827, and 843. The machinery rooms are located at elevation 859.33.

The car platform area is approximately 40 sq ft for each elevator. Control of both elevators is collective automatic designed for push-button operation with a motor-generator and 250-v d-c variable voltage control equipment.

The hoist machines are single worm-geared-traction-type consisting of an electric motor direct-connected through a worm gear to a driving sheave with brake, bearings, and accessory devices. Worm and worm gear are sealed in a bath of oil.

Utility elevators—Two automatic electric traction-type utility elevators, having a rated live-load capacity of 2000 pounds at a rated speed of 200 fpm, were installed for general purpose maintenance service. The travel distance is the same as that for the operators' elevators. The car platform area is approximately 46 sq ft. Hoisting and control equipment is similar to that described for the operators' elevators.

Freight elevator—The freight elevator is the automatic electric traction-type having a rated live-load capacity of 10,000 pounds at a rated speed of 75 fpm. Travel distance is also the same as that for the operators' elevators, but the car serves nine landings which are located at elevations 725, 744, 751, 765, 779, 793, 809, 827, and 843. The machinery room is located at elevation 860.58. The car platform area is approximately 76 sq ft. The hoisting and electrical equipment for the freight elevator is basically similar to that of both the utility and operators elevators.

Testing—After each elevator was installed a runaway test was performed. This test consisted of inserting a resistance in the motor field and running the elevator loaded with sacks of cement down from the top landing at sufficient speed to cause normal action of the overspeed governor and all safety devices. A tachometer was used to establish the car speed at the time the electric cutoff switches opened and the safety jaws set on the governor rope.

Unit control boards, control and metering equipment

Basic design requirements which determine the final layout of unit control rooms, control boards, and instrument locations were essentially the same as those governing the layout of similar equipment at the Johnsonville and Widows Creek Steam Plants. Control boards follow the curved layout pattern of Widows Creek. Control equipment was provided on a unit basis. Control rooms contain equipment for two adjacent units as pictured in figures 36 and 37, except in the case of unit 9 which is only half the size of the other control rooms.

Control boards—The Republic Flow Meters Company supplied all control boards except those for turbine seal and generator hydrogen control for units 1-4 which were furnished by the turbogenerator manufacturer. The principal instruments and controls for the combustion and feedwater systems were also supplied by the Republic Flow Meters Company although they were not in every case Republic products.

Superheat and reheat controls—Superheat and reheat temperature control equipment (exhibits 85 and 86) was furnished by the boiler contractor. Equipment consists of Leeds and Northrup Company's recording controllers, model-S Speedomax-type G, together with switches and drive units, for control of desuperheating water supply valves and burner tilt.

Superheat temperature for units 1-4 is controlled by means of two desuperheater water supply valves

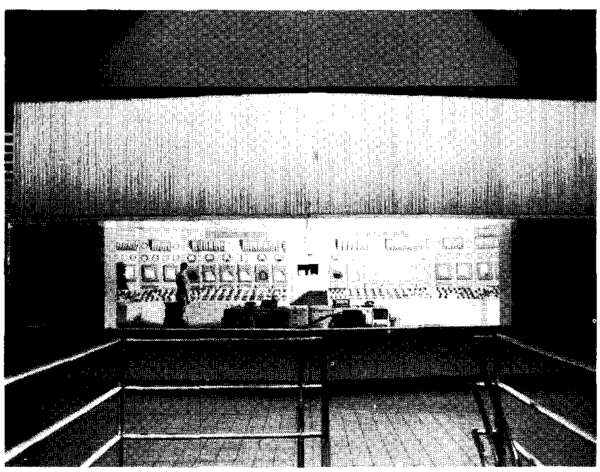


FIGURE 36.—*Looking from the turbogenerator room into the mechanical control room for units 1 and 2. There are five of these rooms from which the nine units are controlled.*

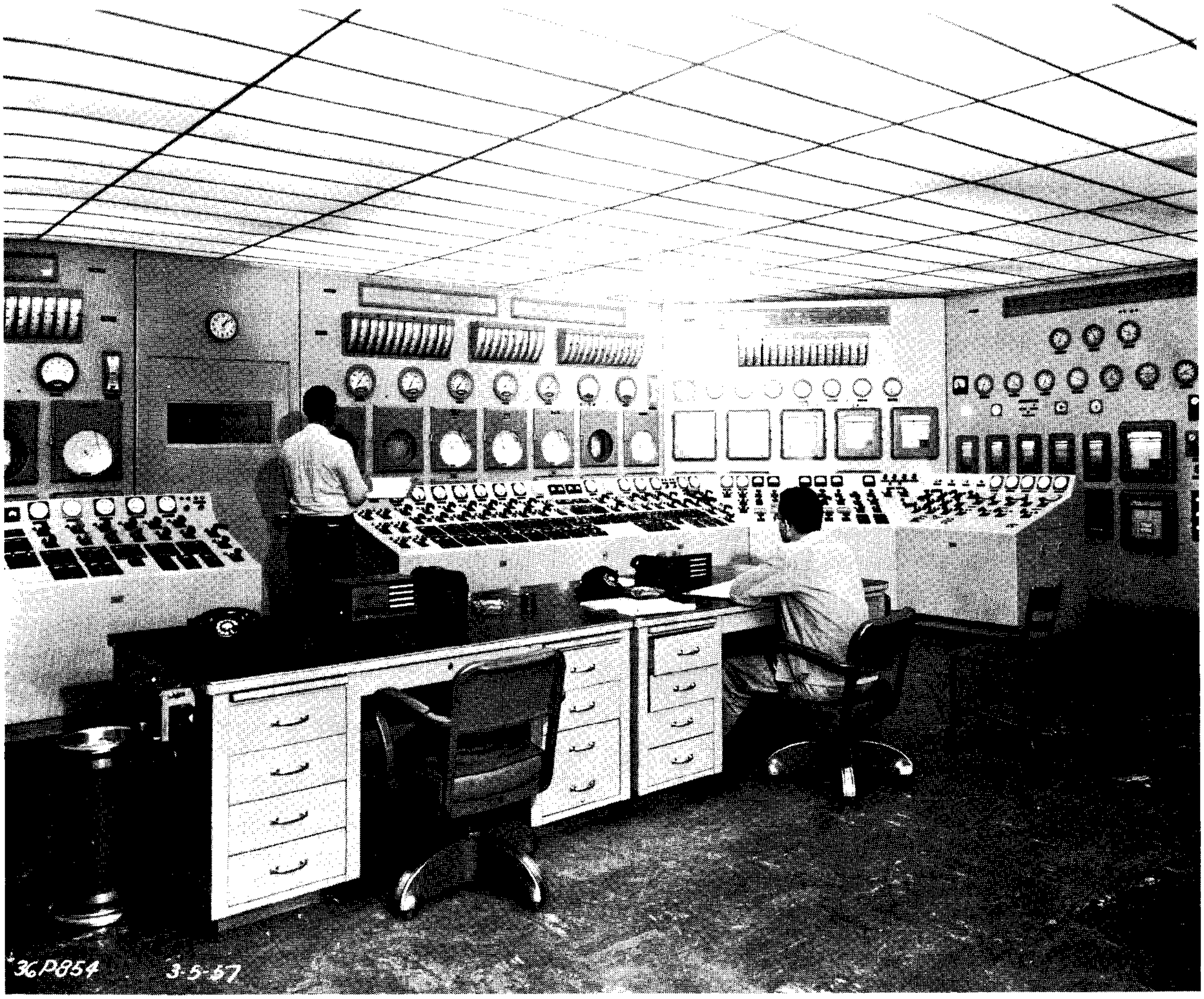


FIGURE 37.—*Units 7 and 8 mechanical control room. The five control rooms and control boards at Kingston were designed for the maximum practical amount of automatic control and supervision in order to keep the number of operators to a minimum. An arrangement of instruments was developed which provided convenience for the operators, while fulfilling the technical control requirements, in a control center of attractive appearance.*

positioned together by and opening on increase of main steam header temperature above 1003°F (± 10 degrees) at the superheater outlet. Manual bias of the two valves is provided and also provision for full closure from temperature regardless of bias.

Reheat temperature for units 1-4 is controlled by tilting burners and two desuperheater water supply valves. Temperature increase above 1003°F (± 10 degrees) at the reheat outlet causes burners to lower. The water valves open only after the burners have reached their low limit. Transfer of control from burners to valves and vice versa is automatic. Manual bias of the two valves is provided and also provision for full closure of both valves from temperature regardless of bias. Transfer to burners will not occur until both valves are fully closed.

Each of the above types of controls will respond to its respective air flow element for repositioning of the burners or valves when boiler air flow changes. This repositioning is in addition to the response of each control type to its respective steam temperature.

For units 5-9 the superheat and reheat steam temperature controls maintain temperatures at 1053°F (± 10 degrees). Controls are essentially the same as for units 1-4 except that these units have one superheat furnace and one reheat furnace per unit, and control systems operate tilting burners and desuperheater water supply valves for each furnace.

Combustion control—The combustion control equipment is pneumatic-electronic automatic-type for each boiler (exhibits 87 and 88). Controls and equipment are arranged to regulate fuel and air input to the furnaces in accordance with the load as indicated by changes in steam header pressure. The control system for units 5-9, due to twin-furnace design, will also equalize or bias air flow to the two furnaces, adjust fuel to each furnace to maintain equal excess air in each furnace, and maintain the same furnace draft in the reheat furnaces as in the superheat furnace. This entire system may be controlled from the impulse generated in the master regulator operating from steam pressure or controlled manually from the control board.

Boiler feedwater control—The feedwater control equipment is pneumatic-electronic-type, 3-element, automatic for each boiler as diagrammed in exhibits 89 and 90.

Metering equipment—Metering equipment is installed for main and reheat steam, boiler feedwater, desuperheating water, condensate, heater drain, and evaporator preheater makeup water flows. The main steam and boiler feedwater flowmeters are recording controllers. Metering equipment added later consists of equipment for indicating and recording building heating steam flows for units 1-4 and for gland leakoff water flows from the boiler circulating pumps on units 5-9. Hydrazine flow indicators and supervisory megawatt meters (showing generator load) were added for each unit, and additional annunciators were added for units 5-9.

Temperature and pressure recorders—There are recorders for accumulating the same type of data as that recorded at the Johnsonville Steam Plant plus turbogenerator bearing temperature recorders for units 5-9. Recorders for boiler drum and turbine metal temperatures were added later to monitor critical metal temperatures during startup and shutdown of units to keep this time to a minimum. Recorders were also added on units 1-4 for turbogenerators bearing temperatures which were originally located on the scanner-recorder.

Miscellaneous controls, indicators, and annunciators—Miscellaneous instruments and controls mounted on the vertical and bench boards consist of: recorders; indicating pressure gauges; receiver-type gauges; multipointer gauges; 50-point indicators; push-button switches; position indicators; voltmeters; ammeters; control switches; pneumatic-selector valves; indicating lights; annunciators; coal-scale counters and bypass push-button switches; drum and reheater outlet-pressure gauges; soot-blower controls; control equipment for burner tilt and desuperheating water valves; controllers for power-control valves; all turbine supervisory instruments, including the hydrogen and turbine-seal control instruments; selector valves for pneumatically operated diaphragm valves in the gland-seal steam supply and seal-unloading valve bypass lines; and level indicators for boiler drums and for heater-drain controls. These instruments are described more fully in Appendix B, "Statistical Summary."

Instrument piping—Pipe and tubing were both used for connecting the instruments and controls. Steel pipe was used for the control-air system to the heater drains, level, overflow, and pressure controllers. Tubing from instruments to equipment and control points was run in groups or bundles of lines to facilitate support and clearance.

Heating, ventilating, and air conditioning

Air conditioning is provided for the control rooms and for the shift engineer's office. The remaining spaces are ventilated and partially heated. A dust-collecting system is used in the coal conveyor gallery, at coal transfer points, and inside the coal scale housings.

Heating—The powerhouse is heated by steam supplemented by portable electric heaters and, during periods of power generation, by heat dissipated from the equipment. The steam heating is divided into two systems—one for preheating the outside air supplied to the plant and the other for space- or spot-heating within the building.

The air-preheating system consists of a separate system for each main boiler-turbine unit. During unit operation, outside air enters the building flowing through heating coils, ventilating all the powerhouse except the turbine room and coal conveyor gallery before ultimately reaching the forced-draft fans. Steam for this system is taken from the main boiler drum and reduced in one stage to 50 psig (exhibits 58 and 59). Before entering the blast coils the steam is reduced to a pressure of 0 to 15 psig. Each unit air-preheating system for units 1-4 is designed to heat approximately 290,000-cfm air through a 60-degree temperature rise, requiring approximately 23,700-pph steam.

Each unit air-preheating system for units 5-9 is designed to heat approximately 403,000-cfm air through a 60-degree temperature rise, requiring approximately 30,400-pph steam. The Btu's extracted from the main boiler are not all lost in this arrangement, inasmuch as warmer supply air to the forced-draft fans reflects in a higher supply air temperature to the boilers. During operation of all nine units the air-preheating systems require approximately 246,800-pph steam.

The building heating system is designed to supplement the heat dissipated from the main boilers and equipment to maintain a minimum of 60°F throughout the powerhouse when the outside temperature is 0°F. During periods of plant shutdown the system provides for a minimum of 40°F, when 0°F outside, to protect the equipment from freezing. For periods of plant shutdown, heat is supplied by two oil-fired, packaged, auxiliary heating boilers.

The turbine room is heated by blast coil and centrifugal fan assemblies that recirculate turbine room air during the heating season. Most spaces of the powerhouse are heated by standard blower-type unit heaters because of the flexibility of design, selection, and application. The control rooms and shift engineer's office are heated by thermostatically controlled steam blast heating coils located in the air-conditioning units and air duct systems serving these rooms. Approximately 17,000-pph steam is required for building heating.

A furnace heating system, for each boiler, consists of a centrifugal fan, steam-blast coil, and connecting ductwork to the main boiler air ducts. When the unit is shut down, heated air is blown into the boiler air ducts and into the furnace which absorbs moisture of condensation formed during the boiling of the furnace gases.

Each of the building heating system's auxiliary heating boilers is a 300-boiler-hp, double-pass, combination oil- or gas-fired steam generating unit having a rated capacity of 10,350-pph steam which may be extended by heavier firing to approximately 12,000-pph steam.

The condensate from the building heating system is collected in two flash tank and condensate receiver tank assemblies. The condensate collected in each flash tank is flashed to a 2-psig system, supplemented by steam reduced to 2 psig and delivered to standard low-pressure unit heaters located in the basement. The condensate collected in each receiver tank is automatically pumped to the auxiliary heating boilers when they are in operation. During plant operation the condensate is automatically pumped to any one or more of the unit condensate drain tanks in use. In order to heat remote points during extended maintenance or testing and to assure standby emergency heating in case of interruption of normal steam supply, portable electric heaters are supplied.

Ventilating systems—The powerhouse is ventilated for the removal of heat and the protection of the equipment, for the removal of heat from solar radiation, for the relief of dampness, and for satisfactory working conditions and safety of the operating personnel. The quantity of air to be supplied or exhausted is determined, in general, on a temperature-rise basis. Ventilation of isolated oil rooms and toilets is computed on a desired number of air changes per hour. During total plant operation, approximately 4,322,770 cfm air is supplied and approximately 4,090,000-cfm air is exhausted.

The boiler room, heater bay, and basement are ventilated during plant operation by the passage of air to the forced-draft fans. Fresh air is supplied under pressure by vaneaxial fans along the east wall and by vaneaxial fans and ducts along the west wall of the basement. Passing through the basement areas and up through gratings around the main boilers, the air is exhausted from near the roof of the boiler room through ducts to the forced-draft fans. Fresh air supplied to the heater bay operating areas is similarly exhausted. Boiler room roof ventilator exhaust fans are provided for ventilation when the unit is out of operation.

The turbine room is ventilated by air supply centrifugal fans located along the east wall of the room. This air is filtered by a number of banks of renewable media filters located in the ventilation gallery. Air is exhausted from the turbine room by two rows of fan-type, power roof ventilators. The air supplied is in excess to that exhausted to prevent infiltration from the adjoining boiler room and basement.

The battery rooms, elevator machinery rooms, oil rooms, and storage rooms are ventilated by supply or exhaust fans. A centrifugal fan supplies fresh air to the cable gallery.

Air-conditioning systems—The control rooms and shift engineer's office are air-conditioned for the protection of electrical equipment and to insure satisfactory working conditions. Packaged air-conditioning units for each room are complete with fresh air supply fan, air filters, cooling coil, heating coil, refrigerant compressor, water-cooled condenser, humidifier, safety devices, and controls. A separate fresh-air supply fan to the air-conditioning unit permits an equal portion of the return air to be exfiltrated from the control room, thus preventing infiltration of dust or heat from the adjoining boiler room or basement. A total of 70.5 tons of refrigeration is installed.

Dust-collecting systems—Dust-collecting systems remove coal dust from the coal conveyor gallery and the coal conveyor belt transfer points at the south end of the gallery. To eliminate dust in the coal conveyor gallery, dust-laden air is exhausted through the coal-tripper chuting to the bunkers from where it is conveyed to cyclone-type dust collector units. The units separate the dust from the air and the clean air is discharged to the outside. The coal conveyor belt transfer point housings are similarly exhausted by dust-collector units. The coal dust from these points is discharged to the main boiler ash-disposal system. Dust-collector units serve to exhaust air through the coal scale housings to prevent harmful corrosion of the weighing mechanisms when handling wet coal.

POWERHOUSE ELECTRICAL FEATURES

Generators

Each generator for units 1-4 has a nominal continuous rating of 150,000 kva, 135,000 kw, 0.9 pf, 0.5 psig H_2, 3 ph, 60 cps, 18,000 v, 3600 rpm, 4810 amp, 0.9 scr.

Each generator for units 5-9 has a nominal continuous rating of 200,000 kva, 180,000 kw, 0.9 pf, 15 psig H_2, 3 ph, 60 cps, 20,000 v, 3600 rpm, 5770 amp, 0.8 scr.

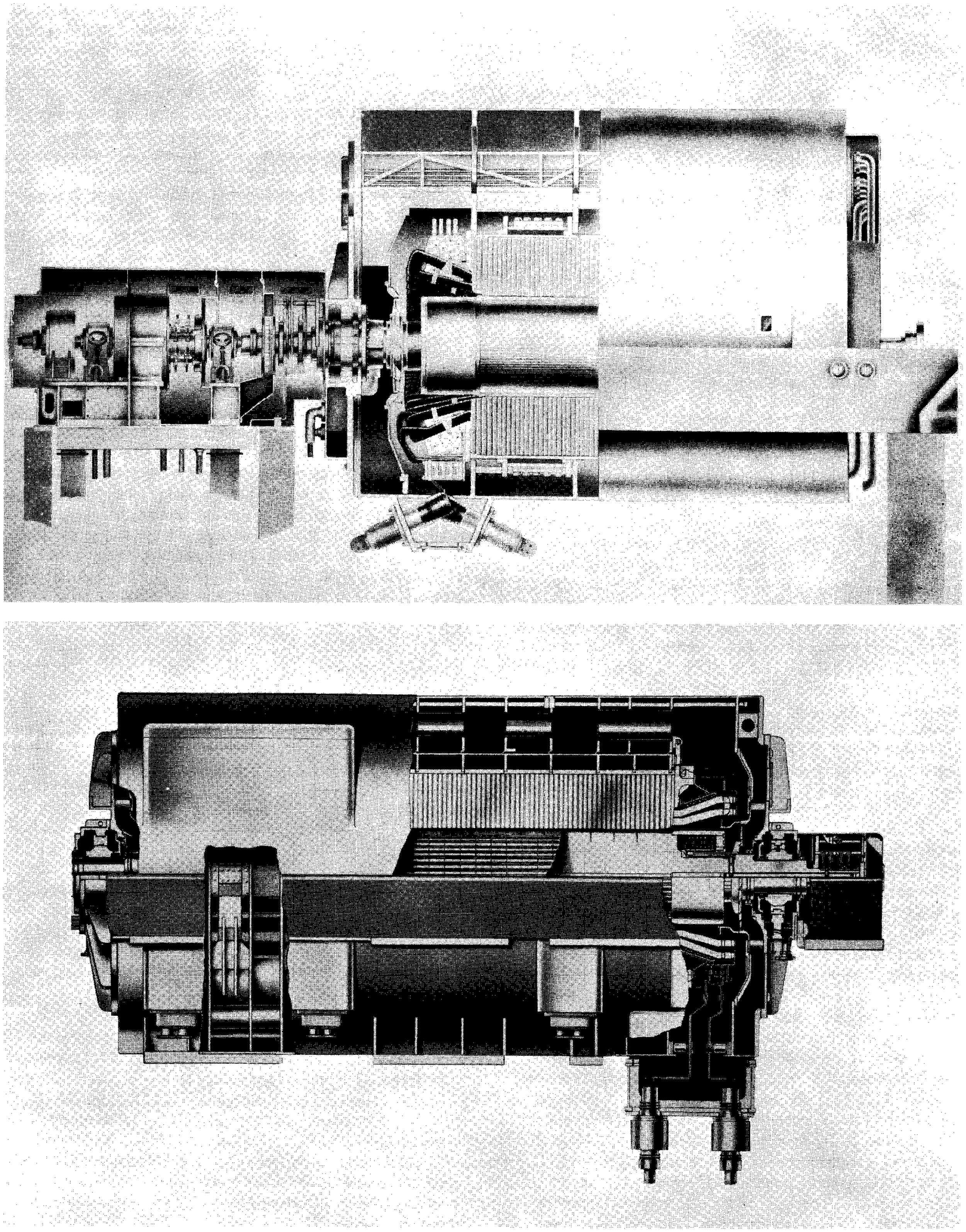


FIGURE 38.—*Cut-a-way of generator units. Westinghouse units 1-4 are illustrated at top; General Electric units 5-9 are illustrated at bottom.*

The generators for units 1-4 are Westinghouse machines and those for units 5-9 are General Electric. However, the principal design features of both machines are essentially the same. With the exceptions noted, the following section describes these features.

The stator frame consists of gastight cylindrical casing of welded plate construction sufficiently reinforced to withstand the force of a hydrogen-air explosion. The armature winding is formed by insulated bars assembled in the slots, joined at the ends to form coils, and connected in the proper phase belts by bus rings.

The armature connections are brought through the terminal boards by means of six porcelain bushings. Two current transformers are mounted on each bushing. Temperature detectors are located between coils in each phase of the armature winding and between coils and bottom of coil slots to measure the temperature of the windings and core at points of highest normal temperature. Other detectors are located so as to measure the temperature of the gas entering and leaving the coolers. These detectors activate relays and temperature indicating and recording instruments.

The rotor consists of a single forging of alloy steel with longitudinal slots machined in the body to hold the field windings. Prior to machining, extensive tests were made to assure that the forging met the specifications for physical and metallurgical properties. The field coils are held in the slots against centrifugal force by steel wedges, both magnetic and nonmagnetic types, to secure proper flux distribution. Fans are assembled near the ends of the rotor with the entrance and discharge conditions of the hydrogen gas controlled by vanes and nozzles. Current is carried to the field winding through the collector rings which are connected to the field winding through insulated copper bars assembled in the drilled-out center of the rotor forging.

The generator is wye-connected, with the neutral bushings brought out, connected together, and grounded through a 75-kva (18,000-220-v for units 1-4; 20,000-220-v for units 5-9) distribution transformer. The 220-v secondary is loaded with a 0.27-ohm, 470-amp resistor for units 1-4, and a 0.25-ohm, 510-amp resistor for units 5-9. This method of grounding limits fault-to-ground current to a maximum of 9 amp and by means of a voltage relay provides sensitive fault detection. The neutral transformer and load resistor are mounted in a sheet metal cubicle and located beneath the neutral bushings.

Hydrogen cooling and hydrogen seal oil systems

The generator ventilating system for all units is self-contained, including gas coolers and fan blades mounted near each end of the rotor. Provision is made for maintaining the gas pressure and purity and for supplying cooling water and hydrogen seal and bearing lubricating oil (exhibit 83).

The hydrogen supply, as originally furnished by the generator manufacturer, was contained in commercial cylinders of 200-cu-ft capacity connected to a manifold located in the basement at the generator foundation. Under a fire-protection improvement program all hydrogen storage has been transferred to two outdoor tube-type trailers. A primary pressure-reducing station is located at each storage trailer; here the pressure is reduced from approximately 2000 to 100 psi. The hydrogen supply is piped underground to a secondary reducing manifold, for each two units. These junctions are located just outside the powerhouse. Duplicate pressure regulators and pneumatically operated valves for reducing to the pressure in the generator are located in control cabinets at these junctions. A 1-inch pipe from the respective control cabinets supplies the hydrogen to each generator. The control switch for operating the valve to admit hydrogen into the generator and the gauges for indicating the hydrogen pressure and purity in the generator are located in the unit control room.

Each generator has a 2½-inch vent pipe to the turbine room roof. The hydrogen can be evacuated by an electrically operated dump valve. In case of fire or any other emergency around a unit the dump valve can be opened the instant the turbine stop button is operated. This will reduce the hydrogen pressure in the generator from 15 to ½ psig in approximately 3 minutes. At the reduced pressure there would be no explosion problem.

Carbon dioxide is used to remove the air or hydrogen from the generator. The gas is contained in commercial 50-pound cylinders, each connected to a manifold by a flexible hose through a valve located on top of each cylinder. The air in the generator must first be replaced by carbon dioxide to eliminate the possibility of an explosive mixture of air and hydrogen. Carbon dioxide is admitted through a manifold at the bottom of the generator housing, and air is discharged through a manifold from the top of the housing through a vent pipe to atmosphere. Approximately 1.5 volumes of carbon dioxide are required to replace the air with the rotor at standstill or on turning gear. Two volumes of carbon dioxide are required to replace the hydrogen at standstill or on turning gear. The correct concentration is determined by a density meter located on the hydrogen panel in the unit control room. Hydrogen is admitted through a manifold located in the top of the generator housing until the density meter indicates the correct concentration. Two and one-half volumes of hydrogen are required at standstill or on turning gear.

A gas drier is used to keep the generator core and windings as dry as possible. The pressure difference between the high- and low-pressure zones in the generator housing is sufficient to circulate gas through the drier at normal speed. The absorbent material is reactivated when it becomes saturated with moisture.

The escape of gas along the generator shaft is prevented by seals of oil under pressure. A pressure-regulating valve maintains a minimum differential pressure of 5 psi between the oil pressure at the seals and the gas pressure in the generator. The shaft seal oil absorbs hydrogen and air; therefore, before being reused it is passed through detraining and vacuum tanks to reduce the possibility of air and moisture being released to the generator housing. As a result the hydrogen purity in the generator is automatically maintained at a value almost equal to that of the hydrogen supply.

Exciters—units 1-4

Excitation for the generator is supplied by a main exciter and a pilot exciter. The main exciter is rated 350 kw and the pilot exciter at 3 kw. The exciters are connected to the generator main shaft through a flexible coupling and speed-reduction gear. The exciters are built as a separate unit, including the reduction gear and main generator collector-brush rigging. A shaft-driven blower rotating at 3600 rpm draws air in through filters in the sides of the base. The air is directed over the exciters and commutator and discharged through a muffler in the top of the housing. The main exciter is equipped with a motor-operated field rheostat; the pilot exciter is equipped with a manually operated field rheostat. The voltage regulator is a high-speed noncontinuously vibrating-type, responsive to average 3-ph voltage and equipped with high-speed response. A 2-panel excitation cubicle is located in the powerhouse adjacent to each unit.

Exciters—units 5-9

Excitation for the generator is supplied by a gear-driven main exciter connected to the end of the generator shaft through a flexible coupling. The exciter is built as a separate unit, containing the speed reduction gear, the generator field collector rings, and brush rigging, mounted on a separate base and enclosed in a housing containing its own ventilating system. The exciter motor-operated field rheostat and the amplidyne voltage regulating equipment are mounted in a 2-panel excitation cubicle located on the intermediate floor adjacent to the generator foundation.

When the generator voltage is higher than normal, the regulator will supply control field current to the amplidyne so the amplidyne voltage will "buck" the exciter voltage impressed across the exciter field. This will reduce the exciter field current, lower the exciter voltage, and decrease the generator field current and the terminal voltage.

When the generator terminal voltage is below normal, the regulator will supply field current to the amplidyne which will produce an amplidyne voltage to "boost" the exciter voltage impressed across the exciter field circuit. This will increase the exciter field current, raise the exciter voltage, increase the generator field current, and raise the generator terminal voltage to normal. The exciter is rated 500 kw for unit 5 and 550 kw for units 6-9.

Generator main connections

The unit system of connections is used. Each generator bus connects to the low-voltage terminals of a 3-ph power transformer without switching. The indoor section of the generator bus consists of two 10-inch aluminum channels per phase, welded construction. The bus is supported on 23-kv, post-type, extra-high-strength porcelain insulators, with a basic insulation level of 150 kv. The 3-ph generator bus is enclosed in a Transite housing with Transite barriers between phases. The housing is supported on an aluminum angle frame. Laminated flexible connectors are used at selected points to allow for expansion. The bus size is based on a temperature rise of 35°C over 40°C ambient. A tap off the main bus connects to two sets of potential transformers, each protected with fuses and current-limiting resistors, and to a 3-pole lightning arrester for surge protection. The housing enclosing this equipment is of similar construction to that of the bus housing. The indoor bus section terminates in porcelain bushings through the ventilation plenum roof.

The outdoor section of the generator bus, from the roof bushings to the low-voltage bushings of the main power transformer, consists of two 8-inch aluminum channels per phase, welded construction. The buses are supported on 23-kv, extra-high-strength, post-type porcelain insulators with a basic insulation of 150 kv. The insulators are supported on a steel structure at a convenient height to connect to the main transformer low-voltage bushings.

An aluminum expanded-metal enclosure, supported on an aluminum angle frame, surrounds the 3-ph bus. The expanded-metal screen protects the buses from phase or ground faults caused by birds or flying debris, allows a bus size based on an open outdoor design, and permits normal rainfall to clean the insulators. Laminated copper flexible connections at each end of the outdoor section relieve the terminal bushings of stress due to bus expansion. Belleville spring washers are used at all bolted connections to maintain good contact pressure. A tap off the main bus, with a disconnecting link, drops down to the high-voltage bushings of the unit station service transformer.

Unit control rooms

In the unit control rooms the controls on the benchboard, the indicating and recording instruments, and annunciation on the vertical panels are largely for control and operation of the turbine, boiler, and associated auxiliaries. On one benchboard panel is mounted the mimic bus, control switches with indicating lights, and indicating instruments for the 4160-v station service transformer breaker, unit start buses 1 and 2, and bus tie breakers for the unit board.

Indicating lights show if the 480-v unit board is energized from the normal or emergency source. On one vertical panel is mounted the distribution air circuit breakers for 250- and 48-v d-c and 120-v a-c preferred and nonpreferred supply.

Motors

Most motors are the 3-ph, squirrel-cage, induction-type arranged for full-voltage start. Motors over 200 hp are rated at 4000 v; motors under 200 hp are rated 440 v except 115- or 230-v single-ph motors utilized for small fractional horsepower ratings. The 250-v d-c motors are limited to use on the turbine controls, the turbine emergency bearing, and the hydrogen seal oil pump drives. Normal-torque motors are used for most of the drives except that the high-torque-type is used for the coal belt conveyor, crusher, and pulverizer drives. Special consideration was given to the torque characteristics of the boiler-feed-pump motors. These pumps can be started with voltages as low as 75 percent of normal. The starting current was limited to that specified in the National Electrical Manufacturers Association's Standards for the 440-v motor and to 600 percent rated amperes for the 4000-v motor except that a higher value was permitted for the high-torque type. Motor enclosures of dripproof design were used generally. Splashproof protection was used, however, for pump-drive motors located in exposed areas. The totally enclosed design was used for conveyor, crusher, and pulverizer drives where dust is present and also for the outdoor condenser circulating-water pumps.

Auxiliary power supply and distribution

Operation of the plant is dependent upon motor-driven auxiliaries; so special attention was given to the design of the auxiliary power system. Studies were made of the regulation of the 4160-v system under various conditions of loading, motor starting, and bus transferring. Because of the increase in rating of units 5-9 which required a larger unit station service transformer than the first four units, it became necessary to install a reactor in common station service transformer circuit to the 4160-v common boards and in the common station service circuit to start-buses 1 and 2 so as not to exceed the breaker interrupting rating of 250,000 kva. This was the maximum-size breakers of this class available at the time.

The neutral leads of the 4160-v windings of the unit and common station service transformers are grounded through a 3-ohm, 800-amp resistor. This limits the ground fault current to a value which will give fast ground relay operation and will prevent damage to cables, motors, and equipment.

The unit system is used to supply auxiliary power under normal operation. The unit station service transformers for units 1-4 are rated at 9000 kva. The corresponding transformers for units 5-9 are rated at 12,000 kva. These transformers are outdoor type and tap the generator bus through disconnecting links. The secondary connections are shown in exhibit 5; figure 39 which shows the 4160- and 480-v unit auxiliary boards.

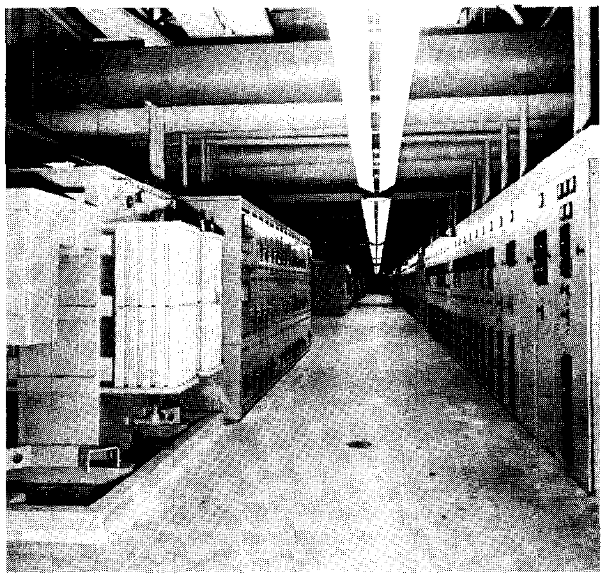


FIGURE 39.—*4160- and 480-v unit boards. Under normal operation this system is used to supply each unit's motor-driven auxiliaries.*

Electric motors rated 200 hp and over are supplied from the 4160-v boards. Smaller motors, electric heaters, and miscellaneous equipment are operated at 480-v, 3 ph, or 240/120 v, single ph.

The common station service system consists of two transformers rated 3 ph, 20,000 kva. Each transformer is supplied from a different bus section of the 161,000-v switchyard which is connected through 161,000-v transmission lines to other power stations and substations in the TVA system. This provides a reliable power supply for starting-up of units and supplies miscellaneous loads when the turbogenerators are out of service. The common station service system supplies power to all auxiliaries not directly required for unit operation, such as coal handling, ash disposal raw water supply, shops, oil purification, air conditioning, and lighting.

The 4160-v secondary connections for common station service transformer A are carried overhead outdoors and are enclosed in an expanded-metal aluminum housing, similar to the main transformer low-voltage connections. The leads enter the powerhouse through roof bushings. The indoor section to common board A is enclosed in a Transite housing with Transite barriers between phases. For common station service transformer B the 4160-v secondary buses are routed through the powerhouse control building cable tunnel to common board B. These buses are enclosed in a Transite housing with Transite barriers between phases.

Current-limiting reactors, metal-enclosed and built as part of the 4160-v common boards, are connected in the common station service transformer circuit before connecting through a 2000-amp air circuit breaker to common boards A and B and to start buses 1 and 2. Each reactor is rated 2000-amp, 4160-v, 48-v drop, with 2 percent reactance.

The two incoming feeder breakers to common boards A and B and tie breakers between boards are so interlocked that the common station service transformers cannot be paralleled. Common station service boards A and B are normally fed from separate common station service transformers with the bus-tie breakers open. In case of power failure, the bus affected is transferred automatically to the other transformer by closing the bus-tie breaker. When the preferred source is restored, an automatic transfer back to this source will take place.

Each common station service transformer, in addition to supplying the common station service load, also supplies power to one section of the unit-start bus. A connection from this bus supplies unit-start power to each 4160-v unit auxiliary board. Each common station service transformer is capable of supplying the common station service load and the starting load for one unit simultaneously.

All auxiliary power boards are totally enclosed, of steel cubicle construction, and equipped with air circuit breakers. The auxiliary boards are divided into groups, depending upon their voltage rating, current rating, and short-circuit requirements, and are located at approximate load centers.

The auxiliary boards can be divided into three classifications:

1. Metal-clad switchgear rated 4160 v, with electrically operated, removable air circuit breakers, rated 1200- and 2000-amp, 250,000-kva interrupting capacity.
2. Metal-enclosed switchgear rated 480 v, with electrically or manually operated drawout type air circuit breakers, rated 25,000- or 50,000-amp interrupting capacity.
3. Control centers rated 480 v, with molded-case air circuit breakers rated 15,000- or 25,000-amp interrupting capacity, combined with contactors where remote operation is required.

An automatic transfer of both sections of the 4160-v unit board to the common station service source will take place automatically if the voltage on the feeder from the unit station service transformer fails or if the generator or station service differential relays trip the unit. Return to normal supply is by manual control. The 4160-v unit board is fed from the common source during starting of a unit. After the generator is synchronized the unit board is transferred manually to the unit station service transformer. Before shutting down, the unit board is transferred manually to the common unit start bus.

The 4160-v air circuit breakers have two phase and one ground overcurrent induction-type relays for circuit protection. Motor circuits in addition are supervised by a thermal relay with characteristics similar to motor heating characteristics. In case of prolonged overload the thermal relay will operate an annunciator. A time-delay undervoltage relay will trip out all major motor circuits in case of prolonged bus voltage failure.

The metal-enclosed 480-v circuit breakers have thermal-magnetic trip for protection of the cable, and contactors with heater coils are provided for remote starting and protection of motors.

The normal feed for the 480-v unit board is taken from the 4160-v unit board through a 750-kva stepdown transformer. If this feeder fails, a voltage-actuated transfer to the 480-v common supply will take place automatically; an automatic transfer back to the normal source will occur when normal source voltage is restored.

Control batteries

Three 250-v station control batteries are provided in the powerhouse for the nine units. The battery rooms are centrally located; the battery distribution circuit breaker panels and motor-generator battery-charging control panels are located in an adjacent room. The charging motor-generator sets and the emergency motor-generator set are located outside each battery room. The battery is floated at 258 v across the output of a 30-kw diverter-pole motor-generator set. There are two spare charging sets for the three batteries which are so connected that a spare set can be connected to any battery. This dependable d-c supply is used for 4160- and 480-v circuit breaker operation, valve operation, control circuits, indicating lights, and during a-c power failure, for emergency lighting, generator hydrogen seal-oil pump, emergency bearing-oil pump, and operation of the 15-kw, 115-v a-c emergency supply to the preferred service bus.

Signals and annunciator system

An audible and visual annunciator system keeps the unit control room operators aware at all times of vital normal and abnormal operations and conditions of equipment. Associated signals are placed in groups of illuminated windows along the top of the vertical panels in each unit control room.

Paging and intercommunication systems

In addition to the telephone facilities described under the control building communication system, the powerhouse area has a paging system consisting of a microphone and control console on each unit control room desk, 250-watt amplifiers for each unit area, approximately twenty loudspeakers per unit, and approximately fourteen control stations per unit;

these loudspeakers and control stations are located at advantageous points throughout the unit areas.

This system enables the unit control room operators to page and give instructions to roving operators. The control console on each unit control room desk is arranged so that the operator can: (1) page over all loudspeakers in his own unit area, (2) page over all loudspeakers in his own unit area plus those in his associated adjacent unit area, (3) page over all loudspeakers in all unit areas, or (4) talk on a party-line basis to anyone at one of the control stations. The control stations can be used for talking on a party-line basis or for paging in their own unit areas.

An intercommunication system is provided for operating personnel. It consists of twelve master intercommunication sets—one on each of nine unit control room desks, in the shift engineer's office, in the water treatment building, and in the main electrical control room. Any station can call any other station on this system.

Cables, cable trays, and tunnels

The 4160-v auxiliary power circuits consist in part of buswork and otherwise of single-conductor cables. In dry areas and areas of high ambient temperatures, cables are rated 5000 v, with asbestos and varnished cambric insulation, metal shielding, and asbestos braid. Cables in damp or wet areas are rated 5000 v, with rubber ozone-resistant insulation, metal shielding, and rubber-like jacket.

The larger cable sizes are determined on the basis of current-carrying capacity. The maximum short circuit for the 4160-v system is 250,000 kva. No power cable smaller than No. 1/0 Awg. The size is adequate to prevent fusion of insulation and conductors at maximum short-circuit conditions for the period of time required for the appropriate relays to trip the circuit.

Cables for 480-v auxiliary power and the various control circuits are generally rated either 1000 v with asbestos and varnished cambric insulation and asbestos braid or 600 v with rubber ozone-resistant insulation and rubber-like jacket or plastic insulation, depending on the areas in which they are used.

Cable trays, 18 inches wide, made of asbestos cement are used extensively throughout the powerhouse where a number of cables converge in the same area, such as at the unit control rooms and auxiliary boards. Separation on trays of 480-v power circuits from control circuits is maintained throughout the plant. Except for runs on trays, cables are carried in rigid galvanized steel conduit.

A cable gallery, running longitudinally throughout the length of the powerhouse and consisting of asbestos-cement trays on steel supports, is used especially to carry power and control circuits to the water-treatment plant where the condenser-cooling water pumps are located. The gallery joins at the outside wall of the powerhouse with an underground, 78-inch id, precast concrete pipe tunnel which connects with the water treatment plant.

Another cable tunnel, built as an integral part of the powerhouse, runs the length of the turbogenerator room, just below grade, and outside of the powerhouse wall. This tunnel is connected to the main control building by two intersecting cable tunnels—one constructed of 78-inch-diam, precast concrete pipe and the other rectangular in shape of reinforced concrete. The latter tunnel houses a 4160-v common station service transformer bus in addition to power and control circuits. In the 161,000-v switchyard a cable tunnel, constructed from 84-inch precast concrete pipe, connects the yard with the control building. Asbestos-cement trays, on a 9-inch vertical spacing, are racked on both sides of the tunnels and carry all low-voltage cables for power and control.

Underground duct system

The wide dispersal of structures and load centers requires an extensive underground duct system with its necessary manholes to distribute power and control circuits. Standard asbestos-cement conduits encased in a concrete envelope are used throughout.

Grounding system

The main electrical grounding system is shown in exhibit 6. As tested by means of the fall of potential method, the ground resistance of the complete system was found to be 0.016 ohm. The top soil consists of yellow clay and the sub soil of weathered shale of various depths with scattered beds of limestone and siltstone throughout the formation. This type of subsoil has a relatively high resistance, but a satisfactorily low ground resistance was obtained by embedding the conductors in layers of rock-free clay.

The ground mat consists of 500-mcm bare copper cable buried in trenches, not less than 9 feet below finished grade. Wherever possible, advantage was taken of excavations for the powerhouse substructure, cable tunnels, and cooling water conduits; the cables were placed near the bottom of excavations and embedded in well-compacted clay. Generator and transformer neutrals, lightning arresters, overhead ground wires, mechanical and electrical equipment frames, building steel, yard structures, fences, railroad tracks, mechanical piping, and conduit work are all tied in with the grounding system.

Lighting

Lighting cabinets in the powerhouse are connected to the single-ph, 3-wire buses of the lighting switchboards through 2-pole air circuit breakers. Four lighting switchboards are installed for the powerhouse units 1-9. Each board has three separate bus sections, each bus section being fed by a single-phase, 167-kva, 480-240/120-v transformer with voltage regulator on the primary side. Distribution is by the usual mains, distribution cabinets, and branch circuits. Practically all lighting in the powerhouse is cabinet-switched. The illumination intensity varies, depending upon the utilization of the area. The intensity in nonworking areas is approximately 10 ft-c, in the turbine room 30 ft-c, and in the unit control room 75 ft-c.

Emergency lighting is supplied from the 250-v station control batteries and is placed at all vital locations, such as unit control rooms, generator rooms, and stairways. The emergency lights are so placed as to form a part of the normal lighting system.

Standard industrial lighting fixtures are used throughout the plant with vaporproof fixtures in the areas subjected to condensation. Fluorescent fixtures are used in the boiler room on the ground floor only, with refractor type glassware units in the turbine room; unit control rooms are lighted by cold cathode fluorescent tubes mounted above a continuous aluminum grid ceiling. Two sources of a-c supply in unit control rooms in addition to emergency d-c supply assure continuous lighting service.

Fire protection

The oil purification room, oil storage room, and lighting-off oil pump room have automatic carbon dioxide fire-extinguishing equipment. Each room has pipe headers equipped with discharge nozzles. The headers connect through routing valves to carbon dioxide cylinders. The control equipment is connected to discharge sufficient carbon dioxide in each room to extinguish a fire. Twenty 50-pound cylinders are installed for protection of the three rooms. Each room is equipped with 165°F thermostats which control the carbon dioxide discharge. Pressure switches on the header give annunciation and warning light indication, operate door and damper releases, and open holding circuits of oil pumps, purifier, and vent fans. Upon operation of a thermostat, annunciation is immediate, but discharge of carbon dioxide and closing of fire door are delayed 20 seconds by means of a time-delay pressure valve to allow time for personnel to leave the room. At the entrance to each room is an alarm bell, a break-glass type control station for manual operation, and a cutout switch with indicating lights for deenergizing the control circuit when any one is working in the room.

Liquid carbon dioxide, 15-pound portable-type fire extinguishers are conveniently located throughout the plant. Around the boilers in high-temperature areas 20-pound, dry-powder, carbon dioxide units are used. In the turbine room a 100-pound liquid carbon dioxide wheeled-type extinguisher is located between each two units at the generator end, and a 150-pound, dry-powder type for each two units at the turbine end. Raw water fire hydrants and hose racks, equipped with fog nozzles for use around electrical equipment, is available for general fire protection. A separate high-pressure water fire-protection system in the powerhouse is described in "Powerhouse Mechanical Features," page 53.

SERVICE BAY AND OFFICE WING

The service bay houses the maintenance shops and store room for equipment and repair parts. It has basement areas for storage of large mechanical and electrical equipment. A covered loading platform extends the full length of the building, adjacent to a rail siding and truck loading yard, facilitating handling of material and equipment into and out of the building. The 2-story office section contains spaces for the operating staff, laboratories, conference and assembly rooms, and accommodations for the visiting public (exhibits 35 and 36).

SUBSTRUCTURE

The substructure is a reinforced concrete box about 210 feet on a side. The basement floor, elevation 751, is 14 feet below the ground floor. The ground contours under the substructure varied from elevations 758 to 742 except adjacent to the powerhouse wall which extended down to elevation 715. Consequently, the depth of backfill varied up to 35 feet. In order that the differential settlements would be uniform and kept to a minimum in this broad lightweight substructure, the entire building area was excavated to elevation 740; the deep cut adjacent to the powerhouse wall was then backfilled to this elevation with river gravel and sand, and blanketed with a 12-inch sand filter. This material was thoroughly compacted by vibrators. Finally, beginning at elevation 740 a clay backfill of approximately 9 feet was placed in layers of 6 inches. The fill, of limestone residuum, was thoroughly compacted by sheepsfoot rollers. The structure rests directly on this fill, and has not experienced settlement of any consequence.

The basement floor is of beam-slab construction, having the beams running perpendicular to the powerhouse. The beams support the structural steel columns as well as the basement slab. The slab is designed to support a live load of 400 psf and to resist 6 feet of uplift due to a maximum flood condition. The basement walls are concrete and of a cantilever type doweled to the base slab. These walls extend up to grade level and support the exterior building columns and the main floor at elevation 765.

Initial shrinkage of the elements of the substructure due to cooling was controlled by locating construction joints in both slabs and walls 50 feet apart. With adequate shrinkage reinforcement in the concrete and a fairly constant room temperature during plant operation, the possibility of shrinkage cracks occurring following the construction period is small. For this reason contraction joints were omitted except at the junction with the north wall of the powerhouse.

SUPERSTRUCTURE

Architecture

The service bay and office wing are attached to the north end of the boiler room. In contrast to the powerhouse the functional design of the two portions is readily apparent. The 1-story shop area is masonry faced with buff-gray brick similar to the base of the powerhouse. This wall also encloses the lower story of the office section, the upper story being of aluminum window-wall construction having end walls of maroon Galbestos panels.

The exposed steel frame and trim are painted dark blue-green. The projecting canopy over the loading dock is supported by steel beams cantilevered from exposed steel wall columns (fig. 40).

The lighter, more graceful design and the use of materials for the office section well express its functions as compared to the massive powerhouse and utilitarian service bay. The lower story has aluminum framed windows of generous size, serving the individual offices which are shaded by a projecting canopy (fig. 41). The second-story front and rear walls are of aluminum window-wall construction with the two upper rows of panels glazed with blue-green heat-absorbing plate glass. The bottom row is of insulated steel panels with outer and inner faces of yellow porcelain enamel. The roof and end walls project to form a hooded shade for the glass wall. Fascia and trim are of steel painted deep blue-green.

Interior—The interior of the service bay is designed for efficiency and minimum maintenance. The structural steel and monorail system which serves all shops are painted blue-green. Floors in working areas are dark terra-cotta colored concrete while those in the storage areas are plain. Walls are unglazed facing tile and the underside of the exposed steel roof deck in the utility areas is painted off-white for good light reflection.

The office area has dark cedar terrazzo floors and bases in the corridors, toilets, and locker rooms, and gray marbleized rubber tile and steel base in the offices and work rooms. The offices have plastered

FIGURE 41.—*Service bay office wing. This 2-story wing contains offices and laboratories, and facilities for the visiting public.*

walls and acoustical tile ceilings. Door frames are pressed steel, and doors are wood, flush-type, natural finish birch.

An assembly room, with a seating capacity of about 200, is equipped for audiovisual demonstrations in connection with the various training courses and special group meetings (fig. 42). The room is about 28 feet wide by 46 feet long, with acoustical plastered suspended ceiling sloping down to the projection screen wall from a coved light trough at the entrance end of the room. Walls are walnut-veneered plywood, natural finish, with acoustical panels of perforated asbestos-cement board backed up with an insulating blanket. Doors are walnut veneer with frames and trim of red birch.

The entrance to the office spaces and visitors lobby is off a landscaped parking area. A broad

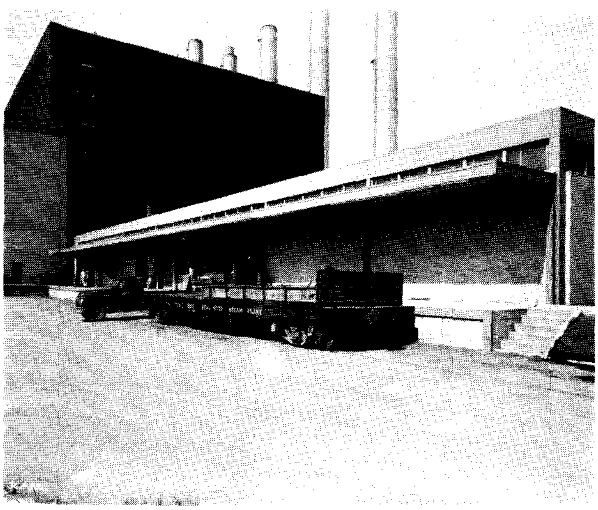


FIGURE 40.—*Powerhouse service bay loading dock. Adjacent rail siding and truck yard facilitates material handling.*

FIGURE 42.—*Assembly room in the service bay seats 200 and is equipped with audio and visual aids.*

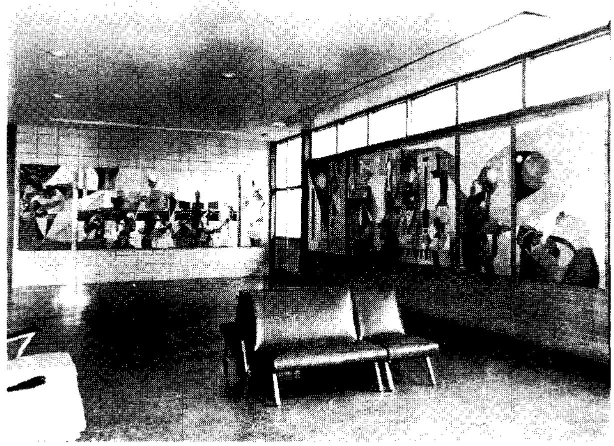


FIGURE 43.—*An attractive lobby is provided for visitors convenience. A colorful mural depicts TVA's role in the nuclear age.*

walk of dark cedar terrazzo leads through the large, glazed, aluminum entrance doors into a lobby with matching terrazzo floor, brick and glazed tile walls, and acoustical plaster ceiling. A stair of matching terrazzo leads to the second-floor visitors lounge, finished the same as the lobby. The stair well balustrade is formed of brick-faced planting boxes which add interest and informality.

The brick panel between the large windows of the front wall and the end wall panel are both occupied by a 6-foot-high 8-panel mural painted by a TVA staff artist. The mural, painted in vivid colors, depicts, in allegorical form, the role played by TVA power in the nuclear age and particularly in operations of the atomic industries at Oak Ridge for which the energy produced at Kingston is utilized. The lobby is shown in figure 43.

From the visitors lounge a corridor overlooking the boiler bay leads to an overlook balcony in the turbine room about 14 feet above the operating floor. Large double-glazed plate glass windows framed in aluminum extend along the outer wall of the corridor, affording a view of the boiler room. The overlook balcony (fig. 44) projects into the turbine room from the corridor and provides a clear view of the entire turbine room.

Structural steel

The service bay framing is the conventional beam and stringer-type with flat roofs. Standard structural sections are used throughout. Overhead crane runway girders and a system of monorail beams serve the shop areas.

Concrete floors

All floors above the basement are of concrete construction supported on steel framing in the same manner and with the same design assumptions as for the cast-in-place slabs in the powerhouse.

Three pieces of equipment—the boring mill, the metal shears, and the drop hammer—located in the machine shop at elevation 765 were too heavy to be carried by this slab. They are supported individually on heavy pedestals extending to the basement floor. A cork joint around the top of these pedestals at the 765 floor prevents vibrations from being transmitted to the rest of the superstructure. An additional piece of equipment—a metal lathe—rests on the slab, but a 31-foot-long supporting concrete wall extending to the basement floor was cast underneath it to prevent any possible differential settlement of the lathe supports.

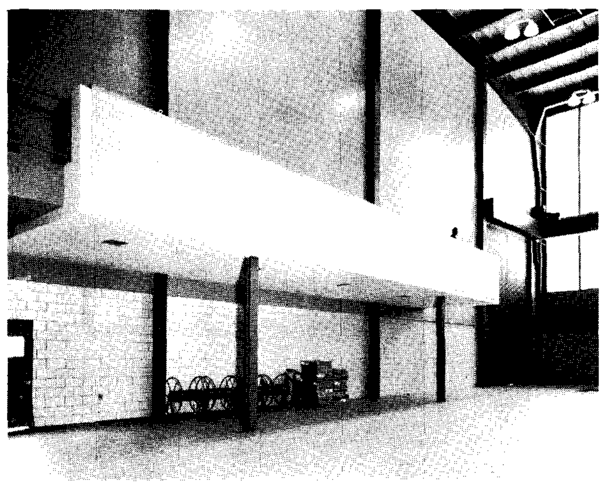


FIGURE 44.—*A visitors overlook balcony provides an unobstructed view of the turbogenerator room (see figure 7, page 22).*

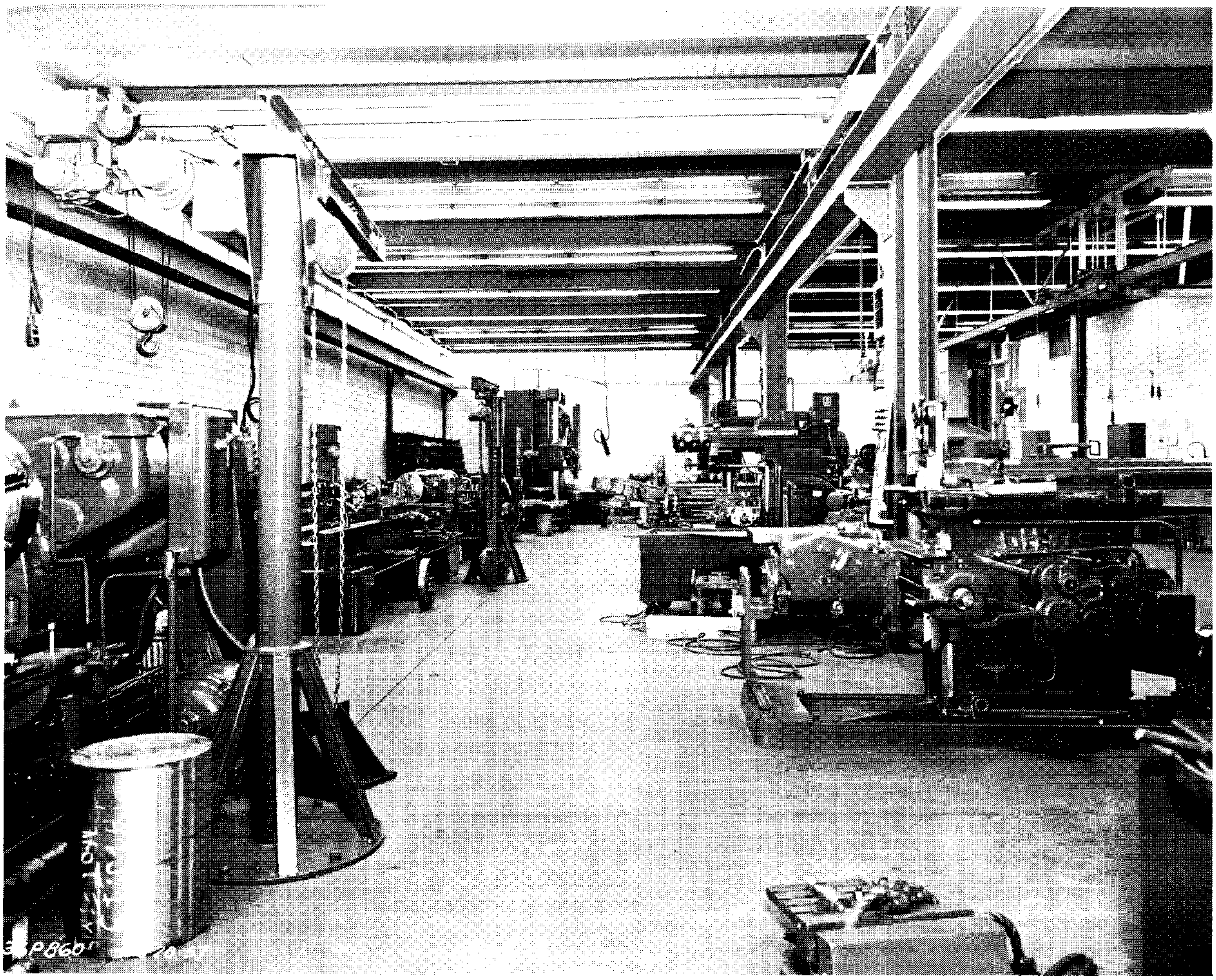


FIGURE 45.—*The service bay machine shop, one of six shops provided for the maintenance and repair of plant equipment.*

MECHANICAL FEATURES

Shops

On the basis of experience obtained by equipping Johnsonville and Widows Creek Steam Plants with machine tools and shop equipment, similar facilities were specified for the Kingston project. A tentative list of shop equipment and its attendant layout were developed from coordinated efforts of TVA's Divisions of Design and Power Operations. After a reasonable period of operating experience, a few additional items of equipment were added to complete the full effectiveness of each shop. A complete list of the equipment installed is given in Appendix B, "Statistical Summary."

The service bay shops are all located at ground level and are bounded by the loading platform equipped with a 2-ton jib crane. Monorail crane facilities are also installed from the loading platform through the machine, boilermaker, blacksmith, and welding shops, and into the boiler room. A storage elevator with an opening onto the loading platform facilitates access to the storage basement under the shops. The general arrangement of the shop equipment is shown in exhibit 36.

A centrally located tool room is convenient to all shops. Fire protection was accomplished by interspersing hose racks, cabinet, and CO_2 and carbon tetrachloride hand and pressure-type extinguishers throughout the shops. Shops and storage rooms containing or handling hazardous materials were provided with appropriate, independent, automatically operated, fire-protection systems. Each of the shops is provided with 1-inch air and water service hose connections and a-c and d-c service receptacles.

Machine shop—The floor area of the machine shop is 50 by 123 feet or approximately 6150 sq ft, and is divided into two longitudinal bays by a row of four interior steel columns (fig. 45). One bay is served by an overhead monorail and the other by a 5-ton overhead traveling crane. Movable jib cranes are supplied for use in connection with work handling at the large lathes and the hydraulic wheel press. An adjoining jig room serves the machine shop. The southwest corner of the machine shop contains a degreasing vat with an exhaust hood and is enclosed by a sheet-metal partition to form a welding booth 12 feet long and 10 feet wide.

Boilermaker, blacksmith, and welding shop—The floor area of this shop is 49 by 64 feet, and, like the machine shop, it is divided into two longitudinal bays by interior steel columns. The monorail traverses the shop both laterally and longitudinally, serving the metal-shear machine, the metal-bending roll-radial drill, bending brake, and welding booth. Hoods for removal of fumes were placed above the oil bath, the forge, and the welding booth. This shop was also supplied with a jig room.

Steamfitter shop—The steamfitter shop is divided into two rooms with a paint shop adjacent to both. The floor areas are approximately 1600 and 850 sq ft. There is an exhaust hood for the welding booth and a jig room for storage to serve this shop.

Electric shop—The electric shop has a floor area of approximately 2050 sq ft. The monorail traverses the electric shop longitudinally. Most of the equipment in this shop was designed and built by TVA.

Paint shop—The floor area of the paint shop is approximately 700 sq ft. The room is equipped with a thermostatically or manually actuated CO_2 fire-protection system. A space 9 by 11 feet at the southwest corner of the paint shop is completely enclosed and ventilated with filtered air to form a spray booth. This room has an independent CO_2 fire-protection system.

Carpenter shop—The area of this shop is approximately 800 sq ft. One longitudinal wall supports racks for storage of lumber. Workbenches and tool cabinets are arranged along the opposite wall, and all operating machines are located down the central part of the room. A bag-type dust collector is installed for the woodworking machines. Protection from fire is insured by an automatically operated water spray system.

Chemical and instrument laboratories—Approximately 1100 sq ft of area on the ground floor of the office section is allotted to laboratory facilities. The laboratories are equipped for making boiler feedwater and condensate analyses and for checking speeds, vibrations, pressures, temperatures, and other general plant tests. It is also equipped for the repair and maintenance of plant instruments and for making photographs.

Small tools and miscellaneous equipment

A sizable list of a variety of small tools, comprising over 900 items for use in all phases of plant work, repair, and maintenance, was compiled from coordinated lists of TVA's' Divisions of Design and Power Operations. The original list was supplemented after the plant obtained operating experience. The following general list indicates the principal small tools:

Warehouse wagon trucks, hand trucks, dollies, ladders, and wheelbarrows.
Tools for machinists, electricians, carpenters, welders, and mechanics.
Electric drills.
Pneumatic hammers.
Riveting hammers.
Electric masonry saws.
Bilge and manhole sump pumps.
Electric paint sprayers and mixers.
Power- and hand-type grease guns.
Oil pumps and tanks.
Hoists, scaffold-hoisting winches, service cans, buckets, and safety belts.
Hydraulic and screw jacks.
Portable arc welders, gas welding equipment, welding rods, regulators, and accessories.
Embossing presses and tape.

Plumbing

The plumbing system for the service bay and office wing includes toilet and shower facilities for all personnel employed in the service bay shops, laboratories, and offices. In addition, there are public toilets, service sinks, drinking fountains, laboratory facilities, a surgeon's scrub-up sink in the treatment room, and four kitchen units (exhibit 81).

Heating, ventilating, and air conditioning

Heating—The service bay and office wing are heated by steam, supplemented by portable electric heaters.

The air-conditioned spaces and main locker room of the office section are heated by thermostatically controlled steam plant heaters located in the air supply ducts to these rooms. Thermostatically controlled steam unit heaters serve the shops and rooms of the service bay including the mechanical equipment room. One of these units is shown in figure 46. Approximately 3360 pph of steam at 15 psi is supplied from the powerhouse building heating system for this service.

The heating facilities are designed to maintain a minimum of 72°F within the office spaces when the outside temperature is 0°F. The shops are heated to a minimum of 60°F.

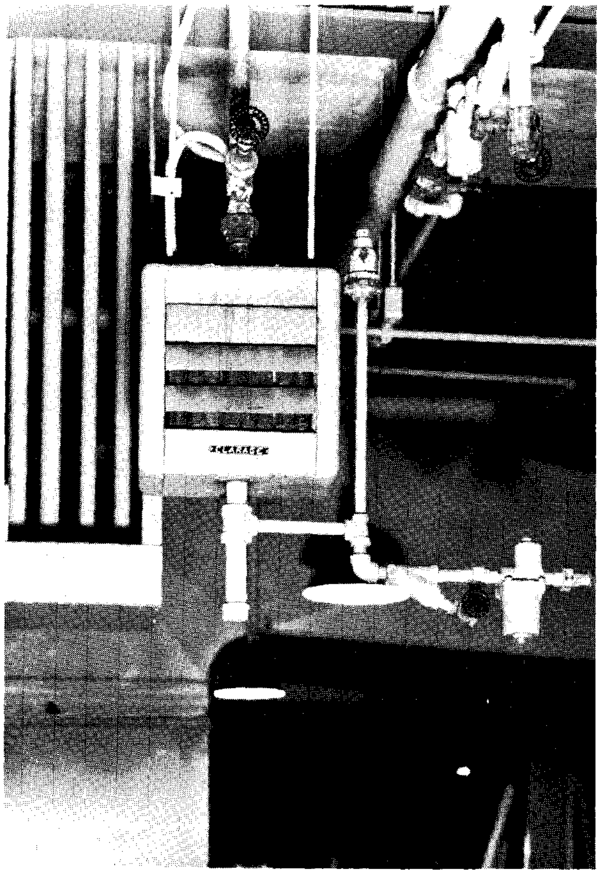


FIGURE 46.—*Thermostatically controlled steam unit heaters serve the non-air-conditioned spaces in the service bay and office wing.*

Ventilating—The service bay and office wing are ventilated for the removal of heat from electrical equipment or objectionable fumes. Air is supplied to and exhausted from shops and other rooms requiring ventilation through a sheet-metal duct system. Air is removed by either centrifugal- or roof-ventilator type fans. The centrifugal fans are generally grouped together for convenience of maintenance, and duct-connected to the spaces served. The air-conditioned spaces and main locker room are ventilated by a separate air supply system at times when neither heating nor cooling is required. For ventilation, 157,050 cfm of air is supplied, and 183,135 cfm of air is exhausted.

Air conditioning—The offices, public spaces, and assembly room are cooled and dehumidified, heated and humidified, or ventilated. A total of 109.37 tons of refrigeration is used. All the mechanical equipment is located in the northwest basement under the office spaces. For flexibility of control and due to type and timing of loads, three separate air-conditioning systems are employed. Each system consists of a supply fan, ductwork, air-distribution fixtures, and a plenum or chamber in which the air is mixed, filtered, cooled, humidified, and heated. Chilled water is used as the cooling medium and is stored in a horizontal insulated tank. The water is cooled by a central water-chilling system shown in figure 47. Cooling and heating is thermostatically controlled and is designed to produce a temperature of 78°F in the conditioned spaces until the outside temperature rises to 85°F. As the outside temperature continues to rise, the thermostats allow the inside temperature to rise to a point that when the outside air temperature reaches 100°F the inside temperature shall be 84°F. Thermostatic, volumetric damper control is provided for rooms served by a common supply duct system. The storekeeper's office in the service bay is served by a separate, self-contained, packaged air-conditioning unit. The main locker and toilet rooms in the service bay are partially cooled by an evaporative cooler located within the supply air system to these rooms.

Storage elevator

A plunger-electric, oil-hydraulic elevator for warehouse trucking and general plant use was installed just inside the east wall of the service bay. Capacity is 10,000 pounds at 30 fpm, and travel extends from the service bay basement floor elevation 751 to the ground level floor at elevation 765. The hydraulic pump unit and the control equipment are located in a machinery room at elevation 751 adjacent to the elevator shaft. Control is push-button

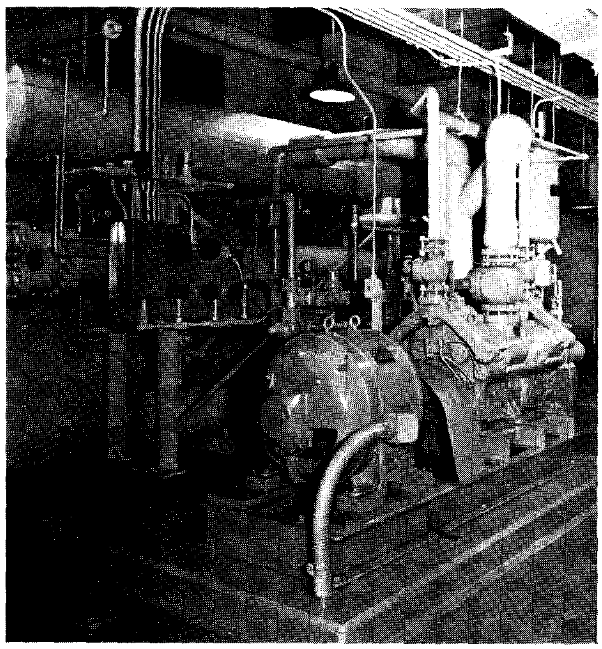


FIGURE 47.—*A central water chilling system in the service bay mechanical equipment room supplies 109.37 tons of refrigeration needed in the service bay and office wing.*

automatic. A 12¾-inch-diam steel cylinder is sunk into the ground beneath the center of the elevator platform for the elevator plunger.

Piping systems

Raw water—The raw water for the service bay is supplied by a 10-inch header from the powerhouse raw water system (exhibit 79) which also connects into the yard raw water system. This header supplies water to 18 fire hoses, 13 service water connections, and the air-conditioning equipment.

Domestic water—Domestic water for the office wing is supplied by a 3-inch pipeline and that for the service bay by a 1½-inch pipeline, both from the powerhouse (exhibit 81). A 1100-gallon-capacity hot water tank equipped with four 9-kw immersion heaters supplies most of the hot water requirements for the service bay and office wing. One small remote area is supplied with hot water from a 50-gallon electric water heater. A hot water distribution header forms a loop through the office section, and a circulating pump controlled by an immersion thermostat in the header ensures that hot water is available at all times.

Compressed air—The compressed air for the service bay is taken from the powerhouse service air system through two 3-inch headers and serves thirty-one 1-inch service outlets located throughout the shop areas and air-conditioning and ventilating equipment room. Air is also served to ten ½-inch outlets in the chemical and physical laboratories and instrument shop (exhibits 72 and 73).

Vacuum cleaning—The vacuum cleaning system in the service bay is connected to the central cleaning system in the powerhouse. Forty-three inlets are located in various places throughout the service bay and office wing.

ELECTRICAL FEATURES

Auxiliary power boards

The power requirements of the service bay and office wing are supplied by four auxiliary boards (exhibit 5). The service bay 480-v auxiliary power board is supplied by duplicate feeders from the powerhouse 480-v common board sections A and B. The incoming feeder breakers and bus-tie breaker are interlocked so the two incoming feeders cannot be paralleled. Each bus section is fed from its own incoming feeder with the bus-tie breaker open. In case of power supply failure, the affected bus will transfer automatically to the other bus section after an adjustable time delay. When the power supply returns, normal conditions will be restored automatically. The service bay ventilating board, air-conditioning board, and lighting and heating board are fed from this board.

The ventilating and air-conditioning boards are control-center type and furnish power to ventilating and air-conditioning equipment which serves the lobby, offices, shops, storage area, and related spaces. The air-conditioning equipment may be used for heating, cooling, or ventilating.

The lighting and heating board is divided into two sections. Each section is fed from a 100-kva, single-ph, 480-240/120-v transformer with an induction type voltage regulator on the primary side to maintain a constant and correct voltage on the lighting circuits.

Lighting

Lighting cabinets in the service bay and office wing are connected to the single-ph, 3-wire buses of the lighting switchboard. Distribution is by the usual mains, distribution cabinets, and branch circuits. Local switching is provided for shops, laboratories, and offices, with cabinet switching for storage areas.

Flourescent fixtures are used throughout the service bay and office wing except in the lobby and public areas where special fixtures were selected to harmonize with the architectural treatment.

The illumination intensity varies with the utilization of the area. The intensity in office areas is 50 to 60 ft-c, in storage areas 20 ft-c, and in machine shop areas 50 ft-c.

Fire protection

The lubricants storage room, paint shop, and paint spray booth have automatic CO_2 fire-extinguishing equipment. Each room has pipe headers equipped with discharge nozzles. Each header connects through routing valves to a bank of twelve 50-pound CO_2 cylinders. The paint spray booth has a supplementary bank of two cylinders. Each room is equipped with 165°F thermostats which initiate the CO_2 discharge. The control equipment is connected so as to discharge the correct number of cylinders in each room to provide sufficient concentration of CO_2 to extinguish the fire. Operation of the system will immediately initiate visual and audible signals, and after a time delay of 20 seconds, to permit personnel to leave the room, the fire door is released and CO_2 gas is discharged. Electrical circuits in the room are deenergized by pressure switches which release contactor holding coils on such equipment as dampers and supply exhaust fans. A break-glass-type control station for manual operation and a cutout switch for deenergizing the control circuits of the system when workmen are busy in the room are located near the entrance to each room.

Portable CO_2 and vaporizing liquid extinguishers are conveniently placed throughout the service bay and office wing.

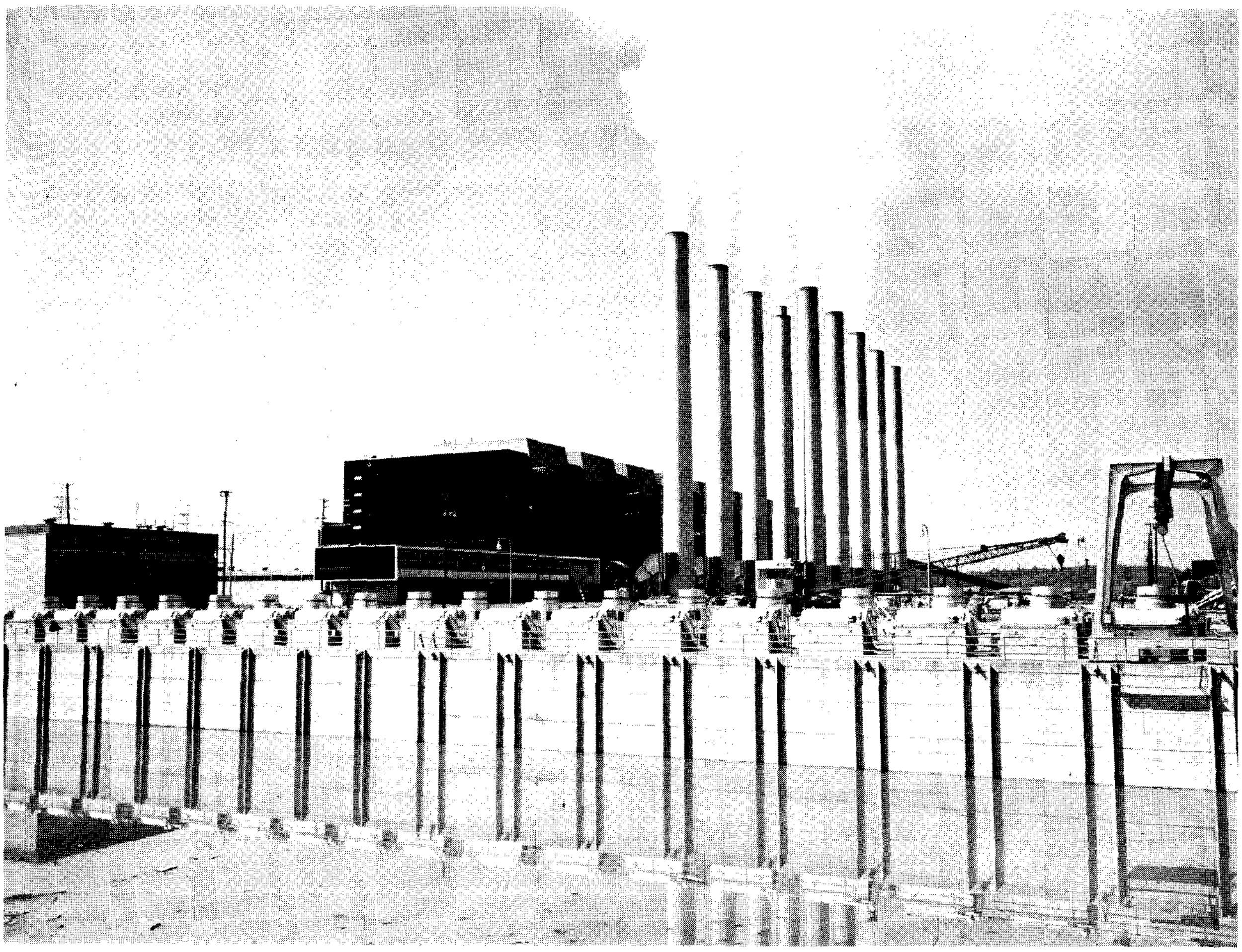


FIGURE 48.—*Intake structure and pumping station. The 18 circulating water pumps are capable of supplying over a million gallons per minute.*

Communication equipment

In addition to the normal telephone facilities the office spaces are equipped with 13 master intercommunication sets located in the superintendent's office and various other offices. Any station can call any other station on this system. An office key telephone system (Key-BX) is also provided for the offices of the superintendent, the clerk, and the receptionist. This Key-BX system has four circuits tied in with the local PAX telephone system and one common battery circuit connected to the manual telephone switchboard in the control building. The receptionist can pick up, answer, hold, and transfer calls on any of these circuits. Similar features are supplied for the other three offices.

A teletypewriter with a terminal in Chattanooga is located in the receptionist's office. The channel connecting the two terminals is via microwave radio.

CIRCULATING WATER SYSTEM

The structures composing the condenser circulating water system include: a combined intake structure and pumping station (fig. 48), a chlorination system, supply conduits between pump and condensers, condensers, discharge conduits between condensers and discharge structures, and the discharge structures. Water flows to the intake from the Emory embayment side of the plant site through an intake channel and is discharged to the Clinch embayment side of the plant site through the outlet channel.

The combined intake structure and pumping station is located north of the powerhouse and houses the equipment for screening debris from the condensing water and pumping it through the condensers (fig. 49). The intake structure also serves as the intake for all other raw water requirements of the

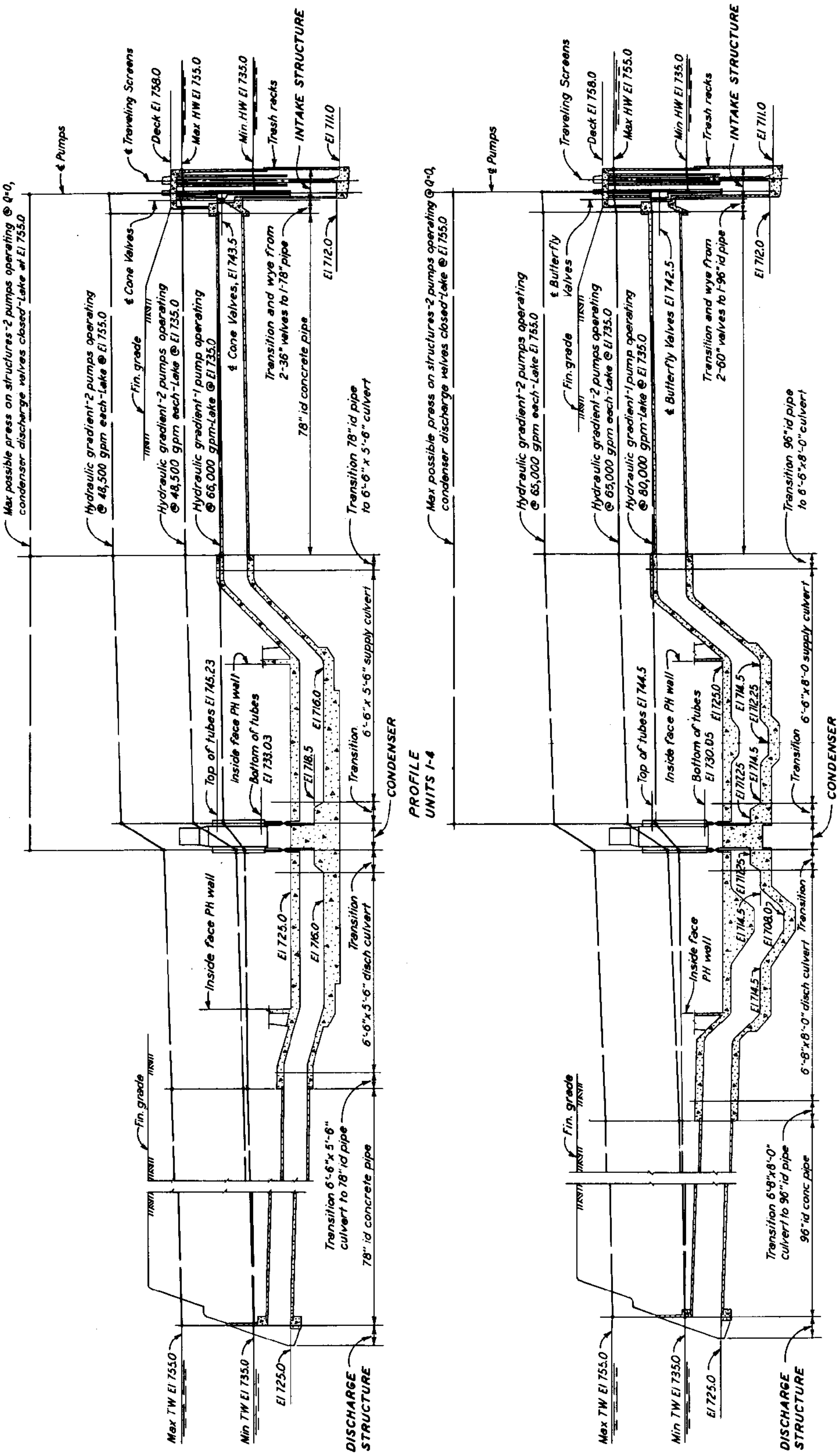


FIGURE 49.—*Condenser circulating water supply system. All heads are due to friction within the system since water is pumped to and from the same lake levels through a closed circuit.*

plant, such as cooling, fire protection, service, and supply for the water-treatment plant.

Each condenser circulating water pump is installed in a separate suction pit covered by a trashrack and traveling screen. The pumps for units 1-4 have 48-inch-diam discharge T's connected through reducers to 36-inch-diam hydraulically operated cone valves. From the cone valves the discharge lines of each pair of pumps are brought together through a wye connection to a 78-inch-diam concrete intake pipe through which the water flows to the powerhouse. The pumps for units 5-9 have 54-inch-diam discharge T's connected through increasers to 60-inch-diam hydraulically operated butterfly valves. From the butterfly valves the discharge lines of each pair of pumps are joined through a wye connection to a 96-inch-diam concrete intake pipe through which the water flows to the powerhouse. Within the powerhouse substructure the concrete pipe connects to a rectangular flume formed in the foundation. Immediately below the condensers each water passage divides into two 54-inch-diam vertical pipes for units 1-4 and 60-inch-diam pipes for units 5-9 flowing through motor-operated gate valves which direct half of the water to each side of the condensers. At the discharge end, piping similar to that on the inlet side conducts the water out through the substructure to the harbor. Motor-operated butterfly valves are used on the outlet side to permit throttling the flow for test purposes. Each of the square concrete discharge tunnels is equipped with a stoplog slot for unwatering purposes. All heads in the system are those due to friction inasmuch as the water is pumped from and to the same lake level through a closed system below siphon break limitations (exhibit 69).

Great care was taken in the hydraulic design of water passages in the system to keep friction losses as low as economically feasible. Velocities throughout the system were maintained at approximately 7 fps except at the reduced sections through the cone valves of units 1-4.

Design flows through the condensers

With an average summer water temperature of 75°F, each generating unit for units 1-4 will require 90,000 gpm to obtain a back pressure in the condenser not exceeding 2-inch Hg absolute, and units 5-9 will require 121,400 gpm under the same conditions. With one circulating pump per unit operating, enough cooling water would be pumped to operate at full-unit capacity at a back pressure of not over 3- to 1-inch Hg absolute at maximum river water temperature of 80°F. Thus, two pumps are normally in service, but in case of a breakdown one pump will provide sufficient water to keep the generating unit operating at full capacity but at a somewhat reduced efficiency. With the colder water available during the winter months, and both pumps operating, back pressures approach 0.5-inch Hg absolute. Under these conditions one pump can furnish enough water to produce full output of one unit at 2-inch Hg absolute back pressure. However, both pumps are operated continuously at design capacity under these conditions because the reduced back pressure produces far more power than is used by the second pump.

Normal and emergency operation

Between each pair of pump pits there are 8-foot-square sluice gates. In case of screen failure these gates may be opened and water obtained from the adjacent pump pits until repairs to the screens can be made. During this time pump efficiencies will be somewhat reduced due to turbulences in the pits, but continued operation of the generating units is possible. The sluice gates are hand-operated from floor stands mounted on the deck of the pumping station. Water enters the intake structure through trashracks consisting of vertical 5/8-inch-thick steel bars spaced so that the clear opening is 3 5/8 inches. The racks are cleaned by a rake operated by the intake gantry crane. The bottom of the screen-well curtain walls is below normal water level. This aids in maintaining stratification of the water, drawing it from the cooler lower depths, and seals the screen chamber from freezing weather. Following the trashracks the water passes through traveling screens having 3/8-inch mesh. Differential pressure gauges are provided to indicate the loss of head across each pair of racks. The loss of head is a measure of screen or rack cleanliness; when velocity through the racks drops to 0.543 fps for units 1-4 and 0.731 fps for units 5-9 the screens and/or racks should be cleaned. Debris collected on the screens is washed off into a sluice trench that extends the length of the pumping station deck and empties into a 27-inch concrete pipe which conveys the trash to the lake downstream from the intake channel.

Before starting a condenser circulating water pump, the system is filled with water to minimize hydraulic disturbances and prevent water hammer which might damage the conduits or condenser. One pump is started at a time. The pump motor and discharge valve are so interconnected that the valve will open as the pump starts to rotate. The valve is opened as slowly as possible in order to produce the least hydraulic disturbance in the system commensurate with pump motor overload. When the first pump of each unit is started the discharge head rises toward shutoff, but as the discharge valve slowly opens, the head drops to about 10 feet, corresponding to a flow of about 68,000 gpm for each of the pumps of units 1-4. For units 5-9 the head drops to about 12 feet, corresponding to a flow of about 80,000 gpm for each pump. The second pump of each unit is then started and its discharge valve opened. The discharge head rises to above the design point and then drops to a stabilized head of 21.5 feet, with a flow of 97,000 gpm for each pair of pumps for units 1-4. For units 5-9 the head drops to 21 feet, with a flow of 130,000 gpm for each pair of pumps. The pumps are also stopped individually. When the first pump is stopped, the pump motor and the discharge valve are so interconnected that the pump will start to decelerate and the valve close together. The closure time of the valve is set to prevent a surge of negative pressure in the condenser system, which will occur if closure is too rapid, and to prevent a reversal of flow through the pump from the second pump which will occur if the closure is too slow. When stopping the second pump, the discharge valve is left open until all flow in the system has ceased, after which it is closed manually.

INTAKE CHANNEL

The pumping station is located at the head of a 4500-foot-long intake channel, which extends to the original streambed of the Emory River in the Swan Pond embayment of Watts Bar Lake (exhibit 1). In order to obtain the cooler water from the bottom of the old streambed a skimmer wall was constructed at the river, and the flow of cooler water which comes under the wall remains separated from the lake in a channel formed by the construction of an earth dike about 3700 feet long running parallel to the lakeshore. To reduce the required length of the skimmer wall, dikes adjacent to each end of the wall were constructed of rock placed on a steep slope of about 1 on 1.35, and in order to restrict the flow of warm surface water through the voids in this rock, the zone between normal pool and maximum drawdown was filled with crushed stone graded from fines to 1-inch size. The dug portion of the intake channel adjacent to the pumping station was cut through earth and shale to a bottom elevation of 711 feet. The size of the ditch was such as to restrict the maximum velocity of the flow to about 3 fps.

Skimmer wall

During the summer season (April through October) the water in Watts Bar Lake in the area near the plant becomes thermally stratified with warm water of up to 90°F temperature near the surface and cooler down to 75°F or below toward the bottom. This stratification has some stability and will be maintained as long as the average velocity of the water is kept below 0.67 fps. With this cooler water available the design of the condensers was based on using water of 75°F maximum temperature and provide a means for supplying it to the condensers.

One scheme involved excavation of a channel of sufficient size to limit the maximum velocity of flow to about 0.5 fps, assuming all flow to be held below elevation 726 all the way to the pumping station. The cost of such an excavation was prohibitive, thus preventing the use of the scheme. Low-temperature water could, however, be obtained at reasonable cost by placing a skimmer wall at the old channel of the Emory River designed to pass only the cooler water into a separated channel leading to the pumping station.

Two types of skimmer walls were investigated—one a floating-type (similar to a floating boom used at Pickwick); the other a fixed skimmer wall supported on piers and with openings at the bottom. Either type of wall would allow only the cooler bottom water to pass through, provided the velocity of flow is held below 0.67 fps. The fixed-types costing less initially and requiring considerably less maintenance, were selected for the final design. The skimmer wall as constructed is shown in figure 50. There are five clear openings having an aggregate area of 3600 sq ft to pass the 1,000,000-gpm flow of cooling water required for the 9-unit plant.

The walls suspended between the piers are made up of two types of prestressed concrete beams, designated type A and type B, respectively. The type A beams are used in the upper portion of the wall, and each beam is designed to carry its full dead load plus a horizontal wave force of 250 psf. The type B beams used for the bottom portion of the wall are designed for their buoyant weight and a reduced horizontal wave force of 125 psf. Each beam has a 1-inch raised portion on the top at each end so that all vertical load is transmitted from beam to beam through the ends only. Flow through the resulting 1-inch aperture between the beams was prevented by a rubber seal cemented to the top of each beam prior to placing (exhibit 12). For handling, two lifting devices, each with a 2-inch-diam pin, are cast in the top of each beam.

Preload Construction Corporation, of New York City, designed the prestressed beams. Prestressing was accomplished by cables wound in grooves cast in the sides of the beams. These grooves were later filled in. The beams were cast and prestressed by Concrete Engineering Company, of Knoxville, Tennessee, in accordance with the design by Preload Construction Corporation. The cylindrical steel-encased concrete piers supporting the walls, made up of the precast concrete beams, are anchored to the bedrock of the riverbed and are each designed for a horizontal force of 1 kip per linear foot of wall, or a total of 59 kips applied at elevation 742.5. The materials and construction procedure for the skimmer wall piers were very carefully selected and planned to provide for pier construction in 40-foot depth of water without the use of a cofferdam. A navigation blinker is installed on top of pier No. 2 to define the right edge of the navigation channel.

Submerged dam

The construction of the skimmer wall substantially lowered the temperature of water delivered to the condensers during the summer months. A still further significant reduction was obtained by the construction of a submerged dam or barrier on the Clinch River near mile 3.9, about one-half mile downstream from the mouth of the Emory River. The computed reduction in temperatures was as much as 4.5°F, resulting in a substantial saving in fuel consumption.

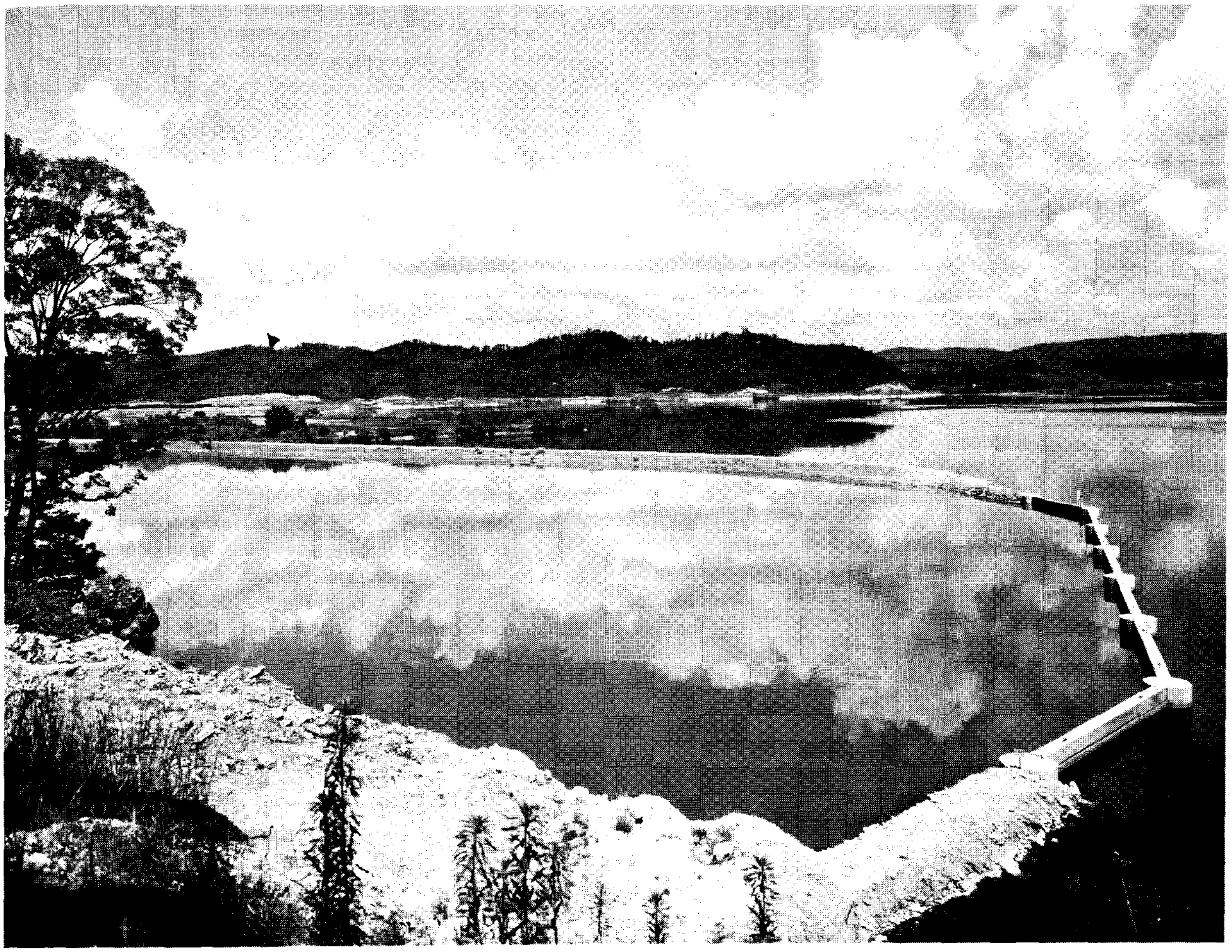


FIGURE 50.—*The water of the Emory River at the north end of Kingston's condenser water intake channel is much colder along the bottom than on the surface. A skimmer wall has been built to use this deep layer of cold water for more efficient operation. The wall literally "skims" off the warmer surface water, and the cold water continues on to the condensers.*

The dam is built of quarry-run limestone dumped into position from barges. The 6-foot-wide crest is at elevation 722, which will ensure an adequate navigation depth at all times.

PUMPING STATION

The pumping station structure (exhibits 13 and 14) is composed of screen wells, pump wells, and a valve room. The structure is about 300 feet long, 53 feet wide, and 50 feet high. A 17-foot-wide truck access deck is constructed at the east end of the structure. The structure rests on bedrock and is divided into three sections to reduce shrinkage stresses. The operating deck is at elevation 758, three feet above maximum design flood. Each of the three sections of the intake structure is designed to be stable against an assumed critical condition for floating and overturning with the reservoir at elevation 755 and the screen and pump wells unwatered up to 50 percent. The trash is washed from the traveling screens into a steel trough flush with the deck and carried to a concrete trench at the east end of the building which discharges into a 27-inch-diam concrete pipeline below the ground level. This pipeline runs underground in a southerly direction for 1442 feet to empty into the outlet channel at the discharge structure.

Intake stoplogs—To permit a screen well or an adjacent condenser pump well to be unwatered for maintenance work, it is necessary to close off one or more intake passages. This is accomplished by the stoplogs provided. Each set consisted of an upper and a lower section comprising a steel skin plate supported by vertical channel end posts and horizontal beams equipped with rubber water seals. Each section is handled independently by the 15-ton deck gantry crane and a special lifting beam.

Condenser circulating water pumps—Each pumping unit is a mixed-flow, vertical, wet-pit-type, consisting of a flanged discharge column with discharge elbow fitted for a Victaulic coupling. The discharge elbow and the Victaulic coupling are above normal water level and accessible so that the entire discharge column may be pulled for repairs without unwatering. The circulating pump shaft bearings are of rubber for units 1-4, of leaded bronze for units 5-9, and are lubricated with filtered raw water. Lubricating water is supplied from the station raw water distribution system.

The pump motors are 350 hp, 272 rpm for units 1-4, and 450 hp, 318 rpm for units 5-9, vertical, induction-type, with self-lubricated oil-type guide bearings and Kingsbury-type thrust bearings.

Screen wash pumps—Six vertical turbine-type pumps located in the valve room of the pumping station provide pressure water for washing debris from the traveling water screens. One 1400-gpm pump is provided for each four screens, and an additional pump is used for a spare. The pumps are located between pairs of circulating pumps and take their supply from the wells directly under the floor slab.

Cone valves—A 36-inch hydraulic-cylinder-operated cone valve is installed in a reduced section of the discharge piping of each circulating water pump for units 1-4. The valves are controlled by solenoid-operated valves interlocked with the pump controls. The cone valve control piping is so arranged that in case of electrical failure or power water failure the valve will remain open. A 3-inch treated water supply line connects to the header supplying power water for the operation of the valves. This line is installed within the building and connects to the treated water pump supply header in the water-treatment plant.

Butterfly valves—A 60-inch hydraulic-cylinder-operated butterfly valve is installed in an increased section of the discharge piping of each circulating water pump for units 5-9. The valves are controlled by solenoid-operated valves interlocked with the pump controls. The butterfly valve control piping is so arranged that in case of electrical failure the valve will remain open. The same treated water header that supplies the cone valves is reduced to 2 inches and provides power water for the operation of the butterfly valves. A spring-loaded check valve is installed in the treated water header between the section that supplies the cone valves and the section for the butterfly valves. Two hydro-pneumatic tanks are connected to this line and provide operating water for the butterfly valves in case of failure of the treated water system.

Raw water supply pumps—Three vertical turbine-type pumps, each with a capacity of 240 gpm against a discharge head of 85 feet, are provided for supplying the raw water to the water-treatment plant and for initially filling the condenser circulating water systems. These pumps operate from the same pits as the screen wash pumps. Two pumps are used normally; the third is a spare.

Controls—The control room for the pumping station is incorporated in the water treatment plant second-floor level and overlooks the pumping station deck. The condenser circulating water pumps can be started and stopped from this point. In addition, indicators show operating conditions, and an alarm and annunciator board warns of abnormal operating conditions.

The instruments in this room include the following: (1) The thrust and guide bearings on the circulating water pump motors are equipped with high temperature thermostats which actuate an alarm system. (2) Pressure switches in the circulating water pump bearing lubricating waterlines actuate the annunciator and sound an alarm for abnormal high or low flows. (3) Controls for operating and indicators to show the positions of the cone valves and butterfly valves on the discharges of the circulating water pumps. (4) Differential head gauges which show loss of head through the screens and trashracks. On loss of head, the annunciator board and an alarm are activated, indicating that the screens or trashracks must be cleaned. Screen wash pumps are started by push-button control on the deck of the intake structure. A pressure switch in the wash water supply pipe to each screen automatically starts the screen motor. The screens will not operate unless the cleaning spray is operating at or above a satisfactory pressure. (5) Indicating lights in the control room show whether the screen motor is operating or not, and a speed indicator shows the screen travel in feet per minute.

The motor-operated valves on the inlets and outlets of the condensers are controlled locally from push-button stations, and lights on the boards in the powerhouse unit control rooms and the control room at the water treatment plant indicate their position.

Drainage sump pumps—Building leakage and drainage from the various functions of the valve room are collected in a concrete gutter and conveyed to a sump. From the sump the water is pumped into the intake channel by a duplex, float-controlled, sump pump. This unit consists of two vertical single-stage pumps, each with a capacity of 30 gpm.

Heating and ventilating—The intake structure valve room is generally heated and ventilated for the protection of the equipment from dampness. The room is heated by thermostatically controlled electric unit heaters, and the supply air for winter ventilation is tempered by a thermostatically controlled electric blast heater. Portable electric heaters provide supplementary heating. The installed heating capacity is 127.5 kw and 24,000 cfm air.

Power and control circuits

The condenser circulating water pump motors, two per unit, are fed from the 4160-v unit boards in the powerhouse. Controls for these motors and their associated cone valves are located on the vertical control panels in the water supply control room in the water treatment plant. Other power requirements for the circulating water system, such as traveling screen motors; wash pump motors; water treatment motors; lighting, heating, and ventilating circuits are fed from the 480-v main and feeder boards and the heating, ventilating, and lighting board in the water supply control room.

Circulating water pump control panels

The circulating water pump control board consists of five vertical panels located in the water supply control room. Mounted on these panels are the circulating water pump motor and valve control switches, indicating lights, ammeters, interlock and annunciator auxiliary relays, and annunciator windows.

Gantry crane, lifting beam, and trash rake

Gantry crane—A permanent traveling gantry crane was erected on the intake structure for installing and servicing the pumps, traveling screens, stoplogs, and trashracks, and for other miscellaneous handling in that area. The installation and servicing of large valves on the landside and the operations of handling trashracks and a trash rake on the waterside required cantilever extensions of the gantry frame. A lifting capacity of 15 tons was essential for lifting the heaviest piece to be handled—the main section of a condenser water pump.

Lifting beam—A special lifting beam facilitates handling of the stoplogs and trashracks at the intake structure by the intake gantry crane. This lifting beam was equipped for attachment to the crane hook, for attaching to and detaching from a stoplog section or trashrack section, and for guiding down the stoplog slots and trashrack guides of the intake structure.

Trash rake—A special design of trash rake was installed for the removal and disposal of accumulated refuse from the trashrack surfaces at the water face of the intake structure.

Chlorination of circulating water

Purpose and operating requirements—The chlorination system intermittently and alternately doses the flow of water to each pair of condenser circulating water pumps to inhibit growth of algae in the water passages and condenser tubes. The water requires dosing at a rate of 1 to 5 ppm in order to obtain a residual of 0.5 ppm at the condenser outlet. At this assumed dosing rate it requires that chlorine be fed at rates between 1100 and 6000 lb per 24 hours and 1500 and 8000 lb per 24 hours, respectively, for the units 1-4 pumps and the larger pumps for units 5-9.

Feeding and distribution system—The installed equipment includes two chlorinators and two liquid chlorine evaporators. The chlorinators are the air-operated water-diaphragm, vacuum-type designed for semiautomatic or start and stop operation. The two liquid chlorine evaporators are the electrically heated, hot water type. The chlorine liquid and gas lines are of extra-heavy, genuine wrought iron; the chlorine solution lines are rubber-lined standard-weight steel. A schematic diagram of the system is shown in exhibit 82.

Operation—The starting and stopping of the operating cycles and the alternation of dosing from one pair of pumps to another are accomplished automatically by a manually adjustable program controller which actuates solenoid air valves on the injector water shutoff valve, the chlorinator air shutoff valve, and the shutoff valves for each pair of pumps. The time and rate of dosing are adjusted manually.

Sufficient meters are furnished so that one chlorinator can be used to dose the units 1-4 pumps and the other the units 5-9 pumps. The use of the chlorinators can be alternated by a manual adjustment on the program controller and by changing the meters.

Chlorine storage—Liquid chlorine is supplied from either a single-unit tank car or one-ton containers to the evaporators where it is changed to a gas and delivered to the chlorinators. The chlorinators measure the gas which is fed to the water-operated injectors where it is mixed with water to form a chlorine solution and delivered to the diffusers at the suctions of the condenser circulating water pumps in the pumping station.

Chlorination building

The 2-level chlorination building is located at the south end of the intake structure. Railroad unloading and chlorine storage facilities are provided at the south end of the upper level (fig. 51). An enclosed chlorination and equipment room is located at the lower level. The building is rectangular, with a length of 70 feet, a width of 30 feet, and a height of 24 feet.

Concrete structures—At one end of the chlorination building is a 1-story reinforced concrete structure 19 by 26 feet, containing chlorination, ventilation, and electrical equipment rooms. The roof for the structure is a 9¾-inch-thick flat slab designed as a 2-way slab, monolithic with the supporting 8-inch-thick walls. Its top face is exposed without any roofing materials being applied.

The 8-inch-thick concrete floor slab of the structure acts as a foundation slab, distributing all the building load to the ground. The steel columns of the building rest on concrete walls that extend 5 feet

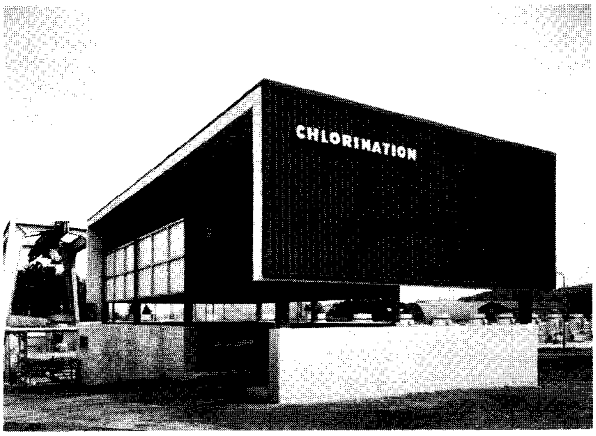


FIGURE 51.—*Chlorination building. Intermittent doses of chlorine, through diffusers located beneath the intakes of the condenser circulating water pumps, inhibit slime growth in water passages and condenser tubes.*

above the floor slab and a minimum of 1 foot below and carry the load to separate foundations carried down to existing ground.

Architecture—While the chlorination building is a part of the water treatment plant and adjacent to the previously described water treatment structure, its function dictated a different architectural treatment.

A low, flat-decked, concrete enclosure houses chlorination, ventilation, and electrical equipment, with the superstructure being of steel frame partially enclosed for storage and with a pass-through for trucks. The end walls of the superstructure are of maroon steel panels extending to within 3 feet of the 5-foot-high concrete base. The sides have steel panels in steel frames set between the structural steel columns, with open space above and below. The color scheme of the office wing is repeated here, with dark blue-green exposed steel frame, maroon siding, and yellow wall panels.

Structural—The upper level of the building is a steel structure consisting of three bays. The end bay is open to permit passage of freight cars. The framing consists of clear-span roof girders, beams, and columns of wide flange sections. The longitudinal framing, selected for aesthetic considerations, was analyzed as a rigid frame. Crane runway beams are suspended from the bottom flange of the roof girders for a 2-ton overhead crane. Both shop and field connections were welded.

Electrical—The electrical equipment room contains a 3-panel, control-center-type, 480-v board which is fed from the water supply 480-v main board. This board supplies the power for heating, ventilating, lighting, and miscellaneous circuits throughout the area. A telephone and telephone jacks are provided for communications.

Heating and ventilating—The chlorinator room is heated by a thermostatically controlled electric blast heater located in the fresh-air supply fan system. Portable electric heaters provide supplementary heating in other rooms. The installed heating capacity is 45 kw, and 3000 cfm air is supplied.

Crane and lifting beam—An underhung crane of 2-ton capacity was provided in the chlorination building to handle 1-ton chlorine containers from railroad cars to storage areas in the building. The capacity of the crane was set by the weight of a filled 1-ton chlorine container, which is approximately 3000 pounds. A special lifting beam was provided for this specific service. The crane consists of two underhung-type end trucks connected by an I-beam girder and bracing members. The end trucks operate on the lower flanges of two I-beams suspended from the roof of the chlorination building. A 2-ton-capacity, trolley-type, electric hoist operates on the lower flange of the crane bridge girder. Hoist, trolley-travel, and bridge-travel motions are powered by electric motors. Power of 440 v, 3 ph, 60 cycles is supplied to the bridge by collectors and enclosed conductors mounted on the roof beams of the building and to the hoist by collectors and enclosed conductors mounted on the crane bridge structure. Controls are the pendant push-button-type.

A special lifting beam was provided with the underhung crane in the chlorination building for handling 1-ton chlorine containers. This lifting beam is provided with a suitable means for attaching to the crane hook and with special swinging hooks for quick attachment to the chlorine container.

INTAKE CONDUITS

Precast concrete pipes

The condenser cooling water flows from the pumping station to the powerhouse in nine concrete pipelines—four of 78-inch id and five of 96-inch id. At the pumping station each pipeline is connected to a steel wye with branches from two pumps. The 78-inch-diam pipe used for units 1-4 will accommodate a flow of 97,000 gpm with a velocity of 6.5 fps, and the 96-inch-diam pipe for units 5-9 will carry a flow of 130,000 gpm with a velocity of 5.75 fps. The intake pipes, as well as the discharge pipes, were all cast in 16-foot lengths with self-centering rubber-gasketed watertight joints and were manufactured at the plant site by the Lock Joint Pipe Company. Leaving the south side of the pumping station the pipes run south and parallel at a slope of approximately 0.3 percent until they separate by two's and join the poured-in-place concrete conduits leading into the powerhouse. These poured-in-place conduits, which vary in length from 74 to 144 feet, were adopted to allow the use of sharper curves than is customary for use where the conduits turn in between the stack foundations. With the exception of the rectangular-formed single conduit No. 9, each poured-in-place section is a double conduit with two rectangular openings having transitions to the round precast pipes. They all have a downward slope of 20 percent or more toward the west wall of the powerhouse.

Powerhouse section

Between the exterior wall of the powerhouse substructure and the condenser, the rectangular conduits are cast into the heavy blocks of the powerhouse base slab. Within the powerhouse a 20-inch-diam cast-iron manhole with a safety lock, to prevent removal under water pressure, is installed for access into the conduits.

DISCHARGE CONDUITS, STOPLOGS AND GUIDES

Discharge conduits

Within the limits of the powerhouse the discharge conduits are similar to the intake. They are constructed in pairs with the exception of the single conduit No. 1, and all return to the west wall. Here, located midway between the intake pairs, the discharge conduits leave the powerhouse as poured-in-place concrete sections which convert to precast pipelines after the sharp turn around the stacks. These pipelines cross underneath the intake pipelines and continue south to the discharge structure. Because of the large external load on these deep pipes, both the 78- and the 96-inch-diam discharge pipelines are supported on a continuous concrete cradle.

The discharge structure is a reinforced concrete headwall consisting of a center wall flanked by two wing walls. The structure is poured around the ends of the nine discharge pipelines and also retains the roadway fill from spilling into the channel.

Discharge conduit stoplogs

There are two stoplogs—one for use in the discharge conduits of units 1-4 and another, somewhat larger, for use in the discharge conduits of units 5-9. The function of these stoplogs is to close the discharge conduits against tailwater to enable the conduits to be unwatered for inspection and repair. Each stoplog consists of a steel skin plate supported by vertical channel end posts and horizontal beams and is equipped with rubber water seals to effect a closure. Suitable lifting chains are provided for handling and dogging by a mobile crane. When not in use, each stoplog is stored in the upper part of one of its respective slots by hanging from a dogging hook attached to the outlet structure.

Stoplog guides

Guides are provided for the discharge conduits to permit closing off the conduits for inspection and repairs. The stoplog slot in each conduit is located at the exit end of the conduit. The guides are made up of heavy 6-inch channel sections to suit the shoes on the side of the stoplogs and extend the full height of the slot. At the lower portion the channels are framed into and welded to $\frac{3}{8}$-inch bent plates which are framed around the openings to provide a true, load-bearing surface for sealing the stoplogs. A sill beam extends across the bottom of the opening. A welded steel dogging hook is provided in each slot near the deck for suspending the stoplogs.

TRANSFORMER YARD

General design

The transformer yard is located just outside the east wall of the turbine room in order to keep the heavy low-voltage generator bus as short as possible. So as not to create a fire hazard to the powerhouse in case of transformer fire, each main transformer, station service transformer, and neutral reactor is surrounded by a water-sprinkler system operated automatically in case of fire or by transformer differential relay operation.

The installation consists of nine main (fig. 52) and nine unit (fig. 53) station service power transformers, one per unit, and two common station service power transformers. See exhibit 93 for general arrangement plan of transformer yard and switchyard and figure 52 showing main transformer connections.

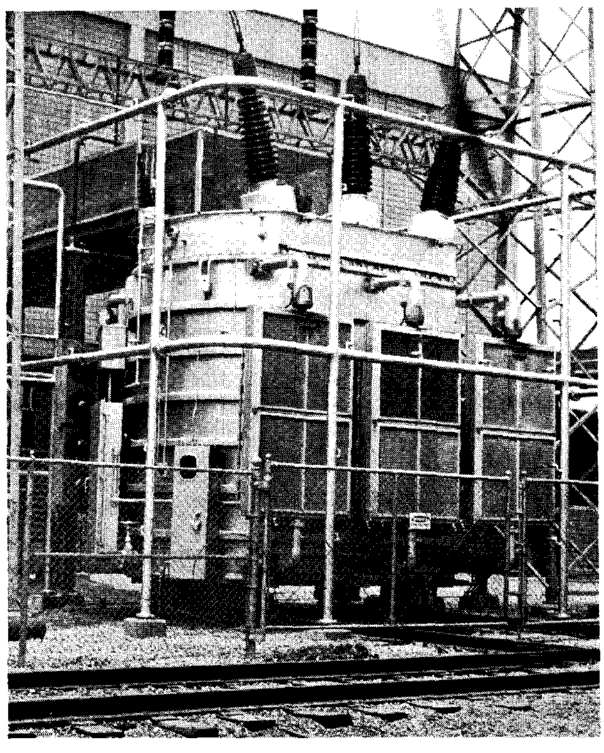


FIGURE 52.—*170,000-kva main transformer No. 2. Location of the transformer yard facilities just outside the east wall of the powerhouse reduces the length of the heavy, low-voltage generator bus.*

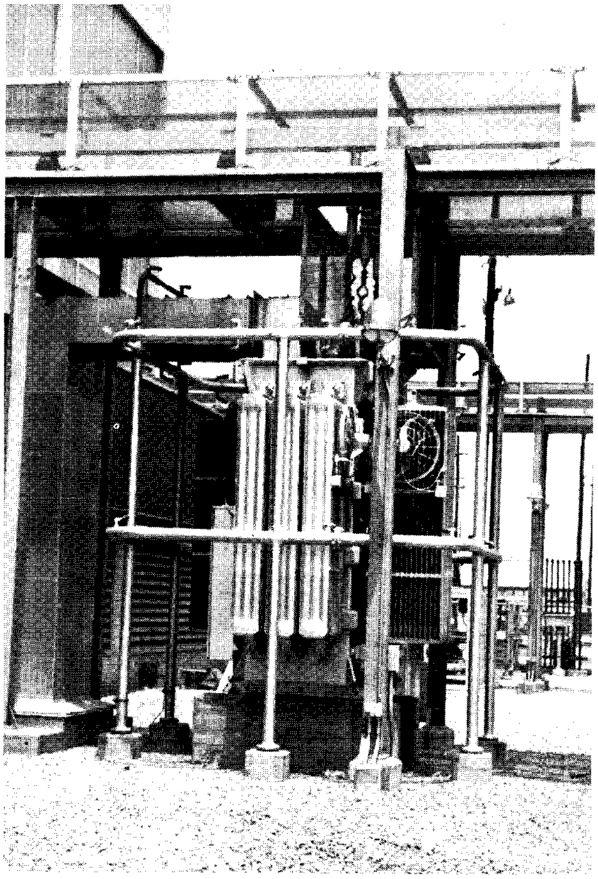


FIGURE 53.—*Unit 1 station service transformer, 9000/11,250 kva, located beneath screen-enclosed generator bus, provides power for unit 1 motor-driven auxiliaries under normal operation.*

A transformer track extends the length of the transformer yard with setdown tracks at a 90-degree angle and at the same elevation, 6 inches above grade. An auxiliary hoist in the powerhouse roof truss provides untanking facilities. The two 90-ton powerhouse cranes are adequate for moving the transformer to the service bay setdown track.

The transformer truck wheels are mounted on a pinion with a fastening device. By jacking the transformer and loosening the fastening device the truck wheels can be rotated 90 degrees. The setdown track gauge is 10 feet; the trucks when rotated fit the standard track gauge of 4 feet 8½ inches.

Main electrical connections

Generation of units 1-4 is at 18,000 v; generation of units 5-9 is at 20,000 v, with a 3-ph step-up transformer for each generator for connection to the TVA 161,000-v transmission system. The outdoor section of the generator bus is carried overhead at a height convenient for connection to the transformer low-voltage bushings. The unit station service transformer is located directly under the generator bus and tapped off this bus through disconnecting links. No switching is provided at generator voltage. Connections from the transformer high-voltage side to the 161,000-v switchyard are made by an overhead line with 161,000-v oil circuit breakers connecting the transformer to either the switchyard main or transfer bus.

A high-voltage buildup at the main and common station service transformer terminals, due to lightning or switching surges, is prevented by mounting 161,000-v lightning arresters, rated 145,000 v rms maximum line to ground, on the transformer tower close to the high-voltage bushings and in such position as not to block movement of transformer to the setdown position. Each common station service transformer is fed from a separate bus section of the 161,000-v switchyard.

Main power transformers and reactors

The main power transformers for units 1-4 are rated 170,000 kva, 161-17.1 kv, forced air and oil cooled; those for units 5-9 are rated 230,000 kva, 161-19 kv, forced air and oil cooled. Each transformer is equipped with inert gas equipment with low gas pressure alarm contact, oil level gauge with low-level alarm contact, oil thermometer with high-temperature alarm contact, and resistance-type winding temperature detectors for operation of a temperature recorder.

Manual no-load, full-capacity, tap-changing equipment is provided on the high-voltage winding with three 2½ percent taps above and one 2½ percent tap below 161,000 v. The high-voltage windings are wye-connected and have a basic impluse insulation level of 750,000 v. The neutral of the 161,000-v windings is grounded through a current-limiting reactor. The low-voltage windings are delta-connected and have a basic impluse insulation level of 150,000 v.

The 161,000-v neutral is grounded through a reactor which is shunted by a surge arrester. The reactor is oil-immersed, self-cooled, and equipped with shielding to prevent excessive heating in the tank walls. The reactors for units 1-4 are rated 12 ohms, and for units 5-9, rated 10 ohms. The transformer neutral end is insulated for 46,000 v. The reactance chosen is sufficient to limit the line-to-ground fault current to a value below the phase-to-phase fault current, yet low enough to assure voltage stability and fast, dependable, ground relay operation.

Unit station service transformers and resistors

The unit station service transformers for units 1-4 are rated 9000/11,250 kva, 17.1-4.16 kv, oil insulated and forced air cooled; those for units 5-9 are rated 12,000/16,000 kva, 19-4.16 kv, oil insulated and forced air cooled Each transformer is equipped with inert gas equipment with gas cylinder low-pressure alarm contact, transformer tank high- and low-pressure alarm contacts, oil gage with low-level alarm contact, oil temperature indicator with high-temperature alarm contact, and winding hot-spot high-temperature alarm contact. A manual no-load, full-capacity tap changer is provided on the high-voltage windings with three 2½ percent taps above and one 2½ percent tap below the high-voltage rating. The high-voltage windings are delta-connected; the low-voltage windings are wye-connected with the neutral grounded through a grounding resistor. The high-voltage bushings are equipped with saturating-type current transformers to provide transformer differential relay protection.

The neutral grounding resistor is the cast-grid-type, air-cooled, mounted in a weatherproof sheet-metal cabinet, and rated 3 ohms, 2400-v drop, 800 amp for 10 seconds, with a grid temperature rise of 500°C over 40°C ambient. The value of resistance was chosen sufficiently high to minimize ground fault damage to cables and equipment, yet sufficiently low to assure fast, dependable, ground relay operation.

Common station service transformers, reactors, and resistors

The common station service transformers are 20,000/25,000 kva, 161-4.16 kv, oil-insulated, forced-air-cooled. Each transformer is equipped with inert gas equipment with low-pressure alarm contact, magnetic oil gauge with low-level alarm contact and temperature thermometer with oil high-temperature alarm, and winding temperature indicator with high-temperature alarm. Manual no-load, full-capacity tap changers are provided on the high-voltage winding with two 2½ percent taps above and two 2½ percent taps below 161,000 v. The 161,000-v windings have a basic impulse insulation level of 750,000 v; the 4160-v windings have a basic impulse insulation level of 95,000 v. The high-voltage windings are wye-connected with the neutral connected through a current-limiting reactor of the same type and rating as described under paragraph "Main power transformers and reactors," page 84. The low-voltage windings are wye-connected with the neutral grounded through a current-limiting resistor of the same type and rating as described under paragraph "Unit station service transformers and resistors." page 84. The transformer has a 4994-v, 7000-kva, delta-connected tertiary winding but no connections are brought out of the tank.

Insulation coordination and lightning protection

Electrical insulation and protective devices were selected and coordinated to allow a safe margin of insulation strength above the maximum abnormal voltages permitted by the protective equipment during faults and switching and lightning surges. The transformer yard is shielded against a direct lightning stroke by a steel ground wire carried the length of the transformer yard and connected to the takeoff tower peaks. The 161,000-v conductors from the transformer towers to the switchyard are shielded by two steel ground wires carried 20 feet above the phase conductors. The ground wires are solidly connected to the transformer tower and switchyard ground wire peaks which in turn are solidly connected to the station ground mat at each column base. All transformer yard equipment and conductors are within a protective cone, making an angle of 30 degrees with a vertical line through the ground wire.

Transformer neutrals are grounded through a current-limiting reactor shunted by a lightning arrester to bypass abnormal voltages due to system faults and switching and lightning surges. Grounded neutral station-type lightning arresters rated 145,000 v rms maximum line to ground are connected close to the transformer high-voltage terminals. The equipment insulation is chosen with a safe margin above the maximum breakdown voltage of the arrester.

Concrete foundations and drainage

The foundations for all structures and equipment are reinforced concrete and are designed to keep the maximum base pressure below 2 tsf. During the construction period at Kingston some differential settlement between the transformers and the structures and equipment connecting to them was noted at some of the other TVA projects. To reduce such differential settlement a combined-type of foundation was designed and used to support transformers Nos. 5 to 9.

All drainage is carried in open-joint pipes of varying sizes laid in stone filled trenches for the length of the yard. The yard is surfaced with 6 to 9 inches of crushed stone which is used to confine burning oil in case of a fire and prevent spreading to adjacent equipment.

Transformer yard track—The track over which the heavy transformers must travel on their own wheels, including the siding into the powerhouse, is supported on a continuous reinforced concrete pad 12 inches thick to prevent displacement or uneven settlement under load. The track enters the powerhouse over a concrete rocker beam which spans the backfilled area adjacent to the building and acts to minimize the effect of any differential settlement.

Generator leads and station service leads housing

The bare aluminum leads extend horizontally between the powerhouse and the transformer bank for approximately 67 feet and are approximately 20 feet above ground. A structural steel framework of columns and beams is provided for supporting the pedestal insulators which in turn support the bare leads. The leads are run in screen enclosures which are made up of expanded aluminum metal on a skeleton framework of aluminum angles, gussets, and bars. All connections and joints are bolted with Everdur bolts and screws. The structural framing is galvanized with bolted connections.

Steel structures

The main transformer towers consist of nine pairs of towers 82 feet high and each pair is framed together with horizontal trussed box members 31 feet long. The towers are the free-standing type with spread legs. There is a similar structure for the common station service transformer A, while that for the common station service transformer B is only 77 feet high.

Fire protection

Four concrete fire equipment houses are built in the transformer yard to house hand-drawn equipment for emergency use. A 4-foot-wide bituminous surface walkway insures easy access to the structures for maintenance or in the event of fire. The fire equipment houses are described in detail under "Auxiliary Yard Structures," page 111. Each fire equipment house contains a steel frame fire hose cart and accessories and a buggy-type, 150-pound, dry-powder-type extinguisher. A 2½-inch hose, 200 feet long, is supplied for each hose cart, with necessary wrenches, playpipes, and adjustable nozzles.

Fire hydrant system—There are eight fire hydrants with two 2½-inch hose connections. Water is supplied through a 6-inch underground header connected to the powerhouse yard water system (exhibit 79).

Transformer water spray system—An independently controlled water spray system surrounds each main transformer, its neutral reactor and unit station service transformer, and each common station service transformer and its neutral reactor. The water supply is taken from the powerhouse raw water system (exhibits 75, 76, 77, and 78). A diaphragm-operated quick-opening control valve with a solenoid-operated pilot, actuated by a thermostat or transformer differential relay opens to supply water to this system. The system may also be operated manually by a switch on the board in the control building. The main control valves may be operated manually in case of current failure. A test station just inside the transformer yard gate can be activated for test purposes.

Insulating oil piping system

An underground piping system consisting of supply and drain headers connecting with the powerhouse oil system supplies oil to the electrical equipment (exhibits 66 and 67). Valve boxes are located near each piece of equipment, and oil is transferred by specially treated synthetic-rubber-lined hose with swivel type connections. Spirally wrapped burlap applied between two coats of hot asphalt affords the necessary corrosion protection for underground piping.

SWITCHYARD

General design

The center line of the 161,000-v switchyard structure is parallel with and approximately 350 feet east of the powerhouse north-south baseline. The fenced area is large enough for twenty-eight 36-foot bays of the 161,000-v structure of which 25 bays are initially installed. Space is reserved north of the 161,000-v structure for nine 26-foot bays of the 69,000-v structure. The natural level terrain was favorable for using the standard wide-type structure, as shown in figure 54. A high degree of operating flexibility is obtained by alternating the line and transformer bays and using the zigzag main and transfer bus scheme as shown on single line diagram, figure 55.

A bus breakup relaying scheme is used; a persistent fault on a line or bus section will trip all circuit breakers on the faulted section, thus isolating the fault and permitting normal operation of the adjacent bus sections.

Three potential transformers connected to each main bus section supply potential for line relaying, metering, and synchronizing. A single potential transformer on each transfer bus is used for synchronizing, and a coupling capacitor with potential device is used on the B-ph of each line for synchronizing. The potential transformers are rated 92,000-155/65.7 v, 500 v-amp. The 92,000- and 65.7-v windings are connected wye with neutral grounded. The 115-v windings are connected broken delta with phase-to-ground potential used for synchronizing and the residual potential used for potential polarized ground relays.

A steel structure in the center of line bays supports powerline carrier equipment which is coupled to the powerline for carrier pilot relaying, telemetering, and communication.

A cable tunnel runs the length of the switchyard and connects to the spreading room of the main control building. Cable trays racked on both sides of the tunnel allow convenient routing of cables to any point in the switchyard.

Main electrical connections

Aluminum tubing, welded construction alloy 63S-T6, is used throughout the switchyard. The 161,000-v main and transfer buses are 4-inch iron-pipe-size aluminum which span the 36-foot bay width without intermediate supports. Bus taps and bay connections are 3-inch iron-pipe-size aluminum; 2-inch iron-pipe-size aluminum is used for other connections where current-carrying capacity is the only consideration. All bays are designed for a current-carrying capacity of 1200 amp. Connections from the disconnecting switches to the oil circuit breakers are made with 1000 mcm stranded copper cable. The overhead connections from the transformer banks to the switchyard are 500 mcm stranded hard-drawn copper cable. All outgoing lines are aluminum cable, steel-reinforced and of the size required.

Each transformer bank connects to both the main and transfer bus through an oil circuit breaker. Each line connects to the main bus through an oil circuit breaker and to the transfer bus through a motor-operated disconnect switch. Each transformer breaker connected to the transfer bus can be used as a spare breaker for any line breaker on the bus section. One spare breaker on each bus section has a set of spare line relays. Each spare breaker is supplied with relaying current transformer transfer blocks, so the spare relays can be used on any spare breaker.

The 161,000-v oil circuit breakers are rated 1600 amp, 10,000,000-kva interrupting capacity, 62,000 amp momentary, pneumatically operated, 3-cycle opening and 20-cycle reclosing. Each 3-ph breaker is mounted on a skid-type base for convenience in shipping and installation.

The 161,000-v disconnect switches are rated 1200 amp, 63,000 amp momentary. The main bus tie switches and all bus sectionalizing switches are rated 2000 amp, 63,000 amp momentary. All breaker isolating switches are manually operated; all line switches and bus sectionalizing switches are motor-operated and controlled from the main control room benchboard.

Powerline carrier tuning and coupling equipment

A steel structure in the center line of the 161,000-v line bays supports the powerline carrier tuning and coupling equipment. These structures also furnish support for the vertical takeoff cables to the lines. The wave traps which confine the carrier frequencies to their respective lines are suspended in the vertical takeoff cables. This structure supports the coupling capacitors which are used on each phase, when required, to provide line-to-ground carrier channels for automatic load control, telemetering, telephone, and carrier pilot relaying. The carrier pilot relaying

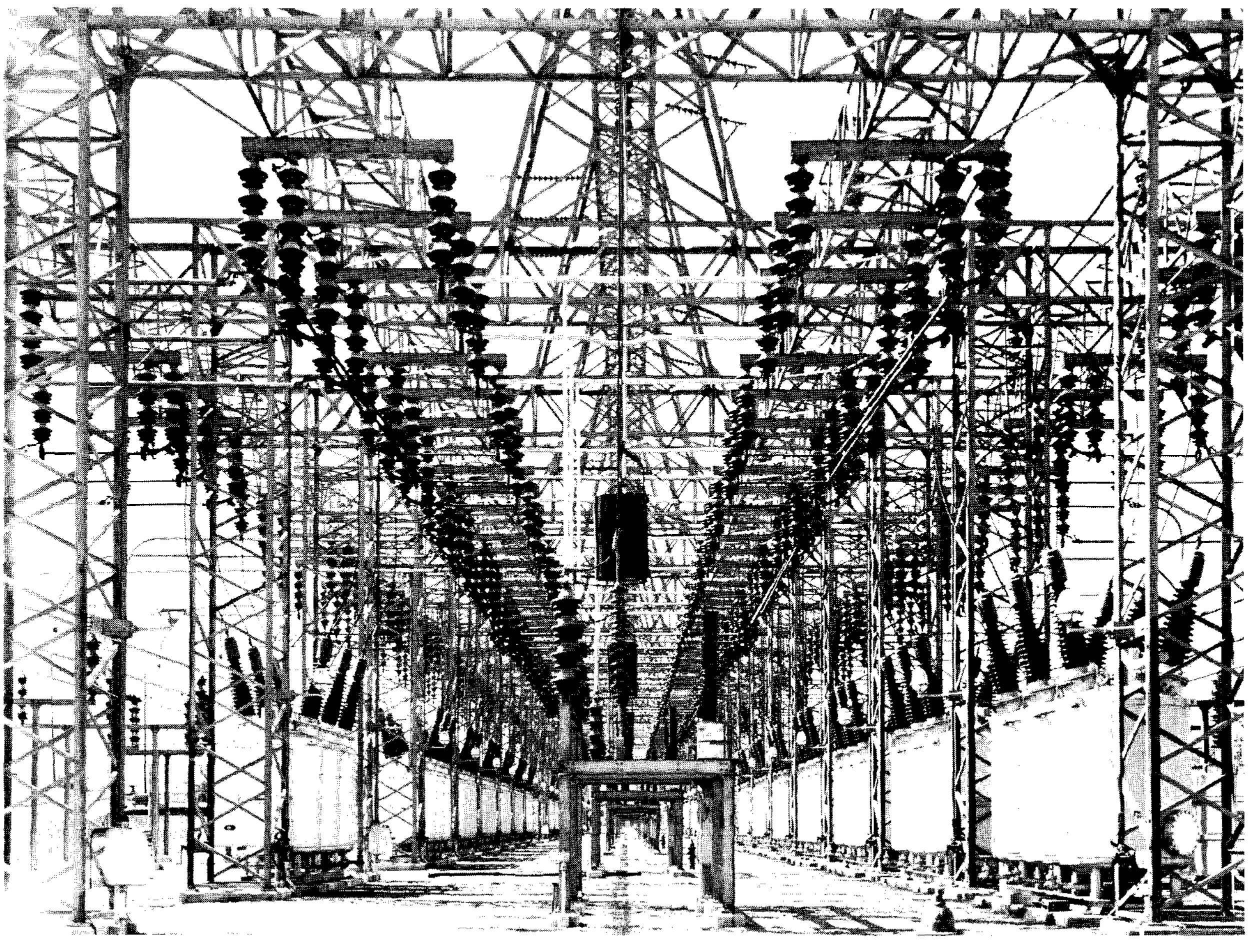


FIGURE 54.—*161-kv switchyard is arranged in 25 bays and contains 33 oil circuit breakers, 90 disconnecting switches, and 24 potential transformers.*

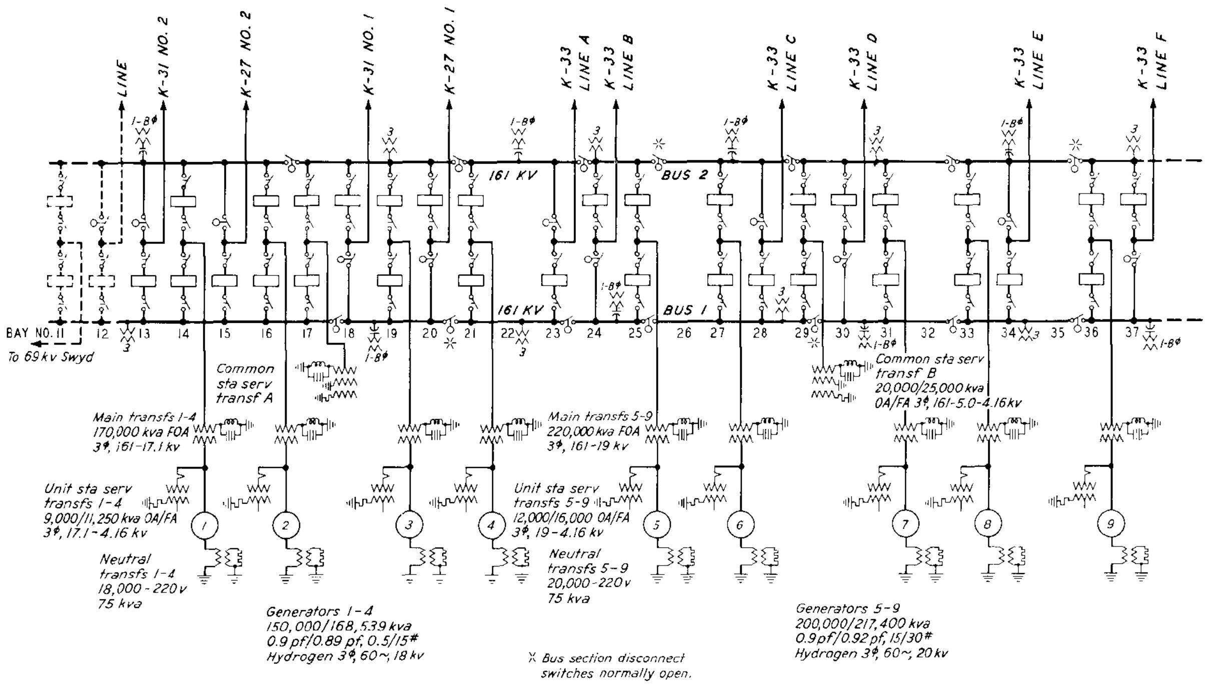


FIGURE 55.—*Single-line diagram—transmission plant.*

channel utilizes B-ph and ground of the respective lines. Each B-ph coupling capacitor is equipped with a potential device in its base and a potential adjustment unit mounted in the spreading room to provide line synchronizing potential. Line-tuning cabinets, single or double frequency as required, are mounted on the carrier-current structure. All carrier-current transmitter-receivers are located in the communication room in the main control building and are connected to their respective line-tuning cabinet and coupling capacitor by coaxial cable.

Insulation coordination and lightning protection

Electrical insulation was carefully selected and coordinated so as to give a safe margin of insulation strength above the maximum abnormal voltages due to faults, system disturbances, switching surges, incoming line lightning surges, and overvoltage caused by excessive generator speed due to loss of load.

The overhead ground wires coming in from the transmission lines on one side and from the transformer towers on the opposite side of the switchyard are carried across the structure to form a network supported by and grounded to the steel peaks extending 20 feet above the top of the line takeoff truss. The shielding network is sufficiently extensive to include all outside equipment and conductors within a line drawn through the ground wire at an angle of 30 degrees with the vertical. Equipment and conductors located between two ground wires are within a protective cone having a base radius of twice its height. The ground wires are solidly connected to the ground wire peaks, and each switchyard column base is connected to the station grounding system which has low average effective ground resistance.

Lighting

Switchyard and transformer yard lighting is obtained from substation-type units located on structural supporting steel and the enclosing fence. Control is simultaneous with other outside lighting which is photo-electrically controlled.

Concrete foundations and drainage

The switchyard is located in an area where both excavation and fill were required. The fill material was specified to be clay and to be spread in 6-inch layers and thoroughly compacted with sheepsfoot rollers. The subgrade is sloped to drain and covered with 6 to 12 inches of crushed stone. A 12-inch open-joint concrete drain laid in a trench of crushed stone runs the full length along the center line of the yard.

All structures are supported on reinforced concrete spread footings designed for a maximum allowable base pressure of 2 tsf and the entire base in compression, assuming no wind or with wind a maximum of 3 tsf and only two-thirds of the base in compression.

Steel structures

The 161,000-v structure has an over-all height of 80½ feet and consists of 25 bays with transverse column spacing of 47½ feet. Columns are 5 feet square. Provision is made for expansion and contraction of the switchyard by a complete break for a contraction joint; 6 feet in the center of the switchyard is allowed.

Fire protection

There are four concrete fire houses with portable equipment along the south fence of the switchyard.

The yard contains eight fire hydrants with two 2½-inch hose connections each. Water is supplied through 6-inch underground headers from the yard water system (exhibit 79).

Insulating oil piping system

Branches from the transformer oil system serve the switchyard. The two systems are isolated by means of valves located at the junction of the headers (exhibits 66 and 67).

CONTROL BUILDING

The control building is centrally located between the transformer yard and the switchyard to avoid long cable runs. It is situated a sufficient distance from the powerhouse to be free from powerhouse noise and vibration.

In the powerhouse unit control room are the control switches; indicating and recording instruments; and annunciation and communication equipment to start, stop, and operate the units and maintain operation of the turbines and all auxiliary equipment required for generation of power. In the control building are the control switches; indicating and recording instruments; relaying systems; automatic load control equipment; and annunciation and communication equipment to synchronize the generators with the system, to maintain the transmission line connections, and to automatically change the generation with changes in load requirements.

SUBSTRUCTURE

The substructure is designed to rest on earth. It is essentially a monolithic reinforced rigid concrete box roughly 132 by 62 feet, with the basement floor 15 feet below grade and 5 feet below the elevation of maximum design flood. The basement floor is a slab and beam construction, designed to carry any resultant uplift forces to the side walls and to withstand the base pressure caused by the dead and live loads of the columns and walls. The walls are cantilevered from the base slab and were designed for a construction condition where they were required to support the back-fill up to grade as a cantilever and for the final condition where the main floor at grade furnishes additional horizontal support.

CABLE TUNNELS

The main electrical conduits from the powerhouse to the control building and from the control building to the bays of the switchyard are carried in Transite trays within cable tunnels constructed either of precast concrete pipe or cast-in-place concrete. From the powerhouse there are two such tunnels—one consisting of a precast reinforced concrete pipeline 78 inches id and the other a 7- by 10-foot rectangular cast-in-place concrete tunnel. The latter passes directly underneath the common station service transformer, which is supported directly on the tunnel structure. The cable tunnel in the switchyard is also a precast pipeline 84 inches id. Each pipeline joint is kept watertight with an endless rubber gasket. Steel frames to support the Transite cable trays are cinch-anchored to the tunnel walls, and a poured-in-place walkway, 24 inches wide along the bottom and having a drainage gutter on each side, serves for pedestrians.

SUPERSTRUCTURE

Architecture

The control building reflects the same over-all use of materials as the powerhouse. A one-story section housing offices, locker and toilet facilities, instrument repair shop, photographic dark room, and public lobby is L-shaped and provides over 2000 sq ft of space. The control room, which requires a higher ceiling to allow for the indirect illumination, is fitted into the corner of the low portion so that the two parts fit together in a well-proportioned, composite structure.

Exterior—The one-story portion is buff-gray brick, with the exposed boxed steel columns and deep steel roof spandrel painted dark blue-green. This, with the recessed entrance of full-height plate glass

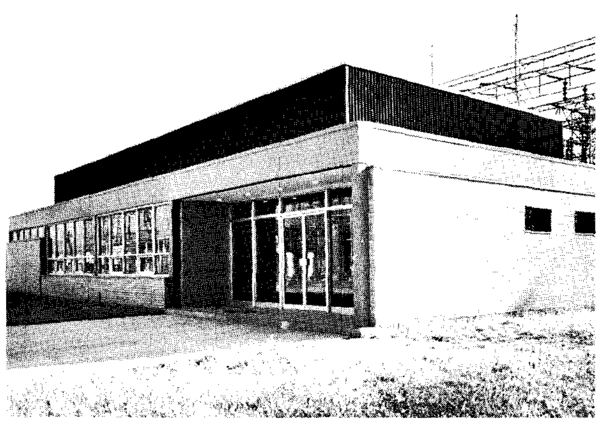


FIGURE 56.—*The electrical control building contains equipment necessary to synchronize the generators, maintain transmission line connections, and adjust generation in accordance with load requirements.*

FIGURE 57.—*Visitors lobby in the control building. This room was provided to afford visitors a view of the electrical control operations.*

and aluminum and the office spaces fronted with aluminum window-wall panels, is an effective contrast with the maroon setback wall of the high-story portion as shown in figure 56.

Interior—Although most of the control building is devoted to the control room and related work areas, the entrance vestibule was extended far enough into the building to create a small lobby where visitors may view the control room through a large observation window (fig. 57). It was not intended to make this a part of the regular public facilities of the project, but because of its interest to technical visitors it was included.

The buff-gray face brick exterior is continued through the glass-paneled entrance into the vestibule, where there is a gradual transition into the plastered walls and ceiling of the lobby. Similarly, the terrazzo entrance floor is carried into the vestibule and continues into the lobby.

The high ceiling of the control room is arched slightly to provide better light distribution from the recessed, indirect fixtures mounted on top of the recording instrument boards. The curved ceiling is 6- by 12-inch acoustical tile placed to accommodate 6-inch-wide air outlet grilles in the center of the arch. The plastered walls are of medium blue-green, the instrument boards of light, warm gray, with the instrument frames slate gray. The floor is gray marbleized rubber tile. The offices and other work areas also have off-white plaster ceilings, medium blue-green plaster walls, and gray marbleized rubber tile floors. Doors are natural red birch set in metal frames of medium blue-green.

Concrete floors

The floors above the basement are cast-in-place reinforced concrete, supported on structural steel framing, with 2 inches of separate cement finish bonded to the slab.

Steel structure and electrical equipment supports

The main framing is standard beam, girder, and column design. Angle bracing is provided in the plane of the roof and in each wall. Continuous channel girts provide supports for the siding, and rolled beams support the roof decking. Cable supports in the control building are similar to those used in the powerhouse.

ELECTRICAL FEATURES

Main control switchboards

Cables from the powerhouse and the switchyard enter the control building spreading room through cable tunnels. Asbestos-cement cable trays are used in the spreading room for convenient routing of the cables to any panel on the floor above. The controls for the generators and for the main common station service 4160-v auxiliary power circuits in the powerhouse and all the electrical equipment in the transformer yard and 161,000-v switchyard are centralized on a 14-panel benchboard located in the main control room. Figure 58 is a general view of the main control room with the benchboard on the right. Mimic buses of distinctive finish to represent different voltages and control switches with handles of different shapes and colors for various functions are arranged on the benchboard to agree with the physical arrangement of the the controlled equipment. The generator controls for adjusting speed and voltage which are necessary for synchronizing the generator to the system are located on this board. All other generator and turbine controls are located on the unit control board in the powerhouse. The operators' desks are in front of the benchboard as shown in figure 58 and exhibit 92.

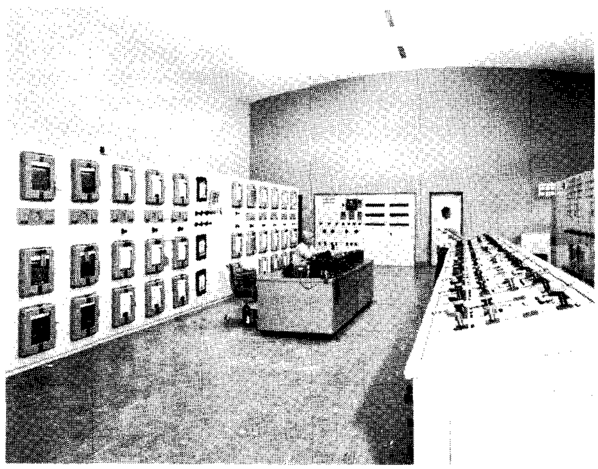


FIGURE 58.—*Electrical control room in control building. From left to right—recording instrument board, operator's desk, motor-generator set board, benchboard, and main instrument board.*

The instrument board is located just back of the benchboard with an aisle space between them. The upper half of this board, which is visible from the operator's desk, contains all the indicating instruments. They include unit speed; generator field amperes and volts; pilot exciter amperes and volts; and amperes, watts, and vars in all major alternating-current circuits. These instruments are rectangular, semiflush-type, with 240-degree scales on white dials. On the lower half of this board are mounted test switches for relaying transmitter-receivers, generator voltage regulators, watt-hour meters, and test blocks. Synchronizing instruments are mounted on small swinging panels, one on each end of the board.

The recording instrument board is located to the rear of the operator's desk. All instruments are semiflush-type with gray bezels and white dials and charts. The recordings for each unit include generator field temperature, generator stator temperature, transformer winding temperature, and generator load in megawatts. Additional recordings include the bus voltage of each 161,000-v bus section, system frequency, and those recordings associated with the automatic load control equipment.

The battery board, duplex-type, is located with the front panels flush with the control room wall. The front panels contain the controls and indicating instruments for two 250-v, battery-charging motor-generator sets, the 115-v a-c emergency motor-generator set, and the 115-v a-c and 48-v d-c distribution air circuit breakers. The rear panels contain the 250-v d-c distribution air circuit breakers.

All relays for the controlled circuits are mounted on vertical-duplex-type boards located in the relay room adjacent to the main control room. All major relays are projection-mounted, drawout or flexitest-type.

Load and frequency control equipment

To maintain prearranged schedules of power interchange on the tie lines to other systems, it is necessary to vary the system generation with changes in load. This is done with automatic load control equipment designed to automatically change generation as required while maintaining the most economical loading of each unit. The control signal derived from interchange readings and system frequency is transmitted from the Chattanooga load dispatcher's office by high-speed variable-frequency telemetering and is received and recorded at Kingston by the load deviation recorder. All recorders, setters, and controls for the automatic load control are mounted on the recording instrument board in the control room. All electronic relays, governor motor actuators, unit sustained response actuators, and associated equipment are mounted on a rack in the communication room.

Relaying

The generator stator windings are protected against grounds, phase-to-phase faults, and open circuits by induction-type percentage-differential relays connected to the secondary of current transformers located in the generator phase and neutral end terminal bushings. In addition to the differential relays, the generator is protected against abnormal overload by time-overcurrent relays, against phase-to-ground faults by an induction-type overvoltage relay connected across the secondary load of the distribution-type generator neutral grounding transformer, and against field failure by a directional mho-type relay, which is connected to a separate current and potential source, and provides backup protection in the event of a failure of other generator relay protection. Reverse-power relays are provided to prevent motoring of the generator. Upon reverse-power relay operation, after a short time delay, reverse-power flow will be annunciated. If the operator has not taken steps to correct this condition within a preset time of 30 seconds, a second annunciation of this condition will be made (see main single-line diagrams, exhibits 21, 22, 23, 24, and 25).

The main power transformers and the common station service and unit station service power transformers are protected by induction-type percentage differential relays. Since there is no switching at generator voltage, the main power transformer differential relay zone includes the generator, the main power transformer, and the 161,000-v oil circuit breakers. Main power transformer or unit station service transformer differential relay operation in addition to tripping the turbine steam valve, exciter field breaker and 161,000- and 4160-v unit station service breakers will automatically operate a fire-protection water-sprinkling system surrounding the transformers. Common station service differential relay operation trips the 161,000-v breakers and 4160-v unit station service breaker and operates the transformer water-sprinkler system.

The 161,000-v transmission lines are protected by mho-type distance relays and high-speed, current-polarized directional ground relays operated in conjunction with powerline carrier-current pilot relays and auxiliaries. In addition, each line is equipped with a potential polarized directional ground backup relay. Two automatic reclosing relays are used—one to effect an immediate high-speed reclosure which is initiated by a breaker "B" auxiliary switch and the other to provide a second reclosure in event of a persistent fault. The second reclosure is supervised by a voltage check or synchronous check relay, depending upon the position of the reclosure selector switch. A set of instantaneous overcurrent relays with a high current setting is used to block the second reclosure in case a severe persistent fault exists.

Bus differential relays are provided for each 161,000-v main bus section. Impedance-type bus breakup relays are applied to each main bus section. In case of a persistent fault on a line or bus, due to failure of normal relay operation, after a preset time delay the breakup relays will trip the bus tie breaker and clear the faulted section of all generation. To avoid unnecessary tripping of important tie lines, line breakers of the faulted section are not tripped by the breakup relays. If a faulted line is not cleared by the protective relays of its own section, or by tripping of all generation on the bus section, the breakers at the far end of the line will be cleared by the second zone range of the relays adjacent to the faulted section.

Each main transformer breaker connected to the transfer bus is provided with a reclosing relay supervised by a synchronous check and a voltage check relay. Immediate or high-speed reclosing is not provided for spare breakers. One set of spare impedance-type relays and potential polarized ground relays is provided for each bus section. Plug-in arrangements are provided so the spare relays can be used with any spare breaker.

Two 12-element automatic oscillographs are located on the relay board for recording transmission line faults and for checking relaying current and potential behavior during fault conditions. The current, potential, and trip circuits are connected to the oscillograph through a test plug and block arrangement.

Communications systems

Various types of communication and allied equipment are located in the communication room in the control building basement. The following equipment is located in this room: private automatic exchange (PAX) cabinet; main distribution frame (MDF); turret relay rack (associated with manual telephone switchboard in control room); powerline carrier telephone transmitter-receivers; powerline carrier relaying transmitter-receivers; telemetering receivers; microwave multiplexing equipment for magneto circuits to manual switchboard, for dial circuits to PAX, and for telegraph circuits to printer-telegraph in powerhouse office wing; amplifiers for paging system; electronic equipment associated with automatic load-frequency control; annunciator relay cabinets; wire chief's test rack; power and supervisory racks; and miscellaneous relay racks.

A manual telephone switchboard and remote control radio console are located in the control room. The radio console is connected to a radio transmitter-receiver some distance away via a leased telephone cable pair. The radio frequency equipment for the microwave radio mentioned above is located in a house at the base of unit 1 stack. The antenna is mounted on the stack.

Dial and manual telephone systems—Local communication and signal facilities for the steam plant are provided by a PAX of the step-by-step-type. This is a 200-line PAX initially equipped for 150 lines and 14 simultaneous calls. Special features provided are code call, reverting call, conference call, executive right-of-way, and two dialing trunks to Chattanooga via microwave radio.

Code call may be used for paging a wanted party, for police recall, or for a fire alarm. Code call may be initiated from any PAX telephone by dialing a designated number. Each employee entitled to code-call service is assigned a special code. When the designated number is dialed, coded horn and bell signals are sounded throughout the whole steam plant area. The paged party can answer the call from any PAX telephone by dialing another predetermined number. Police recall is similar to code call except that other predetermined numbers are used, the signal is not coded, and flashing lights are also used. Dialing another designated number initiates fire alarm, an intermittent but not coded signal. It can be answered from the control room manual switchboard only.

Conference call of the fixed-group-type is provided for ten locations. The superintendent, shift engineer, switchyard, and unit control rooms in the powerhouse, control building, and water treatment building are on this circuit. Executive right-of-way service provides a means for calling a busy telephone. This service is made available only at the main control room switchboard and the shift engineer's office.

Three extensions from the PAX are connected via dialing applique and microwave radio to Chattanooga PBX and the Lonsdale PBX. This provides two dialing circuits from Chattanooga and one dialing circuit from Lonsdale to any PAX telephone at Kingston.

A 20-position cordless manual telephone switchboard is built into the control room operator's desk to serve as a terminal for a number of telephone circuits. The circuits include a dial-type and a magneto-type powerline carrier telephone circuit, three microwave radio circuits of the magneto-type, three local common battery circuits, two 2-way trunks from the PAX, one executive right-of-way circuit from the PAX, one fire alarm answering circuit, and one circuit to the entrance door. A few telephones belonging to the local public telephone company are also available for use in reaching points not covered by the TVA system.

Powerline carrier equipment—Two powerline carrier telephone transmitter-receivers are used for channels from the manual switchboard in the control room to other TVA projects. They make available direct-calling circuits to Watts Bar, Fort Loudoun, Chickamauga, Norris, and the K31 area at the Atomic Energy Commission, Oak Ridge, Tennessee. Both of these transmitter-receivers are amplitude modulated, single frequency. One is dial-type and the other is magneto-type. Ten powerline carrier transmitter-receivers are used for protective relaying channels. One powerline carrier receiver of the frequency-shift-type is used for the high-speed automatic load-frequency control channel.

Signal and annunciator system

Audible and visual alarms are provided for excessive temperatures of generator and transformer windings, for abnormal pressure or oil levels, for shutdown of major turbine and boiler auxiliaries, and for faulty operation or abnormal conditions of equipment throughout the station. In addition to and in conjunction with the annunciator equipment, an operation recorder is provided on the operator's desk in the control room which automatically records all annunciations as well as all normal operations of major switching equipment. Each recording on the chart of the recorder identifies the source of the signal and records the date and time when the signal was printed.

Control batteries, chargers, and battery board

The main control storage battery, rated 474 amp-hr at a 1-hour discharge rate, is floated at 258 v across the output of either of two 30-kw diverter-pole, motor-generator, battery-charger sets. This dependable 250-v d-c supply is used for control of all pneumatically operated oil circuit breakers, control and relaying circuits, and emergency lights. Upon loss of a-c auxiliary power, this battery also furnishes power for operation of a 15-kva motor-generator set to supply 120-v a-c to the 120-v preferred service bus.

The 120-v preferred service bus is used for station clocks, chart drive motors of recording instruments, and carrier-current telephone and telemetering equipment. This bus is normally energized from the lighting switchboard. Starting and stopping of the emergency motor-generator set and transfer of load are accomplished automatically upon loss or restoration of the normal power supply.

Auxiliary power boards

Auxiliary power at 480-v is supplied from two 3-ph, 4160-480-v, 300-kva transformers which are fed from the 4160-v common boards A and B in the powerhouse (exhibit 5). Each transformer has sufficient capacity to carry the auxiliary power, heating, lighting, and air-conditioning loads of the control building. These transformers are located in the spreading room beneath the main control room. They are self-cooled, noninflammable, liquid-filled-type. The secondary of each transformer is connected to one section of the 480-v auxiliary power board by means of enclosed bus. Auxiliary power is distributed through 2- or 3-pole air circuit breakers to the various loads in the area. The 480-v air-conditioning board is located in the air-conditioning equipment room and is supplied by a feeder from the auxiliary power board.

Lighting

The control building a-c lighting system is supplied from one 75-kva, single-phase, 480-240/120-v transformer with a voltage regulator on the primary side. Single lighting switchboard distributes the power through air circuit breakers to the usual mains, distribution cabinets, and branch circuits. Individual rooms, such as offices and communication room, are locally switched, whereas general areas, such as spreading room and control room, are cabinet-switched.

Commercial-type fluorescent fixtures are used in offices, communication room, and relay room. Standard industrial incandescent fixtures are used in other working areas. The main control room has a totally indirect lighting system consisting of rows of reflector-type incandescent lamps recessed in the top of the switchboards and directed toward the ceiling.

MECHANICAL FEATURES

Heating, ventilating, and air conditioning

The air-conditioned spaces are heated by thermostatically controlled electric blast heaters located in the air supply systems for these rooms. The remaining rooms requiring heat have thermostatically controlled unit electric heaters. The installed heating capacity is 141 kw.

The air-conditioned spaces are ventilated by the air-conditioning supply air systems at times when neither heating nor cooling is required. The remaining rooms are served by exhaust fans. Fresh air entering the relay room is filtered for the protection of electrical equipment. The quantity of air mechanically supplied and exhausted is 38,000 cfm.

The control room, test engineer's room, communications room, and public lobby and vestibule are cooled and dehumidified, heated and humidified, and ventilated for the protection of electrical equipment and for human comfort. A total of 30 tons of refrigeration is employed.

Plumbing

In addition to the employees' toilet room there are toilet rooms for visitors located off the public lobby. A kitchen unit and drinking fountain are provided for use of employees; a service sink is located in the janitor's closet; a double-compartment kitchen-type sink is installed in the photographic dark room; a single-compartment kitchen-type sink is installed in the battery room; and a drinking fountain is provided in the public lobby. Hot water is supplied by a 50-gallon electric water heater. Exhibit 81 is a diagrammatic layout of fixtures and distribution system. Sewage from the building flows by gravity to the station sewer system.

Drainage facilities

Roof drains are collected in downspouts and discharged to the yard drainage system by gravity. Drainage from basement floor, condensation between foundation wall and inner finished wall, and drainage from battery room sink flows to a sump in the basement. A float-controlled duplex sump pumping unit discharges this drainage into the yard drainage system.

Compressed air and water system

A 1-inch air line from the station service air system serves six air service outlets in this building (exhibit 74). A 1½-inch raw water line is provided from the yard system to provide water for two 1½-inch fire hose racks in the building. A separate 3-inch line serves the air-conditioning equipment (exhibit 76).

WATER TREATMENT PLANT

The location of the water treatment facilities was principally determined by the requirement that it be close to the intake to allow the operation of both of these features to be controlled from one central location. To avoid interference with the condenser cooling water pipelines, it was located adjacent to the access deck at the east end of the intake.

The function of the water treatment plant is to supply domestic water for the entire project and softened water for boiler feedwater makeup. The water treatment plant building also houses the electrical control room for the pumping station.

Three raw water supply pumps of the vertical-turbine-type, located in the condenser circulating water pumping station, supply screened raw water to the plant. The source of raw water may be the Emory River, the Clinch River, or a combination of the two.

Type of treatment

The primary treatment by this plant consists of prechlorination, chemical dosage, flocculation, sedimentation, and filtration. After filtering, that portion of the water which is to be used for boiler feedwater is softened by the sodium zeolite process, while that used for domestic purposes is chlorinated and stabilized. The zeolite used is a high-capacity polystyrene resin. The prechlorination is for control of algae and disinfection of water for domestic use.

Because of the low silica content no silica removal is necessary. However, precaution was taken in the design to prevent any silica pickup; carborundum plates instead of graded gravel are used for the filter bottoms; anthracite coal is used in lieu of filter sand; and the storage wells are lined with an inert enamel coating.

Capacity

The plant has four filters with a capacity of 120 gpm each; 320 gpm is softened for the boiler feed makeup, and the remainder is used for domestic and plant use. The four zeolite softeners each have a design capacity of 80 gpm which is based on a boiler feed makeup of 1.5 percent. After the initial break-in period the boilers all operate at about 1.25 percent makeup.

Operation

Except for washing of filters, adjusting and servicing chemical feeders, and regulating control valves, the plant is automatically operated. The raw water pumps, located in the valve room of the intake structure, are controlled by float switches in the settling basins. The rate of flow is controlled by a manually adjusted globe valve in the supply line with a manometer installed adjacent to this valve to facilitate accurate valve setting.

The controlled water is prechlorinated before entering a flash mixer. The float switch which controls the raw water supply pumps also controls a solenoid-operated valve on the control waterlines to the chlorinator.

Chemicals are added—a coagulant such as aluminum sulfate and an alkali such as hydrated lime or soda ash—in the flash mixer. Activated carbon is added when needed. The dosed water flows from the flash mixer to two mechanical flocculators for a period of gentle mixing for proper floc formation. Each flocculator has a retention period of about 30 minutes and supplies two settling basins.

From the flocculators the coagulated water flows to four settling basins where it is distributed over the entire width and about half of the depth by means of troughs and perforated wooden vertical baffles to produce uniform distribution. The coagulated water flows through the settling basin at a very low velocity. Most of the floc and absorbed suspended matter settles to the bottom, and relatively clear water passes over the outlet weir and to the filters. The effective volume of the settling basins will give a 4-hour retention period at the design rate of flow. A float switch operated by the level in the settling basins controls the raw water supply pumps, prechlorinator, dry chemical feeders, and flocculator drives.

The settled water enters the filters near the top and flows down through the filter media and porous plates through a 4-inch rate controller and out into the filtered water clearwell. When the clearwell becomes full, the controller closes and water backs up into the settling basin and actuates the float switch which stops the raw water supply pumps and chemical feeders.

The filters require washing when the loss of head through the media becomes 6 to 8 feet, as indicated on the loss-of-head gauges. The filters are equipped for both surface wash and regular washing. Water for the surface wash is obtained from the domestic system, using system pressure, and the flow is controlled by a manually operated valve. Water for the regular wash is obtained from the filtered water well by means of a vertical-turbine-type pump with flow controlled by a manually operated valve. A manometer installed near this valve permits accurate flow adjustment.

The filtered water clearwell supplies filtered water for the domestic and the softened water systems and for washing the filters. A low-level float switch will actuate an alarm in the control room and stop pumps at abnormally low levels.

The domestic water system consists of two supply pumps that pump filtered water from the filtered water well to the domestic water well. A hypochlorite solution and a stabilizing chemical are injected into the pump discharge pipe by hypochlorinators. From the domestic water well two domestic water service pumps supply water to the treated water distribution system and to four storage tanks on the powerhouse roof which float on the system and have a total capacity of 35,000 gallons. The domestic water supply pumps are controlled by the float switch in the domestic water well. The domestic water service pumps are controlled by float-operated mercoid switches installed at the storage tanks.

The softened water system consists of four softener supply pumps, four automatic sodium zeolite softeners, two brine pumps, storage bins, brine-measuring tank, softened water well, and four soft water service pumps. During normal operation the softener supply pumps are controlled by the float switch in the softened water well. The softened water service pumps operate continuously, and the flow of water to the preheaters is controlled by a float valve at the evaporator preheaters in the powerhouse.

A flow diagram of the treatment system is shown in exhibit 80.

SUBSTRUCTURE

The substructure is essentially a reinforced concrete box-like structure resting on earth and containing the clear water wells and salt-storage bins which are formed by suitably arranged division walls. The 24-inch base slab is designed for shrinkage resulting from full restraint and for all conditions of operation, with a maximum allowable soil pressure of 2 tsf. As an added precaution against leakage, all interior wall and floor surfaces of water wells, salt-storage bins, filters, and flash mixer were painted with three coats of a special sealing enamel.

SUPERSTRUCTURE

Architecture

The 2-story enclosed portion of the building, about 53 by 66 feet, houses pump rooms and equipment space on the ground floor and control room, chemical equipment room, and miscellaneous service rooms on the second floor. The four settling basins, about 52 by 61 feet overall, are outdoors and uncovered (exhibits 15 and 16).

Exterior—The entrance face of the building presents two wall panels of buff-gray brick framed by the blue-green exposed steel wall columns and the deep steel roof spandrel of the same color. The brick panels are separated by a 10-foot-wide entrance, featuring a pair of full-glazed hollow metal doors in aluminum frames. Aluminum-framed windows extend above the doors up the full 2-story height to the steel roof fascia (fig. 59). The main structure is flanked on the right by the long, low, brick enclosing wall of the settling tanks. A protective pipe railing painted red in contrast with the dark blue-green color of other exposed steel extends around the top of the settling tanks. The simplicity of this building is expressive of its practical, utilitarian purpose.

Interior—In general, the pump room and other similar areas have uncolored concrete floors and ceilings and buff unglazed facing tile walls. The control room has the same wall construction, but the ceiling is plastered and the floor is covered with gray marbleized rubber tile. The long west wall has a continuous row of large aluminum-framed windows glazed with blue-green, heat-absorbing plate glass shaded by aluminum venetian blinds.

Steel structure

The steel framing consists of standard rolled steel columns with clear span girders and beams of riveted construction and is designed for a maximum allowable stress of 20,000-psi base stress.

Settling basins

The settling basins with the flocculators are contained in reinforced-concrete structure with four main tanks or basins. This structure adjoins the east wall of the treatment plant (fig. 59), and one side of the structure is supported on this wall to prevent differential settlement. Otherwise, the basins rest directly on the ground and are designed for an allowable bearing value of 2 tsf.

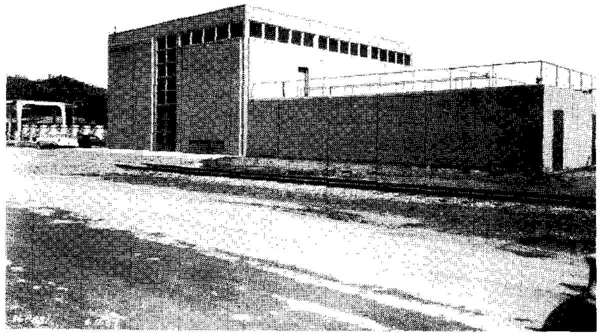


FIGURE 59.—*The water treatment plant houses all facilities for primary treatment of water required for steam plant operation, and for supplying the domestic water requirements throughout the plant.*

Concrete floors and roof

The pump room floor at elevation 762.5 forms the roof of the water wells below. Concrete foundations for the pumps and other equipment are set directly on the reinforced concrete structural floor slab without dowels. Also erected on this floor are the trickling filters, essentially a concrete cellular box containing four filter beds.

The upper floor is 2-level with cast-in-place concrete floor slabs supported on structural steel. The floor slab of the control room at elevation 777.5 is covered with a 12-inch concrete fill for embedding the considerable number of conduits leading to the control equipment for the intake and water treatment plant.

The roof is a steel deck with 2 inches of rigid insulation and 4-ply, smooth-surface, built-up roofing. The painted underside of the steel deck forms the ceiling for storage and equipment areas.

MECHANICAL FEATURES

Pumps

All pumps in the water treatment plant are vertical-turbine-type except the brine pumps which are horizontal-centrifugal-type. Vertical pumps were used to conserve space and piping. Three raw water supply pumps located in the pumping station supply water to the treatment plant through a 6-inch pipe. Each pump has a capacity of 240 gpm against a discharge head of 85 feet. Two of these pumps furnish the desired flow of 480 gpm; the other is a spare. Two pumps may also be used for filling the condenser circulating water conduits.

Four pumps with a capacity of 160 gpm each against a discharge head of 65 feet are provided to pump water from the filtered water well through the softeners and into the softened water well. Two of these pumps are sufficient for normal capacity; the other two are spare but one can be used for washing during the regeneration cycle.

Two domestic water supply pumps, each with a capacity of 40 gpm against a discharge head of 20 feet, are used to pump water from the filtered water well through the chlorination system to the domestic well. Only one pump is operated at a time; the other is a spare.

Two pumps, each with a capacity of 150 gpm against a discharge head of 165 feet, pump water from the domestic water well to the 35,000-gallon elevated storage on the powerhouse roof.

Two pumps are provided for transferring the brine solution from the storage bins to the brine-measuring tank or for transferring brine from one storage bin to the other. Only one pump is used at a time; the other is a spare. Each pump has a capacity of 15 gpm against a discharge head of 30 feet.

Four pumps with a capacity of 160 gpm each against a discharge head of 320 feet are provided to transfer the softened water from the softened water well to the evaporator preheaters in the powerhouse. Two pumps will supply the normal capacity; the other two pumps are spare.

One pump is used for washing the filters. The capacity of this pump is 1050 gpm against a discharge head of 35 feet.

Chemical feeders

Raw water for the treatment plant is dosed with a coagulant and an alkali as it passes through the "flash mixer." Two dry chemical feeders are used to feed these chemicals. A third dry chemical feeder supplies activated carbon to the raw water at the "flash mixer" at times when an unpleasant taste or odor are present in the water.

There are three electric-motor-operated solution feeders and three solution containers for conditioning the filtered water for domestic use. One feeder is used to feed a hypochlorite solution, another is used to feed calgon or an alkali, and the third is a spare. The feeders are the adjustable-stroke diaphragm-type and pump the solution directly into the pipeline under pressure.

Flocculator drives

Each flocculator is equipped with an electric-motor-driven stirring device. This device consists of wooden paddles suspended from cross arms attached to a vertical shaft that is coupled to the drive shaft of a speed reduction unit.

Filters

There are four rapid-sand filters, each 10 by 6 feet which filter at a rate of 2 gal per sq ft. The filters are constructed with a fused alumina porous plate underdrain system and support 33 inches, in two layers, of anthracite filter media.

Filter rate control system

The rate of flow through each filter is controlled by a rate-of-flow controller installed on each filter effluent line. As the filter media becomes clogged and head loss occurs, the controllers will open wider to compensate for the loss of head allowing normal flow to continue. Each controller consists of a venturi metering section, a hydraulically operated tight-closing valve section, and a device for actuating and controlling the throttling section of the valve.

Flowmeters

The rate-of-flow indicators used for the raw water supply to the plant and the wash water for washing the filters are of the single-tube mercury manometer type. The flow differential is measured across an orifice plate installed between two flanges in the pipelines.

A propeller-type water meter is installed in each of the two softened water lines to the powerhouse. These meters indicate the rate of flow in gallons per minute and totalize the number of gallons pumped through each line.

A 3-inch, positive-displacement, disc-type totalizing water meter is installed in the pipeline between the filtered water well and the domestic water well to measure the quantity of domestic water used.

Float switches

Float-actuated electrical switches are used to control the water level in the settling basins, water storage wells, and brine-measuring tank by opening and closing the circuits to various pumps and solenoid valves that control the flow to and from them. These switches also actuate the chemical feeders and flocculator drives and sound alarms when abnormal operating conditions occur or are imminent.

Softeners

Softened water for the boiler feed makeup is provided by four vertical, pressure-type, sodium zeolite softeners, each with a design capacity of 80 gpm. These units may be operated at a much higher rate for short intervals, as might be required when one unit is out of service for regeneration. The zeolite used in this system is a sodium cation exchanger of a high-capacity polystyrene resin having an exchange capacity of 20,000 grains per cu ft.

Because of the variable quality of the raw water a completely automatic zeolite softening system is impractical. A meter on the discharge of each softener initiates an alarm after a predetermined amount of water has been softened. This may be a long or a short run, depending upon whether the Emory or the Clinch River water is the major source. After making hardness tests on the effluent to determine if regeneration is necessary, the operator initiates regeneration by push button on the control panel. The system is automatic from this point throughout the complete cycle of washing, brining, rinsing, and return of the unit to the softening cycle.

Conductivity instruments

A conductivity indicator based on the mineral content is connected into the softener supply line so that the source of raw water may be determined. A low mineral concentration indicates that the principal source is the Emory River and a high concentration or conductivity indicates that the principal source is the Clinch River.

A conductivity recorder records the relative conductivity of the water entering and leaving the softeners and sounds an alarm if any abnormal amount of conducting chemical should leak into the softening system.

Salt-storage bins

The salt used for the regeneration of the zeolite softeners is stored in three underground concrete bins. Each bin is equipped with an access manhole, has a domestic water supply connection, and is located near the roadway for the convenience of unloading salt directly from a truck. The three bins have a combined capacity of approximately 137,000 pounds of salt.

Storage facilities

Chemicals—A ground floor room adjacent to the pump room is for storage of chemicals. A hatch is provided in the floor of the chemical equipment room through which the chemicals are hoisted from the ground floor level by means of a 500-pound, hook-type electrical hoist suspended from a roof beam.

Chlorine—A room at the southwest corner of the water-treatment plant is for the storage of chlorine used for raw water prechlorination.

Drainage system

Drainage from filter washing, softener room floor drains, overflows from the softened and filtered water wells, flash mixer to flocculator piping drain, roof drain header, and the laboratory sink flows by gravity to an outside manhole located at the northeast side of the water treament plant and thence through a drain to a manhole located about 85 feet north of the settling basins where a drain from the settling basins enters. It discharges from this manhole into the intake channel. The drain from the settling basins is a header which drains each settling basin, each settling basin overflow, each flocculator, and the flash mixer. A drain from the prechlorinator room is connected to the trash sluice. Gutter drains in the filter operating and filter piping galleries are piped to the gutter in the access tunnel leading to the pumping station. Drainage from this gutter discharges into the pumping station valve room gutter.

A 4-inch header is connected to two emergency drains for the drainage of the oil from the transformers in the control room, and a 6-inch header is connected to the sumps for each pair of softeners; each of these headers discharges into the trash sluice pipe in the yard.

All the storage wells are equipped with sump pits for all pump suctions so that they may be drained by the respective pumps. The brine storage pits are drained by the brine service pumps.

Heating and ventilating

The water-treatment plant is generally heated by thermostatically controlled electric unit heaters strategically placed for the protection of mechanical and electrical equipment and for the relief of dampness. Portable electric heaters provide any necessary supplementary heating. The total heating capacity is 114 kw.

The building is ventilated for the removal of heat from electrical equipment and solar radiation and for the relief of dampness. A total of 34,700 cfm of air is supplied and exhausted.

CONTROL ROOM

Electrical equipment

The water treatment plant control room contains the 480-v main power board; 480-v feeder board; lighting, heating, and ventilating board; and condenser circulating water pump control panels. The 480-v main power board is in two sections with a tie breaker between. Each section is fed from 4160-v common board A or B in the powerhouse through a 1000-kva, 4160-480-v transformer (exhibit 5).

Communication is obtained by telephone and code-call bells in the control room, on the pump deck, and in the cone valve room. A code-call horn is mounted on the roof of the water treatment plant to alert operators in the outdoor area.

Operations

The control switches, with indicating lights for condenser circulating water pump motors and associated cone valves, are located on the condenser circulating water pump control panels. Traveling screen speed indicators, traveling screen motor, and screen wash pump motor indicating lights are also located on these panels. The operator knows at all times the operating condition of these circuits by means of ammeters, indicating lights, and annunciator windows. Red and green indicating lights and window-type annunciation for the condenser circulating water pump motors are duplicated in the respective unit control rooms so the unit control room operator will know which pumps are in operation and when a trip-out occurs.

Each condenser circulating water pump motor is equipped with a 2-kw strip heater to prevent moisture from damaging the motor winding insulation during periods of shutdown.

The traveling screen motors are interlocked with the screen wash pumps through a pressure switch in the discharge header so they start automatically when the screen wash pumps are operating and the discharge valve is opened. The start-stop push button for the screen wash pumps is on the pump deck in view of the traveling screens.

In addition to the 480-v motors, which are controlled locally by push button or in some instances by float switch, there are numerous fractional horsepower motors required in the water treatment process. These 115-v motors are supplied through a 480-120-v, 5-kva transformer mounted in the feeder board. The control of these chemical feeder motors is by timer or by contacts in the control circuit of associated equipment.

COAL HANDLING AND STORAGE

The basic planning of the Kingston Steam Plant was predicated on the following coal handling and storage requirements (see fig. 60).

1. A storage area capable of storing a 90-day supply of coal based on the needs of the complete plant.
2. Provisions for receiving coal by railroad and by highway truck.
3. A duplex conveying system from the crusher building and the coal storage area to the bunkers of the boiler room to ensure deliveries of coal between these points.
4. Sufficient capacity in the coal handling system to handle the full-load requirements of the plant plus 25 percent of this quantity for stocking-out in the storage area, this operation to be handled on a 2-shift basis, five days a week.

To meet requirement No. 1 a large area west of the powerhouse site was selected. This area was large enough for the required coal storage and for future increase if desired. It permitted good rail and highway access arrangements and was far enough from the main plant so as not to interfere with its activities. The location of this area also minimized the effects of coal dust at the main plant and the contamination of the intake water by drainage from the coal pile. The size of the storage pile was set at 1,350,000 tons, with a pile depth of approximately 25 feet.

Requirement No. 2 was met by providing incoming and outgoing operating and storage railroad tracks and a highway to the truck-unloading facilities. At the rail reception point, two hopper buildings were constructed, each equipped with a rotary-type dumper for power dumping coal from railroad cars. One of the hopper buildings is also provided with a separate combined track and roadway for manually dumping coal from railroad cars or motor trucks. Equipment for obtaining coal samples both automatically and manually is provided at each hopper building. Scales for weighing rail- and truck-received coal are located adjacent to the hopper building.

Requirement No. 3 was met by providing a complete flexible system for sizing, screening, and conveying coal to the bunkers in the powerhouse from either the crusher building or the storage area or from the crusher building to the storage area. It also includes equipment for handling the coal in the storage area.

Requirement No. 4 was met by setting the following capacities for the various coal handling and sizing units:

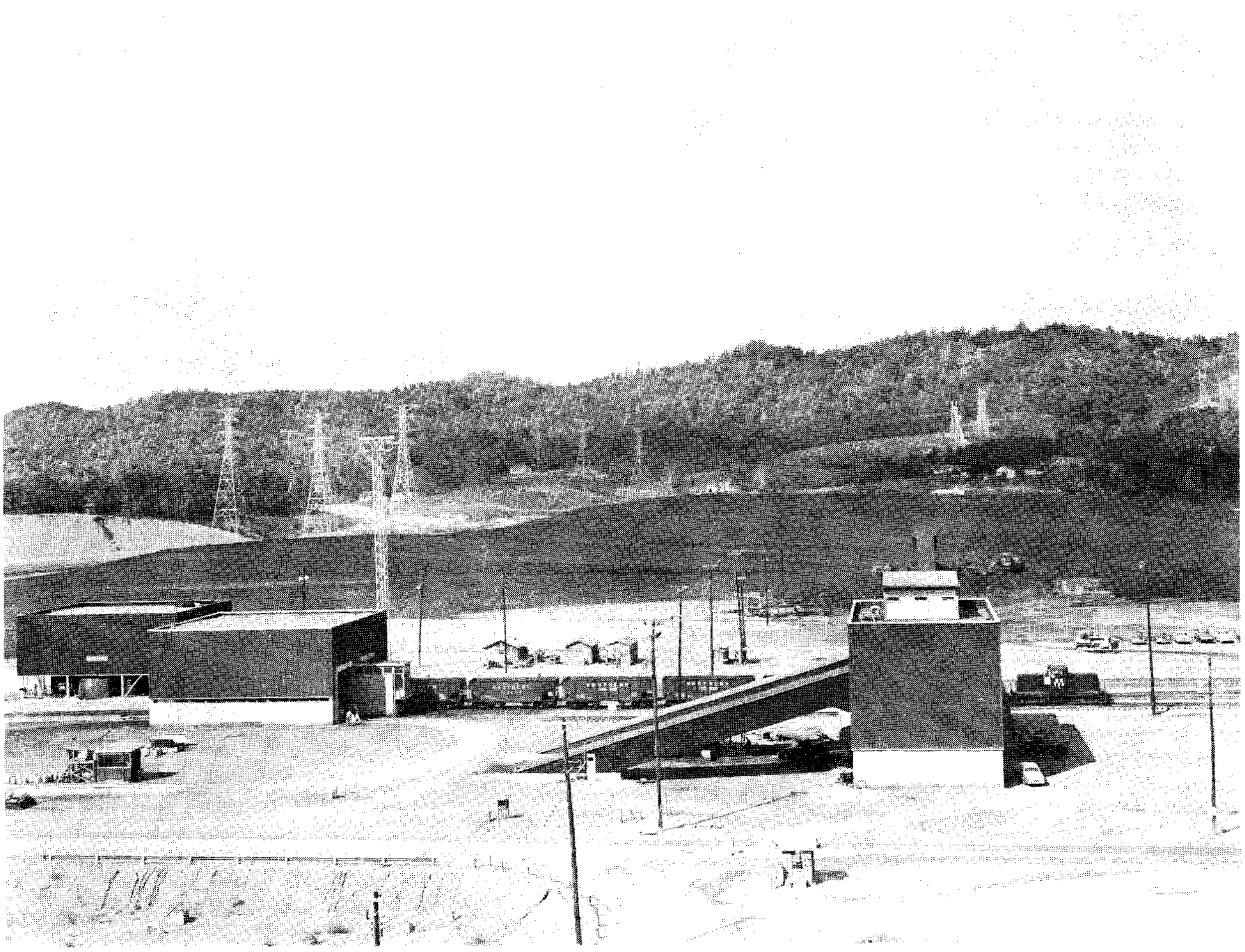


FIGURE 60.—*An over-all view of the coal handling facilities showing the 90-day storage area of 1,350,000-ton capacity. Coal hopper buildings Nos. 1 and 2 are shown at left, each containing rotary rail car dumpers with No. 2 to the right also containing truck unloading facilities. The then incompleted truck scales and sampling building are shown at lower left; the crusher building with control penthouse is shown at right with stocking out conveyor extending beyond.*

Railroad- and truck-received coal	Total capacities
Receiving hoppers (surcharged 30 degrees—total all hoppers)	124 tons
4 vibrating feeders	2000 tph
2 rotary car dumpers	40 cars per hour
2 belt conveyors	2000 tph
Crusher building	
4 vibrating screens	2000 tph
4 crushing units	2000 tph
Conveying to bunkers	
2 inclined belt conveyors	2000 tph
2 horizontal belt conveyors	2000 tph
2 belt trippers	2000 tph
Conveying to storage	
1 inclined belt conveyor	1000 tph
Reclaiming from storage	
2 sets of vibrating feeders	2000 tph
2 belt conveyors	2000 tph

No facilities were designed at this plant for receiving coal by barge shipment. General rail and truck facilities are shown in exhibit 1 and the general conveyor system is shown in exhibit 4.

RAIL AND TRUCK UNLOADING FACILITIES

It was anticipated that at Kingston the major portion of the coal would be delivered by rail and that considerable truck delivery could also be expected. Therefore, the design and planning provided for both types of delivery on a large scale. Pending the development of delivery by truck, adequate rail facilities were installed to provide for the total requirements of units 1-8. When the ninth unit was added the rate of truck delivery had progressed sufficiently that the original rail facilities were still considered adequate.

The following assumptions were used for establishing the capacity of the rail system:

1. The 8-unit plant operating at 100 percent capability (1,400,000 kw) and burning coal at the rate of 0.83 pound per kwh would consume 14,000 tons of coal each 24 hours.
2. The average coal car presently in use is about 40 feet long between couplings and has a capacity of 50 tons. It would require 280 such cars per day to furnish the 14,000 tons of coal burned.
3. To offset irregularities in the delivery of coal and to provide for the building of the coal-storage pile, it was deemed necessary that the interchange yards should have a capacity of 2 days consumption, the loaded car yard 3 days, and the empty car yard 2½ days.

The nearest rail point to the plant is at Emory Gap, about 6 miles from the plant site; this point is served by both the Tennessee Central Railroad and the Southern Railway. As a result of negotiations with these railroads, TVA constructed one interchange yard at Caney Creek to handle cars arriving over the Tennessee Central Railroad, and the Southern Railway built another interchange yard along its line at Emory Gap. The railroads deliver the loaded cars and pick up the empty cars at these yards, and TVA does all the hauling between the interchange yards and the plant.

At the plant site, in addition to the storage yards and access tracks through the hopper buildings between the yards, there is a return track from the empty yard along the loaded yard and back to the access railroad. The track system at the plant is shown in exhibit 1, and the locality map on this exhibit shows the interchange yards and the access railroad.

All tracks were constructed with new 90-pound ARA type A rail, and turnouts are No. 8 with solid manganese steel self-guarded frogs. All multiple tracks are 14 feet on centers. The ballast consists of crushed blast furnace slag applied at the rate of 0.5 cu yd per foot of single track. Crossties of creosoted hardwood, 7 inches by 9 inches by 8 feet 6 inches, were used at the rate of 22 for each 39 feet of track on the main traffic line, and 6 inches by 8 inches by 8 feet 6 inches at the rate of 20 per 39 feet on all other tracks.

The total amount of track constructed for the project was:

	Miles
Interchange yard	3.1
Access railroad	5.9
Loaded car yard	9.2
Empty car yard	8.5
Hopper and return track	2.7
Plant tracks	1.2
Total	30.6

Delivery

Interchange yards—The location finally selected is in the Caney Creek Valley near Emory Gap and approximately 0.4 mile from an existing spur on the Tennessee Central Railroad. The yard was originally designed for an ultimate capacity of about 572 cars, but before the track was laid, authorization of additional units made it necessary to make arrangements also to receive coal from the Southern Railway. Since the Southern chose to install their own facilities for interchange, the contemplated track capacity of the Caney Creek interchange yard was reduced to 254 cars.

The connection to the Southern's interchange yard was made by running a track from TVA's interchange yard in a westerly direction for about 0.7 mile to the Southern's main line.

Loaded yard—The loaded yard consists of 21 tracks with a total length of 48,790 linear feet and provides storage for 854 cars. The original design provided for the construction of sufficient additional tracks to increase the capacity of the yard to 948 cars if required. The yard covers an area of slightly more than 15 acres, and since, for operational purposes, this area is very flat it was necessary to provide an extensive drainage system. The subgrade is corrugated longitudinally with troughs on 28-foot centers, or between every other track. At intervals of about 300 feet concrete catch basins were placed in these troughs and connected transversely with 18-inch concrete pipes which carry the drainage from the yard. The catch basins are covered with cast-iron "beehive" grates, and the ballast is shaped to these grates so as to provide for both open drainage and percolation.

The loaded cars are brought from the loaded yard to the two hopper buildings over a system of tracks which provides for the cars from the eastern half of the yard to pass over the track scales and for all cars to pass through the hopper buildings on either of three tracks.

Empty yard—After the coal cars have been unloaded in the hoppers, they are pushed forward to the humps which are located immediately south of the hoppers. The humps drop the cars 6 feet in a distance of 150 feet and will, even under adverse weather conditions, carry the cars well toward the far end of the yard where a sharp upgrade keeps the cars from overrunning the storage tracks. Since the yard was designed to operate by gravity under adverse weather conditions, during favorable weather the speed of the cars tended to be excessive. After obtaining some operating experience, automatic car retarders were installed at the entrance to the yard, and, through controls located at the hopper buildings, this retarder can be set to control cars over a wide range of speeds.

The empty yard consists of 22 tracks, measuring 44,944 linear feet, and provides a normal storage for 715 cars. In an emergency this can be increased to 770 cars by pushing the cars forward to the clearance points. The drainage system within the yard is similar to that described for the loaded yard.

Truck delivery—Since the plant is within short hauling distance of several coal producing areas, provisions were made to receive coal hauled by truck, and facilities were installed to receive 500 to 600 trucks per 16-hour day. Trucks are diverted from the access highway several hundred feet west of the main entrance gate and follow a channelized roadway pattern to the truck scale where the coal is weighed and sampled, thence through hopper building No. 1 where the coal is dumped in the hopper under the manual car-unloading tracks, and then returned to the access highway. In order to minimize congestion and traffic hazards in the area of the coal receiving facilities, the road system is designed to separate the coal trucks from the employee, visitor, and other traffic to the plant.

Hopper buildings, car dumpers, and sample preparation building

The hopper buildings are located over incoming railroad tracks. Hopper building No. 1 houses a rotary car dumper (fig. 61) and the through track for unloading coal from hopper bottom cars and dump trucks. Hopper building No. 2 houses a rotary car dumper, with no provision to accommodate hopper bottom cars or dump trucks. The sample preparation building is located on the east side and adjacent to hopper building No. 1.

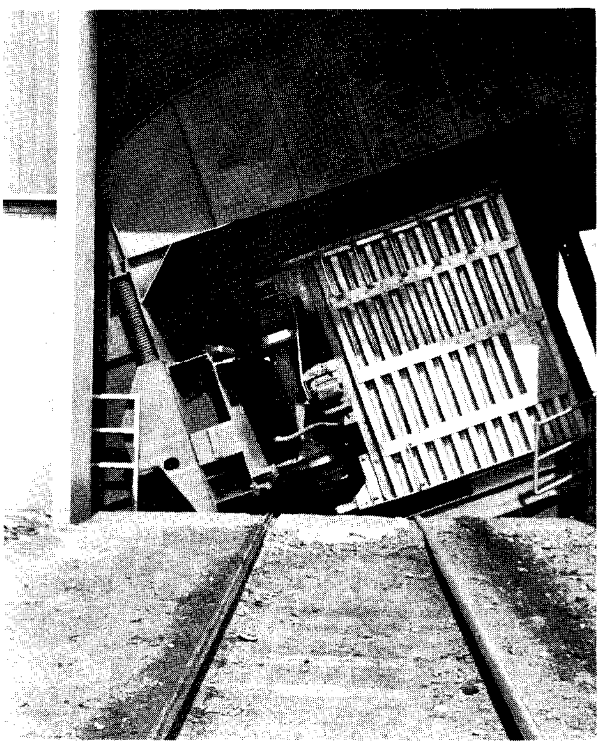


FIGURE 61.—*Each of two car dumpers has a capacity of twenty 50-ton cars per hour.*

Substructure—The main portion of the substructure for hopper building No. 1 appears on exhibit 8. The length and width of the structure were determined by the length of a gondola coal car and by the width of the rotary car dumper plus the width of the manual unloading track. The depth of approximately 53 feet was set by the requirement that the angle between the hopper sides and the horizontal be not less than 50 degrees and by requirements for skirting, vibrators, and conveyor machinery. All construction joints are protected with metal water seals since the bottom is about 40 feet below maximum assumed reservoir level.

Main reinforcement in the sloping hopper faces was kept 6 inches from the surface and a layer of wire mesh placed 3 inches from the surface. This provides an expendable wearing surface and facilitates repair where the concrete erodes.

Where tracks pass into the building, concrete rocker beams 11.5 feet long with one end resting on the substructure wall are placed under each rail to maintain the vertical alignment of the track as cars enter and leave the building.

The substructure for hopper building No. 2 provides a track for the rotary car dumper only. Its width could therefore be made 10 feet less than for hopper building No. 1. Otherwise, the two structures are similar as to detail and construction, with both built on a rock foundation.

Superstructure—Hopper building No. 1 is approximately 64 feet wide, 70 feet long, and 34 feet high, housing a rotary car dumper, with a control and sampling wing 8 feet wide, 18 feet long, and 18 feet high. There are two rolling steel doors at each end of the building.

The upper part of the building is faced with maroon steel panels; the base is buff-gray brick. The projecting steel box frames of the track doors form a pleasing border for the brick-red rolling steel doors (fig. 62).

The wing housing the car dumper controls and sample collection rooms projects lengthwise from the west end of the building between the rolling steel doors. It has an exterior wall of buff-gray face brick with the steel exposed on the outside. The steel louvers are painted medium blue-green and the window wall is blue-green steel sash with aluminum panels.

A sample preparation wing was subsequently added along the east side of the main structure. This is a 1-story addition of approximately 1300 sq ft and houses facilities and equipment for preparing and analyzing coal collected at the sample collection rooms. About half the area is devoted to the sampling facilities and the remaining space is for toilets and showers, locker room, and equipment room. The exterior is of the same brick as the powerhouse. Interior walls are clear-glazed facing tile. The floor of the sampling room is rubber tile and the ceiling is exposed steel decking; toilets and locker room have ceramic tile floors and sand finish plaster ceilings. Other areas have cement floors and exposed steel

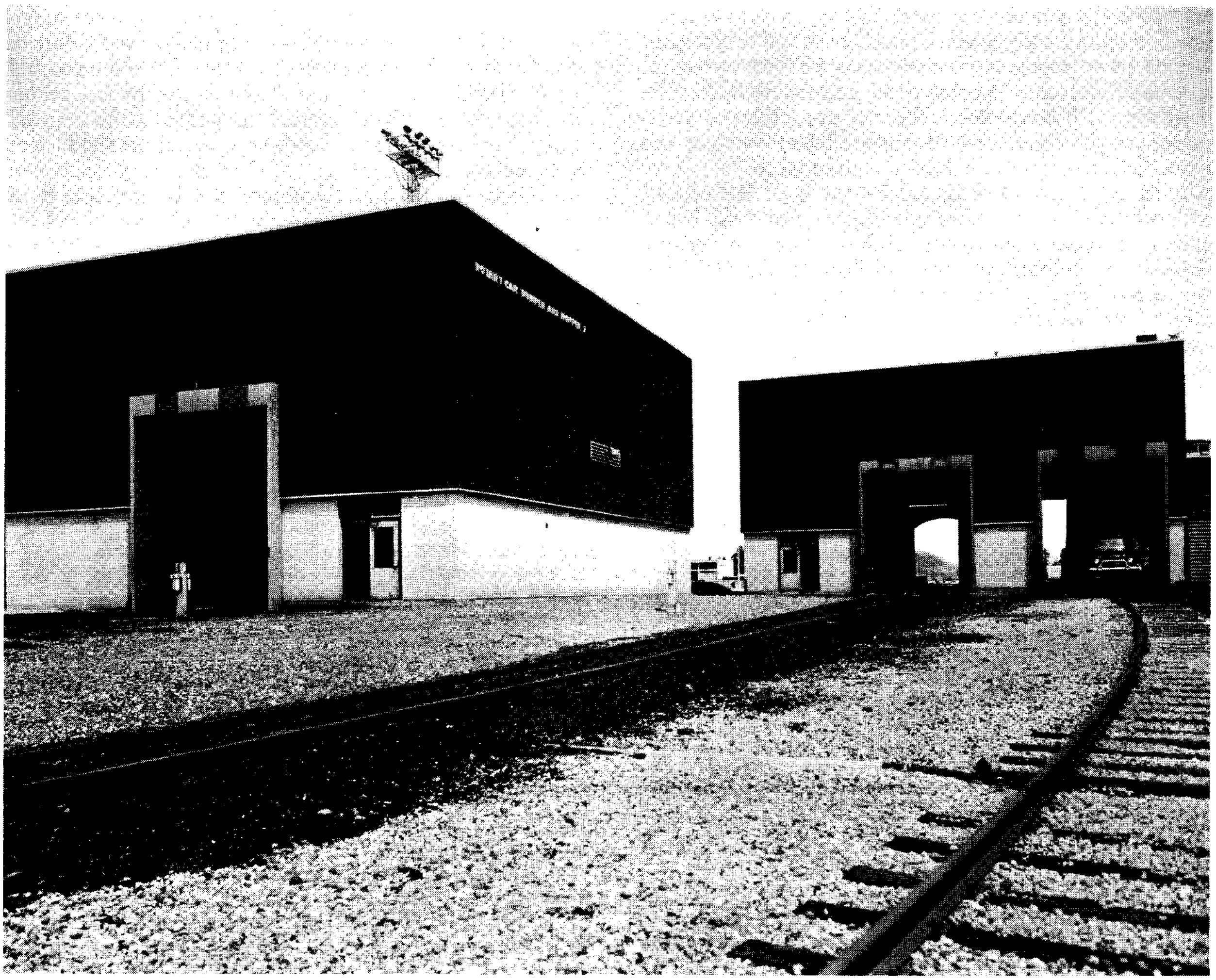


FIGURE 62.—*Hopper buildings No. 1, at right, and No. 2 each house a rotary car dumper. Hopper building No. 1 also provides through-rail tracks and accommodations for coal dump trucks.*

ceilings. Hopper building No. 2 is a duplication of hopper building No. 1 except that it is 10 feet less in width and is provided with only one through track.

The steel framing of the hopper buildings is riveted construction and consists of rolled steel columns, beams, purlins, girts, and bracing. At the ends of the buildings and at approximately the third points roof trusses span the width of the building. The steel framing of the sample preparation building is also of riveted construction. The roof purlins and trusses were designed for a 50-psf live load, and the through track supporting beams were designed using Cooper's locomotive loading standards for Railway Bridges E50 loading. The wing housing the car dumper controls and sample collection rooms has all-welded steel framing. All structures were designed for a 30-psi wind load and an allowable unit stress of 18,000 psi.

The floor of the sampling room at elevation 777.06 is a 6-inch reinforced cast-in-place concrete slab with a cement floor finish supported on structural steel framing. The sample preparation building is constructed on a 10½-inch reinforced concrete floor slab supported on earth.

Rotary car dumpers—The rate of flow of coal from railroad cars or highway trucks to the crusher building was set at 2000 tph. This is forty 50-ton cars per hour, or a car every 1½ minutes, and necessitated two car dumpers. Each unit has a capacity of twenty 50-ton cars per hour, or a car every 3 minutes. The general arrangement of rotary car dumper No. 1 is shown in exhibit 9.

Coal sampling equipment—A representative sample of coal from each carload or truckload received is required for laboratory analysis to determine the quality for contractual purposes. Provision was made at each hopper building for both manual and automatic sampling from the railroad cars. Normal sampling of rail-received coal is by means of the automatic sampling arrangement which functions in conjunction with the operation of each rotary car dumper. In the event the automatic sampling equipment is inoperative, samples are taken manually from each railroad car before it enters the building. Platforms along one side of the control and sample wing of each building provide access to the top of a car. All truck-received coal is manually sampled before it enters the building. The general arrangement of the automatic coal sampling equipment is shown in exhibit 10.

Sample preparation equipment—On the upper floor of the control and sample wing of each hopper building a combined crusher and sampler unit is installed for processing coal samples.

Power supply—Power to hopper building No. 1 is supplied from the 480-v main power board in the crusher building. Two circuits each of six single-conductor, No. 4/0, rubber-jacketed, 600-v cables run underground via duct and manhole to supply two 480-v, 3-ph power cabinets for the rotary car dumper and related equipment. Six single-conductor, No. 4/0, rubber-jacketed, 600-v cables via underground ducts and manhole supply power to a 480-v control-center type auxiliary board in hopper building No. 2 for the rotary car dumper and related equipment. The second feeder to hopper building No. 1 is tapped in a manhole and serves as an emergency feeder for hopper building No. 2. A circuit from this board supplies power to the car retarder.

The sample preparation wing adjacent to hopper building No. 1 is supplied by a separate feeder from the 480-v power board in the crusher building. Three single-conductor, No. 2/0, rubber-jacketed, 600-v cables run underground via duct and manhole to supply a 480-v, 3-ph power cabinet.

Lighting—Standard vaporproof lighting fixtures are used throughout the hopper buildings. The distribution cabinets are dust-tight construction, and the lights are cabinet-switched. The sample preparation wing is lighted with fluorescent-type fixtures.

Dumper dust-control system—A dust-control spray system for each hopper building is installed to control the spreading of dust during dumping operations. Two headers with a total of 22 spray nozzles are attached to the rotary dumper and are opened automatically, each time a car is dumped, by a solenoid valve in the supply line which is actuated by a switch on the rotary dumper. An additional spray header with nine nozzles, controlled by a manual valve, was added after the coal handling system was placed in operation to control the coal dust in the area of the rotary dumper driving mechanism. Two stationary headers with 26 spray nozzles are located under the floor, at hopper building No. 1 only, where trucks and manually dumped railroad cars unload coal. These sprays are operated by a valve located on the operating floor. Exhibit 79 shows a schematic layout of these spray systems.

Drainage facilities—Roof drains are collected in downspouts and discharged to the yard drainage system by gravity. Floors below grade are drained to a sump in the basement. A float-controlled duplex sump pump, in each building, empties the sump contents into the yard drainage system.

Piping systems—A 1-inch line from the station service air system supplies compressed air to four service outlets in each building.

Plumbing—Adequate toilet facilities, showers, kitchen facilities, etc. are provided for the yard employees and for the personnel engaged in coal sample preparation. Waste from the hopper buildings flows by gravity to the station sewer system.

Heating, ventilating, and air conditioning—The hopper buildings are generally open to the outside and are not heated or ventilated. The enclosed control rooms, sampling rooms, warming rooms, and electrical equipment room are heated by thermostatically controlled electric unit heaters. Mechanical ventilation is provided for the control, sampling, and electrical equipment rooms. Air supplied to the electrical equipment room is filtered for the protection of the equipment. The installed heating capacity is 97.5 kw, and 5100 cfm of air is supplied and exhausted.

The sample preparation room of the adjoining sample preparation building is air-conditioned. The remaining rooms of the building are heated by thermostatically controlled electric unit heaters and are mechanically ventilated. Portable electric heaters provide supplementary heating. The installed heating capacity is 56.32 kw, and a total of 7200 cfm of air is supplied and exhausted.

The air-conditioning system supplies filtered air to the sample preparation room with cooling and heating thermostatically controlled to maintain for cooling a maximum of 78°F in the room when the outside air is 95°F and for heating a minimum of 72°F when the outside temperature is 0°F. A total of 17.45 tons of refrigeration is installed.

Track and truck scales and scale houses

Track scale—The function of the track scale is to weigh coal received in railroad cars previous to unloading into the coal handling system of the plant. The location of the track scale is shown in exhibit 1. The location of the scale was governed by the need for sufficient length of track to permit the simultaneous weighing of loaded cars and the unloading of other cars at the railroad hopper building. The scale is mounted out of doors in a concrete pit. It is equipped with a fixed-type reinforced concrete deck and is provided with both "live" and "dead" rails. The dead rails permit passage of cars across the scale without imposing any load on the scale mechanism. On one side a suitable scale house is provided in which the indicating and registering devices of the scale are mounted. In general, the scale meets all the applicable requirements of Specifications for the Manufacture and Installation of Four-Section, Knife-Edge Railway Track Scales—1936, as issued by the Association of American Railroads. The gross weighing capacity of the scale is 325,000 pounds.

Truck scale—It was anticipated that a considerable amount of the coal required for the plant would be delivered by highway trucks, so a 50-ton-capacity truck scale was installed at a convenient point adjacent to hopper building No. 1. The location of this scale is shown in exhibit 1. The scale is mounted out of doors in a concrete pit. It is equipped with a floating-type reinforced concrete deck. On one side a suitable scale house is provided in which the automatic indicating and recording devices of the scale are mounted. The scale comprises a heavy rectangular structural steel frame approximately 10 feet wide and 50 feet long on which the concrete deck is mounted and beneath which two sets of knife-edge weighing levers are arranged. A load placed on the live deck of the scale causes movement of the weighing levers beneath. Through a weighing arm and linkage this movement is transmitted to the indicating and recording devices mounted in the scale house, which automatically indicate and record the weight of the load on the scale.

Pits and drainage—Concrete walls on a base slab approximately 7 feet below the ground form the track scale pit which is 63 feet long and 10 feet wide. Seats in the walls and concrete floor beams carry the steel beams supporting the rails and equipment. A 6-inch fixed deck, sloped to drain, covers the pit. A projection from one side of the pit supports a scale house and provides access to the pit. Concrete rocker beams on each side maintain the vertical alignment of the tracks as they come on the structure. A small sump pump is provided in one corner of the pit to handle drainage.

The truck scale pit is 50 feet long, 10 feet wide, and about 4 feet deep. The scale loads are carried by reinforced concrete beams to the base slab. The deck slab, 6½ inches thick, forms the scale platform. It is sloped to drain and is supported on steel framing. The scale house is adjacent to the pit.

Scale houses—Both buildings are identical and house the dial units and recording equipment for coal weighing. They are approximately 7 feet wide by 11 feet long, with walls of typical maroon-colored corrugated steel panels. The flat metal deck roof projects to form a protective canopy for the hollow metal door at the rear. There are ample windows on all sides to allow an unobstructed view of coal cars or trucks. The structural steel frame is deep blue-green, with the interior steel wall panels painted medium blue-green. The door is brick-red, the ceiling is off-white, and the floor covering is marbleized gray rubber tile.

COAL HANDLING

The coal handling system transports all coal from the two hopper buildings to the crusher building for sizing and then to the bunkers in the powerhouse or to the outdoor storage area. It also includes conveyors for transporting coal from the reclaiming hoppers in the storage area to the bunkers in the powerhouse. Included in the system is special equipment for removing tramp iron, for sizing the coal, for continuously weighing and registering the quantities handled, and for sampling the coal before depositing it in the bunkers.

Rail shipments—Railroad cars are dumped into the large receiving hoppers in the hopper buildings. This is accomplished either by the rotary car dumpers or manual unloading at hopper building No. 1. From the bottom of the hopper in each building the coal is moved by a pair of vibrating feeders onto an inclined belt conveyor which moves it to the top of a transfer structure. As the coal is transported by each of the two conveyors, the amount carried by each is automatically and continuously weighed and the tonnage recorded by a belt-weighing scale mounted near the lower end of each conveyor. At each transfer structure the coal is discharged over a magnetic head pulley into the chuting which feeds it onto another inclined conveyor which carries it to the top of the crusher building. As the coal passes over the magnetic head pulley in each transfer structure, the tramp iron is removed from it and diverted to a tramp-iron chute and to a tramp-iron container for disposal.

At the top of the crusher building the coal from each conveyor is discharged into a double-leg chute by a splitter gate which diverts half the flow of coal into one leg of the chute and half into the other. From each leg of the chute the coal flows downward to an inclined double-deck vibrating screen unit. The major portion of all fine coal, 1¼ inches in size and smaller, is drawn off and flows downward into a hopper and chute arrangement beneath. The larger coal and the remainder of the fine coal are discharged off the lower end of each screen unit into a heavy-duty crushing unit which crushes the larger-size coal to a 1¼-inch size and smaller. From each crusher unit the coal flows downward to a chute arrangement that merges it with the flow of fine coal from the corresponding screen unit. As the coal continues to flow downward it passes into a triple-leg chute arrangement fitted with deflector, or flap gates, by which it is diverted to any one of three belt conveyors. Two of the conveyors transport coal to the bunkers and the third to the stocking-out point in the storage yard. At a point near to the crusher building, the two conveyors leading to the bunkers are equipped with belt-

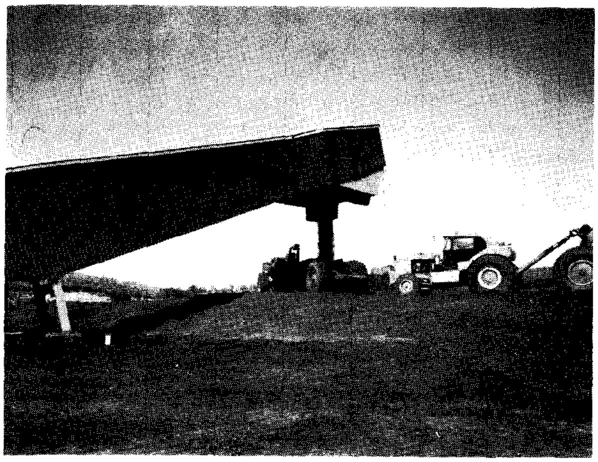


FIGURE 63.—*The stocking-out conveyor transports coal to the general storage area, depositing it in a pile or directly into mobile equipment for placing elsewhere in the storage area.*

weighing scale units which automatically weigh and register the tonnages that pass over the conveyors. A little further away from the crusher building and just above ground level, a large flat magnet is suspended over each of the conveyors to remove pieces of tramp iron from the moving coal. At the upper ends of the belts near the bunkers the conveyors are equipped with automatic sampling and crushing arrangements for taking samples of the coal that passes into the bunkers. At this transfer point the coal is discharged onto horizontal belt conveyors that extend over the top of all the bunkers. Each of the horizontal conveyors is equipped with a tripper unit that discharges the coal into any of the bunkers.

When coal is to be transported to the storage area, it is discharged in a pile on the ground at a stocking-out point. From this pile it is picked up by pneumatic-tired mobile equipment, carried to the storage pile, and distributed. It may also be discharged directly into the pans of the mobile equipment as shown in figure 63.

Truck shipments—After being weighed, a truck loaded with coal is driven into hopper building No. 1 and its load dumped into the receiving hopper. Steel plates set alongside the rails of the manual unloading track in hopper building No. 1 provide a runway for the trucks. From the receiving hopper the flow of coal is as previously described.

Reclaiming coal from storage—In case of interruption of coal shipments by rail and truck, coal is reclaimed from the stockpile by mobile equipment and dumped into the two reclaiming hoppers near the stocking-out conveyor. The reclaiming hoppers are at ground level and each is equipped with a heavy steel grating over which the mobile equipment operates and through which the dumped coal passes into the reclaiming hopper. From the bottom of each of these hoppers coal is drawn off by vibrating feeders and fed to an underground belt conveyor that moves it to a transfer point where it is discharged to one of the inclined belt conveyors leading through the basement of the crusher building and on to the bunkers in the powerhouse.

All units of the coal handling system except the travel drives of the belt trippers are electrically interlocked to provide proper sequence of starting and stopping. All except the belt tripper drives are normally remotely controlled from a benchboard in a control room on top of the crusher building.

Equipment

Hoppers—The receiving hoppers at the hopper buildings and the two reclaiming hoppers in the coal storage yard are welded-steel construction with side plates of copper bearing steel. They are equipped with heavy steel bar gratings having rectangular openings.

Vibrating feeders—Electrically operated, vibrating feeders are installed beneath the hoppers for feeding coal onto the belt conveyors. Each feeder is the heavy-duty type and comprises a steel pan, electrically actuated vibrator unit or units, and local and remote controls and indicating devices.

Belt conveyors—Table 13 lists the belt conveyors for transporting coal from the reception points to the bunkers and storage yard and from storage yard to the bunkers. Exhibit 4, a general plan of the coal handling and storage facilities, indentifies conveyors and transfer points.

Each belt conveyor, typically, comprises a long structural steel conveyor frame; head, tail, bend, and snub pulley units; load-carrying and return idler units; a motorized drive arrangement; gravity takeup unit; an endless conveyor belt; a rotary brush belt-cleaning unit; a head housing; discharge chute; skirtings at load point; and safety guards. The inclined conveyors have automatic holdback arrangements to prevent the conveyor belts from running backward. Conveyors BC-1 and BC-10 have magnetic head pulleys for removing tramp iron from the entering coal. Conveyors BC-3 and BC-4 have suspended flat magnet arrangements for removing tramp iron from the coal. They also have at their discharge end automatic coal-sampling equipment. The drives of conveyors BC-2, BC-3, BC-4, and BC-11 are equipped with fluid couplings. Conveyors BC-5 and BC-6 are equipped with motorized tripper units for discharging the conveyor coal into the bunkers.

Coal sampling equipment—Automatic machinery for sampling the coal before it is transported to the bunkers is installed at each of the discharge points of belt conveyors BC-3 and BC-4. Each set of sampling equipment includes a motor-driven primary sampling unit, a stainless-steel receiving hopper, a vibrating

TABLE 13.—*Coal belt conveyor data.*

No.	Use	Type	Width inches	Speed fpm	Capacity tph	Horizontal distance, ft pulley to pulley
BC-1	Hopper building No. 1 to transfer point A	Inclined	54	390	1000	71.5
BC-2	Transfer point A to crusher building	Inclined	54	400	1000	252.0
BC-3	Transfer point C to transfer point B	Inclined	48	510	1000	824.0
BC-4	Transfer point C to transfer point B	Inclined	48	510	1000	824.0
BC-5	Over bunkers	Horizontal	48	520	1000	911.2
BC-6	Over bunkers	Horizontal	48	520	1000	911.2
BC-7	Crusher building to storage area	Inclined	48	500	1000	600.0
BC-8	Storage area to transfer point C	Inclined	48	500	1000	350.0
BC-9	Storage area to transfer point C	Inclined	48	500	1000	300.0
BC-10	Hopper building No. 2 to transfer point D	Inclined	54	390	1000	187.7
BC-11	Transfer point D to crusher building	Inclined	54	400	1000	338.5

feeder unit, a motor-driven sample crusher, a motor-driven secondary sampling unit, and the necessary supports and controls.

Belt weighing scales—Belt conveyors BC-1, BC-3, BC-4, and BC-10 have automatic, continuous weighing and indicating scales. Each scale weighs the coal transported, locally and remotely records the total tonnage transported, remotely charts the flow of coal over the belt conveyor, and remotely indicates the percentage of full load moving over the belt conveyor.

Belt trippers—Belt conveyors BC-5 and BC-6 have self-propelled trippers for discharging the coal from the belt to a selected bunker. Each tripper consists of a structural steel frame mounted on wheels that travel on rails supported by the conveyor framing, upper and lower bend pulley units mounted in the structural steel frame, a motor-driven travel mechanism for moving the tripper on the rails, a hopper and chute arrangement for diverting the coal flow from the belt to the designated bunkers, an operator's platform, and the necessary controls, brakes, track clamps, overhead conductor system, and limit switches for supplying power to and controlling the travel motions. The chute of each tripper discharges the conveyor coal to a slot in the bunker room floor to one side of the conveyor. Each slot extends practically the full length of the bunker room. Sealing of each slot is accomplished by a belt that lies flat in a recess at the top of the slot and at floor level. At each tripper chute this belt is carried up, over, and down the outside of the tripper chute by suitably placed steel rollers. This permits the tripper to travel freely while maintaining the belt in a position sealing the long floor slot.

Jib cranes at transfer points—At transfer points A and D, which are underground chambers, tramp iron is separated from the coal and accumulated in steel containers. At each of these transfer points a jib crane was mounted at ground level adjacent to the top of a vertical concrete shaft opening into the underground chamber. Each jib crane functions to hoist a loaded container to the top of the shaft and swing it around into a position where its load of tramp iron may be dumped into a motor truck. Each jib crane is the fixed cantilevered boom type with an electric hoist of 3-ton capacity and an electric swing unit. Control is by push buttons mounted on a post adjacent to the base of the crane.

Railroad rolling equipment—A total of three 120-ton Baldwin diesel-electric locomotives was purchased for this project, one of which was used by construction forces. Later, three 80-ton General Electric Company switching locomotives were received one of which was used by construction forces. Radio receiving and transmitting equipment was installed on each with a central station at the utility building. A 50-ton flat car for use around the plant was purchased as used equipment. A small gang car, a Kalamazoo heavy-duty motor car, and two push cars complete the rolling equipment.

Storage yard mobile equipment—Coal is conveyed from the stocking-out conveyor to storage, and from storage to the recovery hoppers by four tractors and scrapers. Coal is generally loaded into the scrapers under the discharge end of the stocking-out conveyor. Recovery from the compacted coal pile often requires double heading to load the scrapers.

All four tractors are MRS models 190 and 200 with rubber tires, steel cabs, heaters, and a maximum speed of 25 miles per hour. One model-200 tractor is attached to a scraper of 30-cu-yd capacity; the other scrapers are 22-cu-yd capacity. Four crawlers with bulldozers are used for dressing the coal pile and for miscellaneous uses in the coal storage area.

On February 11, 1958, a larger MRS tractor (fig. 63) with a 375-hp Cummins diesel and a 42-cu-yd scraper were purchased for handling coal. All the motors on MRS tractors were designed and equipped with special protection against the excessive dust prevalent in the coal handling operations.

Structural

Substructure—tunnels—All coal handling conveyors below ground are in rectangular concrete tunnels of sufficient width to provide a 2-foot-wide walkway. Tunnel sections are generally limited to approximately 40- to 45-foot lengths, with the downhill end of each section connected to a lip projection of the next lower section. Each vertical reinforcement bar tying the sections together is encased in a 3-inch length of rubber hose at the joint to permit some movement.

Conveyor bridges—The conveyor bridges provide support and a sheltered housing for the conveyor belts. They are made up of inclined trusses approximately 8½ feet deep, connected by transverse roof and floor framing and braced for wind loads in the plane of both the upper and lower chords of the trusses. The truss spacing or widths depend on the number and size of conveyors and vary from 8 feet 9 inches for a single 48-inch conveyor to 15 feet 6 inches for two 48-inch conveyors. Panel spacing on the trusses was determined by truss depth and by allowable span of the precast floor slabs. All truss connections are riveted.

The bridges were designed for live loads to suit the conveyors together with a 50-psf loading in the walkway areas and a 20-psf roof load. Conveyor bridges 2 and 11 are alike and each houses the section, above grade, of a 54-inch inclined conveyor which runs from each of the two hopper buildings to the crusher building. The bridges are simple spans 76 feet in length. Pin-connected anchorages were provided at the lower ends of the bridges near ground level, and rollers were installed at the upper end to permit movement. Each bridge has a welded trash hopper, with 5-cu-yd capacity, attached to the truss on the walkway side near the crusher building. Gates were provided in the bottoms of the hoppers so that scrap can be dumped into trucks below.

Conveyor bridges 3 and 4 support the section above grade of two 48-inch inclined conveyors which run from the crusher building to a transfer structure near the powerhouse. It is composed of 3 equal spans forming a continuous bridge 349 feet in length. The two intermediate supporting bents are riveted and K-braced. Provisions for jacking were made at the bases of the bents, and shims were installed in case the foundations settled. A Vierendell truss was used at the upper end of the bridge in the plane of the lower chord to allow space for the conveyor belt takeup pulleys and counterweights. Because of the location of the takeup pulley it was necessary to provide for expansion and contraction at the lower end of the bridge near ground level.

Conveyor bridges 5 and 6 are 40-foot simple spans that support the two 48-inch bunker conveyors from the transfer structure to the powerhouse at unit 9. This section of the bridge is composed of 5 equal spans forming a continuous bridge 550 feet in length which supported the bunker conveyors from the transfer structure to the end of the initial powerhouse construction at unit 4. The depth of the 40-foot span was initially 10 feet, and after it became a part of the permanent construction the roof was raised 6 feet and a false floor installed 8 feet below the walkway to match the architectural features of the transfer structure.

Conveyor bridge 7 houses the 48-inch stocking-out conveyor and consists of a 107-foot truss including a 62-foot cantilever section. The end of the cantilever portion is spread to 14 feet 9 inches to accommodate the drive machinery. The trusses were cambered for dead loads.

The conveyor bridges are supported on a reinforced concrete bent and pedestals set on spread footings. At the stocking-out conveyor the footing was placed on top of piles driven to rock in order to minimize differential settlement between it and the conveyor tunnel, which also is pile-supported. The conveyor bridges have precast concrete floors, made up of lightweight channel slabs, to close off the underside and to provide a walkway for maintenance and inspection. All walkway slabs have Alundum aggregate cast in the top to form a nonskid surface.

Transfer structure for conveyors 3, 4, 5, and 6—This is a unique structure which extends 116 feet above ground level. The structure is supported by four K-braced columns 99 feet high. The lower floor which supports the conveyor machinery and sampling equipment is 73 feet above ground level and is 33 feet by 43 feet 8 inches in area. The floor framing cantilevers several feet beyond the columns on all four sides, thus making it necessary to support the entire floor system on cradle beams, spanning between the columns, below the floor system. The upper floor system is framed into the tops of the main columns and supports the conveyor drive machinery. The framing which houses this floor matches the cross section of conveyor bridges 3 and 4 and flares out to a width of 22 feet 6 inches. The roof over this area follows the roof line of conveyor bridges 3 and 4 and is sloped 16 degrees with the horizontal. The structure is riveted and was designed to compensate for machinery loads, reactions from conveyor bridges, and thrust resulting from tension in the conveyor belts.

The transfer structures, with the exception of the one adjacent to the powerhouse, are all underground, of reinforced concrete placed on rock foundations. The roof of each structure is a concrete slab on concrete beams. Gutters drain to drainage sumps in the basement.

The transfer point at the powerhouse is supported at grade level by a concrete frame supported on bedrock.

Architectural

The transfer structures are enclosed with maroon steel corrugated siding matching that on the powerhouse. The curved roof of the conveyors is covered with black-coated corrugated steel panels. At the eave intersection an aluminum-painted steel fascia angle gives a clean, sharp definition of the conveyor housing outline.

Piping systems

The two reclaiming hoppers have sumps and duplex float-operated sump pumps for collecting the drainage of the floors and conveyor structures. These pumps discharge into a 6-inch drainage header which flows into an open drainage ditch.

Transfer points A, C, and D and an underpass at the railroad tracks near the utility building are below ground level. Drainage from these structures is collected in sumps equipped with duplex pumping units. The drainage from transfer point C is discharged into an open ditch and that from the other structures is discharged into the yard drainage system.

A 2-inch connection from the station service air system in the crusher building serves the 1-inch air service outlets located along the conveyor structure, transfer station, and reclaiming hoppers (exhibit 74). A separate 1-inch connection to the same system is extended along the conveyors from the hopper building to the powerhouse to serve service outlets spaced at approximately 100-foot intervals along these structures.

Electric equipment and services

Power for the crushers, conveyors, and related equipment is supplied from the auxiliary power boards in the crusher building. This is controlled, normally, by the coal handling operator in the crusher building control room overlooking the coal handling structures and storage yard. Local test controls near the motors and at stop stations located along the conveyor every 100 feet are provided also for emergency use.

Vibrating feeders are situated at the base of the various hoppers and control the rate of flow of the coal being fed onto the conveyor belts. Amplitude generators on the vibrating feeders, whose current varies with the frequency of vibration, are connected to indicating meters showing amplitude of vibration. The operator at the control benchboard can adjust, by remote control, the amplitude of vibration, thereby increasing or decreasing the rate of flow of coal through the feeders.

Bindicators attached to the hoppers give an alarm when coal is too high or low in the hoppers. Belt-weighing scales on the belt conveyors give remote information to the operator via two instruments—a load indicator gives the loading on the belt conveyor and a weight counter totals the tonnage of coal passing along the conveyor.

Flap gates, electrically operated and remotely controlled, switch the coal at transfer stations or at hoppers through alternate routes as required. Indicating lights are provided at the powerhouse sampling point to assure correct marking of each sample to indicate into which bunker the sampled coal was dumped. Coal handling areas and storage yards have manually controlled floodlights mounted on towers to facilitate the handling of coal at night.

CONVEYOR CONTROL AND CRUSHER BUILDING

Functionally, the conveyor control and crusher building is the central feature of the coal handling facilities. Here, all coal arrives for screening and sizing and for distribution to the various storage points. Here, too, all control of these operations is either developed or supervised from a central control room on the roof of the structure. The building is strategically located to permit good viewing of the railroad car and truck unloading operations and the storing and reclaiming operations in the coal storage area.

The crusher and conveyor control part of this building is a tall rectangular structure with a deep substructure of reinforced concrete and a totally enclosed, steel-framed superstructure. The power supply and control equipment is in a long, rectangular, single-story wing at ground level.

The control room on the roof of the main structure is partially cantilevered over the west wall. The west front and two side walls of this room are fitted with large areas of plate glass for good visibility.

Substructure

The building substructure is a rectangular structure of reinforced concrete, founded on shale. It has a 3-foot concrete base slab approximately 31 feet below ground level which distributes the loads from the 2-foot-thick walls supporting the machinery and structure above. The crusher room floor has a 15-inch slab on concrete girders supported by the walls and 2-foot-square interior columns.

The electrical equipment wing substructure is separated from the crusher building by a ½-inch expansion joint. It is supported by walls and columns which extend down either directly to shale or to the large conveyor tunnel located underneath. The electrical equipment room at ground level has a 10-inch slab floor over concrete beams built into the walls. The basement floor of this wing consists of a light slab resting directly on earth fill and placed against ½-inch joint filler along the walls.

Superstructure

The main portion of the structure above ground level is 42 by 66 by 46 feet high. The control room, located on top, is 22 feet by 34 feet and is cantilevered 4 feet 10 inches off the main structure. The electrical equipment wing is 33 feet wide and 56 feet long and is connected to the west side of the main structure.

Architecture—The building is finished similar to the boiler room of the powerhouse, with maroon

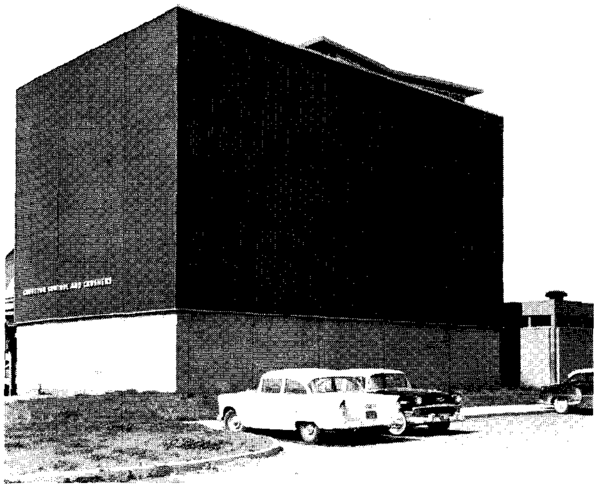


FIGURE 64.—*The crusher and conveyor control building, housing power supply and equipment, is the operating center of the coal handling system. All controls are centrally located in a glass enclosed room on top of the building.*

siding above a buff-gray brick base. The low electrical equipment wing is also of buff-gray brick (fig. 64).

The massive size of the crushers is indicated in the scale and character of this plain rectangular structure. The two conveyor housings, rising in a gradual slope from the ground level and abutting the south wall about midway of its height, offer a key to the functional aspect of the building. In contrast, the control room is of light steel-frame construction, with the observation front formed by a continuous aluminum-framed window wall with the larger upper panels glazed with blue-green, heat-absorbing plate glass and the lower panels of yellow porcelain-enameled steel.

Structural steel—The steel framing is of riveted construction and consists of rolled steel beams, columns, girts, and bracing. The framing was designed for loads imposed by the equipment and live loads varying from 30 to 200 psf, reactions from the conveyor bridges, and thrust from conveyor belt tension.

Concrete floors—The floor of the control room is a 6½-inch cast-concrete slab supported on the structural steel framing.

Vibrating screens

In the crusher building there are four vibrating screens, one above each main crusher. They function to scalp off and bypass around the crushers as much of the fine coal as is practicable and to feed the remainder to the main crushers. Each of these screens is the double-deck type, the upper deck being a perforated steel plate with 3-inch-square openings and the lower deck a woven-wire cloth with 1¼-inch-square openings. Each screen unit is set at a slope of 22½ degrees with the horizontal. Each screen unit is designed to permit 500 tph of coal to pass through to bypass and crusher.

Main crushers

There are four large crushing units for crushing the run-of-mine coal to the size required for the bunkers and yard storage. This coal varies from dust to lumps as large as the grating openings at the receiving hoppers. The coal is fed to each crushing unit at a uniform rate by a double-deck vibrating screen. The crushers crush the coal by the repeated blows of swinging members which are secured to a heavy rotating central member.

Electrical equipment room

The crusher building electrical equipment room is the main power distribution center for all coal handling facilities. Two 4160-v feeders, one from each of the common boards A and B in the powerhouse, are the source of this power supply (exhibit 5). The 4160-v board in this room supplies the larger loads such as the 250-hp coal crusher motors and two 1000-kva, 4160-480-v transformers which supply the coal handling 480-v main and feeder boards located in this room.

The 480-v feeder boards and the heating, ventilating, and lighting board are control-center type. One panel of the heating, ventilating, and lighting board supplies 240/120-v, single-phase power to lighting cabinets located at lighting load centers through a 50-kva transformer and voltage regulator.

Control room

Control switches and indicating and recording instruments for operation of the coal handling system are centralized on a 4-panel benchboard and a 2-panel recording board in the crusher building control room (fig. 65). Mimic buses to represent the conveyor system, with control switches with handles of distinctive shapes and colors for various functions, are arranged on the benchboard to resemble the physical arrangement of the coal handling system. Mimic buses on the apron of the bench panels represent schematically the connections of the 4160- and 480-v coal handling power system, with indicating lights showing the position of all main, bus tie, and crusher motor air circuit breakers. On the 8-inch vertical panel at the back of the benchboard are mounted the various types of indicating instruments. Belt conveyor load recorders are mounted on the vertical recorder board panels.

The entire conveyor system is so interlocked that it can be started only in the proper sequence. Tripping of any of the interlocked equipment trips all interlocked equipment toward the coal supply.

FIGURE 65.—*The control room for the coal handling system, glass enclosed on three sides, is located on top of the conveyor control building and provides an unobstructed view of the entire operation.*

Lighting

Four lighting cabinets, conveniently located, control the lighting for the crusher building and the coal handling control room. Standard vaporproof lighting fixtures are used generally throughout the structure, with fluorescent units being used in the control room and electrical equipment room. Emergency lighting is provided in the electrical equipment room. Distribution cabinets are of dusttight construction, and circuits are cabinet-switched except for the control room, electrical equipment room, and stairways.

Drainage facilities

Roof drainage is collected in downspouts and discharged into the yard drainage system by gravity as are the drains from the ground level floor. Basement floor drainage and drainage from the inclined conveyor tunnels flow by gravity into a basement sump equipped with a sump pump. The pump discharges into the yard drainage system.

Piping systems

Air for service outlets in this building is served by a 2-inch connection into the station service air system. This connection also serves air to the conveyor systems (exhibit 74).

Water for the wet-type dust collector and a 1½-inch fire hose outlet are supplied through a 2-inch connection into the yard raw water system (exhibit 79).

Plumbing

The control room, floor elevation 807.38, is equipped with a kitchen unit, lavatory, water cooler, and water closet for use of the employees stationed there. Hot water is supplied from a 30-gallon electric water heater. A 3-inch sanitary waste line carries the sewage by gravity to the station sewer system.

Heating and ventilating

The conveyor control and crusher building is electrically heated. Warmed areas are provided in the main hopper and crusher room, where maintenance or repair operations may be expected, by unit heaters thermostatically controlled to prevent overheating during mild weather. The remaining rooms are heated to the conventional 72°F by unit heaters. Portable electric heaters are used for supplementary heating. The installed heating load is 211.5 kw.

The building is mechanically ventilated for the removal of heat from electrical equipment and solar radiation. A total of 27,000 cfm of air is supplied and exhausted.

Dust collecting

The dust collecting system is designed to prevent the escape of dust from the coal conveyor housings and chutes at transfer points. The coal dust is separated from the air by a wet-type dust collector, and the cleaned air is discharged to the outside. Collected dust, in a sludge form, is pumped to the ash disposal field.

COAL STORAGE YARD

The coal storage yard covers an area of about 58 acres and when stocked to a depth of 25 feet will contain about 1,350,000 tons of coal, representing approximately 90 days' consumption for the 9-unit plant.

The ground on which the yard is located was originally quite rugged, with a large part of the area inundated by Watts Bar Reservoir. To obtain the smooth and slightly sloping base (about 0.5 percent) needed for the coal storage yard, required the moving of about 500,000 cu yd of earth within the area and the bringing in of an additional 400,000 cu yd of waste material. This base was paved with 6 inches of compacted crushed slag and topped with 6 inches of low-grade coal to reduce the mixing of the subgrade material with steaming coal during reclaiming and stocking-out operations.

Because of the sulfuric acid content of the rainwater draining through the coal pile, vitrified clay pipes are used for the culverts installed to carry this drainage, and the runoff is discharged into the lake below the condenser water outlet.

Lighting

Seven floodlight towers 100 feet high and each supporting a bank of five 1500-w floodlight projectors furnish ample lighting for night operation of the coal storage yard. The floodlight installation is manually controlled. An auxiliary bank of five 1500-w floodlights mounted on one of the towers supplements general yard lighting in the utility building area.

Reclaiming hoppers

Each of the two reclaiming hoppers, located on either side of the stocking-out conveyor, measures 54 by 21 feet at the top, having sufficient space for two steel hoppers. The center portion, which houses the conveyor, is 30 feet deep and is set on bedrock, as are the 18-inch-thick end walls. A 10-foot-high cross beam of reinforced concrete located at the center of the structure furnishes rigidity to the box and support for the loaded grating at ground level.

AUXILIARY YARD STRUCTURES

This group of structures includes the utility and storage buildings, the hydrogen trailer port, and several small miscellaneous structures located in the general yard area.

UTILITY BUILDING

The utility building includes facilities for servicing the equipment used in the unloading, transfer, and storage of coal. To be easily accessible to all these operations, it is located near the crusher building and coal storage area. The structure encloses a main repair area approximately 61 by 120 feet and 26 feet high to the underside of the roof deck and has a 2-story wing on the south side (rear) and a 1-story wing at each end (exhibit 7).

Foundations and floor slabs

The exterior masonry walls are built on continuous concrete footings which extend over the spread footings supporting the bases of the steel columns. The concrete floor slabs which carry heavy rolling equipment were placed in separate sections 20 by 30 feet by 10 inches thick to act as flexible paving slabs. These slabs, reinforced with wire mesh, are keyed together but separated from all footings and pedestals by ½-inch expansion joints. There are two concrete repair pits, separated from the slab by expansion joints; one is for trucks and the other for locomotives. The air compressor room has a 3-foot-thick slab to reduce vibration.

Superstructure

Architecture—The building is designed for the servicing and repair of equipment, storage of tools and parts, and service facilities for employees.

The north and south walls of the central unit (repair shop) each have four large rolling steel doors to facilitate the movement through the shop of the heavier pieces of mobile equipment (fig. 66). Above the doors, clerestory windows of corrugated wire glass extend to steel plate roof spandrels topped by steel copings. The end walls are of masonry construction faced with buff-gray brick to the steel roof

FIGURE 66.—*The utility building is centrally located near the crusher building and houses facilities for servicing all mobile equipment used in coal handling operations.*

spandrels. The exposed steel frame and spandrels are painted blue-green and the rolling steel doors are brick red.

Although joined to the central unit by a corridor, the employees service wing is articulated in such manner as to give the impression of being a separate structure. The south entrance leads to a transverse corridor consisting of glazed hollow metal double doors flanked by glass and louvered panels set in steel frames. On the north side the entrance is through similar doors flanked by aluminum panels. Both entrances are recessed and protected by a metal canopy. The south wall of the employees service wing features a continuous bank of full-height aluminum box-framed windows across the front of the assembly and lunch room.

The repair shop interior has buff-gray unglazed structural facing tile walls with a red concrete floor. The rigid steel roof girders and the exposed underside of the roof deck, together with the clerestory windows and large rolling steel doors, give the shop a spacious appearance.

The south wing is 27 feet wide, 58 feet long, and 18 feet high. Part of this wing is divided into two levels with facilities for storage and distribution of parts. The finish in this wing is in keeping with its function, having exposed concrete and metal deck ceilings, plain concrete floors, and buff-gray structural facing tile on the interior walls. Structural steel panels are deep blue-green.

In contrast, the employees service wing is more colorful with red cement floors, off-white plastered ceilings, and brick or tile walls. The floor in the locker and toilet room is dark cedar terrazzo and the walls are gray glazed tile. The foreman's office is formed of glazed steel partitions with the steel trim painted deep blue-green.

The west wing contains additional locker and shower rooms, plus an area for sand storage which is used by the locomotive. These rooms have cement finish floors, tile walls, and the metal roof decking is painted off-white.

Structural steel—Steel framing consists of rolled steel columns, girders, and beams with clear-span, rigid-frame bents in the shop portion. The rigid frames are built up of standard wide flange sections and plates. Brackets are provided on the column sections for supporting the 21-inch, wide flange crane runway beams and rails. Riveted construction is used throughout, except on the rigid frames which are welded.

Service shop equipment

A service shop in the utility building is provided for the repair and maintenance of the coal handling equipment. The shop layout and selection of machine tools and equipment were made on this basis. The total area of the shop is approximately 7000 sq ft, free of interior columns. The entire area is served by a traveling overhead crane. Repair pits, tools, and equipment are located in the west half of the shop. The remaining area was left clear for movement of large machinery. A 600-ton wheel press was added to the shop after sufficient operating experience had been obtained to be certain of the need for a press of this type. Eight 1-inch air and seven 1-inch water service outlets were installed. Fire protection of the shop area is afforded by fire hose and rack cabinets and portable- and hand-type chemical extinguishers.

Overhead crane

The utility building is equipped with a 5-ton-capacity, single-girder, electrically operated overhead crane for handling parts and materials and for servicing, dismantling, assembling, and repairing mobile equipment such as trucks, tractors, scrapers, yard locomotives, etc.

Electrical equipment

A 4160-v, 3-ph circuit from common board B in the powerhouse connects to the high-voltage side of a 500-kva, 4160-480-v transformer located in the electrical equipment room of the utility building. The low-voltage side of this transformer feeds the utility building main feeder, and 240-v lighting boards, which are the distribution centers for the power requirements in the area. A single-phase, 50-kva lighting transformer with a voltage regulator on the high side supplies 240/120-v power to one panel of the feeder board which connects to lighting and heating cabinets located at load centers. Five lighting cabinets control the lighting for the utility building. Fluorescent-type lighting is used for most areas. Cabinet switching is used for shop areas, with local switching for such areas as office, locker rooms, and lunch room.

Compressed-air system

The utility building houses a station service air compressor, identical to those installed in the powerhouse. The compressor is placed on the ground floor in the south wing of the building. This discharge is connected into the yard and powerhouse system through a 4-inch underground header. A 2-inch line supplies the service outlets in this building and affords a supply from either the powerhouse system or separately by the utility building system.

Drainage facilities

Roof and floor drains discharge by gravity into the yard drainage system. The drainage from the repair pits flows to a sump pit where a float-controlled duplex sump pump discharges it into the yard system.

Fire protection

The oil storage room is equipped with automatic CO_2 fire extinguishing equipment. Two 165°F thermostats which initiate the discharge are near the ceiling. A pipe header with nozzles for dispersing the CO_2 gas connects to two 50-pound CO_2 cylinders through a time-delay pressure valve. This allows for a concentration of 9 cu ft of air per pound of CO_2. Operation of the system will immediately activate visual and audible signals, and after a time delay of 20 seconds, to permit personnel to leave the room, the fire door is released and CO_2 discharged into the room. A break-glass type control station for manual operation and a cutout switch for deenergizing the control circuit of the system, when anyone is working in the room, are located near the entrance door.

Portable CO_2 extinguishers of 5- and 15-pound size and vaporizing liquid extinguishers of 1-quart size are conveniently located throughout the building. A fire-protection equipment shelter containing a 150-pound, buggy-type, dry-powder extinguisher and a hose cart with 200 feet of 2½-inch hose is located outside the utility building for general fire protection.

Plumbing

The utility building houses toilet and shower facilities for all personnel employed in track maintenance, repair and servicing of rolling equipment, and coal handling in the coal storage yard. A lunch room with two kitchen units is also provided.

A 450-gallon hot water tank equipped with two 9-kw immersion heaters supplies all the hot water requirements except those for the west wing of the building. Hot water is circulated in the employees service area by a pump controlled by an immersion thermostat located in the return header. Additional facilities, including a 120-gallon electric water heater, are located in the west wing or carpenter shop of the utility building. Sewage from the building flows by gravity to the station sewer system.

Heating and ventilating

The utility building is heated by thermostatically controlled electric unit heaters, supplemented by electric portable heaters where needed. The heaters are designed to maintain a minimum of 60°F in the main shop and 70°F in the other rooms. A total of 277 kw of heating is installed. The building is mechanically ventilated with a total of 74,900 cfm of air supplied and exhausted.

STORAGE BUILDING

This building, planned as a simple utilitarian warehouse, provides additional storage space for heavy parts and equipment for which there is inadequate space in the service bay of the powerhouse (fig. 67). The building and storage yard are located approximately 1000 feet northeast of the powerhouse and are served by an extension of the plant railroad track and a paved road.

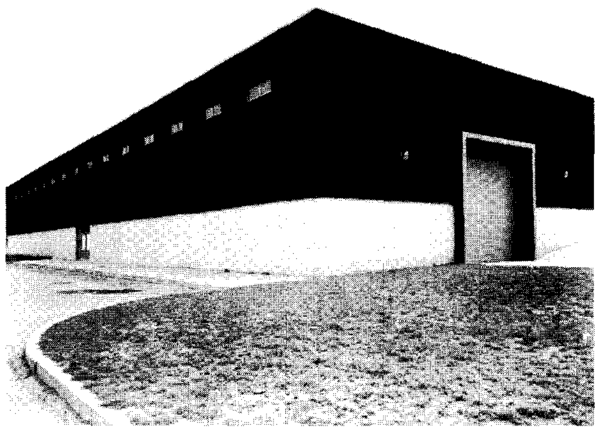


FIGURE 67.—*All heavy parts and materials which cannot be retained in the service bay are housed in the storage building.*

Foundations and unloading platforms

A continuous footing with pedestals around the building supports the masonry walls and building steel. The floor is a 6-inch concrete slab built in sections and separated from the walls by a ½-inch expansion joint. There is an outside railroad loading platform at one end of the building which is serviced from ground level by a concrete ramp up from the main door.

Superstructure

The building is approximately 60 by 200 feet and is 27 feet high with large drive-in rolling steel doors at each end and wire-mesh partitions subdividing storage areas inside. The upper part is enclosed with maroon steel panel siding, pierced near the roof with a row of steel windows. The base is a simple 8-inch concrete block wall painted gray. Windows and the large rolling steel doors at each end are painted blue-green. Three large balconies were added inside for light storage—two for power operations and one for power stores. Along one side is the service entrance comprising a steel door and frame, with glass and flat steel side panel. The steel framing is the conventional mill-type with truss roof. Columns are spaced on 25-foot centers.

Mobile crane and platform scale

The building is equipped with a 4-ton-capacity mobile crane for unloading miscellaneous materials and equipment from railroad cars and trucks and for transporting such loads inside the building. The crane also loads and transports such materials and equipment from the storage building to cars, trucks, and other locations in the steam plant area. A platform scale of 10,000-pound capacity is located in the storage building for weighing the various items of material and equipment handled. The scale is set with its floating platform approximately flush with the finished floor.

Lighting

Industrial-type fluorescent fixtures are used throughout the storage building. Steel standards with conventional street lighting fixtures serve to illuminate the storage yard. Cabinet switching is used for inside lighting while outside lighting is controlled by a time switch.

Drainage

Roof drains discharge through pipes located in the interior of the building into downspouts which run through the floor and leave the building below grade. From the building, the drainage is piped underground to a nearby ditch where it is discharged. Trench drains with gratings are installed across the large rolling door openings at each end of the building to prevent water entering the building under the doors. Discharge from these drains is piped underground to a nearby ditch.

Plumbing

Toilet facilities are provided in this building for use of occasional personnel working there and in the storage yard. Domestic water is supplied from the station distribution system. There are no hot water facilities. Waste flows by gravity to a small septic tank and underground disposal field.

Fire protection

Because this is a remotely located, unattended building in which combustible materials may be stored, a fire hydrant and hose rack are located at an easily accessible point a few feet outside each end of the structure.

Heating and ventilating

The toilet room is heated by a 3-kw thermostatically controlled electric heater. The remainder of the storage building is spot heated by electric portable heaters where necessary. A long roof ventilator provides gravity ventilation, and dampers in it are used to conserve heat during cold weather.

Storage yard

The outdoor fenced storage yard is 205 by 300 feet and is surfaced with an 8-inch layer of stabilized crushed-stone base, covered with a bituminous surface to support mobile cranes and other heavy equipment. Racks are installed for horizontal storage of piping and timber cross ties. The racks consist of rows of parallel steel beams bolted to concrete pedestals 2 feet above ground level.

HYDROGEN SYSTEM

Hydrogen for generator cooling is supplied to the plant in 38-tube motor transport trailers. Two trailers are stored at the plant at all times in concrete trailer ports. One is located approximately 200 feet from the northeast corner of the powerhouse. The second trailer port is 100 feet from the southeast corner of the powerhouse. Only one of the trailers is in use at a time. There are three spare trailers for TVA steam plants using the outdoor method of hydrogen storage. These are used in transit to and from the hydrogen supplier's manufacturing plant to replace any trailer when its hydrogen supply is exhausted.

Trailer storage structures—These are reinforced concrete structures, open on three sides, consisting of a 36- by 20-foot base slab with a heavy end wall projecting vertically from it which partly supports a cantilevered roof of concrete. All concrete members are substantially reinforced to reduce fragmentation in event of trailer fire or explosion (fig. 68, left).

Steel framing channels, together with short pipe columns, are utilized to help support the roof slab. A double-entrance gate of the chain-link fence type and steel doors and covers together with embedded frames complete the structure.

Hydrogen piping system—Hydrogen is piped from the tubes on the trailers to a pressure-reducing control station in a recess in the back wall of the trailer ports (fig. 68, right). From these control stations two underground headers connect the trailer ports with duplicate lines. Valve boxes connected to these headers supply hydrogen for each pair of generating units through cabinets installed near the powerhouse wall in the transformer yard. The cabi-

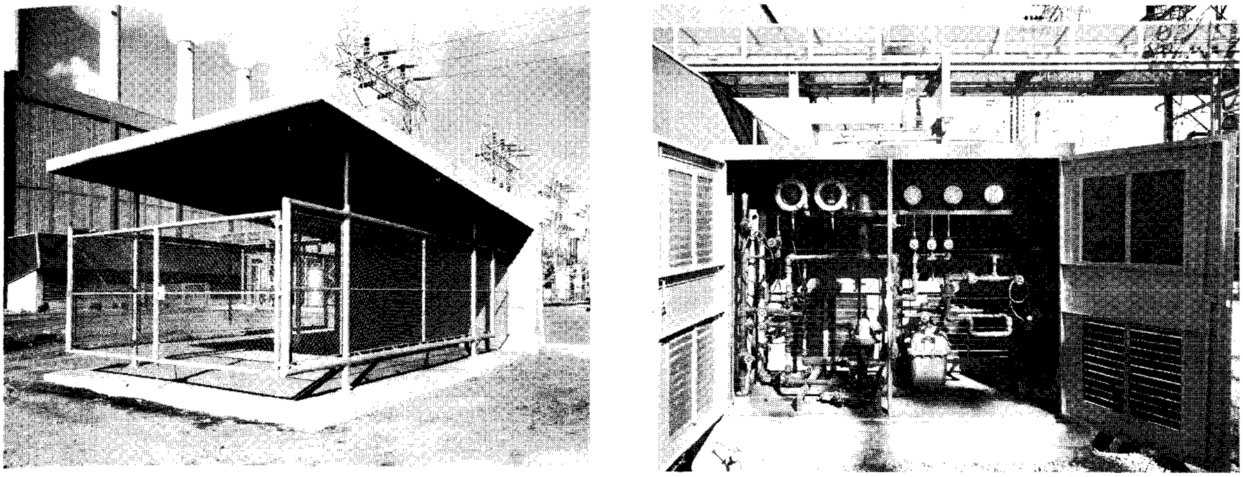


FIGURE 68.—*Hydrogen for generator cooling is transported to the plant on trailers which are placed in two concrete slab trailer ports, one of which is shown at left. The hydrogen is piped directly into the plant from these ports; one is in reserve. Controls for regulating the hydrogen supply is located in a recess in back of the trailer ports, right.*

nets house the pressure control and metering stations for each pair of generating units. From these cabinets hydrogen is piped into the powerhouse to the generators (exhibit 83).

Fire protection of hydrogen trailers—Automatic fog-spray systems were provided for each trailer port actuated by fire detectors located on the underside of the roof. The water for these sprays is supplied from the yard raw water system through a piston-operated check valve located in a cabinet at the rear of the trailer port.

MISCELLANEOUS STRUCTURES

Sewage chlorination building

This is a simple box-like structure, 9½ feet square, with three walls and roof of reinforced concrete. The front is enclosed by a steel-framed panel wall comprising a hollow metal, louvered door with a flat, insulated steel side panel over which is a steel vent sash. The steel frame is painted dark blue-green with door and panel being medium blue-green.

Guard shelter

This structure is located near the entrance to the plant area. It is about 5 by 7½ feet, inside dimensions. For security protection the building is formed of 2-inch panels constructed of two ¼-inch-thick mild steel plates with fiberglass insulation between, in structural steel frame. The door is of similar construction with double-glazed vision panel. There are double-glazed sliding aluminum windows in four sides. The flat, steel roof deck projects about 2 feet and is roofed with marble-surfaced built-up roofing. It is equipped with lighting and heating facilities, a storage cabinet, and a work counter.

Microwave terminal house

This building, about 8½ by 10 feet, is of exposed steel frame with columns resting on low concrete pedestals. It is enclosed with the typical maroon color insulated corrugated steel wall panels and has a steel deck roof and floor. The roof projects about 3 feet at the front and 12 inches on the other three sides and is finished with an aluminum fascia. It is without windows but has a high full-length louver in the rear wall with a flush, hollow metal door in the front. The steel deck floor is covered with plywood subflooring and finished with gray linotile.

Fire protection equipment houses

There are 11 flat-roofed reinforced concrete houses for fire protection equipment located at vital and accessible points around the yard area. The structures are 6 by 12 feet with large hollow metal doors at each end. They shelter hand-drawn fire-fighting equipment which can be readily moved over paved surfaces to any location.

Retarder equipment house

The retarder equipment house, with inside dimensions of 7½ by 10 feet, contains the equipment for controlling the car retarder, a device for slowing the movement of empty coal cars being shunted into the yards. The building is of buff-gray face brick, inside and out, with a flat steel deck roof projecting 7 inches, its four sides finished with an aluminum fascia mold. The front, or track side, is glazed above with windows in a steel frame and has lower panels of flat, insulated steel. A louvered, hollow metal door provides access through the rear wall.

OTHER SERVICES AND YARD FEATURES

Roads and parking areas

An access highway about 0.9 mile in length leads from the relocated U. S. Highway 70 to the plant site. Within the plant area there is the main road passing entirely around the plant, as well as numerous other short roads serving specific areas, as shown in exhibit 1. The main roads are 22 feet wide with bituminous surface treatment on a 6-inch base.

A major parking area with space for 238 cars for both visitors and plant personnel is located in front of the powerhouse. Additional parking areas are located near the crusher building, the utility building, the water treatment plant, the storage building, and the control building; these areas afford parking for an additional 86 cars. Concrete curbs were placed along all parking areas and also at places along the roads necessitated for traffic control. Concrete sidewalks facilitate access to all parking areas and connect them with the buildings they serve. The parking areas have the same bituminous surface as the roads but are constructed with a 4-inch base. The total bituminous surfacing within the plant area is slightly more than 56,000 sq yd.

Plant service tracks

Rail service to plant buildings and areas is provided by spur tracks from the loaded yard. One of these tracks, as shown in exhibit 1, goes to the storage yard and building with sidings to the chlorination building, the powerhouse service bay, the generator room, and the transformer yard, while the other goes to the utility building.

Yard drainage

Storm water is drained from the plant area by three separate drainage systems, one for the north half and two for the southern part, as shown in exhibit 2. These systems are based on a maximum rate of rainfall of 6 inches per hour. More than 8300 linear feet of pipe was laid for storm sewers and 87 manholes, curb inlets, or catch basins were installed.

Ash disposal areas

An area of approximately 59 acres with a potential storage capacity of more than 3,000,000 cu yd, or 90 unit-years, below the elevation of the discharge pipes (765) was provided for disposal of ashes by diking off a section of the lake north of the plant. The dikes were constructed of earth with a top width of 10 feet and have a slope of 1.5 to 1 on the inside and of 6 to 1 on the side exposed to the lake and contain about 222,000 cu yd of fill. The top of the north dike is elevation 746 and top of the east dike adjacent to the condensing water intake channel is elevation 750. It is anticipated that the dikes will be raised, using ash for fill material, as filling progresses.

To prevent sluice water from overtopping the dike, two 30-inch pipe culverts with morning-glory type inlet spillways are installed. As the ash accumulates, the masonry spillways will be raised periodically as required to maintain a sufficient pool of water in the ash area to prevent discharging ashes into the Watts Bar Reservoir.

Tentative designs have been made for a future ash disposal area immediately north of the present one with a capacity of about four times that of the existing area. This future ash disposal area utilizes submerged and lakeshore TVA properties. These areas are shown in exhibit 3.

Ash disposal pipelines and trenches

Ash from the boiler system is piped from the west wall of the powerhouse to the ash disposal area. Within the parking area west of the powerhouse the pipes are placed in concrete trenches. The trenches between units 4 and 5 and units 5 and 6 are 7 feet 3 inches and 5 feet 6 inches wide, respectively, and converge into a trench approximately 14 feet wide west of the stacks. This trench carries four 10-inch-diam bottom-ash and three 10-inch-diam fly-ash lines. The trench between units 6 and 7 is 7 feet wide and carries two 10-inch-diam and one 8-inch-diam fly ash lines.

Steel grating covers the trenches which have a steel curb on each side to support the continuous grating and beams. The grating is rectangular pattern, galvanized, and is 1½ inches deep at the regular runs and 2 inches deep at the roadway crossover sections. The grating at the roadway sections is supplemented with steel beams for additional carrying capacity.

Beyond the parking areas the ash disposal pipes are carried on 12-inch concrete supports spaced 30 feet on centers in an open unpaved ditch. At the railroad crossing the ash sluice pipes pass through pipe sleeves embedded in concrete under the tracks. The pipes are provided with "Rola-grip Couplings" at 100-foot intervals for ease in rotating to combat wear or for replacement.

Mobile yard crane

A mobile crane of 20-ton capacity, arranged for conversion to clamshell service, was purchased for performing the necessary load-lifting and clamshell work needed to handle and transport equipment and materials in and about the plant area. The crane is of the single-engine full-revolving type and is equipped with a 30-foot boom and inserts which will make up into a 70-foot boom plus a 20-foot jib if required.

Yard locomotives

For handling the large number of coal cars, railroad freight, and other materials, three diesel-electric locomotives of 80-ton weight and three of 120-ton weight were provided.

Car thawing equipment

There are four sets of portable hopper car thawing equipment for loaded cars of coal in the plant yard to ensure the free and rapid unloading of the coal when the cars reach the car dumpers. Each set consists of a fuel tank with a built-in pressure pump, two suitable hoses, two burners with handles, and two thawing tubes with skids. The fuel burned is kerosene. The equipment is designed to be handled and placed in position manually.

Car retarders

The handling of empty coal cars after they leave the dumpers is greatly facilitated by use of two automatic retarders located at the entrance to the empty storage yard. The purpose is to reduce, when necessary, the speed of free-rolling cars to the ideal coupling speed so that use of switch engines and extra personnel is not required in the storage yard until cars are moved out. Each retarder system is all-electric and may be operated manually or fully automatically for variable weather and rolling characteristics.

The retarding elements consist of a series of brake shoes mounted at each side of each rail. These shoes press against both sides of each wheel as it goes through the retarder. The pressure from these shoes is supplied by helical springs set in the castings which support the brake shoes. The amount of pressure exerted by these brake shoes is determined by any selected setting of the controls which are arranged for adjustment to any desired values in terms of leaving speeds. The speed of approaching cars is measured as they enter the retarder mechanism by means of electronic equipment which operates the retarder proper as required to obtain the releasing speed.

Yard fences

Closure fences encircle the main plant area, switchyard, transformer yard, and storage yard. The switchyard, transformer yard, and storage yard fences are 6 feet high, made up of galvanized chain-link fabric on pipe framing, conforming to established standards for fences on TVA projects. The storage-area fence is topped by a 1-foot height of 3-strand barbed wire for additional protection. The plant-area fence is made up of 7-foot-high galvanized chain-link fabric on pipe framing topped by a 1-foot guard of 3-strand barbed wire.

Yard lighting

Yard lighting is supplied through two constant-current underground series circuits. Steel lighting standards are a special TVA design with standard pendant-type incandescent street lighting fixtures suspended at the end of the bracket arm. Yard lighting is automatically controlled by a photoelectric cell and operates simultaneously with the switchyard and other outside lighting.

Piping systems and facilities

Raw water distribution and fire protection system—The raw water distribution system supplies water to the various buildings on the station yard for fire protection, cooling water, service, and lawn sprinkling.

The system consists of an 8- and 10-inch pipeline loop around the entire powerhouse which is fed by four 10-inch lines from the powerhouse system. A 50,000-gallon elevated tank floats on the system. Sectionalizing valves permit isolation of certain parts of the loop without interfering with service on the remainder of the system.

Branches are run from the loop to supply raw water service and fire protection to the transformer yard, switchyard, coal yard facilities, and the several auxiliary structures located on the plant reservation. A flow diagram of this system is shown in exhibit 79. Fire hydrants around the powerhouse are located not more than 300 feet apart. Other hydrants are located near outlying structures. Each hydrant is equipped with a bolted-on auxiliary gate valve so that it may be isolated from the system for repairs.

There are four fire equipment shelters located around the powerhouse. Three are concrete houses located near the control building, the utility building, and the outlet channel, while the fourth is a small room within the flocculator structure at the water-treatment plant. Each of these shelters contains a hose cart equipped with hose spanner and hydrant wrenches, hose nozzle and playpipe assemblies, a reel containing 200 feet of 2½-inch double-cotton-jacketed, rubber-lined hose in 50-foot lengths, and a wheel-type extinguisher. The wheel-type extinguishers are 150-pound dry-powder capacity.

Two outdoor-type hose cabinets are located at the fire hydrants near the storage building, each containing 200 feet of hose, a hose nozzle and playpipe assembly, and a combination hose spanner and hydrant wrench.

Lawn sprinklers—The lawn-sprinkling system consists of 1-inch flush hydrants spaced to serve the planted area with 100-foot hose. The hydrants are connected to the raw water system by 1- and 1½-inch tapped saddles and 1- and 1½-inch galvanized wrought-iron pipe with galvanized malleable-iron fittings. Each connection serving one or more hydrants has a service stop and box installed adjacent to the main. All pipe is wrapped with a coal-tar tape coating as a protection from electrolysis and acid corrosion.

Domestic water distribution system—The domestic water system supplies potable water for the powerhouse and the various buildings for use in plumbing fixtures and for the hydraulic system which operates the cone and butterfly valves on the discharge of the condenser circulating water pumps in the pumping station.

The supply for the system is pumped from the water treatment plant clearwell into a 4-inch feeder main on the west side of the power plant, which reduces to a 3-inch feeder main at the southwest corner of the powerhouse and continues on the south and east sides of the powerhouse. On the west side of the powerhouse a 4-inch line branches from the feeder main to supply the powerhouse and the service bay. This line also connects to three 10,000- and one 5000-gallon elevated storage tanks that float on the system and are located on the powerhouse roof. Other smaller lines from the feeder main supply the needs of the various other buildings. The system is provided with sectionalizing valves for the isolation of sections that are to be repaired.

The domestic water service pumps in the water treatment plant are controlled by three float switches located on one of the 10,000-gallon elevated tanks. Exhibit 81 is a diagram of this system.

Compressed-air distribution system—The compressed-air distribution system supplies air service to the various buildings and belt conveyors on the station yard (exhibit 55). The system is fed from two sources—the powerhouse and the utility building—thus providing a supply from either or both sources. Four compressor units are located in the powerhouse and one compressor unit is located in the utility building, each with a capacity of 660 cfm and operating at 100-psig pressure. A 4-inch line between the utility building and the powerhouse connects the systems and serves as a distribution header for smaller lines to the various buildings. Another 1-inch line from the powerhouse to the crusher building connects to the distribution header. No yard sectionalizing valves are provided, but valves are installed inside of each building to provide isolation from the system.

Softened water system—Softened water is the water that has been softened by base exchange in the zeolite softening system for use as evaporator makeup water. The calcium and magnesium have been replaced by sodium which forms no hard scale in the evaporator or preheaters. Although the effluent from the softeners has a zero hardness by soap test, it is very corrosive due to the absence of calcium carbonate, and special piping materials are required to resist this aggressive action.

Two 4-inch aluminum pipelines deliver boiler feedwater makeup from the water treatment plant to the evaporator preheaters in the powerhouse. Water is pumped continuously from the softened water well in the water treatment plant into a 4-inch header which splits into two 4-inch lines just before leaving the water treatment plant. Each of these lines is equipped with a propeller-type meter. Valves are provided at this point so that water may be delivered to the powerhouse through either one or both of the 4-inch lines. Normally both lines are used. One of the lines enters the powerhouse between units 2 and 3 and the other between units 4 and 5.

Because of the increased design pressure in the evaporators for units 5-9 in the powerhouse, it was necessary to install booster pumps to supply softened water for these five units. These pumps are installed in parallel, taking suction from the 4-inch header in the powerhouse and flowing back into the same 4-inch header on the discharge side of a 4-inch check valve which is installed between the suction and discharge. The pumps are manually controlled. Only one pump is used at a time, the other being a spare. Each of these pumps has a capacity of 250 gpm at a discharge head of 55 feet.

Sanitary sewer system—The sewage from each building except the yard storage building is collected in an 8-inch main sewer and conveyed to a main septic tank located near the condensing water discharge structure. The effluent from the septic tank flows through a chlorine contact tank where it is chlorinated and is discharged into the condensing water outlet channel.

The main septic tank is rectangular in shape, proportioned for best performance, and is constructed of reinforced concrete. The septic tank for the yard storage building is precast concrete. The chlorine contact tank is constructed of reinforced concrete with baffles to prevent short circuiting.

Building drainage system—The building drainage system provides for all drainage from a building except sewage. These wastes include roof drainage, waste cooling water, floor drains, sump pump discharges, chemical drains, etc.

All drains leaving a building are underground and below frost line. Wherever possible, these lines are run to the nearest catch basin, curb inlet, or storm sewer manhole of the yard drainage system, but in certain areas it is more economical to run some drains directly to the lake or discharge them into open ditches.

Gasoline and diesel oil facilities—Gasoline service is provided at the utility building for servicing cars and trucks used in the plant area. The gasoline dispenser is located on a service island just outside the building. The service island also has two Islanders, one of which contains air and water service hose with valves and accessories and the other modified so that air and water hose reels and equipment have been omitted and replaced with 120-v electrical outlets for connecting to heaters on various pieces of equipment. The Islanders also contain lighting fixtures with reflectors. The gasoline dispenser is supplied from a 2000-gallon underground storage tank.

Diesel oil service for the yard locomotive and other equipment is supplied from an island located adjacent to the yard tracks and also convenient to the utility building. This island has a diesel oil dispensing unit and other equipment similar to the gasoline dispenser at the utility building. Diesel oil is supplied for the dispensing unit from a 10,000-gallon underground storage tank.

Landscaping

To improve appearance and to control erosion, an integrated plan of landscaping and planting for the plant area was developed and carried out as construction permitted.

Under this plan the islands in the parking areas and all open areas in the immediate vicinity of the buildings were graded, fertilized, and planted with grass, interspersed with beds of shrubbery and ornamental trees. More than 50 varieties of shrubs and trees were used. Outlying areas which had been disturbed during construction were regraded where necessary to prevent erosion and then either seeded with meadow grasses or set out in pine seedlings. Steep slopes, such as occur along the condenser water intake and outlet and along highway and railroad embankments, were planted with honeysuckle vines or lespedeza sericea.

A tree belt about 50 feet wide consisting of ash, linden, maple, oak, cedar, and pine was planted in an open area between the office wing of the powerhouse and the coal storage area. The purpose of the tree belt is to intercept windblown coal dust minimizing dust nuisance at the powerhouse entrance, and to improve the appearance of the area.

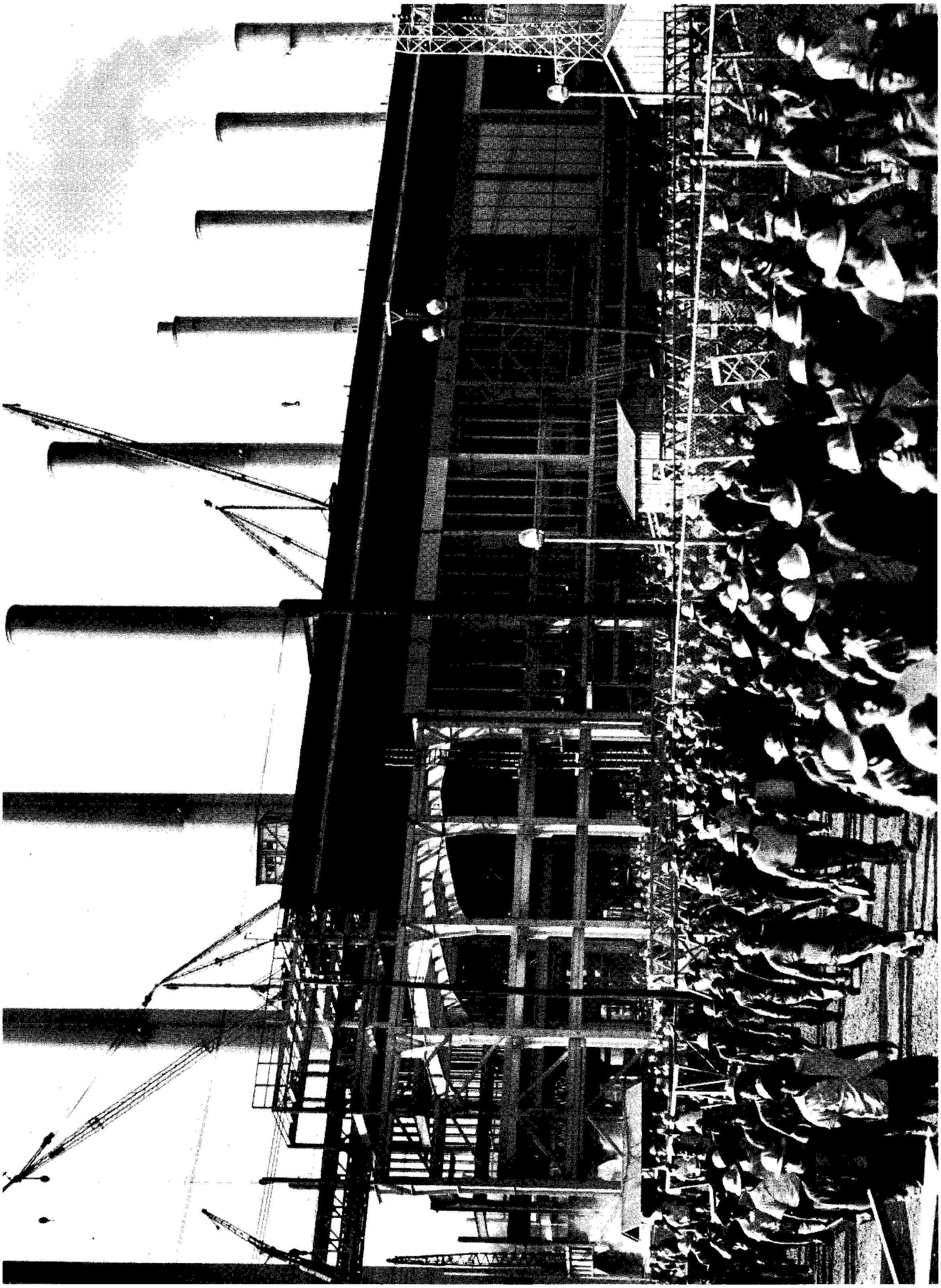


FIGURE 69.—*Mass handling of employees at shift change required efficient and adequate facilities. During the period of major construction operations, work was conducted on a three-shift, 24-hour schedule for five days a week.*

CHAPTER 4

CONSTRUCTION SERVICES

Construction of the Kingston Steam Plant, as at all other TVA construction projects, included many necessary services furnished the Division of Construction by other TVA divisions and branches. Some of these service organizations maintained operating units on the project site. The principal operating units at the project were: (a) the Division of Personnel, which was responsible for employing and training sufficient labor of all categories; (b) the Division of Health and Safety, which established hospital facilities and initiated a job safety program; (c) the Division of Reservoir Properties, which operated the project cafeteria and housing facilities and was responsible for the project security system; (d) the Division of Materials, which established and implemented procedures for procurement of necessary supplies and services; and (e) the Division of Property and Supply. The last named organization was responsible for the acquisition and disposal of all land necessary to the project, for providing office equipment and for supplying and maintaining all transportation equipment. Land and office equipment activities were handled through the Chattanooga office but transportation facilities were provided through a transportation unit on the project.

These units were established as rapidly as possible to serve the needs of the Division of Construction. The first units were set up on a temporary basis in the nearby community of Kingston until suitable quarters at the project could be provided. The services were discontinued as soon as construction conditions were far enough advanced to warrant their termination.

Assistance of a more specialized nature was given to the project by other TVA branches periodically. This included help from the Maps and Surveys Branch, the Geology Branch, and the Hydraulic Data Branch. Brief accounts of the nature of the contributions made to the work of the project by the activities of all these organizations are given in the following paragraphs.

PERSONNEL

Personnel services necessary to construction activities were provided by the Division of Personnel through a personnel office on the site. The office was under the immediate supervision of the Assistant Chief of the Employment Branch in Knoxville. The primary mission of the office was to assist project management in the application of TVA personnel administration objectives, policies, standards, and procedures. Assistance was given in the fields of employment, job classification, pay, work schedules, training, labor relations, and other personnel activities.

The project personnel office opened May 1, 1951. The staff consisted of two personnel officers, a personnel clerk, and a clerk-typist. As construction progressed it was necessary to add a third personnel officer, two additional personnel clerks, and two clerk-typists. This number was maintained through 1954. Some personnel employees were transferred from other TVA offices while members of the clerical staff were recruited locally.

Employment policy

The basic principles of TVA's employment policy are described in the TVA Act. It provides that the selection of employees shall be made on the basis of merit and efficiency and that no political test or qualification shall be permitted or given consideration. Appointments must also be in accord with the regulations of the Veterans' Preference Act of 1944. These basic principles are incorporated in the negotiated General Agreement Between the Tennessee Valley Authority and the Tennessee Valley Trades and Labor Council and in the negotiated Articles of Agreement Between the Tennessee Valley Authority and the Salary Policy Employee Panel. The agreement with the Council recognizes that union membership is advantageous to employees and to management and that such membership is a positive factor in evaluating relative merit and efficiency. It is not, however, a prerequisite to appointment, promotion, or retention in service.

Labor supply

In spite of the great number of construction workers employed at the nearby Oak Ridge project of the Atomic Energy Commission, it was possible to obtain sufficient unskilled, semiskilled, skilled, and

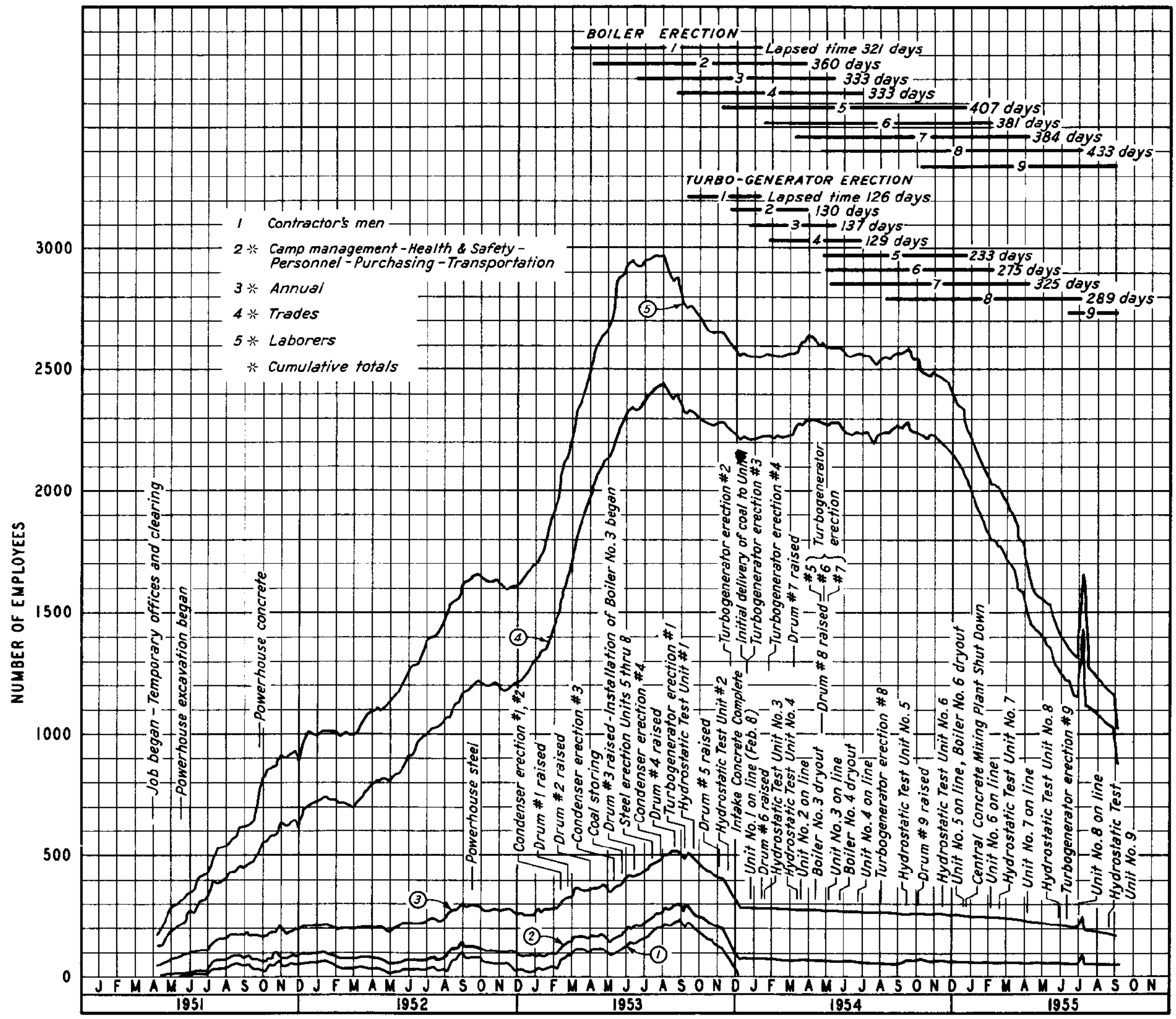


FIGURE 70.—*Trend of employment by categories through the major period of construction as related to particular items pertaining to the erection of boilers and turbogenerators, units 1 through 9. Peak employment reached nearly 3000 in July 1953.*

white-collar applicants in the project vicinity and the Tennessee Valley area to fill all job needs except for the three categories of boilermakers, welders, and structural iron workers. The demand for these categories was supplied through the cooperation of the union representatives for the area. Figure 70 shows the monthly distribution of employees by general classification of work for the construction period at the Kingston Steam Plant project. The peak in employment occurred during July 1953 with almost 3000 workers on the project. The average monthly turnover of labor was not excessive as indicated by table 14. Tables 15 and 16 show the distribution of workers by craft.

TABLE 14.—*Average monthly labor turnover —Kingston Steam Plant.*

Period	Total payroll average monthly	Average terminated per month	Percent of total
1951[1]	555	27	5.5
1952	1,213	52	4.3
1953	2,354	143	5.8
1954	2,467	99	4.0
1955[2]	1,374	168	14.3

1. May through December.
2. Reduction in force in progress.

TABLE 15.—*Distribution of Construction Branch trades and labor forces at the Kingston Steam Plant project.*

Date	Boilermakers	Carpenters	Electricians	Iron Workers	Laborers	Machinists	Millwrights	Operating Engineers	Painters	Teamsters	Cement Finishers	Sheet Metal Workers	Steamfitters
1951													
May	0	43	4	9	82	3	0	4	1	12	0	0	7
July	0	63	24	19	97	4	0	17	5	18	3	0	11
Sept.	0	78	33	28	144	7	0	30	10	23	3	0	21
Nov.	2	82	45	65	289	2	0	75	9	66	3	8	28
1952													
Jan.	2	122	46	87	291	6	0	94	2	70	3	10	38
Mar.	3	126	47	101	274	8	9	105	2	69	3	9	36
May	2	162	43	97	299	20	11	126	2	84	3	10	38
July	2	186	67	115	361	24	10	138	3	87	6	12	42
Sept.	2	215	92	131	410	26	15	148	8	97	15	23	61
Nov.	18	213	115	119	429	30	19	166	11	117	14	33	68
1953													
Jan.	32	176	142	151	406	31	17	170	11	122	15	30	70
Mar.	65	172	197	222	467	33	18	193	12	126	19	35	128
May	220	208	266	254	529	35	28	248	19	143	21	51	168
July	320	204	326	253	601	35	39	261	51	149	21	60	197
Sept.	323	195	345	245	494	23	44	233	62	133	24	68	215
Nov.	307	163	330	222	378	18	56	177	79	113	26	71	252
1954													
Jan.	329	159	349	231	359	33	65	175	81	111	26	71	281
Mar.	335	156	365	226	343	33	72	170	87	102	26	72	276
May	419	155	370	215	332	30	57	174	94	101	26	72	300
July	435	154	360	184	321	29	61	164	94	96	18	72	291
Sept.	477	152	342	164	300	28	65	163	99	89	22	63	301
Nov.	516	110	347	164	262	27	68	148	100	85	17	65	304
1955													
Jan.	503	106	359	107	259	24	62	143	103	77	11	65	292
Mar.	419	95	298	87	229	17	47	108	94	71	11	64	242
May	349	88	215	79	196	17	30	87	95	66	11	43	189
July	216	66	183	68	162	17	25	71	98	61	11	42	163
Sept.	176	65	137	56	153	17	27	66	93	54	11	32	139
Nov.	106	41	85	50	105	13	21	74	46	39	5	30	123
1956													
Jan.	12	34	68	31	89	5	9	19	89	33	5	29	74
Mar.	8	29	67	31	72	5	6	19	89	25	5	16	40
May	7	28	48	22	68	4	4	21	83	27	3	16	37
July	0	23	45	15	54	4	6	24	92	29	2	10	35
Sept.	0	21	41	14	71	4	2	17	80	23	2	8	32
Nov.	0	21	37	14	53	3	2	13	84	23	2	7	26
1957													
Jan.	0	14	35	9	38	2	2	8	48	16	2	7	26
Mar.	0	13	33	6	37	2	0	8	46	16	2	5	29
May	0	12	33	7	33	2	0	9	23	14	2	6	29

The quality of labor was also satisfactory despite the inevitable competition for the most experienced workers by contractors of the Atomic Energy Commission project. The several contractors on the AEC project maintained a force of more than 10,000 construction workers during the period 1952-1955.

Employment procedure

Construction management through frequent conferences made the decisions regarding manpower requirements and requested the project personnel office to fulfill them. The personnel office was then responsible for recruitment and employee processing. Methods of recruitment varied, depending upon such factors as the status of applicant files and urgency for filling the jobs. In a few instances, the employment needs coincided with completed programs at other TVA projects and employees were obtained from those jobs. A chief source of recruitment for trades and labor employees was the local labor unions. Upon being informed of employment needs, the local union

TABLE 16.—*Distribution of Construction and Maintenance Branch trades and labor forces at the Kingston Steam Plant project.*

Date	Carpenters	Electricians	Iron Workers	Laborers	Machinists	Operating Engineers	Teamsters	Cement Finishers	Steamfitters
1951									
May	3	3	0	103	3	18	9	0	1
July	5	3	2	157	38	93	49	1	1
Sept.	19	3	2	193	38	121	71	1	1
Nov.	11	3	3	151	5	157	74	1	3
1952									
Jan.	2	2	1	105	4	121	50	0	2
Mar.	2	2	1	93	3	120	47	0	2
May	0	0	0	0	0	0	0	0	0
July	0	0	0	0	0	0	0	0	0
Sept.	0	0	0	0	0	0	0	0	0
Nov.	0	0	0	0	0	0	0	0	0

business representatives would refer candidates to the project for interview. Candidates completed TVA applications if they were not already on file. If they did not meet TVA requirements, the union was asked for additional candidates.

All appointees were interviewed prior to commencing employment. The personnel office checked and discussed with them their application, established their veteran status, and obtained information required by the personnel security program. Each appointee was also required to pass a physical examination given by a TVA medical officer in the local Health and Safety Unit.

Work schedules and shifts

A work schedule of three shifts, five days a week, was maintained during the major construction phase of the job. The project was placed on an overtime schedule of five 9-hour days each week beginning February 16, 1953. This was done to bring the schedule in line with the Oak Ridge project and keep qualified workers on the job, avoiding frequent and heavy turnover. The overtime schedule was continued to January 31, 1955.

Wage and salary rates

By terms of the TVA Act, the TVA pays its trades and labor employees on the basis of the prevailing rate of pay for work of a similar nature in the vicinity (the entire Tennessee Valley and certain adjacent areas) with due regard to those rates which are established through collective bargaining. The prevailing rate of pay to apply for each class of work on all TVA jobs is determined in wage conferences which have been held annually, usually in December, between TVA representatives and members of the Tennessee Valley Trades and Labor Council. The hourly wage schedules for the period 1951-1955 are included in Appendix A.

The TVA Act also provides that the Board of Directors shall determine and set the pay rates for salary policy employees. Prior to 1951 the policy was to follow generally the pay for similar work in the classified Federal service in spite of the fact that TVA was not under Civil Service. However, in November 1951 TVA and the Salary Policy Employee Panel agreed to change the policy for the employees classified at grades 1 through 7. The TVA Board thereupon adopted a new pay policy whereby TVA salary policy rates were determined by the following criteria:

Grades 1 through 7

(1) Prevailing rates for similar work in vicinity.
(2) Trades and labor annual pay rates where close working relationships exist between salary policy employees and annual trades and labor employees.
(3) The relative difficulty, responsibility, and qualification requirements of jobs.

Grades 8 through 11

An appropriate pay differential to recognize relative difficulty and responsibility and qualification requirements of work performed.

Grades 12 through 14

General conformance to prevailing rates of pay in the Federal service at grades comparable to TVA grades 12 through 14.

Relations with contractors

In addition to the construction work carried out by TVA forces, certain segments of the work were performed under contract. In some cases assistance was given the contractor in recruiting his work force by suggesting employee names or sources for obtaining them. The TVA assumed no responsibility in actual selection of the contractor's employees. The contractor selected his employees in accord with his own policies, and usually through arrangements with the local union. These employees did not report through the TVA personnel office and no personnel records were filed on them by TVA.

All contracts executed by TVA for materials and services require compliance with all applicable statutes, executive orders, and regulations. This includes the requirement that the contractor pay his employees the rates of pay which are not less than those paid for work of a similar nature prevailing in the vicinity and which are not less than the rates paid by TVA to its employees for doing similar work. The maintenance of comparable rates of pay thus necessitated close working relations between the personnel office and the contractor. In order to determine compliance by the contractor with this provision of the contract the payrolls were checked and a spot check was made of his employees to verify wage rates being paid. Job comparability was usually determined by verbal conference with the contractor. Any rate differences found were usually due to revised wage schedules which had not reached the office where the payrolls were prepared. Satisfactory adjustments were always made promptly and without question.

In cases where the contractors employed men in crafts in which TVA had no employees the prevailing rate for such work, as confirmed in writing by the contractor, was accepted. During the course of construction all such contractors on the job had union contracts and the usual negotiated wage scale was in force.

Labor relations

Project union organization—The following policy statement from the Administrative Manual governing the relations between TVA and the employee organizations had been approved by the TVA Board of Directors:

> It is recognized that both employees and management have important responsibilities in carrying out the work of TVA. It is also recognized that the success of TVA's program depends to a large degree on the mutual understanding and unity of purpose between employees and management. Such understanding and unity can best be maintained if employees share in forming and administering the personnel policies and rules which govern the relations between them and if there is ease of communication between them. Responsible unions designated by employees to represent them make it possible for employees to participate more effectively in this task. These organizations also provide a ready means of communication between employees and management. For these reasons TVA encourages its employees to join such organizations and has provided for collective bargaining and negotiation of agreements between these organizations and management on matters affecting employee-management relations.
>
> Agreements between management and employees recognize that TVA as an agency of the Government of the United States of America is accountable to such Government and must operate within the limits of legally delegated authority and responsibility.

Unions which represent a majority of the employees in any defined bargaining unit are recognized as representing all employees in that unit for the purpose of collective bargaining and labor-management cooperation. In order to implement the stated objective and deal with matters which affect trades and labor employees generally, the Tennessee Valley Trades and Labor Council was formed in 1937 by the 12 craft unions of the American Federation of Labor which had jurisdiction over the types of employment in which TVA was engaged. By 1940 relations between the TVA and the Council had matured to a point where both thought it was time to enter into a written agreement. On August 6, 1940, the Council, then including 15 international unions, signed a General Agreement covering matters of mutual concern. In the application of the provisions of the General Agreement local management dealt chiefly with the local union officers.

The representative agency for defined units of "white collar" employees in grades 1 through 7 was the Salary Policy Employee Panel with which TVA also negotiated Articles of Agreement covering matters of mutual concern. The Panel consisted of the Public Safety Service Employees Union, Office Employees International Union, Building Service Employees International Union, TVA Association of Professional Chemists and Chemical Engineers, and the TVA Engineers Association. The first three are AFL-CIO Labor Unions.

The local headquarters of labor unions having union jurisdiction over trades and labor employees employed on the Kingston project were located in Knoxville, with the exception of the painters and boilermakers whose local headquarters was in Chattanooga. Salary policy employees organizations had local chapters at the project. Each trades and labor craft on the project was represented by a job steward who was appointed by the business representative of the union. The job stewards were regular employees and in nearly all crafts performed normal work duties a major part of the time. The project Construction Superintendent conferred with the job stewards in a group each week. Work problems and matters other than grievances were discussed for the purpose of cooperative adjustment.

Salary policy employees were represented by elected officers of their respective organizations. Complaints and job problems could be discussed at any time with management officers, and this avoided many disputes.

Labor disputes—The entire period of construction at the Kingston project was relatively free from labor arguments and disputes. However, there were some disagreements, the majority of which were minor. Most of these arose from jurisdictional claims between crafts and were settled quickly. The most serious of the incidents were the four described as follows:

1. Internal dissension occurred in the iron worker craft caused by one group of workers who wanted to have the job steward replaced because they felt he was not properly representing them. Disagreement over the job steward continued for two days until one of the dissatisfied group suggested that they leave the job until the matter was settled. After an absence of two and one-half days, the men were ordered to return to work by the International Union. The local union officials refused to replace the job steward but conditions improved and there was no further disturbance in this craft.

2. A jurisdictional disagreement occurred between two crafts over distribution of work by the Construction Superintendent. Employees of the steamfitter craft left the job the last two hours of one shift as a protest, saying that the job steward was unable to reach the business representative for advice. They were ordered by the International Representative to return to work the following morning.
3. Dissatisfaction of warehouse employees occurred because of administrative methods used by an assistant supervisor who was charged with "harsh, capricious, and dictatorial supervision." This group of employees left the project in protest. After being absent from work one-half day they were assured of a hearing regarding the complaint and were instructed by their respective unions to return to work.
4. The job steward for truck drivers was scheduled by management to work on an overtime day, but he refused to accept a working assignment. The truck drivers stopped work for an hour to discuss the incident and they were informed by management that they would not be paid for the hour so all went home. They returned to work the following work day.

Because of the mutual attitude of cooperation, and the TVA area-jurisdictional agreements and decisions, disagreements were settled promptly. The time lost from disputes in comparison to the total man-hours worked was negligible and job progress was not significantly affected.

Management-employee organizations—The Trades and Labor Cooperative Committee composed of the hourly job stewards of the 15 crafts, the General Construction Superintendent, and the general foremen from each of the crafts was organized August 1, 1952. It continued in very active status until the final meeting November 17, 1955. Monthly meetings were held on the project, and they were presided over by the alternating co-chairmen from labor and management.

The Salary Policy Cooperative Conference was organized December 6, 1951, and concluded its activities November 17, 1955. Delegates or representatives from salary policy employee organizations and management representatives from accounting and costs, and engineering made up this group. The employee representatives were elected by their respective unions. Supervisors were appointed by the Project Manager, which included the co-chairman. Delegates from employee unions elected their co-chairman. The conference met each month, and the co-chairmen alternated in presiding over the meetings.

The Public Safety Service Cooperative Conference was formed February 18, 1953, as a permanent body and continued meeting regularly after construction was completed. The group is made up of representatives of the Public Safety Service Employees Union and management from the Division of Reservoir Properties. The scope of the activities of this conference is primarily related to work of the Division of Reservoir Properties. It deals with job conditions, work schedules, traffic, fire prevention, and plant protection.

Personnel Officers served as secretaries to the cooperative meetings, editing and distributing the agenda and minutes for the three organizations.

The Trades and Labor Cooperative Committee agreed to interest itself in the following objectives:

> To encourage systematic employee-management cooperation on matters of mutual interest; eliminate waste in construction and production; conserve materials, supplies, and energy; improve quality of workmanship and services; promote education, recreation, and training; correct conditions making for grievances and misunderstandings; maintain good relations with the public; safeguard health; prevent hazards to life and property; better employment conditions; strengthen the morale of the service; attain common understanding of departmental and general TVA programs and policies; stimulate and utilize employee suggestions.

The Salary Policy Cooperative Conference adopted a similar field of objectives.

The organizations also concerned themselves with other community activities. In many instances they jointly took part in or sponsored programs and activities such as picnics, baseball games, dances, and welfare programs. These organizations also made themselves responsible for charitable fund drives among the employees, encouraged defense bond purchases, and promoted other project-wide service activities.

The most spectacular accomplishment of the cooperative organizations was the dedication ceremonies of the Kingston Steam Plant November 17, 1955. In planning the program the cooperative bodies stated that because of the part they played in the day-to-day construction activities of the world's largest steam plant, union-management relations had been substantially strengthened throughout TVA and they asked for permission to sponsor the program. The groups received enthusiastic endorsement from TVA management in this endeavor.

Training—TVA encouraged an apprentice training program from the early stages of the project. A local Joint Apprenticeship Committee was organized July 11, 1951. The committee realized the opportunities which would be available for a training program were important because of the size of the project. It therefore began organizing procedures to begin the employment of apprentices immediately. The personnel office staff arranged to give the qualifying apprentice tests, arranged for classroom space, assisted in the selection of instructors, and met with the craft subcommittees to select apprentices. The Personnel

Office also maintained attendance records and generally assisted with the entire program.

A total of 85 apprentices were being trained during peak operations on the project. This was one of the largest groups of apprentices ever employed on a TVA construction project. By crafts there were 13 carpenters, 1 cement mason, 26 electricians, 4 millwrights, 9 painters, 9 iron workers, 7 sheet metal workers, 14 steamfitters, 1 operating engineer, and 1 equipment mechanic. The operating engineer and equipment mechanic apprentices were the first in those crafts to be enrolled in such a program with TVA.

TVA also promoted a program for training of supervisory employees and 208 of these employees participated. The topics and instructors were arranged for by the Staff Training Officer of the Division of Personnel. The instructors were staff members from the Division of Personnel in Knoxville. In order to give all supervisors training, three separate series of classes were held on the job, all during working hours. The training was designed to increase supervisors knowledge and understanding of TVA personnel policies; improve their ability to apply this knowledge and understanding and the background and reasons for the policies; and to increase generally their qualifications as supervisors. The following topics were covered in each of the three series of conferences: TVA's organization and current information about the TVA program; history, purpose, and principles of the General Agreement; instructing men in their work and developing ability for more responsible work; TVA's policies on nepotism and political participation; proper completion of various status change forms, instruction in reduction in force, and other termination procedures; supervisor-employee relations; grievance procedure; purpose of cooperative committees; and annual wage negotiations, job classification, and evaluation of program by supervisors.

The subject matter was designed to develop a better informed group of supervisors at all levels and to provide better working conditions and relations between them and their employees. Consequently, hourly trades and labor foremen and assistant and general foremen participated in the program. Each supervisor was given a certificate of accomplishment upon completion of the training, and copies were placed with their personnel records.

The training plan was climaxed by a program for journeymen; 700 of whom participated in the program over the three-year period. They attended classes outside of working hours on mathematics, elementary drafting, shop sketching, and blueprint reading. To provide classroom space for the large group, classes were held in the lunch room and the cafeteria building in addition to the personnel office classroom. The classes were two-hour periods Monday through Thursday, each week. Some evenings it was necessary to hold three separate classes at the same time because of the large number of participants. TVA furnished the space, training materials, and instructors. The participants purchased the textbooks and other material. Each employee eventually received a certificate signifying satisfactory completion of the course with appropriate copies for his personnel record. Instructors were selected from engineers, foremen, and journeymen on the job, and were paid under the Smith-Hughes Act by State-Federal funds.

HEALTH AND SAFETY

Medical services

Arrangements were made for the medical unit to be located temporarily in the Swans Pond Boat Dock Building, and services were provided starting April 30, 1950. A health officer, a nurse, and a clerk were the first medical personnel assigned to the project. During the month of May a technician and a clerk supplied X-ray and laboratory services from a mobile X-ray laboratory. Preemployment examinations and other medical services were provided from this location until the permanent medical center building was occupied in July 1951. Because the work area was some distance from the medical center building, a first-aid station was established in the construction area. First-aid services for outlying areas during certain phases of construction were handled by a medical aid working from an ambulance.

Medical services consisted of preemployment examinations, periodic examinations, treatment of service-related illnesses and injuries, immunizations against communicable diseases, treatment of minor non-service-related illnesses and injuries, and advice regarding maintenance of health among employees. The medical program was surveyed and certified by the Occupational Health Institute as meeting all Industrial Medical Association standards for providing medical services to industry, and was awarded the Certificate of Health Maintenance.

As construction activities diminished, the number of medical personnel was reduced according to continuing service needs. The first-aid station was closed as construction of the steam plant moved nearer to the medical center building and transportation was no longer a problem. Medical services for construction personnel were required throughout fiscal year 1956. Table 17 shows the major medical services provided for employees during the construction period.

Industrial hygiene activities at Kingston were aimed at controlling occupational hazards as a means of protecting the health of workers. Wet weather during much of the construction period helped to keep dust exposures from rock drilling at a low level. Rock consisted largely of shale, which was low in free silica, but contained some sandstone seams which were high in free silica (80 percent).

TABLE 17.—*Kingston Steam Plant construction medical services.*

Period	Total visits	Examinations	Service-related treatments	Initial injuries	Non-service related treatments	Laboratory services	Immunizations
May and June 1950 to June 30, 1951	1,694	748	480	229	157	317	356
July 1, 1951 to June 30, 1952	14,644	2,311	4,722	2,153	3,231	4,272	4,814
July 1, 1952 to June 30, 1953	21,007	3,625	8,128	3,117	4,966	9,194	5,091
July 1, 1953 to June 30, 1954	32,374	3,100	15,798	6,733	9,653	6,639	4,633
July 1, 1954 to June 30, 1955	24,975	2,365	12,135	5,967	7,732	3,462	2,944
July 1, 1955 to January 25, 1956	6,372	1,041	2,622	1,255	1,538	1,133	834
Total	101,066	13,190	43,885	19,454	27,277	25,017	18,672

Various levels of lead absorption were encountered among construction workers. Much of the structural steel received at the project had been coated with red lead paint. When operations such as riveting and welding were performed on the steel, atmospheric concentrations of lead became high. As blood levels began to show excessive absorptions, control was undertaken, primarily by limiting the duration of exposure and by improved ventilation.

Employee safety

The safety program began in May 1951 with one project safety engineer under the supervision of an area safety engineer. For short periods during the peak of construction activities, two other safety engineers were assigned to the project. The work, including construction of a railroad from Harriman, was scattered over a wide area.

The safety program was discussed with each person employed and the importance of his own safe practices emphasized. Crew safety meetings were held by all crafts weekly. Monthly meetings were held for foremen and supervisors, and films and talks by TVA officials were used to stimulate greater interest in these safety meetings. A weekly foremen's and supervisors' safety bulletin and a monthly safety bulletin for all employees were published throughout the construction period.

Shortly after construction began, a safety patrol was organized to cover the project periodically. Later the patrol was discontinued and a rotating-type safety committee took its place. This committee met each week to discuss safety problems. A representative was appointed as safety man for each craft. Approximately 75 men completed a 15-hour first-aid course. Safety equipment such as belts, respirators, hard hats, and goggles were stocked in ample supply before construction work began. More than 300 pairs of safety shoes were purchased through the safety office.

Four of the 63 injuries charged to this job were fatalities. A lineman installing a bus line around the wall in the basement of the powerhouse was electrocuted when he apparently got the 220-240-volt lines crossed. An iron worker on a scaffold at the top elevation of the powerhouse fell 123 feet to his death when he was knocked off by a skip pan. A millwright was struck and killed by a scaffold board which was knocked off the top of a crane. A boilermaker was killed in a 36-foot fall when he slipped on a wet guard rail he had climbed to remove a snatch block.

TABLE 18.—*Kingston Steam Plant construction work injury experience.*

Fiscal year	Man-hours[1]	Number of work injuries: Fatal	Permanent partial	Temporary	Total	Number of days lost: Fatal	Permanent partial	Temporary	Total	Rates: Frequency[2]	Severity[3]
1951	137,564	—	—	2	2	—	—	22	22	14.54	160
1952	2,201,490	1	1	6	8	6,000	108	575	6,683	3.63	3,036
1953	3,811,698	—	2	10	12	—	1,725	1,247	2,972	3.15	780
1954	6,392,642	1	5	8	14	6,000	2,165	419	8,584	2.19	1,343
1955	5,309,586	2	3	21	26	12,000	450	2,626	15,076	4.90	2,839
1956	1,158,198	—	—	4	4	—	—	269	269	3.45	232
Total[4]	19,011,178	4	11	51	66	24,000	4,448	5,158	33,606	3.47	1,768
Construction only: Total	18,355,258	4	11	48	63	24,000	4,448	5,102	33,350	3.43	1,828

1. Man-hours first reported March 1951 and carried through December 1955.
2. Number of work injuries charged per million man-hours worked.
3. Number of days charged per million man-hours worked. Comparison with hydro plant data published in previous reports may be made by moving the decimal three points to the left, i.e., 3,036 becomes 3.036.
4. Includes Construction and Maintenance, Reservoir Properties, and Maps and Surveys.

The Kingston project won the National Safety Council's Award of Honor for outstanding safety performance during calendar year 1953. Local safety awards were given to several employees for their outstanding efforts in accident prevention. These awards were in the form of pictorial cards of billfold size signed by the project manager, safety engineer, and departmental supervisor. Table 18 lists the work injury experience during construction of the plant.

Environmental sanitation

Technical supervision was maintained over housing, water supply, food service, sewage disposal, garbage disposal, and other public health engineering activities associated with the construction of the steam plant.

Water for domestic use was obtained through an extension of the system serving the city of Kingston. For isolated crews of workmen, water was made available in conveniently located 20-gallon covered, insulated, galvanized metal cans. The Kingston supply proved to be adequate in quantity until the dry summer of 1954 at which time it was supplemented by water from the permanent filter plant that had been constructed. Subsequently this permanent plant provided water requirements of construction and operating personnel.

Satisfactory garbage disposal was obtained by contracting with an individual who was required to dispose of it in a manner that would not endanger the public health.

Air pollution control

Attention was directed to potential air pollution problems in the vicinity of the Kingston plant because of the size of the plant, the topography, and the presence of nearby urban areas. For units 1-4, 250-foot stacks, and for units 5-9, 300-foot stacks were constructed. An experimental constrictor (fig. 71) was placed in the top of one of the 250-foot stacks to study the effects of doubling the exit velocity of flue gases. Mechanical collectors were installed for fly ash control and provision was made for the subsequent installation of electrostatic precipitators if advisable. Electrostatic percipitators were installed between August 1959 and March 1961 (see Appendix E).

A comprehensive program was undertaken to monitor any effects of air pollution and to study the dispersion of particulate and gaseous wastes (see Appendix E). Initially, a meteorological station was established in January 1952 near the plant site to record the principal meteorological elements believed to affect dispersal of plant effluents. This installation was later supplemented by other meteorological instrumentation on an existing tower extending above the level of ridge crests in the Kingston area.

In the summer of 1954, with the plant having from two to four units in operation, a network of six autometers was established from one to four miles from the plant. These instruments trace a continuous record of the SO_2 concentration in the atmosphere. In June-July 1954 a network of 36 lead peroxide cylinders was established near the plant to test the accuracy of this technique and to supply estimates of SO_2 exposure in areas not monitored by autometers. An automatic smoke sampler was placed in operation in August 1954 to determine whether any soiling effect resulted from atmospheric particulates in the Kingston area. Operation of a network of 12 deposit gages was begun in February 1955 to measure the deposited material. Finally, in July 1955 a high-volume filter was placed in operation to measure the average loading of suspended particulates in the atmosphere.

Special field studies have included continuing surveillance to observe the effect on vegetation, collection of vegetation samples for chemical analysis, mobile sampling, and plume observation for study of diffusion. Operational studies have included extensive investigation of the feasibility of selective feeding of low sulfur coal. In connection with this study, meteorological investigations have led to a system in which use can be made of forecasts for periods of extreme stagnation. A stockpile of low sulfur coal is maintained for use during such periods.

Studies to determine the significance of air pollution in the vicinity of this plant are continuing. Biological observations in 1955 revealed marking of some of the more sensitive common truck crops in a test garden 1.4 miles from the plant and scattered light marking on less tolerant woody and herbaceous plants. Chemical analysis of plant foliage has not shown a significant increase in sulfur content. Examinations of particulate matter from the dust deposit gauges indicate that most of the dust in the area does not originate at the steam plant. The importance of this subject warrants further discussion and presentation of data, which is included in Appendix E.

RESERVOIR PROPERTIES

Employee housing

An investigation of housing locations in the nearby communities of Kingston, Rockwood, and Harriman indicated that sufficient rental units for key project personnel would not be available. This made it necessary to provide housing in some other way. Acquisition of land for the plant included purchase of 37 houses with property parcels. It was necessary to remove some of these and several were used for temporary offices. Of the total, 22 cabins and houses were used for employee housing. In addition six prefabricated houses were transferred from the Upper Holston projects area. The remaining 20 necessary units were purchased from a private

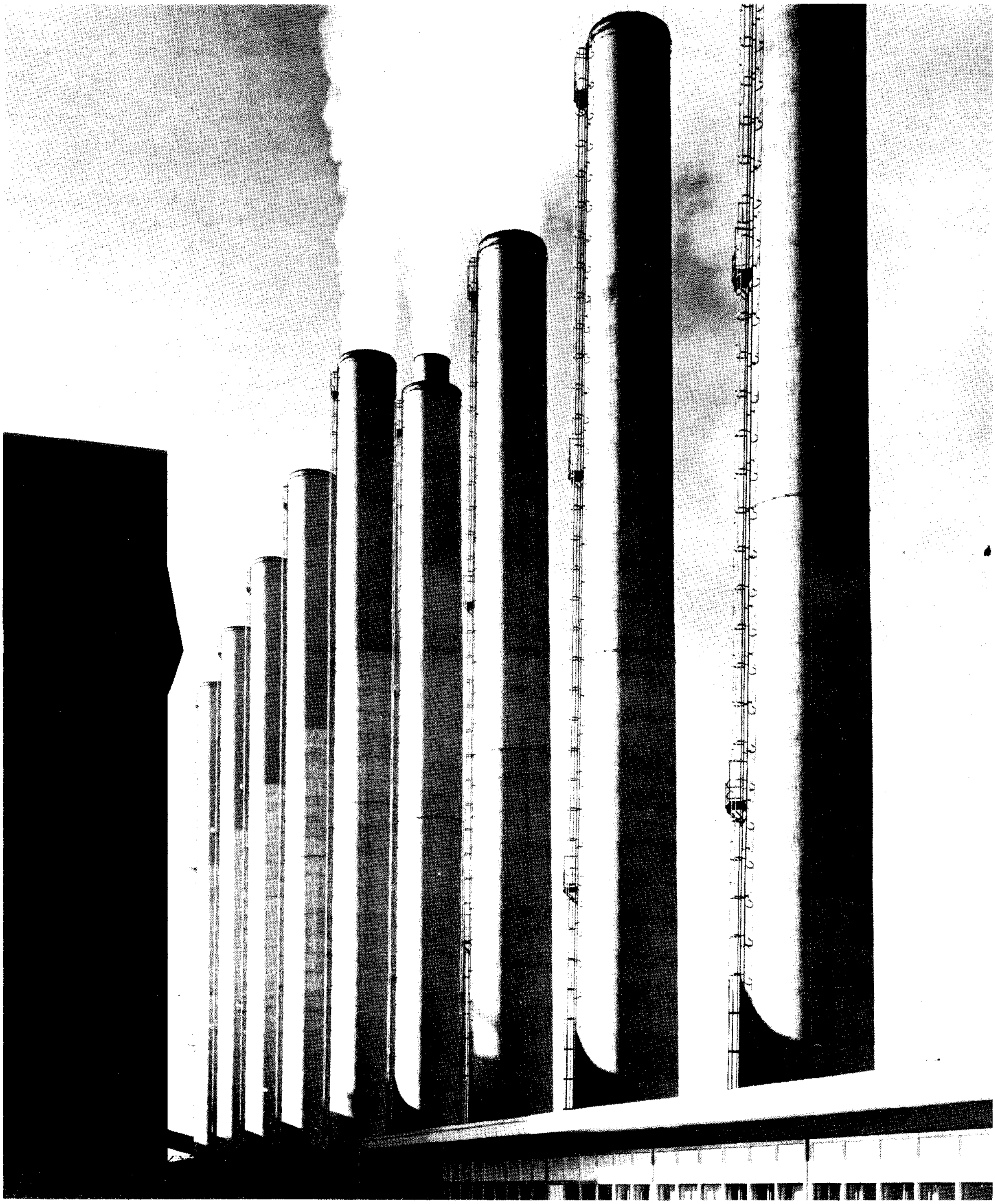


FIGURE 71.—*An experimental constricting tube 10 feet in diameter was installed on top of unit 4 stack to increase the gas velocities from 50 to 100 feet per second. This tube was later removed because the actual results did not justify the increased draft system loss.*

FIGURE 72.—*Laddie Village Addition consisting of 20 homes and lots in the suburbs of Kingston was purchased for employee housing.*

builder and were located in Laddie Village, figure 72, a housing development suburban to the community of Kingston.

The residences, except the prefabricated units, were of conventional construction, and electricity and water were supplied by the local utility system, by the Rockwood municipal electric system, and water by the town of Kingston municipal system. Two of the houses on the project site whose wells were below sanitary standards and were located too far from Kingston to make piped water feasible were supplied with treated water hauled by the construction forces. The reservation roads were maintained by the camp maintenance crew with assistance of construction forces when necessary. Trash removal was handled by construction labor and equipment.

School facilities for employee children residing on the project and at Laddie Village were provided by Roane County in the nearby town of Kingston. Transportation to and from school was also included in the county services. Federal support was given to the county on the basis of the number of children whose parents were TVA employees and working at the project.

Because of the previous "Oak Ridge boom" from 1942 to 1948, during which a reported 30,000 were employed in the area, the schools had expanded their facilities to such an extent that the relatively smaller number of new families resulting from the Kingston project caused no unusual or troublesome impact.

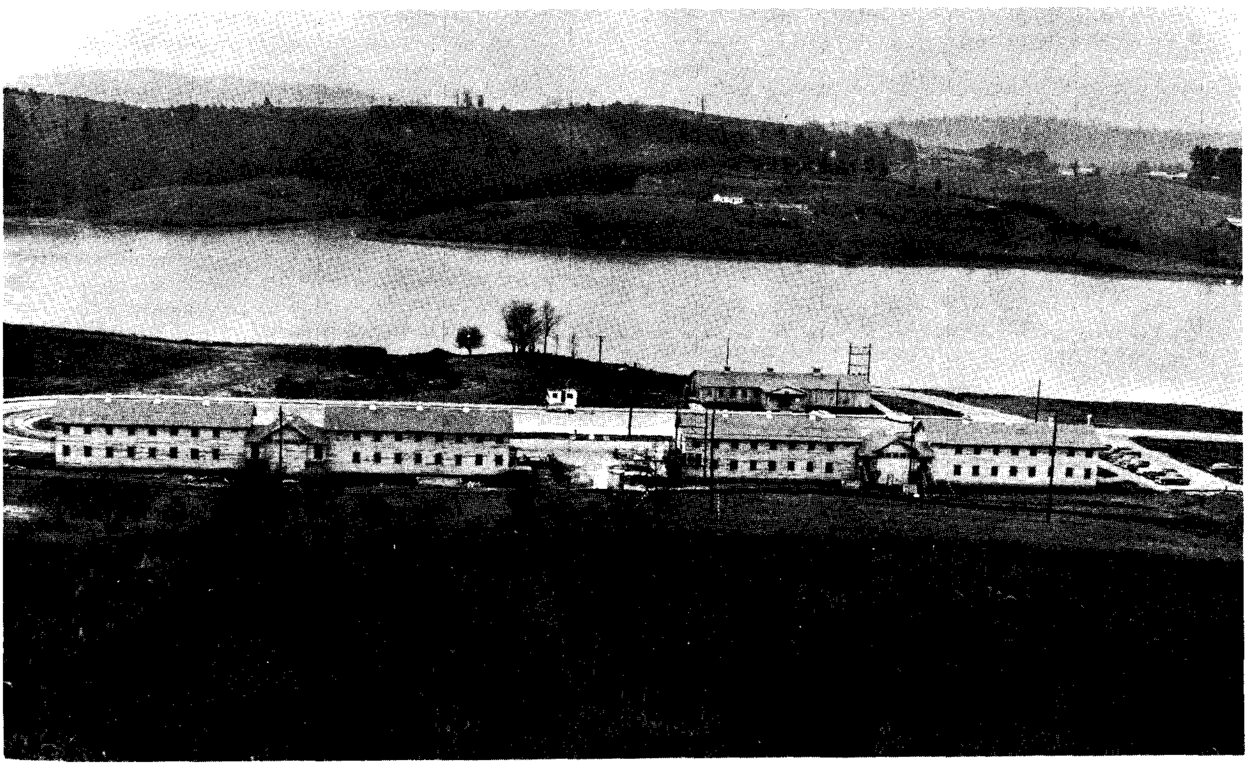


FIGURE 73.—*Two 128-unit dormitories for men and a cafeteria were constructed on the site. Each wing was 200 feet long, two stories high, with bath facilities between two wings.*

Construction camp operations

It was necessary to provide dormitory accommodations for men employees recruited some distance from the project. Three 2-story, 128-man-capacity dormitories were used (fig. 73). Two of these were built at the project (fig. 74) while the third was transferred from Widows Creek project (fig. 75). The structures were rectangular in shape, having two wings with bath facilities in the center. The wing measurement of the buildings was 200 by 24 feet. The dormitories, as well as other camp buildings, were of wood frame construction having drop siding, pine flooring, and celotex ceiling and interior walls. Roofing was of asbestos shingles. All buildings were electrically heated.

Dormitory occupancy reached its peak November 19, 1954, with a total of 333 beds of 342 available. The total unit-night occupancy until this operation ceased amounted to 262,219. The total net income was $53.353. This figure included direct operating costs and income. Overhead, depreciation, and other indirect costs were not included. Disposal of all the dormitory buildings began in November 1955. Removal was completed by successful bidders in January 1956.

No dormitory space was required for women employees. A survey was made among the Negro employees regarding housing requirements and an insufficient number expressed a need to warrant provision of sleeping quarters.

Food service

Dining facilities were essential in connection with dormitory operation, as well as for commuting employees. A lunch room which seated 150 persons was located close to center of construction activities. This was later supplemented by a cafeteria building (fig. 74) constructed to seat 168 employees. In April 1953 both buildings were enlarged to seat 250 and 272 people respectively. Separate feeding facilities for white and colored employees ended in February 1954 by administrative order. A total of 700,274 meals was served at an average per unit loss of $0.08, not including depreciation, overhead, or other indirect costs. The lunch room was operated by a licensee for several months at first, but the operator requested release from the contract because volume of business did not reach expectations.

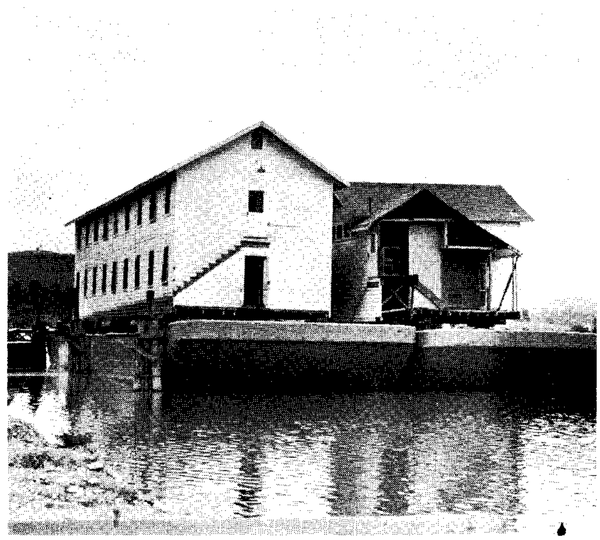


FIGURE 75.—*Dormitories no longer needed at Widows Creek were transported by barge to Kingston for use during construction.*

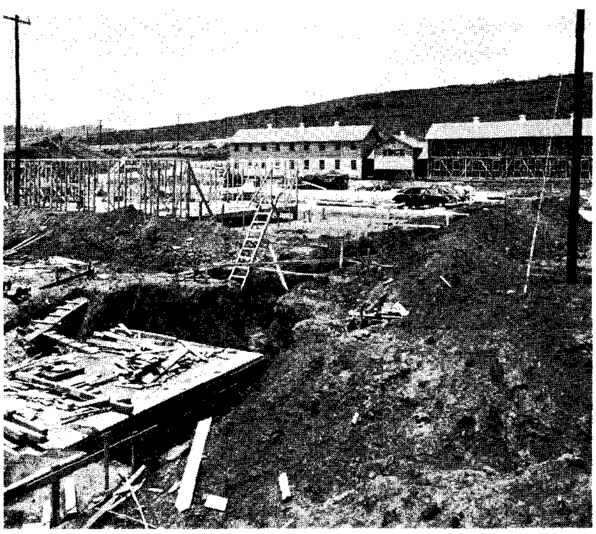


FIGURE 74.—*Construction of the west dormitory is shown at right background. The wall framing for the cafeteria is being erected; a septic tank is being installed in foreground.*

A food canteen located in the center of the construction area provided for the sale of soft drinks and dispensing machines for sandwiches, candies, coffee, cigarettes, pies, and currency change. TVA furnished sandwiches, but all the other services were supplied by a licensee—the Tennessee Service Companies, Inc. TVA received a commission on all sales to pay for the use and maintenance of the canteen building.

Recreation

The proximity of Kingston and other communities obviated the necessity for a full-time supervisor of recreation, particularly since the camp and village were relatively small. The camp manager served as a liason for recreational activity needs, but most of the organized recreation was conducted by the employee organization. There were lounge rooms in the dormitories and two shuffleboard courts and one horseshoe court in the dormitory area. A softball diamond with some spectator facilities was constructed on the project. A picnic area was built by the employees on the lake shore near the project. A small shelter also was constructed for outboard motors belonging to employees. Occasionally, the cafeteria was used for showing moving pictures, usually of an educational or informational nature. Dances and dinners were also held there by the various employee groups.

A camp library was located in one of the dormitory lounge rooms. A contract was made with the Tennessee Regional Library Service of Knoxville for about 500 volumes of assorted fiction as well as current newspapers and magazines.

The Division of Construction supplied electric service, telephone service, water, sewage disposal, street maintenance, and parking areas for all camp facilities. The camp, including the three dormitories and cafeteria, was located near the lake shore about one-fourth mile south of the steam plant site.

Fire protection for the dormitories and other camp buildings consisted of an automatic alarm system, which when activated by high temperatures in each room would set off warning bells to warn all occupants. Additional protection was obtained by a Public Safety Officer patrolling the area regularly seven days a week from 3 p.m. to 7 a.m.

Plant and property protection

The Kingston Public Safety Service was responsible for protection of government property and personnel. Because of the national emergency and the direct connection between Kingston Steam Plant and the Atomic Energy Commission at Oak Ridge, the Public Safety Service was also charged with protecting plant and property from sabotage and espionage. Incidental to its other duties, the Public Safety Service assisted in conducting visitors through the plant, gave automobile drivers tests, instructed employees in traffic safety, and maintained a cooperative relationship with local law enforcement officials.

The public safety service unit was formed April 9, 1951, by an officer from the Fort Loudoun Dam who set up a plant protection unit on the site. He utilized the services of the Fort Loudoun officers as they were needed. The first permanent assignment to the unit was made April 17, 1951, by transfer of three officers from the South Holston project. On May 14, 1951, a lieutenant was transferred as unit supervisor from Widows Creek. The responsibilities and activities of the unit continued to grow until a peak was reached in April 1954. At that time there were 1 captain, 1 lieutenant, 2 firefighters, and 21 other officers on the project filling 8 post assignments, half of them on a 24-hour-per-day schedule and totalling 45,040 man-hours per year.

This unit size was maintained through 1954 and most of 1955, gradually decreasing as construction activities diminished. In February 1956 when the Division of Power was given supervisory responsibility, the Public Safety Service was in the process of being reduced to a permanent operating force of 12 officers including a lieutenant.

The Public Safety Service assisted the Division of Health and Safety in detecting and combatting industrial safety hazards, and in rendering first aid.

Plant security—The Kingston Steam Plant which was to be the largest power producing station in the TVA system (and in the world at time of completion) had more significance in TVA's plant protection plans than other power projects. In addition, it was to have a vital connection with the AEC at Oak Ridge. It was important that practical measures be taken to prevent possible sabotage. Therefore, to augment the regular patrol and inspection service, two 24-hour, 7-day-per-week patrols were instituted within the powerhouse in October 1953. A number of incidents involving possible intent to do damage to property were reported to the Federal Bureau of Investigation for inquiry, but no serious damage occurred during the construction period.

Police activities were generally of a routine nature. Thirty-five arrests were made for violations occurring on the project; and 115 arrests were made for other authorities. TVA arrests generally were for such misdemeanors as drunkenness and disturbing the peace. Arrests for other authorities ranged from misdemeanors to homicide and parole violation. Approximately 1500 papers were served for other authorities. In addition 250 project citations and 900 warnings were issued.

Fire protection—Due to the variety of hazards, protection against fires was of major concern for the duration of construction. Two full-time firefighters were assigned to the group. One of these gave his attention to inspection, fire prevention, and personnel training outside the powerhouse. The other worked full time inside the powerhouse. Fire suppression in the upper levels of the powerhouse was accomplished by a 1½-inch fire hose installed on each level. A 3-stage, 500-gallon-per-minute, truck-mounted pump was used in the lower floors of the powerhouse and for other structures on the project. High pressure water and fog, proportioned with wetting agents, was used on most fires in which the pumper-truck was used.

There were 65 fires between 1951 and 1956, causing damage to TVA property of some $650 or an average of $10 per fire. The largest single fire on the project occurred in September 1952, causing $2,500 damage to a contractor's property.

The project fire fighting equipment was also used in emergencies to assist the nearby communities. The unit was called to the aid of Rockwood, Tennessee, when an asphalt tank exploded killing two city workmen. The fire was quickly extinguished using a combination of fog and dry chemicals.

Traffic control—Due to the proximity to state and Federal highways, traffic control on the project was of some importance. The most critical problem was traffic direction of approximately 800 workers' automobiles at the end of the first shift to clear the parking lots in fifteen minutes. Thirty-five accidents involving TVA vehicles occurring on the project and in the project area were investigated by the Public Safety Service. Three arrests were made. Citations and warnings issued totaled 346 and 1450 respectively; 250 TVA driving examinations were given.

Approximately 250,000 people were conducted on tours of the project. These included the general public and many groups of special visitors sent by various TVA divisions.

MATERIALS

Procurement of materials and services

Procurement for the Kingston Steam Plant was in accordance with Section 9(b) of the TVA Act or with Executive Orders. In general, the Act requires formal advertising with bids submitted in writing and opened and read in public. The Act does, however, permit purchase without advertising when (1) an emergency requires immediate delivery of the supplies or performance of the services; or (2) the purchase is repair parts, accessories, or supplemental equipment or services; or (3) the aggregate amount does not exceed $500. In these cases, the purchase may be made in the open market in the manner common among businessmen.

Before purchasing for this project began, however, TVA had received authorization by Executive Orders, when necessary in the interest of national defense, (1) to make purchases by negotiation, (2) to amend existing contracts without consideration, and (3) to make contracts with provision for advance and progress payments and without performance or payment bonds. Negotiating purchases under these Executive Orders usually made it possible to place contracts quickly and to use available allotments of materials, where the time required for advertising would have delayed getting the contracts entered in production schedules and might also have resulted in losses of allotments.

The Korean War was in progress when purchasing for this project began. Many items—particularly steel, copper, aluminum, lumber, and rubber products—were scarce. A limited priorities system and Federal price controls were in effect. In April 1951 electric utilities were given blanket priority ratings for critical materials for major plant additions and for maintenance, repair, and operating supplies. This rating system was replaced by a nationwide Controlled Materials Plan effective July 1, 1951. Under this regulation, steel, copper, and aluminum became controlled materials. The priority rating for most Kingston construction came under the order which governed utility companies operations.

During 1951, it was very difficult to obtain sufficient materials and equipment to meet construction schedules. The demand for steel far exceeded the supply, and it was often necessary to buy conversion plant steel, which was more costly than mill or warehouse steel. Delays in receiving TVA allotments of controlled materials contributed to the difficulty in getting orders accepted by mills. The TVA purchasing agents frequently had to travel widely outside the valley to locate steel, pipe, and other critical items. On numerous items which had to be manufactured, it was necessary to keep in constant touch with the manufacturers production schedules in an attempt to insure delivery promises. It was frequently necessary to help the manufacturers obtain scarce materials for TVA items. Much effort was devoted to expediting deliveries of items placed on the project's critical list.

By 1952 the Controlled Materials Plan had begun to work satisfactorily. Allotments were received far enough in advance to permit TVA to distribute them promptly to suppliers. Requests for directive assistance were handled more expeditiously by the Defense Electric Power Administration. Early in 1952 the conversion steel market broke unexpectedly, making available additional quantities of steel, in some cases at reduced prices. Aluminum was released for uses other than as conductors on generating projects. Low nickel stainless steel was decontrolled; copper, however, remained in short supply.

A nationwide steel strike began in May 1952 and lasted about three months. After the strike ended, mill orders were filled sooner than anticipated. The mills got into full production rapidly and additional capacity was added by several companies. It was several months, however, before revised delivery schedules could be established on much of the heavy mechanical and electrical equipment, principally turbogenerators, boilers, condensers, and transformers. Deliveries which were rescheduled were usually from one to three months off the prestrike dates. Efforts to improve deliveries of major equipment items were continuous, and in December the National Production Authority agreed to issue freeze orders to equipment manufacturers calling for deliveries for Kingston units 5 through 7 according to an agreed upon schedule.

Price controls were lifted in the first few months of 1953, and prices resumed their upward trend. On February 12, 1953, TVA was authorized by the Defense Electric Power Administration to use the Atomic Energy Commission's defense-agency priority rating E-5 for units 1 through 8. (The E-5 rating for unit 9 was not granted until March 1954.) Benefits from this comparatively high rating were less than expected because decontrol began very soon after the authorization was received. On July 1, 1953, the Controlled Materials Plan was replaced by the Defense Materials System which eased many restrictions of the previous priorities systems. The value of the improvement was offset to some extent by rising prices. At the beginning of 1953, TVA had begun to receive calls from representatives of mills and warehouses which had not solicited orders from TVA for at least five years. Relaxing of Controlled Materials Plan allotment controls and inventory restrictions also contributed to making steel procurement easier. It was soon possible to purchase steel in carload quantities from southern mills. By the middle of 1953, only two or three items, including structural shapes, remained in short supply. In fact, because of the shortage of structural shapes, extensive expediting was necessary to try to keep steel fabricators from falling behind schedule on TVA's orders. Deliveries of construction equipment and some items of machine tools improved markedly. In general, by the middle of the year most materials were available, deliveries were much more satisfactory, and expediting presented fewer problems. The major remaining concern was delivery of units 1 through 4 turbogenerators. The contractor was so busy with other work that it was necessary to obtain Business and Defense Services Administration (BDSA) directives for the equipment and make frequent personal checks of work progress at the factory in conjunction with the AEC and BDSA organization's representatives.

Early in 1954 the BDSA and the TVA both assigned representatives to the units 1 to 4 turbogenerator manufacturer's plant on a full time basis to expedite deliveries. In spite of these efforts, however, the various unit shipping dates were moved back from one to three months. Delays were also experienced with units 5 and 6 whose manufacturers had difficulty with casting work.

An 8-week strike at the plant of the major valve contractor in the fall of 1953 caused additional delays. It was eventually necessary to obtain a BDSA directive to obtain release of important valves impounded as a result of the strike.

Despite continuing difficulty with a few items of major equipment, procurement problems in 1954 were eased by increasing competition among the vendors for TVA's equipment orders, by decreases in prices of some commodities, and by generally improving deliveries.

During most of 1955, however, it was necessary to resume special expediting of the turbogenerators. This resulted principally from defective spindle forgings. A substantial credit was granted by the manufacturer to compensate TVA for delay in operation dates.

Prices continued their upward trend in 1955, especially for steel and copper. Price trends during construction of the project are indicated to some extent by the following index figures from the *Engineering News-Record* Construction Cost Index (1913 = 100):

July 1951	542.36
July 1952	570.65
July 1953	604.10
July 1954	622.49
July 1955	660.09
July 1956	694.75

Most of the major equipment contracts were subject to escalation. Turbogenerators were subject to escalation to price in effect at time of shipment not to exceed 20 percent. The original contract amounts of about $22 million for the steam generating units were escalated about 8 percent. On a total of $8.5 million of contracts for some other equipment, the escalation averaged about 3.5 percent.

Procurement was handled by the central purchasing office at Chattanooga, Tennessee, and a field purchase office at the project. The division had a Washington priorities representative until December 1952. The project field office was opened June 4, 1951, and closed June 30, 1955. The approximate total amount of materials, equipment, supplies and nonpersonal services purchased for the project was $120,726,000. All major purchases of materials and equipment are listed in Appendix C.

Field requisitions for permanent material were written by the project office engineer from drawings or bills of material requesting specific field purchases. These requisitions were distributed by the warehouse after necessary approval. Requests for construction material and equipment were initiated by the construction superintendent and channeled through the warehouse. The warehouse requested necessary materials in order to maintain a stock of selected items used for construction purposes. The office engineer, however, built up a stock of structural steel, steel shapes, sheet steel, pipe, and reinforcing steel necessary for use in the permanent structures. This stock was inventoried and requisitions were issued by the office engineer from time to time to maintain stock. The stock materials for permanent construction were principally used in construction of work detailed in the many field fabrication orders issued by the office engineer.

Inspection and testing

The inspection service which the TVA established in the early years of its existence provided regular inspection at points of manufacture for architectural, electrical, mechanical, and structural equipment and materials. This same procedure was followed for materials and equipment used in the Kingston Steam Plant. This service functioned through the Inspection and Testing Branch of the Division of Design with main offices in Knoxville, Tennessee. District offices were established in strategic manufacturing centers, namely, Pittsburgh, Pennsylvania; Philadelphia, Pennsylvania; Chicago, Illinois; Milwaukee, Wisconsin; Schenectady, New York; and Birmingham, Alabama, for the handling of this work. Specially trained inspectors from these locations covered various mills and shops furnishing materials, equipment, and parts purchased by TVA directly or through suborders of prime contractors.

The inspection and testing of construction materials, such as cement, sand, and gravel, etc., was handled by TVA's Materials Laboratory at Singleton, except in some special cases where the Inspection and Testing Branch was specifically called in for assistance.

Specification and inspection procedure—Specifications were prepared by the branch originating the purchase requisition. These specifications were reviewed by the Specifications Section to see that the proper standards, such as ASTM, AIEE, or ASA, were incorporated and that the specifications were technically correct.

The responsible design engineer usually designated whether or not the equipment was subject to inspection at destination or by the Inspection and Testing Branch at point of manufacture. This statement was then incorporated in the invitation to bid under the special conditions.

When inspection at point of manufacture was designated, the contractor was instructed to handle all matters relating to inspection with the Head Materials Engineer of the Inspection and Testing Branch. Immediately following an award, detail instructions relative to materials and shop inspection were given the contractor. He was notified to furnish copies of suborders placed with suppliers, and upon receipt of these copies, inspection procedure and methods were outlined with the subcontractors. Inspectors witnessed tests of materials at points of manufacture and, when desirable, sent samples for check purposes. Copies of test reports made by the producer or his designated testing laboratory were furnished the inspectors.

In addition to actual inspection for quality and workmanship, the service included periodic and systematic reporting on the production progress as well as a prediction by the inspector as to dates of shipment. Inspectors were furnished information regarding construction schedules, urgently needed materials and equipment, and critical items that might delay construction and erection. When shopwork on such items was being delayed or the progress was such that shipments would not be made on time, the inspector called this to the attention of the responsible officials in the plants with the request that appropriate action be taken to get the items back on schedule. The inspector's firsthand knowledge of the equipment being processed and its current status in the shop gave important assistance to the field engineers in planning construction schedules.

If the prime contract required shop assembly the inspector checked such assembly and made certain that parts were properly match-marked and that a drawing was prepared for use in field erection. In general, the responsibility for crating and packaging of equipment for shipment was that of the contractor and not the inspector. A final report was issued when each contract was completed, stating materials or equipment that had been inspected, accepted, and released for shipment.

For the Kingston Steam Plant, 466 main contracts and orders with a value of approximately 93.5 million dollars were assigned to this branch for inspection at point of manufacture. The material entering into this equipment was furnished by many suppliers. On some contracts there were more than 1000 suborders with various companies for material. The more important materials were inspected and tests made at sources of supply; the remainder were inspected after delivery to the contractors' plants, the suppliers furnishing certified test reports. It is estimated that in addition to inspection at the main-contractors' plants, this branch inspected materials at approximately 1500 subcontractors' plants. The material and equipment which were inspected originated in 32 of the 48 states. The total cost of this inspection was $291,844, or 0.31 percent of the contract price. Similar materials and equipment were inspected at many of the same plants for other projects at the same time, which accounts in part for this low inspection cost.

HYDRAULIC DATA

The Hydraulic Data Branch obtains, analyzes, and reports basic data in hydrology, meteorology, hydraulic model testing,[1] and special studies for use in planning, design, and operation of hydro and steam projects. Extensive investigations were made relative to water temperatures which affected the design of the condenser cooling water works. This study is described in Appendix D. Considerable work was done also in cooperation with the Division of Health and Safety on air pollution studies. This is reported upon more fully in Appendixes D and E. Other contributions made by this Branch are described briefly below.

Condenser conduit loss study

After completion of the 78-inch and 96-inch precast concrete condenser water conduits it was found necessary, because of improper manufacture, to provide them with internal reinforcement. Construction and economic considerations favored the use of a structural steel frame support along the vertical diameter of the conduits. Since available literature contained no data on this type of obstruction inside conduits, the hydraulic laboratory devised and conducted tests to determine the head loss caused by such supporting frames consisting of two 15-inch I-beams placed along the top and bottom of the pipe and held apart by a pipe strut 4½ inches in diameter with and without streamlining. The model scale for the tests, determined by the use of 8-inch cement-asbestos pipe to simulate the conduit, was 1:12.3 and the test section in the laboratory was 156 feet long. The test results showed that streamlining of the downstream side of the struts eliminated nearly half of the head losses incurred by the use of these struts. The tests developed a relatively simple streamlined tail

1. On October 1, 1961, the Engineering Laboratory, which performs all laboratory model testing, became a branch in the Division of Water Control Planning.

consisting of two flat steel plates 18 inches wide and ¼ inch thick. These plates were essentially as effective as an airfoil section. Prototype measurements made in a 322-foot length of the actual conduit after installation of the reinforcement showed that the head loss in the conduit was in agreement with the results of the model test.

Meteorological data

Weather forecasts were supplied daily to construction forces at Kingston Steam Plant from August 1951 until the end of the construction period. An instrument tower (fig. 76) for wind and temperature instruments was installed about a mile east of the plant site late in 1951 and the anemograph, hygrothermograph, and recording therometer, together with a rain gage, were put in service January 21, 1952. Beginning in December 1952, the data on rain, wind, temperature, and humidity were transmitted to the project manager monthly on a standard data sheet. The wind and temperature data were more extensively used in connection with air pollution studies.

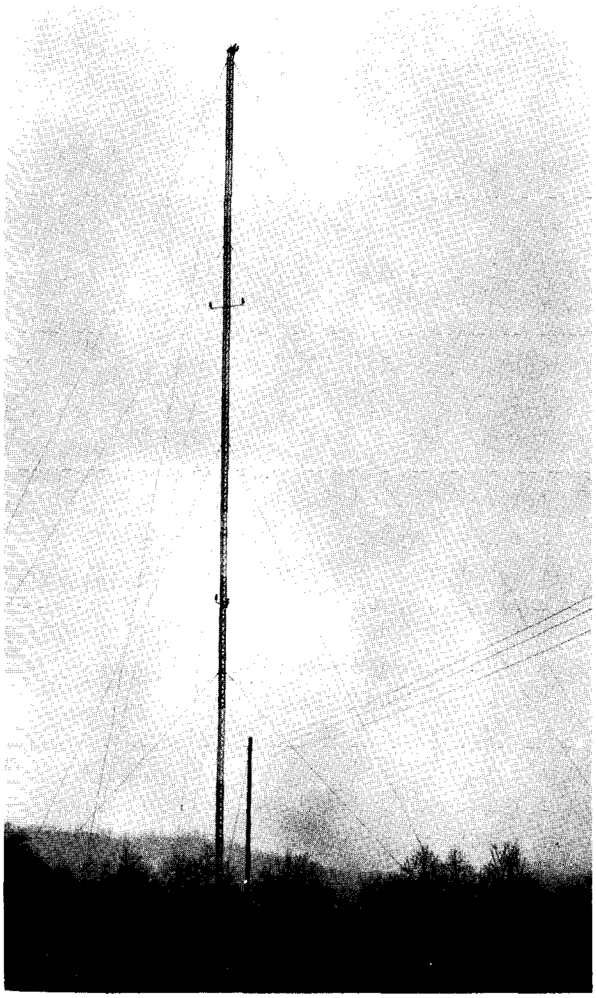


FIGURE 76.—*Anemometer mast erected for the purpose of reading weather statistics for use in weather forecasting and evaluating air pollution.*

Air pollution studies

Appendix E discusses the cooperative studies of air pollution caused by operation of the Kingston Steam Plant.

LAND ACQUISITION

The Kingston Steam Plant occupies an 800-acre peninsula located at the confluence of the Clinch and Emory River embayments of Watts Bar Lake. Kingston, Tennessee, lies about one mile downstream from the site, and the Clinch River enters the Tennessee about three miles downstream.

Acquisition of the site, with its related access railroad and employee village, involved appraisal, title clearance, and negotiation for the purchase of 208 tracts of land containing a total of 851.09 acres valued at $1,067,635.75. See Land Acquisition Map. These 208 tracts include fee land acquired for the steam plant site, the access railroad and the employee village, and permanent easements required for road relocations and other purposes that did not require fee purchase. Additional temporary rights secured during the construction phase of the project, including core drill boring permits, borrow easements, and other similar rights, cost $2,112.50.

Nineteen tracts containing 109.70 acres acquired in fee for Watts Bar Reservoir were incorporated into the steam plant site. These 19 tracts, at the time of purchase in 1941, had an aggregate value of $12,706.32.

The steam plant site

The 697.37 acres of land purchased in fee for the powerhouse site, the transformer and power switching yards, the coal storage area, the railroad yard, and other service facilities, including transmission line connections, cost $636,182.50, with $281,592.50, or 44 percent, allocated to land and $354,590, or 56 percent, to the value of improvements existing at the time of purchase.

Almost one-fourth of the site, 161.39 acres, had been subdivided into parcels of less than 10 acres. Forty-one, or 50 percent of the tracts acquired for the site, contained less than two acres, and 29, or 35 percent, contained more than 2 but less than 10 acres. Twelve tracts, representing 536.08 acres, or about 77 percent of the site, ranged from 10 acres up to 174 acres. Over-all, the 82 tracts acquired averaged 8.5 acres, indicating a significant transition in land use from agricultural to residential development,

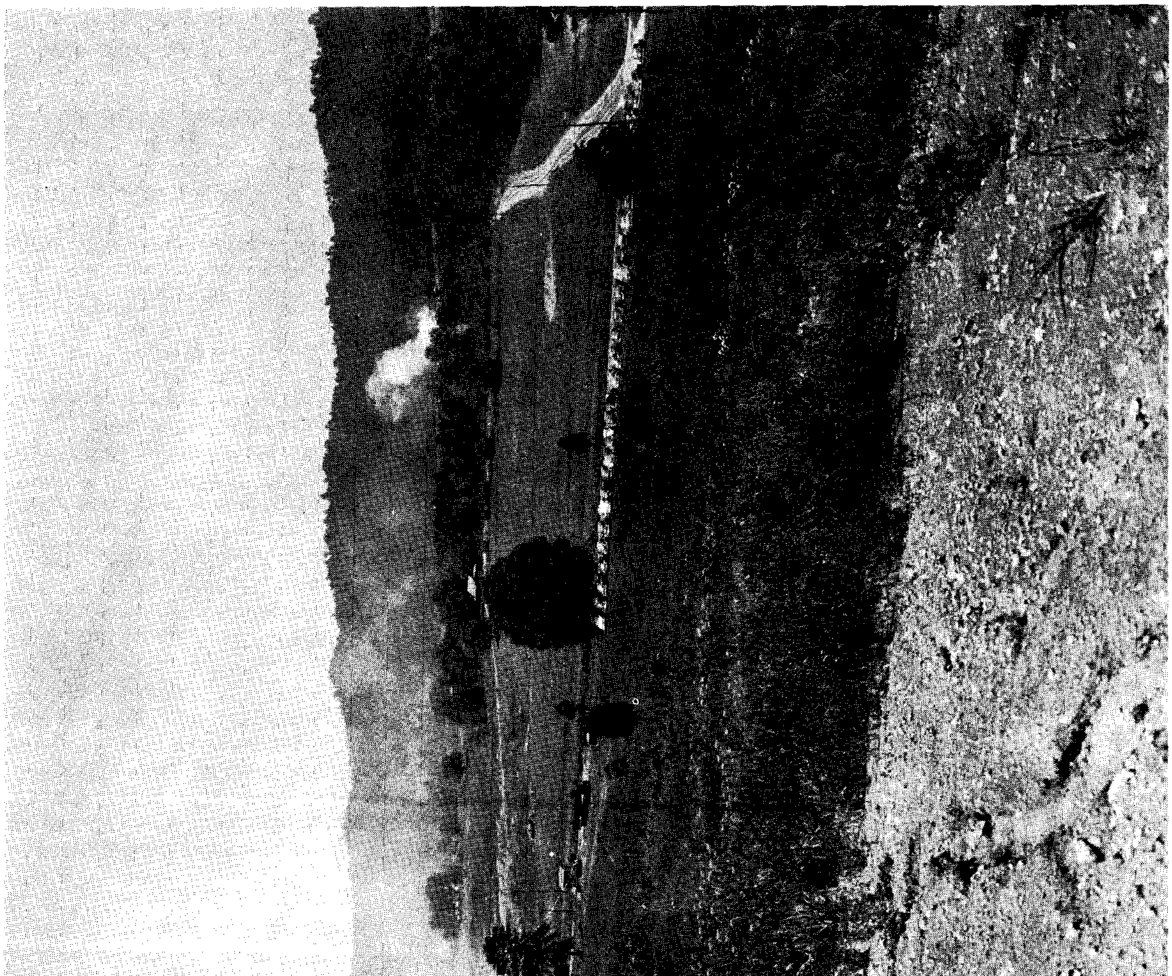
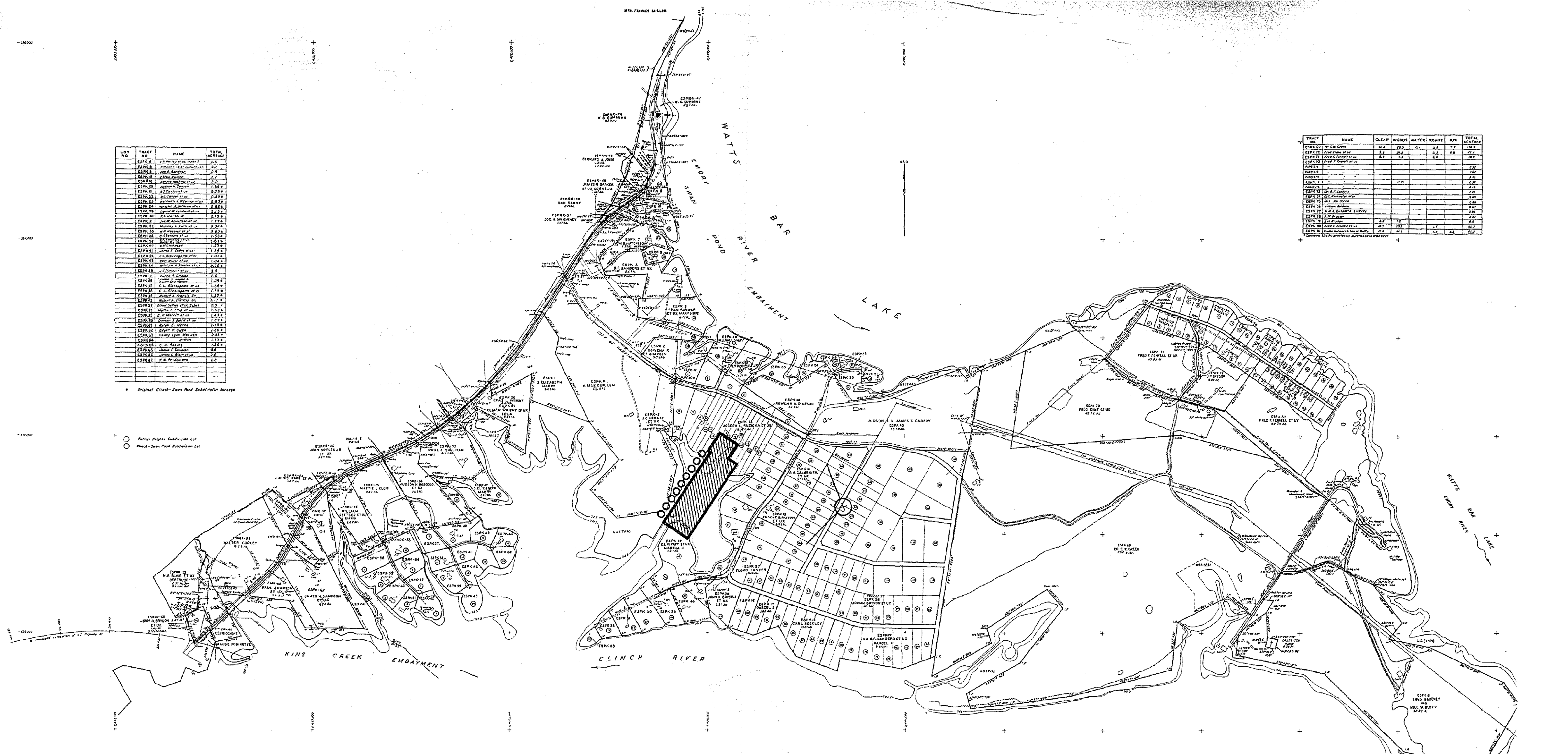


FIGURE 77.—*View of original plant site looking west. The plant location can be identified as extending across the water filled sink at center almost to the country road at right.*



LOT NO.	TRACT NO.	NAME	TOTAL ACREAGE
	ESPK 6	[illegible]	1.5
	ESPK 8	[illegible]	2.1
	ESPK 9	Joe A. Gardner	0.8
	ESPK 10	[illegible]	1.1
	ESPK 18	[illegible]	2.0
	ESPK 20	Judson H. Carson	1.56 *
	ESPK 21	[illegible]	0.78 *
	ESPK 22	[illegible]	0.60 *
	ESPK 23	[illegible]	0.63 *
	ESPK 24	[illegible]	0.88 *
	ESPK 29	[illegible]	2.19 *
	ESPK 30	[illegible]	2.10 *
	ESPK 31	[illegible]	1.57 *
	ESPK 32	[illegible]	0.94 *
	ESPK 33	[illegible]	0.60 *
	ESPK 35	[illegible]	1.56 *
	ESPK 34	[illegible]	0.67 *
	ESPK 40	[illegible]	1.67 *
	ESPK 41	James E. Collins et ux	1.35 *
	ESPK 42	[illegible]	1.01 *
	ESPK 43	[illegible]	1.04 *
	ESPK 44	[illegible]	0.30 *
	ESPK 48	[illegible]	3.0
	ESPK 12	[illegible]	1.0
	ESPK 46	[illegible]	1.08 *
	ESPK 37	C. L. Blassengame et ux	1.36 *
	ESPK 38	C. L. Blassengame et ux	1.10 *
	ESPK 39	Robert A. Francis Sr.	1.37 *
	ESPK 45	Robert A. Francis Sr.	1.17 *
	ESPK 57	Elmer Settles et ux, [illegible]	0.5 *
	ESPK 58	Mattie L. Ellis et vir	1.59 *
	ESPK 59	E. H. Merritt et ux	1.43 *
	ESPK 60	Duncan J. Baird et ux	1.27 *
	ESPK 61	Ralph E. Warne	1.10 *
	ESPK 62	Edgar V. Owen	1.30 *
	ESPK 63	Nancy Lynn Maxwell	0.95 *
	ESPK 64	Hutton	1.37 *
	ESPK 65	C. R. Reaves	1.50 *
	ESPK 66	James T. Simpson	0.6
	ESPK 52	James L. Blair et ux	2.6
	ESPK 82	T. S. Pridemore	1.2

* Original Clinch-Swan Pond Subdivision Acreage

TRACT NO.	NAME	CLEAR	WOODS	WATER	ROADS	R/W	TOTAL ACREAGE
ESPK 69	Dr. C.W. Green	[illegible]	[illegible]	0.1	3.2	7.3	174.9
ESPK 70	[illegible]	[illegible]	[illegible]		0.3	4.8	42.1
ESPK 71	[illegible]	[illegible]	1.3		0.4		10.3
ESPK 72	[illegible]						
PARCEL-1	" " "						1.32
PARCEL-2	" " "						1.02
PARCEL-3	" " "						2.36
PARCEL-4	" " "		0.35				0.38
PARCEL-5	" " "						[illegible]
ESPK 73	Dr. B.F. Sanders						2.81
ESPK 74	[illegible]						0.46
ESPK 75	[illegible]						0.86
ESPK 76	William Baldwin						0.63
ESPK 77	W.M. & Elizabeth Lindsey						2.96
ESPK 78	J. M. Bryson						3.00
ESPK 79	J. M. Bryson	4.8	1.2				6.0
ESPK 80	[illegible]	20.5	20.5		1.7		42.7
ESPK 81	Emma Mahoney & Nell M. Duffy	[illegible]	[illegible]		1.3	[illegible]	42.3

* Contains [illegible] previously purchased in [illegible]

ASSEMBLED FROM LAND ACQUISITION MAPS 36MS421Q501 R5 AND 36MS421PP505 R1

Land acquisition map. Photograph on facing page was taken from position X.

which was undoubtedly accelerated by sale of a TVA-developed subdivision three years before the acquisition program began. The 44 lots that were sold in 1947 were re-acquired for the site. Residential development on adjoining privately owned land also was taking place rapidly, with the more desirable properties near the lake bringing substantial prices.

Forty-eight, or more than one-half of the 82 tracts acquired for the site, included improvements ranging in value from $100 to $29,465. Twenty-three tracts had improvements valued at more than $10,000; the improvements on six of the 23 tracts ranged above $15,000.

Subdivision and rapid development in the area just prior to the acquisition program resulted in high per-acre and per-tract costs. The 697.37 acres averaged $404 an acre for land and $508 an acre for improvements, a total per-acre cost of $912. On a tract basis the 82 tracts averaged $3,434 for land and $4,324 for improvements, an average of $7,758 per tract.

Addition of 109.70 acres of land acquired for Watts Bar Reservoir in 1941 to the 697.37 acres acquired specifically for the steam plant site in 1950 brings the total site, exclusive of lands acquired for other purposes, to 807.07 acres. The value of lands acquired for and reassigned to the site thus totals $648,888.82, or an over-all average of $804 an acre.

The access railroad—road relocation

Complete absence of railroad facilities in the vicinity of Kingston, Tennessee, required the acquisition of approximately 5.1 miles of railroad right-of-way.

Acquired in fee, the right-of-way extends from the steam plant to the vicinity of South Harriman, Tennessee. Two spurs connect with the Tennessee Central Railroad and Southern Railway yards near Emory Gap. The 55 tracts acquired for the access railroad right of way contain 117.81 acres of land that was valued at $131,599.63, an average of $1,117 an acre. Severance damage payments constituted a substantial portion of the amounts assigned.

Construction of the access railroad created road and highway readjustment problems at several locations. As a result of the railroad bed elevation and need for grade separation at the State Highway No. 61 overpass, TVA acquired approximately one mile of right of way near South Harriman. Although the easements acquired for this purpose were relatively small—the 34 tracts made up a total of only 23.55 acres—17 or one-half the properties included improvements valued at $58,010. Added to a land value of $20,875, this brought the cost of the mile of right-of-way to $78,885. On a per-acre basis, the right-of-way cost an average of $3,350.

At other locations, construction of the railroad involved minor readjustments such as realignment to improve grade crossings and to provide access. The 16 easements acquired for this purpose affect 2.91 acres of land with an assigned value of $1,410. Improvements valued at $120 were involved in two cases; the remainder, or $1,290, represented the value of land. In four situations where access was impaired by construction of the railroad, the owners were paid $3,275 for the damages incurred.

Laddie Village

Kingston, Tennessee, the nearest community to the project was experiencing a housing shortage when steam plant construction began. The influx of workers in nearby Oak Ridge had created heavy demands on existing housing, leaving few vacancies in the area. TVA decided to provide housing for key construction employees supervising the project.

In addition to houses acquired with the plant site (p. 129), 20 houses were erected under private contract in the Laddie Village Subdivision in Kingston. Designed to conform to FHA specifications, the 20 houses, with land, cost a total of $219,358.62, or an average of $10,968 for each house. Each lot—the 20 lots were uniform in size, ranging from 0.34 acre to 0.38 acre—was assigned a value of $1,200. Values assigned to the 20 houses ranged from $8,051 to $10,793, depending on the number of rooms, living area, and condition.

All houses have been declared surplus to the needs of TVA and have or will be sold.

TABLE 19.—*Summary of land purchases for Kingston Steam Plant as of June 30, 1960.*[1]

Distribution of land purchases	Tracts	Acres	Total land and improvements cost	Average cost per acre
Fee:				
Plant site	82	697.37	$ 636,182.50	$ 912
Railroad right of way[2]	55	117.81	131,599.63	1,117
Employee housing[3]	20	7.35	219,358.62	3,265[4]
Subtotal fee	157	822.53	987,140.75	1,200
Easements:				
Road relocations[5]	16	2.91	1,410.00	485
State roads	34	23.55	78,885.00	3,350
Flowage easement	1	2.10	200.00	95
Subtotal easements	51	28.56	80,495.00	2,818
Total fee and easement	208	851.09	$1,067,635.75	$1,254

1. Exclusive of land previously acquired for Watts Bar Reservoir: 19 tracts containing 109.70 acres valued at $12,706.32.
2. Includes payment for loss of access affecting 4 tracts. These payments totaled $3,275.
3. Includes 20 houses valued at $195,358.62.
4. Land only exclusive of houses.
5. Minor road relocations resulting from access railroad construction.

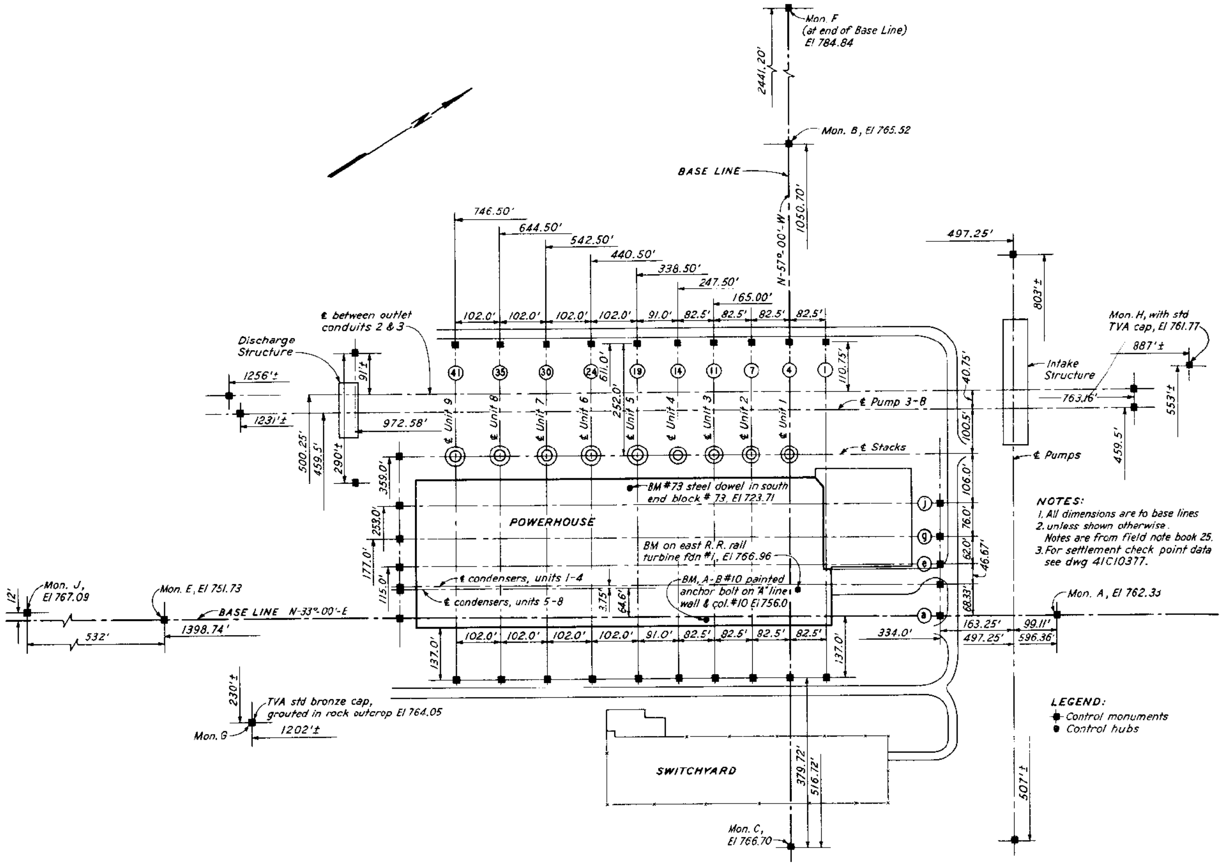


FIGURE 78.—*Control system of hubs and monuments established by Maps and Surveys Branch.*

Summary

Table 19 summarizes the number of transactions, the acreage, and the amounts involved in each kind of acquisition activity for the project.

Ninety-three percent of the 208 tracts acquired for all purposes was obtained by voluntary conveyance. Refusal to sell required condemnation in five cases involving 12.54 acres. Defective title required condemnation in 10 cases involving 42.66 acres.

Eight temporary easements and permits, secured at a total cost of $2,112.50, are not shown in table 19.

The cost of acquiring the land and land rights, including appraisal, title clearance, and final negotiation, amounted to $50,416.

MAPS AND SURVEYS

This organization established the horizontal and vertical control markers (fig. 78) from which the entire project was located and constructed and made property boundary surveys in connection with land acquisition for the plant and access roads. In addition, survey parties were loaned to the project during the early stages of construction to lay out and establish base lines for the permanent plant features. This included the initial surveys for the highway and railroad relocations.

The two survey parties of this branch continued to handle the major portion of the construction layout until the powerhouse excavation for the first four units was substantially completed. Eventually the construction forces had acquired enough personnel to perform all work of this type. The survey parties left the project soon after the access railroad was precisely located.

GEOLOGY

The Geologic Branch makes geologic studies and investigations for the location of TVA structures; interprets the results of exploratory drilling; and determines the requirements for and adequacy of foundation treatment during planning, design, and construction periods. It also investigates mineral rights and possibly quarry sites if necessary. The preliminary work of this branch is described in Chapter 2. Work performed during construction is summarized in the following paragraphs.

Because the foundation for the Kingston plant consists of interbedded shale and limestone which has been complexly sheared, folded and contorted, it was necessary to inspect the foundation area for each block when it was prepared to make sure that a sufficiently sound limestone was present to adequately support the foundation slab. To satisfy design requirements it was necessary that the base slab be thicker than the greatest interval between adjacent limestone beds. In a few instances it was necessary to excavate slightly deeper and thicken the base slab to meet this specification.

In addition to this major assignment, minor geologic problems such as foundation investigation for the intake skimmer wall, inspection of rock cuts in the interchange yard and along the access railroad, foundation investigations for bridges along the access railroad, and investigations for the underwater dam were also made.

Detailed examinations were made also of the Lambert and the Long quarries which furnished aggregate for the project to assure that satisfactory material was produced.

TRANSPORTATION

On June 4, 1951, automotive equipment service and repair facilities were established at the Kingston project by the Transportation Branch. A quonset-type building, provided for the transportation forces, furnished space for servicing several vehicles and for a small office and a stock room.

Maintenance of equipment by the Transportation Branch continued until March 28, 1952; thereafter the Division of Construction handled this work for the Kingston project.

Equipment serviced on the project by the Transportation Branch included medium trucks, winch and derrick trucks, trailers, and Construction and Maintenance Branch Euclids. Most of the sedan and light truck maintenance work was "farmed out" to private shops in Rockwood. After termination of the Transportation Branch services on the project, repair services were provided by the Division of Construction shop, supplemented by the Knoxville Garage and contract shops in Rockwood. Vehicles requiring preventive maintenance inspections or heavy repairs were all sent to the Knoxville Garage or contract shops.

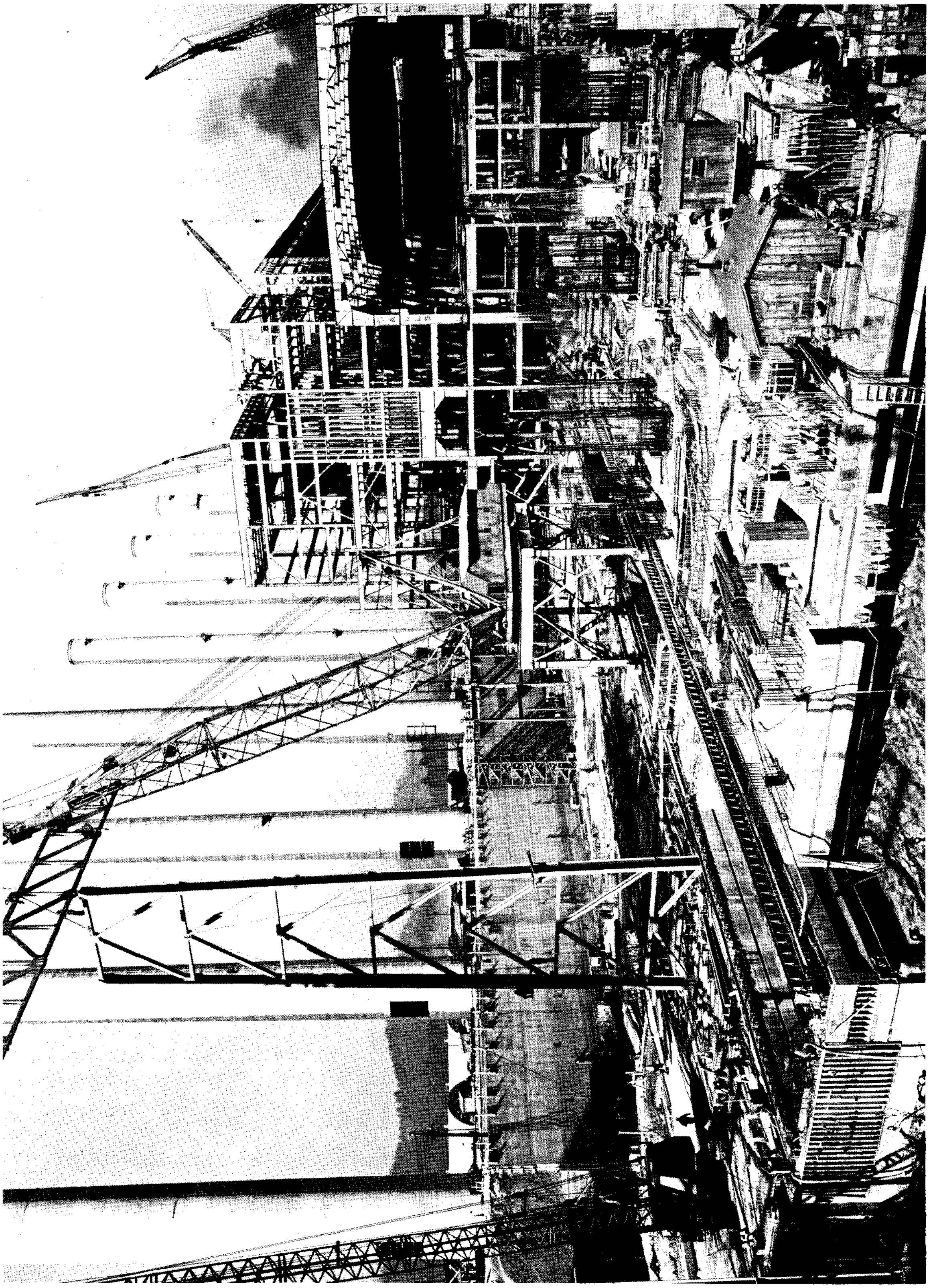


FIGURE 79.—*Construction of the powerhouse November 16, 1963. Erecting steel for unit 5 in background and construction of the substructure for unit 9 in foreground. Construction of turbogenerator foundations at right. Steel erection at top of picture for conveyor bridge BC-5 and 6.*

CHAPTER 5

CONSTRUCTION

This chapter is devoted primarily to the on-site work of the Division of Construction in building the Kingston Steam Plant. Construction services of TVA organizations outside the Division of Construction are described in the preceding chapter.

In spite of the unprecedented economic conditions prevailing during most of the construction period, an eminently satisfactory record of construction costs, speed, and efficiency was attained. The supply of materials and equipment was often critically short, while manpower requirements were sometimes difficult to fully supply. The lengthy steel strike in 1952 also had an adverse effect on the construction schedule.

Construction activities were begun on a limited scale April 30, 1951, with commencement of general grading work. A month and a half later, with the transfer of sufficient equipment and men from the Shawnee Steam Plant project near Paducah, Kentucky, work was begun simultaneously on many specific areas of the project. Concreting in the powerhouse area was begun in October 1951, and the first unit went into commercial operation in February 1954, approximately 2 years and 3 months later. The dates of the principal project construction events are listed as follows:

Construction began—general grading	April 30, 1951
Access railroad grading started	May 28, 1951
Access railroad placed in service—temporary bridge	October 17, 1951
Central concrete mixing plant operation began	October 25, 1951
Powerhouse concreting began	October 29, 1951
Chimney construction started	November 16, 1951
Construction camp opened—cafeteria	September 22, 1952
Powerhouse structural steel erection began	October 16, 1952
Principal piping erection started	March 11, 1953
Coal stocking-out facilities placed in operation	July 1, 1953
Intake channel opened	October 29, 1953
Permanent rail connections completed—Southern Railway	December 18, 1953
Initial steam to turbine, unit 1	January 26, 1954
Intake skimmer wall and dike completed	October 29, 1954
Division of Power Operations occupation of service bay	November 28, 1954
Central concrete mixing plant closed	May 12, 1955
Construction camp closed	September 1, 1955
Celebration recognizing plant completion	November 17, 1955
Initial steam to turbine, unit 9	November 24, 1955

The amount of earth moved, including excavation, during the construction period amounted to approximately 4,316,000 cu yd. Concrete placement totaled 259,800 cu yd, while 27,950 tons of structural steel were erected for all structures including switchyard. The peak of employment occurred during the week of August 18, 1953, with 2964 construction employees, including 195 contractors' employees. The total construction cost amounted to approximately $198,200,000. This includes structures, improvements, equipment, transmission plant, and switchyard. Table 20 is a chronology of unit erection.

TABLE 20.—*Chronology of unit erection.*

Unit	Boiler drum raised	Hartford inspector accepted boiler	Generator erection started[1]	Turbine erection started[1]	Initial steam to turbine	Commercial operating date
1	3-24-53	11- 5-53	9-22-53	10- 7-53	1-26-54	2- 8-54
2	5- 4-53	12-16-53	1- 4-54	12-29-53	4-23-54	4-29-54
3	7-13-53	2-22-54	2- 9-54	1-25-54	6- 4-54	6-11-54
4	8-28-53	4-16-54	2- 8-54	3- 1-54	7-22-54	7-27-54
5	12- 7-53	10-25-54	7- 9-54	7- 7-54	11-25-54	1-18-55
6	2-15-54	12-29-54	9-20-54	9-13-54	2- 2-55	3- 3-55
7	4- 9-54	3-22-55	10-20-54	10-25-54	4-17-55	5- 6-55
8	5-26-54	6- 1-55	11-30-54	10-18-54	7- 7-55	8- 3-55
9	11- 8-54	10- 5-55	7-20-55	7-11-55	11-24-55	12- 2-55

1. Line-up parts.

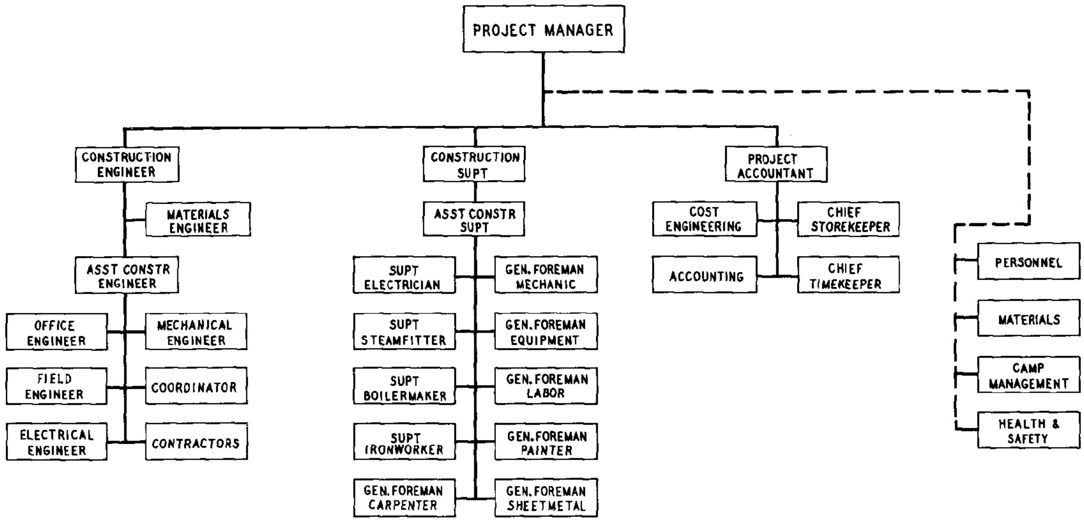


FIGURE 80.—*The construction organization, headed by a Project Manager, consisted of staff branches for engineering, construction, and accounting, and service sections for personnel, materials, camp management, and health and safety.*

CONSTRUCTION ORGANIZATION

The construction program at the Kingston Steam Plant was directed by a project manager who coordinated and supervised the engineering, construction, and accounting organizations. These organizations were headed by the construction engineer, the construction superintendent, and the project accountant, respectively; each was assisted by appropriate field assistants and foremen. The project manager also coordinated the activities of the various service organizations insofar as their responsibilities to the construction program were concerned. This organization is charted in figure 80.

Construction engineering

At the peak of construction the complete engineering organization on the project numbered 75 employees. This organization was headed by a construction engineer with an assistant construction engineer during the period of greatest construction activity. There were five units of engineering, namely: office, field, mechanical, electrical, and materials. All these units were administered directly by the construction engineer with the exception of the materials engineer who reported to the field engineer.

The office engineering unit was supervised by an office engineer. It consisted of a small staff of engineers, draftsmen, and aides, and was responsible for design and preparation of drawings covering construction and erection schemes and miscellaneous items for permanent features not covered by Design Division drawings. This group also made material quantity estimates, initiated permanent materials requisitions for field-procured items, maintained procurement records, and if necessary expedited delivery of permanent materials to insure their delivery in time to avoid interrupting the construction schedule. It was responsible for daily progress reports and job progress photographs, preparation of monthly contractors' estimates and progress reports, drafting service as required by other organizations on the project, and maintenance of working drawing files including distribution of design and manufacturers drawings.

The field engineering organization, composed of shift engineers, survey parties, inspectors, and engineering aides was concerned largely with civil and architectural features of the plant. This group established vertical and horizontal control points and the transfer of those points where necessary to provide building reference lines and elevations required in the construction of permanent plant features. They checked concrete form alignment and embedded parts including reinforcing steel for quantity and location prior to concrete placement; they checked structural steel erection and served as inspectors on installation contracts of architectural items; and they accumulated data for periodically determining job progress.

The mechanical engineering unit composed of engineers and engineering aides checked the installation of all mechanical equipment including associated piping and insulation. They witnessed necessary hydrostatic tests on piping systems and boilers and made certain that boil-out and flushing procedures were carried out in accordance with TVA and manufacturers' instructions. They inspected all mechanical material and equipment as received, giving particular attention to items not previously inspected at the point of manufacture. They checked the location of mechanical parts prior to concrete or backfill placement. They initiated supplemental requests for mechanical material and periodically obtained data for determining job progress.

The electrical engineering unit was responsible for proper installation and operation of electrical equipment in the same manner that the mechanical engineering unit was responsible for mechanical equipment.

The materials engineer was responsible for placement and quality control of concrete and fill material. He was assisted by other engineers and inspectors who checked forms for cleanliness prior to concrete placement, checked concrete mixes and fill material quality and placement. This included field sampling and testing to insure that the materials met specifications.

Construction supervision

The construction superintendent supervised the construction personnel and the operation of construction equipment. There were two assistant construction superintendents, and one superintendent each for electricians, steamfitters, boilermakers, and structural iron workers. There was also one general foreman each for painters, laborers, mechanics, equipment operators, and sheet metal workers. When the number of employees warranted, there were assistant general foremen and subforemen. Work was concentrated as much as practicable on the day shift; but in periods when concrete placement, boiler work, and structural steel erection were heaviest the number of employees on the afternoon shift was increased to approach the day shift level. The night shift was devoted primarily to clean-up and necessary maintenance work.

Accounting

The project accountant supervised the four separate units of the accounting and cost section. These were the accounting unit, cost engineering, timekeeping and payroll, and the warehouse unit. This section was originally organized to serve the Kingston project only; but with authorization of the Gallatin Steam Plant, the project accountant's office provided accounting functions for this project also. This was accomplished by having the Kingston accounting unit assume all general ledger and accounting control functions for both projects.

Responsibilities of the various units are described in the following paragraphs.

The accounting unit was primarily concerned with maintaining the books of account for the Gallatin and Kingston projects and preparing all financial statements. This unit also maintained control of tagged equipment and provided office management services as required for the Kingston project. During the peak of construction there was a total of 19 persons employed in the accounting unit, including personnel required for general office services.

The cost unit was responsible for budgets, estimates, allocation of costs, and preparation of the final cost report in conformance with Federal Power Commission requirements. There was a total of nine persons employed in the work of this unit during the period of peak construction activity.

The timekeeping and payroll unit handled all payroll work for the project and maintained timekeeping controls for trades and labor hourly personnel by means of the "brass check" system supplemented by daily field time checks. During the period of peak construction activity, time and payroll office personnel totaled 23 persons.

The warehouse unit was responsible for receiving, storing, and issuing all material and equipment required for project construction. The warehouse also maintained inventory controls and an expediting service when required. During the peak of construction activities there were approximately 80 employees engaged in warehousing activities on a multiple shift basis.

Contractors

Throughout the course of construction various contractors reported to carry out work covered by their contracts. Reporting dates were established in line with current construction schedules and the contractors were notified accordingly. In general, contract work consisted of installation of architectural, civil, and mechanical features which in TVA's opinion were either highly specialized and could be done more satisfactorily by contractors, or the work involved a craft union with which TVA had no working agreements.

Most of the contracts were typical, lump sum, installation contracts; however, there were three contracts which were somewhat different. Briefly, (a) the contract for the reinforced concrete chimneys provided that TVA furnish the necessary concrete; (b) the principal piping contract, due to the many uncertainties connected with erection of the various piping systems, provided that the contractor furnish necessary labor required to erect the piping for which they were reimbursed as the work progressed; and (c) the contract for the precast reinforced concrete pipe for the condenser circulating water conduits, although not an installation contract, provided that TVA furnish concrete for casting the pipe. The contractors who performed work on the project, and/or furnished materials, are listed in Appendix C, "Major Purchases."

CONSTRUCTION PLANT

The erection of construction plant facilities for the purpose of building the then world's largest steam-electric generating station was a major undertaking in itself. As it subsequently developed, the station capacity was increased to eight generating units about a year after the start of construction of the initial four units, and this was later increased to the ultimate total of nine units. This necessitated a considerable expansion in the construction plant, particularly in the size of the storage areas and other facilities. Contributing to the problem was the fact that the construction schedule was probably the fastest of any plant of comparable size up to that time.

For this kind of growth and expansion the TVA type of organization is particularly well fitted because of the flexibility of the organization, the close and informal relationship between design and field forces, and the long standing TVA practice of close cooperation between the field engineers and the construction supervisors.

At the start, construction personnel were supplied with the general plan and proposed arrangement of the basic construction plant installations as shown in exhibit 94. This drawing served as a guide in organizing and speeding up plant erection.

Other design and detail drawings were supplied for each major temporary building; the concrete and compressed air plants; the electric power substation; the raw water, potable water, sewage disposal, telephone, and power distribution systems; area grading and drainage; and employee parking areas. Drawings not completed in advance were prepared concurrently with construction operations as required to meet the construction schedule. Since these were temporary installations, for use during the construction program, the drawings were revised by the field forces, whenever necessary, to meet local and changing conditions.

Construction plant site topography

The project site consisted of a relatively level area with two large embayments in the immediate vicinity of the powerhouse, some open farm land and extremely high ground to the south and east, and rolling, heavily wooded areas to the north and west. This is shown in exhibit 94. The initial shore line of Watts Bar Lake at the start of construction and the two prominent embayments extending into the powerhouse and coal storage areas are shaded in the locality map of exhibit 1 for better definition. Note relatively high ground to the east of the powerhouse and switchyard, and the permanent-type homes along the shore line to the north of the powerhouse. These permanent dwellings were retained during the initial stages of construction to house construction personnel.

There was adequate space for the construction plant buildings, parking lots, and storage areas, but because of the lack of large level areas it was necessary to disperse these facilities over a rather wide area. This lengthened, to some extent, the construction roads within the plant area, and increased the area to be served by the raw water, treated water, sewage disposal, and electrical distribution systems.

The project had the advantages of easy access from an adjoining asphalt surfaced county road leading to U.S. Highway 70, only 1 mile away, shown in exhibit 1, and the advantage of being close to adequate water and power supplies and river transportation. The nearest rail service was approximately 5 miles distant. However, the site was rough and required a total of approximately 4,316,00 cu yd of excavation and 645,800 cu yd of fill for the completed project. Approximately 176,000 cu yd of earth and 900 cu yd of rock excavation were required in preparing the site for the construction plant. Since most of the construction plant excavation would have been required in preparing for permanent installations, it was not entirely chargeable against the cost of erecting the construction plant.

Raw water for construction operations and fire protection was taken from Watts Bar Lake at a point just northeast of the plant area. Treated water for drinking and the operation of sanitary facilities was obtained from the City of Kingston pumping station located less than 1 mile to the south of the plant area. Electricity for power and lighting was obtained from the construction plant substation located alongside the existing 66,000-v TVA transmission line that crossed the plant area immediately north of the powerhouse.

Site development

Initial work at the site started April 30, 1951. During the early days of construction the existing field roads were used and were kept in repair with patrol graders until they could be surfaced with crushed rock to make them adequate for heavy traffic. They were then incorporated into the permanent construction road system wherever possible. Existing farm buildings and other structures in the immediate vicinity were adapted for use as warehouses, construction offices, etc., until the regular buildings could be constructed.

The sites for the machine shop and warehouse were graded first, followed closely by the site for the carpenter shop and lumber storage area and the employee parking lots. The lumber storage area was located on a steep slope and was graded in a series of five levels so that cuts and fills were approximately balanced. The main parking lot was built as shown in exhibit 94.

Early grading operations also included main plant roads, the site for the quonset huts located to the west of the powerhouse, and the initial construction plant railroad spur needed for early delivery of construction materials. Very little grading was required for the administration, medical, and personnel buildings, and these buildings were located to preserve trees where practicable.

Adequate storage areas were constructed adjacent to shop buildings, quonset huts, and the switchyard. Some space for the storage of materials and equipment was also prepared in the area adjacent to

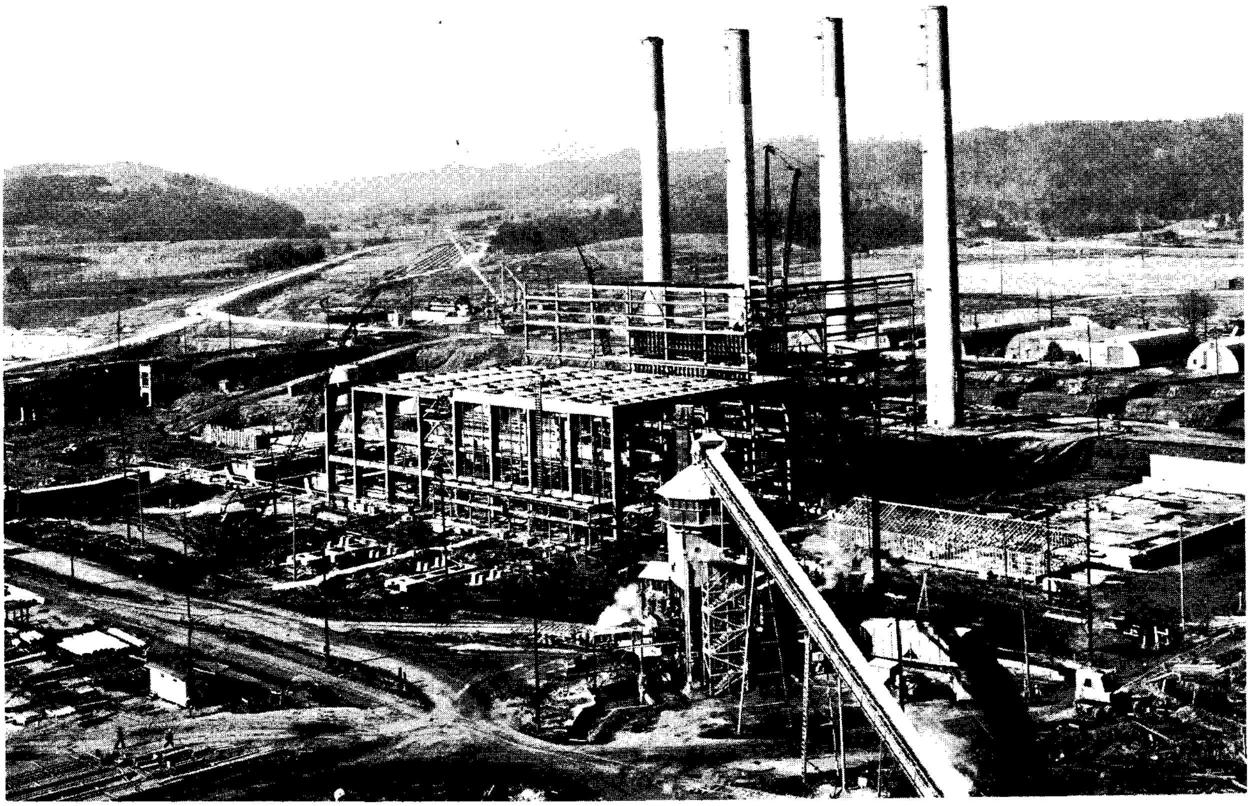


FIGURE 81.—*Construction progress as of February 18, 1953, from top of water tower; stacks of units 1 to 4 from right to left. Central concrete mixing plant is in foreground, and service bay and office wing under construction at right.*

the chimneys, and after completion of the coal storage yard fill the north half of it was used for storage purposes.

Construction roads were surfaced with enough crushed stone to insure the free movement of traffic under all weather conditions, with a normal amount of maintenance.

The initial grading and storm drainage plan prepared by the Construction Plant Branch was modified where necessary as grading progressed to build a system of drains and culverts which would insure adequate drainage of the entire area. Figure 81 shows construction plant facilities and construction operations in February 1953.

CONSTRUCTION PLANT FACILITIES

Buildings and storage facilities

Administration buildings—The location of office buildings and shops may be seen in exhibit 94. The administration building (fig. 82) was a two-story frame structure, 38 feet wide by 91 feet long. It was unpainted, heated electrically, and cooled by an attic exhaust fan. On the first floor were rooms for the project manager, construction engineer, construction superintendent, assistant construction superintendent, drafting room, mail room, and men's wash room. The project accountant, assistant, accounting and cost clerks, conference room, telephone and switchboard, office supplies, map reproduction, and women's room were on the second floor. A fireproof brick vault at the rear of the building extended two stories and was utilized for record storage for both the engineering and accounting sections.

The medical center building was a one-story frame structure, 33 feet wide by 90 feet long. It had a general office and reception room, doctors offices, treatment rooms, X-ray room, etc. At one end of the building was office space for the safety engineer and his staff.

FIGURE 82.—*The administration building was a 2-story unpainted structure. A 2-story brick vault at the rear provided fire-proof storage for engineering and accounting records.*

The personnel and time office building (fig. 83) was a one-story frame structure 33 feet wide by 96 feet long. Approximately two-thirds of the floor space was used for personnel offices and a class or conference room. The remaining floor space was used for the time office. The original structure included a room with five windows for issuing and receiving workers' identification "brass" upon checking in and out. It was necessary eventually to change this method in order to avoid the congestion of employees at the windows checking in and out. Alleys and checking booths (fig. 83) were constructed in a line normal to and to the rear of the main building. These alleys allowed rapid through-passage for the workmen. During the period of peak employment some 2080 men passed through the eight alleys on the day shift and

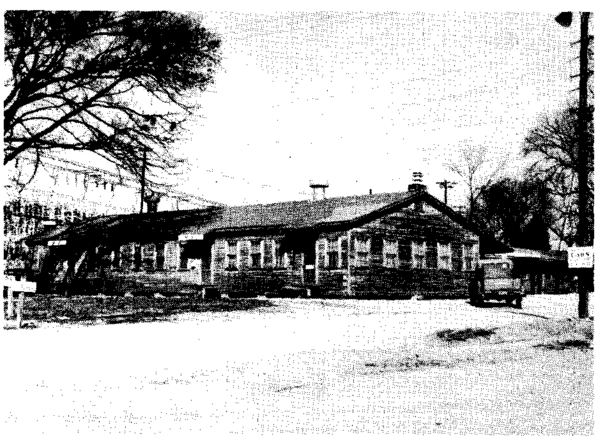


FIGURE 83.—*Personnel and time office building. Eight clock alleys at the rear passed 2080 men on day shift in five minutes.*

dropped their identifying brass within five minutes. The ninth alley was used by the afternoon and night shifts.

A one-story frame structure 26 by 40 feet was used as a public safety headquarters and to house the fire fighting equipment. Later, a 14- by 26-foot addition was made to the building for offices of the camp manager.

The field engineers' office (fig. 84) was a one-story frame structure 30 by 60 feet. It had a large work room containing files of all construction drawings and drafting tables for engineering personnel, various craft supervisors, and others who were frequent users. This room also included desk space for engineering inspectors other than concrete inspectors. Individual offices were provided for the civil, mechanical, and electrical field engineers. After erection of the switchyard fence this building was placed on 12- by 12-inch timber skids and moved to a location north of the control building and west of the switchyard for more efficient use by all groups. At the peak

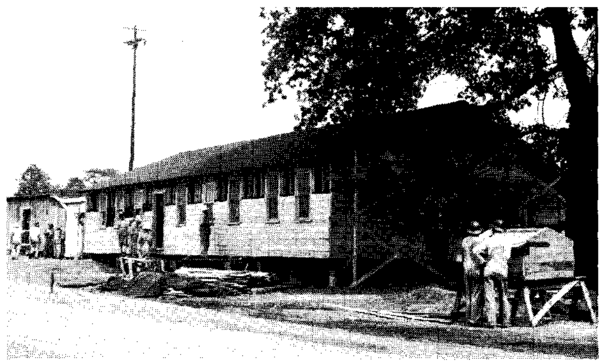


FIGURE 84.—*The field engineer's office provided files and office space for the civil, mechanical, and electrical field engineers, assistant construction engineer, and space for desks and drawing tables for various field engineering and construction personnel.*

of construction activity a 12½- by 30-foot section was added to the south end of the building to allow additional space for mechanical and electrical engineers.

A small one-room structure (formerly the temporary office for the field engineers) was used for a concrete laboratory and office for the materials engineers. This building was located adjacent to and just north of the field engineers' office in its original location. In it were housed scales, screens, various other simple testing devices, and records necessary to the production of concrete.

The general foreman's office was a 20- by 20-foot frame structure on skids. It was used as a meeting place for supervisory personnel to outline or plan their daily work schedule. It was built on the job during the first few days of construction operations, and was first located in the present service bay area and on original ground. When construction activity began in this area it was moved to a point on the north service road between the compressor house and the construction toilet building. Later, it was located southwest of the switchyard on the access road.

A one-story frame structure was built in February and March 1953 for temporary offices of the Division of Power Operations. This building served as office space for the power plant superintendent and other key operating personnel as well as space for a laboratory and limited warehouse facilities. It was located just east of the service bay in the permanent parking lot and loading zone, and was occupied over a period of 20 months while the service bay-office wing of the powerhouse was being completed. Power Operations' personnel vacated the building November 28, 1954, and it was moved soon afterward.

A visitors' overlook building was constructed on the hillside near the time and personnel building, and just north of the principal employee parking area. It consisted of a 5- by 24-foot open front shed on a 12- by 24-foot platform overlooking the project site. The shelter was also used for displaying pictures of other TVA projects and as a place where visitors could get informational pamphlets concerning TVA. Later, the building was moved to the south end of the powerhouse excavation to provide a better view of construction operations in the powerhouse area.

All the above buildings were unpainted and all but the visitors overlook were lined with Celotex wallboard and heated electrically.

Service and equipment buildings—The machine shop building (fig. 85), 60 by 220 feet, housed the electric, sheet metal, heavy equipment repair, machine, blacksmith, and welding shops. A partitioned-off section about the middle of the building along the south side was used for office space and a tool room. Later, when units 5-8 were authorized, the sheetmetal shop was moved to a separate building located between the warehouse and the machine shop. The electric shop was then enlarged to include the space made available by the removal of the sheet-metal shop. In addition to the electric shop, a timber frame, sheetmetal-covered structure was constructed at the east end of the machine shop building for additional shop space. This space was used primarily for cutting and bending electrical conduit and fabrication of other electrical items.

FIGURE 85.—*Machine shop in center and warehouse behind, with compressor building in right foreground.*

Near completion of the project, when it became necessary to vacate the quonset hut which served as a vehicle repair shop, the repair shop equipment was moved to the area in the machine shop building area formerly occupied by the blacksmith shop.

In late 1952, sheetmetal work had expanded to a point where substantially more shop space was required. At this time a one-story frame structure was erected between the machine shop and the warehouse. This building was later enlarged to 40 by 122 feet in size. It had a concrete slab floor, corrugated sheetmetal siding and a roof of asphalt-impregnated roll roofing. It housed all the equipment needed for the fabrication of ducts and the many other items such as copper flashing, gravel stops, etc., for the plant. All the duct work for the heating, ventilating and air conditioning systems, much of the copper flashing, and many small items were fabricated in this building.

The carpenter shop consisted of a timber platform on concrete pedestals with walls and roof of galvanized sheetmetal supported by a structural steel rigid frame. It had a 40- by 60-foot exterior timber deck which was later enlarged to 60 by 70 feet to accommodate the increased formwork when the plant was increased from four to nine units.

A rigging loft (fig. 86) and a timber frame structure 40 by 60 feet, of corrugated sheetmetal, were constructed. The latter was divided to form an office at one end, while the main portion of the building was used for splicing cable, making slings, and other rigging devices.

The structural steel fabricating shop was housed in a quonset building approximately 40 by 100 feet in size. There was a total of 13 quonset buildings on the project, 11 of which were obtained by transfer from the United States Department of the Navy. The structural steel shop was an extremely important component of the construction plant facilities. In it were fabricated virtually all the subframes and other embedded items for the entire project as well as the major portion of the miscellaneous steel. The many steel stairs which were added in the boiler bay and the structural steel frames for the sample preparation and the carpenter shop additions were also fabricated in this shop. The shop was equipped with a 5-ton overhead traveling crane, a power shear and punch, a set roller, two bench grinders, two drill presses, seven welding machines, a plate crimping machine, and various small tools and equipment. A narrow gauge track consisting of 1½-inch slots in the concrete floor and embedded angles was provided beneath the crane for approximately the full length of the building and extending outside the west door. This track carried a push car which permitted the loading of materials by means of a mobile crane outside the building, and the removal of these materials from the car within the building by means of the overhead crane.

The reinforcing steel yard (fig. 87) was located along a railroad spur and had a roadway between the track and stock piles for the crane which was used in unloading and stacking the reinforcing steel. The steel was stacked between rows of posts paralleling the track and on both sides of a roller conveyor. It was then moved along the conveyor to the shearing and bending machines which were located at one end of the row of stock piles.

The pipe shop was located just east of the raw water storage tank. The main building, 40 by 80 feet,

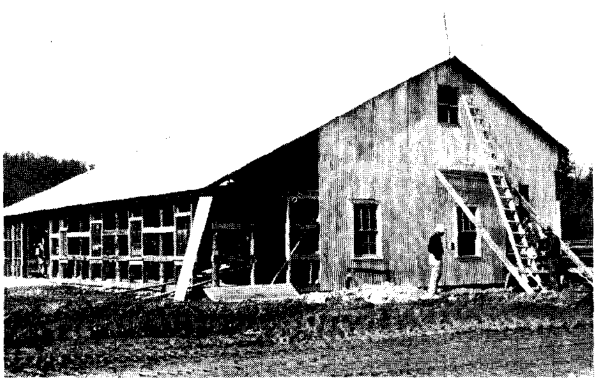


FIGURE 86.—*The rigging loft, of frame construction with corrugated sides and roofing, provided facilities for splicing cable, making slings, and other rigging devices.*

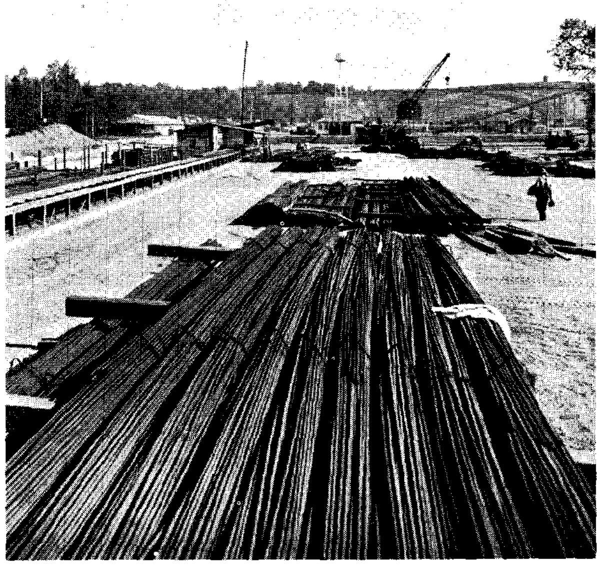


FIGURE 87.—*Steel reinforcing was stacked on either side of a roller conveyor on which it was moved to the shearing and bending machines located at one end of the stock piles.*

was of wood frame covered with corrugated metal siding. The roof was supported by timber trusses and consisted of asphalt-impregnated roll roofing.

Attached to the main building were two shed-type wings. One 12 by 26 feet, served as an office; while the other, 20 by 30 feet, was used for a blacksmith shop. Pipe cutting, threading, and fabrication of all kinds of pipe work, including handrail, were done in this shop. Four terraces cut into the hillside east of the shop served as storage areas for all sizes and types of pipe.

The compressor building 28 by 64 feet was located north of the powerhouse, along the service road, and between the turbine room and the service bay railroad spurs. It was of wood frame construction with sides and roof of galvanized iron and aluminum sheets salvaged from farm buildings originally located on the plant side.

The boilermakers craft along with the boiler manufacturer's erecting personnel occupied a quonset building at the west end of the powerhouse. This building contained offices, a welding shop, and tool and small material storage spaces during the initial stages of construction. When the backfill was completed in the area west of the chimneys the boilermaker offices were moved to a temporary frame building, located in the vicinity of chimney number one. As the work progressed from unit to unit, this building, which was constructed on heavy timber skids, was moved along with the work to a final location in the vicinity of chimney number eight. The boilermakers continued to use the west end of the quonset building for a welding shop and for tool and small material storage. The major portion of this building was occupied by the boiler contractor for offices and tool storage. The boilermakers also used a small frame building, erected on skids, located in the north end of the boiler parts storage area for use of the yard crews.

In addition to these spaces the boilermakers maintained a toolroom on the ground floor of the powerhouse beneath the coal bunkers. This toolroom was moved from time to time as construction progressed.

The paint shop was approximately 35 by 50 feet located in the parking area west of chimney number seven. It was divided into an office for the general painter foreman, a paint mixing room, an issuing counter, and a change room for the painters. Paint was requisitioned from the warehouse as needed and mixed either by hand or by a motor-driven mechanical mixer. Only limited storage was provided in and around the paint shop.

A building 12 by 20 feet located just northwest of the carpenter shop served as a sign painting shop. All signs required for construction activities or for the Division of Power Operations were painted in this shop. Another small shelter was a first-aid station; this was housed in a small building located in the parking area west of the chimneys.

The lunchroom was located just east of the switchyard opposite unit 2. It was a 1-story frame structure originally 32 by 61 feet, later enlarged to 32 by 76 feet.

A canteen was located in the parking area west of the chimneys. It was a 1-story frame structure measuring approximately 20 by 44 feet.

A motor pool was established in the area north of the carpenter shop. This area contained ample space for the parking of trucks and other vehicles. An office for receiving calls and dispatching vehicles was located in the center of the area in a 20-foot-square structure.

A service garage for automobiles and trucks was housed in a quonset building. It was operated by the Transportation Branch until March 28, 1952, at which time it was taken over by the Construction Branch and placed under the supervision of the project general mechanical foreman.

In addition to the toilet facilities provided within the various office and shop buildings, there were two separate toilet buildings 10 by 20 feet in size. One was located along the service road north of the service bay and the other, built later, was located west of the chimneys. The first was connected to the septic tank near the intake channel while the one west of the stacks was connected to the permanent sewage system.

TVA furnished a small wood structure located near the time office for the convenience of a Rockwood bank in cashing employees' pay checks.

In addition to the buildings mentioned above, there were a large number of semi-portable, 1-story frame structures, generally about 20 by 20 feet located in the area west of the chimneys. These buildings were used for offices and small tool storage by the various crafts such as the iron workers, pipefitters, carpenters, and cement finishers; and by contractors, including those on chimney erection, pipe installation, and insulation work. These buildings were moved during the progress of construction in order to provide easy access to the work as it moved south from unit 1 to unit 9 and also to make room for the construction of the parking lot curbs, sidewalks, and pavements extending southward from the service bay.

Storage facilities—At the commencement of construction operations, adequate warehousing facilities were not available. An existing 5-room farm house was utilized for warehouse office space and limited covered storage until such time as adequate buildings were erected. This shortage of initial warehouse facilities was only partially resolved by completion of the main warehouse in September 1951. Adequate storage for materials was never quite achieved due to the sudden approval for the additional units and the resultant tremendous volume of material to be handled, particularly after the rapid rate of delivery was achieved. During the period of initial construction operations, from April 30 to October 17, 1951, no direct rail connections were available at the project

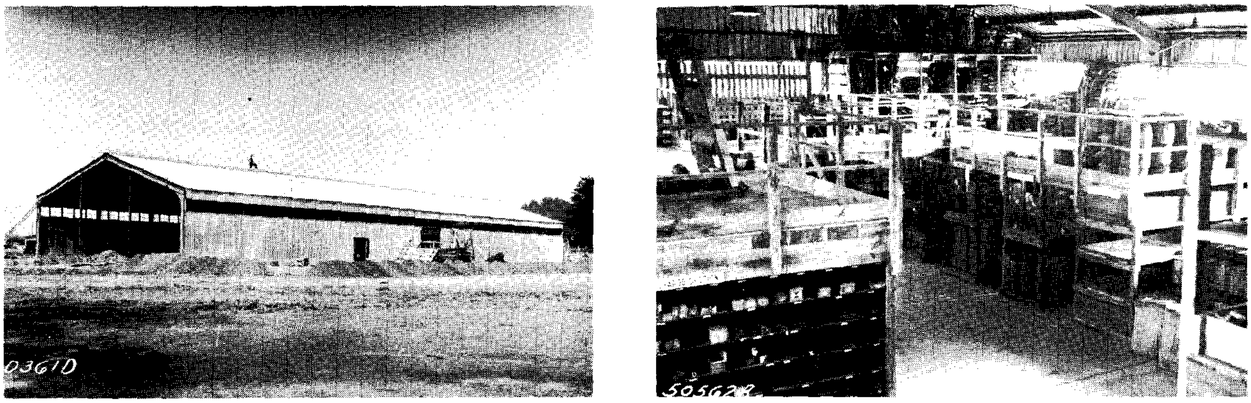


FIGURE 88.—*The main warehouse building, of structural steel construction, was divided one-fifth for office space, one-fifth for construction material, and the remaining space for permanent material. Erection of steel and wooden bins allowed maximum utilization of available space.*

site and all material delivered by railroad was unloaded at Kingston Junction (Emory Gap near South Harriman) and transported by truck to the steam plant site.

The main warehouse building (fig. 88) was practically identical to the machine shop building. It was a large single-story structure constructed of structural steel framing and provided with galvanized sheet iron roof and siding with steel sash windows and steel doors. A concrete footing and curb with piers at column locations was placed around the perimeter and a 3-inch-thick floor slab covered the entire floor area. The inside space was divided so that approximately one-fifth was reserved for construction material, one-fifth for office space, and three-fifths for permanent material. The office space was occupied by the purchasing agent, chief storekeeper, and clerks. The smaller east portion of warehouse space was primarily used for construction plant materials while the west portion was used for the storage of permanent materials. The erection of steel and wooden bins, balconies, and lofts enabled complete utilization of all space within the building proper (fig. 88). The addition at the west end of the building of a 67- by 100-foot raised timber platform with a metal roof and enclosed with wire fencing provided much needed additional covered storage.

Ten quonset-type buildings (fig. 89), approximately 40 by 100 feet, were used for warehouse storage during peak construction activities, and by enclosing the space between the quonset buildings the equivalent of three additional quonset buildings was obtained. Additional covered storage was obtained also through utilization of two large barns and a 2-story frame residence which was not suitable for housing purposes and had been acquired as part of the initial land purchases. Eleven separate storage yards were constructed as storage space for materials and equipment.

During peak construction operations, material and equipment, except for powerhouse structural steel, were delivered mainly by railroad cars at a rate of about 300 cars per month. Rail deliveries totaled approximately 10,000 cars during the course of construction activities. Barge shipments of powerhouse structural steel, approximately 500 tons per barge, totalled 57. In addition to these two primary methods of shipment, a large volume of smaller shipments was

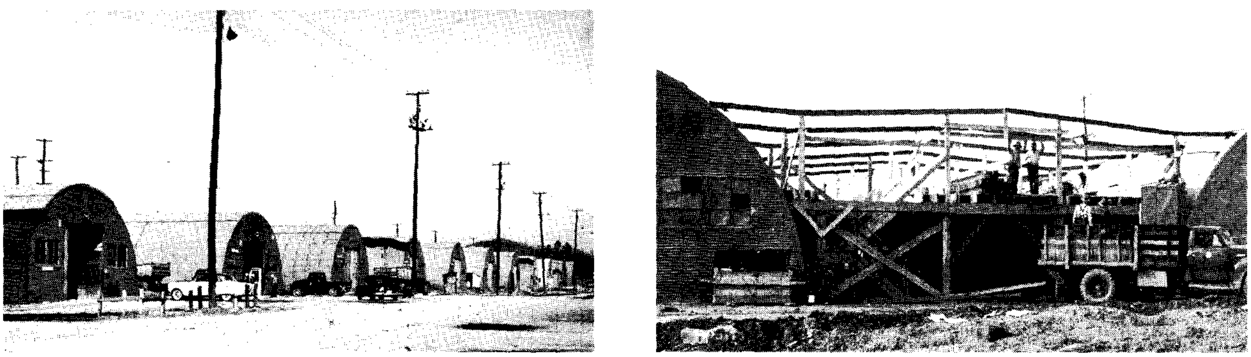


FIGURE 89.—*During the peak period of construction ten quonset huts were used by contractors for offices and storage. The equivalent of three additional huts was obtained by enclosing and covering the areas between.*

received by motor freight. Approximately 10,000,000 fbm of lumber was delivered to the project, nearly all was transported by trailer truck.

The material storage yards, their layout and location, are shown in exhibit 94.

Material stocked in the warehouse inventory during the period of peak construction totalled 25,000 separate items and had a book value of approximately $6,000,000.

Contractors facilities—The contractor for the precast concrete pipe for condenser water intake and discharge conduit was allotted a working area between the west service road and the railroad tracks. This area extended approximately from the centerline of unit 2 northward to the boundary of the steel storage yard adjacent to the steel fabricating shop. A house trailer belonging to the contractor served as an office. The contractor also erected two temporary buildings of rough wood framing and galvanized corrugated iron siding. One building was used for assembling reinforcing steel cages and the other housed a steam boiler and a steam chamber for curing the sections of pipe.

The masonry contractor was assigned a wooden frame building 20 feet square as an office and blueprint room. This building also served as storage for tools and equipment. It contained lockers, a blueprint table, benches, and a stove. Storage space was allocated along the spur track in the western part of the coal storage yard for masonry units. Covered storage for cement and mortar-mix was provided in a frame building in the boilermakers storage yard. These facilities were some distance from the construction area and the contractor hauled materials to the various buildings as needed. This contractor was furnished water and electricity where necessary for performance of his work.

The contractor for furnishing and installing the major portion of metal siding and roof decking was supplied with a building about 8 by 12 feet for an office and storage space for small tools and equipment. He was also allowed to use a quonset building for storage of siding and insulation until it was needed for installation. TVA furnished electricity to this contractor for operating power tools used in the process of erecting the various materials.

The chimney contractor was given storage space along the west service road. A small building located near the chimneys was used for an office. Lining brick was stored near the chimney in which it was to be used. This contractor also installed the units 1-4 boiler refractory material and ash hopper linings and for this was supplied with a portable building 8 by 12 feet for office space and small tool storage.

Insulation for the major portion of piping and equipment for units 1-9 and boilers for units 5-9 was installed by one contractor. This contractor required a sizable storage and working area. A quonset building was used for blueprint and office space, storage, and a fabrication shop where all insulation fittings and removable covers were made. Additional storage space was allocated in the covered area between this quonset building and the one adjacent to it. At one time, practically all available vacant space on the project was used for storage of insulation. In addition, a wood-frame skid-mounted building 12 by 15 feet was located in the vicinity of chimney No. 6 for use of the boiler insulation workmen.

The principal piping contractor was also provided with a quonset building which served for office space, a dark room, storage, and a welding shop for qualifying code welders. Fabricated pipe was received by rail from the fabricating plant and was unloaded and stored in a yard located on the project along the railroad track. Large valves and hangers were stored on wooden mats sheltered by a lean-to type shed attached to the south side of the quonset building.

The boiler manufacturer was supplied with a quonset building as a field office for erection engineers. This building also contained a welding shop in which welding classes and tests were conducted for qualifying code welders. The remaining area on the ground level and a portion of the loft were utilized for storage of small boiler parts. The remaining area on the upper level was used for cable splicing by boilermakers. The area between this quonset building and the adjacent one was enclosed and used for storing boiler trim and insulating materials. The north portion of the coal storage area was used for storing large boiler parts such as duct work headers, casing, and tubes.

A wood structure 15 by 25 feet was constructed in the turbogenerator room underneath the visitors' balcony for the use of the Westinghouse erection engineers while assembling units 1-4 turbogenerators and units 1-9 condensers. This structure was made up of two rooms, one of which was used as an office by the head erection engineer and the other for filing purposes. At the east end of this structure was a boarded enclosure in which was stored small parts and materials. This building was removed soon after unit 4 went into commercial operation.

During the erection of units 5-9 turbogenerators a temporary building 20 by 40 feet was constructed for the contractors erection engineers. It was built just south of the central electrical control building parking area between the roadway and the 161,000-v switchyard. Attached to this structure on the west side was a shed approximately 12 by 40 feet which was partly boarded and partly screened. Small parts and commonly used materials were stored in this shed. The main structure was divided into two rooms with the smaller used as an office. The larger room was used as a shop and for tool storage.

In addition to the above, several other contractors had space for drawings and small tool and material storage. These facilities usually consisted of small skid-type frame buildings which were moved from place to place. In some instances contractors were allotted locked storage in permanent structures while their work was in progress there.

Utilities

Electric power and communications equipment—Erection of a package 2300-v substation was started May 17, 1951. The station consisted of a 2500-kva, 3-ph, 60-cy, 66,000-2300-v transformer feeding into the area distribution system through a switchboard mounted in a switch house erected at the east end of the substation yard. A 1250-kva transformer was set up in the yard for stand-by use but was never connected to the bus. The area distribution is shown in figure 5, page 14. The actual power consumption of the project exceeded the capacity of the substation which was inadequate; it was heavily overloaded at the time the permanent common station service A-transformer was energized June 14, 1953. Each month thereafter at least half the power used was through the station service transformer. The peak consumption, which was divided almost equally between the substation and station service, came in February 1955 when 2,586,344 kwh were consumed by the construction plant, equipment start-up, and test runs. During the peak month, job lighting and heating consumed almost half the peak amount or 1,156,588 kwh and welding machines consumed 398,041 kwh. The major portion of the balance was used in equipment start-up and testing for which the Construction Division was chargeable until the unit was accepted by the Division of Power Operations. Power was still being furnished from the two sources discussed above in June 1956 despite the fact that only a relatively small amount was being used.

TABLE 21.—*Comparison of estimated costs—manual versus automatic telephone system—January 1953 to June 1956.*

MANUAL OPERATION		
Operator salaries:		
From 1-1-53 to 11-30-55 (peak period —35 months)		
One grade 3 operator @ $300/mo.	$10,500	
Two grade 2 operators @ $525/mo.	18,400	
From 12-1-55 to 6-30-56 (7 months)		
One grade 3 operator @ $300/mo.	2,100	
Total operator salaries		$31,000
Equipment rental:		
From 1-1-53 to 6-30-56 (42 months)		
Two 555 switchboards and associated equipment @ $80/mo.	3,400	3,400
Total manual operation		$34,400
AUTOMATIC DIAL OPERATION		
Operator salaries:		
From 1-1-53 to 6-30-56 (42 months)		
One grade 3 operator @ $300/mo.	12,600	12,600
Equipment rental:		
From 1-1-53 to 6-30-56 (42 months)		
One 701-A switchboard and associated equipment @ $187/mo.	7,800	
Dial line terminals, 110 @ $61/mo.	2,600	
Basic termination charge, 18/60 x 3605	1,100	
Total equipment rental		11,500
Total automatic dial operation		$24,100

Telephone service at Kingston Steam Plant was initiated in April 1951 by installing individual phones in temporary offices through the Kingston municipal exchange. The service was expanded as construction activities increased to the extent that an automatic switchboard was installed as a measure of economy and put into operation in December 1952. The cost study of the manual versus the automatic switchboard is shown in table 21. At the peak of construction operations there was a total of 120 stations and 162 instruments handling an average of 2500 calls in 24 hours.

The agreement between TVA and the Southern Bell Telephone & Telegraph Company provided that the telephone company would furnish, install, move, maintain, and remove all instruments, switchboard, and related equipment. TVA furnished and set poles where required.

Compressed air system—The principal source of compressed air for construction needs from August 1951 to April 1956 was a centrally located, stationary, Sullivan twin-angle compound compressor with a capacity of 3000 cfm. An air receiver 6 feet in diameter and 14 feet long was located near the compressor. Contrary to layout drawings this tank was set with its long axis vertical in order to take advantage of a substantial saving in piping cost. The compressor was enclosed in a building located east of the northeast corner of the service bay near the powerhouse north-south base line. This site was chosen because it was centrally located and did not interfere with permanent buildings or yard piping. The compressor was mounted on concrete piers around which a concrete slab was poured to provide a floor and support for the wood frame building.

Air was provided to most shops by 2-inch underground lines, many of which originated from a 4-inch line feeding the machine shop. A 6-inch line ran to the northeast corner of the powerhouse entering the basement fill slab at approximately elevation 722. From this point all service air for the powerhouse was provided by running 6-inch lines down the east wall, across the north wall, and down the west wall underneath the top mat of reinforcing steel. Manifolds with 1-inch connections were provided along this line where needed. Later, as building steel was erected, 6-inch risers were added in each unit with manifold connections for each floor elevation. A 4-inch air line was extended from the southwest end of the powerhouse to the crusher building and No. 1 hopper building area. Later, this line was extended to the boiler parts storage yard which is now the northern portion of the coal storage yard.

As work progressed into the units 5-9 area it became necessary to supplement the air supply by use of portable compressors to supply increasing requirements. A 500-cfm compressor and one of the permanent receivers were located on top of the powerhouse to supply air for structural steel riveting operations. Two 600-cfm portable compressors were moved from place to place as needed. A connection was also made of the construction air line to the permanent station air line at the northwest corner in the basement of the powerhouse. Air was then available from the two permanent 660-cfm station service air compressors which were operated by the Construction Division from June 1953 to January 1954. This provided a maximum compressed air capacity of 6020 cfm at 100 psi.

The increased air demand was due to an accelerated work schedule which required added air-operated equipment. Seven riveting crews were active in the powerhouse and coal handling structures. An 8-ton stiffleg derrick was located in the coal handling area for excavation, placing concrete, and erecting steel. Although originally designed for steam, this derrick was air operated and created a large air demand on the day shift. Backfilling was also at its peak and this required daily use of a number of air-operated tampers. Rain and seepage water removal were handled in part by use of 10 pneumatic sludge pumps and 12 air-operated sump pumps. The machine shop air hammer was in operation two shifts and the ironworkers and steamfitters were using a large number of air grinding and drilling tools in their fabrication shops. There were seventy-three 1-ton pneumatic tugger hoists operating at various locations in the powerhouse raising material for erection and stocking purposes. Six air-operated wagon drills were used to line drill excavations, and 15 jackhammers and six paving breakers plus many hand air tools were in operation. In addition, a large amount of air was used in air and water guns used in "green cutting" the surface of fresh concrete pours to insure bonding of later placements.

To prevent freezing of air lines and equipment, a vaporizer was installed in the main compressor house to automatically feed antifreeze into the compressed air supply lines. As a result, there was no freezing of air lines or equipment.

The stationary compressor was abandoned April 27, 1956, when construction was virtually completed. Workmen started dismantling the compressor house and compressor April 30, 1956. Where feasible, all temporary air lines were removed and the embedded lines in the powerhouse fill slab were cut off below the finish floor and filled with grout. Portable air compressors were used to furnish air for all remaining yard construction work, and permanent plant station air was furnished by the Division of Power Operations for all revisions and additional work inside the buildings in which air was available.

Gasoline, fuel oil, and lubricants—Gasoline and diesel oil were stored in two 15,000-gallon storage tanks located near the northeast end of the project between the lake and the construction carpenter shop. Both tanks were mounted approximately 13 feet above the ground on steel supports resting on concrete footings around which crushed stone was placed.

A concrete wall 3 feet high measuring approximately 22 by 30 feet was built around the tank footings. Piping around the tanks was arranged to facilitate refilling the tanks from transport trailers by means of a common fuel transfer pump which pumped the diesel oil or gasoline into its respective tank. Two outdoor-type electric fuel service pumps were used to dispense the gasoline and diesel oil to the equipment. These pumps were located adjacent to the 15,000-gallon storage tanks. Two 1000-gallon underground storage tanks were connected to the 15,000-gallon storage tanks providing a gravity feed suction storage for the fuel service pumps.

A 650-gallon capacity 3-compartment fuel tank truck was used for refueling heavy equipment at various locations. Smaller fuel burning equipment was refueled from 55-gallon steel drums located in convenient yet safe places. The drums were periodically filled from the fuel tank truck.

Fire control—The construction buildings were protected by a Spurling fire alarm and indicator system. Each of the 13 protected buildings or areas had one or more non-code type break-glass alarm stations equipped with one set of normally closed contacts to initiate the alarm signal and one set of normally open contacts to initiate the local alarm bells. The normally closed contacts of break-glass stations in each building were connected in series and the circuit extended to a fire locator panel in the combination public safety building and fire house.

A total of four break-glass stations, four 8-inch alarm bells, 72 thermostats, and a 4-circuit fire indicator panel was installed for the protection of each of the three dormitories. The break-glass stations were of the non-code type with one set of normally open contacts; stations were arranged so that tests could be made without breaking the glass. The room thermostats were dual action combining "rate of rise" and "fixed" temperature principles with normally open contacts. The dormitory was divided into four sections and the panel circuits marked as to wing and floor. This panel was connected to the panel in the fire house by closed circuit.

Raw water—Raw water was supplied for construction operations and fire protection at the powerhouse and at principal plant buildings and installations. The 50,000-gallon permanent water tank was purchased and erected for use during the construction period to provide a constant source of water for normal daily needs and a storage reserve for emergency use in case of fire or pump failure. Water for fire protection was supplied by direct pumping.

Two 500-gpm electric motor-driven vertical, centrifugal pumps were installed to meet normal pumping demands, and a similar pump with a 1200-gpm capacity was installed alongside for use in case of pump failure or as a supplemental source of supply in case of an emergency such as a fire.

The pumps were mounted on a temporary crib-type intake structure located on the edge of Swan Pond just east of the entrance to the condenser water intake channel. They were housed in a small frame structure to protect the electric motors and motor controls.

Water level float-switch-operated pump controls kept the water tank filled automatically, and an altitude valve prevented the tank from overflowing under continuous pumping conditions such as occurred during fire fighting operations. A pressure relief valve was installed at the pumps to give relief if pumps continued to operate after all fire hydrants had been closed.

The distribution system consisted of underground spiral-welded steel pipe which, when related to the pumping head, provided a minimum of 80 psi residual line pressure at extreme limits of the system when flowing a combined total of 1000 gpm from two hydrants. These pressures were exceeded at points close to the hydrants, but with the addition of the camp after the system was designed, less than the recommended pressure was actually available. However, this shortage was supplemented by the 500-gpm pumper truck that was kept for emergency or supplemental use. Eight-inch pipe was the maximum size required for the distribution system but some 12- and 14-inch pipe which was available on the project was used.

Raw water for fire protection was supplied to the powerhouse structure through a 6-inch feeder line and was distributed through 4-inch risers to 2½-inch feeder lines circling each floor level. Because of the height of the structure, it was necessary to use two horizontal centrifugal booster pumps with a capacity of 700 gpm at 100-foot head to give the necessary pressures on this system. The installation of the piping for this system usually paralleled the air distribution piping previously discussed.

Treated water—Potable water was first obtained from the city of Kingston by a 4-inch line installed by TVA from the project site to the Kingston pumping station. To cross the river with this line required the use of approximately 1050 feet of 4-inch thin-wall pipe welded in one length on the bank. By use of a tug and bulldozer this section of line was floated across the river and sunk in place. In a similar manner a 3-inch galvanized line was laid across the lake arm to supply employee housing in the western project area. The 4-inch supply line entered the project west of the administration building and hospital and extended along the personnel building to the construction camp. A 25,000-gallon wooden tank located on top of the hill east of the switchyard provided treated water storage. A 4-inch branch line was extended down the road between the transformer yard and switchyard then west past the air compressor house, the service bay, and the intake structure ending at a point in line with the row of quonset buildings. By use of saddle clamps, ¾-, 1-, 1½-, and 2-inch underground connections were made to the 4-inch distribution lines to supply all buildings. Two- and three-inch galvanized pipe was used in the immediate area to supply the quonset buildings and construction camp.

Prior to starting the first unit, the water treatment plant was completed and placed in service providing a permanent source for domestic water. A connection was then made joining the temporary construction distribution lines to the permanent supply system making it possible to dispense with the original Kingston supply. This was particularly timely since the domestic water demand was overtaxing the city supply.

The powerhouse was first served by a 2-inch embedded line terminating in the oil storage room at elevation 744, where an ice machine was installed to supply chilled water which in turn was piped to several elevations for drinking fountains. This line was later capped and a separate line was installed terminating between units 4 and 5 boilers where the ice machine was relocated and used until unit 5 went into operation. Permanent piping had been installed by this time and the permanent station water coolers were utilized. Much use was also made of portable containers and paper cups located at all isolated job sites. These containers were refilled daily from a tank mounted on a 2½-ton flat bed truck which also distributed ice during summer months.

Sewage system—In general, the system consisted of 6-inch vitrified clay tile mains and 4-inch tile branch lines. The lines serving the administrative area buildings were all 4-inch vitrified clay tile.

Three septic tanks were required because of the widely scattered areas to be serviced. These tanks were of concrete construction, buried in the ground, and provided with pipe vents. Effluent from the tanks was discharged untreated into Watts Bar Lake.

The outfall for the main plant area was about 100 yards east of the condenser water intake channel. Outfall for the administrative area buildings was at a point on the lake east of the medical center and that of the construction camp was at the nearest shore of the lake south of the camp.

A large part of the excavation for this work was done by a backhoe mounted on a crawler crane. This was particularly true for the deeper excavations in the main construction area. Excavation of the shallower trenches in the administrative area was in part by hand. Pipe was laid and brought to grade by using a measuring stick from a line stretched over batter boards. Joints were caulked with jute and sealed with mortar consisting of one part cement to two parts sand.

In addition to serving the principal buildings of the construction area, the system served a construction toilet building located along the service road north of the powerhouse.

Sewage disposal facilities for the TVA village located off Swan Pond Road were provided by individual septic tanks and disposal fields consisting of 4-inch open-joint tile laid in ditches 2 feet wide and 2 feet deep with 1½-inch crushed stone surrounding the pipe. Excavation was by hand and lines were laid on grades of one-half of one percent in conformance with recommended practice.

Central mixing plant

The initial plant was a C. S. Johnson batcher designed for a 2-cu-yd CMC non-tilt mixer with a hopper for loading dumpcrete trucks adjacent to the plant. Cement was received in bottom dump railroad hopper cars, unloaded onto a screw conveyor feeding to a bucket elevator. The elevator discharged to the cement bin in the batching plant or to a 400-barrel silo from which cement could be conveyed by the same conveyor and elevator to the batching plant bin. Aggregate and sand originally expected to arrive by rail was trucked in and piled conveniently for recovering. A ground level recovering hopper and feeder delivered the sand and aggregate to a belt conveyor from which the material was diverted into the proper storage hopper through a pivoted chute on top of the plant.

A solution container of 4-gallon capacity with automatic dispenser supplied the air entraining agent (Aerolith) to the water batcher. Four aggregate bins, a cement bin and 240-gallon reservoir supplied material by gravity to the batchers and mixers. The batching plant was semi-automatic with a system of lights for informing the operator of batching sequence.

Soon after the batcher was put in operation, a used, 2-cu-yd Ransome non-tilt mixer was placed on timber cribbing west of the batcher. A gated chute permitted using the batcher with the addition of controls and control lights. This mixer was used primarily to furnish concrete to a pumpcrete machine. A second pumpcrete machine was set up east of the truck unloading hopper and a portable conveyor was used to supply this machine from the truck loading hopper by moving into position on a trolley. Lights were installed for the operator or bin man to control the supply of aggregate from the storage yard and direct it to the proper hopper. A 100-hp coal-fired boiler was used for heating water and aggregate in the winter months.

Operation of the plant (fig. 90), including aggregate handling, required a minimum force of 11 men. A capacity of about 90 cu yd per hour was possible most of the time with the 2-mixer unit.

Construction equipment

Figure 91 shows the major items of construction equipment used in the building of Kingston Steam Plant. The numbers shown opposite individual items represent the total equipment on hand and does not necessarily indicate that all were in use at any one time.

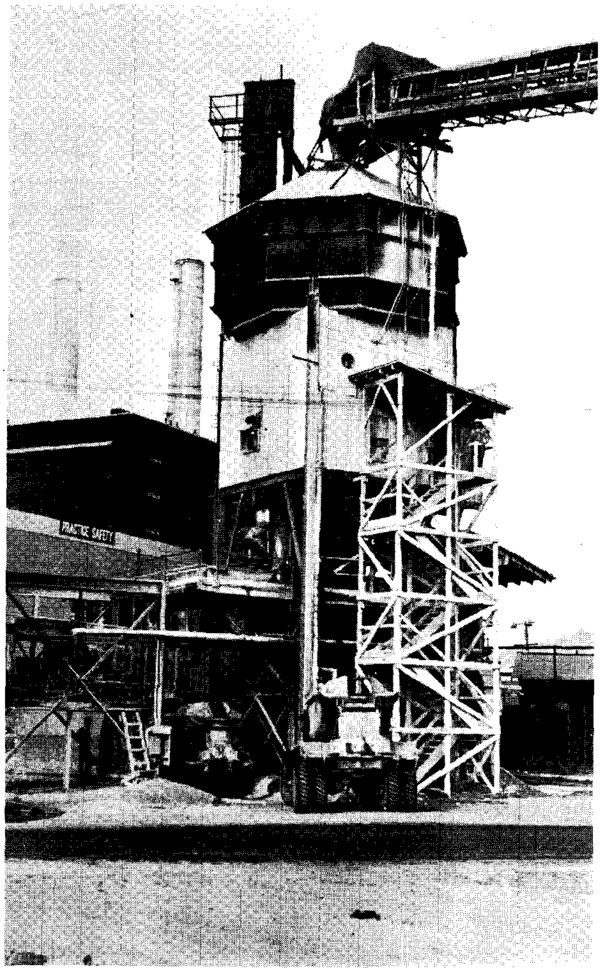


FIGURE 90.—*The central mixing plant was first operated on October 25, 1951. A second 2-cu-yd mixer was added and placed in service January 8, 1952, making a total plant capacity of 90 cu yd per hour.*

Included with the crawler cranes shown are cranes ranging from 20- to 60-ton capacity with boom lengths up to 120 feet. Two of the crawler shovels listed were combination rigs, with both shovel fronts or crane booms available, but since their primary use was as shovels they were shown as such.

Equipment was acquired by purchase, transfer, or rental as construction activities accelerated. At the termination of the scheduled work of the Construction and Maintenance Branch, March 21, 1952, part of the earth-moving equipment was retained for construction use; this included six D-8 caterpillar tractors, six Euclid rear-dump trucks, two 14-cu-yd Heil pans, and two graders. At this time the Kingston Steam Plant Branch also had on rental from the Transportation Branch 24 pieces of equipment and the 40-ton Washington-Marion revolver crane.

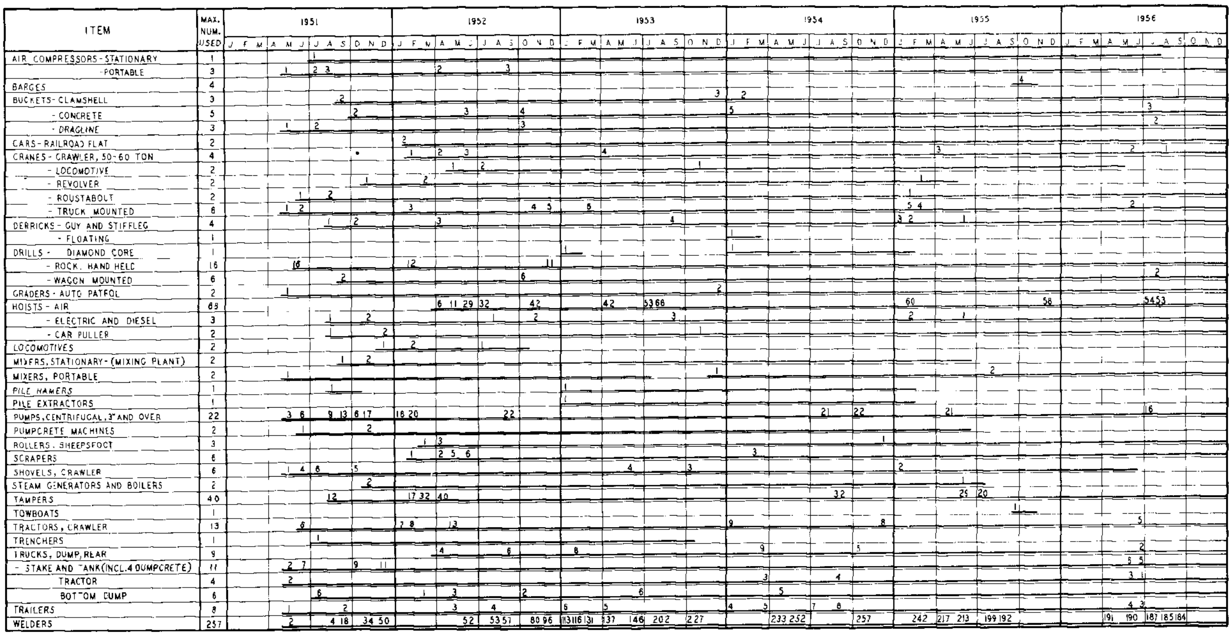


FIGURE 91.—*Schedule of principal construction equipment showing progressive use of each type and the maximum number at any one time.*

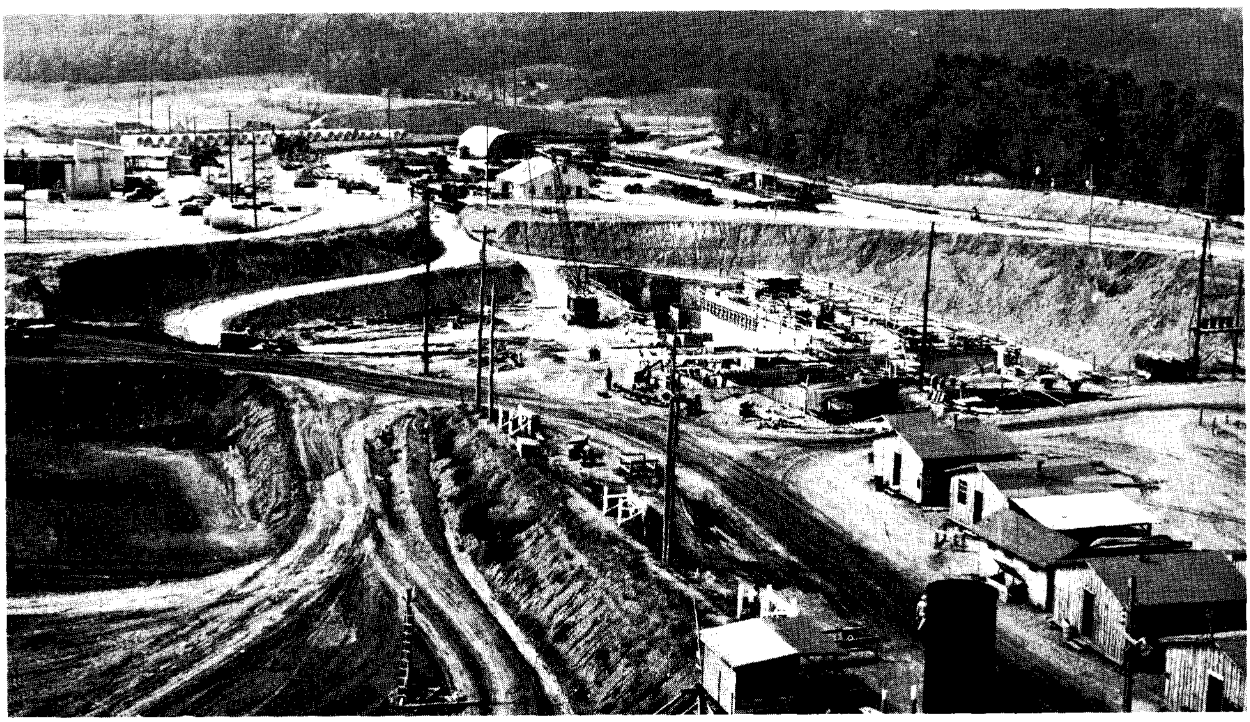


FIGURE 92.—*Early stages of excavation and substructure concreting. Service bay excavation at left and intake structure at right. Note 76-inch id (units 1-4) concrete pipe conduit stock piled in background. Units 5-9 used 96-inch id concrete pipe conduit.*

CONSTRUCTION OPERATIONS

Following the established procedure of TVA construction operations, initial construction work on the Kingston Steam Plant project was assigned to the Construction and Maintenance Branch (C & M) while assembling the continuing project construction force. This involved site clearing, temporary and permanent access highways, connecting railroads and yards, site grading, general plant and yard area excavation and grading, general excavation for the powerhouse and other structures, excavation for the condenser water supply inlet and outlet channels, ash disposal pond dikes, placing of gravel for temporary surfacing of roads and parking areas, supervision of stabilized base construction, and application of bituminous road surfacing over permanent roads and parking areas. The latter work was done as construction work neared completion.

Initial activities by the Construction and Maintenance Branch commenced May 8, 1951, with grading of the access highway and railroad connection. This work was carried on concurrently with site preparation for construction plant facilities. Completion of most of this work by C&M was accomplished by March 21, 1952, after which time the assembled Kingston project forces continued construction operations.

EXCAVATION, GRADING AND FOUNDATION TREATMENT

Excavation and grading

General yard grading—The C & M Branch did practically all the yard grading. The general yard grading for permanent features was carried on simultaneously with that for the construction plant. Equipment employed included tractor-pulled carryall scrapers, power shovels, a dragline, trucks (mostly 10-cu-yd Euclids), bottom-dump Euclid wagons, bulldozers, and road graders. Among the power shovels were the diesel-powered 2½-cu-yd Bucyrus Erie, the 1¾-cu-yd Lorain, the 1½-cu-yd P & H, the electric-powered 4-cu-yd Marion, wagon drills, and jackhammers.

Excavation was required in the vicinity of the present storage building, part of the switchyard, and northwest of the service bay. The excavated material was placed in the fill west of the power plant. Borrow for the remainder of the fill around the plant was obtained from the high hill just east of the switchyard. The fill was placed in layers approximately 6 inches thick and compacted with a sheepsfoot roller.

Powerhouse and service bay—A large amount of heavy equipment was used for the excavating and earth moving operation at the powerhouse and service bay. Carryall scrapers, bulldozers, graders, various types of trucks including 10-cu-yd Euclids and Euclid bottom-dump wagons and several power shovels were used. Excavated material was hauled to several locations. Most of it went to the access highway, railroad, and coal storage yard fills across the lake and to the ash pond dikes.

All this work was carried on by the C & M Branch until they left the project March 21, 1952. Final clean-up of the rock foundation was done by project construction forces.

Excavation for the service bay (fig. 92) was made in May and June 1952. However, most of the service bay area required some 10 feet of rolled clay backfill. The wedge-shaped area between the powerhouse north wall below the service bay excavation line was filled with a sand-gravel mixture compacted in thin layers by means of an electric motor-driven vibrator.

At about the time the excavation for units 1 through 4 was completed, additional units were authorized, so that the excavating operation was carried southward to eventually include unit 9. The backfill around the powerhouse was substantially completed in June 1955.

In those areas prepared for earth foundations, occasional rock outcroppings were over-excavated a minimum of 1 foot and backfilled with compacted earth.

Top soil was removed from the entire plant area and stockpiled for later use. Grading and overburden removal were performed as far as possible with tractor-drawn scrapers. When rock was encountered it was found that an unexpected variation in the top of the rock surface precluded further use of scrapers, and it became necessary to complete the overburden removal with other excavating equipment. The top of bedrock was in the form of numerous pinnacles and pockets, making excavation for structures and trenches expensive.

Rock excavation followed normal procedures of drilling and blasting. Spoil from rock excavation, when not used directly, was stockpiled to provide riprap material.

Foundation treatment

Foundation treatment at Kingston Steam Plant was relatively minor compared with some TVA projects. Preliminary investigations of the Kingston site in 1950 revealed no major foundation problems; further exploration was therefore not required.

Foundation exploration on the access railroad consisted of about two holes for each pier at the overpasses over U. S. Highway 27 and Tennessee State Highway 61. In each case the borings extended some 20 to 25 feet below ground surface, encountering firm rock within 10 to 12 feet of the surface.

All core drilling was done by the Construction and Maintenance Branch under the supervision of the TVA geologist.

CONCRETE

A program of strict control of design and production of concrete was followed throughout construction of the plant. The project concrete laboratory designed appropriate mixes after investigating and testing the approved materials. These mixes were continually checked while being used; new mixes were designed as needed. The procedures for inspection and control of concrete production and placing were the same procedures developed and used on other TVA projects. Concrete operations commenced May 17, 1951, and were completed June 30, 1956. Plant facilities and operations are described under "Construction Plant Facilities," page 147.

Concrete operations

Central mixing plant—The plant (fig. 90) was placed in operation October 25, 1951, and was continued until May 27, 1955, producing 254,192 cu yd of concrete for permanent structures. Incidental concrete before and after that period, in the amount of 14,369 cu yd, was produced by a ½-cu-yd mixer (fig. 93) or was purchased as "ready mix." Figure 94 shows the monthly concrete production.

Formwork—Wood forms were used throughout for concrete placement. Shop built forms were used wherever possible. Panel forms of 1- by 6-inch tongue

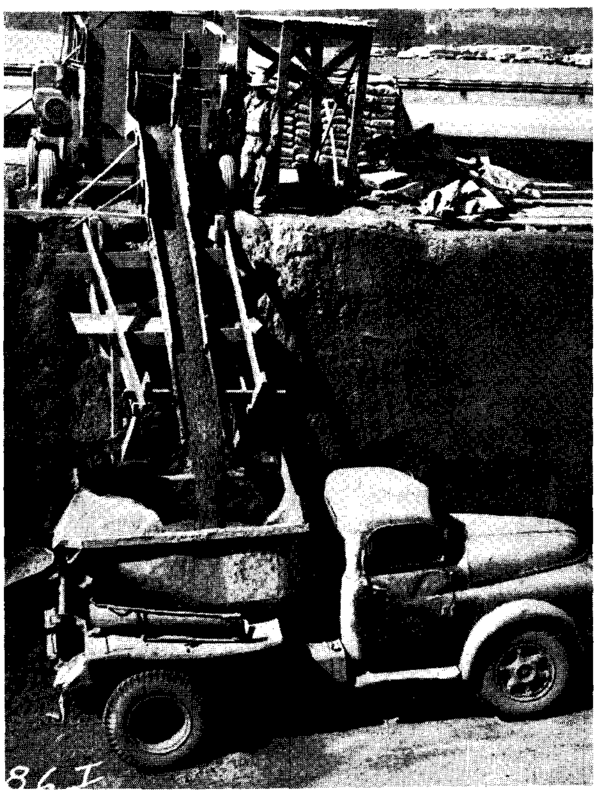


Figure 93.—*Portable mixers were used to supplement the central mixing plant, and for periods before and after the central plant was in operation.*

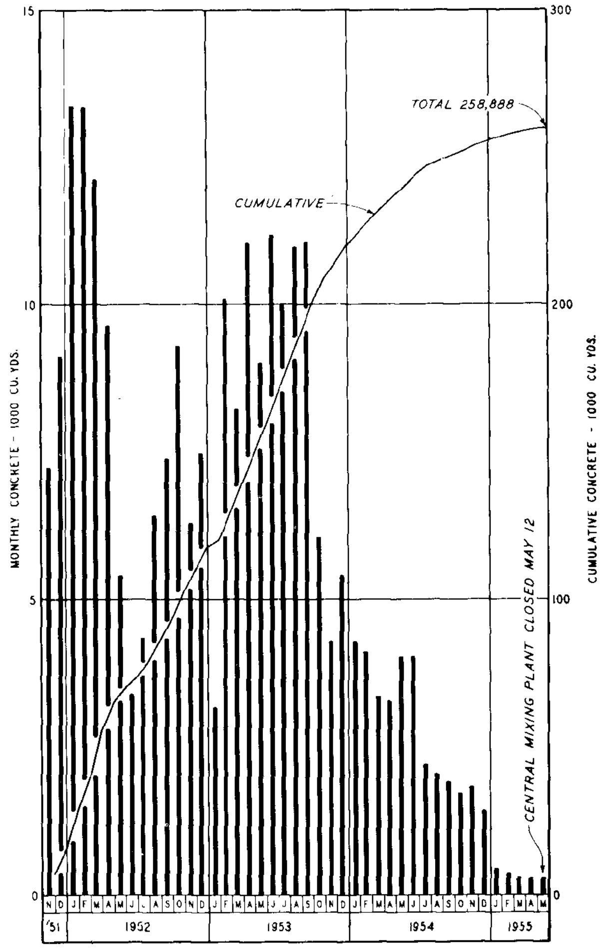


Figure 94.—*Monthly and cumulative production of concrete during period of operation of central mixing plant.*

and groove sheathing nailed to 2- by 6-inch ribs, with rib spacing generally 16 inches on centers, were reused for pours above the first pour in the powerhouse and other structures. Special forms built for the unit 1 turbogenerator foundation were used for all units (fig. 95); however, some changes were necessary to adapt them for use on the 5-9-unit foundations. Conduit transition forms and many other special shop-built forms could only be used once, although some were salvaged and portions reused. Built-in-place forms were usually required for the initial pours on uneven ground or rock surfaces and to fill in areas not suitable for panel forms.

Embedded items—Numerous items were embedded in concrete in addition to reinforcing steel and seals. These included such major items as piping, electrical conduit and boxes, gate guides, various types of frames, castings, base plates, and anchor bolts for all types of equipment. These items were aligned and set to the proper elevation by the responsi-

FIGURE 95.—*Construction progress as of August 19, 1952, showing turbogenerator foundations in progressive stages of construction, units 1-4 reading left to right.*

ble crafts, then braced in position by the use of reinforcing steel rods, steel and wood templates, salvaged pipe, and small steel shapes. Special attention by the concrete placing inspector and placing crew was required to insure that parts were not damaged nor moved by concrete placing equipment.

Transportation and placing—Considerable planning was done by the Construction Plant Branch and the field construction office to determine the most economical manner of placing concrete in the scheduled time. This involved the location of the plant, purchase or transfer of equipment, and available time.

The original plans for transporting concrete were based on the requirements for a 4-unit plant. Concrete for the powerhouse and service bay substructure was to be transported from the central mixing plant to the forms, a maximum distance of 750 feet, by an 8-inch pumpcrete machine (fig. 96). Transportation to other structures was to be with three dumpcrete trucks. In general, the method as originally planned was followed except for the addition of a second mixer and pumpcrete machine.

On October 29, 1951, the first permanent concrete was placed in powerhouse foundation slab No. 2a. On January 8, 1952, the second 2-cu-yd mixer was put in operation at the central mixing plant. With the added capacity, a total of seven dumpcrete trucks was used. Upon completion of the large base slabs of units 1-4, the No. 2 pumpcrete machine was moved to the east bank opposite unit 5, and soon thereafter the No. 1 machine was moved to a location about 50 feet southeast of the 9-unit powerhouse. Dumpcrete trucks unloaded directly into the pumpcrete hoppers at the new locations.

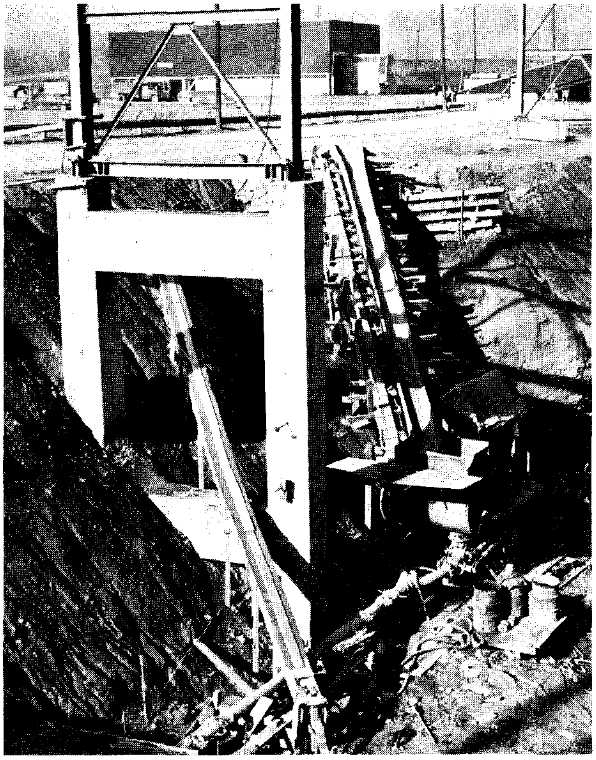


FIGURE 96.—*Pumpcrete plant showing materials chute, mixing hopper, and pump for transporting concrete directly to the forms through 8-inch lines.*

In the late stage of concreting, the No. 2 pumpcrete machine was moved to the southwest corner of the powerhouse. Figure 97 shows the 8-inch pumpcrete line delivering concrete for placement. Finally, concrete was mixed with a ½-cu-yd portable mixer located directly above the machine, and after removing the pumpcrete machine, trucks were loaded at the same location. The greater part of the powerhouse and service bay concrete was placed with the above equipment. Other methods included concrete buckets and chutes with elephants, trunks, and handling of buckets by various cranes including the permanent crane in the turbine room.

Concrete was deposited in the form as near the final position as possible. Generally, each lift was vibrated by electrical, immersion-type vibrators (fig. 97). Joint surfaces were cleaned for future lifts by green cutting, brooming, or if necessary by scarifying by jackhammer to expose fresh, clean surfaces. Just prior to placing the next lift, the concrete surface was wet down and well broomed with a grout coating.

Curing—Vertical surfaces were cured with a sealing compound, Hydracide, applied with a pressure tank type spray gun. Winter curing was accomplished by the delayed removal of forms. Top surfaces were kept moist by frequent wetting and wet sand was used for curing and protecting walkways exposed to the weather.

Interior floor surfaces were cured by covering with a waterproof paper held in place with sand. Wet burlap proved unsatisfactory in preventing concrete checking. In some locations it was possible to flood the floor surface for a period of seven days. Even with the best of care some checking continued, especially on thin topping layers applied to floor slabs.

Steam and coke-burning salamanders were the principal methods of heating for cold weather curing. Steam was supplied by an oil-fired steam generator of 3000-pph capacity. Perforated pipes extending over the exposed concrete surface and covered with tarpaulins provided heat for the walls and base slabs. Portable oil-fired, blower-type heaters were mainly used in protection and curing of the floor slabs in the building. Outlying structures were protected from freezing with salamanders and tarpaulins. On a few occasions concreting was suspended due to extreme cold weather.

Inspection and testing—Control of the manufacture, handling, placing, finishing, and curing of concrete was planned and scheduled by the coordinated efforts of the construction and engineering forces. A weekly schedule of concreting was prepared in advance and made available to all craft and engineering supervisors. A concreting card was prepared for each pour and placed in a metal container attached to the form as preparation of the block started. The usual procedure was for each craft foreman to sign the card as his work was completed and, after inspection by the responsible engineers, the shift engineer and concrete inspector ordered the required quantities and mix, checked workability, and supervised placing methods.

Testing of concrete aggregate was done by TVA at the contractor's crushing plant. A materials tester

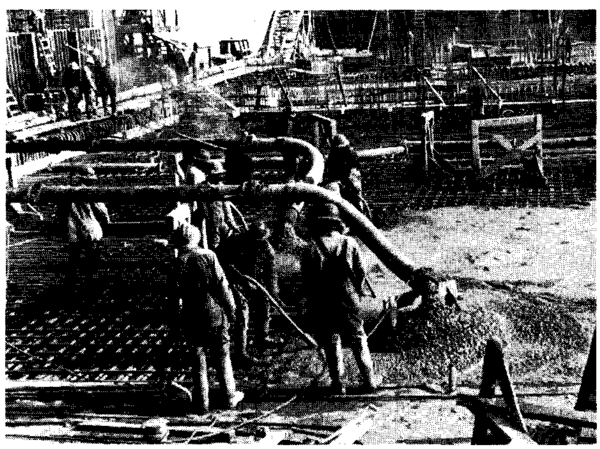


FIGURE 97.—*Immersion-type vibrators aid in placing concrete as it is placed in form through transportation line from pumpcrete machine.*

made daily screen analyses of the aggregate. Similar analyses were made for railroad and highway materials.

A field laboratory was used to test fresh concrete for slump, unit weight, and entrained air. Test cylinders were prepared and shipped to Barrow-Agee Laboratories, Inc., for curing and testing in compression. Daily and monthly reports were made of concrete pours, materials used, and test results.

Concrete materials

Aggregate, sand, and cement—Aggregate used in the central mixing plant and portable mixers was delivered by truck from a quarry five miles northwest of the project. The limestone aggregate was stockpiled, fed into a hopper, and then transported by conveyor system to the separate bins in the mixing plant.

Type I Portland cement was delivered in hopper bottom railroad cars and conveyed from a cement unloading shed to the mixing plant hopper or to an adjacent silo. Very accurate forecasting of quantities and delivery dates was necessary to avoid delays or over supply. Storage capacity for bulk cement was 200 barrels in the mixing plant hopper and 400 barrels in the adjacent silo. The several types of mixes and their use are given in table 22.

Reinforcing steel—Approximately 16,230 tons of intermediate grade deformed reinforcing steel in mill lengths up to 60 feet long were used for this project. Deformed bar sizes from No. 2 to No. 12, 4 by 4 wire mesh and No. 9 wire were stocked and replenished as needed. Tie wire was mostly No. 16 soft steel. For the most part, reinforcing steel was installed using normal construction procedures. Fabrication of reinforcing steel and delivery to the location was made only a short time before use to avoid loss.

Seals and water stops—Seals used on the various concrete structures were TVA types B, C, and D. Copper, 20-ounce ductile purchased in rolls of the required widths, was used as specified for B and D seals. The type-C seal was of ⅛-inch steel plate cut from sheets. All seals were fabricated in the sheet-metal shop.

STRUCTURAL STEEL

Powerhouse structural steel

There are approximately 27,350 tons of structural steel in the 9-unit powerhouse and service bay office wing. This steel was furnished completely fabricated on contract by Ingalls Iron Works Company of Birmingham, Alabama, and included rail for coal trippers and cranes. All steel was fabricated at the contractor's Birmingham, Alabama, and Verona, Pennsylvania, plants. Figure 98 shows the monthly rate of structural steel erection.

Steel shipments by the contractor were scheduled to conform to a plan of erecting all steel for each unit in three stages with a guy derrick operating from one location in each stage. The sequence of stages

TABLE 22.—*Concrete mixes.*

Barrels cement per cu yd	Water-cement ratio	Pounds cement	Pounds water	Pounds sand	Pounds ¾-inch stone	Pounds ½-inch stone	Yards yield	Percent entrained air	Location used
2.00	0.44	752	331	1392	1478	—	1.0	3.0	Floor topping
1.80	.44	677	298	1314	1708	—	1.0	3.0	Floor topping
1.375	.55	1034	570	2304	1840	2250	2.0	3.0	Powerhouse substructure—(bucket placed)
1.375	.55	1034	570	2643	1688	2063	2.0	3.0	Foundations, footings and powerhouse substructure (Pumpcrete)
1.50	.52	1128	587	2592	1654	2021	2.0	3.0	Narrow walls—turbine foundations (Pumpcrete)
1.375	.55	1034	569	2840	3556	—	2.0	3.0	Conduit envelopes
1.50	.52	1128	598	2836	3402	—	2.0	3.0	Structural slabs
1.60	.52	1203	626	2711	3387	—	2.0	3.0	Heavily reinforcing—narrow walls
1.60	.48	1203	578	2767	3460	—	2.0	3.0	Structural slabs finished monolithic
2.00	.46	1504	692	2000	3662	—	2.0	3.0	Lock joint pipe
1.20	.56	903	505	2553	1858	2271	2.0	3.0	Cradles for discharge conduits
1.25	.35	470	165	—	1848	1848	1.0	—	Lining walls of coldwells
2.75	.50	1034	517	2264	—	—	—	—	Grout
3.75	.50	1410	705	1434	—	—	—	—	Grout—sole plates of G.E. turbines
1.75	.52	188	98	320	515	—	0.28591		Chimneys above 765 elevation
1.50	.54	564	305	1177	924	924	1.0	3.0	Access railroad (Brooks Sand & Gravel)

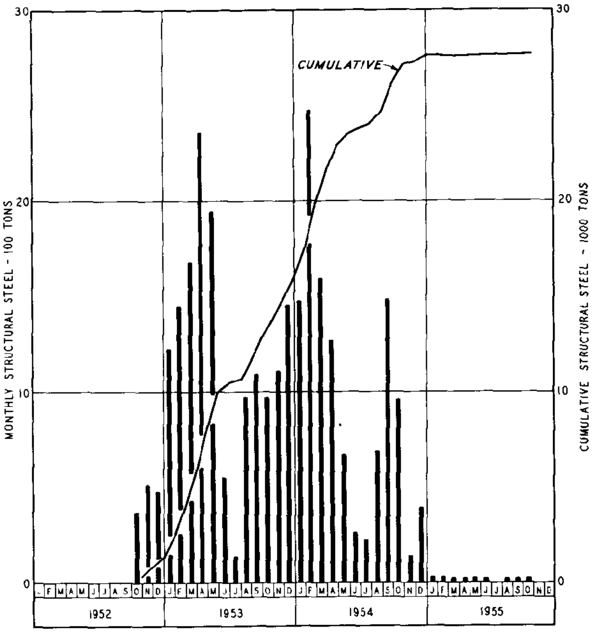


FIGURE 98.—*Monthly and cumulative progress of structural steel erection.*

was as follows: (1) turbogenerator and boiler bays below the 765 elevation, (2) turbine room above the ground floor, and (3) the boiler bay above the ground floor. In general, shipments conformed to the schedule. Nearly all the steel was shipped by barge. The relatively small amount shipped by rail or motor freight consisted of critical items.

Temporary dock facilities were constructed near the south end of the discharge channel on the left bank for unloading the barge shipments. These facilities consisted of a rock-filled, cellular, sheetpiling structure on which an electric revolving crane was mounted. Timber-pile clusters were driven in the channel for mooring the barges.

Only a small amount of steel was bent in shipment. Most of the bent pieces were straightened in the yard while a few were sent to the project fabrication shop for heating before straightening. Other members bent beyond repair were replaced by the fabricator or fabricated from project steel stock.

All steel was stored in a storage area adjacent to the unloading dock, marked on one end according to erection numbers established by the fabricator, and arranged according to floor elevations by areas in order of erection. Each area was identified by a sign readily visible from roads through the yard.

One regular structural iron worker crew of seven men worked in the storage yard at all times with additional personnel being used when required. This crew stored the steel upon receipt and removed it from storage when requested by erection foremen. Both the yard foreman and the project warehouse kept records of the steel as it was received at the plant site and as it was dispatched to the powerhouse for erection.

Setting the column base plates was started July 9, 1952, and steel erection started at the basement elevation of the turbogenerator bay October 16, 1952 (fig. 99).

The usual procedure of the erection crew, consisting of approximately seven men, was to bring a member into position and fasten it with two bolts at each end to prevent it from turning or pivoting. Later, all connections were pinned or bolted with erection bolts in approximately 50 percent of the holes. The newly erected frame work (fig. 100) was then plumbed with cables and turnbuckles. A riveting crew, consisting of four men, tightened all bolts with an impact wrench, drove rivets in the holes not bolted or pinned, removed the bolts and pins, and then riveted the remainder of the holes. An air jam was used to buck the rivets where possible, but various bucking bars and frames were improvised when tight places were encountered. The rivets were inspected after each connection was driven and the loose or defective rivets were replaced.

In general, the quality of the fabricated steel was good. At times standard tolerances were exceeded. Many holes had to be reamed to maintain proper alignment. In several instances it was necessary to redrill columns and some connections had to be entirely reworked. Part of these discrepancies were due to faulty detailing by the fabricator while others were caused by mistakes in shop fabricating. Many more errors were avoided by field office checks of contractors' detailed shop drawings of field connections.

Stairways, handrail and floor grating—Additional structural steel purchased for the powerhouse includes walkways, supporting steel, stairways, stair treads, handrail, and grating. Installation of the walkways was a slow intermittent process as boiler erection would permit. In many cases the steel was partly erected and used for scaffolding supports around the

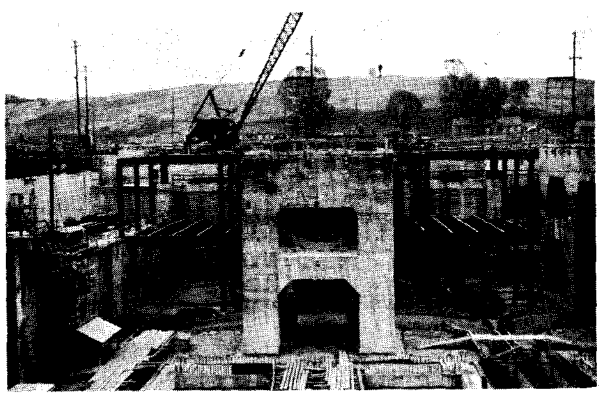


FIGURE 99.—*First steel erection started with column base slabs in basement of turbogenerator room July 19, 1952. Erection of columns and beams started October 16, 1952.*

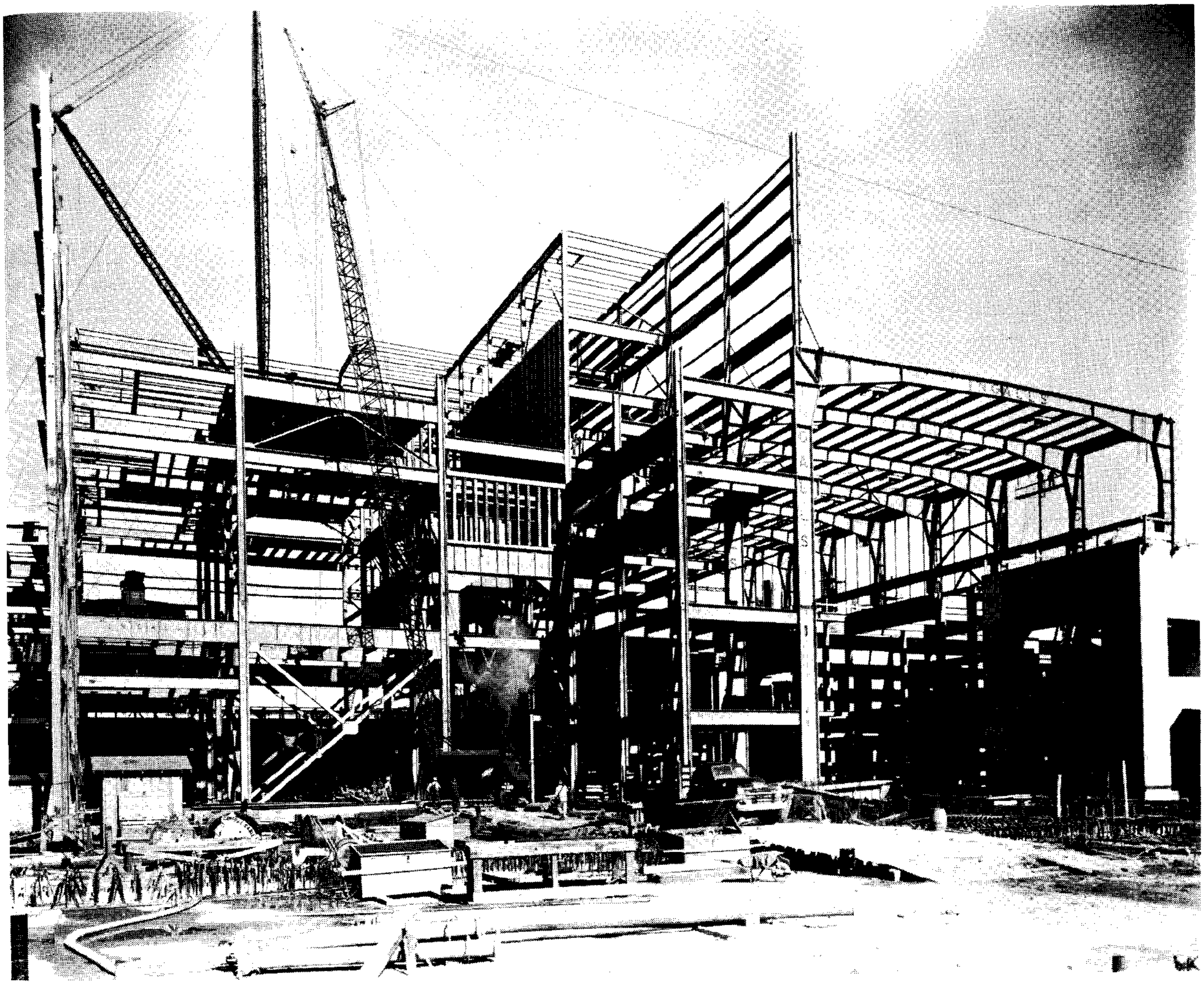


FIGURE 100.—*Structural steel framing was temporarily pinned and bolted in half the holes. After temporary erection was plumbed and braced, remaining holes were riveted, then bolts and pins were replaced with rivets.*

boilers. Installation of stair tread and walkway grating was made as soon as possible after each unit was put in operation, leaving the slower process of installing handrail and fastening down grating until other construction activity had ceased in the area. This latter stage was carried on simultaneously with the installation of floor grating in the boiler areas. Installation of steel for stairways, handrails, and floor gratings started in August 1953 and extended into the spring of 1956.

Auxiliary structures

Fabricated steel structures other than the powerhouse required over 1850 tons of structural steel (fig. 101).

All purchased members were fabricated and painted with red lead, marked with erection numbers by the vendor, and shipped by rail. When received the steel was loaded with truck-mounted or crawler cranes onto floats at the railroad siding and stored adjacent to the erection site.

The sample preparation wing, carpenter shop wing, and condenser cooling water chlorination building steel were detailed in the field engineering office and fabricated by field forces. The greater part of the structural steel was available from warehouse stock for these three buildings.

Erection of all these structures was accomplished without any special erection problems. Crawler cranes were generally used, moving as necessary around the buildings. In some instances tugger hoists were used to place steel in the transfer structures. Table 23 includes the major steel structures with pertinent data.

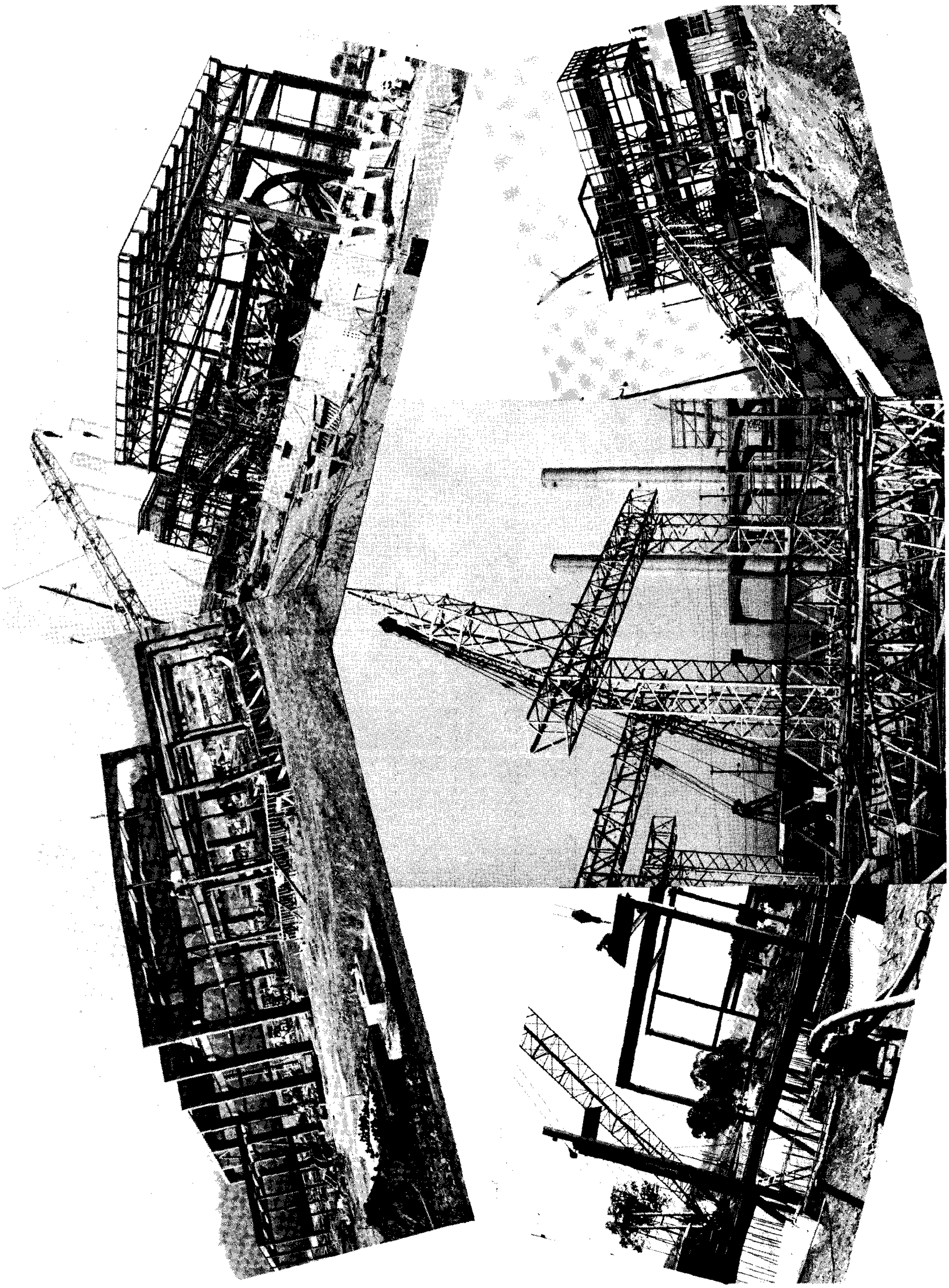


FIGURE 101.—*Erection of steel structures other than the powerhouse was done with crawler crane as on, left to right from top, the utility building, hopper building No. 1, control building, switchyard, and the coal conveyor and crusher building.*

TABLE 23.—*Major steel structures.*

Structure	Fabricator	Erection dates
Control building	Truitt Manufacturing Co.	May 15, 1952-June 16, 1952
Water treatment plant	Bristol Steel & Iron Works	Oct. 22, 1952-Nov. 3, 1952
Switchyard and transformer yard	Bethlehem Steel Co.	Jan. 12, 1953-Sept. 1955
Crusher building	Bristol Steel & Iron Works	March 6, 1953-June 2, 1953
Coal conveyor structures		
BC 2 and 7, transf stas A & C	Bristol Steel & Iron Works	April 1, 1953-April 24, 1953
Hopper building No. 1	Bristol Steel & Iron Works	May 15, 1953-June 1953
Coal conveyor structures		
BC 3 and 4 and transf sta B	Converse Bridge & Steel Co.	June 9, 1953-July 17, 1953
Temporary bridge BC 5-6	Converse Bridge & Steel Co.	Nov. 4, 1953-Jan. 1954
Utility building	Anthracite Bridge Co.	Aug. 31, 1953-Oct. 1, 1953
Storage building	Allied Structural Steel Co.	May 18, 1954-June 8, 1954
Coal conveyor structures		
BC 11 and transf sta D	Decatur Iron & Steel Co.	June 9, 1954-July 1954
Sample preparation wing	Field fabricated	Jan. 2, 1956-Jan. 6, 1956
Carpenter shop wing	Field fabricated	Feb. 13, 1956-Feb 17, 1956
Chlorination building	Field fabricated	Aug. 28, 1956-Sept. 14, 1956

Field fabricated steel

From the beginning of construction, procurement of miscellaneous structural grade steel shapes, rods, and plates for project stock was continuous. As design of construction plant and permanent features was completed, the stock was expanded. The steel situation in the early stages of construction made it necessary to procure many items of steel to take care of unforeseeable conditions which could influence the construction schedule. Considerable steel was transferred from other TVA projects; a sizable amount was purchased from steel warehouses; and some was purchased directly from rolling mills.

From the above stock, which was stored in the vicinity of the steel fabricating shop, steel was drawn to fabricate numerous items for construction plant as well as for permanent features. Field fabricated items were fabricated by several different crafts but the major portion of this work was divided between the structural iron workers, sheet metal workers, steamfitters, and electricians, in that order. Some of the major items fabricated by field forces were generator leads housings, pipe hangers, all embedded guides and frames, including door subframes, access walkways and platforms, electrical boxes, sheet metal ductwork and hangers, pipe handrailing, anchor bolts, main structural steel frames for small structures, steel window sills, wall coping, and many minor items. Items were fabricated as required by the construction schedule with priority given to those items which were to be embedded in concrete or masonry walls.

Because of the vast amount of mechanical piping, conduit, ductwork, and equipment which must go into a plant of this type, a number of interferences were encountered during the course of erection. These problems were considered individually and field drawings were made denoting the changes.

All steel and other materials for permanent use needed for field fabrication were procured on requisitions originating with the office engineer. Steel required by the construction department was drawn from permanent stock. The office engineer kept a running inventory of steel in stock during heaviest activity, and he had to anticipate all requirements to assure that steel items would be available when required in the construction schedule.

ARCHITECTURAL FEATURES

Major architectural features were in most cases furnished and installed by contractors, a list of which is contained in Appendix C, "Major Purchases." Requisitions for practically all architectural work except paint were initiated by the Architectural Design

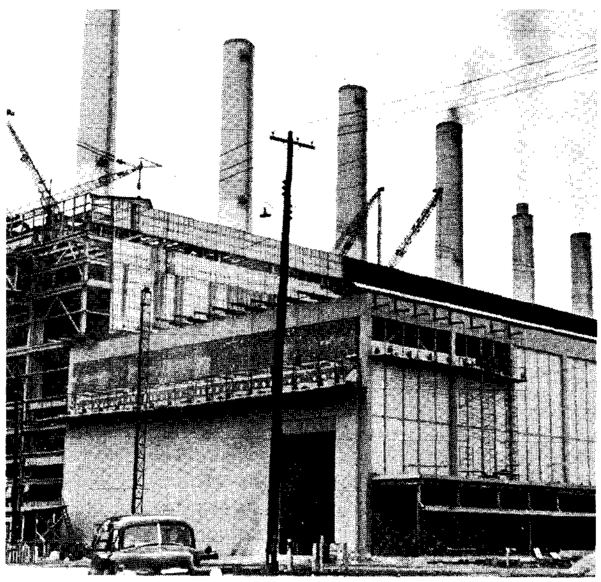


FIGURE 102.—*The south end of the turbogenerator room was constructed of brick and glass block laid from a swinging scaffold suspended from cantilever beams on the roof.*

Branch. Contracts were awarded on a project-wide basis as far as design completion would allow. With the completion of design, contracts were extended by negotiation. Contract extensions were preferred in the interest of economy and matching existing workmanship and material. Where negotiations were unsuccessful, new requisitions were issued. Numerous minor architectural items such as metal trim, louvers, kitchen units, window frames, handrailing, door frames and doors, final painting and others were installed by TVA forces. A general discussion of installation of architectural features follows.

Masonry

All masonry was furnished and installed by Garland Sherman, bricklaying contractor, during the period from April 1953 to February 1956. On all buildings except the storage building, the exterior masonry consisted of vitreous-type face brick. The storage building was of concrete block construction. Glass block was used in the entire exposed area of the south wall of the turbine room (fig. 102).

Masonry interior partition walls were built with the following materials:

- Ventilation plenum—structural hollow tile
- Boiler room—6T series, clear glaze structural facing tile, gray
- Service bay basement—concrete brick
- Service bay shop area—6T series
- Service bay toilets, lockers, and dining rooms—6T series, yellow
- Office wing basement—concrete brick
- Office wing office area—4D series, glazed tile, pewter gray

Interior partitions in the water treatment plant, control building, conveyor control building, and utility building follow similar patterns, with face brick in basements, 4D series glazed tile in toilets and corridors, and 6T series facing glazed tile in shops and offices.

Installation of masonry was done mainly from conventional tubular-type scaffolding. Figure 102 shows a cantilever hanging scaffold suspended from the turbine room roof for construction of the large masonry wall at the south end of the turbine room. Tuck pointing was used in glazed tile walls.

Roofing and precast slabs

Built-up roofing—Installation of built-up roofing on permanent structures was performed by four separate contractors. A list of the contractors and the work performed is included in Appendix C, "Major Purchases."

Temporary 2-ply roofing was installed on the control building, crusher building, utility building, and the turbogenerator room and portions of the ventilation plenum room in the powerhouse. Installation of temporary roofs was considered advisable in anticipation of considerable construction activity in those areas which would likely cause undue damage to permanent roofs. Built-up composition permanent roofing installed was 4-ply, smooth surfaced, asphalt-saturated, perforated, asbestos felt, built-up roofing conforming to the Johns-Manville Corporation's Standard Specification No. 125. The only exceptions were that crushed slag and marble chips were applied to the roofing on the powerhouse precipitator room and guard shelter respectively, and membrane waterproofing was specified for the precipitator room roof. The contractor for powerhouse roof, units 1-4, elected to use 1-inch-thick insulation boards for the 2-inch thickness of insulation, whereas, the units 5-9 contractors used Perlite fill.

Precast concrete roof and floor slabs—Precast concrete roof slabs were installed over all the powerhouse except the service bay to support the permanent roof. Precast concrete floor slabs were installed in the coal conveyor room in the powerhouse and for various belt conveyor structure floors. All slabs were furnished and installed by the Alabama Cement Tile Company of Birmingham, Alabama, on two contracts. Technical inspection during the manufacturing and curing process was performed by the Barrow-Agee Laboratories, Inc., at the contractor's plant. Typical slabs were channel-shaped and contained a reinforcing steel bar in each leg of the channel and wire mesh in the web. After curing, the slabs were shipped to the project by rail. Space for storage was provided immediately west of the coal storage yard near a railroad spur.

After some delay, resulting from the late delivery and erection of building steel, installation of roof slabs was started February 18, 1953, on the turbogenerator room roof. From this time forward slabs were installed immediately following structural steel erection insofar as possible, starting with unit 1 and continuing through unit 9. The necessity of providing covered working space and protection of equipment being installed required several extra visits to the project on the part of the slab contractor to release certain areas to the roofing contractor by a given time. Breakage of slabs caused some concern, but was not considered excessive realizing the concentrated construction activity in certain areas. Floor slabs for conveyors were installed soon after erection of the steel structures to provide working space for installation of conveyor equipment.

Steel roof decking—All roof areas which received built-up roofing and were not covered by precast concrete roof slabs were covered with cellular steel roof decking manufactured by H. H. Robertson Company. This includes the powerhouse service bay office wing and outlying buildings. This company also installed the steel roof decking for most of the structures; however, after the contractor left the project, TVA forces installed the remaining steel roof decking. The latter involved only small buildings and plant additions including the guard shelter, sample preparation wing, carpenter shop, and condenser water chlorination building.

Erection of steel roof decking immediately followed structural steel erection for the various structures. Generally, when hoisting equipment was available the contractor arranged to have the panels hoisted to the various roofs by TVA equipment. However, in some cases the contractor hoisted the panels by hand, utilizing an A-frame. The roof decking was normally positioned with the flat surface down and was fused to the building steel by welding. In one instance the decking was placed with the corrugations down. This was in the sample preparation wing and the corrugated channels were used to conceal wiring in the exposed decking. Roof decking on the condenser cooling water chlorination building was originally specified to be laid with the corrugated face exposed; however, it was placed with the flat surface down and the roofing contractor was allowed an "extra" for the additional light concrete fill required. The same type roof decking, with the flat surface exposed, was used to enclose the conduit duct in the crusher building which extended from the ground floor to the control room or penthouse. This work did not present any unusual problems or require any special erection schemes.

Metal siding and paneling

Exterior—Except for special panels, those included in door and window assemblies and siding on the condenser circulating water chlorinator building, all the exterior metal siding was furnished and installed by two contractors.

H. H. Robertson Company of Pittsburgh, Pennsylvania, manufactured, furnished, and installed the major part of the metal exterior siding and certain interior walls. This contract also included louvers, window framing, and ventilation hoods in specific locations. Included in this contract were the exterior walls of the powerhouse units 1-9; control, crusher, and hopper buildings; scale houses; microwave house; and conveyor structure for BC-5 and 6. For the exterior siding, with minor exceptions, Robertson's Q-panels, type "G" siding was used.

Similar corrugated-type panels were installed by the American Steel Band Company on the storage warehouse, belt conveyor structures 2, 3, 4, 7, and 11 and transfer structure B, including steel louvers on the east side of structure B. These panels were not insulated. They were single corrugated panels of a design matching the siding installed by H. H. Robertson attached directly to the building steel girts with metal screws and neoprene washers. This contract also included 2½-inch corrugated shaped sheets installed as roofing over the conveyors. Except that the roofing was given a coat of black paint, a similar erection procedure was followed.

The American Bronze Company, Inc., furnished and installed the yellow porcelain enameled steel panels with the east and west window assemblies of the service bay office wing. These panels were backed with 1-inch of hard board insulation and in the W-line were also faced with porcelain enamel on the inner side.

Siding on the control room or penthouse of the crusher building was yellow porcelain enameled steel panels. This was furnished and installed by the Bettinger Corporation early in September 1954. These panels consisted of 16-gauge enameled steel panels with flanges, 1-inch insulation, and Vapor-lok back steel sheet. Alumi Seal tape was used to form a water tight seal between the face of the panels and the aluminum stop.

A small area on the utility building south wall was covered with aluminum Zourite without insulation. This was furnished and installed by the Southeastern Glass, Inc. The TVA forces installed the Galbestos siding on the condenser cooling water chlorinator building. The flat insulated panels of the guard shelter were manufactured by the Kirk & Blum Manufacturing Company. TVA forces also installed, and in some cases fabricated and installed, small flat steel wall panel assemblies and steel wall panels incuded with door assemblies furnished by the hollow metal door manufacturer and miscellaneous minor panels.

Interior—There is 47,472 sq ft of sound-absorbing, insulated paneling in the turbogenerator room above elevation 775. These hollow-steel panels have 1½-inch fiberglass batt insulation and ¼-inch perforations on their exposed, interior surface. The panels have interlocking edges and were spot welded to the building steel. Areas covered include a large portion of the room ends, the west wall, and a narrow strip below the structural glass on the east wall. The panels were furnished and installed by H. H. Robertson and spray painted by TVA forces.

Partitions of similar construction, except not perforated or insulated, separate the coal conveyor room over the coal hoppers from the rest of the building. These were also furnished and installed by H. H. Robertson Company.

Zourite, a corrugated aluminum panel, was used as interior wall covering in several areas of the powerhouse. Southeastern Glass Company furnished and installed this material on both sides of the visitors' overlook balcony bannister and on the fronts of the control rooms of units 1-8 facing the turbine room. TVA forces installed 2-inch batt insulation over the control room fronts before the Zourite was installed. The same material was furnished and installed on unit 9 control room front by Binswanger Company in May 1956.

Miscellaneous architecture

Partitions—E. F. Hauserman furnished and installed most of the metal partitions and ceiling panels in the powerhouse and service bay. Ceiling to floor partitions were used in the office wing of the service bay to separate offices along the west side of the service bay. These were interlocking flat hollow metal panels 3 inches thick, filled with mineral wool insulation.

Janitors' closets, combination closets and toilets, were furnished and installed by this contractor in the powerhouse. These were insulated flat steel panel walls 1¾ inches thick with insulated ceiling of the same construction 3¾ inches thick. Hollow metal doors, both single and double, were furnished with fixed ventilating louvers, hardware, and locks; the locks were keyed with the master key system used throughout the project. Open steel shelving was also included in eight of the ten closets. Double utility outlets and switches were provided in the door framing of two closets, but were wired by TVA forces. Ceiling ventilator grilles were included in all closets.

Wire mesh partitions for the powerhouse were standard wire mesh panels framed with channels supported by 2-inch-square tubing extending from floor to ceiling.

Doors and windows—All window sash and doors including special window-door assemblies were installed by TVA forces with one exception. The aluminum sash and enameled panels on the east and west walls of the office wing were furnished and installed by the American Bronze Company.

Hollow metal doors were 1¾ inches thick, flat surfaced, filled with sound and temperature insulation and given one coat of paint at the factory. Doors were furnished with louvers, vents, or opening for glass as specified on the drawings. Steel door frames for both wood and steel doors were also furnished by the door manufacturer.

Wood doors used principally in the office wing and control building were 1¾ inches thick, flat, with plywood surface. Toilet doors 1¼ inches thick, also of the same material, were used in several buildings. All painting was done by TVA. Most of the doors, including toilet doors, in the office wing were finished in clear lacquer.

Aluminum doors and door-window assemblies used for building main entrances were made of flat, square-cornered extrusions and included door frame and trim of the same design; each unit was especially designed for architectural effect. The combination of aluminum entrance doors, adjoining trim, and window sash was used throughout, with the exception of the water treatment plant. In this instance, extra high hollow steel doors having three glass panels were used. Aluminum window framing in combination with Zourite wall covering was used at each control room facing the turbogenerator room. Interior windows between the visitors' corridor and the north end of the boiler room were framed with aluminum. A large window between the visitors' lobby and the control room in the control building was also framed in aluminum and included a window ledge and handrail of the same material in the lobby. Screens were installed in the small ventilation windows in the lunch room of the utility building and were added later to the windows in the control room of the water treatment plant.

Hardware was delivered directly to the metal door manufacturers, fitted into the doors, and removed before shipping to the project. Hardware was fitted to the wood doors as they were installed. The locks were all furnished with a keying system with master, grand master, and great grand master keys. Other materials, including weather stripping, door stops, and saddles, were installed by TVA as specified on the drawings.

Tin clad fire doors of laminated wood covered with tinned sheet steel were furnished complete with track, rollers, cable, fuse link, and weights. All except one door in the powerhouse are operated by CO_2 trips also.

Rolling doors made of interlocking steel slats and suspended from above the door opening operate in guides or channels on each side of the opening. The larger rolling doors are motor operated with facilities for emergency hand operation. Smaller doors and the rolling doors at the supply windows in the service bay are hand operated. Two rolling doors in the utility building are used as fire screens between the shop and office ends of the building. These were purchased with weights and fuse links and will remain rolled up until released by the fuse link in case of fire.

Steel window sash used in all the buildings were manufacturers standard stock material, but in most cases were special sizes. These were furnished with assembling materials and hardware if needed. Special steel window assemblies included door subframes, flat steel insulated panels, supporting members, and in some cases louver vents as shown on the drawings. Typical of these assemblies are the ones used on the sample preparation wing, storage buildings, truck and track scale houses, and car retarder building.

Window sash and doors were installed in the buildings as soon as construction would permit, as a protection against the weather. Windows and glazing were generally completed first. Temporary doors were erected at the building entrances until plastering, floors, and other rough work could be completed. This was done to avoid damage to the doors during construction.

The first window sashes were installed in the control building in May 1953. By the first of December the same year, the building was enclosed, including the entrance doors, except for glazing which was completed two months later.

Plastering—The contracts provided for material and labor to complete the work, including all furring, lathing, plastering, and insulation adjoining the plastering work. The contractor was furnished suitable storage for materials and tools, usually in the vicinity of his work.

In general, the office walls and ceilings were of sand finish gypsum plaster, the corridor walls of sand finish plaster and ceilings of acoustic plaster or tile. The kitchens and baths were plastered with Keene's cement and closets were putty finish gypsum plaster. Sand finish gypsum, putty finish, and acoustical plaster were applied over a 2-coat base. A scratch coat of hard wall gypsum plaster, containing washed long cattle hair, and one part sand was applied first. The second or brown coat of fibered plaster and two parts sand were applied as soon as the scratch coat set. This was broomed to secure bond for the finish coat. The scratch coat was sprinkled lightly with clear water to retard excessive suction before the brown coat was applied. Acoustical tile was also applied over the two undercoats of gypsum plaster as indicated on the ceiling schedule.

Smooth finish Keene's cement plaster and sand finish Portland cement plaster were applied over Portland cement scratch and brown coats.

Floor finishes—Floor finishes utilized in construction of the plant are as follows: (1) monolithic cement, cement floor topping, and cement topping with colored metallic hardener; (2) terrazzo; (3) resilient tile; (4) quarry tile; (5) ceramic mosaic tile; and (6) steel grating.

Most cement floors were installed by applying a topping layer of rich concrete, ranging from 1½ to 3 inches thick, to the structural slab. Floor hardening treatment was used on all cement finish floors not covered or otherwise finished. Cement floors in areas which would be subjected to more than normal wear received a colored metallic floor hardener on the surface. Use of this material produced a colored wearing surface approximately ⅛ inch thick.

Terrazzo floors were installed by the Art Mosaic and Tile Company, Inc. Terrazzo was placed on structural concrete slabs which were poured to within approximately 3 inches of the finish floor level.

The shower room floors were made non-slip by the addition of Alundum aggregate to the marble chip mix. This abrasive material was also used in the precast terrazzo treads for the employee and public stairs.

Resilient tile floor covering throughout the project was furnished and installed by The Munford Company, Inc., of Atlanta, Georgia. Standard installation methods were employed.

Quarry tile was 6 inches square by ¾-inch-thick Greytone as manufactured by Carlyle Tile Company of Ironton, Ohio. All tiles were furnished and installed by Art Mosaic & Tile Company of Nashville, Tenn. For final surface finishing, all tile was cleaned with a solution of 10 percent muriatic acid and water which was thoroughly flushed off with clean water. After drying, the clean tile surface for units 1-4 was treated and polished using a penetrating finishing oil. The units 5-9 tiles were finished using Super Shine-All cleaner as manufactured by Hillyard Chemical Company of St. Joseph, Missouri.

Ceramic mosiac tile floors were installed by Korizon Terrazzo Company.

Steel grating was furnished by several fabricators and all grating was installed by TVA forces. The grating was rectangular in pattern and was banded. In the buildings it was generally dipped in black paint, while grating exposed to the weather was galvanized.

Ceilings—Ceilings in the office areas were, in general, of plaster, and in certain locations acoustic plaster, as described on page 170. Two types of acoustical tile, Celotex Cane Fiber and Celotone Mineral Fiber, attached to plaster base ceilings were used in other finished areas. The powerhouse control room ceilings below fluorescent lighting were of either aluminum or plastic grid, Alumigrid or Gratelite, to screen the fixtures from view and diffuse the light. Both types permit light to enter the control room diffused, with practically no shadow. In the turbine and boiler rooms the pre-cast, unpainted concrete roof slabs and supporting structural steel were exposed on the under side. Concrete floor slabs constituted the ceilings of the lower floors and steel floor grating in the boiler room area. Flat or corrugated steel roof decking in the smaller buildings sufficed for the ceiling where offices or finished rooms were not needed. Ceilings in the powerhouse janitors' closets were of insulated steel panels as mentioned in the section on partitions. The oil storage room in the utility building was covered with steel decking and concrete for fire protection. Corrugated roofing sufficed in the above-ground conveyor enclosures.

Marble—Marble was used extensively in the public toilets, and to varying extent in offices and toilets in working areas on the project (fig. 103). Ampco Marble Division furnished and installed all marble work in the service bay, control building, water treatment plant, and utility building. Light Hamil Gray marble was used. All exposed surfaces were highly polished or honed finish as indicated on the drawings. Marble veining was run horizontally and adjoining pieces were matched for color only. The vendor cut or drilled the marble toilet hardware, accessories, and pipe. Installation of the marble was according to the best standards, using concealed brass anchors embedded in plaster of paris. The contractor cleaned the work with soap and water and protected it with heavy craft paper.

Marble in the toilets and locker room of the sample preparation wing was furnished and installed by American Mosaic & Tile Company. This was part of a contract for furnishing similar buildings at other TVA projects. Gray Eagle gray marble quarried and finished by Tennessee Marble Company was used. The contractor furnished and installed marble toilet stalls in two toilets and marble seats in the locker room.

Louvers and grills—The louvers and grills, with few exceptions, were located on exterior walls and, as a rule were connected directly to ventilation rooms, but were not part of the mechanical heating and ventilating systems. Louvers and grills were fabri-

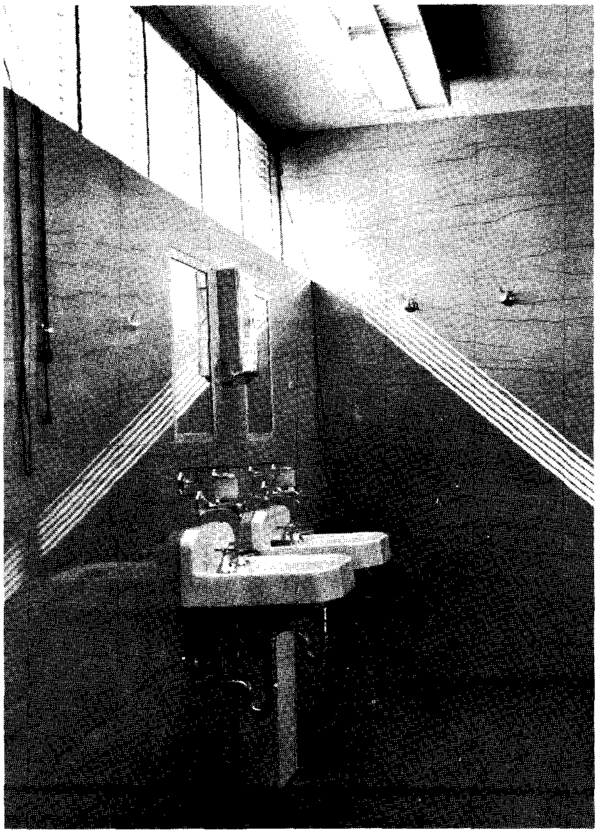


FIGURE 103.—*Typical highly polished marble finish used in public toilets, locker rooms, and some other public areas.*

cated and furnished ready for installation including screens, bolts, and appurtenant accessories necessary for installation. Screens were generally 3- by 3-mesh standard grade hardware cloth galvanized after weaving, in frames or panels, and attached to the louvers with metal screws.

Base cabinets, benches, and tool cabinets—Metal base cabinets and tool cabinets were made in two lengths, 36- and 66-inch with different widths of blank filler panels to make a solid front along the multiple cabinet rows. A 2-inch-thick maple workbench about 3 feet wide formed the top and extended continuously over the row of base cabinets. A back strip extending 8⅜ inches above the bench was attached to the bench and the wall.

The filler panels conformed to the same front outline and provided space for installing electric outlets as needed. Tool cabinets of metal were attached to the walls above the work benches as needed.

A base cabinet with a black Formica covered wood working top was purchased for the dark room in the control building. There are supports and horizontal rods above the back of this cabinet for film drying.

One or more 60- or 72-inch metal top units combined with a continuous top were placed in the service bay storage rooms and the utility building repair shop. Steel service carts having two trays and four wheels, two of which were swivel, were distributed in the same buildings.

Painting—All painting except for the sheet metal siding was done by TVA forces.

Cleaning and preparing the surfaces for painting was a big job in itself. All structural steel was given a shop coat of red lead; after erection it was touched up to cover all steel with red lead before applying the specified color. The turbogenerators were sanded and filled before painting. Much of the turbogenerator painting was done with a spray gun. Acoustical walls and ceilings in the powerhouse were spray painted; and except for a few smaller areas this completed spray painting. Special heat and oil resistant paints were used on some motors and equipment. Noncombustible paint was used on insulated pipe and equipment adjacent to the turbines. All fire protection equipment and hydrogen lines were painted a distinctive red, but later the hydrogen system piping was changed to yellow conforming to military standard 101-A for compressed gas lines. Except for gratings, floors were not painted. The upper portion of the chimneys were painted to protect the concrete from chemical action of the flue gases. The bottom side of the precast concrete ceiling blocks were cleaned but not painted on this project. Names of the major pipe and equipment were painted on after the final painting.

Painting continued from the beginning of steel erection in 1952 and was practically completed by the fall of 1957. In general, painting was completed in the control building and water treatment plant first, followed by the service bay and other smaller buildings. The powerhouse was completed last.

Glass—Glass used in the doors and windows of the powerhouse, units 1-8, and in all other buildings except the sample preparation and carpenter shop wings, and the guard shelter was furnished and installed by Southeastern Glass Company, Inc. Libby Owens Ford glass of several types was furnished. In general, blue-green heat absorbing polished ¼-inch plate glass was furnished for exterior exposed doors and windows, and clear polished ¼-inch plate glass for interior windows. Special insulated windows of two clear polished ¼-inch glass plates separated by a ½-inch air space were used to separate the visitors gallery from the powerhouse boiler room. A blue corrugated plate glass with embedded wire was used between the top of rolling doors and roof along both the north and south sides of the utility building repair shop. Glazing was conventional putty and clips except that the corrugated glass was set in premolded composition channels held in place by special clamping devices to make a continuous window between structural columns. Rubber glazing channels were specified on the original contract for all windows, but

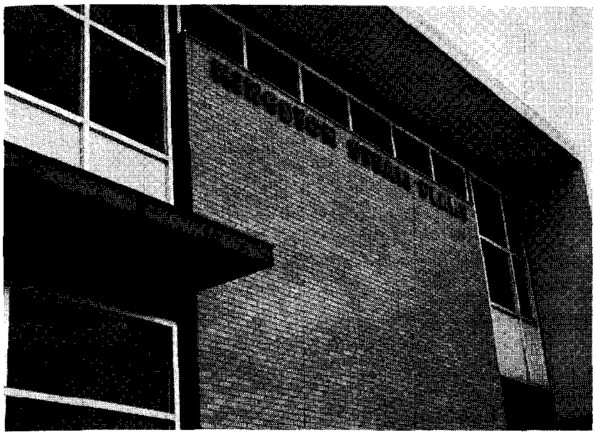


FIGURE 104.—*Building designations with maroon colored porcelain enameled letters provide a distinctive contrast when mounted on exterior buff brick walls.*

the omission of these channels before work started resulted in a material reduction in the contract price.

Metal letters—Building designation was by letters mounted on the outside wall (fig. 104). Contrasting colors were used: aluminum letters on the maroon siding and maroon color porcelain enameled steel letters on cream brick walls. Letters were cut, formed, and welded of 14-gauge metal with three mounting brackets to each letter. Letters were attached to the brick walls with double cinch anchors and bolts, and to metal walls with bolts through previously installed supporting plate. Aluminum letters were 9 inches high and porcelain enamel letters 11 inches high.

Letters and numerals used in the visitors lobby were of satin finish cast aluminum 3 inches high with projecting threaded brass rods in the back side for anchoring in the wall. Holes drilled in the brick and mortar wall were filled with plaster of paris and the letters forced into place before the plaster set.

Furniture—All the chairs, sofas, setees, and tables were constructed on metal framework and legs. Upholstering material is fabric backed vinyl plastic in solid colors. Twin beds, dressers, night stands, grip racks, and chairs of wood finished in natural color are provided in the overnight rooms. Tops of the dressers and night stands are plastic veneer.

Upholstered steel folding chairs were placed in the assembly room. Two chair trucks with a capacity of about 100 folding chairs each were furnished.

Metal chairs and tables were furnished for the kitchens in the powerhouse and utility building. Chairs are all steel and the steel tables are covered with linoleum.

Laboratory furniture and equipment for the service bay and water treatment plants included desks, cabinets, fume hoods, sinks, drying cabinets, electric blowers, switches, and lights with electric, water, and air outlets completely installed by the vendor.

Lockers—A total of 570 lockers and 100 locker stools was purchased including necessary filler panels, scribe plates, and ventilation hoods. There were 12 individual lockers with additional shelving for use in the ladies toilet room and storerooms in the service bay. They were gravity ventilated, without legs, and equipped for padlocks. Eight 6-person lockers were furnished. Each consisted of two standard width lockers with five small compartments in one section and one small compartment in the other, with a coat locker below all with separate doors with provision for padlocking each. These lockers were on legs and were located throughout the powerhouse for the operators' use.

Shelving and related equipment—Standard steel shelving, bins, storage cabinets, shop desks, desk stools, wall hung key cabinets, mounting panels, and tool pegs were purchased for the powerhouse, service bay, control building, water treatment plant, and hopper building No. 1. The shelving was shipped for assembling by TVA forces and was furnished in standard oven baked green enamel.

Heavy duty racks of light structural steel painted dark green were furnished without wood shelving. The racks were assembled and wood decking installed as required by TVA forces.

Venetian blinds—Venetian blinds were installed in the control building, the service bay west offices and conference room, utility building lunch room, crusher building penthouse, water treatment plant, and service bay and utility building.

All blinds were of similar construction and material, being Levolor Lorenten with aluminum slats, plastic tape, and end caps. Blinds over 75 inches wide were multiple lift type.

Service cabinets—Service cabinets are flush wall cabinets housing the lighting switches, water and air outlets, firehouse, fan controls, and miscellaneous equipment in the various buildings. The cabinets consisted of sheet steel frames and doors set flush in the walls, some with metal boxes, some with plate backs, and some with plaster lined recesses. Doors were hinged to the fronts with piano type hinges and the front attached to subframes previously installed. Doors had friction catches and chrome plated brass knobs.

Basket stretcher cabinets were standard size, 12 by 30 by 90 inches, with doors, bonderized, and finished with baked-on gray paint.

Planting boxes—Planting boxes were designed as a permanent part of the public lobby and visitors lounge in the service bay. Several varieties of tropical plants were planted in these boxes and they furnish a very pleasing addition to these rooms. They were located near the foot of the stair and around the stair ledge on the upper floor and were made by field forces of copper with perforated bottoms.

Toilet room accessories—Toilet room accessories including mirrors, glass shelves, soap dishes, soap dispensers, towel rods, coat hooks, waste receptacles, etc. were purchased for the powerhouse, service bay, control building, water treatment plant, utility building, storage building, hopper building No. 2, and sample preparation wing.

Murals—A mural painted by TVA's staff artist was displayed on the south and west brick walls of the public lounge of the service bay under appropriate ceiling lighting. This series of eight related oil paintings of various widths occupies a wall space about 45 feet wide and 6 feet high. The canvas was attached to 3/4-inch plywood panels hung vertically about 2 1/2 inches from the walls.

Wall base—Metal baseboards were used in the plastered rooms with cement finish or rubber tile floors. The base strips were 6 inches wide in rooms with rubber tile floors and 6 1/4 inches for cement finish floors. All were 3/16-inch thick with a bevel along the top side, drilled on 2-foot centers with two rows of holes, and attached to metal backing strips which were installed by the plaster contractor. The baseboards were received in 10-foot lengths with a shop coat of paint and necessary oval head screws. Molded black rubber or terrazzo baseboards were used only with tile walls.

Bulletin boards—Metal framed cork panel bulletin boards 36 by 36 inches and 36 by 48 inches were installed throughout the buildings. Two porcelain-fused-to-steel chalk boards, green color, and backed by plywood were hung on the 725 elevation for ash sluicing data.

A swinging 12-leaf bulletin board with 24- by 36-inch leaves was hung in the shift engineer's office for posting various data on unit operation. Removable soft composition boards were used in steel frames, all hinged from one bracket on the wall.

A large chalk board installed in the assembly room of the service bay is mentioned in the section describing millwork, this page.

Flag and flag pole—A flag pole 88 feet in height, with bucket, trucks, halyard, and 12-inch ball was erected in the parking area west of the service bay. The pole was set in the bucket, grouted, wedged, and caulked.

Handrail and balustrade—metal—In general, handrail was a structural item. Decorative metal handrail and balustrade were employed in areas ordinarily open to the public and visible in the turbo-generator room. All aluminum handrail was made of 1 1/2-inch IPS aluminum pipe with welded joints and necessary fittings. The manufacturer finished this work in an Alumilite or dull satin finish after fabrication and coated it with a protective wax. The structural shapes used in the balustrade were also given the same finish. Wrought steel balustrade was given one factory coat of red lead which was finished in black paint after erection.

Millwork—The small amount of millwork used on this project was confined almost entirely to the service bay.

The walls of the assembly room were covered with matched walnut faced plywood finished in clear lacquer except for areas on three walls which were covered with perforated Transite panels backed with a 1-inch sound isolation blanket.

A chalk board with a birch frame 3 1/2 by 16 feet enclosing a 1/4-inch green plate glass with the surface impregnated with a fine abrasive was attached to the east wall after the paneling was completed.

Cabinets with fronts of natural finish birch were installed in the recesses provided in the conference room, superintendent's office, and treatment room. Sliding doors and locks were featured with adjustable shelving.

Solid red birch handrail finished in clear lacquer was used in the visitors' lobby and approach stairway.

A telephone booth in the public lobby of the service bay was another millwork feature. The booth was recessed in the south wall with only the interior and interior door trim exposed. The booth was of solid birch with birch plywood panels. The upper portion of the walls and the ceilings were perforated plywood with sound insulation backing. A small corner shelf, recessed ceiling light, and telephone constituted the only interior equipment.

Base cabinets with glued and bolted bench tops were the only other major millwork installations.

ELECTRICAL FEATURES

Grounding

The 500 mcm bare copper cable for the main ground mat was installed in the powerhouse area as the backfill was brought up around the substructure, thus eliminating the necessity of digging trenches. Since the main ground mat in the powerhouse was installed in the floor fill slab which was poured much later than the wall, it was necessary to place the ground cables through the walls before the outside mat was laid.

No attempt was made to install the ground cable in the switchyard area as the fill was brought up, since it was decided to bring the entire area to approximate finish grade and then excavate for the individual embedded installations. This allowed unrestricted use of all earth moving equipment and the sheepsfoot roller for compacting the fill. Exhibit 6 shows the plan of the main ground mat.

The surface ground mat, consisting mainly of a network of 4/0 cable, was installed just beneath the surface under the crushed stone in the switchyard and transformer yard. In the chimney area it was buried approximately 6 inches deep and was tied to the 500 mcm risers extended from the main mat which provides grounding circuits for the building steel and exposed equipment. The surface ground mat also serves to prevent excessive potential gradients from occurring between different parts of the yard.

Conduit and cable trays

When the job had progressed to the point where the installation of conduit was to begin, a set of detailed instructions was assembled and issued to all electrical inspectors and to the electrical department for issue to all foremen The purpose of the instructions was to keep the specifications and standards before the men responsible for carrying out the work.

Particular care was given to the installation of expansion couplings, especially in the basement fill pours, to prevent water from entering the conduit at the expansion couplings. A 4-inch pad was poured around all conduit coming out of a slab where it was likely that water might stand around the conduit. A coupling half in and half out of the pour serves the same purpose in many areas and is to be desired even when installed out of a pad or foundation.

Transite conduit, which is generally specified for economy, should eliminate the use of a concrete envelope when buried in the earth. However, it was found that the cost of hand tamping the backfill was greater than the cost of a concrete envelope; therefore, all buried Transite was encased. In several instances where Transite or Korduct embedded in concrete pours was designated, iron pipe was substituted for economy.

Formed asbestos cement cable trays were installed extensively in the powerhouse, the switchyard cable tunnel, the control building, the cable tunnels from the control building to the powerhouse tunnel, the tunnel from the powerhouse to the water treatment building, the intake structure, and the crusher building. Some difficulty was experienced with the supports for the trays in the switchyard tunnel because of irregularities in the precast pipe and irregular trays. The tray irregularities were corrected by the manufacturer on later orders. The greatest installation difficulty was in the powerhouse where innumerable changes had to be made due to piping interferences, uneven concrete surfaces, and for lack of space.

Lighting

Building—Generally speaking, there was very little difficulty experienced with the installation of the lighting. Several changes had to be worked out due to interferences.

Considerable trouble was experienced with the fixtures around the boilers. These individual fixtures were suspended from an aligning box, and the heat around the boiler set up air currents that caused the fixtures to swing continually, eventually causing the fixture wire to break. To correct this the aligner had to be removed or welded rigid. Later, this was corrected by clamping the fixture stem to the box.

Misalignment of high bay lighting fixtures in the turbine room was corrected the same way.

Yard—Standard construction procedure and practices were used in installation of lighting standards; however, it was found to be cheaper to pour concrete envelopes around all steel conduit runs rather than prepare hand tamped backfill for Transite conduit.

The storage yard and condenser water intake structure deck are lit by standards and fixtures similar to those on the roadway; the car retarder area is illuminated by flood lighting.

Communication system

The plant communication system consists of a PAX, code call system, powerhouse paging system, inter-communication system, and 2-way radio facilities for railway coal handling operation. The center of the system is in the communications room of the control building which contains the PAX cabinet with code call equipment, the main distribution frame, and the powerhouse paging system amplifiers.

The 2-way radio system consists of a fixed station in the utility building and mobile unit in each of the five locomotives used for coal handling operations. The 2-way radio system for the coal handling area is used to expedite the handling of loaded and empty coal cars between the coal yard and the interchange yard at Emory Gap. It provides communications between the yard foreman's office in the utility building and any locomotive in the yard area or between the yard area and the interchange yard. It also provides 2-way communications between the locomotives in the yard area.

Switchboards

Due to a strike in the steel industry, the switchboard manufacturers revised their shipping schedules on the switchboards for Kingston. While this delayed their arrival, the majority of the boards were received sufficiently in advance of revised schedules to allow for proper planning. The first of these to arrive were the main 480-v boards for the crusher building and water treatment plant which were delivered on October 9, 1952.

In the installation of the boards, much care was taken in setting the channel bases. Usually, the concrete was finished off inside the channel before the board was set or the finish floor was poured. Figure 105 shows a partially installed 480-v board and the rig used to move and set the board sections in place. This rig was constructed on the job and is limited to use where the small wheels will travel.

Some manufacturers shipped their boards with a plastic coating sprayed on the front and ends of the panels designed to protect the finished surface. When this plastic was removed, and some had to be scraped off, the paint came off too, leaving an ugly uneven

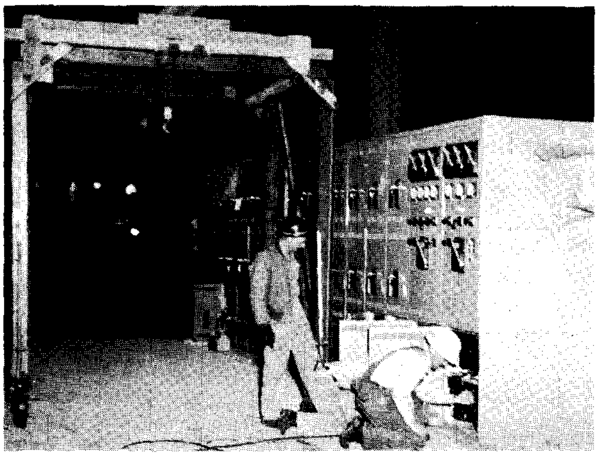


FIGURE 105.—*A job constructed rig used to move and set a 480-v switchboard in place on prepared channel bar.*

mess. The manufacturer let a contract for the refinishing, but even so, it interfered with the work schedule. Before the last of the boards were purchased, it was decided by Design to order them with all but the final coat of paint applied, since the field forces were having to fill and paint them anyway.

All internal wiring of the boards in the control building and unit control rooms was done by TVA. Despite a tight schedule this wiring was done in a very neat and precise manner. Figure 106 shows unit 7 benchboard in the unit control room in the process of being wired. Considerable guttering was used which eliminated a lot of packing and lacing.

D-C equipment

Direct current for the station is supplied from four interconnected systems. These systems are the control building battery, powerhouse battery No. 1, powerhouse battery No. 2, and powerhouse battery No. 3. The principal features of each system are a distribution and control board, motor-generator sets for charging battery and supplying emergency alternating current, and a battery.

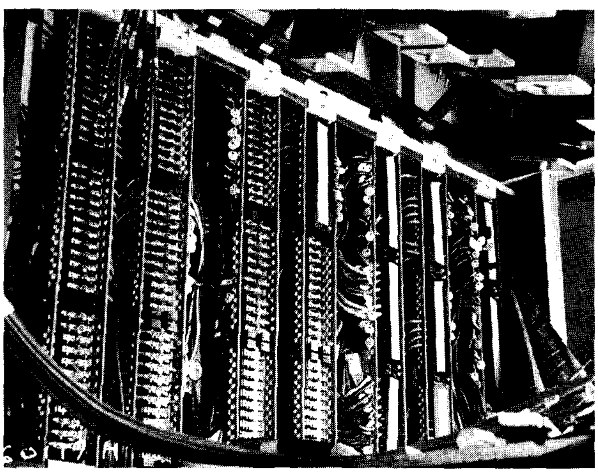


FIGURE 106.—*Unit 7 benchboard for use in the control room in process of having internal wiring installed by TVA forces.*

Switchboards—The control building battery switchboard is composed of two 4-panel sections. Four panels are for 250-v d-c distribution, one panel is for distribution of 12-v a-c preferred service, one panel distributes 48-v d-c, one panel controls the battery charging m-g (motor-generator) set, and one panel controls the emergency alternator set.

Powerhouse battery No. 1 switchboard has five panels. Two panels are for 250-v d-c distribution, one is used for 120-v preferred service distribution, one panel controls the battery charger m-g set, and one controls the emergency alternator.

Powerhouse battery No. 2 switchboard consists of four panels; one 250-v d-c distribution, one for 120-v a-c and 48-v d-c distribution, one for control of the battery charging m-g set, and one for control of the alternator.

The four powerhouse battery No. 3 switchboard panels serve the same purposes as those on the No. 2 system switchboard.

Motor-generators—The 250-v batteries are charged by a 30-kw generator driven by a 50-hp motor. The control building battery and powerhouse batteries Nos. 1 and 2 had two m-g chargers, used alternately. Powerhouse battery No. 3 has only one set. Each system has one 15-kw alternator, driven by a 25-hp d-c motor, supplied by the 250-v battery. These alternators supply 120-v preferred service. Whenever station service fails, or becomes abnormal, these alternators automatically start and replace the station service supply to the preferred service bus.

Batteries—Each system has a 250-v battery. In addition to powering the alternator, these batteries furnish current for emergency lighting, and for control and test circuits. Each system, with the exception of powerhouse battery No. 1, has an electronically charged 48-v battery. They furnish current for the station annunciation. Oscillograph and automotive batteries and chargers are independent of the station systems.

Tagging, testing, and initial operation

Tagging—Impracticability of permanently identifying conduits, cables, and conductors at the time of installation was apparent early in the job. Temporary identification was achieved with preprinted, plastic coated cloth strips. Temporary tags were replaced later by permanent tags. Tags for the first eight units were manufactured on the job by the electricians. Unit 9 tags were ordered from the Electrical Laboratory and Test Branch in Chattanooga.

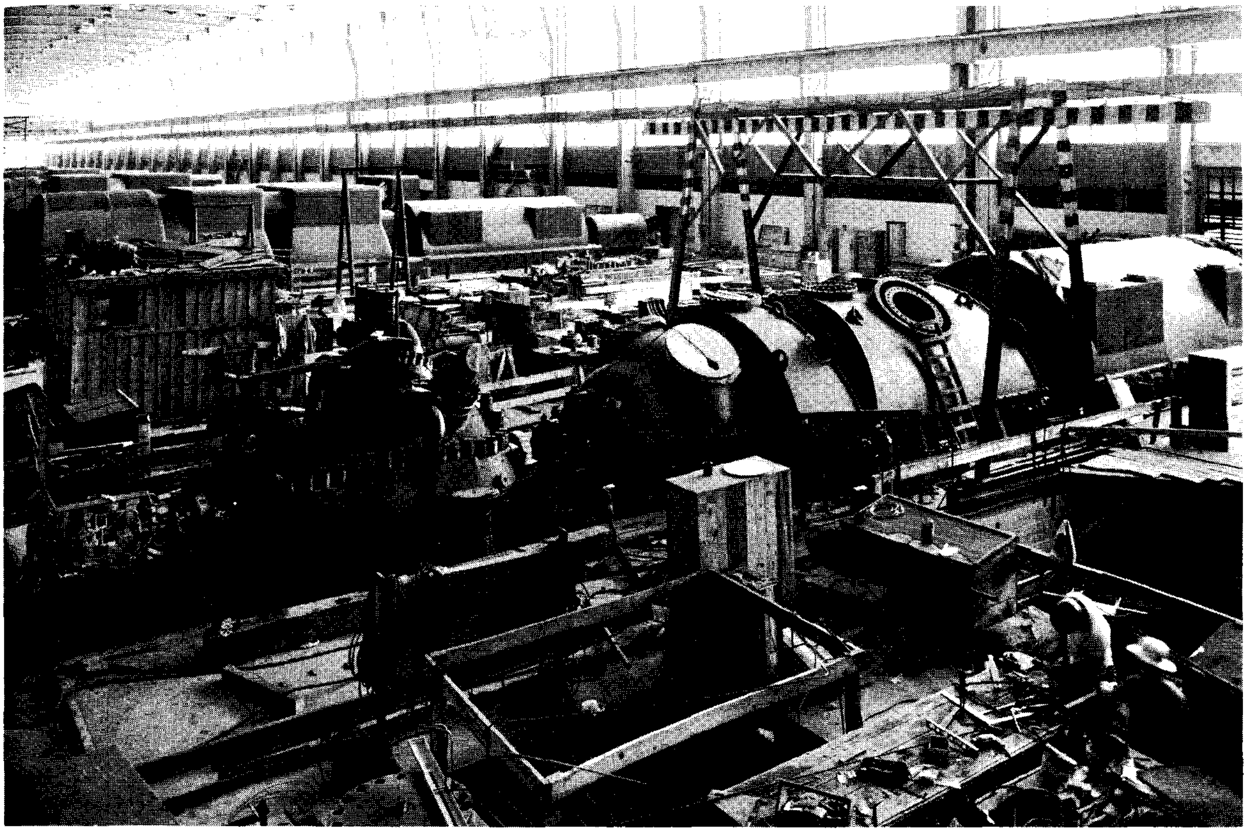


FIGURE 107.—*A 3-ton gantry crane, field designed and job-constructed, for use with a chain hoist, was very helpful in placing and erecting the turbogenerators.*

Testing—Electrical testing of permanent equipment was performed by engineer-electrician teams. A special electrical test crew was created early in the project to standardize and facilitate test procedures. Testing consisted of circuit continuity checks, component testing, and testing for grounds and for shorts. Generator and transmission plant equipment were tested by the Electrical Laboratory and Test Branch, Chattanooga.

Check-out operation—Check-out operation of major permanent equipment was scheduled in staff meetings. A co-ordinator was appointed, whose duty it was to assemble all interested parties for the scheduled start-up. Before a piece of equipment was energized, all hold orders were cleared. A hold order is a cardboard tag form stating that the equipment is not to be operated without the permission of the person who issued or signed it. When all hold orders were cleared, the check-off sheet was signed. The operation procedure was that as recommended by the manufacturer and/or common operating practices as followed by TVA. Check-out operation consisted of test runs and operational checks as needed. When the Division of Power Production's representative present signed the check-off sheet, the equipment was considered accepted for regular service.

MAJOR EQUIPMENT INSTALLATION

Turbogenerators

The turbogenerators for units 1-4 were purchased from Westinghouse Electric Corporation, and those for units 5-9 were purchased from General Electric Company. Erection procedure on each unit was, in general, very similar considering the difference in size and design, and was in the sequence of 1 through 9. As delivery of parts permitted, the succeeding units were started and active assembly was in progress on three units during most of the construction period. Appendix F contains a detailed step-by-step account of the erection procedure of unit 5 turbogenerator.

Receipt and handling—Parts for these units were generally received by rail in carload shipments. When so received they were unloaded with the 90-ton turbine room cranes and stored on the floor. Air freight, motor freight, and direct truck delivery from the factory were occasionally necessary to meet the start-up

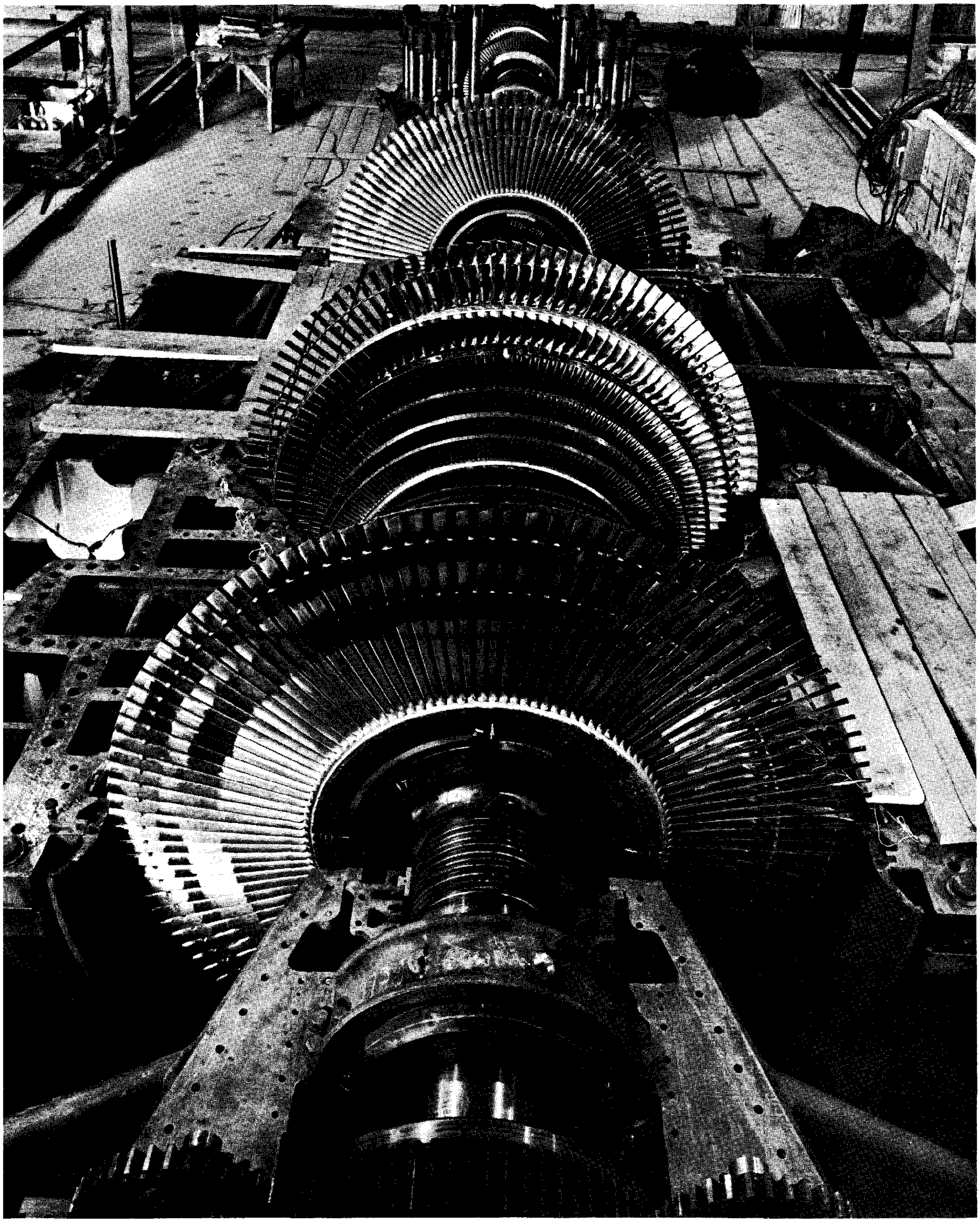


FIGURE 108.—*Unit 6 turbine rotors in place showing low-pressure blades in foreground, intermediate pressure blades beyond, and high-pressure blades at far end.*

schedules. The manufacturers furnished all special tools and the heavy-duty slings, including shoes and plates for sliding generator parts into position. A dolly for supporting one end of the 5-9 rotors during installation or removal from the stator was also furnished by the manufacturer. The field designed and constructed a 3-ton gantry for use with a chain hoist (fig. 107). This gantry, straddling the turbogenerator, was set on temporary rails extending the length of the unit. Constructed in the spring of 1954, it was used for erecting unit 3 and all succeeding units and released the large cranes for other use.

Erection of turbines—Erection of all the turbogenerators was by TVA forces under the direct supervision of the manufacturer's erection engineers. Westinghouse engineers supervised the erection of the units 1-4 turbogenerators and all nine condensers. General Electric Company representatives supervised the erection of units 5-9.

Erection procedure of the steel supporting plates was essentially the same for all units. Each time weight was added during turbine erection the base was checked for proper leveling. Maintenance of alignment and clearances in the turbogenerator was dependent upon a level, rigid base.

Insulation of all units and associated piping was done by contract (fig. 109). The material in each case was furnished by the turbine manufacturer.

Assembly of the units generally started by setting the low-pressure exhaust casing on the base plates (fig. 110). The final work included operational adjustments, insulation, and placing covering.

Erection of generators—units 1 through 4—Generator erection started with the arrival of the stator. This being the largest and heaviest piece of the turbogenerator, it was received on a special flat car with double trucks, front and rear. Because of its width the shipment had special routing and traveled in daylight only The stator assembly was unloaded (fig. 111) by using both powerhouse cranes with the lifting beam and was placed on a structural steel frame approximately 3 feet high over its foundation. In this position the leads box was installed and welded to the stator shell.

After the leads box was welded the stator was lowered onto wooden blocks about 4 inches above the sole plates. While in this position the rotor was installed, together with end plates, bearings, fans, hydrogen seals, etc. The rotor was installed by using one crane with slings around the midsection; a skid was installed on the turbine end that slid along a steel plate installed in the stator bore so as to protect the laminations. Suspended from the crane hook, the rotor was moved into the stator as far as the slings would allow, and the collector end was blocked up so that the slings could be shifted for another move. Rachet hoists were used on the turbine end flange to pull the rotor into the stator bore when the collector end was lifted by the crane.

After rotor installation, the generator was lowered and the terminal bushings were installed in the leads box and connected to the stator winding. These connections were insulated by taping. Connection to the leads bus was made to three of the terminals. The other three were connected together and grounded through the neutral transformer.

Erection of generators—units 5 through 9—The erection procedure for the 200,000-kw machines differed only in one important aspect from the procedure of the first four 150,000-kw machines. The stator assembly was shipped in four large sections and the machine, being longer than units 1-4, required special equipment to install the rotor. Otherwise, the erection was similar.

The stator shell was received in three sections because of railroad tunnel and bridge clearances. These sections were placed in trunnions and rotated until the bore was vertical and then they were stacked in order, bolted together, and the joints welded. This operation was carried out on the 725 elevation. When the welding had been completed the stator shell was rotated to a horizontal position and was placed on cribbing 3 feet 4 inches above its sole plates using one powerhouse crane. While in this position the stator core, complete with windings, was installed by using both powerhouse cranes with lifting beam and an electric hoist rigged to pull the core into the stator shell (fig. 112). The stator was then lowered to 4 inches above its sole plates so that the rotor could be installed.

While the stator was in this position and before the rotor was installed, the leads box was bolted and welded to the stator shell. The leads bushings were installed and connections to the stator terminals

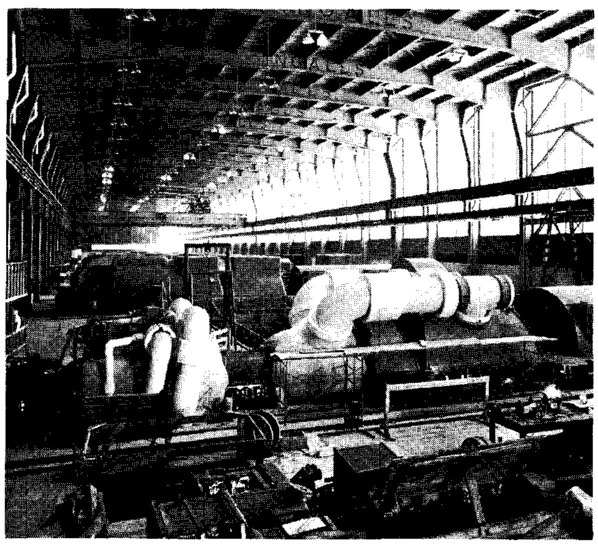


FIGURE 109.—*Insulation applied to turbogenerators and related piping was installed by contract with material provided by the turbine manufacturer.*

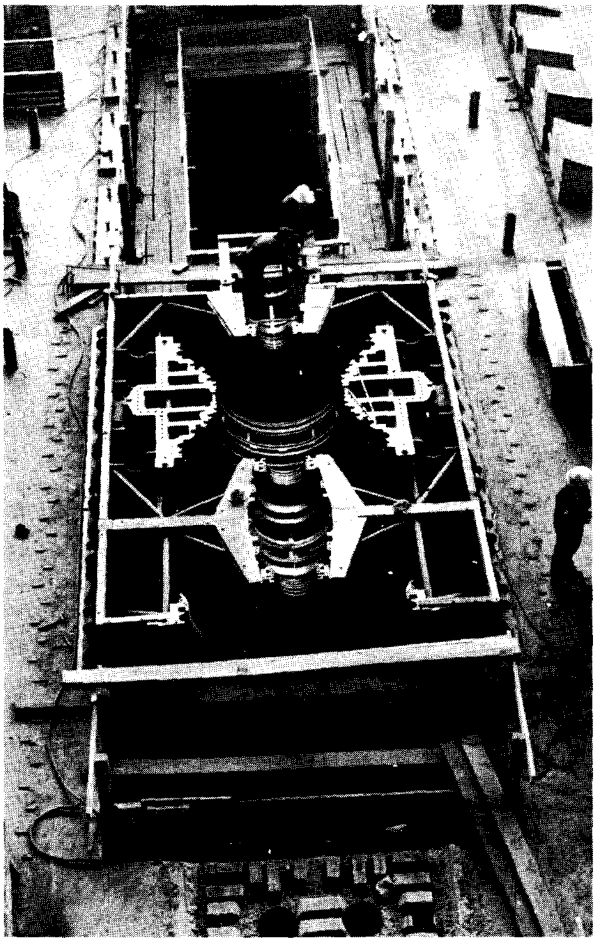


FIGURE 110.—*Low-pressure exhaust casing, unit 8, being aligned and placed on base plates in first step of assembly.*

were made up and taped. No trouble was experienced with the connection between the leads bushing and the bus provided by TVA; the stud connector on the bushing is adjustable vertically.

Units 5-9 have hydrogen-cooled terminal bushings. Hydrogen is circulated through the conductor tube of the bushing by piping the gas from the cool side of the cooler in the generator to the bottom of the bushing tube, and is then allowed to flow upward around the outside of the gas pipe cooling the inside of the bushing. This gas piping is glass from stator shell to top of bushing and Textolite inside bushing tube. The gas returns to the stator shell via the connection box and three 4-inch steel pipes.

After the rotor was installed (fig. 113) the generator end plates, bearings, seals, etc., were bolted in place and the generator was lowered to the sole plates and lined up with the turbine. Several railroad rails were embedded in the foundation to be used to jack the generator into alignment. After alignment these rails were cut off below finished floor level.

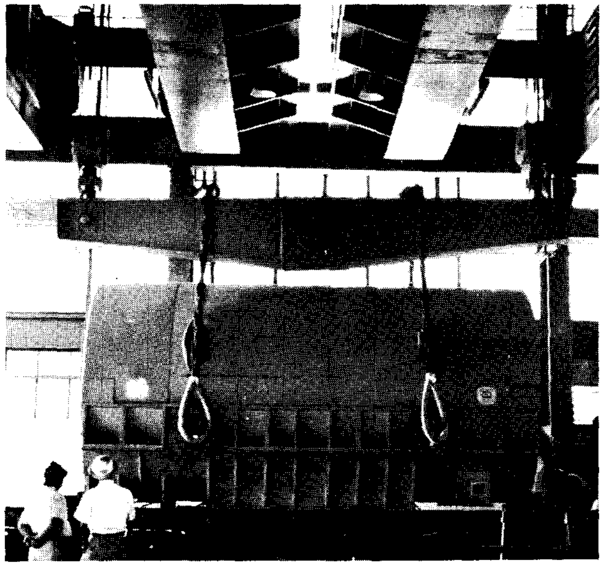


FIGURE 111.—*Unloading unit 1 stator, 198.8 tons, using both overhead cranes with lifting beam.*

The exciters were next lined up with the generator. The exciter with the reduction gear is mounted on a base which is handled as a unit and is coupled to the generator shaft by a flexible coupling. After the exciter was aligned with the generator the collector ring brush rigging was installed and the brushes seated to the rings.

Start-up and initial operation—The actual start-up and initial operation of a unit was of a few days duration, during which time around-the-clock supervision was carried on in the control room with the construction engineering representatives in charge, assisted by necessary standby forces of needed crafts, boiler, turbogenerator, and power operations' repre-

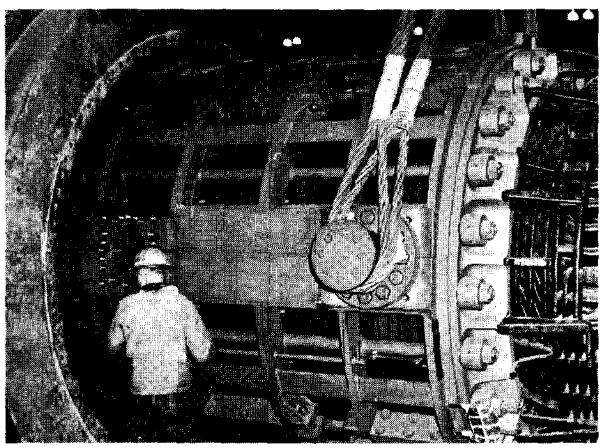


FIGURE 112.—*Stator core suspended from a lifting beam using both powerhouse cranes is pulled into the stator shell with an electric hoist.*

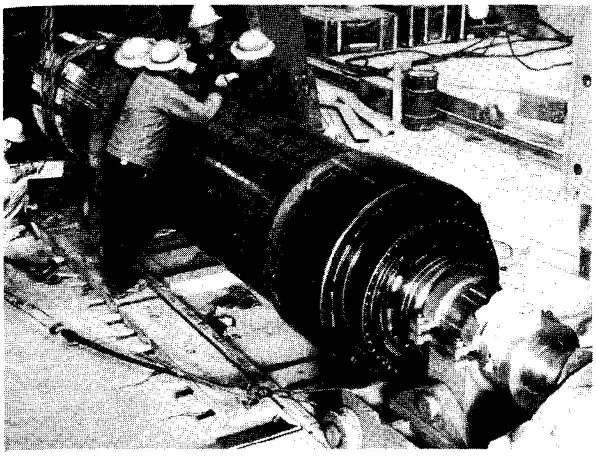


FIGURE 113.—*The rotor of unit 5 was installed using one overhead crane and a small car on rails. Because of its length the rotor had to extend into the powerhouse ventilation plenum to assume position for installation.*

sentatives. A log of the proceedings was kept during this period. This, of course, included start-up of all equipment contributing to the operation of the boilers and turbogenerators.

Several months prior to the scheduled "start-up" date for each unit, a check list of all work to be completed before start-up was distributed to all supervisory personnel. This list was revised and reissued periodically. The construction engineer in conference with the mechanical, civil, electrical, and materials engineers initiated and kept the list up to date, and with the construction superintendent worked toward the scheduled dates (exhibits 95-100). Completion dates were advanced or changed if necessary, but every effort was made to meet the schedule. The work to be completed for unit 1 naturally included completion dates for many items which served all future units. The list for each ensuing unit was somewhat different, but it followed the pattern set out for unit 1.

Accessory equipment—The lubrication system for units 1-4 consists of one oil pump circuit for the bearing oil system and steam chest servomotors plus a second oil pump circuit for the governor oil. Each circuit has separate impellers on the turbine shaft, supplemented with a 60-hp pump for start-up and stopping, besides two 15-hp motor pumps for booster, or for supplying turbine bearings and turning gear. The main oil system and governor oil systems are also used to power the numerous control valves and governors. A reservoir with coolers, filters, and pumps is located at the 744 elevation extending below the floor level.

The lubrication and control system for units 5-9 uses one impeller on the turbine shaft and is supplemented with a 150-hp motor for start-up, a 25-hp turning gear pump, and a 20-hp direct current emergency bearing pump, all located on a large oil reservoir also with cooling and filtering facilities located at the 725 elevation. The system for the larger units is similar in function to the 1-4 units.

Installation of the turbogenerator piping and control valves was done by the TVA pipefitters with necessary supervision by the turbogenerator installation supervisors. Piping, including oil, hydrogen, steam, and drainage as furnished with the turbines, was installed with no unusual difficulty. All stop and intercept valve screens were covered with a fine mesh hardware cloth during the start-up and initial run period to collect fine particles left in the steam system after the blowdown. This screening was removed before the unit was released for service.

All mechanical and electrical controls, gauges, and recording instruments necessary for the operation and control of the turbogenerators were furnished by the turbine manufacturer. The control indicators or operators were either mounted on the turbogenerator casing or on boards, furnished by others, in the powerhouse control room or in the control building, and a few indicating recorders were installed at two or more of these locations. Thermostats and controls were added and changes were made in the controls as the need arose.

Installation of this equipment by TVA forces was without any special difficulty. Additional thermocouples were installed after trouble was experienced with hot thrust bearings. Thermocouples were furnished by General Electric Company for bearing temperature indicators on unit 9 of the large turbines, and those for the others were furnished by TVA. Wiring and special temperature recorders were furnished and installed by TVA.

Steam generators

The steam generators for units 1-4 (fig. 12 page 38), with appurtenant equipment, were furnished by Combustion Engineering, Inc. These boilers, designed to furnish 1,020,000 pph of steam at 1825 psig and 1003°F, are radiant type with superheaters, reheaters, and economizers with natural circulation. Other equipment includes oil and pulverized coal burners, pulverizers, pulverizer fans and piping to the burners, air preheater ducts connecting to the boiler and pulverizers, soot-blowers and controls, safety valves, controls and recorders, boiler suspension steel, insulation and other items necessary for the boiler operation. Erection was by TVA forces under the supervision of the vendor. Total manhours required for each trade to install all steam generating units and equipment are shown in table 24.

The boiler material received by railroad was stored in the coal storage yard, with few exceptions. Boiler drums were stored on cribbing adjacent to the construction track just east of the powerhouse until needed. The first shipment of boiler material, consisting of boiler suspension structural steel, arrived July 15, 1952, and the unit 1 boiler drum arrived

TABLE 24.—*Man hours required to install steam generating units and equipment.*

Craft	Unit 1	Unit 2	Unit 3	Unit 4	Unit 5	Unit 6	Unit 7	Unit 8	Unit 9
Boilermakers	138,397.0	118,328.5	113,369.5	112,397.0	272,001.0	243,043.5	206,177.5	186,973.0	157,314.0
Carpenters	2,254.5	3,428.0	3,513.0	2,839.5	6,066.5	6,513.5	6,242.5	5,864.0	5,097.5
Millwrights	4,832.5	4,537,0	5,528.0	4,818.5	7,370.5	5,427.0	5,801.5	4,629.0	5,413.0
Electricians	791.5	1,042.0	753.0	747.5	5,127.0	3,782.5	3,686.0	3,354.5	4,316.0
Structural steel workers	2,220.0	1,904.5	2,115.5	1,368.5	3,537.0	1,926.5	2,005.0	2,418.0	2,736.0
Steamfitters	16,835.0	13,211.5	11,846.0	12,224.0	28,842.0	20,843.5	21,174.5	19,544.5	19,525.0
Laborers	8,996.0	10,688.0	7,944.0	9,000.0	15,028.5	13,406.0	10,804.0	7,240.0	3,340.0
Operating engineers	14,219.5	12,522.0	10,185.0	10,624.5	19,887.0	17,619.0	18,205.5	16,916.0	13,737.0
Sheet metal workers	421.0	262.0	353.0	256.0	272.5	240.5	345.0	379.0	288.5
Miscellaneous	3,354.0	3,123.0	3,060.0	2,216.0	1,126.5	1,898.0	1,409.5	1,426.0	1,938.0
Total man hours	192,321.0	169,046.5	158,677.0	156,521.5	359,258.5	314,700.0	275,851.0	248,744.0	213,705.0

August 29. Erection of building steel was not sufficiently advanced to start boiler erection before March 1953; however, assembly of the air preheaters started January 1, 1953.

Steam generators for units 5-9 (fig. 13, page 39) were also purchased from Combustion Engineering, Inc. These are twin-furnace type with a capacity of 1,280,000 pph of steam at 1840 psig and 1053°F water-wall boilers with controlled circulation, the reheat section being the south furnace of each boiler.

Installation of these boilers, also under supervision of the vendor, followed a pattern similar to that used on the first four boilers. The most notable variation was that as far as possible boiler tubing was assembled and securely clamped into panels before moving them from the storage yard. These panels, carefully aligned, were raised into position ready for welding. This materially reduced the time of raising the individual tubes, and once the panel was aligned, welding of all the tubes in the panel could be made with little or no adjustments.

Heliarc welds were made on special connections using a welding machine fitted with Heliarc attachment. Several stress relief machines were almost constantly in use; one of these was assembled from available material on the project.

Start of boiler construction generally preceded or followed raising of the boiler drum (fig. 114) by not more than a week.

Erection procedure—boiler drums—Drums were received on flat cars, transferred to a 75-ton float and moved into basement at elevation 725. Short beams for hanging two pairs of 140-ton 8-sheave load blocks were welded on top of permanent drum supporting steel at elevation 871. Lower blocks were attached to drums through load bail and tube hole clamps. Drums were raised by hoisting engine and tilted at an angle to clear the boiler steel at various elevations. When raised about 18 inches above final elevation, permanent U-bolts were raised to saddle the bottom of the drum, and were hung from building steel. The load blocks were slacked off. Drums were checked for rotation and proper elevation, and raising equipment was moved to the next unit. Drums are 66-inch id by 45-foot 11½-inch long by 5$\frac{13}{32}$-inch wall thickness and weigh 313,500 pounds, with internals.

The same general method was used to raise drums for units 5-9 which weigh 189,400 pounds with internals. Some boiler horizontal bracing steel was left out until after drums were hung. In most cases drums were unloaded from rail cars and set outside until ready to load on float. Unit 9 drum was brought into the powerhouse at elevation 765 because access to 725 level was closed.

Erection procedure—water walls, superheaters, and reheaters—Units 1-4 consist of one furnace with high temperature superheater, reheater, and economizer. After the drum was hung, the upper supporting steel was erected (fig. 115). Upper headers for economizers, superheater, reheater, rear and side water walls plus two superheater outlet headers were hung. Connecting tubes from side wall headers to drum and piping from primary superheater to finishing state superheater were erected to hold headers in position along with temporary braces.

The general method was to erect tubes from the top down using air tuggers. The superheater and reheater elements (bent tube assemblies) were hung at the higher elevations along with side and front wall tubes. Tubes were brought in by truck at elevation 765, followed by a line-up gang and qualified code welding crews. The alloy superheater and reheater tubes producing 1000°F steam were stress-relieved after welding. Piping was also stress-relieved where required. As erection of the furnace progressed downward, lower side, front, rear and downtake headers were set in position and properly supported to receive the lower parts of water wall tubes. Burners were set in position to permit framing tubes around them. The primary superheater and economizer are located in a rear section of the boiler where erection of the tubes proceeded independently of the furnace. Other crews lined up connecting piping and put on drains, vents, and valves. During erection, care was taken to keep the internal of all pressure parts as clean as possible. When welding was completed, the unit was hydrostatically tested at 3037-pound pressure. Leaks which developed were repaired. After the test, installation of refractory, insulation, and casing proceeded along with bottom ash hoppers and gas ducts. Figure 116 shows the inside of unit 1 boiler looking up from the ash hopper.

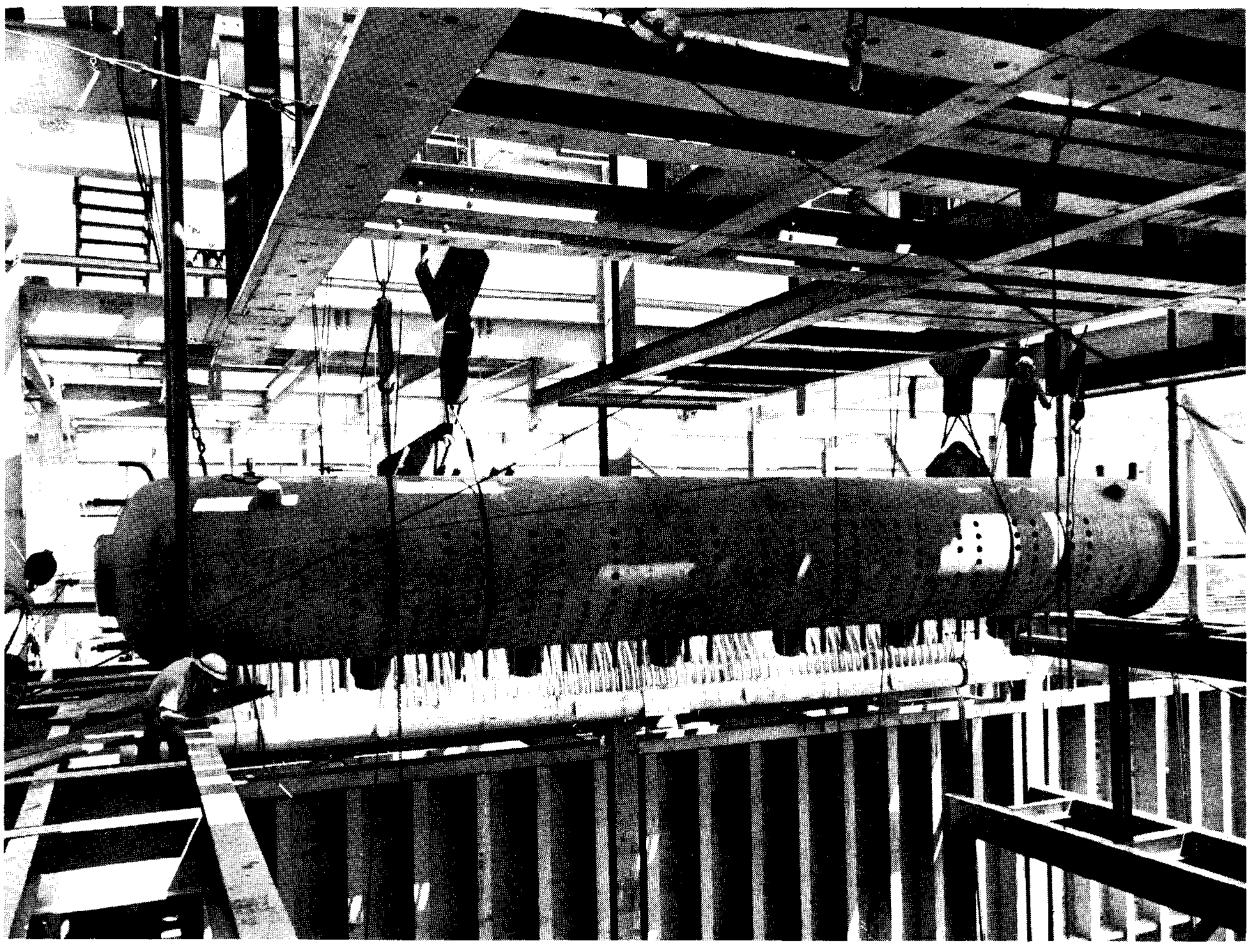


FIGURE 114.—*Raising boiler drum for unit 3, weight 229,000 pounds, using 2 pair of 140-ton 8-sheave load blocks. The drum is 66-inch id by 47 feet 11 inches long.*

Erection procedure for units 5-9 was similar except that these units are forced circulation-type and have a superheat and a reheat furnace. As erection proceeded downward, the water wall tubes were left out between furances to provide access for tubes and other parts. Sectional side elevation of units 5-9 is shown in figure 13, page 39. Starting with unit 7 some of the water wall and rear. wall screen tubes were clamped together in groups of 7 to 15 and raised to location which reduced boilermaker man hours.

Gas ducts and expansion joints were furnished on the contract for the following locations:

Economizer outlet to air preheaters.
Secondary air ducts from air preheaters to burners.
Primary air ducts from air preheaters to pulverizers.

Casing consisted of steel plate stiffened with bars, welded at joints, provided with suitable expansion joints, and insulated outside. Where possible, some

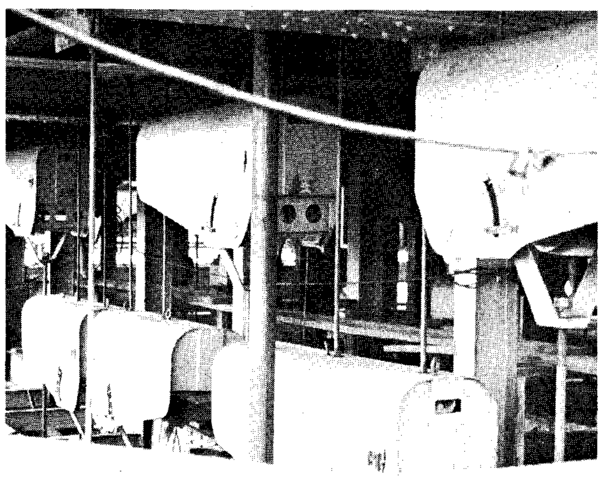


FIGURE 115.—*Upper supporting steel for water walls, superheaters, and reheaters.*

FIGURE 116.—*Inside unit 1 boiler looking up from ash hopper showing tubing for furnace water walls, superheater and reheater elements.*

ducts were assembled at the factory and erected in large sections as they were brought into the boiler room by trucks.

Burners and related items—A burner box is located in the four corners of each furnace through which all fuel and air is supplied for combustion. There are four tilting tangential pulverized coal burners in each burner box of the 1-4 units and three of the same type burners in each corner of the dual furnace boilers of units 5-9. The same number of oil burning pilot torches are located in each burner box for startup and sustaining boiler pressure during no load. Auxiliary air is also supplied through these burner boxes. In addition, there is one removable oil torch which is snapped onto a fixed air and oil supply check valve coupling and extended into the furnaces at each corner, for emergency use only, and removed after the pilot torches and coal burners are in operation. Controls for oil, oil combustion air, auxiliary air and flame directional controls are located in each burner box area, part of which are controlled from the control room. Installation presented no problem; the large burner boxes were swung into place and the boiler wall tubing filled in around them. Adjustments were made on the initial startup and required little adjustment thereafter.

Boiler casing and insulation—The metal casing, refractories, insulation, and materials used in their installation around the furnaces were furnished by Combustion Engineering, Inc. This included insulation around hot air and gas ducts, air preheaters, soot blower steam piping, and ash pit lining, besides covering for boiler drums, headers, and the furnace wall insulation and casing.

The metal casing on all nine boilers was installed by the boiler erection forces under the supervision of

Combustion Engineering, Inc. No particular difficulty was encountered; however, a small portion of casing above elevation 765 of unit 9 was not received and installed until after the unit was in operation.

Furnace refractories, insulation, and ash pit lining for units 1-4 were installed by Rust Engineering Company on contract with TVA. Work was started the middle of September 1953 and, except for minor revisions or changes, was completed in July 1954. Some overtime was allowed to complete the units on schedule.

Carter-Bearden Company had the same contract for units 5-9. They sublet the contract for soft insulation in the furnace walls to Brooks-Fisher Insulation Company which had the contract for duct insulation on the same units. Carter-Bearden Company started July 19, 1954, on unit 5, and completed unit 9 November 3, 1955.

Insulation of the boiler gas ducts and related equipment, headers, drums, sootblowing piping and boiler roof housing for units 1-4 was done by North Brothers starting in November 1953 and completed, with additional work shown on change orders, in September 1954.

Insulation of the corresponding parts of units 5-9 was by Brooks-Fisher Insulating Company. This work started in the early fall of 1954 and was completed April 10, 1956. In connection with the furnace insulation, a change order was issued for installing galvanized wire mesh. Due to constant use of the horizontal runs of hot air ducts as walkways during construction, the contractor agreed to install medium temperature block on the tops of these ducts with no change in contract price. A change was made from the two-coat plastic covering of the ducts on unit 5 to one coat of ¼-inch plastic over poultry wire, scratched, with a ¼-inch hard finish insulation cement troweled smooth.

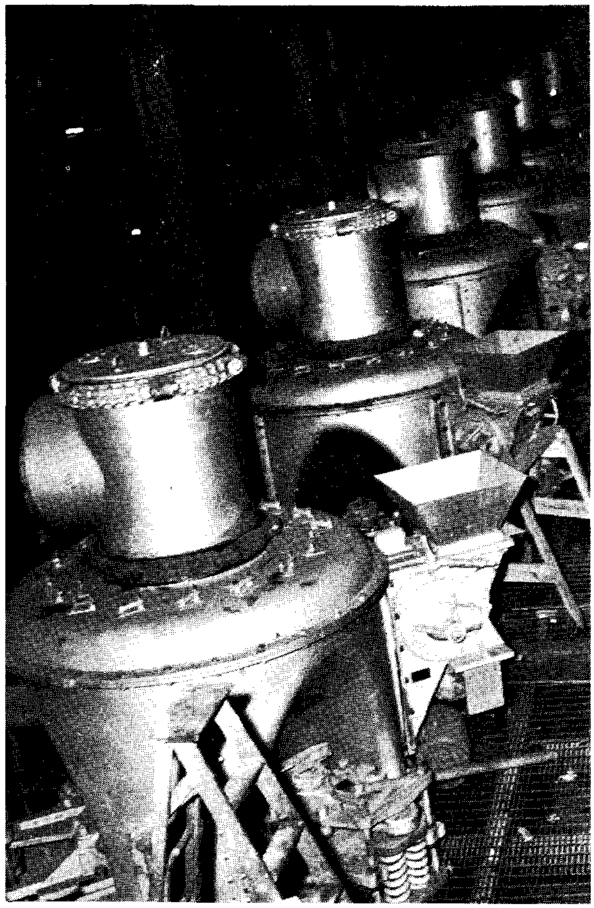


FIGURE 117.—*Bowl mill pulverizers, three for each of the twin furnaces of unit 9, have a capacity of 35,600 pounds of coal per hour.*

Accessory equipment—Pulverizers for all units are Raymond No. 633 bowl mills, of which four mills serve each of the first four boilers and six mills, three for each furnace, serve each of the five larger boilers. These mills (fig. 117) and exhausters (fig. 118) delivering coal to the furnace burners are driven direct from a 350-hp motor on a separate concrete foundation. Some vibration in the fan bearing foundation of one or two fans led to experimenting with a foundation of a welded steel plate base anchored to the floor. Two of these foundations were made in the field and installed with construction forces. Later, six of these bases were purchased; two of these were installed early in 1957.

The exhaust pipes from the pulverizers to the fans carrying pulverized coal are subject to abrasion in a sharp turn. Several special types of steel have been used for patching without appreciable success.

Combustion Engineering, Inc., furnished Copes-Vulcan soot blower systems for all furnaces on their boiler contracts. The automatic sequential soot blower systems for units 1-4 differ from those for the twin furnaces of units 5-9, in that, the first are controlled and motor-powered with compressed air, whereas, the latter are activated with electric controls and motors.

The system for each of units 1-4 consists of 36 water wall deslaggers, retractable, with 12-inch travel. The retractable blowers in the superheat portion of the boiler extends 19 feet into the furnace when in operation. Originally, there were ten of these. Due to insufficient coverage four more were installed in 1955. Included in the system is a steam-cleaning unit for each of the air preheaters; however, these are electrically operated and controlled separately from the soot blowers. The control panel for each unit is located in the control room. The blowers can be operated automatically in a fixed sequence or individually; at no time can more than one blower be operated at a time. This panel also holds the controls for preheater cleaning.

In general, the soot blowers for the 5-9 boilers are similar to those used in the smaller units except

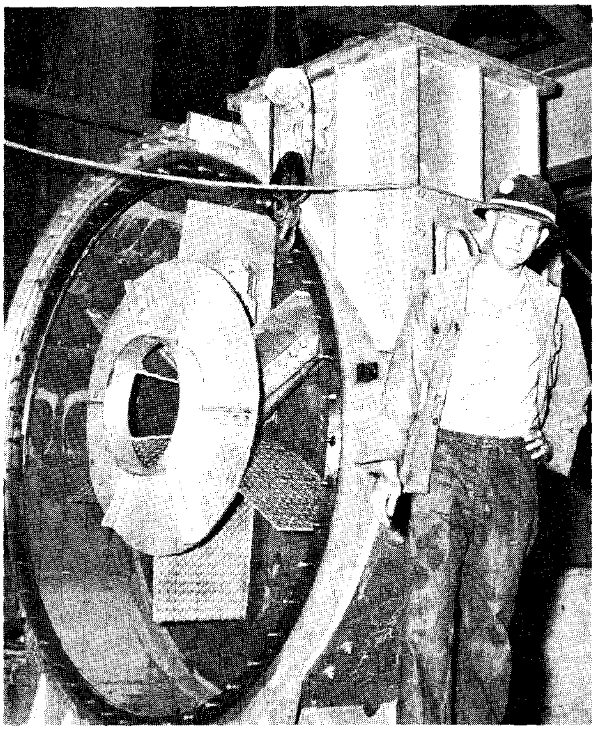


FIGURE 118.—*Pulverizer exhaust fans are driven by the same 350-hp, 4400-volt electric motors which operate the pulverizers.*

they are powered with electric motors. Each boiler is equipped with 48 water wall deslaggers, 18 long retractable, and 8 long retractable rotating blowers in the economizer section which requires a separate rotation motor. The control room control panels, having provision for three future controls, are also entirely automatic with manual control if desired, and also carry the controls for the air preheater cleaners. These panels have individual indicating lights showing the active blower and several other indicating lights and gauges indicating any equipment failure.

No particular difficulty with delivery or installation occurred although the electrically operated equipment required more work and time in installation and adjusting. After the first four units had been in operation the location of several blowers was changed for more efficient operation. In 1956 a series of piping from the fly ash vacuum piping system was extended to the upper doors of the boiler where flexible tubing could be extended into the boiler to remove ash accumulated in areas not accessible to the soot blowers.

Often during the automatic blowdown cycle of units 6-9 the operating blower would repeat its cycle. The difficulty was eliminated by replacing an RS relay by a timer to slow up the stepping switch, this change was made by the manufacturer at no extra cost. Later, leaking steam valves caused the lance tubes to deteriorate, and in some instances drowned out the motors. Valves on units 1-4 were 30-degree-angle setting; a later model valve with 60-degree-angle setting was furnished on units 5-9. Some improvement was noted in these valves but they also leaked badly, and were not satisfactory. An entirely new design requiring some pipe changes was being factory tested, two of which were furnished for trial. In 1958 TVA changed all the valves, units 1-9, to the latest type. Minor changes have since been made in the wiring of the units 5-9 soot blowers.

Combustion Engineering, Inc., furnished Ljungstrom rotating vertical flow air preheaters (fig. 119) for heating boiler combustion air by furnace gases. The type of preheaters and equipment is the same for all boilers except for size. Two preheaters were furnished for each of the nine units. Air temperature is raised to a maximum of about 535°F upon leaving the air preheaters. For units 5-9 only gas recirculation ducts with dampers permit recirculating a portion of warm gas to prevent sweating and soot deposits on startup. The heat transfer elements are rotated with 7½- and 10-hp motors. Auxiliary air-operated motors were also installed for emergency use.

The element cleaning system includes both steam and wash water nozzles attached to an oscillating arm on the downgoing gas side, both of which cover the element area during one complete revolution of the heater elements. These operate from the control room; they are semi-automatic and powered with a ¼-hp electric motor.

The air preheaters were partly assembled in the yard and moved into the building. Preheaters for the first units were raised with cranes and lowered into position through the partly assembled building structure. These were also installed before or with the first boiler erection. Erection procedure was changed for units 8 and 9, after the basement was closed. Boiler material was moved in on the elevation 765 floor from the west side. Part of the building steel was left out at this elevation. After the boiler and

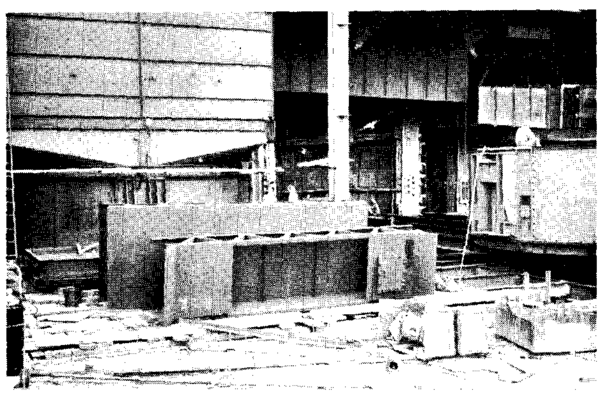


FIGURE 119.—*Air preheater for unit 9 being skidded into place prior to completing the building steel after partial assembly in yard.*

boiler ducts were in place, the air preheaters were skidded into place before completing the building steel.

The preheaters were generally among the first shipments of the boiler components. Assembly of the preheaters was accomplished without undue difficulty. Some trouble with clogging elements in operation resulted in changes to the cleaning units.

For units 1-4 the steam generator manufacturer furnished 12 Consolidated Maxiflow safety valves manufactured by Manning, Maxwell & Moore, Inc. There are four 2½-inch valves at the boiler and one 3-inch at the superheater with a total relieving capacity of 1,211,900 pph of steam, and seven 4-inch on the reheat section reheat inlet and outlet with a total relieving capacity of 1,446,200 pph. These are all flat-seated, spring-loaded reaction type and discharge to pipes extending through the roof. The valves were set during the startup of the unit as near as possible to the specified pop-off pressures which range from 2025 psi to 2085 psi with closing pressures of 30-35 pounds lower on the boiler, and 470 to 550 psi on the reheat section with a closing pressure 10 pounds lower.

The 5-9 units are equipped with 15 safety valves of the same design and manufacture of which seven 2½-inch valves are on the boiler and superheater with a combined total relieving capacity of 1,606,700 pph of steam and eight 4-inch valves are on the reheat side with a combined total capacity of 1,414,200 pph. The boiler and superheat valves were set to open at 2060 to 2120 psi and close about 60-70 pounds lower while the reheat section was set to open between 415 and 450 psi and close at 402-436.

A factory representative assisted in setting the safety valves for each unit. A number of the valves did not adjust to the required limits, chattered or leaked. All were 3-ring type, and after units 1-4 had been in operation for several months, the manufacturer agreed to change all drum safeties to the 2-ring type. The 3-ring type was very difficult to adjust, but permitted finer adjustments than the 2-ring type. Repair and replacement of parts for these valves had previously been made by the factory representative on startup. Several top valve elements were changed to a different metal analysis.

Difficulties with the valves for units 5-9 were about the same as those for units 1-4. A new design spring was installed in the high pressure valves which improved them, and a number of these valves were also changed to the 2-ring type.

The boiler control equipment, furnished by the Republic Flow Meter Company, included the benchboards, boiler controls, and metering equipment, but did not include the superheat temperature controls, soot blower controls, or soot blower control cabinets for units 5-9 which were supplied on the boiler contract.

Other minor equipment too numerous to detail in this report included boiler feed water controls, water level indicators and viewers, fuel and air control, and recording chart instruments. The first shipment was received April 4, 1953; installation of unit 1 benchboards and vertical boards started August 3, 1953, and the unit 9 board, April 15, 1955. Considering the numerous parts obtained from several subcontractors, the delivery, assembly, and initial operation was very satisfactory.

Some changes have been made to improve the operation of several instruments. The Republic Flow Meter Company, without charge, replaced time delay relay assemblies of improved design. Changes were made to the coal-air temperature controls, and the Bailey oxygen recorder sampling systems were revised. One of the barometers was improperly installed and the glass tubing had to be replaced. Several instruments were damaged or broken in shipment; and thus required return to the factory for repair and recalibration. In 1957 the steam pressure regulators were replaced with more efficient equipment. A Republic Flow Meter Company representative checked the operation of the equipment before the startup of each unit.

The units 5-9 no-coal flow detectors with relays for increasing flow of coal through the other pulverizers to the unit caused trouble. The instruments were located above and near the pulverizer feeders of units 5-8. When unit 9 was installed they were located below the feeder roll. Later, the compensating feature was removed from control and the instruments used only as no-coal flow annunciators.

Boiler room coal scales, although purchased separately from the boiler, were closely associated with the boiler operation. Sixteen scales for the first four units were purchased from Richardson Scale Company. The coal that feeds each pulverizer is chuted through the scales which were located on the main floor directly under the coal hoppers. TVA furnished slide gates which were installed between the hoppers and scales, and the coal flowed by gravity from the scales to the 16-bowl mills.

The scales are totally enclosed, all-electric, automatic weighing and recording units with a capacity of about 25 tph as weighed through 500-pound hoppers. All are connected with dust exhaust systems furnished by other contractors. Delivery of this equipment was well in advance of requirements. A factory representative adjusted and examined these machines in place.

Scales for units 5-9, six per unit, of approximately the same construction and capacity, were purchased from Stock Equipment Company. Special connections for dust exhaust were later included in the contract. Remote control (control room) switches permitted the operator to bypass the scales if necessary.

During an inspection trip by the vendor's representative, safety switches were installed, at no added expense, for the protection of persons working at the scales if the bypass button were pushed by the operator.

The steam generators for units 1-4 are natural circulation-type. The 5-9 boilers are forced circulation-type and were furnished with four circulating pumps for each boiler. These are vertical class VEM pumps manufactured by Ingersoll Rand Company, specifically designed for this type of service. The pumps are single stage, end suction, double volute-type with special provisions for packing against the high pressure and water temperatures involved, and are corrosion resistant. Briefly, in the water circulating system, water from the 60-inch steam drum is delivered by gravity to a pump suction manifold, then pumped to a discharge manifold forcing it to the front and rear wall drums of both superheat and reheat furnaces and then up through the wall tubes. Injection water from the boiler feed water pumps is forced through a smothering-type gland above the impeller to cool the pump shaft and confine the circulating water. In addition, a cooling water gland is also installed below the motor. The pumps are supported by and welded to the boiler circulating water piping.

One of the circulating pumps on unit 5 failed about three months after the boiler went into service. Examination revealed that the shaft end and nut below the impeller had broken off and the velocity of the circulating water forced the broken part against the impeller vanes, damaging them. The nut had been drawn too tight and had broken from the expansion of the impeller hub. Some trouble was experienced from leakage around the shaft, but was generally corrected by adjustments and controlling injection water pressure.

Appendix G describes in detail the sequence of starting up a boiler as pertaining particularly to unit 6.

Testing and acceptance

Final acceptance followed a routine throughout the construction period. An effort was made to test and release to the Division of Power Operations the component parts of each unit as they were completed. This system also applies to the equipment and materials installed in the service bay, smaller buildings, and yard. This saved time and confusion when putting the particular unit into operation. The pump, fan, valve, etc. as installed in operable condition was operated in the presence of delegated power operations' representatives, field engineers responsible for its installation, and necessary craftsmen to assist with the operation. A schedule was posted in advance of the release date. On the date set, the item was carefully examined, and if acceptable to the power operations' representatives, an acceptance form was signed by both divisions. The testing consisted of activating the equipment, examination for alignment, vibration, electrical operation, and/or special tests as applicable.

The boilers were inspected during and after construction by the state-authorized steam boiler inspectors. Elevators and scales were also inspected and approved by their respective state-delegated representatives.

All electrical instruments were calibrated and equipment was tested for capacity, insulation, performance, etc. by the Electrical Laboratory and Test Branch of the Division of Power Operations.

Principal piping

The principal piping system includes all pressure piping and valves in the transfer of steam and boiler water from the boiler to the turbine and return (fig. 120). This also includes piping to auxiliary equipment such as heaters, condensers, and blow-off piping. National Valve & Manufacturing Company had the contract for furnishing and installing this piping. The contract was extended by memoranda to cover installation of the turbine steam leads.

Approximately 2500 tons of piping material, including some 6000 valves and 106,000 pounds of welding rod, were used on this installation. The welding operation involved the greatest man-hour expenditure on this contract. During the peak of work, one-third of the force were welders and almost as many were assisting as chippers, wrappers, and stress relief machine operators. Code or "hot" welding alone was for many months a 24-hour-day operation requiring continuous service of five stress relief machines. The largest joints required an average of 50 hours to complete, and required 125 pounds of welding rod each. More than 900 welds were radiographically examined for defects.

Second largest operation was the handling and erecting of the many large prefabricated piping assemblies. The fit-up of these assemblies was remarkably accurate and a minimum of tailoring was needed. The largest single piece of pipe erected was 50 feet long with a wall thickness of 2½ inches and weighed over 10 tons.

Material deliveries were satisfactory and completion schedules were met as required. The installa-

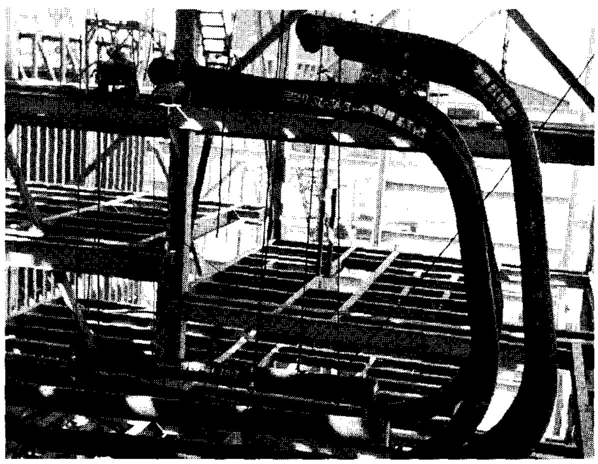


FIGURE 120.—*Erection of the main steam piping for all nine units required 548,000 man-hours and 106,000 pounds of welding rod; the largest joints required 125 pounds.*

tion time required for the nine units was 548,000 man-hours. The man-hours decreased as work progressed on identical units. Unit 4 was completed in 7000 man-hours less than unit 1, and unit 9 in 16,000 man-hours less than unit 5.

Erection of piping started March 2, 1953, on unit 1, and the contract for the nine units was completed in January 1956.

All welders were qualified in accordance with ASA code for pressure piping and ASME boiler construction code. Each welder accepted had to pass these tests conducted at the jobsite before being employed.

Auxiliary piping

All piping throughout the powerhouse and project, except the principal piping system mentioned above and minor piping installations made on some equipment, was installed by TVA forces. This included the building heating systems, compressed air, control air, oil and hydrogen piping, drainage piping, etc. It was often necessary to change piping and conduit from the locations indicated on the drawings to avoid interference. This was done by the foremen in charge with the consent of the field engineers; the field engineers noted the changes on their prints for future as-constructed revisions. Standard types of pipe and fittings purchased from numerous manufacturers and dealers were stocked with little regard for the particular location for which it was purchased. Special material was marked and kept separated. Piping installation followed the standard practice. Water pipe laid in the ground was painted with bitumastic or was covered with plastic tape.

Insulation—Insulation for piping of all nine units was furnished and installed by contract and includes insulating heaters, various tanks, draft fans, fly ash collectors, and gas and air ducts.

Fuel oil piping—Fuel oil for lighting off the boilers is provided to each unit from six 12,536-gallon capacity underground storage tanks (exhibits 64 and 65). These tanks are located 38 feet off the northeast corner of the turbine room. Underground piping connects the six tanks to the fuel oil pump room located in the powerhouse. Genuine wrought iron piping, 2 and 3 inches, with 3000-pound socket weld fittings was used throughout. A common loop header ran from the fuel oil pump discharge in the pump room to each boiler.

The copper tubing connecting the oil burners of each boiler to the loop header was originally installed using cast-bronze, soldered-joint-type fittings and lead-base solder. A fire occurred around one burner on unit 5 and the heat melted several fittings loose on the fuel oil tubing allowing fuel oil to spray on the fire. Serious damage was avoided by closing the supply valves; subsequent design revisions called for changing from soldered-joint to compression-type fittings on all fuel oil piping around the boilers.

Insulating oil piping—Insulating oil piping (exhibits 66 and 67) was installed in the same manner as the fuel oil piping. Three 12,536-gallon underground storage tanks were located in the same area as the six fuel oil tanks for the purpose of storing clean insulating oil, dirty circuit-breaker oil, and dirty transformer oil. Underground piping connects these tanks to two pumps and an oil purifier located in the powerhouse oil purification room. The oil room equipment is connected to both the transformer yard and switchyard by a common, underground, 4-inch oil supply line and a 6-inch oil return line running the full length of each yard. A valve box connection is provided for each unit to which a flexible hose can be connected for draining and refilling transformers and oil circuit breakers. The insulating oil lines are standard weight genuine wrought iron pipe with all-welded fittings.

Lubricating oil piping—Lubricating oil for the turbines was delivered to the job in 55-gallon drums which were emptied into the system at the lubricating oil fill-and-reject flush mounted box located outside the northeast corner of the turbine room. The fill-and-reject line connects underground to the powerhouse oil room where a common header interconnects an oil purifier, transfer pump, and four oil storage tanks. A clean oil and dirty oil storage capacity of 7769 gallons each is provided by two 5760-gallon and two 2009-gallon tanks located in the lubricating oil storage room at elevation 744 in the powerhouse (exhibits 62 and 63). Three-inch supply and return lines connect the transfer pump and oil purifier to the 6000-gallon turbine oil reservoirs for each unit. Each turbine oil reservoir is equipped with coolers and pumps for maintaining proper lubrication of the turbine. Piping is so arranged that continuous centrifuging can be done to clean the oil without requiring a unit shut-down. All lubricating oil piping is schedule 40, standard weight steel, with threaded and socket-weld fittings.

Compressed air system—Station service air is provided throughout the powerhouse (exhibits 72 and 73) and to all major outlying buildings (exhibit 74) with the exception of the storage building. The system is supplied with air by five air compressors having a combined capacity of 3300 cfm. Four compressors are located in the powerhouse, two each at the northeast corner of unit 1 and between units 8 and 9. The fifth compressor in the system is located in the utility building, and it is presently being maintained as a spare. All buildings furnished with station service air have 1-inch outlets equipped with Universal hose couplings.

Draft equipment

Forced and induced draft fans—The forced and induced draft fans (figs. 121 and 122) for the 9-unit plant were furnished by Sturtevant Division of Westinghouse Electric Corporation. The heavy duty fans

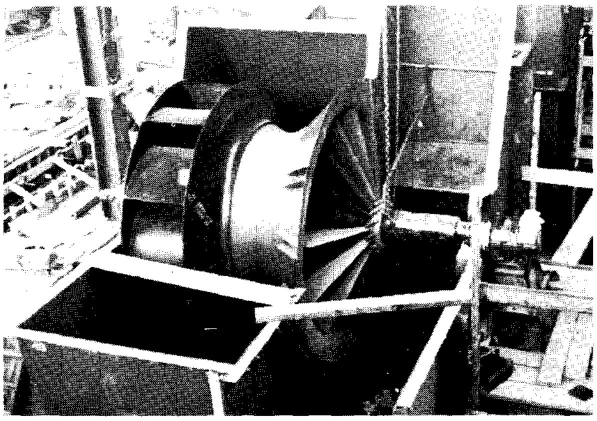


FIGURE 121.—*Installation of forced draft fan, one of a total of 18 for the 9-unit plant. See also figure 17, page 44.*

for both size units are similar except for size. Appendix B, "Statistical Summary," gives further design details.

The fan manufacturer furnished thermocouples for all bearings; however, TVA supplied the wiring and the automatic controls and wiring for the dampers supplied with the fans. The induced draft fans located outdoors are equipped with water-cooled fixed bearings and the motors with heater strips.

Air and gas ducts—The heavy duty ducts which were not a part of the boiler contract were furnished by Connery Construction Company on separate contracts for units 1-4 and units 5-9. These include the combustion air intake ducts and the gas ducts to the chimneys. Dampers were furnished at the entrance of flue gas to the dust collectors of units 1-4; none were used for the 5-9 units.

The ducts outside the building and the induced draft fans are of necessity supported on earth fill. To

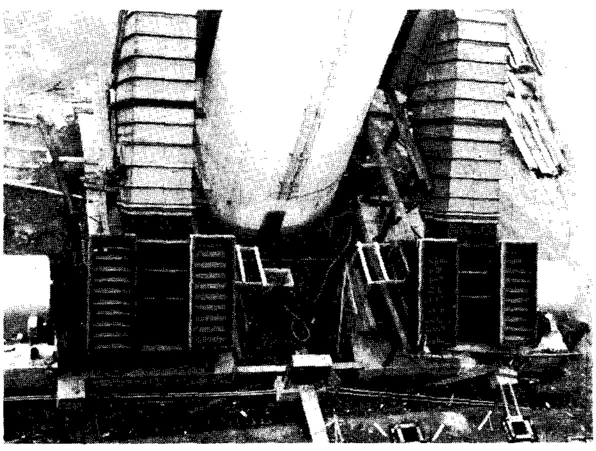


FIGURE 122.—*Installation of double-inlet induced-draft fans and ducts at base of chimney, as viewed from top of powerhouse.*

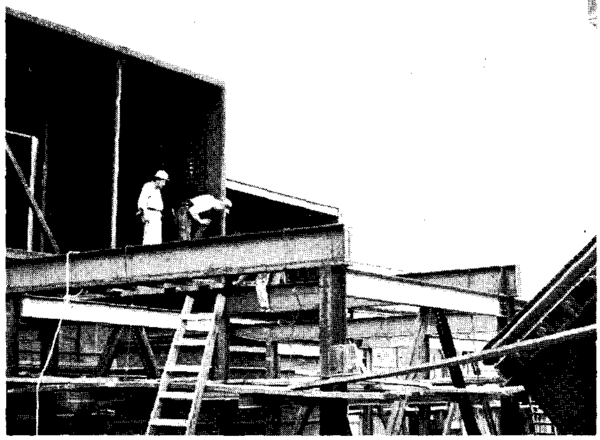


FIGURE 123.—*Structural steel erection for induced draft fan duct, unit 5.*

assure a good foundation, 10-inch steel bearing piles (fig. 123) were driven to refusal, cut off, and the footing for the duct supporting structure placed. One pile was used at each supporting column; 4474 linear feet of piling was required.

Insulation was placed on all gas ducts by the insulation contractor over the wire mesh furnished with the ducts. The insulation exposed to the weather was given a coating of mastic, a heavy coat of aluminum paint, and finally painted with exterior paint as indicated on the powerhouse paint schedule.

Chimneys—The chimneys, one for each unit, are comprised of a reinforced concrete shell with a brick lining and an air space between the concrete shell and the brick lining. Chimneys for units 1-4 are 250 feet high above ground level while those for units 5-9 extend 300 feet above ground level.

The bases of all chimneys extend 41 feet below ground level. This base portion is a hollow cylindrical shell of reinforced concrete, resting on a reinforced concrete pad 6 feet thick and octagonal in shape (fig. 124). All chimneys rest on a foundation composed of a mixture of hard shale and limestone at approximately elevation 724.

Concrete for the sections of the chimneys below ground level was furnished by TVA and placed by the contractor. Concrete for the portion above ground was made and placed by the contractor from materials furnished by TVA.

The top 50 feet of chimneys 1-4 and the top 100 feet of chimneys 5-9 were given three coats of chemical resistant paint, the last coat being a medium gray color.

Heating, ventilating, and air conditioning

The powerhouse and service bay are heated by steam through the ventilation system. Steam is normally supplied from the main boilers at 15 psi to

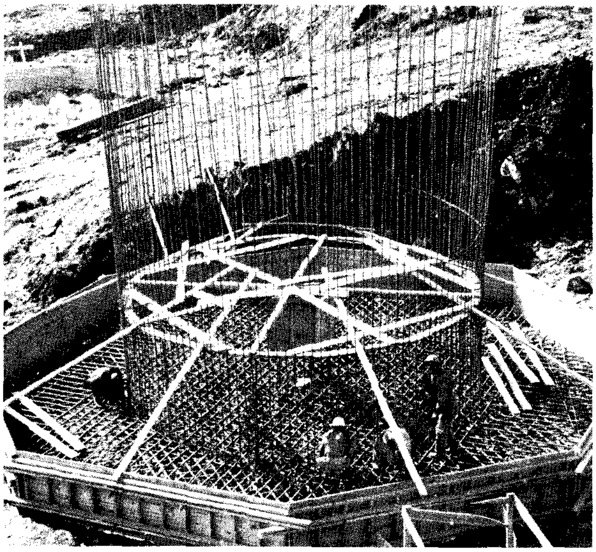


FIGURE 124.—*Construction of base for reinforced chimney for unit 1 began November 16, 1951. The foundations for all nine chimney bases are 41 feet below ground surface.*

the several heating systems. Two oil-fired boilers of sufficient capacity to supply heating requirements for the combined building are located on the 751 elevation floor of the service bay for emergency use. Before unit 1 was activated, one of these boilers supplied heat for the service bay and the completed heating systems in units 1 and 2 areas.

Each generating unit has a complete heating system, consisting of the east basement heating coils; west basement heating coils; turbine room heating coils; heater bay heating coils; and blower type, suspended, steam unit heaters located in the boiler bay, the heater bay, the coal conveyor gallery, and the basement. The sheet metal ducts and piping for this system were prefabricated in the craft shops.

Piping was installed from the east basement heating coil blowoff valves, through the powerhouse east wall, to the transformer yard. This was to eliminate the possibility of condensate dropping on the high voltage boards at lower elevations.

Heating for the service bay office wing is supplied by steam coils located in the ventilation plenum. The maintenance shops are heated by blower-type suspended steam unit heaters. Fan-type electric space heaters are provided for all outlying buildings.

Supply and exhaust fans provide ventilation in the powerhouse and outlying buildings. The duct work for these systems was prefabricated by sheet-metal workers and installed as building erection progressed.

The five unit control rooms, shift engineers' office, and storekeeper's office are air-conditioned by 5-ton package air-conditioning units. The service bay office wing is air conditioned by a 104-ton refrigerating unit. The control building office area is air conditioned by a 30-ton refrigerating unit. A 17-ton refrigerating unit is installed in the sample preparation wing of hopper building No. 1.

Ash handling

The ash handling system in the powerhouse was furnished by Allen-Sherman-Hoff and installed by TVA forces, including numerous changes and alterations. TVA furnished raw water, air, electrical wiring, pipe supports, and concrete foundations.

Furnace ash, pyrites, and fly ash—Essentially there are two systems of piping: The furnace ash, collected in a wet hopper below the boiler, is manually flushed periodically into a small hopper and propelled through a Hydrovactor or water jet suction to the outside ash sluice piping. The pyrites are also hydraulically moved from hoppers at the individual pulverizers to the small hoppers at the furnace and picked up by the furnace ash disposal system. Fly ash is handled separately and delivered to the ash pond in separate pipes. Ash from the fly ash collectors is automatically delivered to a manifold by a sequential jetting-type system, opening slide valves at consecutive hoppers. The fly ash is lifted through a Hydrovactor in the upper part of the building and flows by gravity to the ash disposal area. Dust from the coal bunker dust collectors and transfer structure B dust collector is also delivered to this system. Dust from the vacuum cleaning system hoppers in the basement is directed into the pyrites suction pipe.

Unit 1 had been in operation less than two weeks when the furnace ash discharge piping had to be replaced at certain locations due to holes wearing through the pipe. Considerable repair and replacement, using repaired pipe, was necessary. The vendor's engineer, on examining the system, made several changes as follows: The pressure in the furnace ash discharge lines was reduced by reducing the openings in the raw water supply lines to the Hydrovactors. Hopper grids were changed from cast iron to sheet steel. Nozzles were added in the back third of the furnace hoppers to facilitate clearing the hoppers. Poke holes were installed in the sides of the hopper for manually breaking up crowning and fused chunks. TVA purchased clinker grinders for all hoppers (two each for 5-9 boilers). Check valves deleted from the contract were later installed and still later moved down close to the hoppers. Hopper access doors were rebuilt because of excessive water leaks. The piping arrangement was changed, units 1-4 furnace ash being directed into one discharge pipe and units 5-9, into two others. Cost of replacement pipe was high, later special alloy pipe sections were purchased for certain locations which had caused trouble. Pressure gauges were installed on Hydrovactors. Hydrovactors largely replaced original Hydroejectors.

Fly ash collectors—Fly ash collectors for units 1-4 (fig. 125) were furnished by Buell Engineering Company. Installation was without difficulties.

FIGURE 125.—*Unit 1 fly ash collectors. There are 16 cyclonic elements assembled in a steel housing with two assemblies per unit.*

Dampers used only at the inlet of the units 1-4 collectors were not furnished for units 5-9 and insulation was included in the boiler duct insulation contract. Some difficulty with abrasion inside the unit during the early months of operation was principally caused by allowing the dust hoppers to become overloaded which did not permit designed circulation of gases.

American Blower Corporation furnished the fly ash collectors for units 5-9. These were delivered assembled as far as possible and were installed with little difficulty. After inspection of the No. 7A collector in July 1956, with the vendor's engineer present, the equipment was accepted.

Yard piping and ash disposal—The ash sluice piping system from the powerhouse to the ash disposal pond was constructed by force account. The yard piping consists of extra strong steel pipe, long bends, fittings, and cross-over sections. Pipe was welded in lengths of approximately 100 feet and connected with Rolagrip couplings to permit rotating the pipe to maintain uniform wear. The general plan is shown in exhibit 1.

The ash disposal piping for units 1-4 consists of two 10-inch fly ash and two 10-inch bottom ash pipe leaving the building in a group just south of unit 4. Unit 5 bottom ash is included with units 1-4 piping. Two bottom ash pipes serving units 6-9 extend through the west wall between units 5 and 6, with a third pipe as a spare laid to the ash pond.

Pipe for units 1-4 is in a concrete trench extending west 387 feet from the powerhouse. The entire length of the trench is covered with galvanized grating, including two road crossings reinforced to support heavy traffic. Right angle bends direct the pipe toward the ash pond through an open trench. The pipe is supported on concrete supports or saddles (fig. 126) extending across the trench at 30-foot intervals and passes through 12-inch corrugated pipe sleeves in the yard track bridge. The pipes are above the graded yard for some distance before extending 100 feet out on a timber structure, discharging directly into the pond area approximately 10 feet below. Pipe from between units 6 and 7 was extended to the ash pond in a similar manner. The additional piping between units 5 and 6 that was carried west to clear the chimneys, angles north to the north trench, and using the south wall of that trench as one side, parallels that portion of the concrete trench to the open trench and to the ash pond. Pipe lengths vary from about 1600 to 1800 feet each. Two coal dust sluice pipes from the crusher building were laid on the west side of the open trench on the same supporting saddles.

The original ash disposal pond covered an area of approximately 57.5 acres, ranging up to about 40 feet in depth below the top of the dike. This pond had no outlet as the water began approaching the top

FIGURE 126.—*Concrete supports for ash sluice piping in open trench. Note 12-inch corrugated pipe sleeves (background) through which ash pipes were carried under yard tracks.*

of the dike in the fall of 1955. In December 1955, two drop inlets were constructed to hold the water at a constant elevation of about 740. During the spring and summer of 1958, this area was materially enlarged and drop inlets were installed during construction.

WATER SUPPLY AND DRAINAGE

Circulating water system

Intake structure—The intake structure (fig. 127) lies at the south end of the intake channel. It is of heavily reinforced concrete construction, 292 feet long, 50 feet high, and 53 feet 5 inches wide. It houses 18 pumps which supply condenser water to 9 units.

Due to the numerous interconnected walls and the embedded gate guides and other embedded items in this structure, it was necessary to work out a detailed plan of concrete placement sequence in order to avoid delays.

To accomplish this purpose the structure was divided into five sections horizontally and nine sections vertically. Concrete was placed in every other section, skipping a section between. This permitted nearly continuous concrete placement, avoiding delays due to lack of forms being stripped, etc.

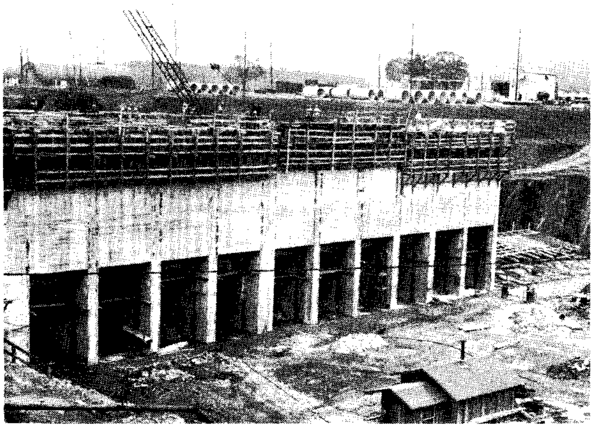


FIGURE 127.—*Work on the condenser water intake structure commenced December 1951 and concreting was essentially completed in February 1953.*

Condenser cooling water pumps—Eight pumps and motors for units 1-4 are vertical, single-stage pumps directly connected to outdoor type motors supported on the deck of the intake structure (fig. 128). The pumps were installed by TVA forces with the supervision of a factory representative. Installation started February 11, 1953, and was substantially completed in March of the following year as the pumps were received.

The pumps for units 5-9 are the same type as furnished for the first four units. Installation of these pumps and motors started with unit 5 March 16, 1954. A factory representative assisted in the installation of these pumps, which were completed as needed; unit 9 being completed in September 1955.

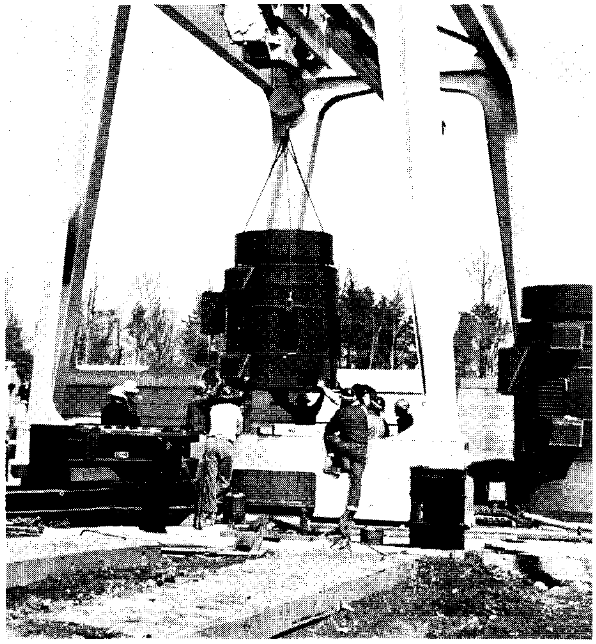


FIGURE 128.—*Setting unit 4 cooling water pumps. There are two pumps per unit with a capacity of 48,000 gpm each against a head of 21.5 feet. Each is driven with a 350-hp motor.*

Traveling screens—Trashracks at the outer face of the intake structure prevent logs and large trash from entering the pump wells. Small trash such as leaves, twigs, and sometimes fish is removed from the water with traveling screens between the trashracks and the pumps. Two traveling screens (fig. 129) for each unit entirely cover the entrance of water to

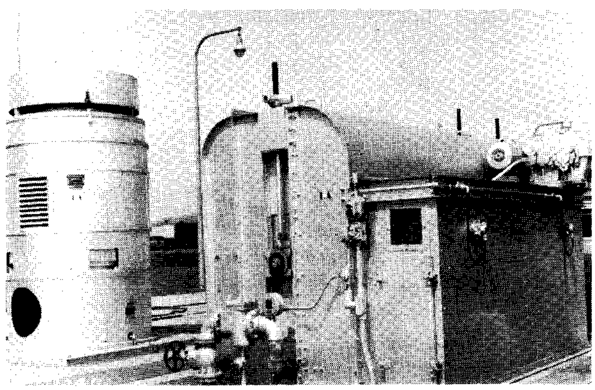


FIGURE 129.—*Housing over traveling screen. One screen for each pump removes all water-borne objects greater than ⅜ inch before reaching the pump suction.*

the pumps. They are made of 2- by 10-foot screen panels interlocked and attached to chains operating between sprockets at the bottom and drive sprockets supported on the intake structure deck. The baskets or screen panels are made of 12-gauge galvanized wire with ⅜-inch square openings. The tachometers were wired to the control instrument panels in the water treatment plant by TVA forces. Wash water pumps, piping, wiring, controls, and sluicing facilities in connection with the screens, except for the screen washing nozzles and pipe under the hood, were furnished by TVA.

Several changes were made after the screens were accepted. Lights and exterior switches were installed in all screen hoods and a glass window placed to view the screen washing area. Pressure switches were installed on the screen wash water piping and interlocked so screens could not be run without wash water.

Conduits—The condenser water conduits consist of reinforced concrete pipe sections (fig. 130) which were precast on the job site by the Lock Joint Pipe Company. These pipe sections have inside diameter of 78 inches for units 1 through 4, and 96 inches for units 5 through 9. Joints were provided with steel facings and a round rubber gasket provided a flexible watertight joint.

Pipe sections were cast in a vertical position. A sheet iron enclosure surrounded the casting platform and steam curing was applied for about 24 hours. Concrete was furnished by TVA and placed under TVA inspection.

Installation of the intake conduit pipe was begun in March 1952. Intake pipes were bedded in sand while the discharge pipes were placed on a concrete slab and concrete cradles poured in place to engage the bottom segment of the pipe.

After the placement of pipes, copper bands provided with steel flanges and bolts for tightening at the top were placed around the joints and thin grout poured into a space left at the top. This grout filled the open groove between pipe sections and served to protect the rubber gasket. After this grout had set, the bands were moved forward and reused. The conduit was then ready for backfilling.

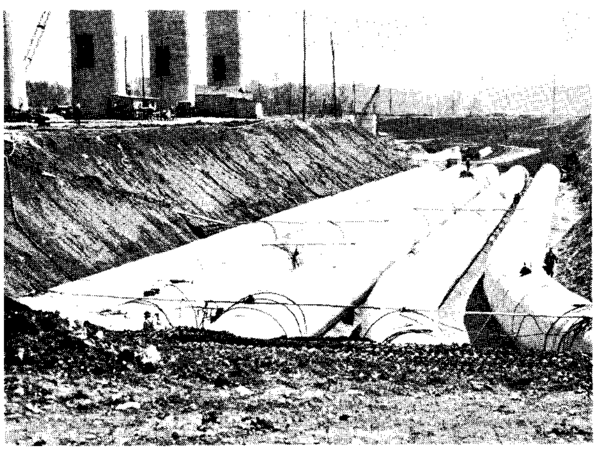


FIGURE 130.—*Reinforced concrete condenser water intake conduits, 96-inch id, for units 5-9. The pipe was precast by contract on the job. Joints were steel faced and made watertight with flexible round rubber gaskets.*

At the powerhouse end, passing between the chimneys and extending for distances varying from approximately 75 to 100 feet, poured-in-place reinforced concrete box culverts are used in place of the pipe conduits. These sections are rectangular in shape at the powerhouse end with a transition section to a circular shape near the outer end. A 3-foot section of Lock Joint pipe was placed and embedded in the end pour to provide a connection with the pipe conduit.

The installation of the intake pipe was completed in June 1953. The placing of discharge pipe was begun in December 1951 and was completed in June 1953.

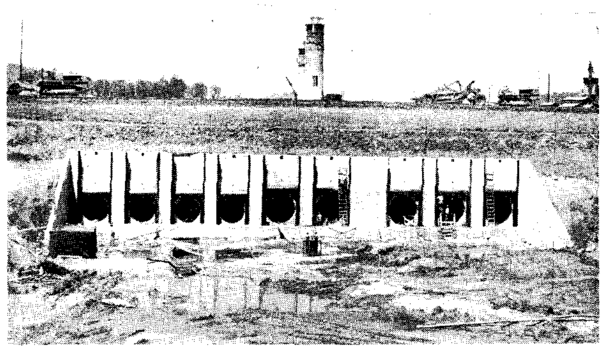


FIGURE 131.—*The permanent access road passes over the discharge structure.*

Discharge structure—The discharge structure (fig. 131) is located southwest of the powerhouse. It is a reinforced concrete head-wall type of structure with wing walls and apron and is the discharge terminal of the condenser cooling water system. Each conduit outlet is provided with stop-log guides. Only two permanent stop-logs were purchased. These stop-logs are to be placed and removed with a mobile crane as required.

Construction of this structure started March 24, 1952, and was completed in July of the same year.

Condensers and auxiliary equipment—Condensers and auxiliary equipment include condensers, hot well pumps, priming ejectors, and steam jet air pumps or air ejectors with related gauges and condensate flow controls (see figs. 24, 29, and 19, pages 48, 51, and 45).

The condensers for units 1-4 are rated at 60,000 sq ft and those for units 5-9 at 80,000 sq ft, all radial

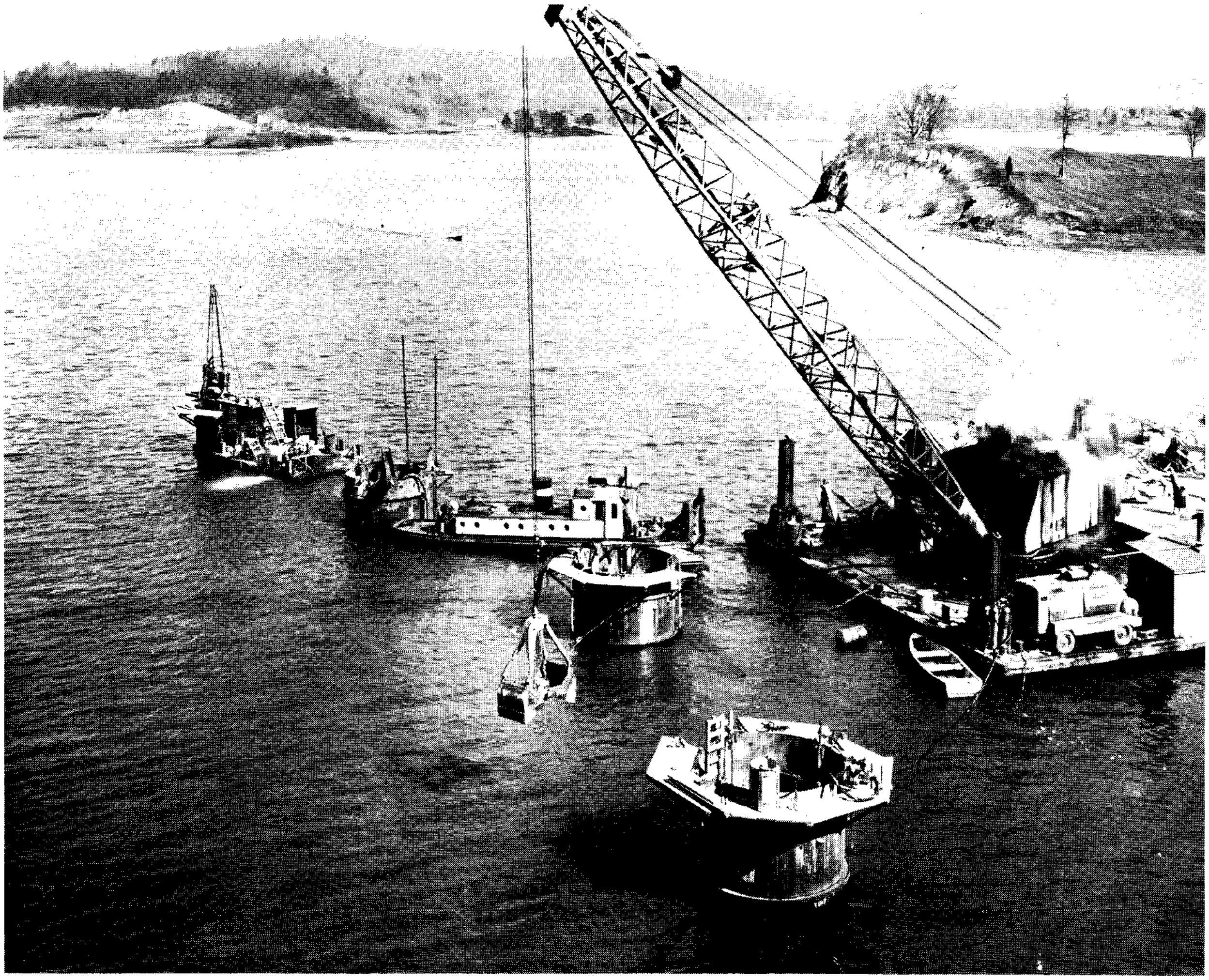


FIGURE 132.—*Installation of steel shells 45 feet long by 11 feet in diameter for the intake skimmer wall piers.*

flow, one-pass type. Welded to and supported by the turbine exhaust hood, the condensers are also partly supported on coil springs at the four corners. Condensate that collects in the hot well comprising the lower portion of the condenser is pumped out through two vertical pumps located near the condensers. Regulating equipment prevents removing condensate in the hot well below a fixed elevation. A venturi-type steam jet ejector for ejecting air on start-up, and, if necessary, for assisting in maintaining a negative pressure in the condenser during operation, was furnished on this contract. A steam jet air pump was furnished for continuous air ejection consisting of two-stage condensers and jetting steam for removing air from the condensate. This is located on the 744 elevation floor. Erection of the condensers and equipment was done under the supervision of a representative of the vendor.

Skimmer wall—A skimmer wall (fig. 50, page 79) was constructed at the entrance to the condenser cooling water intake channel from the Emory River arm of Watts Bar Lake. Steel shells for the piers, each consisting of an 11-foot-diam shell 45 feet long, were centered, leveled, anchored, and braced from four concrete anchors set in the water (fig. 132). After cleaning the rock surface with compressed air these shells were poured to elevation 715. An 8-foot-diam shell 30 feet long with slots for receiving the beams was centered in the larger shell and poured up to elevation 745. After completion of the pier, the outer shell was cut off under water at elevation 715 and removed. The eight piers were completed between January 28 and July 22, 1954.

Prestressed concrete beams constitute the wall between each two piers. A rubber seal (fig. 133) was placed between the beams. This seal, extending the length of the beam, is a strip approximately 1½ inches square, with a ⅝-inch-diam hole through the center, and was glued to the top of the beams before setting in place.

On July 23, 1954, 30 of these beams were placed with the floating crane and all were in place by August 2. Grouting these beams at the piers was completed soon afterward.

Rockfill at the south abutment was started by pushing rock off the adjoining bluff, but this was discontinued because of excessive overburden. Later, purchased quarry run rock and furnace slag were loaded on barges at the north end of the channel entrance, floated to the south side, and pushed off the barge with a bulldozer to complete the fill. The north abutment was filled with the same material dumped directly into the lake from the vendor's trucks to elevation 745 completing the installation October 27 except for the navigation light which was installed November 12, 1954.

Submerged dam—Engineering layout and a profile of the channel along the axis of the dam located at mile 3.9 on the Clinch River and about ½ mile downstream from the mouth of the Emory River were accomplished in March 1955. The profile showed the low point of the channel to be approximately elevation 701.5, thus requiring a maximum height of fill of 20.5 feet to the crest of the dam at elevation 722, which is 13 feet below minimum flat pool level.

The possibility of making the fill from local deposits of shale either adjacent to or within a short haul from the dam site was considered. However, a series of tests proved the available material to be too friable and so the idea was abandoned. A contract was made with a local supplier to furnish quarry-run limestone at $1.08 per ton. The quantity placed in the dam was 16,735.80 tons.

As the fill progressed, continuous soundings were taken to ascertain the height of the rock. When the fill had been brought to the plan crest of 722 a cross-section was taken by means of sounding. These sections showed that the rock stabilized itself on a slope varying from about 1:1 to 1.5:1. Observation indicated that this variation in slope was largely due to the amount of fine material in the rock. The average slope is very close to 1.25:1.

It was essential that the completed dam crest be no higher than 722 in order to provide proper channel clearance for shipping. To remove the excess, the 1½-cu-yd drag bucket was replaced by a ¾-cu-yd clam. By painting the load line at the proper height it was possible to check the height of the dam by sweeping the bucket transversely as the floating rig was moved along the axis of the dam. Excess material was clammed off and cast aside. This clean-up operation required slightly more than one day. Final soundings indicated the dam crest to be very close to the plan elevation of 722 with projections of only some 6 inches above this.

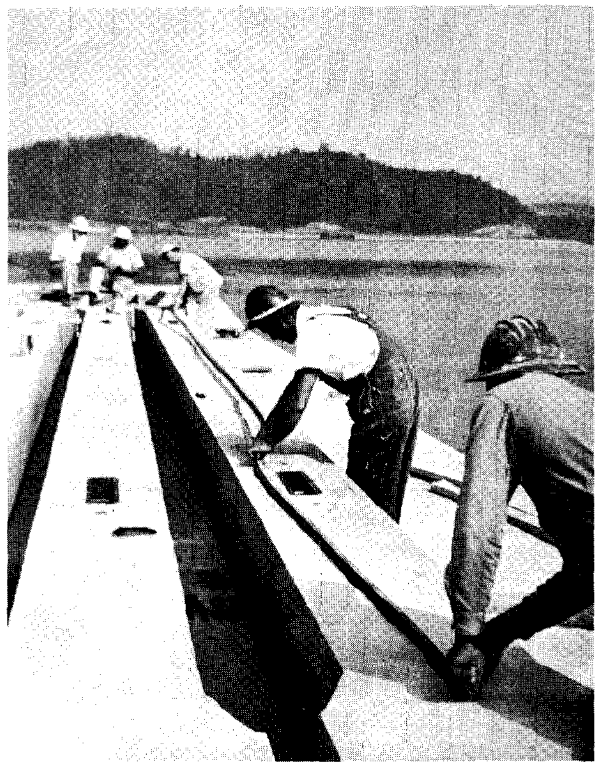


FIGURE 133.—*Leakage between the concrete skimmer wall beams was minimized by using rubber seal strips glued in position before placing the beams.*

Raw water system

Raw water is provided for the powerhouse, general yard area, and all outlying buildings, with the exception of the storage building (exhibits 75 through 79). Raw water is used for the fire protection system, lawn sprinkling system, cooling water for various underground equipment, and miscellaneous use.

The raw water system is supplied by ten electric-motor-driven, horizontal, centrifugal pumping units located in the powerhouse near the east wall. Four pumps each have a capacity of 2500 gpm against a discharge head of 175 feet. Six pumps have a capacity of 4000 gpm against a discharge head of 175 feet. Suction for the pumps is taken from the condenser cooling water intake conduits. The pumps discharge into the plant raw water system which supplies a fill line for the elevated 50,000-gallon-capacity raw water storage tank, located in the general yard area northeast of the powerhouse.

Main piping headers running the entire length of the powerhouse were installed following erection of building steel. Installation of branch lines from the mains progressed with completion of other construction work in the area. Standard weight steel pipe was used for all raw water piping inside the buildings.

All piping 4 inches and larger was assembled with welded fittings, whereas, all smaller piping was assembled using threaded screwed fittings.

Cast iron bell and spigot pipe was used on all lines 3 inches and larger in the yard area. Standard weight, galvanized, wrought iron pipe was used for all underground lawn sprinkler piping.

Treated water system

Raw water from the condenser cooling water intake structure is filtered and treated in the water treatment plant (exhibit 80). Potable water is processed and chlorinated according to the prevailing standards for human consumption. Water for use in the boilers is given a primary softening treatment (exhibit 80) with Zeolite and piped directly to the powerhouse.

On the powerhouse roof are four tanks or reservoirs, with a total capacity of 35,650 gallons, connected with the potable water system (exhibit 81) to maintain constant pressure throughout the system. Float valves and switches in the tanks control the supply pumps at the water treatment plant.

In addition to the usual use of potable water for drinking fountain, bathrooms, kitchen, and laboratories, this water was used in condenser water and sewage chlorination systems and for hydraulically operating the cone valves and butterfly valves in the condenser cooling water intake structure. Originally, this water was the only means of operating these valves, but later, connections were made with the raw water system for emergency use.

Plumbing

Plumbing facilities are provided for the powerhouse and all major outlying buildings. The storage building has an individual septic tank and field for sewage disposal. All other buildings' sewage is disposed of in the plant septic tank located at the southwest corner of the discharge structure. The effluent from this tank discharges into the condenser cooling water discharge channel. A sewage chlorination building was later added to the disposal system.

Drainage

A complete drainage system is provided for the powerhouse, all outlying buildings, and the general yard area (exhibit 2). In locations where the elevation prevents gravity drain to the main yard trunk line, sump pumps were installed. The powerhouse has five station sumps, each equipped with two vertical turbine type electric-motor-driven pumps located near the east wall. Each pump has a capacity of 2000 gpm against a discharge head of 70 feet. Small duplex sump pumps were installed for de-watering various outside structures.

COAL HANDLING SYSTEM

Handling facilities

Two hopper buildings are provided to unload coal delivered to the plant by truck or rail. On unloading, the coal is conveyed to the crusher building for sizing, and thence to the outdoor storage area or directly to the bunkers in the powerhouse. Figure 60, page 99, is a general view of the hopper buildings, crusher building, and coal storage area. A general plan of the coal handling system appears in exhibit 4. A detailed description of the system appears in Chapter 3 under "Coal Handling," page 98. Construction quantities for the principal features of the system appear in table 25.

TABLE 25.—*Construction quantities—coal handling structures.*

Structure	Excavation cu yd	Concrete cu yd	Reinforcing steel tons	Superstructure structural steel tons
Hopper building No. 1	10,241	1913	173.8	86.3
Hopper building No. 2	3,306	1644	158.2	53.9
Crusher building	6,310	1634	169.1	110.6
Conveying facilities	58,519	9119	663.9	331.2

Excavation—Initial excavation for the coal handling system, including crusher and hopper buildings, was started in April 1952. Carryall scrapers were used where possible; some drilling and blasting were necessary at the lower elevations where 1¾ cu yd backhoes were used to load pans or Euclids. Approximately 80,000 cu yd of earth and rock was excavated for the coal handling facilities. Most of the excavated shale was used for coal yard fill.

Concreting—Major concreting began in June 1952 on transfer structure A, BC-1 tunnel, and hopper building No. 1—after grouting exposed rock to prevent spalling of the shaly foundation. Rather complex formwork resulted in slow progress. Concrete was placed with buckets and an air-operated skid rig. Figure 134 shows the foundation construction for hopper building No. 2, BC-10 tunnel, and erection of the rotary car dumper in hopper building No. 1. For ease of installation, major equipment was placed as building substructures were raised. The greater part of the conveyor system is underground and housed in rectangular, reinforced concrete tunnels—generally poured in three lifts. Tunnel foundations are of hard shale or compacted clay, and the tunnels were backfilled with clay. Seals were used at construction joints, and sump pumps are located at low points for removing excess water.

Steel erection—Major steel erection on coal handling features began with the crusher building early in March 1953. Approximately 600 tons of structural steel was involved in erection of the buildings, transfer structures, and conveyors. Erection procedures

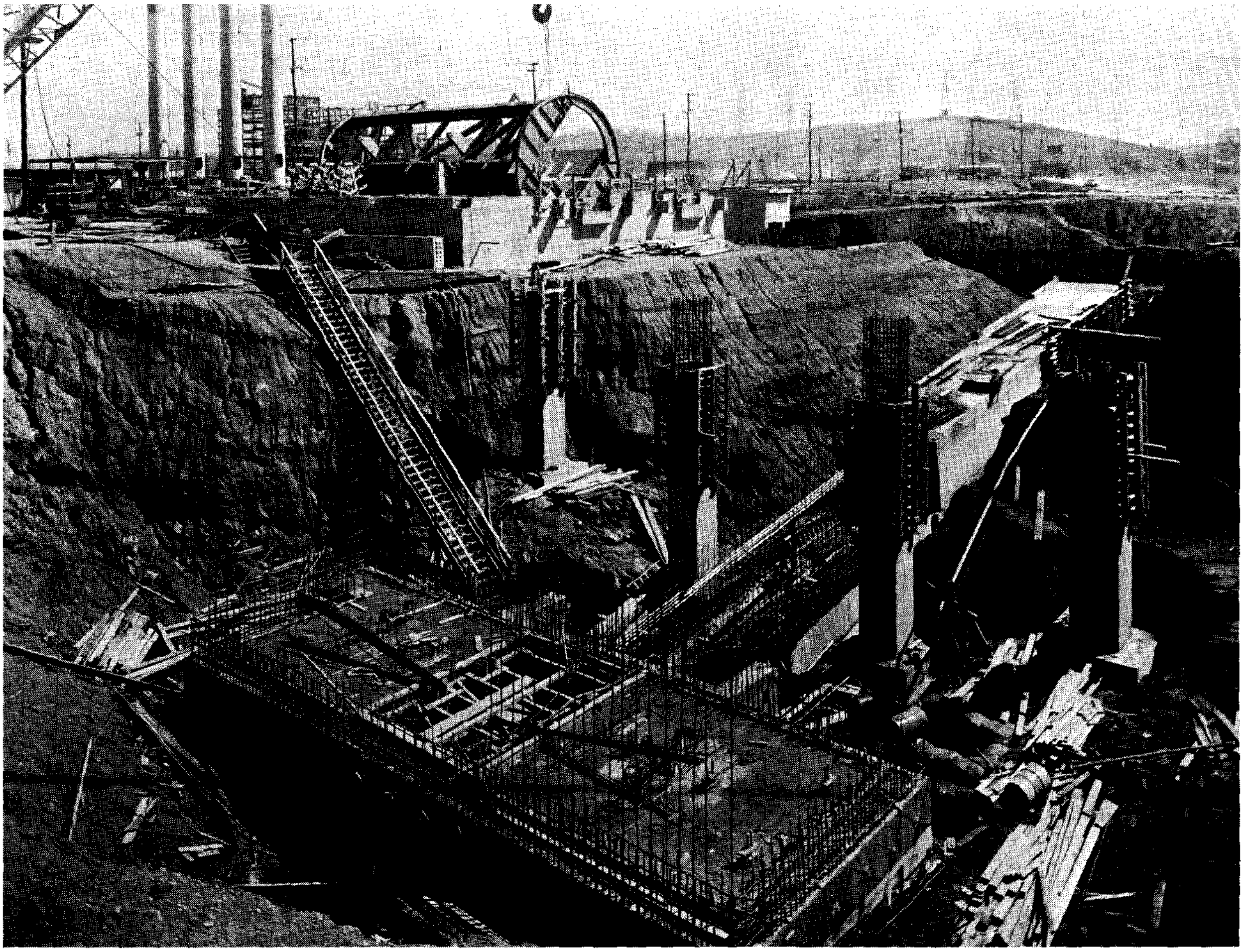


FIGURE 134.—*Construction progress as of March 20, 1953, showing placement of concrete for hopper building No. 2, BC-10 tunnel, and erection of the rotary car dumper in hopper building No. 1.*

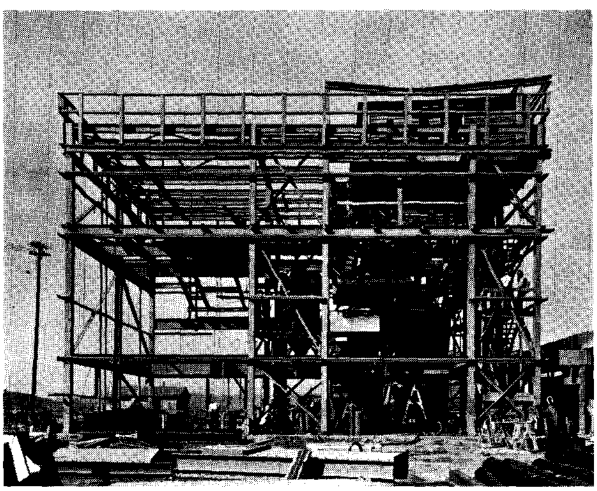


FIGURE 135.—*Installation of coal chutes, vibrating screens, and crushers in the crusher building January 19, 1953.*

were similar to those described under "Powerhouse Structural Steel," page 163. Figures 135 and 136 show crusher building and conveyor bridge steel erection.

Coal storage yard

The coal storage yard (fig. 60, page 99), located west of the crusher building, includes an area of 58 acres with an ultimate storage capacity of 1,350,000 tons, sufficient to supply the 9-unit plant for approximately 90 days.

The northern portion was above grade while a large part of the south half was below lake level. Earth-moving operations were started in September 1951 after clearing. Much of the fill material for the southern portion of the yard was obtained from excavation in the northern portion. Additional fill material was required; this was obtained from several areas including the loaded car storage area, powerhouse intake and discharge channels, and excavation for coal handling facilities. A total of 468,300 cu

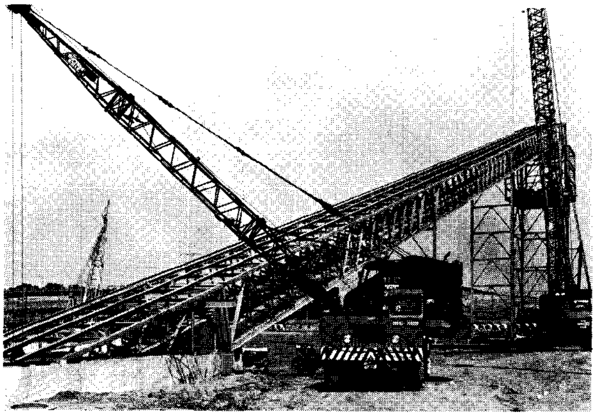


FIGURE 136.—*Structural steel erection completed for transfer structure B and inclined conveyor bridge BC-3 and 4, January 14, 1953. Installation of the conveyor tables and rollers is in progress.*

yd of material was excavated in the coal yard while 891,500 cu yd were required for the fill. Earth moving was done by carryall scrapers in the yard area and with Euclids for the longer hauls where hard shale and rock required shovel loading.

Although the entire area for the 9-unit plant storage yard was graded, the south central area was first prepared for receiving coal in July 1953. After fine grading was completed in this area a blanket of crushed furnace slag 6 inches deep was spread and a low-grade fine coal was placed as an additional cover of 6 inches. The north and west part of the storage yard was graded and covered with the crushed slag mat at the same time but was used by contractors and construction forces as a storage lot for permanent materials, with railroad switch and tracks.

Six concrete settlement slabs were poured at widely separated locations for checking depth of coal at future dates.

TRANSMISSION PLANT

The transmission plant includes the facilities for transmitting power generated by the nine generating units from the generators to the transmission lines which egress from the 161-kv switchyard (fig. 137).

Construction involved 138,999 cu yd of grading, 2966 cu yd of concrete for structure and equipment foundations, and 556 tons of galvanized structural steel.

A general arrangement plan of the transmission plant appears in exhibit 93. Exhibit 6 contains the general ground map plan. Equipment data is tabulated in the "Statistical Summary," page 276.

Generator busses

The generator busses, which carry power from the generators to the main power transformers, were fabricated and erected by construction forces. The busses (fig. 53, page 84) for the first four units inside the powerhouse are made from two 10-inch 8.89-pound aluminum channels, and those outside the building are made from two 8-inch, 4.89-pound aluminum channels. The busses for units 5-9 inside the powerhouse are made from two 10-inch 10.02-pound aluminum channels, and those outside the building are made from two 8-inch, 6.78-pound aluminum channels. Common station service transformer A leads are made from two 6-inch, 4.63-pound aluminum channel inside the building and 5-inch IPS aluminum tubing outside the building. Common station service transformer B leads are made from two 6-inch, 4.63-pound aluminum channels inside and outside the building, as it runs in the cable tunnel from the powerhouse to the transformer. The inside busses are enclosed in Transite housings, while those outside are protected by expanded metal on aluminum frames supported by the buss structure.

Transformer yard

To minimize the effect of differential settlement, special caution was taken in compacting the earth backfill on which the transformer footings are located. The fill was placed in 6-inch layers and compacted by use of sheepsfoot rollers pulled by bulldozers.

The nine main transformers were received by rail on special drop-center flat cars (fig. 138). Because of their weight, they were unloaded in the turbine room by the two traveling cranes and set on their trucks. A 60-ton locomotive was used to move them to the transformer yard. The weight of transformers 1 through 4 was 160 tons less oil and accessories, and 5 through 9 weighed 170 tons less oil and accessories.

The transformer yard towers support the conductors of the 161-kv circuits to the switchyard, the high-voltage lightning arresters, and serve as anchors for the overhead ground wires about 77 feet above the ground. These conductors are 500 mcm copper cables. The towers (fig. 139) were purchased completely fabricated and galvanized. The conductors on the towers are 1½-inch aluminum tubing for units 1-4 and the common station service transformers and 2-inch aluminum tubing for units 5-9.

Considerable difficulty was encountered with the electro-coolers furnished for the main transformers. Originally furnished with 440-v, single-phase fans, these fans burned out after several days of operation and were returned to the manufacturer and rewound as 230-v, single-phase fans. The radiators began to leak after several days of operation, and several of these had to be returned to the manufacturer for repairs.

Switchyard

Structural steel erection in the switchyard began in January 1953, and bays 13 to 25 for units 1-4 were completed the following March. Since it was necessary to energize common station service transformer B before completion of bays 26 to 37 for units 5-9, this transformer was energized temporarily through OCB

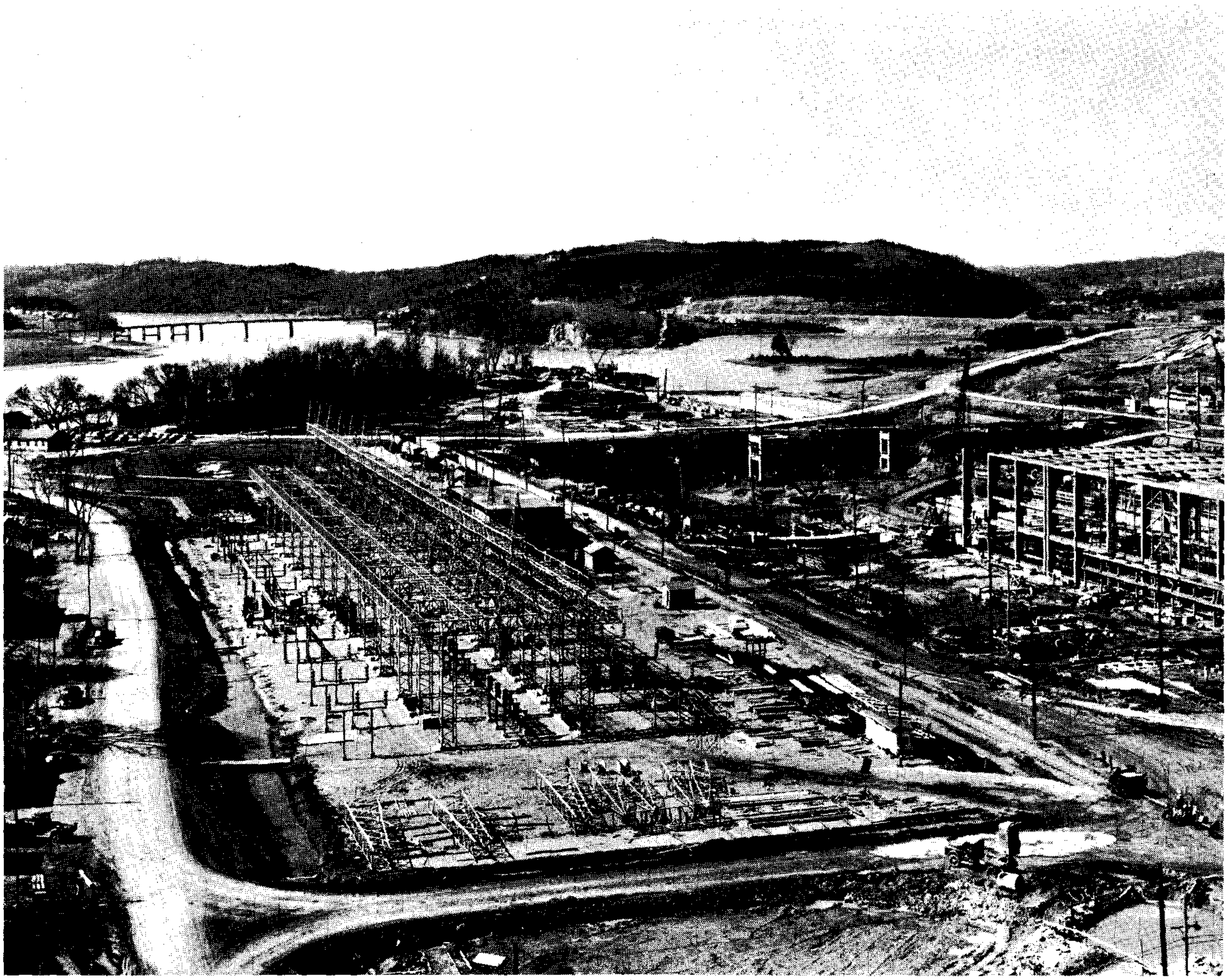


FIGURE 137.—*Structural steel erection of switchyard March 19, 1953, looking south from top of water storage tank. Powerhouse structure is at extreme right.*

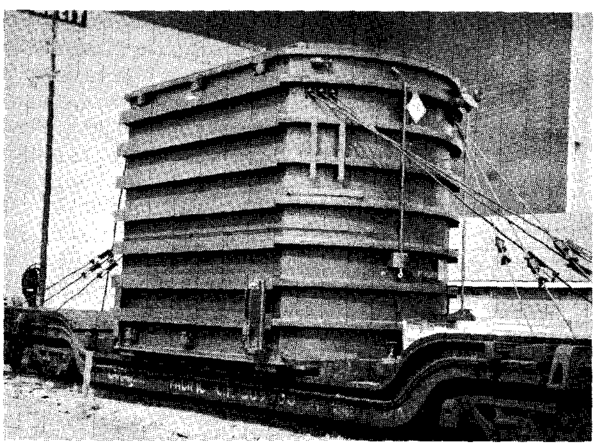


FIGURE 138.—*Unit 5 main transformer, weight 170 tons, being received by rail on special drop-center flat car.*

954 in bay 25. Common station service transformer B was placed in service from its permanent location in bay 29 in June 1955.

The bolted steel structures with the exception of bay 26 were erected by the iron workers. Electrical construction forces erected bay 26 and installed all switchyard electrical equipment. Figure 140 shows excavation and formwork for switchyard foundations; steel erection is shown in figure 137.

The transmission lines were energized in the following sequence:

K27-1	5-28-53	K33 Line F	10- 6-54
K31-1	6-13-53	K33 Line E	11-16-54
K33 Line A	3-22-54	K33 Line C	6-25-55
K33 Line B	4-22-54	K27-2	8- 5-55
K33 Line D	9- 9-54	K31-2	8-16-55

The only difficulty experienced with electrical equipment in the switchyard was the failure of two strain clamps used to support the wave traps, causing

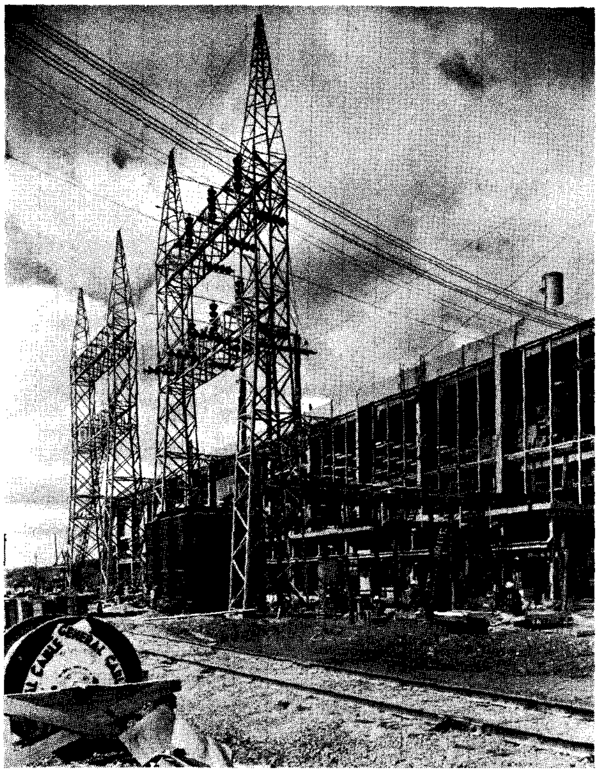


FIGURE 139.—*Installation of common station service transformer A and leads in transformer yard, April 20, 1953.*

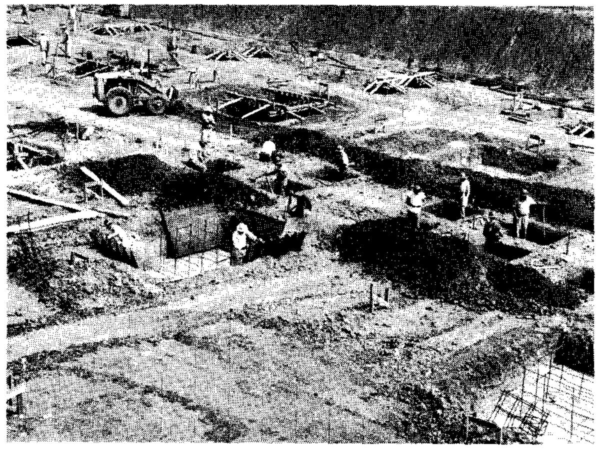


FIGURE 140.—*Excavation and formwork for switchyard foundations.*

total loss of the traps and trap hardware and nearby insulator stocks. All these clamps were replaced as soon as possible.

YARD FACILITIES

A description of the utility building, storage building, hydrogen system, and miscellaneous yard structures and services are covered in Chapter 3, "Design." Installation of these facilities involved no special construction problems.

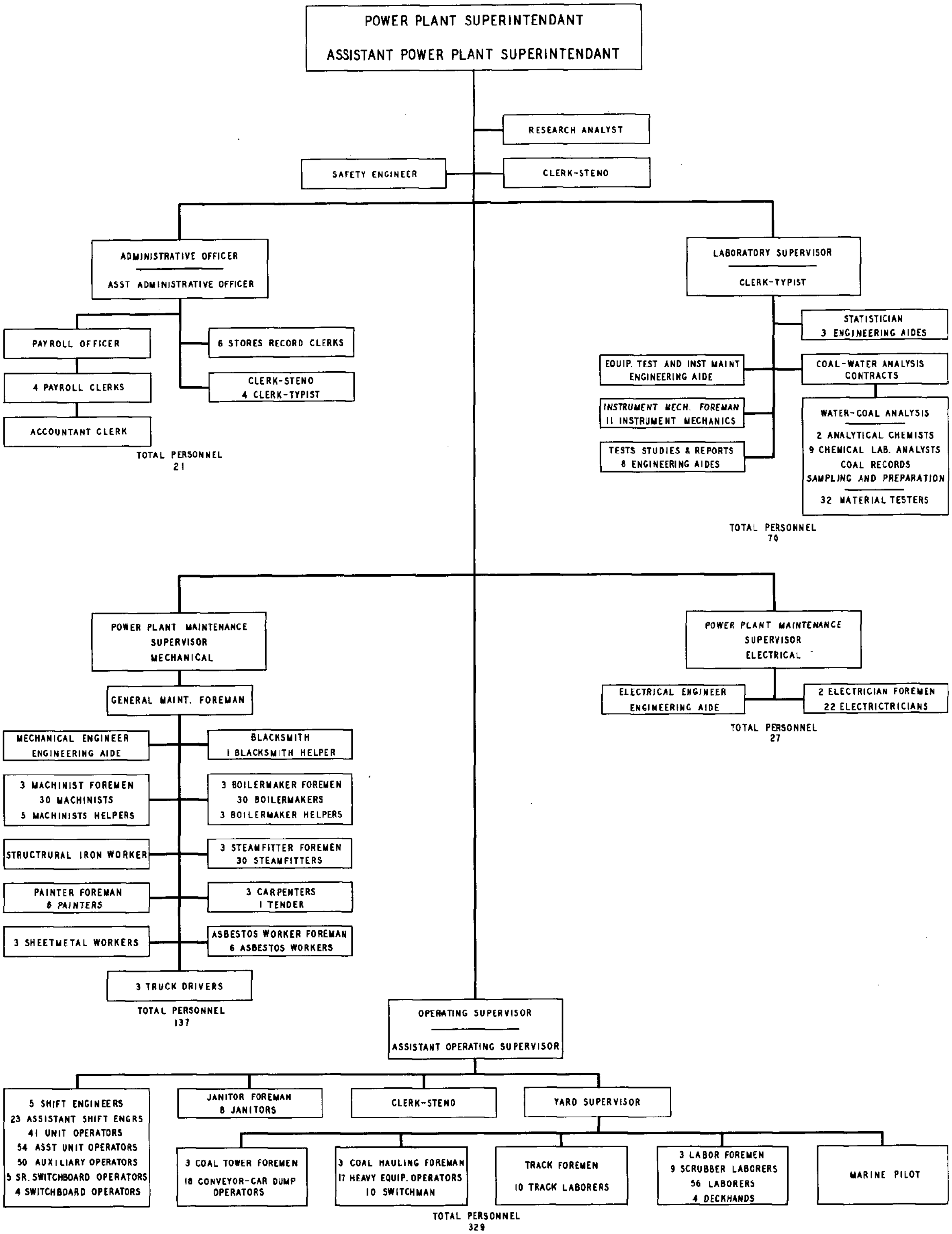


FIGURE 141.—*Organization chart of plant operating personnel providing around-the-clock supervision, maintenance, and production.*

CHAPTER 6

INITIAL OPERATIONS

The period of initial operations begins with the first unit operation in January 1954 through all nine units to June 1958. Since initial operation of the first unit, the plant was used to assist in carrying the system base load. After each unit was balanced and test-operated at various loads, it was put into commercial operation and removed from service only for annual inspections or for short periods to perform necessary maintenance. The operating organization, as shown in figure 141, is based on a 40-hour work-week and continuous operation of all nine units at full load.

Personnel requirements

While the plant was being built, student operators were placed in training at Watts Bar Steam Plant to take care of anticipated requirements for operators. During the period of construction the Widows Creek, Johnsonville, and Shawnee Steam Plants were placed in commercial operation and operators from these unit-type plants were transferred to Kingston Steam Plant to serve as a nucleus for the operating organization there. As additional units were placed in operation, personnel requirements were supplied largely from within the TVA training program.

POWER PRODUCTION RECORD

The dates of initial operation and commercial operation for the nine units are as follows:

Unit	Initial operation	Commercial operation
1	January 30, 1954	February 8, 1954
2	April 25, 1954	April 29, 1954
3	June 5, 1954	June 11, 1954
4	July 23, 1954	July 27, 1954
5	November 26, 1954	January 18, 1955
6	February 3, 1955	March 3, 1955
7	April 19, 1955	May 6, 1955
8	July 9, 1955	August 3, 1955
9	November 25, 1955	December 2, 1955

The plant operated continuously since the first unit was released for commercial operation with the exception of a few short periods during the first four months when one or more of the units were out of service for adjustments and maintenance. Table 26 lists operating data for the fiscal years 1954-1958.

EQUIPMENT PERFORMANCE

Operation of major steam plant equipment continually involves difficulties of one kind or another, and during the initial operations period, especially, numerous equipment adjustments and repairs are expected. The difficulties related in this section were satisfactorily corrected in most cases. In all cases the operating limitations of the equipment were determined.

Boilers

Boiler deficiencies had a significant effect on operating and maintenance procedures. Frequent unit outages were experienced from boiler tube failures caused by excessively high tube metal temperatures in the high- and low-temperature superheaters and reheaters. During the early stages of operation of units 1 through 4, the boiler manufacturer placed a limit on the metal temperatures of the low-temperature superheater terminal tubes. This limitation frequently determined the maximum load that could be carried. The limitation was removed after a series of boiler revisions that included changing low-temperature superheater surface to economizer surface, bypassing low-temperature superheater elements, and experimenting with flue gas diversion. However, difficulties continued with tube failures in this section. The thinning of reheater tubes from oxidation contributed to most of the reheater tube failures in units 1 through 4. The boilers of units 5 through 9 experienced a large number of outages due to superheater and reheater tube failures. Many of these failures occurred in type 321 austenitic stainless-steel tubing. This difficulty has been attributed to the low-creep-rupture strength of type 321 alloy when heat-treated at temperatures in the order of 1750°F. The stainless-steel tubing of unit 5 was replaced with new material. The tubing from unit 5 was heat-treated and reinstalled in unit 6. The corresponding tubing for units 6, 7, 8, and 9 was removed from the boilers, heat-treated, and then replaced in each succeeding boiler. Tube failures in the low-temperature superheater resulted in the replacement of certain tubes with higher alloy tube material. Many water wall tubes failed as a result of internal corrosion. Changes in boiler water treatment, the enlargement

TABLE 26.—*Generation by months—fiscal years 1954 through 1958.*

Fiscal year	Gross generation, kwh	Net generation, kwh	Net peak load, kw	Average hourly gross generation per unit, kw	Rated capacity, kw	Btu per net kwh	Unit availability factor, percent
1954							
January	653,000	-5,000	40,000	34,880	135,000	—	—
February	80,649,000	76,258,000	146,000	116,350	135,000	10,080	100.0
March	100,567,000	95,002,500	154,000	151,160	135,000	9,960	89.9
April	115,112,000	108,783,500	282,000	157,830	270,000	9,900	96.5
May	164,019,000	155,105,500	290,000	136,470	270,000	9,950	81.1
June	236,198,000	223,412,500	422,000	138,060	405,000	9,850	89.9
	697,198,000	658,557,000	422,000	145,010	405,000	9,880	89.2
1955							
July	306,233,000	290,011,300	557,000	133,700	540,000	9,760	95.2
August	378,187,000	358,842,500	594,000	140,700	540,000	9,610	96.1
September	401,112,000	380,648,500	597,000	141,960	540,000	9,660	98.5
October	433,295,000	411,024,500	580,000	146,400	540,000	9,590	99.5
November	375,240,120	355,606,620	644,000	146,000	720,000	9,680	88.2
December	479,281,690	456,795,440	785,000	146,390	720,000	9,720	100.0
January	529,377,450	499,843,450	759,000	152,090	720,000	9,710	98.2
February	478,602,970	452,801,970	866,000	148,910	900,000	9,650	82.9
March	591,546,580	561,204,580	910,000	158,570	900,000	9,640	83.4
April	609,752,880	577,945,880	1,068,000	148,440	1,080,000	9,560	92.0
May	764,451,000	725,999,000	1,140,000	162,450	1,080,000	9,580	91.9
June	789,468,000	749,861,000	1,126,000	164,050	1,080,000	9,600	95.5
	6,136,547,690	5,820,234,740	1,140,000	155,850	1,080,000	9,640	92.5
1956							
July	873,098,000	828,657,000	1,284,000	171,140	1,260,000	9,730	98.0
August	896,785,000	850,769,000	1,282,000	167,160	1,260,000	9,630	90.9
September	921,352,000	874,909,000	1,300,000	169,520	1,260,000	9,630	94.4
October	948,909,000	900,816,000	1,337,000	171,370	1,260,000	9,650	93.0
November	889,181,000	843,251,000	1,364,000	169,050	1,440,000	9,720	90.1
December	1,047,400,000	994,300,000	1,488,000	172,110	1,440,000	9,570	91.2
January	1,133,650,000	1,076,293,000	1,530,000	174,276	1,440,000	9,700	97.6
February	908,382,000	860,328,000	1,548,000	160,281	1,440,000	9,780	90.5
March	890,135,000	842,047,000	1,218,000	149,667	1,440,000	9,570	89.4
April	870,376,000	823,514,000	1,326,000	152,883	1,440,000	9,670	87.9
May	1,036,980,000	983,001,000	1,491,000	169,903	1,440,000	9,480	91.8
June	1,019,763,000	967,242,000	1,555,000	176,897	1,440,000	9,560	89.3
	11,436,011,000	10,845,127,000	1,555,000	167,320	1,440,000	9,640	91.9
1957							
July	1,064,273,000	1,008,983,000	1,538,000	174,940	1,440,000	9,520	91.4
August	1,046,212,000	991,797,000	1,527,000	171,210	1,440,000	9,580	92.2
September	1,005,447,000	952,740,668	1,524,000	174,050	1,440,000	9,600	89.7
October	1,076,074,000	1,019,681,000	1,504,000	171,740	1,440,000	9,660	94.0
November	1,016,649,000	962,763,000	1,485,000	176,980	1,440,000	9,460	89.9
December	1,072,346,000	1,015,611,000	1,492,000	173,720	1,440,000	9,600	93.3
January	1,130,603,000	1,070,930,000	1,521,000	172,570	1,440,000	9,650	98.3
February	985,158,000	932,980,000	1,511,000	171,050	1,440,000	9,650	95.2
March	1,022,127,000	967,143,000	1,508,000	170,190	1,440,000	9,500	90.5
April	1,006,334,000	952,625,000	1,511,000	173,170	1,440,000	9,600	90.4
May	1,023,530,000	968,918,000	1,457,000	175,740	1,440,000	9,510	87.8
June	976,851,000	924,292,000	1,481,000	175,700	1,440,000	9,580	86.8
	12,425,604,000	11,768,463,668	1,538,000	173,450	1,440,000	9,580	91.6

TABLE 26.—*Generation by months—fiscal years 1954 through 1958*—Continued.

Fiscal year	Gross generation, kwh	Net generation, kwh	Net peak load, kw	Average hourly gross generation per unit, kw	Rated capacity, kw	Btu per net kwh	Unit availability factor, percent
1958							
July	977,778,000	924,323,000	1,477,000	167,490	1,440,000	9,540	87.6
August	1,009,630,000	954,305,000	1,466,000	173,430	1,440,000	9,710	87.7
September	948,947,000	896,597,000	1,481,000	169,750	1,440,000	9,670	87.1
October	1,006,341,000	951,145,000	1,470,000	171,910	1,440,000	9,740	88.2
November	946,865,000	894,664,000	1,293,000	167,330	1,440,000	9,820	87.7
December	1,003,152,000	947,414,000	1,491,000	164,710	1,440,000	9,840	91.7
January	978,097,000	923,187,000	1,301,000	168,170	1,440,000	9,830	87.3
February	895,493,000	844,829,000	1,482,000	167,980	1,440,000	9,840	89.2
March	978,869,000	924,355,000	1,299,000	167,300	1,440,000	9,840	87.9
April	862,616,000	813,756,000	1,290,000	164,790	1,440,000	9,830	86.5
May	924,492,000	872,796,000	1,299,000	160,720	1,440,000	9,780	86.5
June	871,233,000	822,031,000	1,294,000	164,950	1,440,000	9,740	83.1
	11,403,513,000	10,769,402,000	1,491,000	167,400	1,440,000	9,770	87.5

of selected tube circuit orifices, and the chemical removal of operational deposits practically eliminated water tube failures.

Low-temperature superheater terminal tubes and other tubes in the high-temperature zones of units 1 through 9 experienced failures ranging from cracks to complete ruptures. The alloy used in these tubes was not adequate for the temperatures encountered. A partial substitution of better alloy tubing was made in units 5 through 9.

Boiler circulating water pumps—units 5 through 9

Failures of discharge valve stems were corrected by a change in material. Pump shaft failures were experienced where the shafts were threaded for the impeller nuts. This difficulty was corrected by a change in shaft material. Revisions to the pump packing glands and lubricating system were necessary as the result of failures of the radial and thrust bearings. Serious failures of the casing joint studs were corrected by the use of studs of improved design and by the spot-facing of the nut seats. These pumps experienced frequent unintentional shutdowns resulting from vibration and shock effects on certain components of the pump controls. This condition was corrected by the relocation of the affected controls to positions free from shock and vibration.

Pulverizers

Failures of the concrete bearing pedestals for the pulverizer exhauster fans occurred, resulting in extensive damage to the pulverizer drive motors, the exhauster fans, and the concrete foundations. Those pedestals that failed were replaced by fabricated steel pedestals. Severe erosion in the pulverized-coal transport system led to the use of seamless-steel exhauster elbows in place of fabricated elbows, resulting in increased life and reduced maintenance of these parts.

Induced draft fans

The induced draft fans of units 1 through 4 have inadequate static pressure characteristics to handle the required gas flow for full-load operation of these units. Higher-than-expected draft losses through the gas path are largely responsible for this difficulty. Some fans have been equipped with spin-stop sheets in the fan inlet housings. This action resulted in a modest increase in the fan static pressure and capacity. The induced draft fans of units 5 through 9 experienced welding failures, which permitted the infiltration of fly ash into the void space between the fan rotor center disc and deflection cones, resulting in unbalance and vibration of the fan rotor. This difficulty was corrected or prevented on all 18 induced draft fans by the plant maintenance organization. Several failures occurred on the induced draft fan motor centrifugal switches, resulting in shutdowns of the pulverizers and forced draft fans. Plant forces made corrective modifications to these switches on all induced draft fans.

Forced draft fans

Welding failures occurred at the attachment of the side disc to the hub. The addition of gussets and heavier cones, hub to disc, corrected the weld failures at that point. All fan blades were reinforced at this point with doubling plates. Excessive vibration of the fan housings was corrected by the installation of additional internal and external reinforcing members. This action greatly reduced excessive maintenance on the fan casing insulation.

Air heaters

Performance tests on the regenerative air preheaters indicated substandard performance. Sealing strips were installed to reduce the bypassing of gas around the heating elements. Subsequent tests indicated reductions of about 10°F in the exit-gas temperatures.

Turbogenerators

Units 1 through 4 turbogenerator thrust bearings have caused a serious problem. These bearings operated with excessive temperatures just under the point of bearing failure. Several bearing modifications were effected, including a more liberal oil supply. The combined benefit of these revisions allows continuous operation with a reasonable margin of safety as long as no sudden additional thrust load is applied. Bypassing high-pressure heaters at full load frequently imposes an additional thrust load sufficient to cause thrust bearing failure. The automatic-bypass feature has been disconnected, and the operator is relied upon to bypass the high-pressure heaters manually when necessary. A substantial block of load is dropped before bypassing the heaters in order to bring the total thrust within range of the bearing capability.

The intermediate-pressure turbine spindles of units 1 through 4 cracked where the blades fasten into the spindle groove. A temperature limitation of 950°F was imposed on all four units by the manufacturer. A revised method of blade installation and an improved locking device were adopted, and cooling steam was supplied to the shaft that had experienced potential failure. The reheat temperature was returned to the normal 1000°F after the revisions were completed on each unit.

Spindle, blade, and shroud difficulties were experienced in the high-pressure turbines of identical machines elsewhere. To minimize this possibility at Kingston, the superheat temperature on units 1 through 4 was reduced from 1000°F to 950°F and remained at this level until appropriate revisions were made by the manufacturer. These limitations complicated operations, increased maintenance, and reduced efficiency.

The unit 5 turbine experienced blade failure shortly after it was placed in service. The manufacturer made a series of tests to determine the trouble and took corrective action on units 5 through 9. These turbines have performed satisfactorily since the revisions were made.

The generators of units 1 through 4 experienced some difficulties which resulted from looseness of the stator laminations. Small pieces of stator laminations have broken loose and caused localized stray currents in the stator core. On one occasion sufficient heat was generated to cause a stator winding failure. Efforts to correct this condition involved the shrinking, in place, of the core rings to maintain tightness of the stator laminations. The generators of units 5 through 9 experienced considerable difficulty with vibration and burning of the collector rings, a condition which required the resurfacing of the rings and a change in the grade of brushes.

Transformers

A large number of motor failures occurred on the main transformer cooling fans, requiring rewinding of the fan motors. Many of the main transformer oil coolers experienced leaks that necessitated return of the coolers to the manufacturer for repairs.

Fly ash collectors

The cyclone collectors of units 1 through 4 resulted in high maintenance costs due to excessive erosion of the collector cones. Changes in the grade of steel used for the collector cones proved to be ineffective. Current experiments indicate that a moldable refractory repaired at about 6-month intervals is effective in preventing cone wear and in reducing induced draft fan erosion. The tubular precipitators of units 5 through 9 experienced rapid wearing through of the tubes, causing the dust-laden flue gas to bypass the precipitator tubes. This situation resulted in low-dust-collection efficiency and severe erosion of the induced draft fans. One collector was equipped with cast-iron precipitator tubes to evaluate its erosion resistance properties.

FUEL SOURCES AND DELIVERY

TVA purchases coal in accordance with Section 9(b) of the TVA Act and an administrative code approved by the Board of Directors. All coal except occasional emergency purchases is bought on the open market after competitive bidding. Not less than 75 percent of the estimated burn tonnage for the power system is purchased by term contracts; the remainder is obtained by spot purchases.

All term-contract coal purchases are based on sealed bids submitted in response to invitations to bid, which have been well advertised in the coal industry. The contracts are usually made for a term in the range of 1 to 3 years, although some may run for as little as 6 months, and a few have been written for possible maximum terms as long as 10 years. Spot purchases, which are required to maintain the best delivery ratio to burn tonnage, are the result of awards made weekly on unsealed bids submitted in response to monthly invitations which are mailed to possible suppliers over a wide area. Delivery on these short-term purchases is limited to four weeks.

Contracts and spot purchases of coal are awarded to vendors on the basis of the lowest evaluated cost per million Btu delivered to the plants. The evaluation includes an adjustment for the excess of total ash and sulphur content over a standard of 5 percent. In addition to the cost of the fuel such factors as conformance of coal quality with specifications; delivery schedule; and financial responsibility, skill, experience, and record of integrity of the vendor are considered in awarding the contracts.

TVA began the purchase of coal for the operation of the Kingston Steam Plant in 1953. Listed in table 27 are the amounts of coal purchased and consumed during fiscal years 1953 through 1958.

TABLE 27.—*Tons purchased and consumed—1953-1958.*

F.Y.	Tons purchased	Tons consumed
1953	362	—
1954	988,905	262,807
1955	2,439,291	2,315,007
1956	4,105,278	4,290,073
1957	5,122,495	4,698,506
1958	4,217,808	4,325,671

The majority of coal deliveries were made from mines in District No. 8.[1] These mines are located in Anderson, Campbell, Claiborne, Cumberland, Fentress, Morgan, Overton, Roane, and Scott Counties in Tennessee and Bell, Clay, Harlan, Knox, Laurel, Leslie, McCreary, Pulaski, Rockcastle, and Whitley Counties in Kentucky. Lesser amounts of coal were received from mines in District No. 13.[1] These mines are located in Bledsoe, Hamilton, Marion, Rhea, and Sequatchie Counties in Tennessee.

Some typical analyses of the principal seams from which coal is obtained are listed in table 28.

TABLE 28.—*Coal analyses.*

Coal contents as received	District No. 8 Dean	District No. 8 Bon Air	District No. 13 Sewanee
Moisture, percent	4.3	5.0	4.5
Volatile matter, percent	35.0	33.8	30.2
Fixed carbon, percent	46.2	47.7	55.8
Ash, percent	14.5	13.5	11.5
Sulfur, percent	3.8	3.4	1.5
Heat units, Btu/lb	12,000	11,870	12,600

Direct rail deliveries from Tennessee are made by the Tennessee Central Railroad, and from Tennessee and Kentucky by the Southern Railway and Louisville & Nashville Railroad. Direct barge deliveries are made from District No. 13.[1] Only Tennessee coal is received by truck. At certain times rail-barge coal has been received from West Kentucky District No. 9.[1] Table 29 shows Kingston coal receipts by state of origin.

FUEL HANDLING

Permanent handling facilities are provided for rail and truck coal only. However, a temporary barge unloader has been utilized extensively in the fuel supply program, and future permanent barge-unloading facilities are considered a possibility. The location of the plant is particularly favorable to direct truck shipment from the mines, and increasing quantities of coal are received in this manner. Since no permanent facilities for barged coal were provided and long-range supplies of truck coal are unpredictable, the rail facilities were provided with the capacity to handle the entire station coal requirements. Table 30 shows Kingston coal receipts by mode of delivery. The powerhouse bunkers have a nominal capacity of 2400 tons each, or approximately 41½-hour supply for units 1 through 4; 2600 tons, or 34-hour supply for units 5 through 8; and 2800 tons, or 36½-hour supply for unit 9.

Highway trucks delivering coal to the plant are weighed and sampled individually. There are separate facilities for processing two lanes of trucks, including weighing, sampling, and dumping. As many as 800 trucks can be processed in one 8-hour shift by using all the truck-handling facilities. Each truck scale is rated at 50-ton capacity.

TABLE 29.—*Kingston coal receipts by state of origin—in thousands of tons.*

Fiscal year	Tennessee	East Kentucky	West Kentucky	Total
1953	(1)	—	—	(1)
1954	918	68	3	989
1955	1,950	487	2	2,439
1956	3,363	713	29	4,105
1957	4,308	813	1	5,122
1958	3,691	527	—	4,218

1. Less than 500 tons.

TABLE 30.—*Kingston coal receipts by mode of delivery—in thousands of tons.*

Fiscal year	Rail	Rail-barge	Barge	Truck	Total
1953	(1)	—	—	(1)	(1)
1954	837	—	—	152	989
1955	1,972	—	—	467	2,439
1956	2,726	83	264	1,032	4,105
1957	3,204	439	149	1,330	5,122
1958	2,017	289	220	1,692	4,218

1. Less than 500 tons.

Coal is stored in a tightly compacted pile through the use of large rubber-tired tractor-scraper units that also self-load from the pile during reclaiming operations. The 58-acre storage area will accommodate 1,900,000 tons, or 119-day supply, at a height of 25 feet and up to 3,000,000 tons, or 188-day supply, at a height of 40 feet. The 1000-tph capacity cantilever-type, stocking-out conveyor extends from the crusher building to the east side of the storage yard, terminating at sufficient height above ground level to permit coal to be discharged directly into the scraper bowls for placement on the storage pile. There are two 100-ton-capacity re-

1. Producing district designated by the Federal Bituminous Coal Act of 1937.

claiming hoppers, one on each side of the stocking-out conveyor. Each hopper feeds a separate 1000-tph conveyor system to the powerhouse bunkers. The rubber-tired tractor-scraper units transfer the coal from the storage pile to the reclaiming hoppers. Both crawler-type and rubber-tired tractors are used for cleanup dozing at the reclaiming hoppers and the stocking-out conveyor. One tractor-scraper combination with 47-cu-yd struck capacity, one with 30-cu-yd struck capacity, and three with 24-cu-yd struck capacity; one rubber-tired and three crawler-type tractor-dozers; and one 24-cu-yd scraper for standby use comprised the mobile equipment on the storage yard at the time of this initial operations report (June 1958).

The temporary barge-unloading facility consists of a 60-ton crawler-type revolving crane converted from diesel to electric power operation and mounted on a sheet-pile cell. An average unloading rate of 300 tons an hour can be maintained with the use of a 6-cu-yd clamshell bucket. A capstan-type winch and a 410-hp, twin-engine towboat provide the means for handling barges.

The plant is a primary source of power for the Oak Ridge atomic energy project. The nature of this load has required continuous maximum generation from all available units. Units 1 through 4 have operated at net loads of 135,000 kw or greater and units 5 through 9 have operated at loads of 200,000 kw or greater for sustained periods of time. In fact, the station was designed to operate base-loaded a major portion of the time. The operating procedures are consistent with this aim, in that, when units are removed from service for scheduled and nonscheduled outages they are returned to service as quickly as sound operating practice will allow. Occasionally system requirements demand a reasonable departure from established practice long enough to satisfy an emergency.

The highest over-all plant efficiency and the lowest possible maintenance cost are prime objectives of this station; however, the heavy demand factor of the Oak Ridge load has made it impossible to follow the most desirable program of operation and maintenance. As system capacity increases, the Kingston operation is expected to assume a less demanding pace.

Controls for each two units are housed in a common control room. The unit design has followed the unit-type construction with the exception of a few items, such as raw water, control and station air, lighting-off oil, etc., which are common to the plant. The grouping of controls for two units into one control room has made possible a more productive utilization of operators time and has also allowed more attention to equipment during emergencies, since the operators assist each other during such periods.

Considerable attention has been given to the quick starting of units. Quick-starting procedures, in general, are limited by gas temperature entering the boiler screens and boiler drum temperature differential. A careful monitoring of these two items on natural-circulation boilers allows considerable reduction in time required for placing boilers in service over that normally expected. However, other factors, such as the necessity of warming generator rotors, setting safety valves, and checking various other items associated with the return of a unit to service after an extended outage for maintenance, make quick starting an infrequently used procedure. With the forced-circulation boilers supplying units 5 through 9, boiler drum temperature differential is no problem. The drum circulation is such that water traverses its entire periphery and therefore obviates any material temperature differential. There have been times when the demand for power was such that the quick-starting procedure was utilized to considerable advantage.

CHAPTER 7

COSTS

ORGANIZATION AND DIVISION OF WORK

The responsibility for accounting of construction costs for the Kingston Steam Plant was assigned to the Chattanooga Construction Accounting Office, which also performed the accounting for the Widows Creek Steam Plant, various hydro plant additions, and the work of the Construction and Maintenance Branch. The chief accountant of the Chattanooga Construction Accounting Office coordinated the field work in accounting, costs, payrolls, and warehousing through his field liaison officer.

Accounting

Bookkeeping postings were made from documents such as public vouchers for purchases and services other than personal, journal vouchers, shipping tickets, retirement notices, invoices issued, cash collection reports, and shop orders. They were made directly to cost accounts, with a description showing the nature of the item, the document number, and the amount. These postings were made with a bookkeeping machine, and a cumulative total for the month was automatically extended. Each ledger sheet account was made in triplicate, and the balance of the account at the beginning of the month was the last entry at the end of the month, so that both the monthly and the to-date totals appeared on the face of each account. Since the divisional budgets of TVA are prepared in terms of objects of expenditures, as well as in terms of purposes for which the expenditures are made, separate object-of-expenditure sheets were set up to record expenditures, identified and grouped to show income and expenditures according to the nature of the service or article involved and by organization. Totals on cost account ledger sheets were balanced by organizations with totals on object-of-expenditure ledger sheets, eliminating the necessity for maintaining other control accounts for the cost account ledger sheets. Monthly financial reports were prepared directly from the ledger sheets and consisted of trial balance, organization statements and object-of-expenditure report.

Invoices were received by the accounting office, dated, verified, and checked against proper purchase order and/or contract. Receiving reports were prepared by the warehouse and forwarded to the accounting office along with delivery tickets, freight bills, and, if applicable, over, short, and defective reports. These data formed the basis of final acceptance of the charge. Vouchers were then prepared and forwarded to the Knoxville office for payment. The accounting office retained one copy of the voucher complete with supporting documents, which, after entry, was filed numerically by months, and one copy of the voucher, with no supporting data, which was known as the vendor's file, was filed alphabetically.

Payroll distributions, warehouse issues, machine time distributing, clearing account distribution, transfers from other offices, and corrections and adjustments were summarized on journal vouchers. These vouchers were filed numerically by months with supporting papers attached with the exception of warehouse issues and machine time distribution. Warehouse issues were filed by account number by months, and machine time reports were filed by machines by months.

Incoming shipping tickets supported charges from other offices and were summarized on journal voucher. Outgoing shipping tickets, or those covering shipments of materials or equipment from the project, were posted and filed numerically.

Billings to outside parties were made on an invoice form, one copy of which, with attachments, was retained for posting to the ledgers.

Cost of fabrication of permanent materials only was collected on individual job orders and at the end of the month journalized and filed with the journal voucher.

Cost engineering

This unit established and maintained a job classification of accounts in accordance with requirements of the master classification of construction accounts; set up the total budget at the beginning of construction from information obtained from construction schedules, the original estimates, and the job classification of accounts; prepared monthly budget studies to incorporate quantity and cost changes as the work progressed; and prepared fiscal year budgets based upon the original budget as modified by changes in both the construction schedule and actual costs. This unit established routines for the collection of field data such as: use of electricity, compressed air, raw water, and other clearing accounts to enable monthly clearances of these facilities. In addition, this unit informed the field and office engineers of data required for distribution of costs such as concrete, reinforcing steel, and permanent electrical conductor and conduit; coded all labor, material, machine time and shop costs; established use rates for machine time, checking these rates periodically for correctness; prepared requests for inventory to be obtained from the field and office engineers for preparation of cost and final plant record reports; prepared periodic cost analyses for the information of job management; currently prepared analyses of accounting records, and upon completion of work reconciled these records with final inventory data furnished by the various engineers; and then from these reconciliations prepared the final cost report and plant record reports.

Timekeeping

Timekeeping for hourly employees was controlled by use of the brass check system. Each employee, upon reporting for work for the first time, was assigned a number and given an identification badge and brass check bearing this number. He was instructed to draw the check when reporting to work at the beginning of each shift and to drop it at the check booth after completing his work for the shift. In addition to control obtained by this method of checking starting and quitting time, field time checks were made twice a day, and the employee's presence was noted on the time checker's sheets. These sheets were turned over to a payroll clerk for comparison with reports turned in daily by each foreman which listed the employees in his crew and the hours each worked on an identified job. The result of these comparisons formed the basis for payment of hourly employees. The time was posted to individual employees ledger sheets from these records, and the payrolls were prepared from the ledger sheets. Time of annually rated employees was obtained from monthly time sheets approved by their immediate and general supervisors. In connection with the payroll preparation, the time office was charged with the responsibility for making various payroll deductions, such as tax, retirement, FICA, Blue Cross, and cash advances. The time office verified and distributed pay checks on scheduled pay days.

Warehousing

Permanent material requisitions were prepared by the Division of Design and forwarded to the Division of Materials. Copies were sent to the project office. For temporary construction materials, repair parts and plant equipment, a request for purchase was prepared by the designated foreman, supervisor, or engineer. The request went to the warehouse where a purchase requisition was written and forwarded to proper offices for signature and certification. All local requisitions were approved by the project manager. The local requisitions were then forwarded to the Division of Materials which handled all purchases through regular procedures as established by the TVA Act. Upon delivery, receiving reports were prepared, checked with the purchase order and/or contract, and forwarded to the accounting office.

Receipt of material involved proper tagging and storage, and entry on the stock ledgers for inventory items. If the material was not an inventory item, it was tagged and stored pending need for installation or use. In order to account for these latter items a commodity file was kept; requisitions, purchase orders and/or contracts, receiving reports which recorded location in warehouse or storage yard, and storeroom requisitions listing date of withdrawal and person making withdrawal were filed by requisition number.

All inventory material was issued to the job on storeroom requisitions. This requisition described the use for which the material was intended, listed the items issued and their location, was approved and signed by an authorized person, and was signed by the issue clerk and the receiver. They were then numbered consecutively, coded by the cost engineer, priced and extended, accumulated monthly, and cleared to cost accounts by journal vouchers.

All materials leaving the project were listed on shipping tickets. These were prepared in the warehouse and transmitted to the accounting office when billing was made against the receiving agency. Receipt for incoming material from other branches or divisions of TVA was effected through completion of the inspector's copy of the shipping ticket.

All collect freight shipments were made on government bills of lading; carriers rendered freight bills showing the bill of lading number and accepted the "accomplished" copy of the bill of lading in lieu of payment. Settlement for freight charges was made by the Knoxville office after audit by the General Accounting Office in Washington. The liability for the transportation charges was recorded through field voucher.

SUMMARY OF COSTS

Costs of the original nine-unit Kingston Steam Plant were transferred from construction in progress accounts to completed plant accounts on a final basis on June 30, 1961. During the preparation of the final cost report, following the transfer of costs to completed plant, certain adjustments internal to and between subproject accounts were found necessary. The final costs as reported herein at $198,199,849.95 (general summary, page 211) reflect these internal adjustments.

The reported costs include steam production plant consisting of land, land rights, structures, improvements, and equipment; transmission plant comprising the related primary substation located on the steam plant site and constructed concurrently with the steam plant; and general plant consisting of intersite communication equipment.

The final cost of the project, by character of expenditures, is as follows (detail summary, page 212):

Land costs		$ 911,975.94
Construction costs		
Direct construction	$184,505,994.38	
Indirect construction	3,428,580.64	187,934,575.02
Distributive general expense		
Design and construction engineering	5,666,552.71	
Executive and administrative	2,383,115.13	
Other general	1,408,072.99	9,457,740.83
		198,304,291.79
Transferred depreciation		(27,541.84)
Estimate to complete —contra		(76,900.00)
		$198,199,849.95

( ) Denotes credit.

Land costs amount to $911,975.94 and cover steam plant and employee housing site land, and access road and railway right-of-way purchased in fee simple; and permanent right-of-way easements for railway and relocated highways.

Direct construction costs total $184,505,994.38 and cover labor, material, equipment, construction plant, tools, shop expense, warehousing, transportation, and other similar expenditures.

Indirect construction costs totaling $3,428,580.64 include superintendence, accounting, cost engineering, and timekeeping; personal travel and subsistence of employees when in official travel status; office supplies and expense; construction plant studies, design, and cost estimates; employee housing; Federal Employees Group Life Insurance and Blue Cross expense; and public safety expense (page 248).

Design and construction engineering amounting to $5,666,552.71 includes salaries and expenses of the project manager; field, executive, supervisory, and office engineers; concrete technicians and inspectors; and consultants. Included among engineering services are foundation borings and explorations, field layout and inspection, design of permanent structures and equipment, engineering for relocations, and preparation of plans for site landscaping (page 248).

Executive and administrative costs total $2,383,115.13 and consist of the Kingston project's proportion of the total general administration of the Tennessee Valley Authority (page 248).

Other general costs amount to $1,408,072.99 and cover such items as surveys for basic controls, basic hydrographic and meteorologic data, reservoir water temperature studies, general project investigations and studies, materials and equipment purchasing expense, safety and public health engineering, personnel and training services, and construction medical expense (page 249).

All the foregoing costs (indirect, design and construction engineering, executive and administrative, and other general costs) have been distributed to their related direct construction costs. The detail summary, page 212 of this report, shows these costs as they have been applied to subproject accounts.

Transferred depreciation in the amount of $27,541.84 applies to depreciation accumulated on certain items of permanent equipment at the time of their transfer to Kingston from other projects (page 249).

Estimates to complete total $76,900.00 and cover the estimated cost of preparing the final cost report; completion of corrections to design drawings; and the preparation of the final project report (page 249).

Various statements of cost details are presented in the following schedules.

TABLE 31.—*Final project cost—general summary*

Account	Description	Amount
	STEAM PRODUCTION PLANT	
10	Land and land rights	$ 1,150,053.66
11	Structures and improvements	34,730,801.49
12	Boiler plant equipment	83,782,210.33
14	Turbogenerator units	56,268,656.41
15	Accessory electric equipment	11,611,079.46
16	Miscellaneous power plant equipment	2,126,699.59
		$189,669,500.94
	TRANSMISSION PLANT	
42	Structures and improvements	1,045,153.21
43	Station equipment	7,415,621.07
		8,460,774.28
	GENERAL PLANT	
78	Communication equipment	174,016.57
		174,016.57
		198,304,291.79
Deduct:		
	Accumulated depreciation on permanent equipment transferred from other projects	27,541.84
	Estimate to complete—contra	76,900.00
	Total	$198,199,849.95

TABLE 32.—*Final project cost—detail summary.*

	Item	Land costs	Construction costs: Direct	Construction costs: Indirect	Total Land and construction costs	Distributive general expense: Design and construction engineering	Distributive general expense: Executive and administrative	Distributive general expense: Other general	Total
	STEAM PRODUCTION PLANT								
	Land and land rights								
100	Purchase price of land	$757,505.28	$ 11,307.45	$ 210.12	$ 769,022.85	$ 346.98	$ 145.99	$ 86.26	$ 769,602.08
101	Expense of land and privilege acquisition	59,242.38	—	—	59,242.38	—	728.96	430.70	60,402.04
104	Relocating highways and highway bridges	95,228.28	125,124.01	2,325.12	222,677.41	3,839.57	1,804.33	1,066.10	229,387.41
107	Relocating other structures and improvements	—	80,193.28	1,490.19	81,683.47	7,238.03	1,094.15	646.48	90,662.13
		911,975.94	216,624.74	4,025.43	1,132,626.11	11,424.58	3,773.43	2,229.54	1,150,053.66
	Structures and improvements								
110	Access roads for permanent use	—	395,195.41	7,343.72	402,539.13	12,127.02	5,102.33	3,014.73	422,783.21
111	General preparation of site	—	38,396.95	713.51	39,110.46	1,178.25	495.74	292.92	41,077.37
112	General yard improvements	—	2,181,080.95	40,529.91	2,221,610.86	66,928.94	28,159.72	16,638.28	2,333,337.80
113	Powerhouse	—	27,575,999.81	512,430.72	28,088,430.53	846,200.80	356,030.98	210,362.32	29,501,024.63
114	Control building	—	441,279.61	8,200.07	449,479.68	13,541.17	5,697.32	3,366.28	472,084.45
116	Miscellaneous buildings	—	792,037.61	14,718.03	806,755.64	24,304.57	10,225.92	6,042.02	847,328.15
118	Water front improvements	—	1,040,528.68	19,335.61	1,059,864.29	31,929.80	13,434.16	7,937.63	1,113,165.88
		—	32,464,519.02	603,271.57	33,067,790.59	996,210.55	419,146.17	247,654.18	34,730,801.49
	Boiler plant equipment								
120	Boilers and accessories	—	28,708,889.67	533,482.63	29,242,372.30	880,964.81	370,657.61	219,004.52	30,712,999.24
121	Draft equipment	—	11,002,388.41	204,451.76	11,206,840.17	337,620.76	142,050.74	83,931.24	11,770,442.91
122	Feed water equipment	—	6,335,072.36	117,721.42	6,452,793.78	194,398.87	81,791.49	48,326.83	6,777,310.97
123	Coal handling and storing facilities	—	9,629,882.55	178,947.19	9,808,829.74	295,503.86	124,330.46	73,461.14	10,302,125.20
124	Fuel burning equipment	—	5,505,500.80	102,305.91	5,607,806.71	168,942.53	71,080.97	41,998.47	5,889,828.68
125	Ash handling equipment	—	4,134,390.88	76,827.27	4,211,218.15	126,868.47	53,378.71	31,539.02	4,423,004.35
126	Water supply and treating systems	—	1,681,491.38	31,246.30	1,712,737.68	51,598.47	21,709.57	12,827.18	1,798,872.90
128	Boiler plant boards, instruments, and controls	—	2,951,000.15	54,836.93	3,005,837.08	90,554.78	38,100.07	22,511.58	3,157,003.51
129	Boiler plant piping	—	8,366,569.28	155,471.68	8,522,040.96	256,737.66	108,019.94	63,824.01	8,950,622.57
		—	78,315,185.48	1,455,291.09	79,770,476.57	2,403,190.21	1,011,119.56	597,423.99	83,782,210.33
	Turbogenerator units								
140	Turbogenerators	—	41,622,789.53	773,455.04	42,396,244.57	1,277,242.46	537,387.69	317,517.64	44,528,392.36
141	Circulating water system	—	5,617,559.11	104,388.23	5,721,947.34	172,381.17	72,527.75	42,853.31	6,009,709.57
142	Condensers and auxiliaries	—	4,082,068.61	75,854.99	4,157,923.60	125,262.90	52,703.18	31,139.88	4,367,029.56
143	Central lubricating system	—	89,077.58	1,655,28	90,732.86	2,733.44	1,150.07	679.53	95,295.90
144	Turbine plant boards, instruments, and controls	—	443,539.04	8,242.06	451,781.10	13,610.50	5,726.49	3,383.52	474,501.61
145	Turbine plant piping	—	364,989.96	6,782.42	371,772.38	11,200.13	4,712.35	2,784.31	390,469.17
146	Auxiliary equipment for generators	—	292,490.71	5,435.21	297,925.92	8,975.41	3,776.32	2,231.25	312,908.90
149	Other turbine plant equipment	—	84,453.80	1,569.36	86,023.16	2,591.56	1,090.37	644.25	90,349.34
		—	52,596,968.34	977,382.59	53,574,350.93	1,613,997.57	679,074.22	401,233.69	56,268,656.41
	Accessory electric equipment								
151	Switchgear	—	1,604,256.72	29,811.08	1,634,067.80	49,228.44	20,712.40	12,238.00	1,716,246.64
152	Switchboards	—	3,340,275.28	62,070.63	3,402,345.91	102,500.13	43,152.96	25,481.15	3,573,453.15
153	Protective equipment	—	260,131.27	4,833.89	264,965.16	7,982.42	3,358.53	1,984.40	278,290.51
154	Electrical structures	—	478,752.58	8,896.41	487,648.99	14,691.07	6,181.13	3,652.14	512,173.33
155	Conduit work	—	2,068,140.86	38,431.21	2,106,572.07	63,463.24	26,701.56	15,776.72	2,212,513.59
156	Power and control wiring	—	1,974,042.54	36,682.62	2,010,725.16	60,575.73	25,486.67	15,058.90	2,111,846.46
159	Station service equipment	—	1,127,824.62	20,957.79	1,148,782.41	34,608.58	14,561.23	8,603.56	1,206,555.78
		—	10,853,423.87	201,683.63	11,055,107.50	333,049.61	140,127.48	82,794.87	11,611,079.46
	Miscellaneous power plant equipment								
162	Station maintenance equipment	—	600,197.99	11,153.17	611,351.16	18,417.76	7,749.10	4,578.58	642,096.60
165	Cranes and hoisting equipment	—	518,228.91	9,629.98	527,858.89	15,902.44	6,690.80	3,953.29	554,405.42
166	Compressed air and vacuum cleaning systems	—	297,560.82	5,529.42	303,090.24	9,130.99	3,841.78	2,269.93	318,332.94
169	Other miscellaneous equipment	—	571,938.74	10,628.05	582,566.79	17,550.59	7,384.24	4,363.01	611,864.63
		—	1,987,926.46	36,940.62	2,024,867.08	61,001.78	25,665.92	15,164.81	2,126,699.59
	Total steam production plant	911,975.94	176,434,647.91	3,278,594.93	180,625,218.78	5,418,874.30	2,278,906.78	1,346,501.08	189,669,500.94

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TABLE 32.—*Final project cost—detail summary*—Continued.

Item	Land costs	Construction costs: Direct	Construction costs: Indirect	Total Land and construction costs	Distributive general expense: Design and construction engineering	Distributive general expense: Executive and administrative	Distributive general expense: Other general	Total
TRANSMISSION PLANT								
Structures and improvements								
422 General yard improvements	—	$ 254,000.31	$ 4,719.96	$ 258,720.27	$ 7,794.29	$ 3,279.37	$ 1,937.63	$ 271,731.56
424 Outdoor substation structure	—	722,953.72	13,434.28	736,388.00	22,184.65	9,333.98	5,515.02	773,421.65
	—	976,954.03	18,154.24	995,108.27	29,978.94	12,613.35	7,452.65	1,045,153.21
Station equipment								
431 Switchgear	—	2,454,954.51	45,619.16	2,500,573.67	75,333.06	31,695.68	18,727.52	2,626,329.93
432 Switchboards	—	418.62	7.78	426.40	12.85	5.40	3.19	447.84
433 Protective equipment	—	210,224.90	3,906.50	214,131.40	6,450.99	2,714.19	1,603.69	224,900.27
435 Conduit work	—	156,636.90	2,910.70	159,547.60	4,806.58	2,022.32	1,194.90	167,571.40
436 Power and control wiring	—	362,821.51	6,742.13	369,563.64	11,133.59	4,684.35	2,767.77	388,149.35
438 Main conversion equipment	—	3,631,567.27	67,483.56	3,699,050.83	111,438.76	46,886.80	27,703.25	3,885,079.64
439 Station service equipment	—	115,107.23	2,138.98	117,246.21	3,532.19	1,486.15	878.09	123,142.64
	—	6,931,730.94	128,808.81	7,060,539.75	212,708.02	89,494.89	52,878.41	7,415,621.07
Total transmission plant	—	7,908,684.97	146,963.05	8,055,648.02	242,686.96	102,108.24	60,331.06	8,460,774.28
GENERAL PLANT								
Intersite communication plant								
378 Communication equipment	—	162,661.50	3,022.66	165,684.16	4,991.45	2,100.11	1,240.85	174,016.57
Total general plant	—	162,661.50	3,022.66	165,684.16	4,991.45	2,100.11	1,240.85	174,016.57
	911,975.94	184,505,994.38	3,428,580.64	188,846,550.96	5,666,552.71	2,383,115.13	1,408,072.99	198,304,291.79
Deduct:								
Accumulated depreciation on permanent equipment transferred from other projects	—	27,541.84	—	27,541.84	—	—	—	27,541.84
Estimated cost to complete the original project	—	2,000.00	47,000.00	49,000.00	11,000.00	—	16,900.00	76,900.00
	—	29,541.84	47,000.00	76,541.84	11,000.00	—	16,900.00	104,441.84
TOTALS	$911,975.94	$184,476,452.54	$3,381,580.64	$188,770,009.12	$5,655,552.71	$2,383,115.13	$1,391,172.99	$198,199,849.95

TVA-00020267

TABLE 33.—*Detailed land and direct construction costs.*

STEAM PRODUCTION PLANT

LAND AND LAND RIGHTS

Account	Description	Quantity	Unit	Rate	Amount
100	Purchase price of land: The land quantities and costs shown immediately following cover steam production plant site and access railway right-of-way purchased in fee simple and permanent access road and railway right-of-way easements acquired for the needs of the Kingston project.				
	Steam plant site, access railway right-of-way and employee housing land purchased in fee simple (146 tracts)	820.46	Acre	916.74	$752,145.28
	Access railway and road right-of-way permanent easements (14 tracts)	2.65	Acre	2,022.64	5,360.00
	Total purchase price of land and land rights	823.11	Acre	920.30	757,505.28
	Buildings acquired with the land, and which had to be removed to permit construction. Cost of demolition of such structures is shown below.				
	Demolition and removal of buildings				11,307.45
	Total account No. 100				768,812.73
101	Expense of land and privilege acquisition: Cost of acquiring land and land rights set forth in account No. 100 (823.11 acres)	160	Tract	370.26	59,242.38
	Total account No. 101				59,242.38
104	Relocating highways and highway bridges: Cost of relocation, adjustment, and realignment of sections of state, county, and tertiary roads.				
	Tennessee State highway No. 61				8,706.23
	Roane County highways				
	Swan Pond pike				188,554.75
	Jet Valley road				4,764.91
	Total Roane County highways				193,319.66
	Tertiary roads				18,326.40
	Total account No. 104				220,352.29
107	Relocating and protecting other structures and improvements:				
-0	Public utilities(power and telephone lines)				34,139.15
-4	Municipal facilities				
-40	City of Kingston water supply main				46,054.13
	Total account No. 107				80,193.28
	Total land and land rights				1,128,600.68

TABLE 33.—*Detailed land and direct construction costs*—Continued.

STEAM PRODUCTION PLANT—Continued

STRUCTURES AND IMPROVEMENTS

Account	Description	Quantity	Unit	Rate	Amount
110	Access roads for permanent use:				
-2	Grading roadway:				
-20	Clearing and grubbing	3.6	Acre	732.63	$ 2,637.48
-23	Excavation and fill				220,303.45
	Total account No. 110-2				222,940.93
-3	Surfacing:				
-30	Crushed stone shoulders	10,194	Square yard	0.27	2,770.73
-31	Stabilized base (6-inch)	20,712	Square yard	0.91	18,926.70
-33	Bituminous surfacing (5-inch penetration macadam)	17,141	Square yard	1.89	32,419.34
-35	Concrete pavement	3,571	Square yard	7.93	28,304.48
-36	Concrete curbs	2,451	Linear foot	8.00	19,616.58
	Total account No. 110-3				102,037.83
-4	Culverts (pipe)				33,111.07
-7	Slope protection and landscaping:				
-70	Crushed stone blanket	1,639	Ton	1.05	1,716.26
-71	Riprap or rock revetments	3,687	Cubic yard	1.25	4,601.58
-72	Seeding and sodding of slopes	24,594	Square yard	0.24	6,018.11
	Total account No. 110-7				12,335.95
-8	Guards and signs				20,459.47
-9	Maintain travel during construction				4,310.16
	Total account No. 110				395,195.41
111	General preparation of site	127.5	Acre	301.15	38,396.95
	Total account No. 111				38,396.95
112	General yard improvements:				
-0	Grading and landscaping:				
-00	General grading	953,913	Cubic yard	0.63	598,604.51
-01	Landscaping:				
-011	Planting (planting shrubbery and trees; and seeding and sodding)	157	Acre	1,070.22	168,025.26
	Total account No. 112-0				766,629.77
-1	Roads, sidewalks, bridges, and trestles:				
-10	Roadways, drives, and courts:				
-100	Concrete pavement (9-inch slab over 6-inch stabilized crushed stone base)	6,209	Square yard	13.38	83,066.22
-101	Other surfacing (surfacing: 85,352 sq yd 4- to 12-inch bituminous; 21,725 sq yd 6- to 9-inch crushed stone; and 9258 sq yd 6-inch slag)				212,078.78
-11	Sidewalks (concrete, 4607 sq yd)	879	Cubic yard	64.14	56,375.68
-12	Curbs (concrete)	13,336	Linear foot	10.84	144,579.21
-14	Bridges, trestles, and culverts:				
-141	Bridges (steel footbridge 26 by 5 feet)	1	Bridge		2,972.11
-142	Culverts (pipe)				4,904.70
-16	Railroad trackage	1.01	Mile	84,166.29	85,007.95
	Total account No. 112-1				588,984.65
-2	Retaining walls, fences, gates and railings:				
-21	Fences, gates, and railings (6917 feet 72-inch cyclone fence; 1900 feet steel plate guard rail; and 45 steel guard posts)				63,138.43

TABLE 33.—*Detailed land and direct construction costs*—Continued.

STEAM PRODUCTION PLANT—Continued

STRUCTURES AND IMPROVEMENTS—Continued

Account	Description	Quantity	Unit	Rate	Amount
112	General yard improvements—Continued				
-4	Water treating, pumping, and storing equipment:				
-40	Water treating plant				$ 1,633.75
-41	Pumping equipment				4,755.07
-42	Storing equipment (three 10,000- and one 5200-gallon steel tanks)				18,703.33
-43	Intake structure and supply lines				10,655.20
	Total account No. 112-4				35,747.35
-5	Water distribution system:				
-50	Raw water lines				188,786.56
-51	Treated water lines				37,073.28
	Total account No. 112-5				225,859.84
-6	Sewers and drainage systems:				
-60	Paved gutters				619.39
-61	Pipe lines (including trenching and backfill)				203,371.97
-62	Manholes and catch basins				38,238.15
-69	Common sanitary sewerage system:				
-690	Tanks (concrete: septic tank—24.5 by 13 by 13 feet and chlorine contact 9.5 by 10 by 10.5 feet)				14,650.12
-691	Piping				49,177.64
-692	Manholes	30	Manhole	400.49	12,014.57
-693	Treating system:				
-6930	Chlorinating building	1	Building		6,329.19
-6931	Equipment	1	Chlorinator		1,000.78
	Total account No. 112-6				325,401.81
-8	Miscellaneous structures:				
-80	Flagpole (steel, 80 feet)	1	Pole		3,564.52
-83	Project identification signs and markers				8,299.50
	Total account No. 112-8				11,864.02
-9	Lighting:				
-91	Feeder to Hydraulic Data Branch temperature installations				3,568.64
-92	Lighting cabinets				780.75
-93	Grounding				7,812.50
-95	Conduit work (steel 8666 lb and nonmetallic—32,372 lb)				61,381.50
-96	Cable				13,571.17
-98	Transformers (one 25-kw and one 15-kw constant current 480-v/6.6-amp; fifty-three 6.6-amp/120-v series multiple; and nine 7.5-kva, 440-220/110-v)				8,594.25
-99	Lighting towers, standards, fixtures, and lamps				67,746.27
	Total account No. 112-9				163,455.08
	Total account No. 112				2,181,080.95
113	Powerhouse				
-1	Diversion and care of water				183,923.04
-2	Excavation and backfill				
-27	Unclassified excavation	363,234	Cubic yard	1.31	475,656.71
-28	Backfilling	104,548	Cubic yard	2.29	239,510.70
	Total account No. 113-2				715,167.41

TABLE 33.—*Detailed land and direct construction costs*—Continued.

STEAM PRODUCTION PLANT—Continued

STRUCTURES AND IMPROVEMENTS—Continued

Account	Description	Quantity	Unit	Rate	Amount
113	Powerhouse—Continued				
-4	Substructure concrete				
-40	Concreting	160,023	Cubic yard	17.60	$2,815,743.39
-41	Formwork	904,515	Square foot	1.52	1,376,867.74
-42	Reinforcing steel	11,048	Ton	219.79	2,428,253.67
	Total account No. 113-4	160,023	Cubic yard	41.37	6,620,864.80
-5	Joints, stops, waterproofing, and drains				195,047.44
-6	Superstructure:				
-60	Superstructure concrete:				
-601	Concreting	1,617	Cubic yard	27.95	45,195.88
-602	Formwork	86,062	Square foot	0.88	75,760.56
-603	Reinforcing steel	117.23	Ton	699.41	81,991.74
	Total superstructure concrete	1,617	Cubic yard	125.51	202,948.18
-61	Structural steel frame	27,268.57	Ton	303.25	8,269,063.38
-62	Exterior walls				
-622	Combination walls				105,604.35
-627	Glass blocks	63,690	Block	1.42	90,465.88
-629	Metal siding	201,900	Square foot	2.26	455,687.68
-63	Roofing, flashing, and sheet metalwork				
-630	Precast concrete roof slabs	235,537	Square foot	0.81	189,994.98
-631	Metal roof deck	47,843	Square foot	1.07	51,253.94
-634	Concrete	564	Cubic yard	72.04	40,633.10
-636	Built-up roofing and flashing	303,195	Square foot	0.94	284,653.23
-64	Interior masonry and partitions				
-640	Structural tile	88.05	Thousand	742.83	65,406.31
-641	Brick work—all types	481.06	Thousand	222.36	106,968.98
-645	Sheet metal partitions				92,598.60
-647	Wire mesh partitions				2,146.05
-65	Doors, windows and millwork:				
-650	Doors				
-6500	Entrance swinging door assemblies				4,675.38
-6501	Overhead rolling door assemblies (two 20 by 27 feet, three 9 by 10 feet, and two 5 by 4 feet)				11,419.09
-6502	Folding gates				303.84
-6503	Hollow metal doors				65,299.51
-6504	Wood doors				22,608.15
-6505	Toilet stall doors				2,470.90
-6508	Fire doors				2,317.90
-651	Windows				
-6510	Aluminum sash				68,457.13
-6514	Other metal sash				6,998.14
-652	Millwork				193.72
-653	Curtains, shades, and blinds				2,141.35
-66	Wall and ceiling finish				
-660	Glazed tile—colored	87.58	Thousand	1,273.41	111,524.97
-662	Unglazed tile	210.20	Thousand	893.98	187,913.76
-663	Metal wall finish				145,217.66
-664	Marble work	2,232	Square foot	3.81	8,500.51
-665	Plastering, including lathing and furring	4,894	Square yard	11.76	57,544.49
-666	Wood paneling	1,422	Square foot	4.52	6,432.84
-667	Acoustical tile, including furring and supports	7,572	Square foot	0.64	4,853.53
-668	Metal ceiling	1,924	Square foot	1.80	3,460.39
-67	Floor finish				
-670	Cement	380,172	Square foot	0.92	349,422.15
-671	Master plate or other armored floors	23,180	Square foot	0.59	13,627.42
-672	Precast concrete floor slabs	10,274	Square foot	0.97	9,952.24
-673	Quarry tile	129,783	Square foot	1.53	198,757.79
-676	Rubber tile	18,035	Square foot	0.62	11,158.76

TABLE 33.—*Detailed land and direct construction costs*—Continued.

STEAM PRODUCTION PLANT—Continued

STRUCTURES AND IMPROVEMENTS—Continued

Account	Description	Quantity	Unit	Rate	Amount
113	Powerhouse—Continued				
-6	Superstructure—Continued				
-678	Rubber mats	3,099	Square foot	0.84	$ 2,601.02
-679	Terrazzo	14,554	Square foot	1.91	27,839.52
-68	Miscellaneous metalwork				
-681	Floor gratings	1,939.15	Ton	362.77	703,465.10
-682	Steel louvers	11,799	Square foot	6.44	75,965.41
-683	Aluminum louvers	4,287	Square foot	13.99	59,978.02
-685	Handrailing				248,860.63
-686	Miscellaneous aluminum work				17,691.53
-687	Bunker dust control plates				8,570.98
-688	Other miscellaneous metalwork	1,992.27	Ton	746.87	1,487,957.55
-689	Painting				115,971.17
-69	Painting, glazing, insulation, protection, and cleanup				
-690	Painting				963,558.85
-691	Glass and glazing	4,443	Square foot	1.90	8,420.01
-693	Insulation	10,694	Square foot	0.44	4,704.71
-699	Protection and cleanup				12,189.56
	Total account No. 113-6				14,990,450.34
-8	Service work:				
-80	Plumbing and drainage				
-800	Plumbing system				155,869.94
-801	Drainage system				765,163.56
-82	Heating, electric				4,492.04
-83	Ventilating systems				
-830	Conditioned air system				
-8300	Ducts, dampers, and grilles				171,528.51
-8301	Equipment and controls				69,417.26
-8302	Piping				7,390.12
-831	Non-conditioned air system				
-8310	Ducts, dampers, and grilles				953,489.31
-8311	Equipment and controls				342,085.35
-84	Heating, steam (two auxiliary steam generators complete with stacks and breeching; condensate pumps, tanks and controls; steam heating units and coils; and distribution piping for normal service from the main steam generators and emergency service from auxiliary steam generators)				965,941.72
-88	Elevators				
-881	Utility elevators (2000-lb capacity, 200-fpm, 118-ft travel)	2	Elevator	27,004.78	54,009.56
-882	Operators' elevator (1500-lb capacity, 300-fpm, 118-ft travel)	2	Elevator	28,804.51	57,609.02
-883	Freight elevator (6000-lb capacity, 150-fpm, 118-ft travel)	1	Elevator		50,996.94
-884	Service bay elevator (10,000-lb capacity, 30-fpm, 14-ft travel)	1	Elevator		9,855.34
-885	Dumbwaiter (500-lb capacity, 20-fpm, 14-ft travel)	1	Dumbwaiter		5,435.47
-89	Lighting				
-890	Control panels and cabinets				39,242.34
-891	Conduit work (steel)	327,050	Pound	2.05	668,842.80
-892	Wiring				128,841.57
-895	Fixtures, switches, and receptacles	13,729	Outlet	30.62	420,335.93
	Total account No. 113-8				4,870,546.78
	Total account No. 113				27,575,999.81

TABLE 33.—*Detailed land and direct construction costs*—Continued.

STEAM PRODUCTION PLANT—Continued

STRUCTURES AND IMPROVEMENTS—Continued

Account	Description	Quantity	Unit	Rate	Amount
114	Control Building				
-1	Diversion and care of water				$ 2,224.50
-2	Excavation and backfill (earth excavation 4655 cu yd— backfill 1184 cu yd)				11,148.00
-4	Concrete				
-40	Concreting	1,223	Cubic yard	19.63	24,010.62
-41	Formwork	22,193	Square foot	1.26	27,900.03
-42	Reinforcing steel	103.10	Ton	248.71	25,642.40
	Total account No. 114-4	1,223	Cubic yard	63.41	77,553.05
-5	Joints, stops, waterproofing and drains				1,612.47
-6	Superstructure				
-61	Structural steel frame	115.86	Ton	354.24	41,041.92
-62	Exterior walls				
-622	Combination walls				6,821.38
-626	Sills and coping—masonry or metal (metal)				258.55
-629	Metal siding	4,761	Square foot	2.34	11,133.79
-63	Roofing, flashing, and sheet metalwork				
-631	Metal roof deck	6,783	Square foot	1.49	10,117.48
-636	Built-up roofing and flashing	6,783	Square foot	1.00	6,762.82
-64	Interior masonry and partitions				
-640	Structural tile	6.54	Thousand	573.52	3,750.85
-641	Brick work—all types	24.57	Thousand	193.64	4,757.69
-643	Combination walls				1,145.48
-65	Doors, windows, and millwork				
-650	Doors				
-6500	Entrance swinging door assemblies				3,501.85
-6503	Hollow metal doors				5,274.73
-6504	Wood doors				5,296.91
-6505	Toilet stall doors				324.47
-651	Windows				
-6510	Aluminum sash				3,773.12
-6514	Other metal sash (steel)				2,770.11
-653	Curtains, shades, and blinds (venetian blinds)	380	Square foot	0.48	182.40
-66	Wall and ceiling finish				
-660	Glazed tile—colored	4.04	Thousand	880.26	3,556.24
-662	Unglazed tile	6.95	Thousand	1,070.46	7,439.72
-664	Marble work	515	Square foot	3.09	1,592.70
-665	Plastering, including lathing and furring	1,400	Square yard	17.64	24,702.98
-667	Acoustical tile	2,129	Square foot	0.39	822.90
-67	Floor finish				
-670	Cement	12,729	Square foot	1.38	17,522.69
-676	Rubber tile	4,983	Square foot	0.66	3,291.60
-678	Rubber mats	52	Square foot	0.54	28.18
-679	Terrazzo	1,425	Square foot	1.77	2,524.03
-68	Miscellaneous metalwork				42,368.48
-69	Painting, glazing, insulation, protection, and cleanup				11,700.93
	Total account No. 114-6				222,464.00
-8	Service work				
-80	Plumbing and drainage				
-800	Plumbing system				12,557.87
-801	Drainage system				9,845.47
-82	Heating, electric				5,784.93
-83	Ventilating systems				
-830	Conditioned air system				
-8300	Ducts, dampers, and grilles				33,744.65
-8301	Equipment and controls				12,280.96

TABLE 33.—*Detailed land and direct construction costs*—Continued.

STEAM PRODUCTION PLANT—Continued

STRUCTURES AND IMPROVEMENTS—Continued

Account	Description	Quantity	Unit	Rate	Amount
114	Control building—Continued				
-8	Service work—Continued				
-831	Nonconditioned air system				
-8310	Ducts, dampers, and grilles				$ 21,384.34
-8311	Equipment and controls				3,876.50
-86	Piping systems				
-860	Compressed air				948.98
-861	Raw water				1,997.49
-89	Lighting				
-890	Control panels and cabinets				1,239.88
-891	Conduit work	6,381	Pound	1.79	11,392.40
-892	Wiring				2,042.13
-895	Fixtures, switches, and receptacles	324	Outlet	28.34	9,181.99
	Total account No. 114-8				126,277.59
	Total account No. 114				441,279.61
116	Miscellaneous buildings:				
-0	Utility building:				
-01	Diversion and care of water				1,884.86
-02	Excavation and backfill				24,715.22
-04	Concrete	1,129	Cubic yard	57.84	65,297.63
-05	Joints, stops, waterproofing, and drains				526.43
-06	Superstructure				
-061	Structural steel frame	183.71	Ton	339.90	62,442.12
-062	Exterior walls				17,560.49
-063	Roofing, flashing, and sheet metal-work				
-0631	Metal roof decking	12,634	Square foot	1.18	14,913.07
-0636	Built-up roofing and flashing	12,485	Square foot	0.74	9,298.39
-064	Interior masonry and partitions				7,781.94
-065	Doors, windows, and millwork				
-0650	Doors				30,315.76
-0651	Windows				13,490.06
-0653	Curtains, shades, and blinds				143.14
-066	Wall and ceiling finish				37,352.87
-067	Floor finish				17,895.70
-068	Miscellaneous metalwork				32,914.58
-069	Painting, glazing, insulation, protection, and cleanup				12,901.72
-08	Service work				
-080	Plumbing and drainage				
-0800	Plumbing system				29,232.95
-0801	Drainage system				19,527.61
-082	Heating, electric				10,838.23
-083	Ventilating systems				
-0831	Nonconditioned air system				14,062.79
-086	Piping systems				
-0860	Compressed air system				25,013.70
-0861	Raw water system				5,542.39
-087	Fire protection system				1,524.15
-089	Lighting	210	Outlet	148.18	31,118.54
-09	Power and control system				
-092	Switchboards				14,960.45
-093	Grounding system				1,563.72
-095	Conduit work				45,439.30
-096	Power and control wiring				17,005.97
-098	Transformers (one 500-kva, 4160-480-v; one 50-kva, 480-220/110-v; one 37.5-kva, 480-220/110-v; one 10-kva, 480-220/110-v; and one voltage regulator, 4.8-kva, 480-v, 100-amp)				9,423.13
	Total account No. 116-0				574,686.91

TABLE 33.—*Detailed land and direct construction costs*—Continued.

STEAM PRODUCTION PLANT—Continued

STRUCTURES AND IMPROVEMENTS—Continued

Account	Description	Quantity	Unit	Rate	Amount
116	Miscellaneous buildings—Continued				
-1	Storage building No. 1:				
-11	Diversion and care of water				$ 266.69
-12	Excavation and backfill				7,429.21
-14	Concrete	541	Cubic yard	53.54	28,963.06
-16	Superstructure				
-161	Structural steel frame	114.72	Ton	280.05	32,126.77
-162	Exterior walls				14,574.08
-163	Roofing, flashing, and sheet metal-work	12,044	Square foot	0.88	10,562.52
-164	Interior masonry and partitions				2,730.72
-165	Doors, windows, and millwork				5,335.84
-168	Miscellaneous metalwork				6,156.21
-169	Painting, glazing, protection, and cleanup				6,558.14
-18	Service work				
-180	Plumbing and drainage				9,445.63
-182	Heating, electric				127.88
-189	Lighting	74	Outlet	205.14	15,180.16
-19	Power and control system				16,214.42
	Total account No. 116-1				155,671.33
-2	Fire extinguisher houses	3	House	2,521.22	7,563.67
-3	Guard shelter	1	Shelter		5,165.81
-4	Storage building No. 2:				
-42	Excavation and backfill				1,703.60
-44	Concrete	182	Cubic yard	45.99	8,369.85
-46	Superstructure (prefabricated steel)				18,113.85
-48	Service work				
-489	Lighting	38	Outlet	70.50	2,678.98
-49	Power and control system				6,716.45
	Total account No. 116-4				37,582.73
-7	Material storage rack—outdoor				11,367.16
	Total account No. 116				792,037.61
118	Water front improvements:				
-1	Diversion and care of water				68,935.87
-2	Excavation (unclassified)	299,001	Cubic yard	1.19	356,651.36
-3	Fill				
-30	Intake and discharge canals	204,412	Cubic yard	0.30	60,928.66
-31	Dike extension	110,817	Cubic yard	1.70	187,966.13
	Total account No. 118-3				248,894.79
-5	Docks (sheet steel pile cell—51-foot diameter)	1	Cell		17,339.40
-7	Miscellaneous structures:				
-70	Submerged dam (quarry-run limestone)	16,736	Ton	1.84	30,763.94
-71	Skimmer wall:				
-710	Piers (eight—reinforced concrete)	895	Cubic yard	196.82	176,153.97
-711	Precast concrete beams (forty-two 52.42 by 2.17 by 2.33 feet and sixty-three 52.42 by 1.75 by 1.58 feet)				71,215.79
	Total account No. 118-7				278,133.70

TABLE 33.—*Detailed land and direct construction costs*—Continued.

STEAM PRODUCTION PLANT—Continued

STRUCTURES AND IMPROVEMENTS—Continued

Account	Description	Quantity	Unit	Rate	Amount
118	Water front improvements—Continued				
-8	Slope protection:				
-81	Slag blanket	2,140	Cubic yard	2.71	$ 5,795.19
-82	Riprap	17,077	Ton	3.70	63,135.17
-83	Seeding and sodding				1,643.20
	Total account No. 118-8				70,573.56
	Total account No. 118				1,040,528.68
	Total structures and improvements				32,464,519.02

BOILER PLANT EQUIPMENT

Account	Description	Quantity	Unit	Rate	Amount
120	Boilers and Accessories:				
-1	Boilers, including integral economizers, superheaters, and reheaters: (Steam generator—units 1-4 radiant-reheat type, natural circulation design, single-drum, single-furnace, water-wall; complete with two-stage superheaters, interstage reheaters, and continuous-tube economizers; rated capacity 1,100,000 lbs steam per hour with pressure at the superheater outlet of 2025 psig and 1003°F temperature. Units 5-9 radiant-reheat type, controlled circulation design, single-drum, twin-furnace, water-wall; complete with two-stage superheaters, multistage reheaters, and continuous-tube economizers; rated capacity 1,280,000 lbs steam per hour with pressure at the superheater outlet of 2060 psig and 1053°F temperature)				25,945,935.49
-3	Forced circulation equipment:				
-30	Boiler water pumps (units 5-9, four per boiler—5080-gpm against 124-ft head, driven by 200-hp 4160-volt motors; complete with suction and discharge valves)	20	Pump	54,572.00	1,091,440.01
-31	Gland seal water system				
-310	Pumps (units 5-9—five 150-gpm against 157.6-ft static head, driven by 15-hp motor; and one spare pump with motor $4,016.25)				30,784.41
-312	Piping				126,254.04
	Total account No. 120-3				1,248,478.46
-8	Soot blower system: (retractable-type blowers: units 1-4, pneumatically operated, 56 per unit; units 5-9, electrically operated, 76 per unit)				1,492,430.86
-9	Air blast heaters:	18	Heater	1,224.71	22,044.86
	Total account No. 120				28,708,889.67
121	Draft equipment:				
-1	Forced draft system:				
-10	Duct work	1,110	Ton	1,606.07	1,782,740.77

TABLE 33.—*Detailed land and direct construction costs*—Continued.

STEAM PRODUCTION PLANT—Continued

BOILER PLANT EQUIPMENT—Continued

Account	Description	Quantity	Unit	Rate	Amount
121	Draft equipment—Continued				
-11	Fans (units 1-4—eight 200,000-cfm, driven by 450-hp 4160-volt motors; units 5-9—ten 270,000-cfm, driven by 700-hp 4160-volt motors; two spare stators—$13,287.28; and six spare bearings—$3,654.00)				$ 769,289.43
	Total account No. 121-1				2,552,030.20
-2	Induced draft system:				
-20	Duct work	2,214	Ton	1,424.99	3,154,937.46
-21	Fans (units 1-4—eight 290,000-cfm, driven by 1400-hp 4160-volt motors; units 5-9—ten 400,000-cfm, driven by 1750-hp 4160-volt motors; two spare wheels—$8,807.00; two spare shafts—$5,991.00; two spare stators—$63,439.66; and 13 spare bearings—$12,092.21)				1,650,127.91
	Total account No. 121-2				4,805,065.37
-4	Air preheaters (units 1-4—eight 80,900-sq ft heating surface; units 5-9—ten 114,400-sq-ft heating surface; one spare 7½-hp motor—$283.19; one spare 10-hp motor—$338.70; and two spare speed reducers—$2,865.73)				2,621,906.97
-5	Stacks (reinforced concrete, brick lined, one per unit: units 1-4—26-ft od at bottom, 16-ft 6-inch od at top, 250-feet high above ground; units 5-9—25-ft 5-inch od at bottom, 19-ft 3-inch od at top, 300-feet high above ground)				1,023,385.87
	Total account No. 121				11,002,388.41
122	Feed water equipment:				
-1	Deaerators (units 1-4—heater: horizontal, cylindrical, contact-tray type, capacity 1,012,940 lbs per hr; storage tank: horizontal, 11-ft diam by 42 feet 4 inches long. Units 5-9—heater: horizontal, cylindrical, contact-tray type, capacity 1,312,720 lbs per hr; storage tank: horizontal, 12-ft diam by 44 feet 8 inches long)				611,671.84
-2	Evaporators (units 1-4—evaporator: horizontal, 20,000 lbs per hr; preheater: vertical, deaerating-tray type, 26,070 lbs per hr. Units 5-9—evaporator: horizontal, 26,000 lbs per hr; preheater: vertical, deaerating-tray type, 36,185 lbs per hr)				198,941.03
-4	Feed water heaters (horizontal, U-tube, closed type: units 1-4—three high-pressure and three low-pressure heaters per unit; units 5-9—three high-pressure and four low-pressure heaters per unit)				1,904,982.10

TABLE 33.—*Detailed land and direct construction costs*—Continued.

STEAM PRODUCTION PLANT—Continued

BOILER PLANT EQUIPMENT—Continued

Account	Description	Quantity	Unit	Rate	Amount
122	Feed water equipment—Continued				
-6	Feed water pumps:				
-60	Boiler feed pumps (Units 1-4: three per boiler, 1102-gpm at 6075-ft tdh, driven by 2000-hp 4000-volt motor through fluid drive; one spare inner element—$12,750.00; and one spare oil pump—$1,170.00. Units 5-9: three per boiler, 1445-gpm at 6365-ft tdh, driven by 3000-hp 4000-volt motor through fluid drive; one spare inner element—$17,156.96; and one spare oil pump—$987.00)				$3,300,857.81
-61	Distilled water pumps (3-stage, 600-gpm at 360-ft tdh, driven by 75-hp motors)	9	Pump	5,359.05	48,231.42
-62	Drain pumps (Units 1-4: four condensate drain tank pumps, 125-gpm at 300-ft tdh, driven by 20-hp motors; four No. 5 and 6 heater drain pumps, 200-gpm at 275-ft tdh, driven by 25-hp motors; one spare No. 5 and 6 heater drain pump and motor as above—$730.49; four No. 7 heater drain pumps, 120-gpm at 320-ft tdh, driven by 20-hp motors; and one spare No. 7 heater drain pump and motor as above—$548.87. Units 5-9: five condensate drain tank pumps, 135-gpm at 300-ft tdh, driven by 20-hp motors; five No. 5 and 6 heater drain pumps, 195-gpm at 330-ft tdh, driven by 30-hp motors; one spare No. 5 and 6 heater drain pump and motor as above—$828.15; five No. 7 and 8 heater drain pumps, 260-gpm at 410-ft tdh, driven by 50-hp motor; and one spare No. 7 and 8 heater drain pump and motor as above—$996.98)				42,336.52
	Total account No. 122-6				3,391,425.75
-7	Heat exchangers (horizontal, shell and tube type, capacity 53,800,000-btu per hr)	9	Exchanger	6,609.02	59,481.18
-8	Tanks:				
-82	Distilled water cold wells (carbon brick lining only)	23,792	Square foot	5.00	118,968.91
-83	Condensate drain tanks (steel, 440-gal capacity)	9	Tank	1,349.95	12,149.59
-84	Heater drain tanks (flash tanks and level control reservoirs)				37,451.96
	Total account No. 122-8				168,570.46
	Total account No. 122				6,335,072.36
123	Coal handling and storing facilities:				
-1	Barge unloading equipment:				
-13	Towing winches (capstan-type, driven by 10-hp, 220/440-volt motor)	1	Winch		1,255.00
-2	Rail facilities:				
-21	Coal tracks	28.84	Mile	106,924.96	3,083,715.99

TABLE 33.—*Detailed land and direct construction costs*—Continued.

STEAM PRODUCTION PLANT—Continued

BOILER PLANT EQUIPMENT—Continued

Account	Description	Quantity	Unit	Rate	Amount
123	Coal handling and storing facilities—Cont.				
-2	Rail facilities—Continued				
-22	Track scale house	1	House		$ 25,364.06
-23	Track scales	1	Scale		17,933.65
-24	Truck scale house	1	House		14,649.98
-25	Truck scales	2	Scale	9,643.04	19,286.08
-26	Hopper buildings:				
-260	Hopper building No. 1:				
-2601	Diversion and care of water				8,084.55
-2602	Excavation and backfill (earth excavation 10,241 cu yd—backfill—3597 cu yd)				6,046.49
-2604	Concrete:				
-26040	Concreting	1,913	Cubic yard	25.70	49,166.50
-26041	Formwork	28,954	Square foot	2.32	67,100.39
-26042	Reinforcing steel	173.80	Ton	265.79	46,194.87
	Total concrete	1,913	Cubic yard	84.93	162,461.76
-2605	Joints, stops, waterproofing, and drains				3,576.94
-2606	Superstructure:				
-26061	Structural steel frame	86.25	Ton	440.46	37,989.63
-26062	Exterior walls				21,204.69
-26063	Roofing, flashing, and sheet metalwork	5,863	Square foot	2.19	12,826.01
-26064	Interior masonry and partitions				262.21
-26065	Doors, windows, and millwork				19,431.62
-26066	Wall and ceiling finish				13,957.24
-26067	Floor finish				2,882.93
-26068	Miscellaneous metalwork				28,402.11
-26069	Painting, glazing, and insulation				6,607.54
-2608	Service work:				
-26080	Plumbing and drainage				20,146.53
-26082	Heating, electric				2,455.82
-26083	Ventilating systems				15,222.61
-26086	Piping systems (compressed air and raw water)				6,978.46
-26089	Lighting	108	Outlet	140.58	15,183.13
	Total hopper building No. 1				383,720.27
-261	Hopper building No. 2:				
-2611	Diversion and care of water				10,817.57
-2612	Excavation and backfill (earth excavation 3306 cu yd—backfill 988 cu yd)				1,269.36
-2614	Concrete:				
-26140	Concreting	1,644	Cubic yard	26.58	43,699.74
-26141	Formwork	27,756	Square foot	2.52	70,221.54
-26142	Reinforcing steel	158.19	Ton	280.76	44,413.65
	Total concrete	1,644	Cubic yard	96.31	158,334.93
-2615	Joints, stops, waterproofing, and drains				5,547.69
-2616	Superstructure:				
-26161	Structural steel frame	53.93	Ton	489.03	26,373.46
-26162	Exterior walls				20,751.39
-26163	Roofing, flashing, and sheet metalwork	3,826	Square foot	1.98	7,574.69
-26165	Doors, windows, and millwork				12,807.61
-26166	Wall and ceiling finish				7,380.66
-26167	Floor finish				666.15
-26168	Miscellaneous metalwork				17,370.71
-26169	Painting, glazing, and insulation				3,527.74

TABLE 33.—*Detailed land and direct construction costs*—Continued.

STEAM PRODUCTION PLANT—Continued

BOILER PLANT EQUIPMENT—Continued

Account	Description	Quantity	Unit	Rate	Amount
123	Coal handling and storing facilities—Cont.				
-2	Rail facilities—Continued				
-2618	Service work:				
-26180	Plumbing and drainage				$ 11,841.13
-26182	Heating, electric				1,935.32
-26183	Ventilating systems				5,007.36
-26186	Piping systems (compressed air and raw water)				7,658.97
-26189	Lighting	90	Outlet	143.31	12,897.82
	Total hopper building No. 2				311,762.56
-27	Car dumpers (rotary type, 25 cars per hr at maximum car capacity of 70 tons)	2	Dumper	112,014.76	224,029.52
-29	Car thawing facilities (twenty 2-burner oil-fired thawing pits, one oil pumping unit, one air compressor, two oil-storage tanks, and accessories)				81,671.13
	Total account No. 123-2				4,162,133.24
-3	Crushing facilities:				
-30	Crusher building:				
-301	Diversion and care of water				6,649.03
-302	Excavation and backfill (earth excavation 6310 cu yd—backfill 1954 cu yd)				2,442.94
-303	Foundation preparation and treatment (pressure grouting)	548	Cubic foot	3.23	1,770.70
-304	Concrete:				
-3040	Concreting	1,634	Cubic yard	19.57	31,982.58
-3041	Formwork	8,994	Square foot	3.90	35,045.40
-3042	Reinforcing steel	169.07	Ton	222.29	37,582.52
	Total concrete	1,634	Cubic yard	64.02	104,610.50
-305	Joints, stops, waterproofing, and drains				2,962.30
-306	Superstructure:				
-3061	Structural steel frame	110.60	Ton	446.03	49,330.73
-3062	Exterior walls				24,502.31
-3063	Roofing, flashing, and sheet metalwork	4,964	Square foot	2.75	13,653.90
-3064	Interior masonry and partitions				4,202.85
-3065	Doors, windows, and millwork				13,228.77
-3066	Wall and ceiling finish				8,573.65
-3067	Floor finish				4,340.20
-3068	Miscellaneous metalwork				48,517.78
-3069	Painting, glazing, and insulation				9,468.08
-308	Service work:				
-3080	Plumbing and drainage				15,196.78
-3082	Heating, electric				9,220.50
-3083	Ventilating systems				13,505.36
-3086	Piping systems (compressed air and raw water)				4,983.80
-3089	Lighting	172	Outlet	143.75	24,725.16
	Total crusher building				361,885.34
-31	Crushing equipment (four Flextooth-type crushers, 500-tph capacity, driven by 250-hp 4000-volt motors; two spare stator coils—$3,753.27; and one spare rotor assembly—$3,768.64)				122,259.15
	Total account No. 123-3				484,144.49

TABLE 33.—*Detailed land and direct construction costs*—Continued.

STEAM PRODUCTION PLANT—Continued

BOILER PLANT EQUIPMENT—Continued

Account	Description	Quantity	Unit	Rate	Amount
123	Coal handling and storing facilities—Cont.				
-4	Conveying facilities:				
-41	Diversion and care of water				$ 14,202.20
-42	Excavation and backfill (earth excavation 58,519 cu yd—backfill 42,896 cu yd)				46,343.05
-43	Foundation preparation and treatment (steel pile)	14.08	Ton	605.64	8,527.43
-44	Concrete:				
-440	Concreting	9,119	Cubic yard	19.53	178,049.06
-441	Formwork	41,639	Square foot	4.32	179,988.09
-442	Reinforcing steel	663.87	Ton	244.23	162,140.23
	Total concrete	9,119	Cubic yard	57.04	520,177.38
-45	Joints, stops, waterproofing, and drains				29,492.12
-46	Structural steel	331.22	Ton	623.68	206,574.46
-47	Architectural work:				
-472	Exterior walls	30,348	Square foot	0.90	27,425.43
-473	Roofing and flashing				3,434.24
-474	Interior masonry and partitions				59.15
-475	Doors, windows, and millwork				2,773.85
-477	Floor finish (precast concrete walkway slabs)	12,766	Square foot	1.13	14,481.28
-478	Miscellaneous metalwork				53,581.14
-479	Painting and glazing				28,321.72
-48	Service work:				
-480	Plumbing and drainage (drainage)				21,197.73
-486	Piping systems (compressed air and raw water)				9,010.91
-489	Lighting	358	Outlet	91.23	32,661.83
-49	Conveyor equipment:				
-490	Conveyors (railway and truck unloading hopper to crushers, stocking out, reclaiming, and powerhouse service; maximum capacity 1000 tph; 12 flights having a total length of 5488 feet; 1851 feet of 54-inch belt and 9835 feet of 48-inch belt; complete with belt trippers, cleaners, scales, feeders, drives, and sampling facilities; four spare speed reducers—$10,402.25, and two spare sets of stator coils—$1,636.40)				1,135,721.09
-491	Dust collector systems:				
-4910	Crusher building	1	System		24,862.27
-4911	Powerhouse	18	System	5,927.70	106,698.58
-4912	Transfer point	1	System		18,160.58
-492	Hoppers:				
-4921	Reclaiming hoppers	4	Hopper	12,486.59	49,946.37
-4922	Car and truck unloading hoppers	3	Hopper	11,474.67	34,424.01
-493	Jib cranes (3-ton capacity, electric)	2	Crane	9,711.79	19,423.57
-494	Coal dust spraying system	1	System		2,699.07
	Total account No. 123-4				2,410,199.46
-5	Storage area:				
-50	Grading and surfacing:				
-500	Grading	1,359,761	Cubic yard	0.30	404,802.20
-501	Slag surfacing	60,267	Ton	1.66	99,811.02
-502	Low grade coal surfacing	32,770	Ton	3.82	125,094.29
-503	Furnace ash surfacing	41,415	Cubic yard	0.57	23,581.84
-504	Culvert (pipe)				1,031.61
-505	Stone surfacing	236	Ton	2.09	493.41
	Total account No. 123-5				654,814.37

TABLE 33.—*Detailed land and direct construction costs*—Continued.

STEAM PRODUCTION PLANT—Continued

BOILER PLANT EQUIPMENT—Continued

Account	Description	Quantity	Unit	Rate	Amount
123	Coal handling and storing facilities—Cont.				
-7	Miscellaneous coal handling buildings:				
-70	Truck sampler building:				
-702	Excavation and backfill (earth excavation 1225 cu yd—backfill 362 cu yd)				$ 8,029.13
-704	Concrete	266	Cubic yard	111.62	29,690.47
-705	Joints, stops, waterproofing and drains				89.26
-706	Superstructure:				
-7061	Structural steel frame	15.93	Ton	535.71	8,533.91
-7062	Exterior walls				5,634.47
-7063	Roofing, flashing, and sheet metalwork	1,172	Square foot	3.87	4,533.08
-7064	Interior masonry and partitions				1,342.04
-7065	Doors, windows, and millwork				7,328.84
-7066	Wall and ceiling finish				4,417.47
-7068	Miscellaneous metalwork				7,989.77
-7069	Painting, glazing, and insulation				3,641.06
-708	Service work:				
-7080	Plumbing and drainage				7,748.34
-7082	Heating, electric				1,968.07
-7083	Ventilating systems				6,030.05
-7086	Piping systems (compressed air)				899.55
-7089	Lighting	67	Outlet	130.88	8,769.00
	Total truck sampler building				106,644.51
-73	Dock service building (10 by 16 feet, skid mounted)				109.71
	Total account No. 123-7				106,754.22
-8	Power and control system:				
-80	Control boards for coal handling system				22,336.56
-81	Switchboards:				
-810	4160-volt auxiliary power board	1	Switchboard		52,797.14
-811	480-volt main auxiliary power board	1	Switchboard		31,586.58
-812	480-volt feeder boards "A" and "B"	2	Switchboard	12,598.65	25,197.30
-813	480-volt lighting, heating, and ventilating board	1	Switchboard		8,294.15
-814	480-volt feeder board, hopper building No. 2	1	Switchboard		7,752.69
-817	Power distribution cabinets	6	Cabinet	716.84	4,301.02
-819	Control centers				496.87
-84	Protective equipment:				
-842	Grounding system				20,874.56
-85	Conduit work:				
-851	Metallic conduit	162,803	Pound	1.09	176,718.74
-852	Nonmetallic conduit	91,710	Pound	0.37	33,769.30
-853	Conduit boxes				9,209.30
-854	Concrete envelopes	1,179	Cubic yard	35.62	41,998.61
-855	Manholes and covers	5	Manhole	2,134.52	11,572.60
-857	Plug receptacles	28	Outlet	32.26	903.34
-86	Power and control wiring				201,603.80
-87	Cable trays				6,741.07
-88	Feeder circuit to equipment				4,164.08
-89	Transformers:				
-890	Auxiliary power (two 1000-kva, 4160-480-v; three 100-kva, 4160/2400-480/240/120-v; two 75-kva, 4160/2400-480/240/120-v; two 37.5-kva 480-240/120-v; and one 10-kva, 2400-240/110-v)				24,667.83

Table 33.—*Detailed land and direct construction costs*—Continued.

STEAM PRODUCTION PLANT—Continued

Boiler Plant Equipment—Continued

Account	Description	Quantity	Unit	Rate	Amount
123	Coal handling and storage facilities—Cont.				
-8	Power and control system—Continued				
-89	Transformers—Continued				
-891	Lighting and heating (480-240/120-volt as follows: one 50-kva, two 25-kva, four 15-kva, and one 7.5-kva; one 480-120-v, 7.5-kva; and one 115/230-32-v, 2-kva)				$ 4,877.31
-893	Voltage regulators (4.8-kva, 480-v)	1	Regulator		784.66
	Total account No. 123-8				690,647.51
-9	Miscellaneous coal handling equipment:				
-90	Fueling facilities for mobile equipment (one 10,318-gal and one 2056-gal cylindrical steel tanks; two pumps and two dispensing units for diesel oil: one gasoline dispensing unit; and four islanders)				21,872.84
-91	Additional gasoline storage tank (one 8000-gal cylindrical steel tank)				4,104.08
-99	Mobile equipment (one diesel towboat; three 120-ton and three 80-ton diesel locomotives; one 60-ton mobile crane with 6-cu-yd clamshell bucket; one rubber-tired tractor-scraper unit; five rubber-tired tractor units; three crawler tractor-bulldozer units; and five rubber-tired scraper units)				1,093,957.34
	Total account No. 123-9				1,119,934.26
	Total account No. 123				9,629,882.55
124	Fuel burning equipment:				
-1	Pulverizer fuel equipment:				
-11	Pulverizers (units 1-4 four per boiler, units 5-9 six per boiler—bowl mill type, 35,600-lb per hr capacity, driven by 350-hp 4160-volt motors; one spare motor—$15,396.04; one spare set stator coils— $2,431.25; and two spare shafts with integral worm gears—$2,622.18)				3,878,880.69
-12	Coal valves (units 1-4 four per boiler, units 5-9 six per boiler)	46	Valve	611.33	28,121.09
-13	Automatic weighing devices (units 1-4 four per boiler, units 5-9 six per boiler)	46	Scale	4,295.73	197,603.48
-14	Raw and pulverized coal transport ducts (units 1-4—sixteen 20-inch-od downspouts from scales to pulverizers and 4397-lin-ft 11-inch-id coal and air transport piping with accessories from exhausters to burners; units 5-9 thirty 20-inch-od downspouts from scales to pulverizers and 6200-lin-ft 12-inch-id coal and air transport piping with accessories from exhausters to burners)				412,361.64
-15	Burners, lighters, and fuel oil system				
-150	Burners and lighters (units 1-4—sixteen burners, units 5-9—forty burners; each with one ignition oil control panel and associated piping to burners)				817,755.27

TABLE 33.—*Detailed land and direct construction costs*—Continued.

STEAM PRODUCTION PLANT—Continued

BOILER PLANT EQUIPMENT—Continued

Account	Description	Quantity	Unit	Rate	Amount
124	Fuel burning equipment—Continued				
-1	Pulverizer fuel equipment—Continued				
-15	Burners, lighters, and fuel oil system—Continued				
-151	Lighter fuel oil system:				
-1510	Storage tanks (steel, cylindrical, 12,536-gal capacity)	6	Tank	4,258.65	$ 25,551.92
-1511	Pumps (rotary type, 35-gpm, driven by 5-hp 220/440-volt motors)	3	Pump	1,074.52	3,223.57
-1512	Piping				65,536.14
-18	Pyrites removal system				76,467.00
	Total account No. 124-1				5,505,500.80
	Total account No. 124				5,505,500.80
125	Ash handling equipment:				
-2	Storage area (grading, diking, drainage, and surfacing)				135,414.53
-3	Bottom ash disposal system:				
-30	Collecting and handling equipment (units 1-4—four hoppers, four clinker grinders driven by 10-hp 220/440-volt motors, and four hydro-ejectors; units 5-9—ten hoppers, ten clinker grinders driven by 10-hp 220/440-volt motors, and ten hydro-ejectors)	14	Assembly	30,934.82	433,087.44
-31	Disposal piping:				
-310	Piping:				
-3100	Pipe inside powerhouse (10-inch chrome-iron alloy)	2,613	Linear foot	76.56	200,040.61
-3101	Pipe outside powerhouse (10-inch steel)	8,600	Linear foot	9.47	81,420.97
-311	Pipe trenches (1197 cu yd concrete, 44.6 tons grating, timber supports, and 119 tons riprap)				120,567.03
-32	Water supply system (five pumps, 2600-gpm at 1000-ft head, driven by 900-hp, 4160-volt motors; pipe and accessories; and one spare set stator coils—$3,430.28)				384,477.69
	Total account No. 125-3				1,219,593.74
-6	Fly ash disposal system:				
-60	Collecting and handling equipment:				
-600	Electrostatic precipitators (one per boiler: units 1-4—2-unit collectors, 49,500 sq ft collecting area, capacity 490,000-cfm flue gas at 330°F; units 5-9—4-unit collectors, 71,200 sq ft collecting area, capacity 680,000-cfm flue gas at 330°F)				1,597,378.88
-601	Mechanical collectors (cyclone type: units 1-4—eight with flue gas capacity of 239,000-cfm at 305°F; units 5-9—ten with flue gas capacity of 310,000-cfm at 295°F)				640,934.09
-603	Handling equipment (pipe, valves, slide gates, and hydrovactors)				287,314.10

TABLE 33.—*Detailed land and direct construction costs*—Continued.

STEAM PRODUCTION PLANT—Continued

BOILER PLANT EQUIPMENT—Continued

Account	Description	Quantity	Unit	Rate	Amount
125	Ash handling equipment—Continued				
-6	Fly ash disposal system—Continued				
-61	Ash disposal piping:				
-610	Piping inside powerhouse (2027 lin ft 8- and 10-inch chrome-iron alloy)				$ 60,362.92
-611	Piping outside powerhouse (8800 lin ft 8- and 10-inch steel)				76,145.59
-62	Water supply system (four pumps, 1925-gpm at 520-ft head, driven by 350-hp 4160-volt motors; and pipe with accessories)				117,247.03
	Total account No. 125-6				2,779,382.61
	Total account No. 125				4,134,390.88
126	Water supply and treating systems:				
-1	Raw water system:				
-10	Pumps (units 1-4—four 2500-gpm at 175-ft head, driven by 150-hp 440-volt motors; units 5-9—six 4000-gpm at 175-ft head, driven by 250-hp 440-volt motors)				56,369.01
-11	Tanks (steel, elevated, 50,000-gal capacity)	1	Tank		27,651.44
-12	Piping, including hose, hose racks, and cabinets				937,248.91
	Total account No. 126-1				1,021,269.36
-4	Purification and treating system:				
-40	Structure:				
-401	Diversion and care of water				2,484.65
-402	Excavation and backfill (earth excavation 2146 cu yd—backfill 325 cu yd)				3,382.71
-404	Concrete:				
-4040	Concreting	1,682	Cubic yard	24.80	41,712.59
-4041	Formwork	12,955	Square foot	4.11	53,238.81
-4042	Reinforcing steel	156.8	Ton	240.04	37,638.55
	Total concrete	1,682	Cubic yard	78.83	132,589.95
-405	Joints, stops, waterproofing, and drains				3,936.38
-406	Superstructure:				
-4061	Structural steel frame	73.68	Ton	273.97	20,186.04
-4062	Exterior walls				15,136.03
-4063	Roofing, flashing, and sheet metalwork	3,144	Square foot	2.26	7,096.83
-4064	Interior masonry and partitions				2,417.42
-4065	Doors, windows, and millwork				19,331.72
-4066	Wall and ceiling finish				25,265.70
-4067	Floor finish				7,885.96
-4068	Miscellaneous metalwork				23,119.42
-4069	Painting, glazing, and insulation				9,280.37
-408	Service work:				
-4080	Plumbing and drainage				12,496.11
-4082	Heating, electric				7,579.61
-4083	Ventilating systems (nonconditioned air)				8,077.70
-4089	Lighting	139	Outlet	162.65	22,608.64
	Total structure				322,875.24

TABLE 33.—*Detailed land and direct construction costs*—Continued.

STEAM PRODUCTION PLANT—Continued

BOILER PLANT EQUIPMENT—Continued

Account	Description	Quantity	Unit	Rate	Amount
126	Water supply and treating systems—Cont.				
-4	Purification and treating system—Cont.				
-41	Filter plant equipment—primary (four 10-inch 240-gpm pumps; four filter rate controllers; four chemical feeders; and piping integral to system)				$ 67,044.19
-42	Softeners and accessories (one Zeolite softening system; pumps—four 160-gpm at 65-foot head, four 160-gpm at 320-foot head, two 250-gpm at 55-foot head, and two 15-gpm at 30-foot head; two 4-inch flowmeters; and piping integral to system)				89,484.56
-43	Chemical treating system—secondary (pumps: four 74-gph at 2300-psi, four 66-gph at 2300-psi, six 6-gph at 700-psi, five 4-gph at 150-psi, and two ½- to 5-gph; 14 steel tanks 25- to 500-gal capacity; and integral piping system)				133,961.42
	Total account No. 126-4				613,365.41
-5	Gland seal water system:				
-50	Pumps (single stage, 150-gpm, driven by 15-hp motors)	5	Pump	1,272.36	6,361.78
-51	Tanks (steel, cylindrical, 634-gal capacity)	3	Tank	1,085.24	3,255.73
-52	Piping				37,239.10
	Total account No. 126-5				46,856.61
	Total account No. 126				1,681,491.38
128	Boiler plant boards, instruments, and controls:				
-0	Control equipment (facilities for automatic and manual control and instrumentation of boiler plant combustion, superheat, draft, feed water, and heater drains)				2,099,400.46
-1	Isolated recording gages, meters, and instruments				43,147.47
-2	Compressed air equipment (control air) (units 1-4—two 440-cfm compressors driven by 100-hp 440-volt motors, and two 286-cu-ft air receivers; units 5-9—two 657-cfm compressors driven by 125-hp 440-volt motors, and two 286-cu-ft air receivers)				59,471.56
-3	Control and instrument piping and tubing				691,199.66
-4	Camera cooling equipment:				
-40	Equipment (two 400-cfm turbocompressors with filters, driven by 10-hp motors; and fourteen 12-inch fans driven by ¾-hp motors)				7,948.78
-41	Duct work (insulated steel duct, 28 air filters, and accessories)				49,832.22
	Total account No. 128-4				57,781.00
	Total account No. 128				2,951,000.15

TABLE 33.—*Detailed land and direct construction costs*—Continued.

STEAM PRODUCTION PLANT—Continued

BOILER PLANT EQUIPMENT—Continued

Account	Description	Quantity	Unit	Rate	Amount
129	Boiler plant piping: (Installed for the unit boiler steaming and feed water cycles and consisting of main, auxiliary, and extraction steam lines; condensate, feed water, blowdown, and acid cleaning lines; and associated drains)				$ 8,366,569.28
	Total account No. 129				8,366,569.28
	Total boiler plant equipment				78,315,185.48

TURBOGENERATOR UNITS

Account	Description	Quantity	Unit	Rate	Amount
140	Turbogenerators:				
-0	Foundations:				
-00	Concrete:				
-000	Concreting	14,438	Cubic yard	16.63	240,058.54
-001	Formwork	85,193	Square foot	3.87	329,924.06
-002	Reinforcing steel	1,656.93	Ton	229.69	380,582.21
-01	Miscellaneous steel and iron (rails, plates, anchors, sleeves, curbs, and frames)	75.72	Ton	407.56	30,860.54
	Total account No. 140-0	14,438	Cubic yard	67.98	981,425.35
-1	Turbogenerators and accessories (Each unit operates with initial steam conditions at the throttle of 1000°F and 1800 psig with reheat to 1000°F for units 1-4, of 1050°F and 1800 psig with reheat to 1050°F for units 5-9, all units exhausting at 2 inches of mercury absolute back pressure; capabilities are 150,000 kw for units 1-4 and 200,000 kw for units 5-9. All turbines are tandem-compound, triple-flow exhaust, condensing, with reheat; units 1-4 are 44-stage and units 5-9 are 24-stage. Generators for units 1-4 are 18-kv, those for units 5-9 are 20-kv; and all are 3600-rpm, hydrogen cooled, with direct connected main exciters. Auxiliaries consist of unit lubricating and governor oil systems and hydrogen cooling facilities. Included are one spare 3-part turbine spindle—$434,207.56, one spare 3-part turbine spindle—$714,000.00, one spare generator field rotor—$340,000.00, and two spare exciter rotors—$27,400.00.)				40,641,364.18
	Total account No. 140				41,622,789.53
141	Circulating water system:				
-1	Intake structure:				
-11	Diversion and care of water				10,988.69
-12	Excavation and backfill (earth and unclassified excavation 44,044 cu yd—backfill 13,841 cu yd)				74,628.98
-14	Concrete:				
-140	Concreting	10,970	Cubic yard	19.30	211,690.82
-141	Formwork	142,904	Square foot	1.31	187,376.26

TABLE 33.—*Detailed land and direct construction costs*—Continued.

STEAM PRODUCTION PLANT—Continued

TURBOGENERATOR UNITS—Continued

Account	Description	Quantity	Unit	Rate	Amount
141	Circulating water system—Continued				
-1	Intake structure—Continued				
-142	Reinforcing steel	755.78	Ton	245.22	$185,332.86
	Total concrete	10,970	Cubic yard	53.27	584,399.94
-15	Joints, stops, waterproofing, and drains				6,244.92
-16	Superstructure:				
-165	Doors, windows, and millwork				270.47
-168	Miscellaneous metalwork				72,818.85
-169	Painting, glazing, and insulation				7,689.18
-18	Service equipment:				
-180	Plumbing and drainage				18,356.60
-182	Heating, electric				4,951.48
-183	Ventilating systems				6,715.54
-186	Piping systems (compressed air and raw water)				6,934.97
-189	Lighting	143	Outlet	96.99	13,869.58
	Total account No. 141-1				807,869.20
-2	Pumping and regulating equipment:				
-20	Main supply pumps:				
-200	Circulating water pumps (units 1-4—eight pumps, 48,500-gpm at 22.25-ft tdh, driven by 350-hp 4160-volt motors; units 5-9—ten pumps 65,500-gpm at 21.65 ft tdh, driven by 450-hp 4160-volt motors; one set spare parts for 48,500-gpm pump—$6,800.00; one set spare parts for 65,500-gpm pump—$4,350.00; and one set spare stator coils for 450-hp motor—$6,412.45)				955,606.26
-202	Main valves (hydraulically operarted, solenoid-controlled—units 1-4 eight 36-inch cone valves, units 5-9 ten 60-inch butterfly valves)				238,040.39
-204	Piping				123,483.50
-205	Tanks (hydro-pneumatic, steel, cylindrical, 380-gal capacity)	2	Tank	541.16	1,082.32
-21	Traveling screens:				
-210	Screens	18	Screen	17,861.10	321,499.76
-211	Screen washing facilities:				
-2110	Pumps (1400-gpm at 240-ft head, driven by 125-hp 440-volt motors)	6	Pump	4,698.46	28,190.73
-2111	Piping				27,968.88
-2112	Wash water disposal sluiceway (concrete pipe, manholes, and steel sluice trough)				38,112.98
-22	Gates and appurtenances:				
-200	Trashracks (eighteen 3-section racks 12 feet 8 inches wide by 7 feet high, 18 sets of trashrack guides, and one trash rake)				51,420.20
-221	Sluice gates (five 8-foot-sq and twelve 12-inch-diam)				65,231.65
-222	Stop logs (two 2-section stop logs and 36 sets of guides)				118,828.60
-23	Cranes and hoists:				
-230	Crane (15-ton traveling gantry)	1	Crane		52,454.37

TABLE 33.—*Detailed land and direct construction costs*—Continued.

STEAM PRODUCTION PLANT—Continued

TURBOGENERATOR UNITS—Continued

Account	Description	Quantity	Unit	Rate	Amount
141	Circulating water system—Continued				
-2	Pumping and regulating equipment—Continued				
-23	Cranes and hoists—Continued				
-231	Crane track (60-lb rail)	600	Linear foot	11.02	$ 6,614.00
	Total account No. 141-2				2,028,533.64
-3	Supply lines:				
-30	Concrete pipe fabrication (2294 lin ft 78-inch pipe and 5399 lin ft 96-inch pipe)				525,954.46
-31	Diversion and care of water				57,469.26
-32	Excavation and backfill (earth and unclassified excavation 130,477 cu yd—backfill 39,121 cu yd)				239,884.12
-34	Concrete:				
-340	Intake conduits:				
-3400	Concreting	2,507	Cubic yard	17.03	42,697.98
-3401	Formwork	16,591	Square foot	2.27	37,709.38
-3402	Reinforcing steel	131.91	Ton	244.15	32,205.86
	Total intake conduit concrete	2,507	Cubic yard	44.92	112,613.22
-35	Joints, stops, and drains				12,634.77
-36	Laying pipe				192,363.62
	Total account No. 141-3				1,140,919.45
-4	Condenser connections (units 1-4—sixteen 54-inch-diam inlet and outlet pipe sections with expansion joints and sixteen 54-inch motor-operated butterfly valves with 4-inch bypass and drain lines; units 5-9—twenty 60-inch-diam inlet and outlet pipe sections with expansion joints and twenty 60-inch motor-operated butterfly valves with 4-inch bypass and drain lines)				339,758.66
-5	Discharge lines:				
-50	Concrete pipe:				
-500	Pipe fabrication 3572 lin ft 78-inch pipe and 2165 lin ft 96-inch pipe)				383,104.02
-501	Laying pipe				59,456.96
-51	Diversion and care of water				50,888.19
-52	Excavation and backfill (unclassified excavation 124,587 cu yd—backfill 101,779 cu yd)				342,438.36
-54	Concrete:				
-540	Discharge structure:				
-5400	Concreting	755	Cubic yard	15.93	12,027.36
-5401	Formwork	5,571	Square foot	1.26	7,041.84
-5402	Reinforcing steel	21.41	Ton	255.60	5,472.47
	Total discharge structure concrete	755	Cubic yard	32.51	24,541.67
-541	Discharge pipe continuous cradle:				
-5410	Concreting	10,543	Cubic yard	13.04	137,516.24
-5411	Formwork	6,108	Square foot	2.29	13,987.91
-5412	Reinforcing steel	0.82	Ton	250.18	205.15
	Total discharge pipe continuous cradle concrete	10,543	Cubic yard	14.39	151,709.30
-542	Discharge conduits:				
-5420	Concreting	2,911	Cubic yard	16.63	48,406.93
-5421	Formwork	15,468	Square foot	2.94	45,435.75

TABLE 33.—*Detailed land and direct construction costs*—Continued.

STEAM PRODUCTION PLANT—Continued

TURBOGENERATOR UNITS—Continued

Account	Description	Quantity	Unit	Rate	Amount
141	Circulating water system—Continued				
-5	Discharge lines—Continued				
-54	Concrete—Continued				
-542	Discharge conduits—Continued				
-5422	Reinforcing steel	160.48	Ton	243.73	$ 39,113.42
	Total discharge conduit concrete	2,911	Cubic yard	45.67	132,956.10
-55	Joints, stops, and drains				11,846.20
-56	Gates and other metalwork (one single-section stop log, nine sets of guides, and 122 lin ft of pipe handrailing)				22,701.81
	Total account No. 141-5				1,179,642.61
-6	Water treating system:				
-60	Structure:				
-602	Excavation and backfill				3,123.53
-604	Concrete	107	Cubic yard	152.58	16,325.63
-605	Joints, stops, waterproofing, and drains				147.45
-606	Superstructure				22,084.94
-608	Service work				9,591.92
-61	Treating equipment (two solution feed chlorinators and two liquid chlorine evaporators with appurtenances)				26,267.01
-62	Solution piping				43,295.07
	Total account No. 141-6				120,835.55
	Total account No. 141				5,617,559.11
142	Condensers and auxiliaries (components include: one horizontal single-pass surface condenser per unit with divided water boxes using cooling water at 75°F temperature and operating at a back pressure of 2 inches mercury vacuum absolute, capacity of units 1-4—685,000 pph steam with 60,000-sq-ft surface area, capacity of units 5-9—920,000 pph steam with 80,000-sq-ft surface area; two condensate pumps per unit—units 1-4—1700-gpm at 370-ft head driven by 250-hp 4160-volt motors, and units 5-9—2250-gpm at 470-ft head driven by 400-hp 4160-volt motors; one 2-stage, twin-element, steam jet air pump per unit with 72 pph capacity; one single-stage, noncondensing, primary air ejector per unit; air removal piping, and appurtenances.)				4,082,068.61
	Total account No. 142				4,082,068.61
143	Central lubricating system:				
-1	Treating and pumping equipment (one stationary purifying unit, one portable purifying unit, one clean oil transfer pump, and nine dirty oil transfer pumps)				25,489.76
-2	Tanks (steel, vertical, cylindrical, with immersion heaters and accessories—two 5760-gal capacity and two 2000-gal capacity)				7,572.08

TABLE 33.—*Detailed land and direct construction costs*—Continued.

STEAM PRODUCTION PLANT—Continued

TURBOGENERATOR UNITS—Continued

Account	Description	Quantity	Unit	Rate	Amount
143	Central lubricating system—Continued				
-3	Piping				$ 41,957.62
-4	Oil in storage	14,674	Gallon	0.96	14,058.12
	Total account No. 143				89,077.58
144	Turbine plant boards, instruments, and controls:				
-0	Control equipment (facilities for automatic and manual control and instrumentation of the turbogenerator units)				368,085.72
-3	Control and instrument piping and tubing				75,453.32
	Total account No. 144				443,539.04
145	Turbine plant piping:				
-6	Drip, drain, and vent				364,989.96
	Total account No. 145				364,989.96
146	Auxiliary equipment for generators:				
-0	Excitation panels, switches, and rheostats (units 1-4—four rheostatic type cubicles; units 5-9—five amplidyne type cubicles)				89,692.08
-2	Central hydrogen cooling system:				
-20	Structures:				
-200	Excavation and backfill				767.37
-201	Structure concrete	216	Cubic yard	72.64	15,689.85
-202	Roof and floor drains				940.70
-203	Structure supports and enclosures				9,586.46
-204	Fire protection system				3,616.16
-205	Electrical work				12,067.02
-21	Hydrogen piping system:				
-210	Piping				117,091.11
-211	Valve boxes				3,856.75
-212	Secondary control stations	5	Station	2,161.88	10,809.38
-29	Hydrogen transport facilities (mobile gas storage and supply trailers each with 38 cylinders or tubes and accessories and a capacity of 49,000 cu ft of gas)	2	Trailer	14,186.92	28,373.83
	Total account No. 146-2				202,798.63
	Total account No. 146				292,490.71
149	Other turbine plant equipment:				
-1	Gland seal water system:				
-10	Pumps (125 to 140-gpm driven by 10-hp 220/440-volt motor)	4	Pump	1,290.58	5,162.30
-11	Tanks (steel, cylindrical, 634-gal capacity)	4	Tank	1,946.26	7,785.05
-12	Piping				46,994.84
	Total account No. 149-1				59,942.19
-4	Vacuum priming system:				
-40	Pumps (units 1-4—two 130-cfm driven by 10-hp 220/440-volt motors; units 5-9—two 136-cfm driven by 10-hp 220/440-volt motors)	4	Pump	1,820.03	7,280.13

TABLE 33.—*Detailed land and direct construction costs*—Continued.

STEAM PRODUCTION PLANT—Continued

TURBOGENERATOR UNITS—Continued

Account	Description	Quantity	Unit	Rate	Amount
149	Other turbine plant equipment—Cont.				
-4	Vacuum priming system—Continued				
-41	Tanks (steel, cylindrical, 23-cu-ft capacity)	2	Tank	797.80	$ 1,595.60
-42	Piping				15,635.88
	Total account No. 149-4				24,511.61
	Total account No. 149				84,453.80
	Total turbogenerator units				52,596,968.34

ACCESSORY ELECTRIC EQUIPMENT

Account	Description	Quantity	Unit	Rate	Amount
151	Switchgear:				
-1	Assembled switchgear:				
-12	Assembled main switchgear—job assembly:				
-121	Housing (steel)	9	Housing	34,314.52	308,830.69
-122	Bus, insulators, and insulator hardware				184,922.82
-123	Equipment				85,538.11
-15	Assembled neutral switchgear—purchased assembly	9	Cubicle	10,946.73	98,520.54
	Total account No. 151-1				677,812.16
-2	Station service switchgear connections:				
-21	4160-volt bus work				926,444.56
	Total account No. 151				1,604,256.72
152	Switchboards:				
-1	Control boards and terminal cabinets:				
-10	Main control boards and terminal cabinets (main bench, instrument, relay, and recording instrument boards for generating station and switchyard)				671,768.21
-11	Condenser circulating water pump control board	1	Switchboard		27,343.85
	Total account No. 152-1				699,112.06
-2	4160-volt auxiliary power boards:				
-21	Units boards	9	Switchboard	143,465.77	1,291,191.90
-22	Common boards	2	Switchboard	136,289.19	272,578.38
	Total account No. 152-2				1,563,770.28
-3	480-volt auxiliary power boards:				
-30	Powerhouse boards:				
-300	Unit boards	9	Switchboard	44,716.59	402,449.35
-301	Common boards	2	Switchboard	52,550.77	105,101.54
-302	Service bay boards:				
-3020	Main board	1	Switchboard		15,534.64
-3021	Air conditioning board	1	Switchboard		14,285.52
-3022	Ventilating board	1	Switchboard		5,157.82
-304	Turbine room ventilating boards	9	Switchboard	7,658.47	68,926.19
-305	Boiler room ventilating boards	5	Switchboard	8,162.12	40,810.59
-306	Chemical feed boards:				
-3060	Board No. 1	1	Switchboard		6,782.15
-3061	Board No. 2	1	Switchboard		6,761.87
-307	Oil purification board	1	Switchboard		5,653.80
-308	Raw water boards:				
-3080	Board No. 1	1	Switchboard		39,927.75
-3081	Board No. 2	1	Switchboard		41,634.10

TABLE 33.—*Detailed land and direct construction costs*—Continued.

STEAM PRODUCTION PLANT—Continued

ACCESSORY ELECTRIC EQUIPMENT—Continued

Account	Description	Quantity	Unit	Rate	Amount
152	Switchboards—Continued				
-3	480-volt auxiliary power boards—Cont.				
-30	Powerhouse boards—Continued				
-309	Precipitator boards	9	Switchboard	3,565.82	$ 32,092.41
-32	Control building boards:				
-320	Main board	1	Switchboard		19,291.06
-321	Air conditioning board	1	Switchboard		6,473.95
-34	Water treatment plant boards:				
-340	Main board	1	Switchboard		28,376.48
-341	Feeder board	1	Switchboard		21,424.61
-39	Chlorination building board	1	Switchboard		2,971.48
	Total account No. 152-3				863,655.31
-4	220-volt auxiliary power boards:				
-40	Lighting and heating boards—powerhouse	5	Switchboard	7,933.56	39,667.82
-41	Lighting and heating board—control building	1	Switchboard		3,810.83
-42	Heating, ventilating, and lighting board—water treatment plant	1	Switchboard		9,152.76
	Total account No. 152-4				52,631.41
-5	Battery boards:				
-50	Powerhouse boards	3	Switchboard	15,065.64	45,196.92
-51	Control building board	1	Switchboard		25,015.68
	Total account No. 152-5				70,212.60
-6	Signal system boards				49,439.88
-7	Power distribution cabinets				29,555.00
-9	Other switchboard equipment:				
-90	Load indicator board	1	Switchboard		4,038.95
-91	Isolated instrument transformers				4,199.74
-92	Isolated circuit breakers				2,291.53
-93	Control centers				1,368.52
	Total account No. 152-9				11,898.74
	Total account No. 152				3,340,275.28
153	Protective equipment:				
-1	Grounding system				238,792.12
-4	Resistors and reactors				21,339.15
	Total account No. 153				260,131.27
154	Electrical structures:				
-2	Cable tunnels:				
-21	Water treatment plant pipe cable tunnel:				
-210	Excavation and backfill (earth excavation 2842 cu yd—backfill 2142 cu yd)				7,494.90
-211	Concrete pipe (78-inch reinforced)	424.6	Linear foot	70.32	29,859.99
-213	Lighting system	38	Outlet	49.75	1,890.52
	Total water treatment plant pipe cable tunnel				39,245.41
-22	Control building pipe cable tunnel:				
-220	Excavation and backfill (earth excavation 1536 cu yd—backfill 1447 cu yd)				4,113.49
-221	Concrete pipe (78-inch reinforced)	220	Linear foot	57.97	12,753.24
-223	Lighting system	19	Outlet	61.17	1,162.27
	Total control building pipe cable tunnel				18,029.00

TABLE 33.—*Detailed land and direct construction costs*—Continued.

STEAM PRODUCTION PLANT—Continued

ACCESSORY ELECTRIC EQUIPMENT—Continued

Account	Description	Quantity	Unit	Rate	Amount
154	Electrical structures—Continued				
-2	Cable tunnels—Continued				
-23	Control building rectangular cable tunnel:				
-230	Excavation and backfill (earth excavation 1644 cu yd—backfill 1063 cu yd)				$ 3,697.48
-231	Concrete (7 by 10 feet inside)	548	Cubic yard	61.55	33,731.65
-233	Lighting system	15	Outlet	67.63	1,014.50
	Total control building rectangular cable tunnel				38,443.63
	Total account No. 154-2				95,718.04
-5	Cable trays (asbestos cement with steel supports)				383,034.54
	Total account No. 154				478,752.58
155	Conduit work:				
-1	Metallic conduit (rigid steel—1,471,873 lb, flexible steel—12,581 lb)				1,915,200.40
-2	Nonmetallic conduit	44,875	Pound	0.57	25,594.93
-3	Conduit boxes				85,328.56
-4	Concrete envelopes	628	Cubic yard	42.73	26,834.11
-7	Plug receptacles	374	Outlet	40.60	15,182.86
	Total account No. 155				2,068,140.86
156	Power and control wiring:				
-1	Control auxiliary power, and excitation wiring—4160-volt and under				1,974,042.54
	Total account No. 156				1,974,042.54
159	Station service equipment:				
-1	*Transformers:*				
-11	Auxiliary power transformers:				
-110	Unit station service (four 17.1-4.16-kv, 9000-kva self cooled, 11,250-kva forced-air cooled and five 19.0-4.16-kv, 12,000-kva self cooled, 16,000-kva forced-air cooled)				394,445.27
-111	Common station service (161-4.16-kv, 20,000-kva self cooled, 25,000-kva forced-air cooled)	2	Transformer	141,969.69	283,939.37
-112	Other auxiliary power (4160-480-volt: ten 1000-kva, nine 750-kva, and two 300-kva; 480-120/240-volt: one 50-kva, fifteen 7.5-kva, five 3-kva, and twenty-two 2-kva)				194,735.74
-12	Lighting (480-120/240-volt: twelve 167-kva, two 100-kva, one 75-kva, one 50-kva, one 15-kva, and forty-five 2-kva)				39,656.57
-13	Voltage regulators (480-volt: twelve 18-kva, two 12-kva, one 7.2-kva, and one 4.8-kva)				38,173.61
	Total account No. 159-1				950,950.56

TABLE 33.—*Detailed land and direct construction costs*—Continued.

STEAM PRODUCTION PLANT—Continued

ACCESSORY ELECTRIC EQUIPMENT—Continued

Account	Description	Quantity	Unit	Rate	Amount
159	Station service equipment—Continued				
-2	Batteries, charging equipment, and other motor generator sets (Batteries: four 250-volt, 120-cell; two 48-volt, 24-cell; one 46-volt, 23-cell. Seven service motor-generator sets with 30-kw, 250-volt d-c generator driven by 50-hp, 480-volt a-c motor. Four emergency motor-generator sets with tachometer generators and including the following: 18.5-kva, 120-volt a-c generator; 2/3-kw, 125-volt, 5.3-amp d-c generator; and 25-hp, 258-volt d-c drive motor. Two 48-volt d-c annunciator battery chargers; and one 50-volt d-c telephone battery charger.)				$ 176,874.06
	Total account No. 159				1,127,824.62
	Total accessory electric equipment				10,853,423.87

MISCELLANEOUS POWER PLANT EQUIPMENT

Account	Description	Quantity	Unit	Rate	Amount
162	Station maintenance equipment: (Installed milling and boring machines, lathes, saws, drills, grinders, shears, shapers, and presses; portable power driven tools and other relatively substantial portable items identified by TVA accountability tags; and the initial complement of expendable small tools)				600,197.99
	Total account No. 162				600,197.99
165	Cranes and hoisting equipment:				
-0	Bridge cranes:				
-00	Turbine room cranes				
-000	Cranes (90-ton main hoist and 25-ton auxiliary hoist)	2	Crane	165,614.32	331,228.63
-001	Crane track (175-lb)	887	Linear foot	21.88	19,406.45
-002	Collector rails	2,665	Linear foot	7.47	19,911.18
-01	Service bay crane (5-ton with 247 feet of rail, 120 feet of busway track, and one trolley)	1	Crane		10,415.02
-02	Utility building crane (5-ton with 239 feet of 40-lb rail and cable reel)	1	Crane		15,237.97
-03	Chlorination building crane:				
-030	Crane (2-ton)	1	Crane		6,664.03
-301	Crane runway				1,484.96
	Total account No. 165-0				404,348.24
-1	Gantry cranes (5-ton with 200 feet of 90-lb rail)	1	Crane		2,039.28
-3	Jib cranes (one 2-ton electric; one ¾-ton mobile; and one 2-ton and two ¼-ton manually operated)				7,041.18
-7	Hoists:				
-70	Electric (two 6-ton, one 5-ton, one 2-ton, one 1-ton, and one ¼-ton)				13,694.72

TABLE 33.—*Detailed land and direct construction costs*—Continued.

STEAM PRODUCTION PLANT—Continued

MISCELLANEOUS POWER PLANT EQUIPMENT—Continued

Account	Description	Quantity	Unit	Rate	Amount
165	Cranes and hoisting equipment—Cont.				
-7	Hoists—Continued				
-72	Chain (two 15-ton, one 10-ton, two 6-ton, two 3-ton, ten 2-ton, three 1-ton, and four ¼-ton; and thirteen 2-ton trolleys)				$ 5,964.25
-73	Untanking hoist (one 15-ton electric, with 240 lin ft of collector rail)				12,681.72
-79	Monorail beams, switches, and collector rails				20,871.84
	Total account No. 165-7				53,212.53
-9	Mobile cranes (one 20-ton and one 4-ton)				51,587.68
	Total account No. 165				518,228.91
166	Compressed air and vacuum cleaning systems:				
-0	Compressed air system:				
-01	Equipment (four 600-cfm compressors and four 286-cu-ft capacity receivers)				68,813.92
-02	Piping				133,375.77
-03	Portable compressors (one 100-cfm with 7 cu ft receiver)				3,595.07
	Total account No. 166-0				205,784.76
-1	Vacuum cleaning system:				
-10	Equipment (vacuum producer 15-hp, 450-cfm with 19.6-cu-ft primary collector and 7.8-cu-ft secondary collector)	2	Unit	4,181.03	8,362.05
-11	Piping				83,414.01
	Total account No. 166-1				91,776.06
	Total account No. 166				297,560.82
169	Other miscellaneous equipment:				
-0	Local communication system:				
-00	Cable				77,849.79
-01	Equipment (intrasite communication facilities consisting of automatic and manual telephone equipment and intercommunication and paging systems)				158,750.51
	Total account No. 169-0				236,600.30
-1	Fire extinguishing equipment:				
-10	Fire protection systems (CO_2: one 20-cylinder, one 12-cylinder, and one 2-cylinder banks)				16,460.52
-11	Portable fire extinguishers (CO_2 type: fifteen 100-lb wheeled, two-hundred ten 15 lb, and six 5 lb; dry chemical type: nine 150-lb wheeled, three 30-lb, one-hundred forty-eight 20-lb, and seventeen 4- to 10-lb; vaporizing liquid: seventy 1-gal and fifty-nine 1-qt)				27,259.87
-12	Hose carts	21	Cart	406.68	8,540.37
	Total account No. 169-1				52,260.76

TABLE 33.—*Detailed land and direct construction costs*—Continued.

STEAM PRODUCTION PLANT—Continued

MISCELLANEOUS POWER PLANT EQUIPMENT—Continued

Account	Description	Quantity	Unit	Rate	Amount
169	Other miscellaneous equipment—Cont.				
-2	Furniture and fixtures				$ 75,165.25
-3	Lockers, shelves, and cabinets				140,966.29
-4	Cleaning equipment				21,798.72
-5	Miscellaneous instruments				37,700.69
-7	Meteorological installations:				
-70	Structure (building—steel panel 5 feet 4 inches square by 7 feet high and 150-foot high steel tower)				2,673.57
-71	Equipment (one anemograph transmitter and recorder and one temperature recorder)				3,192.67
	Total account No. 169-7				5,866.24
-9	Equipment not otherwise classified:				
-92	Central oxygen and acetylene piping systems				1,580.49
	Total account No. 169				571,938.74
	Total miscellaneous power plant equipment				1,987,926.46

TABLE 33.—*Detailed land and direct construction costs*—Continued.

TRANSMISSION PLANT

STRUCTURES AND IMPROVEMENTS

Account	Description	Quantity	Unit	Rate	Amount
422	General yard improvements:				
-0	Grading and landscaping:				
-00	Grading	138,999	Cubic yard	0.30	$ 41,089.97
-02	Yard surfacing (crushed rock)	8,011	Ton	5.76	46,177.25
	Total account No. 422-0				87,267.22
-1	Drives, parking areas, and walks:				
-11	Walks (4-inch bituminous surfacing)	3,075	Square yard	3.15	9,674.07
-2	Retaining walls, fences, gates, and railings:				
-21	Fences, gates, and railings	3,287	Linear foot	10.82	35,578.78
-8	Drainage				14,575.52
-9	Water supply system				106,904.72
	Total account No. 422				254,000.31
424	Outdoor substation structure:				
-1	Foundations (for structures and equipment):				
-14	Concrete foundations	2,966	Cubic yard	88.96	263,868.42
-15	Transformer, support rails (591 feet 90-lb rail and 9 crossovers)	22.79	Ton	432.70	9,861.33
	Total account No. 424-1				273,729.75
-3	Superstructure (galvanized structural steel)	556.21	Ton	447.72	249,024.68
-6	Transformer tracks (1279 feet long including one switch and supporting concrete slab containing 323 cubic yards)				37,686.15
-7	Cable and pipe tunnel:				
-70	Excavation and backfill:				
-702	Unclassified excavation	7,895	Cubic yard	0.72	5,648.24
-708	Backfill	5,943	Cubic yard	1.72	10,228.43
-71	Tunnel structure:				
-710	Concrete	257	Cubic yard	95.96	24,660.48
-711	Concrete pipe (84-inch diameter)	772.9	Linear foot	65.38	50,533.34
-715	Joints and waterproofing				818.93
-72	Ventilating system				318.35
-73	Lighting system	74	Outlet	87.54	6,478.09
-75	Miscellaneous metalwork				890.63
-76	Masonry work				243.11
	Total account No. 424-7				99,819.60
-8	Miscellaneous structures:				
-80	Fire extinguisher houses	8	House	2,125.90	17,007.21
-9	Lighting:				
-90	Cabinets	7	Panelboard	939.27	6,574.87
-91	Conduit (steel)	21,499	Pound	1.09	23,405.03
-92	Wiring				5,425.82
-93	Fixtures, switches, and receptacles	213	Outlet	48.27	10,280.61
	Total account No. 424-9				45,686.33
	Total account No. 424				722,953.72
	Total structures and improvements				976,954.03

TABLE 33.—*Detailed land and direct construction costs*—Continued.

TRANSMISSION PLANT—Continued

STATION EQUIPMENT

Account	Description	Quantity	Unit	Rate	Amount
431	Switchgear:				
-1	Circuit breakers:				
-14	161-kv breakers (1600-amp, 10,000-mva interrupting capacity)	32	Breaker	57,774.92	$1,848,797.34
-2	Disconnecting switches:				
-24	161-kv disconnects (3-pole, gang operated: 57 manual and 10 motor-operated 1200-amp; and 8 manual and 14 motor-operated 2000 amp)				455,647.66
-3	Instrument transformers (24 potential 161-kv; and 9 current 400/200-5-amp)				150,509.51
	Total account No. 431				2,454,954.51
432	Switchboards:				
-7	Power distribution cabinets	1	Panelboard		418.62
	Total account No. 432				418.62
433	Protective equipment:				
-1	Lightning arresters and gaps (single-pole 145-kv for use on 161-kv neutral grounding)	33	Arrester	1,678.50	55,390.37
-2	Grounding system				82,066.32
-3	Guards, signs, locks, and keys				440.03
-4	Resistors and reactors (neutral grounding)	9	Reactor	8,036.46	72,328.18
	Total account No. 433				210,224.90
	Conduit work:				
435	Metallic conduit (steel)	139,772	Pound	0.58	80,588.82
-1	Nonmetallic conduit				10,166.66
-2	Conduit boxes				1,701.98
-3	Concrete envelopes	838	Cubic yard	75.98	63,671.30
-4	Plugs and receptacles	12	Outlet	42.35	508.14
-7					
	Total account No. 435				156,636.90

TABLE 33.—*Detailed land and direct construction costs*—Continued.

TRANSMISSION PLANT—Continued

STATION EQUIPMENT—Continued

Account	Description	Quantity	Unit	Rate	Amount
436	Power and control wiring:				
-1	Control and auxiliary power wiring—4160-volt and under				$ 129,581.09
-4	Bare conductors (copper cable—33,258 lb; aluminum tubing and bar—43,858 lb)				122,258.59
-5	Insulators and hardware				80,731.53
-7	Cable trays and supports (asbestos cement with steel supports)	9,420	Square foot	3.21	30,250.30
	Total account No. 436				362,821.51
438	Main conversion equipment:				
-1	Main step-up power transformers (3-phase, oil immersed, forced oil and air cooled: four 170,000-kva, 161,000-17,000-v; five 230,000-kva, 161,000-19,000-v; two spare pumping units—$1,974.00; seven spare cooler units—$11,640.27, and one lifting device with slings—$688.00)				3,631,567.27
	Total account No. 438				3,631,567.27
439	Station service equipment:				
-1	Station service transformers:				
-11	Lighting transformers (five 25-kva and two 15-kva, 440-220/110-v)				3,281.91
-6	Insulating oil system:				
-61	Piping				71,613.74
-62	Tanks (steel, 12,536-gal capacity)	3	Tank	4,285.50	14,476.51
-63	Oil treating and pumping equipment				14,301.78
-64	Oil in storage	14,496	Gallon	0.31	4,494.27
	Total account No. 439-6				104,886.30
-9	Equipment not otherwise classified:				
-95	Fire protective equipment:				
-952	Portable fire fighting equipment (eight hose carts and eight 150-lb wheeled dry chemical type extinguishers)				6,939.02
	Total account No. 439				115,107.23
	Total station equipment				6,931,730.94

TABLE 33.—*Detailed land and direct construction costs*—Continued.

GENERAL PLANT

INTERSITE COMMUNICATION PLANT

Account	Description	Quantity	Unit	Rate	Amount
378	Communication equipment:				
-2	Conductor, cable, conductor hardware, and protective devices:				
-22	Cable (9648 feet 2/C coaxial)				$ 5,306.22
-4	Station installations (power line and wire carrier transmitter-receiver facilities for intersite telephone, telemetering, load-frequency control, pilot relaying, and teletype service)				30,275.11
-5	Space radio equipment:				
-51	Broadcast stations:				
-511	Equipment (radio remote control console)				473.91
-52	Microwave radio stations:				
-520	Microwave house (structural steel frame sheet metal structure 10 feet by 8 feet 7 inches by 10 feet high, complete with electric lighting, heating, and ventilation)	1	Building		6,041.08
-521	Equipment (multiplexing, radio frequency, monitoring, and in-dial signaling facilities)				20,087.02
-522	Antenna assemblies (parabolic type mounted on unit No. 1 chimney and cable)				3,253.96
	Total account No. 378-5				29,855.97
-9	General service equipment:				
94	Coupling capacitors, line traps, and tuning units				97,224.20
	Total account No. 378				162,661.50
	Total intersite communication plant				162,661.50

TABLE 34.—*Indirect construction costs.*

Superintendence, accounting, and timekeeping: Salaries and expenses of the superintendent of construction and his immediate assistants in the field and office; salaries and expenses in connection with field accounting, timekeeping, and cost engineering; and proration of computer center operating costs applicable to the job	$1,754,224.94
Travel and subsistence: Personal transportation, per diem allowance and miscellaneous expense of personnel when in official travel status	66,113.98
Office supplies and expense: Miscellaneous expense of the field office including stationary and other office supplies; blueprints, photostats, and pictures; telephone and telegraph; and maintenance of office space including heat, light, and water	523,055.42
Camp operation: Cost of constructing employee village and dormitory facilities and equipment, and rehabilitation cost of existing dwellings; cost of commissary; and expense of employee library, recreational, and educational services; less revenue from rental and sale of dwellings and dormitories and operation of commissary	481,500.60
Police and guide service: Police and guide service maintained for the benefit of the project	542,366.07
Safety activities, public facilities and accommodation of guests : Assistance given the safety engineer and cost of safety signs, posters, and bulletins; minor expenses for damages or injuries involving nonemployees; and minor expenses for public facilities and accommodation of guests	13,301.39
Construction plant studies and design: Preliminary investigations, studies, and design of construction plant facilities; and estimates of construction schedules and costs	63,978.03
Insurance expense: Insurance expense paid by TVA for benefit of employees consisting of Federal Income Contribution Act prior to January 1, 1957, and Federal Employees Life Insurance and Blue Cross prior to July 1, 1957. Subsequent to these dates these costs are included in direct labor	53,333.36
Temporary access road: Cost of initial repair and surfacing of parts of Swan Pond Road to provide temporary access to the job for delivery of equipment and materials and for employee vehicular access to and from the job, and cost of maintaining the road until permanent access facilities were provided	11,382.39
Liquidated damages and other credits: Liquidated damages collected from contractors or vendors, and credits for percentages added to bills against vendors, contractors, and others for overhead charges on services by the Tennessee Valley Authority	(80,675.54)
Total indirect construction costs	3,428,580.64

( ) Credit

TABLE 35.—*Distributive general expense.*

DESIGN AND CONSTRUCTION ENGINEERING COSTS

Engineering—field and office: Salaries and expenses of project manager and his immediate assistants; field, executive, supervisory, and office engineers; concrete technicians and inspectors; and consultants. Cost of foundation investigation and engineering for horizontal and vertical control; and engineering for utility line relocations	$2,545,329.61
Design: Design of all structures, improvements, and equipment for the project, including preparation of specifications for material and equipment; and landscape planning and design at site	3,121,223.10
Total design and construction engineering	5,666,552.71

EXECUTIVE AND ADMINISTRATIVE COSTS

General administration: Proration to the Kingston project of its portion of general construction and operating expenses (principally supervision and general expenses of operating and construction divisions but excluding temporary field construction organizations) and administrative and general expenses (central administrative service divisions) that are relatively difficult to trace with assurance to the specific accounts or programs which benefit from the services performed. Distributions of these expenses is made each fiscal year according to studies of direction and extent of effort devoted to the various projects and programs	2,383,115.13
Total executive and administrative	2,383,115.13

TABLE 35.—*Distributive general expense*—Continued.

OTHER GENERAL COSTS

Personnel: Services of personnel representatives, interviewers, and clerical staff engaged in recruitment, placement, promotion, classification, service rating, and pay; promotion of desirable employee-management relationships; and conducting employee-in-service training and recreation programs	$210,632.49
Materials procurement: Proration and direct charges to the project of its portion of the total Division of Materials procurement expenses for services performed for the Division of Construction	383,392.87
Maps and surveys: Surveys for basic controls, preparation of topographic maps, staking out drill holes, and other preliminary investigations required in planning and preparation for construction of steam plant	43,610.16
General project investigations: General studies, investigations, and planning bearing on feasibility of project, selection of site, general plans, and layout; preliminary appraisal of site land values; quantity and cost estimates; inspections of geologic characteristics and foundation drillings; collection of meteorologic and hydrographic data; reservoir water temperature, flood, and steam plant location studies	187,532.93
Agricultural lands operations: Net income from agricultural and forest lands operation during the construction period	(105.00)
Construction medical services: Operation of medical center for treatment and care of employees claiming service-connected injuries, including preparation of compensation claims; employee placement and periodic physical examinations; treatment of minor illness occurring to employees while on duty; application of industrial hygiene protective and control measures; and service of safety and public health engineers	562,542.93
Final project report: Editing individual reports on planning, design, construction, cost, and initial operation of the project into one comprehensive report, including the preparation of additional drawings or illustrations and printing and binding	20,466.61
Total other general	1,408,072.99

( ) Credit

TABLE 36.—*Transferred depreciation and estimate to complete the original project.*

TRANSFERRED DEPRECIATION

Accumulated depreciation on permanent equipment transferred from other projects	($27,541.84)
Total	(27,541.84)

ESTIMATE TO COMPLETE THE ORIGINAL PROJECT(1)

Direct construction costs: Estimated cost of completing and testing the high pressure fire protection system	(2,000.00)
Indirect construction costs: Estimated cost of completing analysis of costs by accounts; reconciliation of accounting records with engineers' inventories; and preparation of construction cost report	(47,000.00)
Design and construction engineering: Estimated cost of completing the physical inventories of final installations and making final field revisions to "as constructed" drawings, and final revisions to design drawing tracings	(11,000.00)
Other general costs: Estimated cost of preparing the final project report, including editing of individual reports on planning, design, construction, cost, and initial operation of the project into one comprehensive report, including the preparation of illustrations, printing, and binding	(16,900.00)
Total	(76,900.00)

( ) Credit
(1) Contra debits are included in the appropriate schedules of direct and indirect construction, design and construction engineering, and other general costs.

TABLE 37.—*Details of indirect construction costs and certain distributive general expense by originating offices.*

Item	Project accounting office	Central accounting office	Total
INDIRECT CONSTRUCTION COSTS			
Superintendence	$ 297,819.82		
Accounting, cost engineering, and timekeeping	1,325,311.60		$1,754,224.94
Charges from other divisions	131,093.52		
Travel and subsistence	66,113.98		66,113.98
Office supplies and expense	523,055.42		523,055.42
Employee housing construction	439,301.37	$ 59,506.03	481,500.60
Credit from operation of employee housing and concessions		(17,306.80)	
Police and guide service		542,366.07	542,366.07
Safety activities	4,207.45		
Public liabilities	5,388.99		13,301.39
Public facilities and accommodation of guests	3,704.95		
Construction plant studies and design		63,978.03	63,978.03
Federal employee group life insurance	48,720.41		
Blue Cross	3,738.86		53,333.36
Federal income contribution act	874.09		
Temporary access road	11,382.39		11,382.39
Liquidated damages and other credits	(80,675.54)		(80,675.54)
Total	2,780,037.31	648,543.33	3,428,580.64
DISTRIBUTIVE GENERAL EXPENSE			
Engineering—field and office	2,532,839.68	4,777.21	
Consulting service	5,207.52		2,545,329.61
Tests and inspection	2,505.20		
Design		3,099,314.09	3,121,223.10
Site planning		21,909.01	
Total	2,540,552.40	3,126,000.31	5,666,552.71

( ) Credit

BIBLIOGRAPHY

This bibliography includes published material concerning the Kingston Steam Plant. The fact that a publication is included should not be interpreted as giving official endorsement or confirmation of its contents.

The bibliography is not intended to include references to all phases of TVA activities; however, these titles will enable the reader to obtain specific information on the Kingston Steam Plant. The Agricultural Index, Applied Science & Technology Index, Engineering Index, Reader's Guide to Periodical Literature, Public Affairs Information Service Bulletin, and Education Index, available in many public and educational libraries, will aid the reader in making his own reading list or in exploring any of the special phases of the TVA program.

The following indexes prepared by the TVA and available in many libraries throughout the United States and in some foreign countries will give the reader additional references to the TVA program: (1) Indexed Bibliography of the Tennessee Valley Authority; (2) A Bibliography for the TVA Program; (3) Congressional Hearings, Reports and Documents Relating to TVA.

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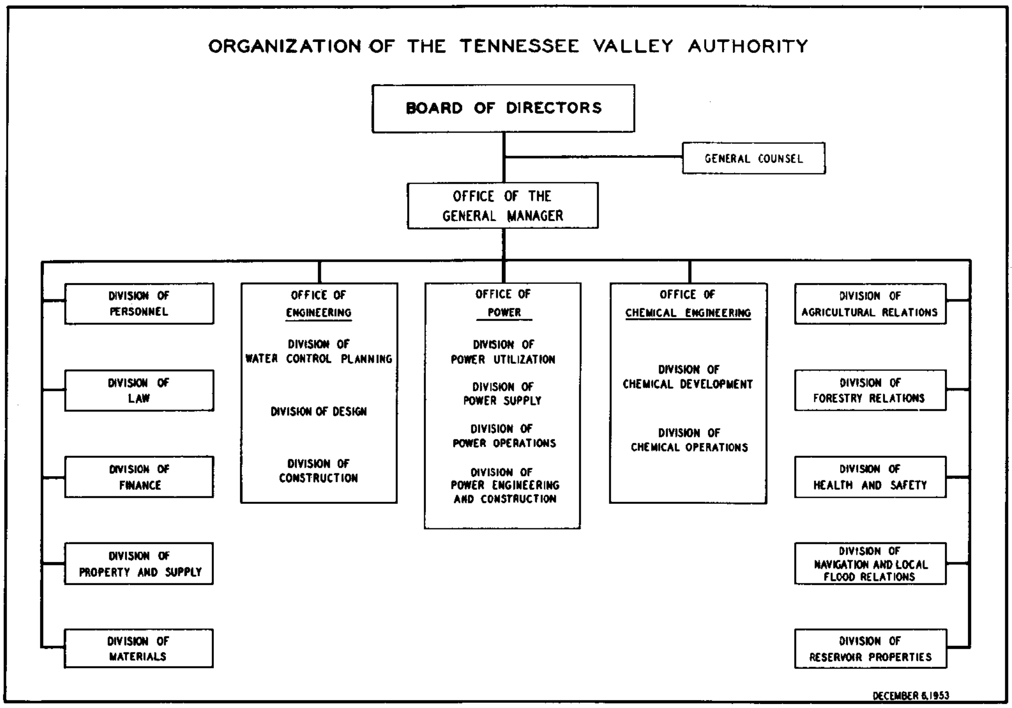
*TVA staff member or former staff member.



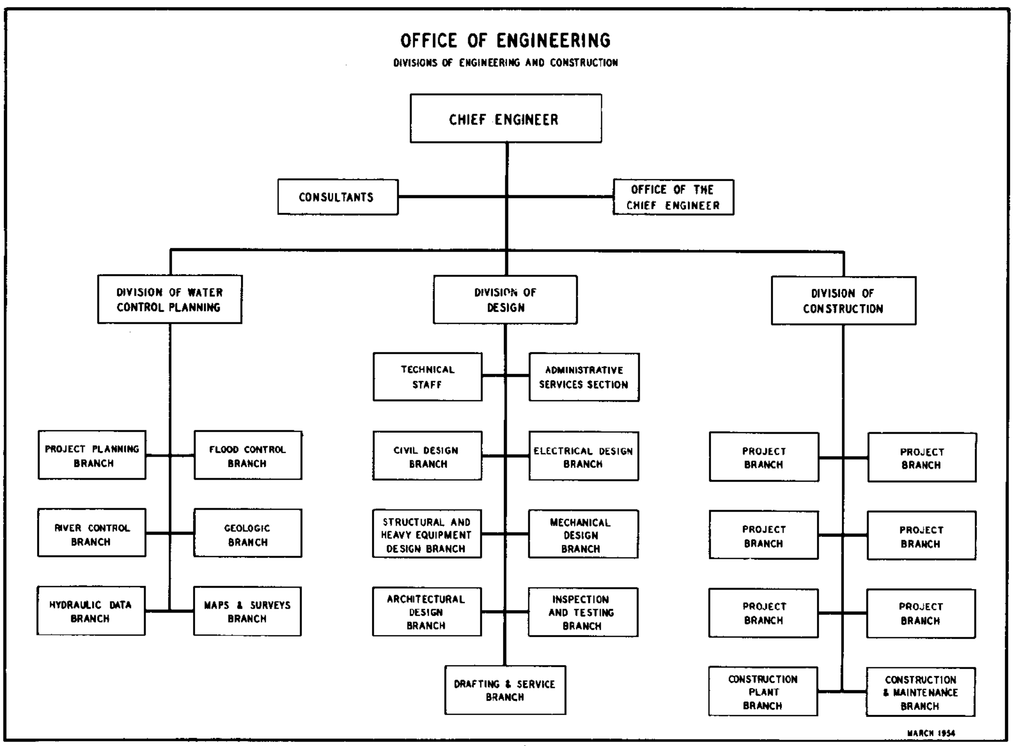


FIGURE 142.—*Organization charts of TVA and Office of Engineering which prevailed through most of the construction period of 1951 through 1955.*

APPENDIX A

PERSONNEL

The chart shown in figure 142 represents the organization of the Tennessee Valley Authority during the construction period of units 1-9 at the Kingston Steam Plant. In conformance with the outline of this chart, a limited list of key personnel is given which corresponds to the principal construction period —May 1951 to July 1956. Various changes in the organizational structure occurred during the construction period, and the arrangement shown is considered to be the most representative.

A more extensive list of supervisory personnel is given covering the divisions of the Office of Engineering since they had the responsibility for the planning, design, and construction of the project. It is regretted that space does not permit listing all persons who were identified with the project.

Project personnel relations are discussed in Chapter 5, Construction Services, because of their close association with construction operations.

Trades and labor rates of pay conclude this appendix.

BOARD OF DIRECTORS

GORDON R. CLAPP, *Chairman,* until May 1954
HERBERT D. VOGEL, *Chairman,* after August 1954

HARRY A. CURTIS, *Director*

RAYMOND R. PATY, *Director*

OFFICE OF THE GENERAL MANAGER

JOHN OLIVER, *General Manager,* until September 1954
AUBREY J. WAGNER, *General Manager,* after September 1954
Assistant, after November 1951
E. A. ACKERMAN, *Assistant,* August 1952 until December 1954
L. J. VAN MOL, *Assistant,* after December 1955

Budget Staff
JOHN H. CLARK, until January 1954
L. J. VAN MOL, after January 1954

Government Relations and Economics Staff[1]
L. L. DURISCH
S. H. ROBOCK

Information Staff
W. L. STURDEVANT, until July 1952
PAUL L. EVANS, after July 1952

Washington Staff
MARGUERITE OWEN

DIVISION OF PERSONNEL[2]

HARRY L. CASE, *Director*
L. J. VAN MOL, *Assistant,* until February 1954
FRANKLIN PITCHER, *Personnel Officer*

Personnel Services
L. J. VAN MOL, until April 1952
BRYANT W. RUTHVEN, after April 1952

Labor Relations
EDWIN B. SHULTZ

Training and Educational Relations
MILDRED TEASLEY, *Acting Chief,* until February 1952
RICHARD O. NIEHOFF, until October 1953

Employment
GLENN A. DOOLEY, until March 1952
E. A. SHELLEY, after March 1952
COY E. FULTON, *Kingston Area Personnel Officer*

1. Government Relations and Economics Staff was incorporated into General Manager's Office in December 1953 when the Division of Regional Studies was abolished.
2. Effective October 1953, the Division of Personnel consists of the following branches: Personnel Services, Labor Relations, and Employment. Training and Educational Relations Branch was abolished this same date.

DIVISION OF LAW

JOSEPH C. SWIDLER, *General Counsel*

THOMAS J. GRIFFIN, *Solicitor,* until July 1953
CHARLES J. MCCARTHY, *Solicitor,* after July 1953

ROBERT H. MARQUIS, *Assistant General Counsel*
CHARLES J. MCCARTHY, *Assistant General Counsel,* until July 1953
THOMAS A. PEDERSEN, *Assistant General Counsel,* after July 1953

DIVISION OF FINANCE[3]

E. ARNOLD SUNSTROM, *Comptroller,* until December 1951
GIFFORD G. CRUZE, *Comptroller,* after December 1951
Assistant to, until December 1951
NEWTON B. DICKS, *Assistant to,* after February 1953
LLOYD G. PEASE, *Administrative Officer*
W. H. RAUDENBUSH, *Staff Accountant*
R. E. ALLEN, *Classification Accountant*
HOMER L. COOPER, *Reports Accountant*

Treasury
H. K. ROBINSON

Central Accounting
W. H. RAUDENBUSH, until February 1953
D. W. LACKEY, after February 1953

Auditing
A. J. ROBERTSON

Plant Accounting
PAUL FAHEY, until September 1952
L. L. LAUGHLIN, after September 1952

Chemical Accounting
J. E. BRABHAM

Power Accounting
H. S. CARPENTER

Construction Accounting
PAUL FAHEY, until September 1952
GEORGE P. EBERLE, after January 1953

DIVISION OF PROPERTY AND SUPPLY

JOHN I. SNYDER, *Director,* until June 1954
ASHFORD TODD, JR., *Director,* after June 1954;
Assistant, until June 1954
JOHN RANDOLPH PERRY, *Assistant to,* after December 1954
RUFUS J. PARTAIN, *Administrative Officer*

Land

GEORGE M. BAKER, *Chief*
ROBERT J. COKER, *Assistant*

Supervisor of Titles
JOHN RANDOLPH PERRY, until December 1954
JOHN D. RATHER, after December 1954

Supervisor of Administrative Services
T. H. KENAN

Supervisor of Buying
LEROY F. SIMONS

Supervisor of Sales
ROBERT J. COKER

Supervisor of Appraisals
W. E. SANFORD

3. Effective February 1953 the Division of Finance consists of the Office of Comptroller which includes Procedures, Account Classification, and Reports Staffs, and the following branches: Central Accounting, Chemical Accounting, Power Accounting, Plant Accounting, Auditing, and Treasury.

Office Service

CHARLES E. LEX, JR., *Chief,* until January 1956
RICHARD M. JONES, JR., *Chief,* after January 1956
WILLIAM L. HOOFF, JR., *Assistant,* after April 1956
HERBERT F. GOUGH, *Administrative Officer*

Specialist in Office Management
CHARLES E. LEX, JR.

Western District
S. PAUL LEWIS

Office Methods
CHARLES O. LIBBEY

Central District
T. R. CLAXTON

Administrative Services
L. G. PAYNE, until April 1955
JAMES C. ORR, after April 1955

Eastern District
WILLIAM L. HOOFF, JR., until April 1956
A. L. BOYD, after April 1956

Transportation

GEORGE H. IRISH, *Chief*
CHARLES H. HUDSON, *Assistant*
W. B. BERNER, *Administrative Services*

Western District
JOHN A. HEFFERNAN

Central District
R. BRUCE YATES

Eastern District
THOMAS J. HOSKINS

DIVISION OF MATERIALS[4]

R. M. MILLS, *Chief,* until August 1952
PAUL FAHEY, *Chief,* after August 1952
H. B. HENDRIX, *Assistant to*
JULIAN W. CAMPBELL, *Administrative Officer*
ALICE M. SHEA, *Administrative Services*

General Procurement
L. B. ROCKWELL

Traffic
J. EDWIN DAUGHERTY

Coal Procurement
R. M. CLAYTOR

OFFICE OF ENGINEERING

C. E. BLEE, *Chief Engineer*
HARRY WIERSEMA, *Assistant to*

Special Assignments and Reports
VAN COURT HARE, until October 1954
JOHN C. VOORHEES, after October 1954
JACK W. HIND

Budgets and Estimates
B. B. BRIER
A. B. WILKINSON

Personnel
E. R. BRABHAM
W. N. ROGERS, after January 1953

4. Until December 1953 the Division of Materials was the Materials Branch of Division of Property and Supply.

DIVISION OF WATER CONTROL PLANNING

J. S. Bowman, *Chief Water Control Planning Engineer,* until May 1955
R. A. Elliot, *Chief Water Control Planning Engineer,* after May 1955; *Assistant,* April 1954 to May 1955
W. A. Bowmaster, *Assistant to*

Hydraulic Data

A. S. Fry
J. H. Wilkinson
Ritchey Hume
J. E. Goddard, until December 1953
J. W. Beverage
W. C. Ackermann, until May 1954
James Smallshaw
R. A. Elder
L. R. Engstrom
A. J. Cooper
H. D. Gehres

Maps and Surveys

N. H. Sayford, until February 1952
R. E. Frierson
W. B. Jackson
Paul Morris
Benjamin Holmes
W. S. Massa
P. F. Meredith
C. F. Shalibo

Project Planning

R. A. Elliot, until April 1954
D. H. Mattern
E. S. Brosell
W. E. Loose
G. W. Hamilton
Julian Hinton, after March 1954
Erwin Maerker, until November 1954

Flood Control

C. W. Okey
E. J. Rutter
B. J. Buehler
E. S. Weed

River Control

N. W. Bowden

Power Studies[5]

D. M. Wood, until March 1954
Julian Hinton

Geology

B. C. Moneymaker
L. F. Grant

DIVISION OF DESIGN

R. A. Monroe, *Chief Design Engineer*
W. C. Boop, *Assistant to*
J. C. Voorhees, *Priorities,* June 1951 to November 1954

Technical Staff (Until May 1955)

Civil Engineering

R. M. Riegel, until October 1951
A. A. Meyer,
W. F. Emmons

Electrical Engineering

R. A. Hopkins, until October 1954
S. Kvaven
H. M. Osmun

Mechanical Engineering

H. J. Petersen
R. M. Gardner
J. R. Parrish

Architecture

H. B. Tour
F. G. Roth, until April 1952
H. H. Ostrander

Materials Engineering

P. J. Freeman, until August 1951
G. I. Teasley

Structural and Heavy Equipment Engineering

G. P. Palo
W. R. Mathews
E. M. Titus

Highway and Railroad Engineering

F. W. Webster
H. Colditz

Administrative

B. C. Erskine

5. The Power Studies Branch was combined with the Project Planning Branch in March 1954

Design Branches[6]

Architectural Design
H. B. Tour
H. H. Ostrander
R. H. Owens
J. R. Passonneau
G. R. Bowman
R. T. Case
L. V. Gibney

Mechanical Design
H. J. Petersen
R. M. Gardner
J. R. Parrish
R. E. Lyon
C. W. Bolieau
R. H. Dunham
B. S. Montgomery
M. A. Bryant
M. M. Williamson
R. M. Stewart
H. G. Smith
R. D. Hunter
L. W. Snyder
W. M. Dexter
J. A. Hudson
J. I. Givens

Civil Design
A. A. Meyer
G. P. Palo
W. F. Emmons
W. N. Calvert
A. Grini
F. E. Bosland
R. C. Brown
H. B. Henry

Structural Steel, Heavy Equipment, and Bridge Design[6]
G. P. Palo
E. M. Titus
W. R. Mathews
N. E. Way
E. Scroggie
D. P. Tsagaris
R. F. Tiry
R. H. Leech
C. O. White
C. H. Glaze
S. Kesler, Jr.

Electrical Design
S. Kvaven
H. M. Osmun
E. S. Haynes
V. K. Yagodkin
L. R. Sellers
H. W. Bowen
E. R. Snyder
R. M. Alspaugh
A. M. McNerney
C. R. Einfalt
R. R. Lewis
W. Paynter, Jr.
P. J. Rugg
H. W. Westby
J. C. Ebersole
F. J. O'Brien
C. V. Poling
J. A. Akerman
C. McCord
C. Corneliussen
L. F. Rhodes
C. H. Mock
R. C. Nix

Service Branches

Drafting Services
F. W. Ray
T. Benson

Inspection and Testing
P. J. Freeman
G. I. Teasley
W. Nixon
D. G. Bagwell

Specifications
R. E. Gibson

DIVISION OF CONSTRUCTION

Geo. K. Leonard, *Chief Construction Engineer*
Glenn A. Dooley, *Assistant to,* after March 1952

Kingston Steam Plant Construction

Henry T. Lofft, *Project Manager*
George H. Kimmons, *Construction Engineer*
Joe H. Timberlake, *Assistant Construction Engineer*
J. Harvey Gray, *Construction Superintendent,* until July 1953
John C. McCraw, *Construction Superintendent,* after July 1953
Arthur J. McVay, *Assistant Construction Superintendent*
Ulie C. Byrum, *Assistant Construction Superintendent*
William F. Baker, *Project Accountant*

ENGINEERING

Office Engineering
Charles M. DuBois, until August 1953
William Kelleghan, until July 1955
Charles Bonine, Jr., after July 1955

Field Engineering
Frank Kane

Mechanical Engineering
John M. Lile, Jr.

Electrical Engineering
George S. Mauney

Materials
Roscoe W. Conner

6. Effective May 1955 the Civil Engineering Branch and the Structural Steel, Heavy Equipment, and Bridge Engineering Branch were combined.

CONSTRUCTION

WILLIAM R. FOSTER, *General Foreman*
TROY M. WARREN, *General Electrical Foreman*
AARON D. TATE, *General Mechanical Foreman,* until May 1953
PAUL W. BEAUCHAMP, *General Mechanical Foreman,* after May 1953
JOHN R. EVERHART, *General Ironworker Foreman*
WILLIAM S. CASON, *General Steamfitter Foreman*
McCOY C. BRIGMAN, *General Carpenter Foreman*
SCOTT K. FITTS, *General Boilermaker Foreman*
BUSTER B. POSTON, *General Equipment Foreman*
CECIL G. LOWE, *General Sheetmetal Foreman*
LEWIS E. PEREW, *General Painter Foreman*

ACCOUNTING

WILLIAM F. BAKER, *Project Accountant*
DAVID R. HASTON, *Accounting*
BOBBIE MAX HARBIN, *Costs,* until October 1955
ROBERT R. BARTLEY, *Costs,* after October 1955
EUGENE A. THOMPSON, *Timekeeping*
WILLIAM E. LAWHON, *Warehouse,* until September 1955
JOHN T. CAGLE, *Warehouse,* after September 1955

Construction Plant

JOHN F. PARTRIDGE, *Construction Plant Engineer,* until September 1953
LEE M. RAGSDALE, *Construction Plant Engineer,* after September 1953
J. C. BUCHANAN, *Electrical Engineer*
P. A. SCHWAB, *Mechanical Engineer*
O. R. BENGSTON, *Civil Engineer*
O. W. ANDERTON, *Equipment Administrator*
C. HOMER GEORGE, *Costs*

Construction and Maintenance

THOMAS D. LEBBY, *Chief,* until September 1951
W. B. RICHARDSON, *Chief,* after September 1951
LEE M. RAGSDALE, *Area Superintendent,* until September 1953

DIVISION OF NAVIGATION AND LOCAL FLOOD RELATIONS[7]

J. PORTER TAYLOR, *Director*

Local Flood Relations
JAMES E. GODDARD

Navigation Economics
GEORGE B. TULLY

Navigation Engineering
ROBERT B. NICHOLS

DIVISION OF HEALTH AND SAFETY

O. M. DERRYBERRY, *Director*

Environmental Hygiene
C. M. DAVIDSON

Malaria Control
G. S. CHRISTOPHER

Occupational Health
G. H. COLLINGS, JR.

Safety
H. H. HAYES
WILLIAM CLARK, *Kingston Safety Officer*

Health Office
E. E. CARRIER
HU E. LADD, *Kingston Medical Officer*

7. Established in December 1953 when the Division of Regional Studies was abolished.

DIVISION OF RESERVOIR PROPERTIES

J. Ed Campbell, *Director*
M. A. Devoe, *Assistant,* until July 1954
Robert M. Howes, *Assistant to,* after December 1954

Budgets and Accounts
S. Y. Cross

Site Planning
O. H. Graves

Property Use
F. C. Manning

Recreation
Robert M. Howes

Administrative Services and Property Protection
Alan Richardson

Manager, Kingston Properties
H. E. Hudson, until July 1954
M. A. Devoe, after July 1954

Eugene Evans, *Kingston Public Safety Supervisor*

John W. Peters, *Kingston Camp Manager,* until January 1954
Frank J. Eckels, *Kingston Camp Manager,* after January 1954

OFFICE OF POWER

G. O. Wessenauer, *Manager*
R. A. Kampmeier, *Assistant*
Merrill DeMerit, *Chief Power Engineer*
Llewellyn Evans, *Chief Consulting Electrical Engineer,* until July 1952
H. P. Corden, *General Office Engineer*
R. L. Forshay, *Chief Personnel Officer*
L. B. Marks, *Reports Officer*

Division of Power Operation
C. L. Karr

Division of Power Engineering and Construction
W. W. Woodruff

Division of Power Supply[8]
R. A. Kampmeier

Division of Power Utilization
R. A. Kampmeier, until April 1952
James E. Watson, after April 1952

DIVISION OF AGRICULTURAL RELATIONS[9]

J. W. Moon, *Director,* until June 1952
Eric Winters, *Acting,* until October 1952
Leland G. Allbaugh, *Director,* after October 1952
Martin E. Weeks, *Assistant,* after February 1954
B. I. Rose, *Assistant to*
W. M. Landess, *Agriculturist*

Agricultural Economics
John Blackmore

Fertilizer Distribution
S. L. Clement

Test Demonstration
R. E. McKnight

Soils and Fertilizer Research
D. W. Thorne

Agricultural Engineering[10]
A. T. Hendrix

8. The Division of Power Supply was established April 1952.
9. The Office of Chief Conservation Engineer in which this Division was formerly included was abolished December 1951. Neil Bass was Chief Conservation Engineer until that date.
10. The Agricultural Engineering Branch no longer exists because its work projects were completed June 1954.

DIVISION OF FORESTRY RELATIONS[11]

WILLIS M. BAKER, *Director,* until April 1954
RICHARD KILBOURNE, *Director,* after April 1954; *Assistant,* until April 1954
CHARLES L. GOUFFON, *Assistant to,* after May 1954
JOHN M. HICKEY, *Administrative Officer*

Forestry Investigations
E. G. WIESEHUEGEL

Fish and Game
ABRAHAM H. WIEBE

Forest Development
KENNETH J. SEIGWORTH

OFFICE OF CHEMICAL ENGINEERING[12]

CHARLES H. YOUNG, *Manager*

Division of Chemical Development
JOHN H. WALTHALL

Division of Chemical Operations
S. A. HARVEY

11. The Office of Chief Conservation Engineer in which this Division was formerly included was abolished December 1951. Neil Bass was Chief Conservation Engineer until that date.
12. The Office of Chemical Engineering was established from the former Division of Chemical Engineering March 1952 with a Division of Chemical Development and a Division of Chemical Operations.

TABLE 38.—*Labor classifications and hourly rates of pay.*

Classifications	Effective Jan. 7, 1951	Effective Jan. 6, 1952	Effective Jan. 4, 1953	Effective Jan. 2, 1954	Effective Jan. 1, 1955	Effective Dec. 31, 1955
Apprentice (all trades after January 4, 1953):						
1st period—first half	$1.25	$1.30	$1.40	$1.475	$1.525	$1.625
second half	1.40	1.45	1.50	1.60	1.65	1.75
2nd period	1.60	1.65	1.75	1.825	1.875	1.975
3rd period	1.80	1.85	1.95	2.025	2.10	2.20
4th period[1]	1.935—2.475	2.05—2.62	2.14—2.70	2.205—2.79	2.25—2.70	2.32—2.79
5th period (Steamfitter only)	—	—	—	—	2.70	2.79
Apprentice—structural ironworker:[2]						
1st period	1.20	—	—	—	—	—
2nd period	1.44	—	—	—	—	—
3rd period	1.60	—	—	—	—	—
Apprentice—machinist:[3]						
1st period—first half	—	1.25	—	—	—	—
second half	—	1.40	—	—	—	—
2nd period	—	1.60	—	—	—	—
3rd period	—	1.80	—	—	—	—
4th period	—	2.07	—	—	—	—
Foreman (this classification used only with skilled trades):						
Craft journeyman rate plus[8]	.25	.25	.25	.25	—	—
Sub-foreman (this classification used with skilled trades only in accordance with agreement reached with the Tennessee Valley Trades and Labor Council): Craft journeyman rate plus	.125	.125	.125	.125	.125	.125
Powerhouse crane operator	2.50	2.65	2.775	2.875	3.00	3.10
International Brotherhood of Boilermakers, Iron Ship Builders, Blacksmiths, Forgers, and Helpers:						
Blacksmith	2.25	2.60	2.75	2.90	2.975	3.10
Blacksmith helper	1.50	2.35	2.50	2.65	2.725	2.85
Blacksmith welder	2.25	2.60	2.75	2.90	2.975	3.10
Boilermaker	2.475	2.60	2.75	2.90	2.975	3.10
Boilermaker Assistant Foreman[9]	—	—	—	—	3.225	3.35
Boilermaker Foreman[9]	—	—	—	—	3.475	3.60
Boilermaker helper	2.225	2.35	2.50	2.65	2.725	2.85
Boilermaker welder	2.475	2.60	2.75	2.90	2.975	3.10
Drill bit grinder	1.50	—	—	—	—	—
Drill sharpener operator	2.25	—	—	—	—	—
Power hammer operator	1.50	—	—	—	—	—
Bricklayers, Masons, and Plasterers International Union of America:						
Bricklayer	2.75	2.915	3.00	3.10	3.15	3.275
Bricklayer foreman[9]	—	—	—	—	3.40	3.525
Marble setter	2.50	2.75	2.80	2.90	2.95	3.15
Stone mason	2.75	2.915	3.00	3.10	3.15	3.275
Terrazzo worker	2.50	2.75	2.80	2.90	2.95	3.15
Tile setter	2.50	2.75	2.80	2.90	2.95	3.15
United Brotherhood of Carpenters and Joiners of America:						
Carpenter[11]	2.15	2.275	2.375	2.475	2.55	2.70
Carpenter foreman[9]	—	—	—	—	2.80	2.95
Carpenter welder	—	2.275	2.375	2.475	2.55	2.70
Millwright	2.15	2.325	2.375	2.55	2.65	2.775
Millwright foreman[9]	—	—	—	—	2.90	3.025

See footnotes at end of table.

TABLE 38.—*Labor classifications and hourly rates of pay*—Continued.

Classifications	Effective Jan. 7, 1951	Effective Jan. 6, 1952	Effective Jan. 4, 1953	Effective Jan. 2, 1954	Effective Jan. 1, 1955	Effective Dec. 31, 1955
United Brotherhood of Carpenters and Joiners of America—Continued						
Millwright helper	$1.50	—	—	—	—	—
Millwright welder	—	$2.325	$2.375	$2.55	$2.65	$2.775
Saw filer	2.15	2.275	2.375	2.475	2.55	2.70
Sawyer	2.15	2.275	2.375	2.475	2.55	2.70
International Brotherhood of Electrical Workers:						
Armature winder	2.50	2.65	—	—	—	—
Driver—special line equipment	—	2.50	2.625	2.725	2.85	2.95
Electrician	2.50	2.65	2.775	2.875	3.00	3.10
Electrician foreman[9]	—	—	—	—	3.25	3.35
Electrician welder	2.50	2.65	2.775	2.875	3.00	3.10
Groundman (line crew)	1.60	1.675	1.80	1.90	1.975	2.025
Groundman foreman[12]	—	—	—	—	—	3.10
Groundman trainee—A	—	—	1.40	1.475	1.525	1.625
Groundman trainee—B	1.25	1.30	1.50	1.60	1.65	1.75
Lineman	2.50	2.65	2.775	2.875	3.00	3.10
Lineman foreman[9]	—	—	—	—	3.25	3.35
Right-of-way clearing foreman[9]	—	—	—	—	2.30	2.40
Spray (maintenance only)	—	—	—	—	—	1.80
International Hod Carriers Building and Common Laborers Union of America:						
Asphalt raker and smoother	—	—	—	—	—	1.80
Axe filer	1.25	1.30	1.35	1.425	1.475	1.58
Cement gun nozzleman	1.80	1.87	1.95	2.00	2.075	2.175
Cement pump operator helper[13]	1.25	1.30	1.35	1.425	1.475	—
Chuck tender	—	1.75	1.85	1.95	2.00	2.075
Clerical-first aid laborer, land clearance[9]	—	—	—	—	1.475	1.58
Concrete placing foreman	2.05	2.15	2.20	2.25	2.30	2.40
Construction laborer	1.25	1.30	1.35	1.425	1.475	1.58
Deckhand[4]	1.25	—	—	—	—	—
Edgerman	1.35	1.40	1.45	—	—	—
Excavation foreman	2.05	2.15	2.20	2.25	2.30	2.40
Flagman	1.50	1.70	1.75	1.80	1.85	1.90
Form stripper	1.40	1.40	1.475	1.55	1.60	1.675
Jackhammer operator	1.35	1.40	1.475	1.55	1.60	1.70
Labor foreman	1.90	2.00	2.075	2.125	2.175	2.275
Labor sub-foreman	1.35	1.35	—	—	—	—
Laborer (unclassified)	1.15	1.20	1.30	1.375	1.425	1.525
Larvicidal boat operator[9]	—	—	—	—	1.475	1.58
Mortar mixer	1.35	1.40	1.475	1.525	1.55	1.675
Powder foreman	1.90	2.00	2.075	2.125	2.175	2.275
Powderman	1.625	1.90	1.95	2.00	2.05	2.175
Shaft and tunnel foreman	1.90	2.00	2.075	—	—	—
Shaft and tunnel miner	1.35	1.35	1.475	—	—	—
Power saw operator[9] (right-of-way clearing)	—	—	—	—	1.475	1.58
Sewer foreman[9]	—	—	—	—	2.175	2.275
Timber cross-cut saw filer[9] (land clearance)	—	—	—	—	1.525	1.63
Timber rigger[9]	—	—	—	—	1.475	1.58
Track foreman	2.05	2.15	2.20	2.25	2.30	2.40
Tunnel laborer	1.25	1.50	1.70	1.775	1.825	1.90
Tunnel miner	2.00	2.00	2.15	2.225	2.275	2.35
Tunnel miner foreman[9]	—	—	—	—	2.525	2.60
Wagon drill operator	1.50	1.55	1.625	1.70	1.75	1.85
Watchman	1.15	1.20	1.30	1.375	1.425	1.525
International Association of Bridge, Structural, and Ornamental Iron Workers of America:						
Ornamental iron worker	2.40	2.525	2.65	2.775	2.85	2.925
Ornamental iron worker foreman[9]	—	—	—	—	3.10	3.175
Reinforcing iron worker	2.275	2.40	2.525	2.65	2.75	2.825
Reinforcing iron worker foreman[9]	—	—	—	—	3.00	3.075
Structural iron worker	2.40	2.525	2.65	2.775	2.85	2.925
Structural iron worker foreman[9]	—	—	—	—	3.10	3.175
Structural iron worker welder	2.40	2.525	2.65	2.775	2.85	2.925
Wood, Wire, and Metal Lathers International Union:						
Lather	2.25	2.40	2.55	2.65	2.70	2.80
Lather foreman[9]	—	—	—	—	2.95	3.05
International Association of Machinists:						
Bolt threading machine operator	1.50	1.50	1.65	1.75	1.80	1.90
Gas and diesel mechanic	2.30	2.30	2.45	2.55	2.65	2.775
Gas and diesel mechanic foreman[9]	—	—	—	—	2.90	3.025
Gas and diesel mechanic helper	1.50	1.50	1.65	1.75	1.80	1.90
Machinist	2.30	2.30	2.45	2.55	2.65	2.775
Machinist foreman[9]	—	—	—	—	2.90	3.025
Machinist helper	1.50	1.50	1.65	1.75	1.80	1.90
Machinist welder	2.30	2.30	2.45	2.55	2.65	2.775
Outside machinist	2.30	2.30	2.45	2.55	2.65	2.775
Outside machinist foreman[12]	—	—	—	—	—	3.025
Outside machinist helper	1.50	1.50	1.65	1.75	1.80	1.90
Outside machinist welder[12]	—	—	—	—	—	2.775
International Union of Operating Engineers:						
Group A equipment operators:						
Crane operator	2.35	2.50	2.60	2.725	2.825	2.95
Derrick operator (live boom)	2.35	2.50	2.60	2.725	2.825	2.95
Dragline operator	2.35	2.50	2.60	2.725	2.825	2.95
Dredge operator	2.35	2.50	2.60	2.725	2.825	2.95
Equipment mechanic	—	—	2.60	2.725	2.825	2.95
Equipment mechanic welder	—	—	2.60	2.725	2.825	2.95
Euclid loader operator	2.35	2.50	2.60	2.725	2.825	2.95
Pile driver operator	2.35	2.50	2.60	2.725	2.825	2.95
Power shovel operator	2.35	2.50	2.60	2.725	2.825	2.95

See footnotes at end of table.

TABLE 38.—*Labor classifications and hourly rates of pay*—Continued.

Classifications	Effective Jan. 7, 1951	Effective Jan. 6, 1952	Effective Jan. 4, 1953	Effective Jan. 2, 1954	Effective Jan. 1, 1955	Effective Dec. 31, 1955
International Union of Operating Engineers—Continued						
Group B equipment operators:						
Bulldozer operator	$2.10	$2.20	$2.25	$2.35	$2.40	$2.55
Carry-all operator	2.10	2.20	2.25	2.35	2.40	2.55
Chief filter plant operator	—	2.20	2.25	2.35	2.40	2.55
Concrete mixer operator (21S and over)	2.10	2.20	2.25	2.35	2.40	2.55
Concrete pump operator	2.10	2.20	2.25	2.35	2.40	2.55
Elevating grader operator	2.10	2.20	2.25	2.35	2.40	2.55
Grader operator	2.10	2.20	2.25	2.35	2.40	2.55
Hoist operator (two drums)	2.10	2.20	2.25	2.35	2.40	2.55
Locomotive operator (20T and over)	2.10	2.20	2.25	2.35	2.40	2.55
Marine engineer	2.10	2.20	2.25	2.35	2.40	2.55
Marine pilot	2.10	2.20	2.25	2.35	2.40	2.55
Pan scraper operator	2.10	2.20	2.25	2.35	2.40	2.55
Trenching machine operator	2.10	2.20	2.25	2.35	2.40	2.55
Yard conductor	2.10	2.20	2.25	2.35	2.40	2.55
Group C equipment operators:						
Bituminous distributor operator	1.85	1.90	1.95	2.00	2.075	2.20
Central compressor plant operator	1.85	1.90	1.95	2.00	2.075	2.20
Core drill operator	1.85	1.90	1.95	2.00	2.075	2.20
Filter plant operator	—	1.90	1.95	2.00	2.075	2.20
Hoist operator (one drum)	1.85	1.90	1.95	2.00	2.075	2.20
Locomotive operator (less than 20T)[10]	1.85	1.90	1.95	2.00	—	—
Motor crane driver and oiler	1.85	1.90	1.95	2.00	2.075	2.20
Mulching machine operator[9]	—	—	—	—	2.075	2.20
Portable concrete mixer operator[9]	—	—	—	—	2.075	2.20
Road roller operator	1.85	1.90	1.95	2.00	2.075	2.20
Tractor operator (50 horsepower and over)	1.85	1.90	1.95	2.00	2.075	2.20
Tunnel motorman	1.85	1.90	1.95	2.00	2.075	2.20
Group D equipment operators:						
Concrete mixer operator (under 21S)[10]	1.70	1.80	1.85	1.90	—	—
Conveyor operator[9]	—	—	—	—	1.90	2.00
Core drill helper[9]	—	—	—	—	1.90	2.00
Crane car operator	1.70	1.80	1.85	1.90	1.90	2.00
Crusher operator[10]	1.70	1.80	1.85	1.90	—	—
Equipment mechanic helper[9]	—	—	—	—	1.90	2.00
Fireman A[5]	—	1.80	1.85	1.90	1.90	2.00
Grout pump operator[9]	—	—	—	—	1.90	2.00
Loading machine operator[9]	—	—	—	—	1.90	2.00
Oiler A[5]	—	1.80	1.85	1.90	1.90	2.00
Portable compressor operator[9]	—	—	—	—	1.90	2.00
Pump operator[9]	—	—	—	—	1.90	2.00
Switchman[9]	—	—	—	—	1.90	2.00
Tractor operator (under 50 horsepower)	1.70	1.80	1.85	1.90	1.90	2.00
Trenching machine helper[9]	—	—	—	—	1.90	2.00
Welding machine operator[9]	—	—	—	—	1.90	2.00
Well drill operator (6 inches and over)[10]	1.70	1.80	1.85	1.90	—	—
Work boat operator[9]	—	—	—	—	1.90	2.00
Group E equipment operators:[10]						
Cement pump operator	1.50	1.60	1.65	1.75	—	—
Conveyor operator	1.50	1.60	1.65	1.75	—	—
Core drill helper	1.50	1.60	1.65	1.75	—	—
Crushing plant helper	1.50	1.60	1.65	1.75	—	—
Equipment mechanic helper	—	1.60	1.65	1.75	—	—
Fireman B[6]	1.50	1.60	1.65	1.75	—	—
Loading machine operator	1.50	1.60	1.65	1.75	—	—
Motorboat operator (inboard)	1.25	—	—	—	—	—
Motorboat operator (outboard)	1.25	1.30	1.35	—	—	—
Oiler B[6]	1.50	1.60	1.65	1.75	—	—
Portable compressor operator	1.50	1.60	1.65	1.75	—	—
Pump operator	1.50	1.60	1.65	1.75	—	—
Sand classifier operator	1.50	1.60	1.65	1.75	—	—
Switchman	1.50	1.60	1.65	1.75	—	—
Trenching machine helper	1.50	1.60	1.65	1.75	—	—
Welding machine operator	—	1.60	1.65	1.75	—	—
Well drill helper (6 inches and over)	1.50	1.60	1.65	1.75	—	—
Work boat operator	—	—	1.65	1.75	—	—
Equipment operator foremen:						
Central mixing plant foreman	2.35	2.45	2.50	2.60	2.65	2.80
Core drill foreman	2.10	2.15	2.20	2.25	2.325	2.45
Crushing plant foreman[10]	1.95	2.05	2.10	2.15	—	—
Dredge mate[7]	2.60	2.75	2.85	2.975	3.10	3.20
Drill boat foreman	2.00	2.00	2.075	2.125	2.175	2.275
Equipment foreman	2.60	2.75	2.85	2.975	3.10	3.20
Equipment mechanic foreman	—	—	2.85	2.975	3.10	3.20
Grade foreman	2.35	2.45	2.50	2.60	2.65	2.80
Greaser foreman	—	2.20	2.25	2.35	2.40	2.55
Well drill foreman (6 inches and over)[10]	1.95	2.05	2.10	2.15	—	—
Brotherhood of Painters, Decorators, and Paperhangers:						
Glazier	1.80	2.00	—	—	—	—
Painter	2.15	2.275	2.375	2.50	2.575	2.70
Painter foreman[9]	—	—	—	—	2.825	2.95
Sign painter	2.15	2.275	2.375	2.50	2.575	2.70
Operative Plasterers and Cement Masons International Association:						
Cement mason	2.20	2.25	2.38	2.45	2.50	2.575
Cement mason foreman[9]	—	—	—	—	2.75	2.825
Plasterer	2.575	2.575	2.75	2.825	2.875	2.975
United Slate, Tile, and Composition Roofers, Damp and Waterproof Workers Association:						
Roofer (composition, builtup, waterproofing)	1.80	1.85	2.05	2.075	2.125	2.20

See footnotes at end of table.

TVA-00020316

TABLE 38.—*Labor classifications and hourly rates of pay*—Continued.

Classifications	Effective Jan. 7, 1951	Effective Jan. 6, 1952	Effective Jan. 4, 1953	Effective Jan. 2, 1954	Effective Jan. 1, 1955	Effective Dec. 31, 1955
United Slate, Tile, and Composition Roofers, Damp and Waterproof Workers Association—Continued						
Roofer (slate and tile)	$2.00	$2.05	$2.15	$2.20	$2.25	$2.40
Roofer (composition, builtup, waterproofing) foreman[9]	—	—	—	—	2.375	2.45
Roofer (slate and tile) foreman[9]	—	—	—	—	2.50	2.65
Sheetmetal Workers International Association:						
Sheetmetal worker	2.25	2.35	2.50	2.625	2.725	2.90
Sheetmetal worker foreman[9]	—	—	—	—	2.975	3.15
Sheetmetal worker-sketchman	—	—	2.75	2.875	2.975	3.15
Sheetmetal worker welder	2.25	2.35	2.50	2.625	2.725	2.90
United Association of Journeymen and Apprentices of the Plumbing and Pipe Fitting Industry of the United States and Canada:						
Lead burner	2.75	2.75	3.175	3.35	3.35	3.50
Plumber	2.50	2.65	2.775	2.90	3.00	3.10
Plumber foreman[9]	—	—	—	—	3.25	3.35
Steamfitter	2.50	2.65	2.775	2.90	3.00	3.10
Steamfitter foreman[9]	—	—	—	—	3.25	3.35
Steamfitter welder	2.50	2.65	2.775	2.90	3.00	3.10
International Brotherhood of Teamsters, Chauffeurs, Warehousemen, and Helpers of America:						
Garage attendant	—	1.55	1.65	1.675	1.725	1.825
Truck dispatcher	—	—	—	—	2.10	2.20
Truck driver I (dump trucks 3 cubic yards and under; other trucks under 3 tons unless covered by truck driver III)	1.40	1.50	1.60	1.625	1.675	1.775
Truck driver II (dump trucks over 3 cubic yards up to and including 6 cubic yards; other trucks over 3 tons up to and including 5 tons unless covered by truck driver III)	1.60	1.70	1.80	1.825	1.85	1.95
Truck driver III (dump trucks over 6 cubic yards; other trucks over 5 tons unless covered by truck driver IV)	1.75	1.85	1.95	1.975	2.025	2.125
Truck driver IV (includes only tractor type having a G.U.W. of 65,000 pounds or more)	1.75	2.05	2.15	2.175	2.175	2.175
Truck foreman	1.95	2.30	2.40	2.425	2.425	2.475
Truck helper—power construction[12]	—	—	—	—	—	1.75
Warehouseman	1.30	1.40	1.50	1.55	1.60	1.75
Warehouse foreman	—	2.00	2.10	2.15	2.175	2.275

1. Rates vary according to and are based on craft journeyman rates.
2. Effective March 6, 1949; eliminated January 6, 1952.
3. Effective January 6, 1952; eliminated January 4, 1953.
4. Combined with construction laborer classification after date indicated.
5. Serving equipment normally operated by group A operators.
6. Serving equipment not normally operated by group A operators.
7. Effective August 21, 1949.
8. This scale discontinued January 1, 1955; foremen individually designated.
9. This classification effective January 1, 1955.
10. This classification discontinued January 1, 1955.
11. Effective December 31, 1955, carpenter receives $0.25 above journeyman rate when handling creosote lumber for more than 4 hours.
12. This classification effective December 31, 1955.
13. This classification discontinued December 31, 1955.
14. This classification effective June 16, 1956.

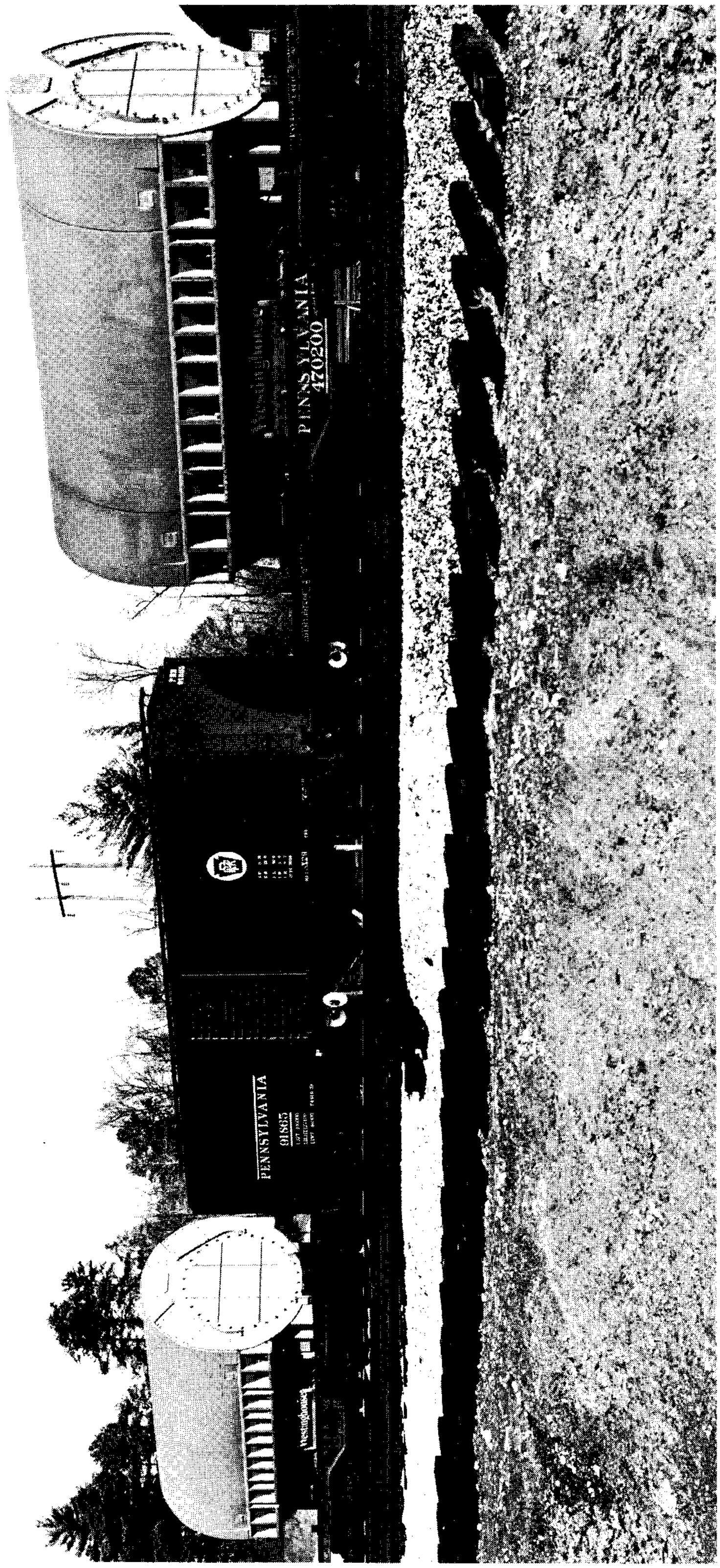


FIGURE 143.—*Stators for units 2 and 3, each weighing 397,600 pounds arrive on special flat cars having double trucks front and rear.*

APPENDIX B

STATISTICAL SUMMARY

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GENERAL DATA

Location

On peninsula formed by Clinch and Emory River arms of Watts Bar Lake, 2 miles northeast of Kingston, Tennessee

Access

Highway: 1.1 miles constructed from U. S. Highway No. 70
Railroad: 6.7 miles constructed from connections with Tennessee Central Railroad and Southern Railway at Emory Gap
Water: On 9-foot navigable channel connected with Inland Waterway System; no permanent docking facilities constructed

Chronology

Initial appropriations:
- Units 1-4: January 6, 1951
- Units 5-6: July 5, 1952
- Units 7-8: July 15, 1952
- Unit 9: July 27, 1953

Construction started at site: April 30, 1951
Commercial operation:
- Unit 1: February 8, 1954
- Unit 2: April 29, 1954
- Unit 3: June 11, 1954
- Unit 4: July 27, 1954
- Unit 5: January 18, 1955
- Unit 6: March 3, 1955
- Unit 7: May 6, 1955
- Unit 8: August 3, 1955
- Unit 9: December 2, 1955

Power Installation

Rated capacity:
- Units 1-4, each: 135,000 kw
- Units 5-9, each: 180,000 kw
- Units 1-9, total: 1,440,000 kw

Capability:
- Units 1-4, each: 150,000 kw
- Units 5-9, each: 200,000 kw
- Units 1-9, total: 1,600,000 kw

Coal Consumption (approximate)

Annual, 9-unit plant: 4,300,000 tons based on 80-percent plant load factor
Per hour, each unit:
- Units 1-4: 58 tons operating at rated load
- Units 5-9: 76.5 tons operating at rated load

Per kwh, each unit:
- Units 1-4: 0.78 pound[1]
- Units 5-9: 0.77 pound[1]

1. Based on 12,000 Btu per pound coal and operating at maximum capability and 2 in. Hg absolute exhaust pressure

Throttle Operating Conditions

Pressure, units 1-9: 1800 psig
Temperature:
- Units 1-4: 1000°F
- Units 5-9: 1050°F

Construction Quantities (estimated totals)

Excavation: 4,316,000 cu yd
Fill: 645,800 cu yd
Concrete: 259,800 cu yd
Reinforcing steel: 17,000 tons
Formwork: 1,825,000 sq ft
Structural steel (main contracts):
- Powerhouse: 26,460 tons
- Service bay: 895 tons
- Switchyard and transformer yard: 595 tons

Masonry: 1,750,000 units
Galbestos siding (powerhouse): 202,800 sq ft

Cost

Generating plant: $189,669,500.94; $119 per kw of capability
Switchyard: $8,460,774.28
General plant: $174,016.57
(Credit) Transferred depreciation: ($27,541.84)
(Credit) Contra debit: ($76,900.00)
Total project: $198,199,849.95; $124 per kw of capability

Datum

Elevations are based on the U. S. C. & G. S. 1936 Supplementary Adjustment

POWERHOUSE AND SERVICE BAY

Structural Data

Foundation:
- Material: Shale with interbedded layers of limestone
- Allowable bearing pressure: 5 tons per sq ft

Type of construction:
- Substructure: Reinforced concrete
- Superstructure: Masonry, reinforced concrete, and steel

Principal dimensions:
- Powerhouse: 895- by 115-foot turbine room, 868- by 138-foot boiler room and heater bay; maximum height; 151 feet above basement floor, 111 feet above ground
- Service bay (shops and office): 200 by 205 feet

Turbine room cranes: 2; 90-ton capacity each; manufactured by Cyclops Iron Works
Stacks (1 per unit): Reinforced concrete with brick lining; units 1-4: 14 feet id, 250 feet high above ground; units 5-9: 16.5 feet id, 300 feet high above ground; built by Rust Engineering Co.

Architecture

Exterior walls: Steel frame, gray face brick base with insulated maroon asbestos-protected steel V-beam siding above; glass block wall east side turbogenerator room; yellow porcelain enameled panels and aluminum window frames in office wing; aluminum copings

Interior walls: Glazed tile and perforated accoustical steel panels in turbogenerator room; glazed tile in toilets and locker rooms; glazed tile and gray face brick in public areas; marble walls in public toilets; unglazed tile elsewhere; plaster and movable metal partitions in office areas

Roof: Smooth-surface asphalt and felt built-up roofing over rigid insulation on precast concrete slabs and cellular steel decking

Floors: "Greytone" quarry tile in turbogenerator room and boiler bay; terrazzo in toilets, public areas, and corridors; rubber tile in offices; colored metallic hardened cement elsewhere

Windows: Steel sash, aluminum sash, and special aluminum windows and entrance assemblies

STEAM GENERATORS

General Data

Manufacturer: Combustion Engineering-Superheater, Inc.

Type:
- Units 1-4: Natural circulation, reheat, radiant boiler
- Units 5-9: Twin furnace, reheat, controlled circulation

Rated capacity, each unit:
- Units 1-4: 1,020,000 pph steam
- Units 5-9: 1,280,000 pph steam

Maximum 4-hour capacity, each unit:
- Units 1-4: 1,120,000 pph steam
- Units 5-9: 1,410,000 pph steam

Steam pressure (at superheater outlet):
- Units 1-4: 1825 psig
- Units 5-9: 1840 psig

Steam temperature (at superheater outlet):
- Units 1-4: 1003°F
- Units 5-9: 1053°F

Efficiency (guaranteed at rated load):
- Units 1-4: 88.64 percent
- Units 5-9: 88.46 percent

Drums (1 per unit)

Location: Elevation 852.0

Size:
- Units 1-4: 66 inches id, 45 feet 11½ inches straight length, 5$\frac{13}{32}$-inch wall
- Units 5-9: 60 inches id, 53 feet 3 inches straight length, 4½-inch wall

Weight (internals included):
- Units 1-4: 313,500 pounds
- Units 5-9: 189,400 pounds

Design pressure:
- Units 1-4: 2025 psig
- Units 5-9: 2060 psig

Furnaces

Type:
- Units 1-4: Radiant, water wall, dry bottom
- Units 5-9: Controlled circulation, twin water wall, dry bottom

Principal dimensions:
- Units 1-4: 38 feet 2 inches wide, 28 feet 1¼ inches deep, 108 feet high
- Units 5-9: 2; each 25 feet 4¾ inches wide, 22 feet 10½ inches deep, 108 feet high

Heating surface:
- Units 1-4: 44,720 sq ft
- Units 5-9: 70,600 sq ft

Total volume:
- Units 1-4: 93,000 cu ft
- Units 5-9: 109,300 cu ft

Superheaters

Type: 2-stage Elesco

Tube size:
- Units 1-4: 2⅛ inches od
- Units 5-9: 2 inches od

Heating surface:
- Units 1-4: 82,285 sq ft
- Units 5-9: 125,000 sq ft

Design pressure:
- Units 1-4: 2025 psig
- Units 5-9: 2060 psig

Design temperature:
- Units 1-4: 1003°F
- Units 5-9: 1053°F

Economizers

Type: Elesco "CF-S," horizontal fintube, parallel flow

Tube size: 2 inches od

Heating surface:
- Units 1-4: 26,000 sq ft
- Units 5-9: 30,450 sq ft

Design pressure: 2100 psig

Reheaters

Type:
- Units 1-4: Elesco vertical, continuous flow
- Units 5-9: Vertical, continuous flow

Tube size: 2½ and 2⅛ inches od

Heating surface:
- Units 1-4: 18,893 sq ft
- Units 5-9: 25,300 sq ft

Rated capacity, each unit:
- Units 1-4: 870,000 pph
- Units 5-9: 1,116,000 pph

Design pressure:
- Units 1-4: 550 psig
- Units 5-9: 500 psig

Design temperature:
- Units 1-4: 1003°F
- Units 5-9: 1053°F

Operating inlet pressure:
- Units 1-4: 435 psig, design[2]
- Units 5-9: 387 psig, design[2]

Operating outlet pressure:
- Units 1-4: 390 psig, design[2]
- Units 5-9: 347 psig, design[2]

Operating inlet temperature:
- Units 1-4: 640°F, design[2]
- Units 5-9: 668°F, design[2]

Operating outlet temperature:
- Units 1-4: 1003°F, design[2]
- Units 5-9: 1053°F, design[2]

Air Preheaters (2 per unit)

Manufacturer: Air Preheater Corp.

Type:
- Units 1-4: Ljungstrom continuous, regenerative, counter flow
- Units 5-9: Continuous, regenerative, counter flow

Element height: Design, 56 inches maximum installed, two layers, 36 and 12 inches high

Heating surface, each unit:
- Units 1-4: 80,900 sq ft
- Units 5-9: 114,400 sq ft

Design temperature gases (entering):
- Units 1-4: 660°F
- Units 5-9: 650°F

Design temperature gases (leaving):
- Units 1-4: 310°F uncorrected
- Units 5-9: 300°F uncorrected

Design temperature air (entering):
- Units 1-9: 80°F

Design temperature air (leaving):
- Units 1-4: 512°F
- Units 5-9: 532°F

Firing Equipment (per unit)

Burners (adjustable tangential):
- Units 1-4: 16
- Units 5-9: 24

Pulverizers (C. E. Raymond Bowl No. 633):
- Units 1-4: 4
- Units 5-9: 6

Feeders:
- Units 1-4: 4; Raymond; integral with pulverizers
- Units 5-9: 6; Raymond; integral with pulverizers

Lighting-off torches:
- Units 1-4: 16; automatic retractable ignition
- Units 5-9: 24; C-E standard ignition

Oil burners:
- Units 1-4: 4
- Units 5-9: 8

2. Varies with load.

Controls

Combustion and feedwater: Electronic-pneumatic, manufactured by Republic Flow Meters Co.

Superheater: Burner tilt and desuperheater, manufactured by Leeds & Northrup Co.

FANS

Forced Draft (2 per unit)

Manufacturer: Westinghouse Electric Corp., Sturtevant Division

Type and size:
- Units 1-4: 175, TV special, single width, single inlet
- Units 5-9: 185, TV-12, single width, single inlet

Rated capacity, each:
- Units 1-4: 200,000 cfm
- Units 5-9: 270,000 cfm

Rated static pressure (at test block):
- Units 1-4: 11.5 inches H_2O
- Units 5-9: 13.0 inches H_2O

Rated temperature (at test block): 140°F

Control: Inlet louvers

Design temperature (air leaving fan): 80 to 100°F

Motors:
- Manufacturer: Westinghouse Electric Corp.
- Type:
  - Units 1-4: 450 hp, 705 rpm, squirrel cage, drip-proof protected
  - Units 5-9: 700 hp, 705 rpm, squirrel cage, drip-proof protected

Induced Draft (2 per unit)

Manufacturer: Westinghouse Electric Corp., Sturtevant Division

Type and size:
- Units 1-4: MVID 16½
- Units 5-9: MVID 16

Rated capacity, each:
- Units 1-4: 290,000 cfm
- Units 5-9: 400,000 cfm

Rated static pressure (at test block):
- Units 1-4: 20.5 inches H_2O
- Units 5-9: 20.0 inches H_2O

Rated temperature (at test block): 320°F

Control: Inlet louvers

Motors:
- Manufacturer: Westinghouse Electric Corp.
- Type:
  - Units 1-4: 1400 hp, 590 rpm, squirrel cage, totally enclosed, fan cooled
  - Units 5-9: 1750 hp, 593 rpm, squirrel cage, totally enclosed, fan cooled

ASH HANDLING

Method

Fly and bottom ash collection and sluice system to disposal area

Fly Ash Collectors (2 per unit)

Manufacturer:
Units 1-4: Buell Engineering Co., Inc.
Units 5-9: American Blower Corp.
Type: Mechanical
Size:
Units 1-4: 4 groups of 4 No. 13 FAC
Units 5-9: No. 504-ARRT. 42W12, series 342, design 56V
Rated capacity:
Units 1-4: 239,000 cfm at 305°F
Units 5-9: 310,000 cfm at 295°F
Efficiency: 85 percent ± (guaranteed overall)
Pressure drop (at rated capacity):
Units 1-4: 3.05 inches H_2O
Units 5-9: 3.0 inches H_2O

Bottom Ash System

Type: V-type furnace bottom hoppers with water sluice
Manufacturer: Allen-Sherman-Hoff Co.

Water Pumps

Bottom ash sluice: 5; 8x20-SDO type, 2600 gpm rated capacity, 1000-foot head, manufactured by Byron Jackson Company
Fly ash sluice: 4; 8-inch TU-17 type, 1925 gpm rated capacity, 520-foot head, manufactured by Peerless Pump Division

DUST COLLECTORS

At Coal Bunkers (1 per unit)

Type and capacity: Cyclone; 4500 cfm
Manufacturer:
Units 1-4: Kirk & Blum Manufacturing Co.
Units 5-9: Day Company

At Coal Scales (1 per unit)

Type and capacity: Units 1-4: Multiclone; 1200 cfm
Units 5-9: Cyclone: 1800 cfm
Manufacturer:
Units 1-4: Western Precipitation Corp.
Units 5-9: Day Company

At Coal Conveyor Transfer Point (2—total)

Type and capacity: Multiclone; 4500 cfm
Manufacturer: American Blower Corp.

TURBOGENERATORS

Foundations

Type: Reinforced concrete frame

Turbines

Manufacturer:
Units 1-4: Westinghouse Electric Corp.
Units 5-9: General Electric Co.
Type and speed: Tandem compound, triple-flow exhaust, condensing, reheat; 3600 rpm
Rated capacity, each unit:
Units 1-4: 135,000 kw
Units 5-9: 180,000 kw
Maximum capability, each unit:
Units 1-4: 150,000 kw
Units 5-9: 200,000 kw
Throttle pressure: 1800 psig
Throttle temperature:
Units 1-4: 1000°F
Units 5-9: 1050°F
Reheated steam pressure (at maximum capability)
Units 1-4: 390 psig
Units 5-9: 347 psig
Reheated steam temperature (at maximum capability):
Units 1-4: 1000°F
Units 5-9: 1050°F
Number of stages, each unit:
Units 1-4: 44
Units 5-9: 24
Extraction points and stage numbers:
Units 1-4: 7 (16, 21, 30, 36, 38, 40, 42)
Units 5-9: 8 (6, 9, 13, 16, 18, 19, 21, 22)
Design backpressure: 2 inches Hg absolute
Total rotor weight:
Units 1-4: 105,000 pounds
Units 5-9: 114,100 pounds
Turbine heat rate (guaranteed at maximum capability and 2 inches Hg absolute exhaust pressure):
Units 1-4: 7807 Btu per kwh
Units 5-9: 7777 Btu per kwh
Net plant heat rate (expected at maximum capability and 2 inches Hg absolute exhaust pressure):
Units 1-4: 9367 Btu per kwh
Units 5-9: 9288 Btu per kwh

Generators

Manufacturer:
Units 1-4: Westinghouse Electric Corp.
Units 5-9: General Electric Company
Rating each unit:
Units 1-4: 150,000 kva, 135,000 kw, 0.9 pf, 3 ph, 60 cycles, 18,000 v, 3600 rpm, 4810. amp, 0.9 short circuit ratio
Units 5-9: 200,000 kva, 180,000 kw, 0.9 pf, 3 ph, 60 cycles, 20,000 v, 3600 rpm, 5770 amp, 0.8 short circuit ratio
Maximum capability, each unit:
Units 1-4: 168,540 kva, 150,000 kw, 0.89 pf, 5400 amp
Units 5-9: 217,400 kva, 200,000 kw, 0.92 pf, 6275 amp
Temperature rise: Stator, 60°C; rotor, 85°C

Cooling:
  Units 1-4: Hydrogen; 0.5 psig at rated capacity, 15 psig at maximum capability
  Units 5-9: Hydrogen; 15 psig at rated capacity, 30 psig at maximum capability
Hydrogen treatment: Vacuum detraining
Rotor weight:
  Units 1-4: 105,000 pounds
  Unit 5: 111,200 pounds
  Units 6-9: 108,800 pounds
Stator weight:
  Units 1-4: 397,600 pounds
  Unit 5: 612,800 pounds
  Units 6-9: 636,800 pounds
Excitation:
  Units 1-4: Pilot exciter
  Units 5-9: Rotating amplifier
Exciter rating:
  Units 1-4: 350 kw, 375 v, 900 rpm, shunt wound, direct connected
  Unit 5: 500 kw, 375 v, 890 rpm, shunt wound, direct connected
  Units 6-9: 550 kw, 375 v, 890 rpm, shunt wound, direct connected
Pilot exciter rating:
  Units 1-4: 3 kw, 250 v, 900 rpm, compound wound, direct connected
  Units 5-9: 5 kw, 250 v, 1750 rpm, motor-driven, amplidyne type
Neutral grounding:
  Units 1-4: Transformer, 75 kva, 18,000-200 v; secondary resistor, 0.27 ohm, 470 amp (60 seconds)
  Units 5-9; Transformer, 75 kva, 20,000-220 v; secondary resistor, 0.25 ohm, 510 amp (60 seconds)
Surge protection: Lightning arresters only

Generator Leads

Connections: Unit type, no switching at generator voltage
Rating (at 35°C rise above 40°C ambient temperature indoor):
  Units 1-4: 6000 amp
  Units 5-9: 7000 amp
Bus material: Aluminum channels
Bus enclosure:
  Indoor: Transite, segregated phase
  Outdoor: Expanded aluminum and aluminum framing supported on structural steel
Manufacturer: Designed and fabricated by TVA

AUXILIARY POWER

Voltage

Normal, starting, and emergency supply: 4160 and 480 v

Common and Unit Boards

Voltage: 4160 and 480 v
Type: Metal-clad switchgear
Breaker rating:
  4160-v: 250,000 kva
  480-v: 25,000 amp
Manufacturer:
  4160-v: Westinghouse Electric Corp.
  480-v: I-T-E Circuit Breaker Co.

Control Batteries

Voltage and rating: 250 v; 1 hour, 474 amp
Type: 25-plate, heavy-duty, glass-cell
Manufacturer: Electric Storage Battery Co.

CONDENSERS (1 per unit)

General Data

Type: Single pass, surface, divided water box
Manufacturer: Westinghouse Electric Corp.
Surface area, each unit:
  Units 1-4: 60,000 sq ft
  Units 5-9: 80,000 sq ft

Design Conditions (at rated load)

Steam condensed, each unit:
  Units 1-4: 672,000 pph
  Units 5-9: 887,000 pph
Backpressure: 2 inches Hg absolute
Cooling water flow:
  Units 1-4: 90,000 gpm each
  Units 5-9: 121,400 gpm each
Cooling water temperature: 75°F
Cooling water tube velocity:
  Units 1-4: 6.9 feet per second
  Units 5-9: 7.0 feet per second
Tube cleanliness: 85 percent

Tubes

Number, each unit:
  Units 1-4: 8,808
  Units 5-9: 11,742
Dimensions, each tube:
  Outside diameter: ⅞ inch
  Length overall: 30 feet
Material: Inhibited admiralty
Manufacturer:
  Units 1-4: Phelps Dodge Copper Products Co.
  Units 5-9: Scovill Manufacturing Company

FEEDWATER EQUIPMENT

Closed Heaters

Type: Horizontal
Number per unit: Units 1-4, 6; units 5-9, 7
Manufacturer:
  Units 1-4: The Lummus Co.
  Units 5-9: Griscom-Russell Co.

Shell design pressure, psig:

Heater No.	Units 1-4	Units 5-9
1	650	725
2	475	450
3	250	250
5	50 and 30 inches Hg vacuum	50 inches Hg vacuum
6	50 and 30 inches Hg vacuum	50 and 30 inches Hg vacuum
7	50 and 30 inches Hg vacuum	50 and 30 inches Hg vacuum
8	—	50 and 30 inches Hg vacuum

Tubes:
- Design pressure, psig: HP heaters, 2900; LP heaters 250
- Material: HP, 70-30 Cu Ni; LP, inhibited admiralty

Deaerating Heaters (No. 4, 1 per unit)

Type: Deaerating tray
Manufacturer:
  Units 1-4: Cochrane Corp.
  Units 5-9: Worthington Corp.
Storage tank dimensions:
  Units 1-4: Diameter 11 feet; over-all length, 42 feet 4 inches
  Units 5-9: Diameter 12 feet; over-all length, 44 feet 8 inches
Design pressure:
  Units 1-4: 65 psig
  Units 5-9: 85 psig
Capacity:
  Units 1-4: 1,012,940 pph
  Units 5-9: 1,312,720 pph

Evaporators (1 per unit)

Type: Horizontal, single effect
Manufacturer:
  Units 1-4: Graham Manufacturing Co.
  Units 5-9: Griscom-Russell Co.
Evaporative capacity:
  Units 1-4: 20,000 pph
  Units 5-9: 26,000 pph
Shell design pressure:
  Units 1-4: 75 psig
  Units 5-9: 85 psig
Tube design pressure:
  Units 1-4: 225 psig
  Units 5-9: 250 psig
Tube design temperature:
  Units 1-4: 850°F
  Units 5-9: 950°F
Tube material:
  Units 1-4: Monel
  Units 5-9: Type 304 stainless

Boiler Feedwater Pumps (3 per unit)

Type and stages: Horizontal; units 1-4, 12; units 5-9, 9
Rated capacity, each:
  Units 1-4: 1102 gpm
  Units 5-9: 1445 gpm
Rated head:
  Units 1-4: 6075 feet
  Units 5-9: 6305 feet
Manufacturer:
  Units 1-4: Byron Jackson Co.
  Units 5-9: Worthington Corp.
Motors:
  Manufacturer: Electric Machinery Co.
  Rating:
    Units 1-4: 2000 hp, 3575 rpm
    Units 5-9: 3000 hp, 3570 rpm

Condensate Pumps (2 per unit)

Stages and type: 5-stage, vertical, multi-stage, deep-well, centrifugal
Rated capacity, each:
  Units 1-4: 1700 gpm
  Units 5-9: 2250 gpm
Rated head:
  Units 1-4: 370 feet
  Units 5-9: 470 feet
Manufacturer: Westinghouse Electric Corp.
Motors:
  Units 1-4: 250 hp, 1170 rpm
  Units 5-9: 400 hp, 1170 rpm

Internal Water Treatment (units 1-4)

Sodium phosphate pumps: 4; duplex-plunger type; manufactured by Hills-McCanna; 66.6 gallons per hour at 2375 psi rated capacity; 3-hp motor
Sodium sulphite and sodium hydroxide pumps: 5; duplex-plunger type, one head for sulphite and one for caustic; manufactured by Hills-McCanna; 2.0 gallons per hour at 1500 psi rated capacity each head; ⅓-hp motor

Internal Water Treatment (units 5-9)

Sodium phosphate pumps: 5; duplex-plunger type; manufactured by Milton Roy Co.; 74 gallons per hour at 2300 psi rated capacity; 5-hp motor
Sodium sulphite and sodium hydroxide pumps: 6; duplex-plunger type, one head for sulphite and one for caustic; manufactured by Milton Roy Co.; 3.0 gallons per hour at 700 psi rated capacity head; ¼-hp motor

MECHANICAL CONTROL EQUIPMENT

Unit Control Room

Principal features: Centralized control; two units in one room with 9th unit in separate room; supplied by Republic Flow Meters Co.

PRINCIPAL PIPING

Fabricator

National Valve & Manufacturing Co.

Main Steam

Design pressure:
Units 1-4: 1935 psig
Units 5-9: 1945 psig
Design temperature:
Units 1-4: 1003°F
Units 5-9: 1053°F
Material:
Units 1-4: Alloy steel, A158-50T, symbol P11, 1¼ percent Cr, ½ percent Mo
Units 5-9: Alloy steel, A335-52T, symbol P22, 2¼ percent Cr, 1 percent Mo
Full flow sections (forged and bored):
Units 1-4: 16¼-inch od, 2⅜-inch wall thickness
Units 5-9: 17-inch od, 2½-inch wall thickness
Half flow sections (forged and bored):
Units 1-4: 13½-inch od, 2-inch wall thickness
Units 5-9: 15½-inch od, 2⅜-inch wall thickness

Steam to Reheater

Design pressure:
Units 1-4: 500 psig
Units 5-9: 435 psig
Design temperature:
Units 1-4: 665°F
Units 5-9: 700°F
Material:
Units 1-4: Carbon steel, A106-48T, grade B
Units 5-9: Carbon steel, A106-51T, grade B
Flow sections (seamless pipe):
Units 1-4:
Full: 20-inch od, ½-inch wall thickness
Half: 14-inch od, ⅜-inch wall thickness
Units 5-9: 2 sections; 18-inch od, ⅜-inch wall thickness

Steam from Reheater

Design pressure:
Units 1-4: 470 psig
Units 5-9: 415 psig
Design temperature:
Units 1-4: 1003°F
Units 5-9: 1053°F
Material:
Units 1-4: Alloy steel, A158-50T, symbol P11, 1¼ percent Cr, ½ percent Mo
Units 5-9: Alloy steel, A155-52T, class 1, 2¼ percent Cr, 1 percent Mo
Full flow sections:
Units 1-4: Forged and bored, 20-inch od, 1.031-inch wall thickness
Units 5-9: Rolled and welded, 24-inch od, 1-inch wall thickness
Half flow sections:
Units 1-4: Cupped and drawn, 16-inch od, 0.843-inch wall thickness
Units 5-9: Rolled and welded, 18-inch od, ¾-inch wall thickness

HEATING, VENTILATING AND AIR CONDITIONING

Powerhouse

Building heating: 21,940 pph steam
Air preheating: 246,600 pph steam
Ventilating air: 4,308,000 cfm supplied; 2,225,000 cfm exhausted
Air conditioning: Control rooms, 67½ tons; shift engineer's office, 3 tons; packaged unit type; units 1-4 manufactured by Worthington Corp., units 5-9 by Nevinger Manufacturing Co., Inc.

Service Bay (shop area)

Heating: 1400 pph steam
Ventilating air: 65,800 cfm supplied; 102,500 cfm exhausted
Air conditioning (storekeeper's office): 5 tons; packaged unit type; manufactured by Nevinger Manufacturing Co., Inc.

Service Bay (office area)

Heating: 2270 pph steam
Ventilating air: 18,900 cfm supplied; 44,800 cfm exhausted
Air conditioning: 104 tons; built-up central water chilling system type; manufactured by York Corp.

COAL HANDLING FACILITIES

DELIVERY

Barge

No permanent facilities provided

Rail

Trackage: 30.5 miles including yards
Storage yards: Capacities (40-foot cars): Caney Creek interchange yard (with Tennessee Central RR), 254; Southern Ry interchange by Southern Ry; loaded yard, 854; empty yard, 715; gravity movement from dumpers to empty storage with speed controlled by two friction-type, electronically operated retarder systems, fully automatic with optional manual control; manufactured by General Railway Signal Co.
Locomotives: Three 120-ton diesel-electric, manufactured by Baldwin-Lima-Hamilton Corp.; three 80-ton diesel-electric, manufactured by General Electric Co.
Rotary car dumpers: 2; maximum capacity (each); 70-ton car, 18 cars per hour; No. 1 manufactured by Heyl & Patterson, Inc., No. 2 by The Wellman Engineering Co.
Scales: Capacity, 162.5 tons; platform size, 56 by 11.5 feet (with dead rail); manufactured by Fairbanks Morse & Co.

Truck

Unloading: Dumper on manual unloading track in hopper building
Scales: Capacity, 50 tons; platform size, 50 by 10 feet; manufactured by The Howe Scale Co.

CRUSHING, STORAGE, AND CONVEYING

Structures

Hopper buildings: 2; substructure, reinforced concrete; superstructure, steel framing with masonry and Galbestos siding; No. 1, 70 by 63 feet by 35 feet high above railroad tracks; No. 2, 68 by 52 feet by 33 feet high above railroad tracks
Crusher building: Substructure, reinforced concrete; superstructure, steel framing with masonry and Galbestos siding; 68 by 42 feet by 46 feet high (with control house on roof)
Sample preparation building: East side of hopper building No. 1; steel frame; flat roof; 19 by 69 feet by 12 feet high
Architecture:
- Hopper and crusher buildings: Gray face brick base with insulated maroon asbestos-protected steel V-beam siding above, aluminum copings, steel sash, aluminum window frame assembly, and yellow porcelain-enameled panels in conveyor control house on crusher building
Conveyors: Maroon V-beam siding sheets and black corrugated roofing sheets of uninsulated asbestos-protected steel
Heating and ventilating, all three buildings: 371 kw; 35,100 cfm
Air conditioning, hopper and sample preparation building: 17.4 tons; built-up direct-expansion system; manufactured by the Trane Co.

Crushing

Method: Impact type (by hammermills); run-of-mine to 1¼-inch ring size
Crushers: 4; 500 tph each; two manufactured by Stephens-Adamson Manufacturing Co., and two by Jeffrey Manufacturing Co.

Storage

Yard:
- Area: 58 acres
- Capacity: 1,350,000 tons (90-day supply, 25 feet high)
Mobile equipment: 4 No. TD-24 crawler-type, 180-hp, International Harvester Co. tractors; 4 No. B250, cable-operated, 22-cu-yd Bucyrus-Erie Co. scrapers; two 275-hp, single-engine MRS 190 rubber-tired tractor units; two 300-hp, single-engine MRS 200 rubber-tired tractor units; 1 rubber-tired, 30-35-cu-yd scraper type OS-260A Wooldridge Mfg. Div.; 1 rubber-tired tractor-bulldozer, 275-hp LeTourneau-Westinghouse model C with angledozer

Dust Collectors

Number, type and location: 1; wet type, in crusher building
Capacity: 20,000 cfm
Manufacturer: American Air Filter Co., Inc.

Conveyor System

Manufacturers:
- Belt conveyors: Link-Belt Co.
- Belts: Goodyear Tire and Rubber Co. and B. F. Goodrich Co.
- Vibrating feeders: 6 by Jeffrey Mfg. Co., 2 by Syntron Co.
- Belt weighing scales: Fairbanks, Morse & Co.
Principal equipment features:
- Belts to bunkers: 2
- Reclaiming hoppers: 2
- Stocking-out conveyors: 1
Belt widths and capacities: Belts handling run-of-mine coal from unloading points to crusher building are 54 inches wide, 1000 tph; all other belts are 48 inches wide, 1000 tph

Electrical Features

Equipment voltage rating: 4160-v board for 250-hp crusher motors; 480-v board for smaller motors
Control: Central control room for crushing, storage, and conveying equipment
Control board manufacturer: Allis-Chalmers Mfg. Co.

WATER SUPPLY

CIRCULATING WATER FOR CONDENSERS AND RAW WATER SYSTEM

General Data

Source: Emory and Clinch River arms of Watts Bar Lake
Lake stages: Low water elevation 735; normal high water elevation 741; design flood elevation 755
Flow: Units 1-4, 215 cfs each; units 5-9, 290 cfs each; units 1-9, 2310 cfs total
Chlorination: None; provision is made for future installation of a chlorination system to inhibit slime growth

Intake

Channel: Excavated and natural; approximately 4500 feet from Emory River arm of lake with skimmer wall in channel to obtain cool water
Structure:
- Type: Reinforced concrete with provision for unwatering; 284 by 54 feet by 50 feet high
- Heating and ventilating: 127 kw; 24,000 cfm
Trashracks: 2 per unit, each 21 feet high (three 7-foot sections) by 12 feet 8 inches wide
Traveling screens: 2 per unit, 10 feet wide; manufactured by Chain-Belt Co.

Circulating pumps: Units 1-9: 2 per unit, mixed flow, vertical
- Units 1-4: 48 inches; 48,500 gpm; 21.5-foot head; 350-hp, 272-rpm motor; manufactured by Westinghouse Electric Corp.
- Units 5-9: 54 inches; 65,000 gpm; 21.0-foot head; 450-hp, 318-rpm motor; manufactured by Westinghouse Electric Corp.

Gantry crane: 15-ton capacity; manufactured by Pacific Coast Engineering Co.

Conduits

Intake and discharge:
- Type: Concrete pressure pipe
- Manufacturer: Lock Joint Pipe Co.
- Dimensions:
  - Units 1-4: 78 inches id, 5880 feet long (total)
  - Units 5-9: 96 inches id, 7450 feet long (total)

Discharge

Structure: Reinforced concrete headwall with stoplog guides

Channel: Excavated and natural; approximate 2200 feet to Clinch River arm of lake

WATER TREATMENT PLANT

Structure

Type:
- Substructure: Reinforced concrete
- Superstructure: Steel framing and masonry, 53 by 67 feet by 28 feet high above floor
- Architecture: Exposed steel frame, gray face brick exterior walls, aluminum windows
- Heating and ventilating: 114 kw; 35,000 cfm

Equipment

Settling basins: 4; 28,800-gallon effective capacity each; 4-hour retention

Filters: 4; 60-sq-ft size; 120-gpm capacity each

Storage walls: Filtered, 46,800 gallons; softened, 25,350 gallons; domestic, 10,050 gallons

Pumps:
- Raw water supply: 3 of 240-gpm capacity at 85-foot head
- Filter wash water: 1 of 1050-gpm capacity at 35-foot head
- Softener supply: 4 of 160-gpm capacity at 65-foot head
- Soft water service: 4 of 160-gpm capacity at 320-foot head
- Domestic water supply: 2 of 40-gpm capacity at 20-foot head
- Domestic water service: 2 of 150-gpm capacity at 165-foot head

Softening: Zeolite system; manufactured by Hungerford & Terry, Inc.; capacities: 320 gpm at design rate, 4000 kilograins of hardness removed between regenerations; 4 tanks

CONTROL BUILDING

Structure

Location: Adjoining switchyard east of powerhouse, about opposite unit 5

Type:
- Substructure: Reinforced concrete
- Superstructure: Steel framing with masonry and Galbestos siding
- Dimensions: 132 by 62 feet by 25 feet high from finished floor
- Architecture: Gray face brick with maroon insulated asbestos-protected steel V-beam siding above; exposed structural steel frame; gray face brick exterior walls for low-level office area structure; steel sash; aluminum windows; aluminum copings

Heating and ventilating: 141 kw; 25,500 cfm

Air conditioning: 30-ton capacity, built-up direct expansion system, manufactured by Worthington Corp.

Switchboards

Arrangement: Instrument, recorder, automatic load control, d-c boards and control benchboard in control room; duplex type relay boards in separate room

Manufacturer: Allis-Chalmers Manufacturing Co.

TRANSFORMERS

Main Power

Number and type:
- Units 1-4: 4; FOA (forced oil, forced air cooled), 3 ph
- Units 5-9: 5; FOA (forced oil, forced air cooled), 3 ph

Rating:
- Units 1-4: 17.1-161 kv, 170,000 kva
- Units 5-9: 19-161 kv, 230,000 kva

Manufacturer: Allis-Chalmers Manufacturing Co.

Common Auxiliary Power

Number and type: 2; OA/FA (oil immersed, air cooled/forced air cooled), 3 ph

Rating: 161-4.16 kv, 20,000/25,000 kva

Manufacturer: General Electric Co.

Unit Auxiliary Power

Number and type:
- Units 1-4: 4; OA/FA (oil immersed, air cooled/forced air cooled), 3 ph
- Units 5-9: 5; OA/FA (oil immersed, air cooled/forced air cooled), 3 ph

Rating:
- Units 1-4: 17.1-4.16 kv, 9,000/11,250 kva
- Units 5-9: 19.0-4.16 kv, 12,000/16,000 kva

Manufacturer: Westinghouse Electric Corp.

SWITCHYARD, 161 KV

Bays: 25 (10-line, 11-transformer, 4 unassigned)
Conductors: Aluminum tubing; welded construction
Disconnect switches: 1200 and 2000 amp, 63,000 amp momentary; manufactured by Southern States Equipment Corp.
Oil circuit breakers: 33; 1600 amp, 10,000,000 kva interrupting capacity, 3/20 cycle reclosing; manufactured by General Electric Co.

OTHER ELECTRICAL FEATURES

Cables

Power:
- 5-kv: Single conductor, AVCSB (asbestos and varnished cambric insulated, shielded, asbestos braided) and ROSJ (ozone resisting, rubber insulated, shielded, rubber jacketed)
- 600-v: Single conductor, AVA (asbestos and varnished cambric insulated, rubber jacketed) and multiconductor MI (mineral insulated)

Control:
- 600-v: Multiple conductor, ROJJ (rubber insulated, rubber jacketed, overall jacketed)

Lighting Arresters

Rating, 161-kv circuit: 145 kv maximum line to ground
Manufacturer: General Electrical Company

Communication Systems

Telephone: PAX, manual, line carrier, microwave, and radio
Printer telegraph: Microwave
Paging and intercommunication: Powerhouse area
Telemetering: Line carrier and microwave
Automatic load control: Line carrier

Illumination

System: Single phase, 220/110 v
Turbine room: Incandescent high-bay units
Boiler house: Firing aisle, industrial fluorescent; other areas, incandescent
Control building: Control room, indirect incandescent; other areas, fluorescent
Service bay: Mostly fluorescent
Yard: Incandescent for coal handling, street lighting, and flood lighting; 7 floodlight towers 100 feet high with banks of 1500-watt floodlights totaling 40 lamps and 60 kw in coal storage yard

OTHER BUILDINGS AND YARD FEATURES

Buildings

Storage: Concrete block base with maroon V-beam siding sheets of uninsulated asbestos-protected steel above; steel framing; 61 by 202 feet by 19 feet high; equipped with Austin-Western 4-ton rubber-tired mobile crane
Utility: Exposed structural steel frame, gray face brick exterior walls, blue corrugated glass high-level windows; repair shop area, 120 by 60 feet by 29 feet high with 8 exterior rolling steel doors
Carpenter shop: At west end of utility building, steel frame, flat roof, 20 by 40 feet by 12 feet high
Heating and ventilating: 290 kw; 73,000 cfm

Yard

Ash disposal area:
- Location: Diked area in lake north of plant
- Area: 60 acres
- Storage capacity: 90 unit-years to elevation 765
- Future area: 275 acres

Mobile equipment: One 20-ton, rubber-tired, diesel-powered crane, Bucyrus-Erie No. 22B, ¾-cu-yd Erie-Strayer bucket, for general yard service
Parking area: Capacity, 300 automobiles
Miscellaneous: Provision for future radio antenna and anemometer tower on top of water tank

APPENDIX C

MAJOR PURCHASES

TABLE 39.—*Major purchases of material and equipment.*[1]

Item	Vendor	Amount	Date
ARCHITECTURAL			
Carbon brick	National Carbon Co.	$17,189.04	2-52
Concrete roof and floor slabs	Alabama Cement Tile Co.	47,565.00	3-52
Metal siding panels	H. H. Robertson Co.	318,834.00	6-52
Masonry materials	Garland Sherman	509,484.68	6-52
Steel stairs	Henry E. Gremp Co.	33,359.00	7-52
Stair railings	Reliance Art Metal Co.	11,024.00	7-52
Grating, stair treads, etc	Reliance Steel Prod. Co.	187,463.46	7-52
Aluminum windows, steel panels	American Bronze Co.	52,500.00	7-52
Roofing	Burn-Rite Prod. Co.	6,700.00	7-52
Laboratory furniture and equipment	Kewaunee Mfg. Co.	14,461.00	7-52
Steel roof decking and accessories	H. H. Robertson Co.	9,599.00	8-52
Chain-link fence	United States Steel Co.	7,573.17	8-52
Roofing and sheet metal work	Tri-State Roofing Co.	114,107.00	8-52
Glass and glazing	Southeastern Glass, Inc.	20,281.44	8-52
Buildings	USN Dept. Office of the Chief	7,400.00	8-52
Roof decking	H. H. Robertson Co.	78,287.00	9-52
Windows, window and door assemblies	Newman Bros.	21,173.00	9-52
Flooring	The Munford Co., Inc.	13,953.00	10-52
Furring, lathing, plastering and insulation	Hopton Bros.	81,500.00	10-52
Steel lockers, stools and hood	Lyon Metal Prod.	8,514.21	10-52
Steel shelving	Ditto	19,236.89	10-52
Metal partitions and ceiling panels	The E. F. Hauserman Co.	11,400.00	10-52
Steel benches and cabinets	Electric Service Mfg. Co.	27,701.42	11-52
Marble, quarry tile and terrazzo work	Ampco Marble Div. and/or H. W. Wiese	8,650.00	11-52
Ditto	Art Mosaic & Tile Co., Inc.	194,883.00	11-52
Buildings	USN Advance Base Supply	74,000.00	1-53
Doors, frames, etc	Wm. E. McGill	28,452.00	4-53
Carbon brick	National Carbon Co.	23,503.50	4-53
Alumigrid finish ceilings	Standard Glass Co.	5,893.00	4-53
Aluminum louvers and grilles	Aluminum Structures	52,581.00	5-53
Steel sash, sills and stools	The American Bronze Co.	8,880.00	7-53
Paint and paint products	Gilman Paint & Varnish Co.	7,730.80	8-53
Carbon brick	National Carbon Co.	7,086.41	10-53
Built-up fill—insulation—flashing	Ensley Roofing Co.	78,548.00	12-53
Steel grating, etc	Blaw-Knox Equipment Div.	218,248.40	1-54
Steel louvers	Linderking Metal Products	10,654.75	1-54
Metal siding, roof vents, etc	American Steel Band Co.	13,250.28	3-54
Alumigrid finish ceilings	Standard Glass Co.	6,190.00	7-54
Steel floor grating	Blaw-Knox Equipment	60,494.29	7-54
Steel gratings, etc	Irving Subway Grating	5,823.00	9-54
Built-up roofing	Alabama Roofing Co.	19,544.00	9-54
Steel roof decking	American Steel Band Co.	29,095.00	11-54
Metal siding	H. H. Robertson Co.	234,659.00	11-54
Aluminum railing	General Metals Co.	8,919.00	2-55
Interior aluminum louvers	Newman Bros.	5,796.00	6-55
Hollow metal work	Overly Mfg. Co.	8,531.00	6-55
Ditto	Waggstaff Hardware	5,749.00	6-55
Galvanized steel grating	Reliance Steel Products	5,319.60	6-55
Paint	Gilman Paint & Varnish Co.	7,777.00	8-55

1. Includes contracts of $5,000 and over.

TABLE 39.—*Major purchases of material and equipment*—Continued.

Item	Vendor	Amount	Date
CIVIL AND STRUCTURAL			
Tarpaulins	Tenn. Valley Awning Co.	$18,508.00	4-51
Carrying crane	Power Equipment Co.	20,508.00	4-51
Structural steel	The Ingalls Iron Works Co.	2,125,360.00	4-51
Pipe and flanges	Tenn. Metal Culvert Co.	18,858.90	4-51
Yellow pine	L. U. West Lumber Co.	28,299.00	4-51
Yellow pine	South Miss. Lumber Corp.	14,416.25	4-51
Yellow pine	Tumlin & Groover, Inc.	37,680.00	4-51
Shovel	R. L. Harris, Inc.	52,883.25	4-51
Steel beams	Tenn. Coal, Iron & Railroad Co.	35,960.68	4-51
Steel plates	Siskin Steel & Supply Co.	7,650.93	4-51
Concrete pipe	Sherman Concrete Pipe	5,334.80	4-51
Ditto	Ditto	8,000.00	4-51
Steel	Tenn. Coal, Iron & Railroad Co.	40,360.96	4-51
Concrete placing equipment	Nixon Machinery & Supply Co.	33,388.15	5-51
Creosoted cross ties and switch ties	Columbus Wood Preserving Co.	14,797.86	5-51
Gasoline	McLain & Bryson Oil Co.	10,110.00	5-51
Southern yellow pine	Stowers Lumber & Mfg. Co.	5,214.00	5-51
Crushed limestone	Superior Sand & Gravel Co.	20,950.00	5-51
Complete dragline attachment	Fairview Collieries Corp.	15,000.00	5-51
Steel shapes	Tenn. Coal, Iron & Railroad Co.	118,119.33	5-51
Motor grader	Osborne Equipment	11,970.00	5-51
Wire rope	R. G. LeTourneau, Inc.	11,573.00	5-51
Steel angles	Glazer Steel Co. of New Orleans	6,800.00	5-51
Structural steel	Irvington Steel & Iron Works, Inc.	5,131.62	5-51
Gasoline engine	Knox-Mack Distributers, Inc.	15,075.30	5-51
Steel	Glazer Steel Co. of New Orleans	23,850.00	5-51
Cross ties	Wyoming Tie & Timber	35,000.00	5-51
Cross ties	T. J. Moss Tie Co.	89,600.00	5-51
Ditto	Koppers Co.	29,900.00	5-51
Crawler crane with boom and jib	Tag Equipment Co.	65,165.10	5-51
Ditto	Ditto	57,155.34	5-51
Rental of tractor	Power Equipment Co.	26,580.00	5-51
Plates	D. Loveman & Sons	14,100.00	5-51
Reinforcing steel	Charles Steel Co.	18,100.00	5-51
Drag shovel attachment	Power Equipment	5,890.00	5-51
Continuous deck plate girder unit	Nashville Bridge Co.	28,320.00	6-51
Crawler crane	Buchanan-Rooney Equipment Co.	23,583.88	6-51
Metal bending roll, electric motor driven	The Webb Corp.	6,518.00	6-51
Southern yellow pine	South Miss. Lumber Corp.	7,910.04	6-51
Crawler crane	Osborne Equipment	15,000.00	6-51
Steel shapes	Irvington Steel & Iron Works, Inc.	7,220.78	6-51
Reinforcing steel	Charles Steel Co.	59,500.00	6-51
Pipe	Sherman Concrete Pipe Co.	6,071.32	6-51
Concrete aggregate	Acme Block & Concrete Co.	13,670.00	6-51
Dynamite	E. I. duPont de Nemours & Co.	12,800.00	6-51
Discharge hose	Knox-Tenn Equipment Co.	5,096.00	6-51
Grease	The Texas Co.	6,416.47	7-51
Lubricating oil	Shell Oil Co.	12,000.00	7-51
Concrete pipe	Sherman Concrete Pipe Co. of Knoxville, Inc	5,407.96	7-51
Diesel engine fuel oil	McLain & Bryson Oil Co.	27,000.00	7-51
Mobile crane	T.A.G. Equipment Co.	36,265.25	7-51
Diesel-electric locomotive crane	The Browning Crane & Shovel Co.	116,008.00	7-51
Rubber expansion joints	C. D. Genter Co.	14,607.00	7-51
Trenching machine	Gordon Nichol Tractor Co.	5,765.15	7-51
Hydraulic lift dump trucks	C. E. Scott	109,368.00	7-51
Miscellaneous steel fabrications	Truitt Manufacturing Co.	11,916.00	7-51
Portland cement	Volunteer Portland Cement Co.	368,100.00	7-51
Rails	Standard Iron & Steel Co.	22,365.00	7-51
Steel	Charles Steel Co.	193,419.00	7-51
Carbon steel	D. Loveman & Sons	5,520.00	7-51
Structural shapes	Charles Steel Co.	12,022.80	7-51
Steel bars	Calumet Iron & Supply Co.	10,800.00	7-51
Steel strip	Ditto	15,950.00	7-51
Steel bars	Ditto	7,170.00	7-51
Steel shapes	Ditto	6,707.00	7-51
Beams	Ditto	6,250.00	7-51
Steel angles	Ditto	22,213.06	7-51
Steel angles	Ditto	5,554.19	7-51
Reinforcing steel	Charles Steel Co.	107,695.00	7-51

TABLE 39.—*Major purchases of material and equipment*—Continued.

Item	Vendor	Amount	Date
CIVIL AND STRUCTURAL—Continued			
Reinforcing steel	Glazer Steel Co. of New Orleans	$51,700.00	7-51
Wire	Calumet Iron & Supply Co	7,375.00	7-51
Steel shapes	Charles Steel Co	8,775.00	7-51
Steel plates	Calumet Iron & Supply Co	6,519.20	7-51
Angles	Ditto	9,238.98	7-51
Beams	Ditto	6,604.50	7-51
Angles	Ditto	8,063.83	7-51
Steel sheets	Ditto	12,328.40	7-51
Steel sheets	Calumet Iron & Supply Co	14,335.59	8-51
Steel sheets	Ditto	14,398.50	8-51
Steel shapes	Ditto	6,371.96	8-51
Steel plates	Ditto	7,017.60	8-51
Steel sheets	Ditto	15,489.69	8-51
Steel reinforcing	Ditto	9,600.00	8-51
Blocks	W. S. Murrian Co	29,902.22	8-51
Diesel electric locomotive	General Electric Co	61,800.00	8-51
Rails and accessories	Weir Kilby Corp	39,561.30	8-51
Concrete pressure pipe	Lock Joint Pipe Co	314,071.74	8-51
Southern yellow pine	Tumlin & Groover, Inc	63,944.35	8-51
Southern yellow pine	W. T. Vick Lumber Co	25,050.00	8-51
Expansion joint filler	The American Brass Co	5,886.51	8-51
Tar	Reilly Tar & Chemical Corp	5,118.80	8-51
Reinforced concrete chimneys	The Rust Engineering Co	284,450.00	8-51
Structural steel	Truitt Manufacturing Co	27,750.00	8-51
Crushed limestone	Superior Sand & Gravel Co	12,800.00	8-51
Pipe	W. S. Dickey Clay Mfg. Co	7,590.00	8-51
Lumber	S. Miss. Lumber Corp	6,081.63	8-51
Pipe fittings	Jones-Sylar Supply Co	6,030.44	9-51
Cross and switch ties	Southern Wood Preserving Co	100,608.39	9-51
Coarse and fine aggregate	Lambert Brothers, Inc	380,518.80	9-51
Plates, etc	Tenn. Coal, Iron & Railroad Co	318,569.00	9-51
Rail anchors	The P & M Co	13,080.00	9-51
Joints	The Rail Joint Co	18,018.00	9-51
Plates	Calumet Iron & Supply Co	12,385.00	9-51
Reinforcing steel	Ditto	192,000.00	9-51
Steel shapes	Ditto	15,626.54	9-51
Steel shapes	Ditto	5,065.77	9-51
Steel bars	Ditto	5,596.06	9-51
Steel structural shapes	Siskin Steel & Supply Co	9,963.79	9-51
Steel plates	Calumet Iron & Supply Co	14,772.60	9-51
Steel strips	Trinler, Inc	6,083.80	9-51
Steel reinforcing	Siskin Steel & Supply Co	7,081.05	9-51
Steel channels and bars	Calumet Iron & Supply Co	6,612.53	9-51
Steel	Ditto	287,232.00	9-51
Wire	Ditto	5,900.00	9-51
Concrete posts	Tennessee Metal Culvert Co	9,247.86	10-51
Primacord	The Equitable Powder Mfg. Co	7,450.00	10-51
Iron	Noland Company	5,301.97	10-51
Frogs steel	American Brake Shoe Co	9,581.25	10-51
Structural shapes	Charles Steel Co	10,206.48	10-51
Steel reinforcing	The American Ind. Prod. Co	370,025.00	10-51
Steel shapes	Calumet Iron & Supply Co	9,350.00	10-51
Steel reinforcing	The American Ind. Prod. Co	76,875.00	10-51
Steel shapes	Charles Steel Co	5,875.00	10-51
Diesel-electric locomotives	Baldwin-Lima-Hamilton Corp	211,102.00	10-51
Bars	American Ind. Prod. Co	10,422.75	11-51
Structural shapes	Calumet Iron & Supply Co	14,208.51	11-51
Relay rail	Ditto	8,330.00	11-51
Steel fabrication	Converse Bridge & Steel Co	13,920.00	11-51
Structural shapes	Calumet Iron & Supply Co	26,265.72	11-51
Bars steel	American Ind. Prod. Co	17,861.25	11-51
Angles	Calumet Iron & Supply Co	5,507.04	11-51
Steel plate	Ditto	12,771.08	11-51
Beams, channels, etc	Ditto	12,590.25	11-51
Crusher run rock	Rockwood Slag Products, Inc	7,100.00	12-51
Angles	Calumet Iron & Supply Co	6,060.00	12-51
Channels	Ditto	6,321.61	12-51
Structural steel shapes, etc	Siskin Steel & Supply Co	23,277.76	12-51
Channels	Calumet Iron & Supply Co	7,185.00	12-51

TABLE 39.—*Major purchases of material and equipment*—Continued.

Item	Vendor	Amount	Date
CIVIL AND STRUCTURAL—Continued			
Angles	Calumet Iron & Supply Co.	$6,642.00	12-51
Bars, etc.	Ditto	11,197.80	12-51
Angles, channels, etc.	Ditto	9,400.00	12-51
Reinforcing steel	Bethlehem Steel Co.	145,500.00	1-52
Steel channels, etc.	Ditto	12,766.16	1-52
Reinforcing steel	Siskin Steel & Supply Co.	8,098.00	1-52
Reinforcing steel	Glazer Steel of New Orleans	48,250.00	1-52
Rail	Standard Iron & Steel Co.	10,240.00	1-52
Plates	Calumet Iron & Supply Co.	7,549.85	1-52
Steel	Ditto	31,638.15	1-52
Angles	Charles Steel Co.	5,888.16	1-52
Dynamite	E. I. duPont de Nemours Co.	13,600.00	1-52
Steel plates and shapes	Calumet Iron & Supply Co.	14,912.06	1-52
Slag	Rockwood Slag Products, Inc.	14,090.52	2-52
Riprap material	Rockwood Slag Products, Inc.	7,500.00	2-52
Pine lumber	Roane Lumber Co.	13,864.23	2-52
Concrete pipe	Universal Concrete Pipe Co.	46,247.75	2-52
Structural steel	Bethlehem Steel Co.	109,400.00	2-52
Structural steel	Bristol Steel & Iron Works, Inc.	14,361.00	2-52
Reinforcing steel	Calumet Iron & Supply Co.	78,000.00	3-52
Angles and shapes	Siskin Steel & Supply Co.	9,057.09	3-52
Platform trailer	Fontaine Truck Equipment Co.	5,388.65	3-52
Lumber	Lee K. Wert	15,801.64	3-52
Lumber	Ray E. Loper Lumber Co.	53,370.00	3-52
Lumber	Stringfellow Lumber Co.	17,790.00	3-52
Sand	Rockwood Slag Prod. Inc.	13,620.00	3-52
Steel plates	D. Loveman & Son	14,307.23	3-52
Steel plates	Ditto	22,627.53	3-52
Steel	Calumet Iron & Supply Co.	24,200.00	3-52
Sand and gravel	Brooks Sand & Gravel Co.	44,000.00	3-52
Steel	U. S. Steel Supply Div.	20,600.00	3-52
Steel	Calumet Iron & Supply Co.	21,200.00	3-52
Asbestos cement board	Kesbey & Mattison Co.	6,757.50	4-52
Steel	Converse Bridge & Steel Co.	23,840.00	4-52
Reinforcing steel	D. Loveman & Son	78,400.00	4-52
Channels	Ingalls Iron Works	5,020.00	4-52
Structural steel	Truitt Manufacturing Co.	117,696.00	4-52
Fire protection equipment	Grinnell Co.	9,836.60	4-52
Stop logs	Nashville Bridge Co.	6,370.00	4-52
Miscellaneous steel	Burn-Rite Products Co.	28,106.64	4-52
Aluminum housings	The Kirk & Blum Mfg. Co.	12,300.00	4-52
Arc welding machines	Delta Oxygen Co.	28,250.00	5-52
Diesel fuel	St. Oil Co., Inc., in Ky.	28,650.00	5-52
Structural steel	Bristol Steel & Iron Works, Inc.	46,565.00	5-52
Channel and fittings	Unistrut Products Co.	20,751.88	5-52
Steel fabrications	Converse Bridge & Steel Co.	14,900.00	6-52
Structural steel	Bristol Steel & Iron Works	34,272.00	6-52
Slag	Rockwood Slag Products	40,278.00	6-52
Portable fire extinguishers	The General Detroit Corp.	5,139.65	6-52
Concrete pipe	Sherman Concrete Pipe Co. of Knox	15,961.90	7-52
Gasoline	Harriman Oil Co.	37,920.00	7-52
Diesel fuel	Harriman Oil Co.	53,760.00	7-52
Structural steel	Converse Bridge & Steel Co.	132,280.40	7-52
Shapes, sheets, plates	Burn-Rite Products Co.	12,027.35	7-52
Culvert pipe	Universal Concrete Pipe Co.	6,300.00	8-52
Mesh steel	LaClede Steel Co.	5,882.25	8-52
Structural steel	Anthracite Bridge Co.	43,767.00	8-52
Steel	U. S. Steel Supply Div.	28,250.00	8-52
Reinforced concrete chimneys	The Rust Engineering Co.	332,500.00	9-52
Steel floodlight towers	The Charles E. Schuler Engr. Co.	13,626.77	9-52
Wire guards	Leinart Engr. Co.	6,742.68	9-52
Yellow pine	Tenn. Eastern Lbr. Co.	6,750.00	9-52
Wagon drills	Chicago Pneumatic Tool Co.	8,336.00	9-52
Yellow pine	Lee K. Wert	37,365.21	9-52
Yellow pine	Tumlin & Groover, Inc.	101,062.50	9-52
Reinforcing steel	Tenn. Coal & Iron Div.	24,300.00	9-52
Steel pipe	Jones-Sylar Supply Co., Inc.	5,353.00	10-52
Rubber expansion joints	U. S. Rubber Co.	13,117.84	10-52
Portland cement	Volunteer Portland Cement Co.	474,650.00	10-52

TABLE 39.—*Major purchases of material and equipment*—Continued.

Item	Vendor	Amount	Date
CIVIL AND STRUCTURAL—Continued			
Joints	Moisson Packing & Rubber Co.	$23,719.00	10-52
Steel reinforcing	Calumet Iron & Supply Co.	10,912.02	10-52
Steel	D. Loveman & Son	12,616.00	10-52
Steel	Siskin Steel & Supply Co.	36,720.00	10-52
Reinforcing steel	D. Loveman & Son	29,040.00	10-52
Yellow pine	Tumlin & Groover, Inc.	23,000.00	10-52
Crushed stone	Ralph Rogers & Co.	6,450.00	11-52
Dynamite	E. I. duPont de Nemours & Co.	6,800.00	11-52
Reinforcing steel	Calumet Iron & Supply Co.	40,600.00	11-52
Creosoted timber ties	Southern Wood Preserving Co.	92,191.90	11-52
Steel	Calumet Iron & Supply Co.	87,780.00	11-52
Reinforcing steel	The Rust Engineering Co.	7,231.98	11-52
Steel bars and angles	Calumet Iron & Supply Co.	6,950.00	11-52
Bars	Rail Joint Co., Inc.	8,640.00	12-52
Wire rope	Noland Co., Inc.	18,394.80	12-52
Railroad rail and accessories	M. K. Frank	7,219.00	12-52
Ditto	Bethlehem Steel Co.	12,233.02	12-52
Ditto	Weir Kilby Corp.	23,409.40	12-52
Fire extinguisher equipment	C-O-Two Fire Equipment Co.	9,969.50	12-52
Rock	Rockwood Slag Products Co., Inc.	8,200.00	1-53
Culvert pipe	Sherman Concrete Pipe Co. of Knox	11,235.00	1-53
Steel fabrications	Chattanooga Boiler & Tank Co.	8,730.00	1-53
Reinforcing steel	Siskin Steel & Supply Co.	115,600.00	1-53
Ditto	Ditto	57,800.00	1-53
Deck plate girder spans	American Bridge Div. U. S. Steel	33,250.00	1-53
Crushed stone	Ralph Rogers & Co.	37,840.00	2-53
Concrete	A. B. Long Construction Co.	17,937.50[2]	2-53
Steel	Tenn. Coal & Iron Div.	16,300.00	3-53
Crushed stone	Rockwood Slag Products, Inc.	9,100.00	4-53
Southern yellow pine	Tumlin & Groover, Inc.	16,500.00	4-53
Ditto	Batey Lumber Co.	17,250.00	4-53
Road stone	A. B. Long Construction Co.	8,058.75	5-53
Oak lumber	Mowery Saw Mill	6,575.00	5-53
Concrete pipe	Sherman Concrete Pipe Co. of Knox	6,095.00	5-53
Riprap material	Rockwood Slag Products, Inc.	15,990.00	5-53
Reinforced concrete pipe	Universal Concrete Pipe	10,102.40	5-53
Electric locomotive	General Electric Co.	134,440.00	6-53
Dynamite	E. I. duPont de Nemours Co.	6,340.00	6-53
Yellow pine lumber	L. C. Fuller, Jr.	13,195.58	6-53
Tees, angles, bars	Reynolds Metal	6,079.29	7-53
Aluminum metal	Penn Metal Co.	5,176.60	7-53
Arc welding machine	Brooks Welding Supply Co.	8,010.00	7-53
Precast concrete roof and floor slabs	Alabama Cement Tile Co.	73,248.00	7-53
Lumber	Tenn. Eastern Lumber Co.	5,900.00	8-53
Earth moving equipment	Power Equipment Co.	53,392.00	8-53
Steel caissons	Converse Bridge & Steel Co.	28,000.00	8-53
Dairy products	Broadacre Dairies, Inc.	7,155.20	9-53
Bakery products	Charlie's Pie Shop	8,695.30	9-53
Steel stairs, etc.	Henry E. Gremp	16,995.00	9-53
Welding rods	Alabama Oxygen Co.	11,487.10	10-53
Portland cement	Volunteer Portland Cement	14,500.00	10-53
Structural steel	Allied Structural Steel	23,459.14	10-53
Railroad rail accessories	Wooding Forge & Tool	9,162.60	10-53
Ditto	Siskin Steel & Supply Co.	12,570.30	10-53
Ditto	Weir Kilby	9,506.25	10-53
Ditto	Rampo Ajax Division	13,806.00	10-53
Structural steel	Henry E. Gremp	99,415.00	10-53
Electric welders	U. S. Atomic Energy Commission	14,926.46	10-53
Scaffolding	Universal Manufacturing Co.	6,041.58	11-53
Cement board, etc.	Johns-Manville Sales Corp.	8,640.29	11-53
Power loader	Power Equipment Co.	12,917.00	11-53
Concrete beams	Pre-Load Construction Co.	58,590.00	11-53
Files	Root Brothers	5,139.59	12-53
Steel channel framing	I.M.C. Equipment Co.	12,456.97	12-53
Steel structural shapes	Tenn. Coal & Iron Div.	5,873.20	12-53
Steel bars	Connors Steel Div.	23,329.00	12-53
Tractor unit	M. R. S. Manufacturing Co.	23,287.00	12-53

2. Approximate.

TABLE 39.—*Major purchases of material and equipment*—Continued.

Item	Vendor	Amount	Date
CIVIL AND STRUCTURAL—Continued			
Structural steel	Decatur Iron & Steel	$23,865.00	1-54
Crushed stone	A. B. Long Construction	15,858.70	2-54
Car retarder systems	General Railway Signal Co	45,313.33	2-54
Jib cranes	Detroit Steel Hoist Co	16,650.00	3-54
Electric arc welding machine	Harnischfeger Corp	9,975.00	4-54
Crushed slag	Rockwood Slag Products	42,600.00	4-54
Steel angles	Tenn. Coal, Iron & Railroad	7,305.25	4-54
Cement	Volunteer Portland Cement Co	6,960.00	5-54
Steel bars	Tenn. Coal, Iron & Railroad	7,452.50	5-54
Diesel electric locomotive	Baldwin Lima Hamilton Co	106,754.39	5-54
Oil	The Pure Oil Co	6,285.00	7-54
Aragon gas	Air Reduction Sales	8,043.75	7-54
Canvas cement	The Arabol Mfg. Co	5,413.72	7-54
Tractor unit	M. R. S. Manufacturing Co	30,041.00	7-54
Dairy products	Norris Creamery, Inc	6,749.60	9-54
Bakery products	Charlie's Pie Shop	7,334.60	9-54
Structural steel	Nashville Bridge Co	90,042.00	9-54
Mobile cranes	Power Electric Co	36,357.00	12-54
Maintenance tractor	Dempster Bros	5,600.00	12-54
Aggregate	A. B. Long Construction Co	8,352.00	1-55
Cement	Volunteer Cement Co	9,150.00	3-55
Portland cement	Ditto	9,450.00	7-55
Limestone	A. B. Long Construction Co	22,356.00	10-55
Fence	American Steel & Wire	11,962.43	11-55
Cement	Volunteer Portland Cement Co	5,100.00	1-56
Crushed stone	A. B. Long Construction Co	5,838.00	2-56
ELECTRICAL			
Copper wire, etc	Manhattan & Bronx	16,324.05	2-51
Fixtures, etc	G. E. Supply Co	7,253.36	2-51
Copper wire	Nehring Electrical Works	9,942.00	3-51
Conduit and fittings	Johns-Manville Sales Corp	18,560.00	4-51
Bare copper cable	General Cable Corp	56,572.66	4-51
Power transformers	Westinghouse Electric Corp	132,082.00	5-51
Power transformers, neutral grounding reactors	General Electric Co	254,443.00	5-51
Electric heaters	Mills & Lupton Supply Co	8,296.39	8-51
Insulated cable	Ditto	14,747.45	8-51
Ditto	Rome Cable Corp	6,290.00	8-51
Ditto	Phelps Dodge Copper Prod. Corp. Habirshaw Cable & Wire Div	60,835.80	8-51
Ditto	Ditto	59,232.20	8-51
Ditto	Westinghouse Electric Supply Co	66,515.50	8-51
Ditto	U. S. Rubber Co	86,446.00	8-51
Fuse	National Powder Co	7,375.00	9-51
Coupling capacitors	General Electric Co	23,550.00	9-51
Disconnecting switches	Southern States Equipment Corp	174,203.34	9-51
Line traps	General Electric Co	8,039.00	9-51
Entrance bushings	Lapp Insulator Co	9,092.00	9-51
Bare aluminum conductors	Aluminum Co. of America	14,179.30	10-51
Unit board, etc	Westinghouse Electric Corp	811,709.00	10-51
Oscillograph	Hathaway Instrument Co	6,756.30	11-51
Instrument transformers	Westinghouse Electric Corp	125,288.88	11-51
Carrier relay terminals	General Electric Co	37,330.00	11-51
Bus insulators	South East Joslyn Co	40,656.00	11-51
Switchboard wire	Graybar Electric Co	7,587.72	11-51
Suspension type insulators	The R. Thomas & Sons Co	7,147.56	12-51
Special valves and controllers	Leinart Engr. Co	15,362.67	12-51
Welding electrodes	C. D. Genter Co	6,788.00	12-51
Insulated cable	The Ansonia Electric Co	6,248.00	1-52
Ditto	Tenn. Coal, Iron & Railroad Co	29,845.00	1-52
Load frequency and temp. recorders	Leeds & Northrup Co	14,445.00	1-52
ROJ insulated cable	Phelps Dodge Copper Prod. Corp., Habirshaw Cable & Wire Div	9,056.00	1-52
ROSJ insulated cable	Tenn. Coal & Iron Div., U. S. Steel Co	81,500.00	1-52
Insulated cable	Ditto	20,127.60	1-52
Telephone	Automatic Electric Sales Corp	32,355.00	1-52
Galvanized conduit and couplings	Graybar Electric Co	109,766.20	1-52
Bars and tubing	Aluminum Co. of America	15,823.64	2-52

TABLE 39.—*Major purchases of material and equipment*—Continued.

Item	Vendor	Amount	Date
ELECTRICAL—Continued			
ROJ insulated cable	General Cable Corp	$44,072.00	2-52
Ditto	Phelps Dodge Copper Prod. Corp., Habirshaw Cable & Wire Div	43,890.00	2-52
Copper bare conductor	The American Brass Co	7,492.99	2-52
Electrical material	Westinghouse Electric Corp	7,195.66	2-52
Operation recording and annunciating equipment	The Autocall Co	34,744.00	3-52
Switchboards	Allis-Chalmers Mfg. Co	166,364.00	3-52
Transformers, auxiliary	Moloney Electric Co	15,374.64	3-52
Voltage regulators	General Electric Co	15,437.00	3-52
Cable	Wells Electric Supply Co	19,403.10	3-52
Cable	Sies Electric Supply Co	18,956.00	3-52
Lightning arrestor	General Electric Co	27,148.32	3-52
Copper wire	General Electric Supply Corp	26,034.13	4-52
Insulators	Lapp Insulator Co	15,739.14	4-52
Bare conductor fittings	Anderson Brass Works	6,631.66	4-52
Panelboards and cabinets	General Electric Supply Corp	11,342.30	4-52
Tel. and carrier frequency cable	The Ansonia Electrical Co	7,148.90	4-52
Wire	Southern Electric Corp	20,382.80	5-52
Conduit, fittings, cable	Wells Electric Supply Co	8,389.47	5-52
Ditto	Sies Electric Supply Co	24,481.84	5-52
Portable cable	Roden Electric Supply Co	15,560.00	5-52
Motor control equipment	Westinghouse Electric Corp	8,947.21	5-52
Ditto	Ditto	6,485.87	5-52
Voltage regulator	Moloney Electric Co	24,036.00	6-52
Oil circuit breaker	Allis-Chalmers Mfg. Co	16,840.00	6-52
Control batteries	Electric Storage Battery Co	48,986.40	6-52
Transformers	Allis-Chalmers Mfg. Co	51,240.00	6-52
Control equipment	Leeds & Northrup Co	34,417.70	6-52
Asbestos-cement cable trays	Johns-Manville Sales Corp	37,086.04	7-52
Insulated cable	Minn. Honeywell Reg. Co	5,680.00	7-52
Paging and intercommunication cable	The Ansonia Electric Co	5,180.00	7-52
Copper wire	Southern Electrical Corp	8,580.23	8-52
Insulators	South East Joslyn Co	16,803.20	9-52
Unit board, etc	Northeast Engr., Inc	168,240.23	10-52
Ditto	I. T. E. Circuit Breaker Co	657,543.00	10-52
Lighting fixtures	Electrical Ind. Equipment & Supply Corp	5,383.75	11-52
Intercommunication equipment	GAI-Tronics Corp	18,385.80	11-52
Transformers	Wagner Electrical Corp	17,910.63	11-52
Voltage regulators	General Electrical Co	20,826.00	11-52
Wire and cable	Wells Electric Supply Co	18,210.00	1-53
Ditto	Welding Gas Products Co	6,700.00	1-53
Low frequency induction heater	Electric Arc, Inc	13,802.00	2-53
Panelboards and cabinets	Sies Electric Supply Co	10,206.30	2-53
Load control equipment	Leeds & Northrup Co	29,859.53	3-53
Single conductor cable	Noland Company, Inc	5,970.80	4-53
Single conductor cable	Rome Cable Co	64,464.00	5-53
Lightning arresters	General Electric Co	18,098.88	5-53
Generator back-up relays	General Electric Co	15,721.55	5-53
Rigid steel conduit	S.B.S. Electric Supply Co	75,939.15	5-53
Insulators	Porcelain Insulator Co	13,552.00	5-53
Lamps	General Electric Co	6,170.74	6-53
Entrance bushings	Lapp Insulator Co	7,890.72	6-53
Flourescent lights	Baitinger Electric Co., Inc	38,668.86	6-53
Insulators	Lapp Insulator Co	7,608.45	6-53
Transformers	Westinghouse Electric Corp	26,782.24	6-53
Telephone and annunciator batteries	Electric Storage Battery Co	49,082.29	6-53
Aluminum bare connectors	Aluminum Corp of America	15,721.55	6-53
Insulated cable	Phelps Dodge Copper Prod. Corp	64,599.00	6-53
Ditto	U. S. Rubber Co	59,136.00	6-53
Ditto	Hazard Insulated Wire Works	16,428.00	6-53
Insulated conductor	Tenn. Coal, Iron & Railroad Co	6,240.00	7-53
Switchboard wire	R. I. Insulated Wire	7,057.50	7-53
Carrier relay terminals	General Electric Co	41,320.00	7-53
Insulated cable	Industrial Pyrometer & Supply	6,420.00	7-53
Ditto	Minn. Honeywell Regulator Co	5,582.50	7-53
Insulated conductor cable	Tenn. Coal, Iron & Railroad Co	53,613.00	8-53
Battery charging motor—generator sets	The Electric Products Co	7,248.00	8-53
Rigid steel conduit	Jones & Lee Supply	6,573.00	9-53

TABLE 39.—*Major purchases of material and equipment*—Continued.

Item	Vendor	Amount	Date
ELECTRICAL—Continued			
Fluorescent lighting fixtures	General Electric Supply Co.	$6,526.27	9-53
Bare copper cable	Nehring Electrical Works	16,388.22	9-53
Telephone equipment	Automatic Electric Sales	5,064.08	11-53
Control equipment	Tenn. Armature & Electric Co.	5,785.00	11-53
Aluminum station service leads housings	Kirk & Blum Mfg. Co.	15,300.00	11-53
Control equipment	Westinghouse Electric Corp.	12,247.96	12-53
Lighting fixtures	Stokes Electric Co.	13,501.74	12-53
Ditto	Thurman Logan Electric Co.	15,324.10	12-53
Ditto	Baitinger Electric	10,215.06	12-53
Cable	Ansonia Wire & Cable Co.	6,433.50	1-54
Panelboards	Graybar Electric Co.	11,398.14	1-54
Auxiliary transformers	John G. Pettyjohn Co.	6,408.00	2-54
Fuse mounting	S & C Electric Co.	5,128.20	2-54
Voltage regulator	General Electric Co.	7,905.00	3-54
Flexible connectors	Southern States Equipment Corp.	5,618.75	3-54
Oscillograph	Hathaway Instruments Co.	7,303.01	3-54
Cable trays	Johns-Manville Sales Corp.	63,783.55	3-54
Insulated conductor	Roden Electric Co.	7,104.00	3-54
Soot blower control cubicles	Westinghouse Electric Corp.	60,900.00	4-54
Control boards, etc.	Hagan Corp.	215,346.00	5-54
Paging system equipment	Gai-Tronics	17,752.50	5-54
Transformers	Westinghouse Electric Corp.	6,782.56	7-54
Railway communication equipment	Bendix Radio Division	6,625.59	7-54
Spare stators	Westinghouse Electric Corp.	76,613.46	8-54
Insulated conductor	Ansonia Wire & Cable	9,624.71	8-54
Ditto	Plastic Wire & Cable	8,424.00	8-54
Rigid steel conduit	Graybar Electric Co.	24,938.20	8-54
Lamps	Sylvania Lamp Division	5,381.80	8-54
Unistrut material	Southeastern, Inc.	7,034.19	8-54
Motor and arrestors	General Electric Co.	5,195.16	11-54
Switchboard wire	Graybar Electric Co.	6,170.00	1-55
Lightning arresters	General Electric Co.	17,903.04	2-55
Thermocouple cable	Industrial Pyrometer & Supply Co.	5,118.00	8-55
Generator repair	General Electric Co.	12,598.30	9-55
Circuit breakers	Westinghouse Electric Corp.	5,010.00	1-56
TV equipment	Dage Telev. Div., Thompson Prod., Inc.	47,449.36	2-56
MECHANICAL			
Steam generating units 1-4	Combustion Engineering-Superheater	7,582,340.00	1-51
Turbogenerators units 1-4	Westinghouse Electric Corp.	11,543,000.00	2-51
Feeder and belt	Brooks Equipment Co.	14,161.04	3-51
Air compressor	Fred Chenoweth Equipment Co.	15,500.00	4-51
Ditto	Thompson & Greene Mfg. Co.	12,899.00	4-51
Fire fighting equipment	Industrial Belting & Supply Co.	6,116.10	4-51
Rotary car dumpers	Link-Belt Co.	30,611.33	4-51
Ditto	Heyl & Patterson, Inc.	57,666.66	4-51
Valves and flanges	Gray Hodges Corp.	5,220.20	4-51
Centrifugal pumps and hose	Brooks Equipment & Mfg. Co.	7,554.00	4-51
Pipe and flanges	Albert Pipe Supply Co.	17,308.50	4-51
Ditto	A. Greenspon Pipe Co.	5,130.00	4-51
Heavy duty engine lathe	W. S. Murrian Co.	7,696.70	4-51
Valves and fittings	Hajoca Corp.	7,421.62	4-51
Pipe, etc.	Columbus Steel Supply	22,250.00	5-51
Cast iron pipe	James B. Clow & Sons	9,156.00	5-51
Air and suction hose	Knox-Tenn Equipment Co.	13,330.18	5-51
Feedwater heaters, storage tanks	Cochrane Corp.	143,120.00	5-51
Closed type feedwater heaters (1-4)	The Lummus Co.	624,167.00	5-51
Traveling cranes and lighting beams	Cyclops Iron Works	266,837.50	6-51
Arc welding machines	C. D. Genter Co.	28,224.00	6-51
Evaporators and preheaters (1-4)	Graham Mfg. Co.	53,723.00	6-51
Boiler feed pumps (1-4)	Byron Jackson Co.	1,107,321.00	6-51
Fittings, pipe and accessories	National Cast Iron Pipe Div., James B. Clow & Sons	11,384.13	6-51
Dust collector units	The Kirk & Blum Mfg. Co.	8,520.00	6-51
Condenser circulating water pumps (1-4)	Westinghouse Electric Corp.	342,461.00	6-51
Raw water strainers	Gray-Hodges Corp.	7,024.00	7-51
Refrigeration equipment	Worthington Pump & Machinery Corp.	7,770.00	7-51
Centrifugal pumping units	Pennsylvania Pump & Compressor Co.	12,509.00	7-51

TABLE 39.—*Major purchases of material and equipment*—Continued.

Item	Vendor	Amount	Date
MECHANICAL—Continued			
Clamshell coal valves	The Columbus Conveyor Co.	$8,620.00	7-51
Stationary electric driven air compressors	Pennsylvania Pump & Compressor Co.	33,567.00	7-51
Metal condenser	Phelps Dodge Copper Products Corp.	261,945.69	7-51
Oil and gas-fired steam generators	Dempster Brothers, Inc.	13,496.79	7-51
Fly ash collectors (1-4)	Buell Engineering Co.	206,663.14	7-51
Oil purifying units, insulating and lubricating	Burford, Hall & Smith	17,945.00	7-51
Shaper, heavy duty	George M. Meriwether	7,874.01	7-51
Acetylene and oxygen	Noah Harding Welding Supply Co.	6,700.00	7-51
Tires	The Goodyear Tire & Rubber Co.	5,395.04	7-51
Tires and tubes	The B. F. Goodrich Co.	5,064.68	7-51
Milling machine	Noland Co., Inc.	8,300.00	7-51
Steel pipe	Calumet Iron & Supply Co.	7,970.57	7-51
Boiler room coal scales	Richardson Scale Co.	55,170.00	7-51
Repair parts	R. L. Harris, Inc.	5,640.00	8-51
Lathe	Noland Co., Inc.	8,319.00	8-51
Principal piping units 1-4	National Valve & Mfg. Co.	3,000,000.00[4]	8-51
Heat exchangers	The Lummus Co.	18,140.00	8-51
Fittings, cast-iron	Hardie-Tynes Mfg. Co.	9,251.50	8-51
Radial drill	Cincinnati Gilbert Machine Tool Co.	10,450.00	8-51
Zeolite softening system	Hungerford & Terry, Inc.	7,928.00	8-51
Draft fans (1-4)	Westinghouse Electric Corp., Sturtevant Div.	636,441.00	8-51
Valves and sluice gates	The Chapman Valve Mfg. Co.	128,509.00	8-51
Ditto	Henry Pratt Co., Inc.	83,808.00	8-51
Power control valves	Manning, Maxwell & Moore, Inc.	9,519.40	8-51
Pipe	Calumet Iron & Supply Co.	5,131.40	9-51
Boiler feedwater pump	Worthington Pump & Machinery Corp.	26,077.00	9-51
Overhead cranes	Moffett Engineering Co.	9,555.20	9-51
Trashracks	Truitt Mfg. Co.	11,550.00	9-51
Plumbing fixtures, electric water coolers and water heaters	Jones-Sylar Supply Co.	6,762.83	9-51
Overhead cranes	Pidgeon-Thomas Iron Co.	7,669.70	9-51
Air compressors	Worthington Pump & Machinery Corp.	18,291.00	9-51
Pipe	Gray-Hodges Corp.	16,474.47	10-51
Heater drainers	Fisher Governor Co.	55,537.68	10-51
Oil pumping units	Worthington Pump & Machinery Corp.	5,874.00	10-51
Traveling water screens	Chain Belt Co.	131,322.00	10-51
Ash handling equipment—units 1-4, 5-8 and 9[3]	The Allen-Sherman-Hoff Co.	391,727.00	10-51
Turbine type pumping units	Worthington Pump & Machinery Corp.	23,651.00	10-51
Steel tanks	Stover Steel Tank & Mfg. Co.	43,198.00	10-51
Tubing	Slip-Not Belting Co.	8,835.26	10-51
Track spikes	L. B. Foster, Co., Inc.	7,212.50	10-51
Tires and tubes	The B. F. Goodrich Co.	5,550.40	10-51
Plunger-electric elevator	Southeastern Elevator Co.	8,808.00	11-51
Repair parts	Power Equipment Co.	12,884.28	11-51
Pipe	I. Burack, Inc.	6,700.82	11-51
Pipe	Noland Co.	91,086.67	11-51
Pipe	Valley Steel Prod. Co.	6,384.00	11-51
Pipe	Jones Sylar Supply Co.	45,919.76	11-51
Coils, tubing, etc.	Noland Co.	17,362.64	11-51
Pipe	Grinnell Co.	16,262.62	11-51
Chemical feeding equipment	Hills-McCanna Co.	13,633.00	11-51
Electrically operated elevators	Otis Elevator Co.	79,935.00	11-51
Sump pumps	Yeomans Brothers Co.	11,693.00	12-51
Pipe hanger materials	Gray-Hodges Corp.	18,395.37	1-52
Ditto	Grinnell Co.	11,967.40	1-52
Dust collector	American Air Filter Co.	9,407.00	1-52
Fittings, pipe and accessories	American Radiator & Standard San. Corp.	5,030.71	1-52
Valves, fittings, and accessories	Gray-Hodges Corp.	6,101.54	1-52
Highway crossing protection signal systems	Union Switch & Signal Div. of Westinghouse Air Brake Co.	9,980.00	1-52
Wire mesh	Calumet Iron & Supply Co.	6,295.00	1-52
Hoists	Ingersoll-Rand	28,848.75	1-52
Fans and flexible duct	Chicago Blower Corp.	20,775.97	2-52
Ditto	Bullalo Forge Co.	5,677.20	2-52
Ditto	Joy Mfg. Co.	5,652.00	2-52
Ditto	The Burt Mfg. Co.	24,526.90	2-52

3. Includes equipment added by change of order for additional units as shown.
4. Estimate.

TABLE 39.—*Major purchases of material and equipment*—Continued.

Item	Vendor	Amount	Date
MECHANICAL—Continued			
Fans and flexible duct	Eustis Lancaster Assoc.	$9,090.00	2-52
Ash sluice water pumps	Byron Jackson Co.	40,174.00	2-52
Ditto	Peerless Pump Div.	13,991.60	2-52
Heating devices and filters	Mills & Lupton Supply Co.	6,241.20	2-52
Ditto	Dollinger Corp.	7,730.50	2-52
Tarpaulins	Federal Prison Industries	8,360.00	2-52
Tools	Independent Pneumatic Tool Co.	8,367.52	2-52
Valves, fittings, pipe and accessories	Gray-Hodges Corp.	6,517.22	2-52
Ditto	American Cast Iron Pipe Co.	25,227.27	2-52
Air and gas ducts	Connery Construction Co.	285,000.00	2-52
Valves, fittings and accessories	Gray-Hodges Corp.	17,601.49	3-52
Truck scales	The Howe Scale Co.	7,471.00	3-52
Water chilling equipment	York Corp.	12,561.00	3-52
Heating devices and filters	McQuay, Inc.	20,706.00	3-52
Valves, fittings and accessories	Grinnell Co.	5,276.46	3-52
Ditto	Gray-Hodges Corp.	17,912.18	4-52
Ditto	Chas. F. Guyon, Inc.	14,602.02	4-52
Coal handling equipment	Link-Belt Co.	502,730.00	4-52
Track scale	Fairbanks, Morse & Co.	12,913.00	4-52
Wire rope	Sunbury Wire Rope Mfg. Co.	25,691.00	4-52
Pipe	I. Burack, Inc.	10,222.26	4-52
Coal-handling equipment	Stephens-Adamson Mfg. Co.	40,807.00	5-52
Ditto	Fairbanks, Morse & Co.	8,658.00	5-52
Valves, fittings and accessories	Gray-Hodges Corp.	8,630.48	5-52
Ditto	Chas. F. Guyon, Inc.	5,632.36	5-52
Valves, fittings, specialties, controls	Gray-Hodges Corp.	12,312.74	5-52
Ditto	Grinnell Co.	5,947.38	5-52
Ditto	Spence Engineering Co.	7,864.51	5-52
Ditto	Smolka Co., Inc.	8,665.55	5-52
Ditto	Jones-Sylar Supply Co.	15,236.36	5-52
Coal handling equipment	The Jeffrey Mfg. Co.	81,938.40	5-52
Valves, fittings and accessories	Gray-Hodges Corp.	13,662.21	6-52
Screw and cinch anchors	Tennessee Belting & Supply, Inc.	8,339.05	6-52
Wire guards, dampers, etc.	Titus Mfg. Corp.	8,357.18	7-52
Heat insulation	The Brooks Fisher Insulating Co.	524,882.26	7-52
Steam generating units 5-8	Combustion Engineering-Superheater	11,656,966.00	7-52
Turbogenerators—units 5-8	General Electric Co.	14,800,000.00	7-52
Steel cylinders	Harrisburg Steel Corp.	9,765.30	7-52
Acetylene and oxygen	Noah Harding Welding Supply Co.	10,200.00	7-52
Joint filler	Servicised Products Corp.	8,000.00	8-52
Valves, fittings	I. Burack, Inc.	8,147.01	8-52
Lubricating oil	The Pure Oil Co.	9,918.00	8-52
Parts for heating and air conditioning	The Burt Mfg. Co.	36,593.15	8-52
Pumping unit	Peerless Pump Div., Food Mach. Corp.	7,074.83	9-52
Pump	Byron-Jackson Co.	14,407.00	9-52
Dust collector unit	Kirk & Blum Mfg. Co.	12,780.00	9-52
Trashracks	Reliance Steel Prod. Co.	7,495.00	9-52
Conveyor belts	The B. F. Goodrich Co.	78,077.93	9-52
Feedwater heaters	Worthington Corp.	234,450.00	9-52
Untanking hoists	George M. Meriwether	30,405.00	9-52
Butterfly valves	Henry Pratt Co.	176,456.00	9-52
Units	Byron-Jackson Co.	46,284.00	9-52
Pumps	Nash Engineering Co.	5,860.00	10-52
Manifold reducers	Stover Steel Tank & Mfg. Co.	9,188.00	10-52
Pump	Peerless Pump Div. Food Mach. Co.	7,074.83	10-52
Pumps	Byron-Jackson Co.	20,087.00	10-52
Fittings, pipe, accessories	James B. Clow & Sons	16,872.61	10-52
Refractories and ash hopper lining	The Rust Engineering Co.	206,710.00	10-52
Raw water strainers	J. A. Zurn Mfg. Co.	9,320.00	10-52
Evaporators and preheaters—units 5-8 and 9[3]	The Griscom-Russell Co.	100,596.00	10-52
Clamshell coal valves	The Columbus Conveyor Co.	12,840.00	10-52
Water pumps, circulating—units 5-8 and 9[3]	Fairbanks, Morse & Co.	464,464.00	10-52
Zeolite softening system	Hungerford & Terry, Inc.	7,991.00	10-52
Installing insulation	North Brothers	205,600.00	10-52
Tarpaulins	Federal Prison Industries, Inc.	8,360.00	10-52
Feedwater heaters—units 5-8 and 9[3]	The Griscom-Russell Co.	961,511.00	10-52
Tubing	Scovill Mfg. Co.	365,383.25	10-52

3. Includes equipment added by change of order for additional units as shown.

TABLE 39.—*Major purchases of material and equipment*—Continued.

Item	Vendor	Amount	Date
MECHANICAL—Continued			
Boiler feedwater pumps	Worthington Corp	$29,154.00	10-52
Fly ash collecting units 5-8 and 9[3]	American Blower Corp	223,490.00	11-52
Fabricated steel tanks	Lucey Boiler & Mfg. Corp	15,522.30	11-52
Coal weighing scales	Stock Equipment Co	79,596.00	11-52
Electric motor driven forced and induced draft fans, units 5-8 and 9[3]	Westinghouse Electric Corp	966,350.00	11-52
Horizontal centrifugal pumps	Fairbanks, Morse & Co	17,116.00	12-52
Vertical boring mill	Noland Co	64,222.50	12-52
Boiler feed pumps	Worthington Corp	1,748,309.00	12-52
Cast iron fittings	Thomas Foundries, Inc	11,714.80	12-52
Heat exchanger	Dowington Iron Works, Inc	20,625.00	12-52
Tarpaulins	Chattanooga Awning Co	5,080.00	12-52
Tires	The Goodyear Tire & Rubber Co	5,273.78	12-52
Pipe	Grinnell Co	6,972.51	1-53
Pipe	I. Burack, Inc	7,690.00	1-53
Pipe	Ditto	23,732.00	1-53
Pipe, steel	Engineered Products Corp	5,206.47	1-53
Pipe, steel	Siskin Steel & Supply Co	5,366.40	1-53
Steel pipe	Engineered Products Corp	15,966.65	1-53
Steel bearing	Tenn. Coal & Iron Div	8,568.00	1-53
Valves and controllers	I. Burack, Inc	17,690.00	1-53
Vertical, turbine-type pumping units	Worthington Corp	19,860.00	1-53
Combination oil and gas fired steam generators	Dempster Bros	13,892.79	1-53
Tires and tubes	The Goodyear Tire & Rubber Co	7,716.26	2-53
Insulation materials	North Brothers	58,368.00	2-53
Valves and controllers	Leinart Engineering Co	15,307.20	2-53
Air conditioning unit	Eustis Lancaster Associates	5,640.00	2-53
Black pipe	Siskin Steel & Supply Co	7,571.00	2-53
Wire rope	Tennessee Coal & Iron Division	11,625.00	3-53
Welding electrodes	Post Welding Supply Co	6,977.50	3-53
Dust collector units	The Day Co	6,384.00	3-53
Chemical feeding equipment	Milton Roy Co	12,041.00	3-53
Services for radiographic exams	Combustion Engineering	15,600.00	3-53
Coal crushers	Jeffery Mfg. Co	41,124.00	4-53
Machine bolts	C. M. McClung & Co	6,198.09	5-53
Heating devices and filters	Eustis Lancaster Associates	26,588.48	5-53
Ditto	American Air Filter	8,560.00	5-53
Water pump control board extension	A. C. Mfg. Co	5,382.00	5-53
Fans	The Trane Co	19,085.40	5-53
Valves, fittings, etc	Mills & Lupton Supply Co	8,305.80	5-53
Ditto	American Steel Band Co	22,403.00	5-53
Ditto	Gray-Hodges Corp	13,092.12	5-53
Air and gas ducts	Connery Construction Co	365,000.00	5-53
Principal piping—units 5-8	National Valve & Mfg. Co	4,000,000.00[4]	5-53
Gate valves	Gray-Hodges Corp	5,796.90	6-53
Coal handling equipment	Link Belt Co	101,203.00	6-53
Coal handling equipment	Syntron Co	18,927.00	6-53
Fittings, pipe, etc	American Radiator & Stand. San. Corp	37,085.01	6-53
Roof ventilator	Burt Mfg. Co	34,811.30	6-53
Oxygen and acetylene	Linde Air Products Co	18,680.00	6-53
Conveyor belts	Goodyear Tire & Rubber Co	13,972.45	7-53
Fans	The Moore Co	10,252.59	7-53
Fibre rope	The Cord-Tex Co	5,062.83	7-53
Fans	The Harvey P. Dartman Co	17,080.00	8-53
20-inch engine lathes	Noland Co., Inc	13,651.00	8-53
Wire guards, dampers, etc	American Foundry & Furnace	44,039.84	8-53
Wire guards, etc	Titus Mfg. Co	14,737.60	8-53
Valves, fittings, etc	Jones Sylar Supply Co	5,399.77	8-53
Valves, fittings, pipe, etc	Chas. F. Guyon	15,208.00	8-53
Ditto	American Radiator & Std. San. Corp	8,897.33	8-53
Ditto	Jones Sylar Supply Co	5,275.76	8-53
Turbogenerator unit 9	General Electric Co	3,849,590.00	8-53
Valves, fittings, pipe, etc	Jones Sylar Supply Co	10,770.45	8-53
Ditto	O. C. Keckley	10,122.00	8-53
Ditto	Willis Plumbing Supply	6,630.56	8-53
Ditto	Gray-Hodges Corp	48,389.73	9-53
Fittings and pipe	Ditto	35,334.38	9-53

3. Includes equipment added by change of order for additional units as shown.
4. Estimate.

TABLE 39.—*Major purchases of material and equipment*—Continued.

Item	Vendor	Amount	Date
MECHANICAL—Continued			
Fittings and pipe	I. Burack, Inc.	$12,929.37	9-53
Miscellaneous steel covers	Chattanooga Boiler & Tank	5,500.00	9-53
Pressure gauge	Mills & Lupton Supply Co.	6,387.05	10-53
Valves, etc.	Leinart Engineering	5,807.70	10-53
Valves, fittings, etc.	Bethlehem Steel	7,086.98	10-53
Pumping units	Universal Mfg. Co.	14,263.00	10-53
Additions to sup. I	National Valve & Mfg. Co.	112,333.78	10-53
Steam generating unit 9	Combustion Engineering-Superheater	3,104,278.00	10-53
Valves, fittings	Gray-Hodges Corp.	7,099.41	11-53
Refractories	C. O. Henrikson	146,986.00	11-53
Air intake housings	Decatur Iron & Steel	14,291.00	11-53
Valves, fittings, etc.	Gray-Hodges Corp.	6,834.75	11-53
Principal piping unit 9	National Valve & Mfg. Co.	1,000,000.00[4]	11-53
Power control valves	Manning, Maxwell & Moore	6,804.10	12-53
Steel cylinders	Harrisburg Steel	16,706.98	12-53
Water pumping units	Ingersoll Rand	24,102.00	12-53
Insulation	Brooks Fisher Insulating Co.	37,536.00	1-54
Insulation for piping	Brooks Fisher Insulating Co.	512,505.67	1-54
Centrifugal pumps	Economy Pump	28,480.00	2-54
Wire guards, etc.	Burt Mfg. Co.	10,036.00	2-54
Insulation	Brooks Fisher Insulating Co.	367,595.00	2-54
Refractories and ash hopper lining	Carter Bearden Co.	272,260.00	2-54
Tubing	Wolverine Tube Division	99,758.41	2-54
Crushers	Jeffrey Mfg. Co.	20,608.00	2-54
Oil lubricant	Pure Oil Co.	12,920.00	2-54
Structural steel boiler	Henry E. Gremp	22,553.00	5-54
Traveling water screen	Chain Belt Co.	27,825.00	5-54
Insulation	Brooks Fisher Insulating Co.	53,210.00	5-54
Oxygen and acetylene	Linde Air Products Co.	57,750.00	7-54
Valves, fittings, etc.	Smolka Co.	7,025.89	7-54
Ditto	Siskin Steel & Supply Co.	12,190.39	7-54
Ditto	Ditto	45,403.50	7-54
Coal handling equipment	Link Belt Co.	476,137.00	7-54
Welded wire fabric	Siskin Steel & Supply Co.	9,424.80	7-54
Wire guards, etc.	Burt Mfg. Co.	30,344.60	9-54
Ditto	Titus Mfg. Co.	8,742.84	9-54
Valves, fittings, etc.	Noland Co.	5,580.53	10-54
Ditto	Gray-Hodges Corp.	8,413.26	10-54
Ditto	Chas. F. Guyon	5,567.51	10-54
Turbine repair	General Electric Co.	66,660.00	10-54
Water storage tanks	Richmond Engr.	5,735.00	1-55
Parts	I.M.C. Equipment, Inc.	6,803.50	1-55
Heavy equipment	Wooldridge Mfg.	16,554.25	3-55
Ditto	M. R. S. Mfg.	30,674.00	3-55
Ditto	Dempster Bros.	28,190.00	3-55
Fittings and pipe	Allen-Sherman Hoff Co.	7,815.70	3-55
Wheel presses	Noland Co.	14,518.42	4-55
Water pumping units	Byron Jackson Co.	37,538.00	5-55
Steel pipe	Siskin Steel & Supply Co.	37,481.88	5-55
Valves, fittings	Mills & Lupton Supply Co.	6,947.50	5-55
Ditto	Gray-Hodges Corp.	5,119.97	5-55
Universal milling machine	Noland Co.	32,517.03	6-55
Additional material	Westinghouse Electric Corp.	433,500.00	6-55
Motor operators for valves	Chas. F. Guyon, Inc.	13,414.72	8-55
Utiliscope repair	Diamond Power Specialty Co.	5,290.00	9-55
Sump pumps	Tidewater Supply Co.	9,810.00	9-55
Acetylene	Linde Air Products Co.	18,962.50	10-55
Chain wheels	Scott Valve Mfg. Co.	5,012.04	10-55
Sluice valves	Chapman Valve Mfg. Co.	15,773.17	11-55
Sluice pump	Peerless Pump Division	8,471.70	12-55
Steel cabinets	Fidelity Sales Corp.	6,513.11	12-55
Floor scrubbers	Fidelity Sales Corp.	13,758.00	2-56
Chlorinating equipment	Wallace & Tiernan Co.	28,710.00	2-56
Valves	Noland Co., Inc.	15,474.68	4-56

4. Estimate.

SPECIAL STUDIES

Condenser water temperature studies

One of the most important contributions to the economical operation of the Kingston Steam Plant was the research and development, conducted by the TVA's Hydraulic Data Branch, of a means of reducing the temperature of the water entering the condensers.

Figure 144 shows that the Kingston Steam Plant is located on the neck of a peninsula formed by the Emory and Clinch River embayments of the Watts Bar Reservoir. During the summer months the only appreciable flows in the reservoir occur as thermal density underflows in the Clinch River arm. The source of these underflowing waters is TVA's Norris Reservoir some 78 miles upstream. Because of stratification in Norris Reservoir, relatively cold water is discharged through the powerhouse turbines from spring until late fall. Under normal conditions the Emory River flows are negligible during the summer months. As a consequence the cold Clinch underflows push their way up the original Emory River channel. Temperatures measured at the mouth of the Emory and at mile 2.0 on the Emory indicated

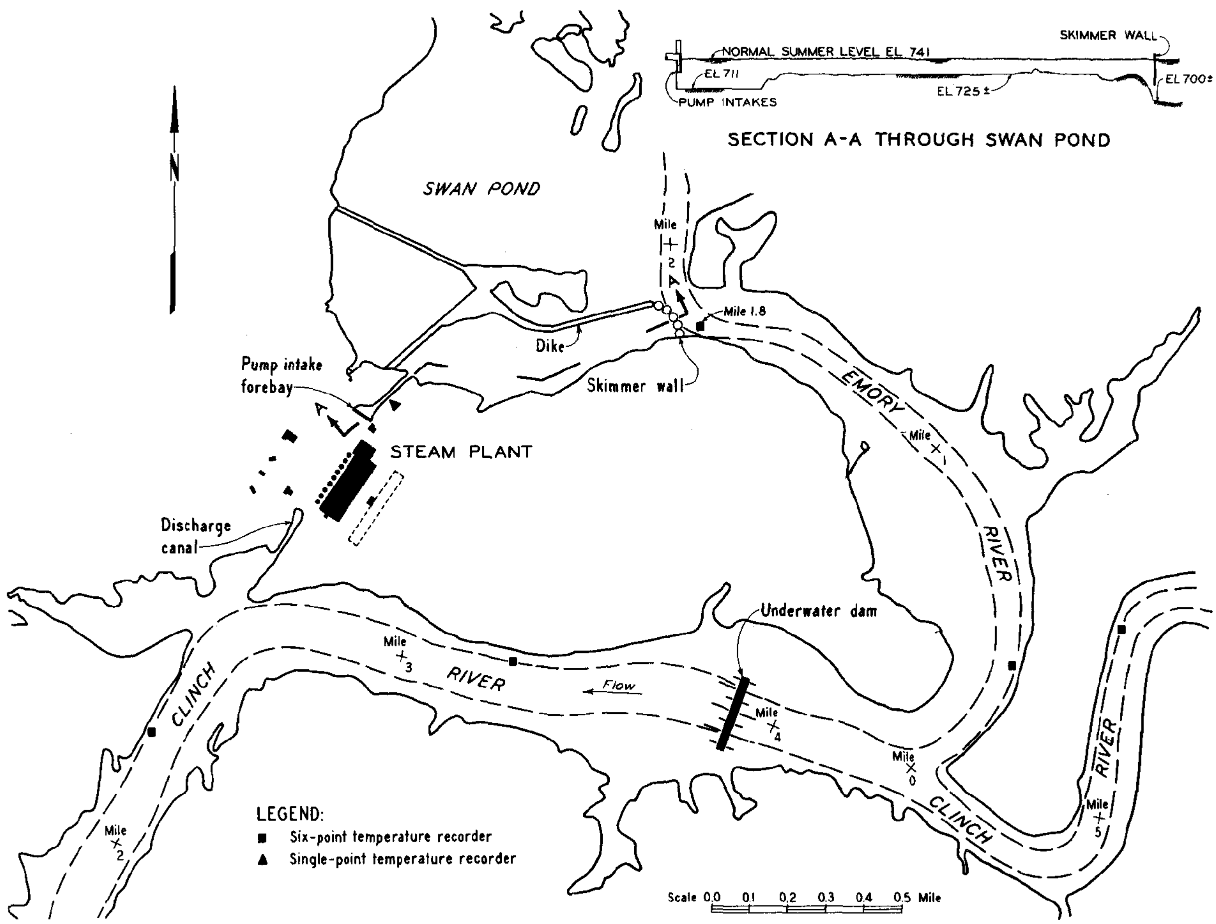

FIGURE 144.—*Location of underwater dam which diverts lower stratum of cooler water through the subsurface apertures of the upstream intake skimmer wall.*

that the Clinch River waters penetrate and thus control the Emory River temperatures in the immediate area of the Kingston plant except for the surface temperatures. The surface temperatures are affected in this location by the Swan Pond embayment. Swan Pond, as can be seen in figure 144, is generally 25 to 35 feet shallower than the main channel of the Emory River. Because of its shallow depths, the surface temperatures become very hot, reaching 95°F. on occasions.

Over-all steam plant considerations required that the condensing waters be drawn from the north or Swan Pond side of the peninsula and discharged on the south or Clinch River side.

It was necessary, therefore, to develop facilities which would divert the cold waters which pass the site as thermally stratified density underflows and cause them to be drawn approximately 2 miles up the Emory River channel at the same depth as the original channel, after which they would cross one mile of the Swan Pond embayment at an elevation 20 to 25 feet higher than the Emory River channel. The unique solution to this problem consisted of a canal across the high ground area at the end of which was placed a skimmer wall structure which allowed only the cold waters in the bottom of the side channel to flow into the canal. A diversion dam was also placed underwater immediately downstream from the side channel. The final design of the skimmer wall is shown in figure 145.

In making the thermal density underflow studies which were at the heart of the problem, the Hydraulic Data Branch retained the consulting services of Dr. Arthur T. Ippen of the Massachusetts Institute of Technology, and as an aid in the hydraulic design of the skimmer wall structure, model studies were conducted in the Hydrodynamics Laboratory at M. I. T.

The economic feasibility of the proposed design was confirmed by a study, made by the Hydraulic Data Branch, of the savings that would be attributable to the design both with and without the underwater dam.

It was found that the skimmer wall and dike system would save $75,000 per year in coal purchase costs alone and that the underwater dam would contribute $24,000 per year savings. The estimated costs for the dike and skimmer wall were $450,000 and for the underwater dam $75,000.

Since the dike and skimmer wall were built in the fall of 1954 and the underwater dam in the winter of 1955-1956, performance data are available for one season without the dam to compare with the final conditions. The savings, based only upon the purchase cost of the additional coal necessary to run

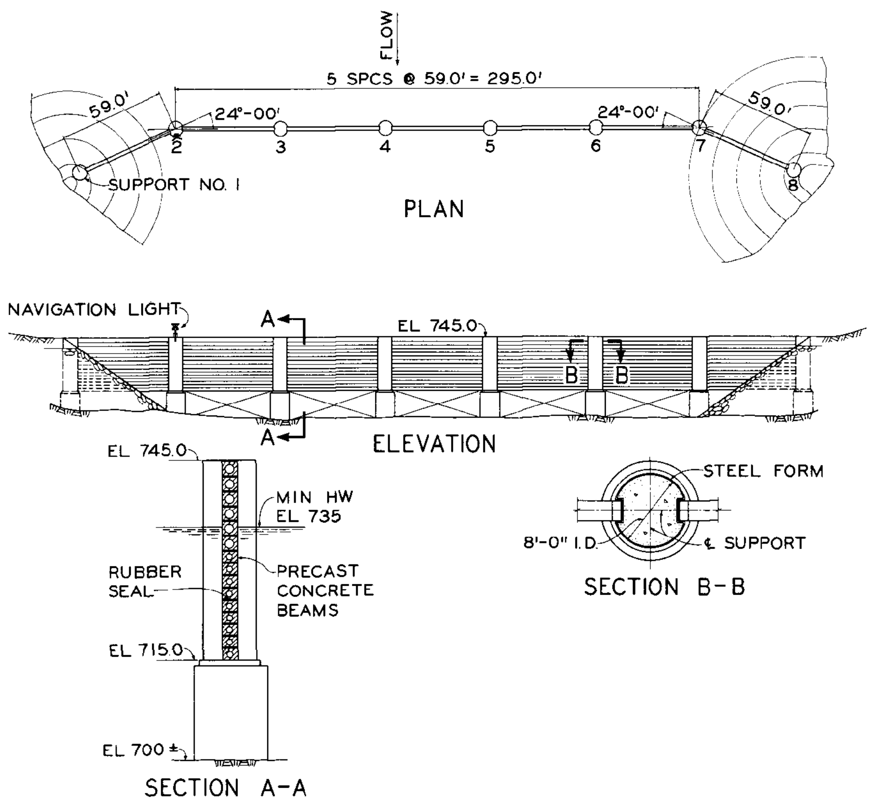

FIGURE 145.—*Plan and elevation of skimmer wall; see figure 144.*

the plant at 0.9 rated capability without the diversion structures, amounted to $105,000 in 1955 due to the skimmer wall and dike system and $155,000 in 1956 when the underwater dam was added. Inclusion of the handling and processing costs of the extra coal would increase by about 20 percent the figures representing the savings, and if the valuation were made upon the basis of additional energy sales, the benefits would be still greater. The actual construction costs of skimmer wall were $251,000; of the dike system $191,000; and of the underwater dam $31,000. These total $473,000 for all the works. Assuming that the year 1956 is representative of the annual benefits from the system, then in the short course of only three years or less, the total benefits will equal the entire cost.

Condenser conduit loss study

After completion of the 78- and 96-inch concrete condenser water pipes it was found necessary, because of improper manufacture, to provide them with internal reinforcement. Construction and economic considerations favored the use of a structural steel frame on the vertical diameter. Calculations of the head loss caused by such a structure were impossible since available literature contained no data on this type of obstructions. The TVA Hydraulic Laboratory therefore conducted tests to determine the loss caused by frames consisting of two 15-inch I-beams placed along the top and bottom of the pipe and held apart by a pipe strut 4½ inches in diameter with or without streamlining. The model scale for the tests, determined by the use of 8-inch cement-asbestos pipe to simulate the conduit, was 1:12.3 and the test section in the laboratory was 156 feet long. The test results showed that streamlining of the downstream side of the struts eliminated nearly half of the head losses incurred by the use of these struts. The tests developed a relatively simple streamlined tail, consisting of two flat steel plates 18 inches wide and ¼ inch thick. These plates were essentially as effective as an airfoil section. Prototype measurements made in a 322-foot length of the actual conduit after installation of the reinforcement showed that the head loss in the conduit was in agreement with the results of the model test.

Meteorological and hydraulic data

Weather forecasts were supplied daily to construction forces at Kingston Steam Plant from August 1951 until the end of the construction period. An instrument tower for wind and temperature instruments was installed about a mile east of the plant site late in 1951 and the anemograph, hygrothermograph, and recording thermometer, together with a rain gage, were put in service January 21, 1952. Beginning in December 1952, the data on rain, wind, temperature, and humidity were transmitted to the project manager monthly on a standard data sheet. The wind and temperature data were more extensively used in connection with air pollution studies.

Air pollution studies (reported by Hydraulic Data Branch)

The Hydraulic Data Branch cooperated with the Division of Health and Safety in extensive studies of air quality in the vicinity of the steam plant. Necessary instruments maintained and operated in connection with this program included the anemograph and air temperature recorder mentioned above, 11 autometers, 42 lead peroxide cylinders, 12 deposited dust collectors, 3 high-volume air samplers, a suspended dust sampler, a stack gas autometer, and 4 pyrheliometers.

An anemograph and air temperature recorder combination was used at three locations. From January 21, 1952, until February 11, 1957, one combination was used in conjunction with a 150-foot guyed steel mast located one mile east-northeast of the plant. From September 28, 1954, until September 6, 1957, a second combination was located on a 200-foot guyed mast, 1¾ miles west-southwest of the plant. The third combination, also located 1¾ miles west-southwest of the plant, was installed on the relocated 150-foot guyed mast September 6, 1957.

The temperature recorder provided a record of dry-bulb temperature at the ground level, wet-bulb depression at ground level, and of the dry-bulb differential between the ground and the top of the tower. The pyrheliometers record the radiant solar energy and were installed in locations which would provide exposure to the open sky with as low a horizon angle in all directions as could be found. Other instruments used in connection with the air pollution investigations are more fully described in the following discussions of the major elements in the problem, sulphur dioxide (SO_2) and fly ash.

The instruments have been maintained by personnel of the Field Investigations Section, the Hydraulic Laboratory, and the Water and Sediment Laboratory. Data collected over several years have been put on punch cards for analysis by mechanical methods.

Sulphur dioxide observations—In May 1954, soon after the first unit of the steam plant went into operation, the first of 11 autometers was placed in service in the vicinity. These autometers are equipped to provide an instantaneous continuous record, with integrated averages at 30-minute intervals, of the SO_2 content of the air at the sampling point. The recording shows the SO_2 concentration to the nearest 0.05 ppm within a range from 0 to 5 ppm. Five more instruments were installed at selected locations during June and August 1954, and additional ones were placed in subsequent years, some being transferred from the vicinity of other TVA steam plants. The autometers are mounted in trailers for mobility, so that records can be easily initiated at new locations after significant data have been accumulated at the existing sites. For a brief period one of the autometers was built and installed on unit 3 of the steam plant in such a manner as to record the SO_2 concentration of the stack gases.

Additional data on SO_2 concentrations were also obtained by the use of lead peroxide (PbO_2) stations. These each consist of a cylindrical gauze surface coated with PbO_2, attached to a small glass bottle enclosed in a louver-ventilated shelter 4 feet above the ground. The SO_2 content of the atmosphere is found by determining the amount of $PbSO_4$ resulting from action of the fumes on the PbO_2 during the period of exposure. The cylinders are replaced approximately at 4-month intervals and turned over to the Division of Health and Safety for analysis. Four of the cylinders were mounted in known uncontaminated areas, such as Clingmans Dome in the Great Smoky Mountains, for use in comparing the results with those in the area of investigation.

Economic studies were also made as to possible methods of reducing SO_2 concentrations reaching the ground, including chemical methods for SO_2 removal, construction of higher stacks, and use of low-sulphur coal. The last method named was found the most practicable, particularly since SO_2 concentration around the plant is likely to become a serious problem only during periods of air stagnation when normal dispersal of the stack effluent is inhibited. By switching to low-sulphur coal during such periods, any adverse effect can be minimized. Accordingly, arrangements have been made for the Weather Bureau to transmit to TVA information concerning the imminence of such stagnation periods.

The classes of bulletins used are the Semi-weekly Stagnation Trend Advisory, the Stagnation Alert Bulletin, and the Extreme Stagnation Warning. When the advisory becomes positive, field engineers of the Hydraulic Data Branch make special observations of the autometers and transmit the readings, together with pertinent temperature and fog data, to the Division of Health and Safety. When an alert is issued, the Hydraulic Data Branch is responsible for notifying other Divisions concerned in the event of failure in normal communication channels, and also its Hydraulic Laboratory staff is alerted for prompt repairs to any malfunctioning air testing instruments. During the alert or warning periods, when the Division of Power Operations is using low-sulphur coal in the steam plant, the field engineers of the Hydraulic Data Branch make frequent observations of all pertinent instruments as requested and transmit the data directly to the Weather Bureau for its use in determining the duration of the alert.

Fly ash observations—Another important element in the consideration of air quality is the presence of fly ash. In February 1955, the Hydraulic Data Branch installed 12 deposited fly ash collectors at locations varying from 1.2 to 9.0 miles away from the plant. These each consist of a 6-inch glass jar 12 inches deep with the top open, suitably protected and mounted 8 feet above ground, partially filled with water and provided when necessary with antifreeze. Samples are collected monthly and analyzed at the Water and Sediment Laboratory of the Branch. The samples obviously could contain, in addition to the fly ash, any sediments capable of being airborne at least 8 feet above the ground.

In August 1954 an automatic air sampler was put in operation at the site of the autometer in the TVA housing development at Kingston. This was designed to provide a continuous record on filter paper of the suspended particles, and samples were collected at 2-hour intervals. The operation of this unit was suspended in February 1957. In July 1955 a high-volume air sampler, designed for sampling large volumes of air for particulate matter by filter paper collections, was installed at the same location. The turbine-type motor provides gaged flow of about 65 cfm, and the glass fiber filter pad removes particles with a diameter as small as 0.01 micron. Later, a second sampler was placed at the same station and a

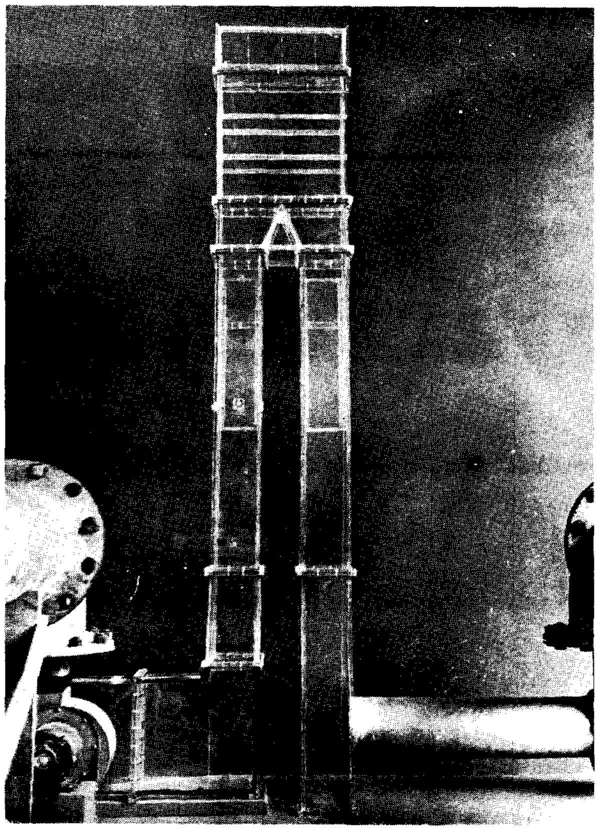

FIGURE 146.—*Model of air duct from air intake to forced draft fan, units 5 to 9, tested to determine reliable method of metering air flows and to determine modification which would decrease pressure losses.*

third at another station. In order to determine the correlation between SO_2 and suspended particulate matter, one of the samplers at the twin installation was equipped in November 1957 with an automatic switching device, developed at the Hydraulic Laboratory, for operating the sampler motor only when the SO_2 concentration equals or exceeds a predetermined value. Upon advice of the Environmental Hygiene Branch, data have been collected at settings of 0.1 and 0.2 ppm. A running-time meter was provided to indicate the duration of sampler operation. Considerable difficulty was experienced with the flow meters on these gages. Because of this no really acceptable data collected until May 1959.

Wind tunnel tests—The effect of stack height on plume dispersal at the plant was studied by 1:540-scale model tests in the wind tunnel at New York University. No analytical means was available for determining the effect of stack height upon the dispersion of smoke in an area characterized by such steep ridges and winding valleys. The specific area studied was a strip extending in a southeasterly direction from the steam plant toward the residential area where an autometer and the high-volume air samplers are situated. The tests provided results significant with respect to the high wind conditions which occur in the area but not to the thermal conditions which develop. The Hydraulic Laboratory of TVA kept in close touch with the tests and evaluated their results with respect to their applicability to the prototype plant. It was concluded that the model operation was similar from a diffusion standpoint to the special meteorological condition which produced the greatest fumigation in the area tested, and that the test data should be indicative of the changes that might be expected to result from the various stack arrangements tested.

Air duct model studies

The ducts providing combustion air to the Kingston furnaces were arranged so that two adjacent units had a common intake structure. Field tests showed that the accuracy of the air metering device for one unit was materially affected by changes in air flows to the adjacent unit. At the request of the Power Production Branch, the Hydraulic Laboratory staff tested a 1:16-scale model of a typical air duct unit for units 5 through 9 to determine a reliable means of metering air flows through the ducts and to determine possible modifications which would decrease pressure losses in the duct system. The model shown in figure 146 simulated the ductwork from the air intake to the forced draft fan. The metering section was a constriction in the duct to produce a pressure effect similar to that of a venturi meter. A metering method involving a segmental orifice instead of the quasi-venturi section, a partition wall separating the common intake into two passages all the way from the intake, and a single curved vane to direct the air around the bend at the intake were found to eliminate the difficulties and to provide stabilized flow of the air.

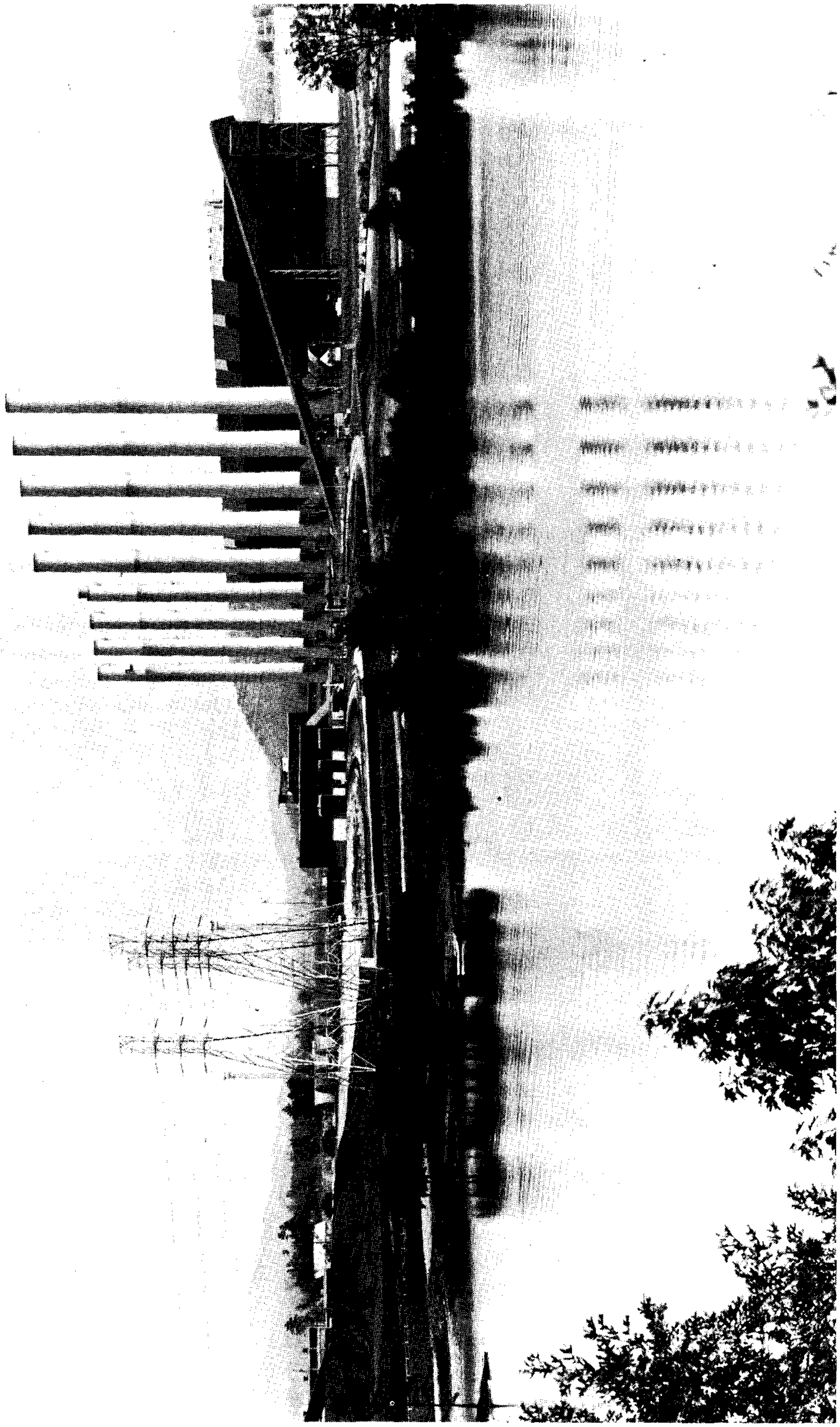

FIGURE 147.—*Kingston Steam Plant October 17, 1956, in cleanup stage and prior to installation of electrostatic precipitators.*

APPENDIX E

ELECTROSTATIC PRECIPITATORS

After the 9-unit Kingston Steam Plant had been in operation for a time, it became apparent that the mechanical collectors were not in themselves sufficient to protect the town of Kingston and surrounding areas from the excessive dropout of fly ash.

Several studies were made to determine the best course to follow in eliminating the fly ash problem. Considerations were as follows:

1. Increase the height of all stacks for better gas dispersion.
2. Build new and higher stacks with each stack serving two units.
3. Install electrostatic precipitators.

The final decision to install the electrostatic precipitators was based on the feeling that this was the most positive and effective action TVA could take for minimizing the fly ash problem although it was not the most economical.

TVA had recognized the possible need for future addition of electrostatic precipitators in the initial design of all its large fuel plants. Consequently, the space required for addition of this equipment was available in the area occupied by gas ducts leading to induced draft fans (fig. 148).

Field erection was done by TVA forces between June 1959 and April 1961.

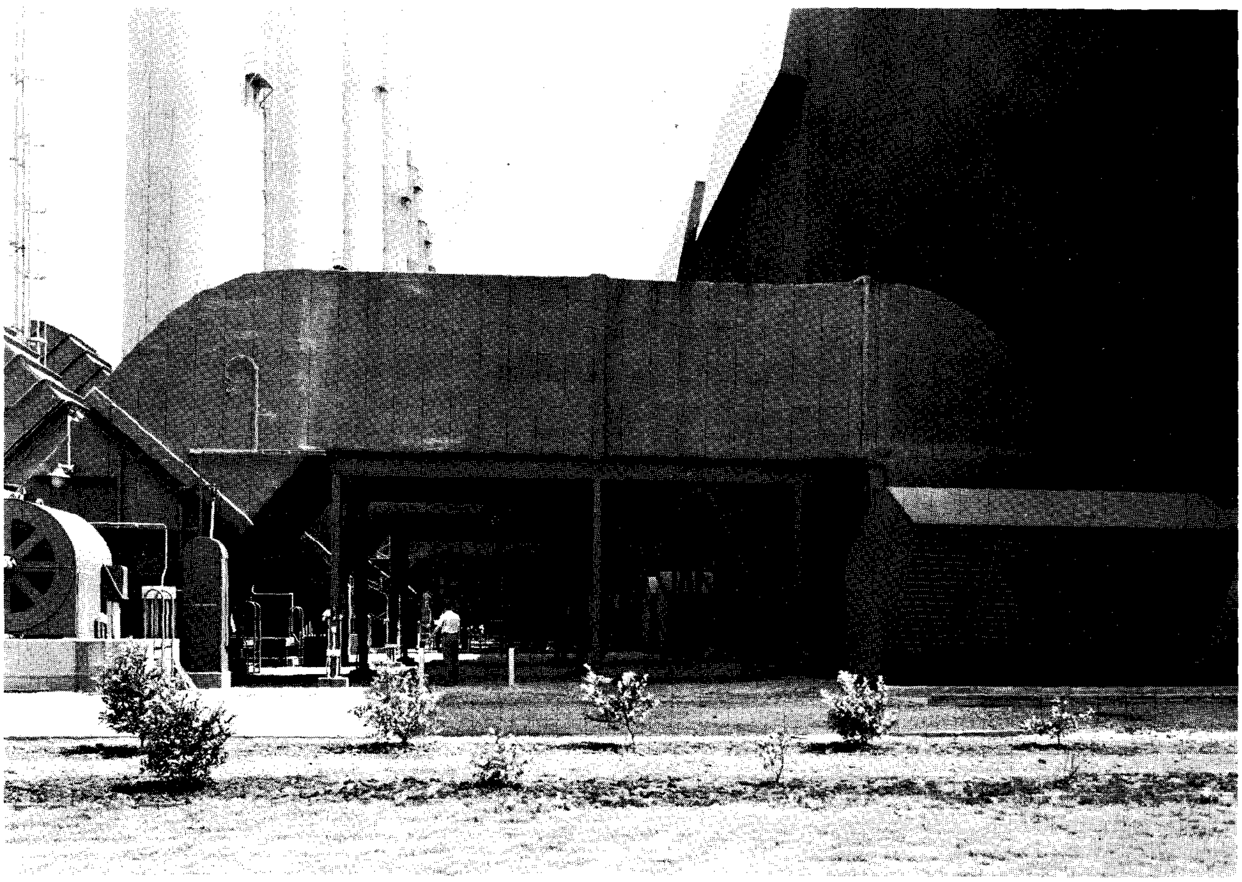

FIGURE 148.—*Original gas ducts, unit 9 in foreground, carried flue gas from mechanical fly ash collectors, right, to induced draft fans to be exhausted into stacks.*

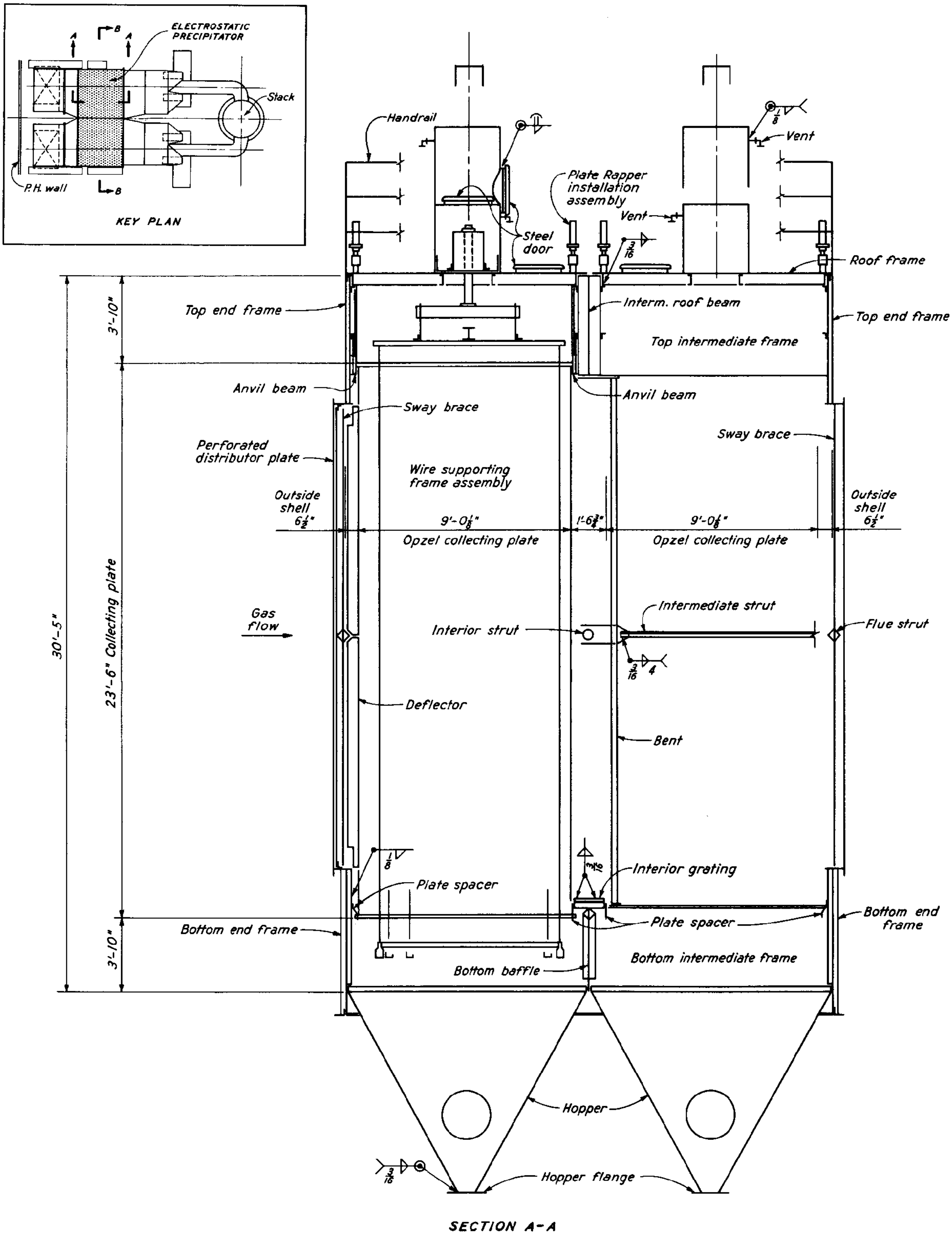

FIGURE 149.—*Sectional side elevation of electrostatic precipitator.*

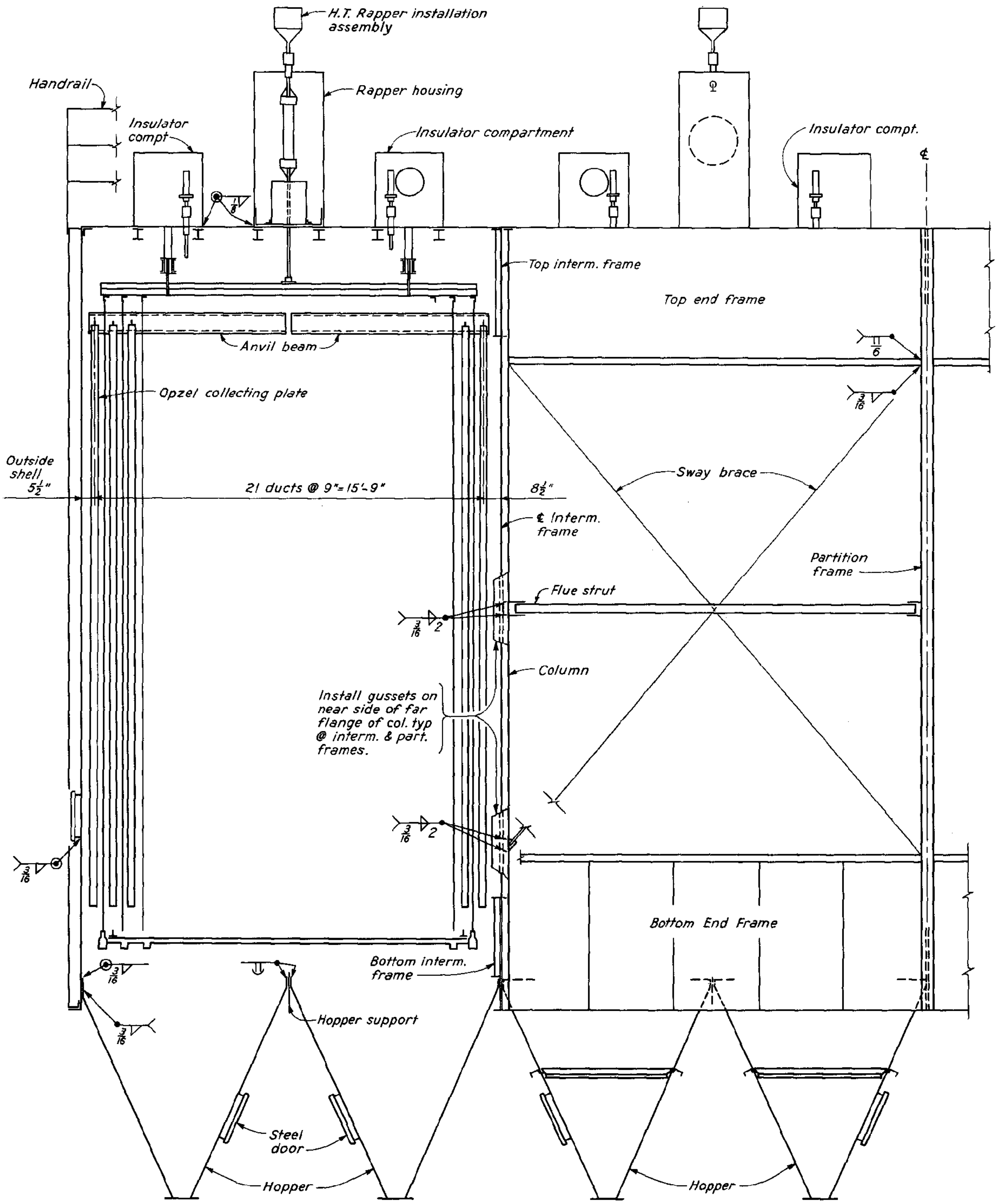

FIGURE 150.—*Sectional end elevation of electrostatic precipitator.*

DESIGN

Precipitators

Units 1-4 precipitators (fig. 151) are each 2-unit collectors, each designed for 95 percent collection efficiency when operating with a normal gas flow of 490,000 cfm and a fly ash loading of 0.815 grains per cu ft entering the collector at a temperature of 330°F. They are also suitable for a maximum gas flow of 540,000 cfm.

Units 5-9 precipitators (fig. 151) are each 4-unit collectors, each designed for the same operating conditions as units 1-4 except the normal gas flow is 680,000 cfm and maximum is 750,000 cfm.

The sectional views of drawing, figure 149 and 150, applicable to both the 2-unit and the 4-unit installations, show the essential operating elements of the precipitators.

All precipitators were designed and built by Research-Cottrell, Inc. They are structurally designed to withstand a negative operating pressure of not less than 20 inches of water and a wind pressure of 30 psf. All plates exposed to flue gas were specified to be Corten for its corrosion resistance qualities.

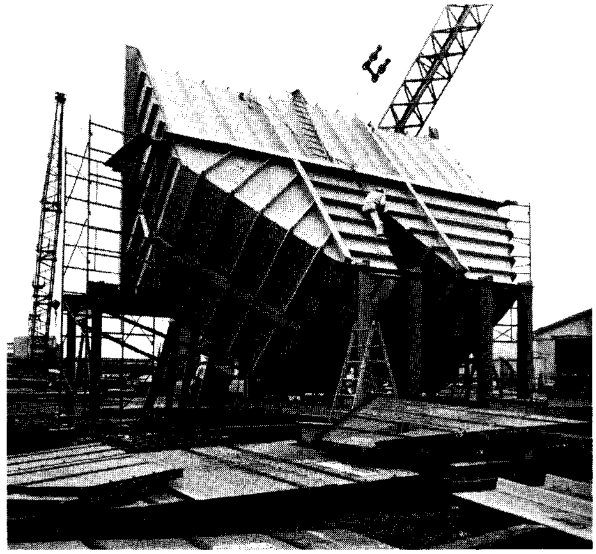

FIGURE 152.—*Outlet ducts for unit 5 were preassembled in sections weighing 15 tons. This did not prove practicable. On other units, ducts were installed in place panel by panel.*

Gas ducts

Gas ducts (fig. 152) were furnished by Connery Construction Company. The ducts for all nine units were made of new ¼-inch Manten steel plate reinforced with internal guide vanes. Contracts were awarded on the basis of re-using portions of the old ducts. Approximately 22½ percent of the original duct was refabricated and re-used for units 5-9, and 33.8 percent of duct, for units 1-4. TVA forces erected the new and refabricated the old ducts.

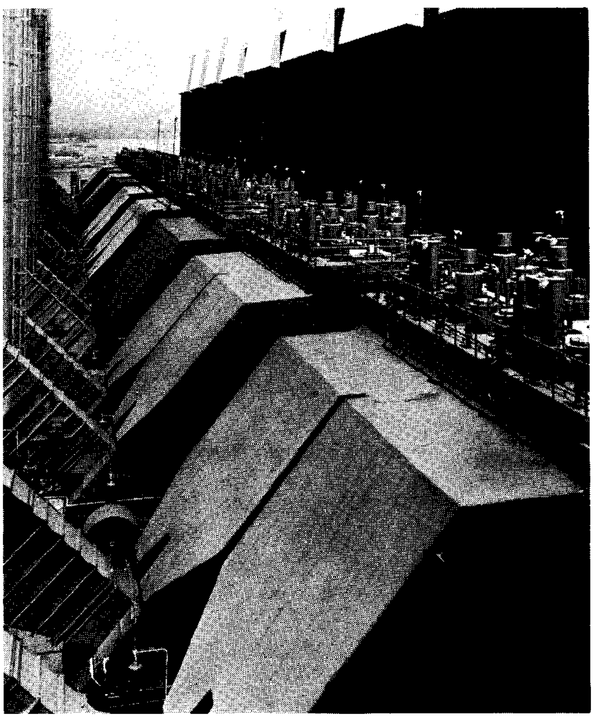

FIGURE 151.—*Electronic precipitators, unit 9 in foreground, remove the fly ash from the flue gas and deposit it in a series of hoppers which discharge into a removal piping system.*

Insulation

North Brothers Company furnished and applied the insulation for units 5-9, and Brooks Fisher Insulating Company performed similar work on units 1-4. Calcium silicate blocks, 2 inches thick with a ½-inch coat of waterproof mastic for weather protection, were specified for insulation which was a departure from the standard 85 percent magnesia used on previous installations. The insulation blocking is secured by lacing wire tied to 6 by 6 by No. 6 wire fabric which is attached to angles or studs welded to duct plates.

Fly ash removal system

Allen-Sherman-Hoff furnished the fly ash removal system for all units. The system consists essentially of materials handling valves on the bottom of each hopper and segregating valves for each branch tied in to the existing Hydrovator system. Valves are operated by an electro-pneumatic system controlled by a rotating distributor switch. When the vacuum on one hopper drops below a predetermined value, the distributor switch rotates to the next hopper and dwells until its fly ash is removed. This process proceeds in sequence for 16 hoppers on each of units 5-9 and the eight on each of units 1-4. Fly ash is conveyed under vacuum by means of the existing Hydrovator system to a water mixing chamber and flows out to the ash pond area as slurry.

SCHEDULING

All nine turbogenerator units had been in commercial operation since December 1955. The installation of electrostatic fly ash precipitators required unit outages and the outage time became an important economic factor. When any one of units 5-9 was off the line, the increased cost of transmitting 200 megawatts from another source could be as much as $2000 per week depending on system conditions.

During a preliminary discussion with the Division of Power Production in February 1959, it was estimated that for any unit, 7 to 8 weeks would be required to erect the precipitator only, and 10 days to erect the inlet and outlet ducts. Insulated ducts purchased at a cost of $57,000 were to be erected, used for 7 to 8 weeks to transport the flue gasses completely around the precipitator working area, then dismantled and erected on the next unit. Proper accounting required that the entire cost of the bypass ducts would be chargeable to Power Production if used less than one year. With this arrangement, it was believed that a total outage of 20 days, consisting of 10 days at the beginning to install bypass ducts and a second 10-day outage at the completion of precipitator erection would be sufficient to remove bypass duct connections.

Outage and erection time

Outage for unit 5 was begun August 22, 1959. Erection of bypass ducts was completed September 11, 1959, but unit maintenance was not completed until October 22. The unit was operated from October 22 to November 20, then bypass ducts were removed and permanent ducts were completed December 10, 1959.

Bypass ducts were completely erected for unit 6 on December 24, then removed January 15, 1960, after extensive maintenance was scheduled on units 5-9. Subsequently, it was decided to carry on with precipitator and duct installation during boiler rehabilitation in unit sequence of 8, 7, and 9 as tabulated in table 40. Consequently, bypass ducts were not needed.

The result was a reduction of elapsed erection time from 108 days for unit 5 to 38 days for unit 7. Average outage increased from 32½ days for units 5 and 6 to 44 days for units 8, 7, and 9. Probable increased cost of transmitting outage power was $3000 per unit which was more than offset by a reduction in the erection cost of $10,000 per unit. Unit 9 was released for operation July 8, 1960, about 84 days in advance of the originally planned schedule. A similar procedure involving close cooperation with the Division of Power Production was followed for units 1-4 to coincide with plant maintenance work.

TABLE 40.—*Progress of erection.*

Unit No.[1]	Date of start[2]	Date release for operation[3]	Total days[4]	Boiler repair and re-habili-tation	Con-struc-tion days	Date of completion
5	8-26-59	12-11-59	113	20	75	3- 6-61[5]
6	12-14-59	2-12-60	61	30	43	4-28-61
8	2-24-60	4-14-60	63	54	38	4- 6-61
7	4-18-60	5-25-60	43	41	28	4-19-61
9	5-27-60	7- 8-60	46	36	30	3-27-61
1	7-18-60	8-23-60	42	37	27	3-15-61
3	9- 2-60	9-30-60	36	29	20	3-14-61
2	10- 3-60	11- 4-60	35	32	25	3- 3-61[5]
4	11- 7-60	12-14-60	40	39	24	3-22-61[5]

1. Beginning with unit 6, sequence of erection was set up to concur with unit outage scheduled by Division of Power Production for boiler repair and rehabilitation.
2. Actual start of precipitator erection after preliminary work.
3. Release to Division of Power Production; not complete for items of insulation, painting, and lighting.
4. Except for unit 5, the boiler repair and rehabilitation was carried on concurrently with precipitator erection so that the total days from date of start to date of operation is somewhat less than the total of boiler repair and construction days.
5. Final painting later than date shown.

ERECTION METHODS

Construction equipment and facilities

An unloading yard was built in the area south of No. 1 storage building on each side of the railroad to provide storage space for duct plates, precipitator shell, and electrical components. There was an old sheetmetal shop on the project which was used for part of the duct assembly. A shed with one side open was erected with a layout table for pieces of the ducts, the idea being that work would proceed in an assembly line method. Since time for erection was limited, it was decided to work two cranes on either side of the precipitator to speed up the work. A third crane was used almost continuously in the storage yard to unload materials and to move duct plates in and out of the fabrication shed; a fourth crane was used at times in the erection area to handle and preassemble the precipitator collection plates. Welding equipment and power supply were set up in the stack area as well as the boilermaker shop. About six construction shacks, including toilets and time check booth were set up in the stack area with drinking fountains at the top and bottom of the precipitators so the men would not have to come down for drinking water. A central oxygen and acetylene station was piped up and moved from unit to unit which reduced man-hours over the old method of using individual tanks. Wooden stairs leading to the exit side of the precipitator were erected for easy access. Permanent stair towers were used for construction access to the top of the precipitator wherever possible.

Preliminary work

In June 1959 it was realized that there might be considerable underground conduit and piping interferences with the foundation piling. An exploration was made and the interferences were located. Design drawings were revised to eliminate these interferences and to permit driving piling with original gas ducts in place. Existing underground lighting and welding conduit was relocated; new precipitator power and control conduit was laid, encased in concrete and backfilled. Piling was driven, pile caps and grade beams were poured, and water and drain lines were relocated. Foundations on the roof at elevation 764.4 and stair tower foundations were poured and roof repaired. All this work progressed on units 5-9 and units 1-4 ahead of precipitator erection.

Foundations inside the powerhouse for precipitator control cubicles at elevation 765 outside of unit control rooms were poured. Power panels were mounted on the E-line walls, conduit was roughed in and cable pulled previous to unit outage. Efforts to secure early delivery of the control cubicles were not always successful because the manufacturer had limited shop testing facilities.

New precipitator support steel was then erected by using temporary shoring for the old ducts while the units were in operation.

Precipitator erection

All precipitators were erected by TVA forces with the assistance of a Research-Cottrell erection engineer who also helped to expedite shipments.

Erection of one precipitator is principally the assembly of about 23,000 loose parts. Most of the parts were unloaded from rail cars in the north construction area, sorted and carefully checked. Components were later moved to the erection site near the chimneys when space became available. Side panels of the precipitator shell were welded together on the ground, and door frames were installed. The other preassembly work consisted of the bolting together of the top beams for hanging collecting plates, the anvil beams, and the wire frames. Doors were welded on the roof plates, insulator and vibrator housings before erection. Seal rings were welded inside insulator housing, and insulator bushings were put in place and caulked with asbestos rope. All this was much easier to do on the ground than when erected in position.

The process of erection consisted of the assembly of the shell and hoppers using fit-up bolts, plumbing and squaring the shell by diagonal tie rods, and seal welding inside to prevent gas leakage. One of the big jobs of preassembly consisted of bolting together two 4½-foot-wide plates about 23 feet long to form a plate 9 feet wide. All bolts were tack-welded to prevent loosening. The collecting plates were stacked vertically and were hung in position by crawler crane. The spacing crew followed the erection gang and roughly spaced the collecting plates. After all plates had been hung, the top wire support frames were laid on top of them. Roof plates were welded in position so electricians could then suspend the wire support frames by means of temporary rods through the roof deck. Some of the discharge wires were hung as guides to determine if the wire support frames had to be shifted, and adjustments were made. The permanent support rods were then placed through the insulator bushings enclosed in the housing.

The next step consisted of hanging 1984 discharge wires from the top wire frames, followed by attaching 14-pound plumb-bob weights at the bottom. Extreme care was used to prevent kinking the wires which could cause future breakage. After the discharge wires were hung the process of checking clearances of wires to plates was resumed, in many cases with a combined crew of boilermakers and electricians working together. The checking crew worked two weeks to get the proper clearance of about 4½ inches.

As soon as the roof deck plates were welded to form a working deck, the electricians began to place electrical apparatus on the roof of the precipitator. The rectifier transformers were set in position and the vibrator housings were erected along with the rappers. Temporary roof shelters were moved by crane as needed to permit working on rainy days.

As soon as the shell was erected, conduit work was run to the various rappers, vibrator cabinets, and to the rectifier transformers. Vertical conduit runs on side panels were put in place while panels were on the ground. As the crews became more experienced, it was possible to erect a precipitator and complete the electrical work ready for check-out in 20 to 25 workdays.

Duct erection

About 6400 pieces of new material for nine units consisting of ¼-inch plate with 5-inch integral ribs, channels, beams, and angles were shipped loose. The new pieces were designed to fit with job-fabricated pieces of the old ducts to form larger panels. Material was checked in detail, sorted, and unloaded from railroad cars in a 3-acre storage yard north of the warehouse (fig. 153). Considerable expediting of shipments was necessary.

Wherever possible, pieces were preassembled at the fabrication shed, outdoors in the construction yard, or at the erection site. Raising crews using two crawler cranes put the preassembled panels in place, followed by fit-up crews and welders.

The original schedule for the first unit allowed only 10 days for installation of the revised gas ducts. Outlet ducts for unit 5 were assembled in larger sections weighing 15 tons while inlet ducts were assembled in 5- to 10-ton sections.

The remaining work was presumed to consist of bolting or welding large sections together which could easily be done in ten 8-hour days. It did not work so easily because the large duct sections did not fit well at connections. It took longer to rig and set

FIGURE 153.—*Gas duct panels, made up of pieces from the old duct, cut, punched, and tack welded, were placed on outdoor tables to be assembled with some new panel pieces, beams, and stiffeners.*

the sections, there was much pulling and jacking, and half-inch welding gaps were difficult to weld closed. The elapsed time was 18 days. The complaint was that assembled large sections like the 15-ton outlet could not face up to the two-fan inlet bolted flanges and also line up to the perimeter of the 32- by 18-foot duct above. It was decided that by starting from the fan and building up panel by panel, there would be more flexibility, thus allowing better alignment of all connections. A longer outage was needed.

Somewhat delayed, but beginning with unit 6 outage, schedules were rearranged to erect ducts panel by panel. Suggestions were invited from foremen, superintendent, and engineers about how to decrease the erection man-hours; how to shorten the outage time for each unit since this was repetitive work. Many suggestions were received, such as changing duct panel assemblies to facilitate connections; welding door frames to panels on the ground; working two erection crews on opposite sides of the outlet and inlet to precipitator; preassembling turning vanes in groups; more welders who would work as combination boilermakers and welders; more scaffold and stairs for access to ducts; more tarpaulins to make temporary rain shelters; and drinking fountains all around the work area. Most of the suggestions were adopted. A reduced number of lost rainy days were traded for more production on fair-weather days. The plan worked. Duct erection man-hours were reduced from 7082 for unit 5 to 5380 for unit 7. Elapsed time decreased from 113 days for unit 5 to 43 days for unit 7 (table 40).

The general method of erection beginning with unit 6 consisted of erection of duct support structure followed by bottom inlet and outlet plates to form a working platform. Panels with external stiffeners were erected using button-head bolts at the joints which were later seal welded, preferably inside, to form gas tight ducts. Turning vanes, splitter plates, and perforated plates were set in place before the roof plates were erected. Vanes and splitters were checked for dimensions as work progressed and securely welded inside. To prevent warping of the precipitator shell, duct connections to precipitator flanges were made without pulling or jacking.

Fabrication of ducts

Panels of the revised gas ducts were composed of pieces refabricated from the old ducts plus the new ducts. Erection of revised gas ducts could not proceed until pieces of old duct were refabricated. A 2-acre yard north of the powerhouse was leveled with cinder fill and 80-foot layout tables were set up under a wood frame shed so work could continue in rainy weather.

Usually, two days after the unit was shut down, pieces of the old duct were cut into sections weighing about 10 tons each, moved to the north yard where they were washed with a water and air jet, cut to approximate size, and numbered. A motor crane moved pieces to one end of the layout table where they were cut to final size, laid out, punched, and tack welded in a straight line operation. The pieces were assembled in panels with new pieces plus beam and channel stiffeners, then moved to the erection site on trailer trucks. In instances when the erection crews were waiting for panels, partially welded panels were moved to the erection site where welding was completed on tables set up on the grass plots near the chimneys.

COST AND COST CONTROL

Final total cost of the 9-unit installation of precipitators and facilities was $3,273,000. The largest items of cost were the erection of precipitator gas ducts and the installation of conduit and wiring. Tabulation of precipitator man-hours indicated a reducing trend for units 5 through 7, but the addition of double discharge wires on unit 9 increased the man-hours somewhat. Gas duct erection costs decreased progressively on units 5-9 and averaged about $168 per ton. Gas ducts on units 1-4 were smaller in size but quite different in arrangement. There were many more inside turning vanes and splitter plates which increased the cost of erection to an average of $208 per ton.

Cost of electrical work consisting of 12 components was not broken down by units for the 5-9 group. Electrical costs for the 1-4 group were broken down by units, showing small variations except for unit 2 where there was more underground conduit interference.

The cost of refabricating the old ducts, beginning with unit 5, decreased through units 6, 8, and 7 in sequence, but rose with unit 9. The refabrication cost averaged around $340 per ton for units 5-9. Fabrication of units 1-4 was more complicated and there were 44 percent more pieces to fabricate but cost was decreased by improved supervision. The refabrication cost averaged around $320 per ton for units 1-4. If all new ducts had been purchased, the cost less salvage value of old ducts would have been about $462 per ton. A total of 232.9 tons of old ducts was refabricated at the job site for an average cost of $331.80 per ton, resulting in a saving of about $30,000.

According to Research-Cottrell, the 5-9 unit cost of $29,000 and 9.0 man-hours per thousand cfm of flue gas was low. The average duct erection cost of $168 per ton and 34.3 man-hours was reasonable. The fly ash disposal piping was high on the basis of cost per linear foot, but quite reasonable when consideration is given to the fact that units 5-9 had 19 valves in a 276-foot run of piping with job-fabricated hangers at 5-foot spacing.

The cost per sq ft of the first application of paint for units 5-8 of $0.02695 by TVA forces is considered to be equal to a contractor's cost. The final cost for painting on units 5-8 was very high because it was necessary to repaint over black surfaces where the insulation contractor had to return to add more Insul-Kote over areas previously painted.

Miscellaneous metal work consisted of stair towers, platforms and grating. The erection was broken up in stages which increased the cost to some extent because the stair towers were needed for access to the roof of the precipitators at the start of erection and ironworkers had to return to erect other platforms after precipitator ducts were erected. Several platforms were altered to leave clearance for precipitator insulation which brought the total cost to $135 per ton.

Total man-hours and labor costs are summarized as follows:

Units 1-4:
- Total man-hours, 72,870
- Average man-hours per unit, 18,217.5
- Total cost, $330,104
- Average cost per unit, $82,526

Units 5-9:
- Total man-hours, 108,160
- Average man-hours per unit, 21,632
- Total cost, $499,405
- Average cost per unit, $99,881

APPENDIX F

UNIT 5 TURBOGENERATOR ERECTION PROCEDURE

The following log of unit 5 turbogenerator erection procedure illustrates the numerous items involved in erection and testing from installation of sole plates to commercial operation, a period which varies with different units according to the problems encountered.

5-25-54
Set bench marks for sole plate elevations. Sole plates in power house. Using sole plates for No. 6 turbine. No. 5 sole plates not on job.

5-26-54
Cleaning sole plates and setting in place. Hole centers and two governor end plates were drilled wrong. Moved hole centers 3½".

5-27-54
Located sole plates for this unit, changed out No. 6 plates.

5-28-54
Leveling sole plates.

6-1-54
Leveling sole plates.

6-2-54
Forming generator sub sole plates.

6-3-54
Checked turbine sole plates. Forming generator sub sole plates. Set iron horse on foundation.

6-4-54
Forming sub sole plates. Installed light bulbs in exciter for heat.

6-7-54
Grouted generator sub sole plates.

6-8-54
Grout exhauster hood sub sole plates.

6-9-54
Removed generator sole plates and trimmed up grout around sub sole plates.

6-10-54
Removed turbine sole plates and trimmed up grout around sub sole plates.

6-11-54
Removed three sub sole plates, right side under No. 2 plate and regrouted same.

6-14-54
Making metal grout forms for generator foundation. Setting sub sole plates. Leveling sub sole plates for exciter.

6-15-54
Setting sub sole plates and leveling sub sole plates for exciter.

6-16-54
Forming sub sole plates for exciter. Making metal grout forms for generator and exhauster foundations.

6-17-54
Forming sub sole plates for exciter. Grouting in seal oil unit.

6-18-54
Cleaning and oiling sole plates.

6-21-54
Set tight line brackets while lining case to foundation.

6-22-54
Checked center line on foundations.

6-23-54 to 6-30-54
No work.

7-1-54
Installing pipe hangers.

7-2-54
Installing pipe hangers.

7-6-54
Moving pipe, turbine shell and diaphragms into building.

7-7-54
Hanging oil pipe. Moving equipment into powerhouse Started night shift. Unloading and cleaning parts. Cleaned and set L.P. lower exhaust casing, generator end. The casing is sitting on 1½" block, the condenser was $3/16$" too high for casing to sit on sole plates.

7-8-54
Set lower half exhaust hood, generator end, on foundation. Machine 10 mils from top of key on right side exhauster sole plate. Held up by NAVCO and lack of base plate bolts. Set lower half of low pressure inner casing in place on jack bolts. Set lower turbine end exhaust hood, made joint with Crane 425 compound and tightened temporary bolts. The dowels were too small, two new dowels are being made. Changed tight line brackets at No. 6 bearing to get point for center line. Had to remove both water catcher rings from LP inner casing to get down.

7-9-54
Pulled lower sections of exhaust hood together with temporary bolts. Brought lower half of exhaust hoods to station line. Set station turning pedestals in place. Removed lower half of LP inner casing. Cleaned upper half of LP inner casing. Set No. 1, No. 2 and No. 3 sections of intermediate inner casing in place temporarily. Removed man hole covers from LP outer casing. Checked nuts on valve gear (HP). Built and installed tight line brackets for LP casing.

7-12-54
Cleaned horizontal joint of intermediate outer shell and bolts for same. Unloaded turbine end of generator stator frame. Tack weld brackets to inner case of plumb check.

7-13-54
Finished making temporary horizontal joint on TB end of exhaust hood. Installed inner and outer LP upper casings and made up temporary joints. Set tight line for taking vertical readings on TB end of LP casing. Retightened anchor bolts on LP casing. Set inner exhaust case. Set TB end of exhaust hood upper half. Tightened vertical bolts in exhaust hood. Set exciter end of generator shell in hole.

7-14-54
Turned collector end of stator frame. Set coupling end in hole and turned. Raised and lowered exhaust hood to iron out the kinks. Loosened and tightened exhaust hood bolts. Run line through exhaust hood. Raised top half of turbine end low pressure exhaust and checked joints. Reset same and realigned vertical and horizontal joint. Made tight wire check on right and left of vertical joint as shown on sheet.

7-15-54
Run line through exhaust hood. Turning generator frame. Straightened sole plates under LP exhaust casing. Check vertical face of LP casing as shown on line sheet. Tightened trunion on generator stator, removed tie brackets from support bars in generator stator casing and cleaned support pads.
7-16-54
Assembled generator frame in hole, work wise. Removed LP inner casing, and checked horizontal joint of same. Replaced LP upper shell and bolted up. Raised generator end of exhaust casing and checked sole plates and casing feet.
7-19-54
Bolted up vertical joint between exhaust sections. Run line through exhaust hood. Unloaded armature core, ask G.E. to install circular heaters in core. Removed outer LP upper casing. Installed inner LP casing and replaced outer LP cover. All joints made up temporary with oil between joints. No. 13 dowel in LP outer casing is too loose for the hole. Removed inner end shield from generator stator. Opened No. 1 standard and removed governor and some piping. Checked joint of inner casing with feeler gauges and found it to be together at joint of inner bore.
7-20-54
Brought exhaust to station line. Checked line through exhaust with cases bolted up. Started internal weld on generator at 10:30 am (Four welders). Completed 1½ passes on coupling end joint.
7-21-54
Grouted in exhaust hood. Welded on internal seam of generator (4 welders). Started setting sub pads for No. 2 sole plate.
7-22-54
Completed internal weld on generator frame. Started external weld at 3:00 pm (4 welders). Run line through exhaust hood after grouting. Leveling standard plates. Removed top half of LP exhaust shell. Taking vertical wire readings before unbolting exhaust hood.
7-23-54
Completed setting of foundation plates for standards. Welding on generator frame (3 men). Run line with hoods off. Bringing condenser up to exhaust hood for welding. Ready for condenser weld.
7-26-54
Completed second pass on external weld of generator at noon. Formed sub sole plates under standard for grouting. Condenser flange being welded to take up gap between flange and turbine exhaust. Burned backing strip to help gap.
7-27-54
Grouted front and middle standard sub sole plates. Magnafluxed external weld on generator frame, collector end. Ground five places that were cracked. Setting condenser. Put tram marks on condenser feet.
7-28-54
Made first pass on condenser weld. Magnafluxed seams on generator frame coupling end, six cracks found, ground and rewelded cracks on collector end seam and continued welding (5 welders). Removed standard plates and trimmed grout around sub sole plates.
7-29-54
Made second pass on condenser weld. Continued weld on generator (6 welders). Shimmed loose sub pads under No. 1 standard sole plate. Checked for level and found very good. Placed No. 2 standard on sole plates.
7-30-54
Set HP lower shell in place and cleaned joints. Continued weld in generator frame (six welders). Unloaded generator field and requested heat to keep it dry. Checked axle clearance of diaphragms and corrected the ones that were out of tolerance.
7-31-54
Made pass No. 3 on condenser weld.
8-1-54
Condenser weld not doing too good. Heated and peened sides—no help. Peened under No. 6 bearing—made it worse. Flame cut through to the first pass in places.
8-2-54
Continued work on condenser weld.
8-3-54
Continued welding on condenser and generator.
8-4-54
Welding under No. 4 end of turbine. Welding under traverse key, right hand side, where crack was cut out. Ground weld on generator casing.
8-5-54
Welding on condenser and generator frame. Ground weld on lower seam of generator shell.
8-6-54
Magnafluxed generator frame welds. Installed upper inner low pressure casing, outer upper low pressure casing, upper intermediate casing. All joints made up temporary with oil in joints and every other bolt tight. Made feeler gauge check between exhaust supports and sole plates.
8-7-54
Run tight line check with hoods on. Weld on generator complete and magnafluxed. Made feeler gauge check between sole plates and exhauster support feet.
8-9-54
Alignment ok'd with hoods on after welding was completed.
8-11-54
Shimmed front standard and run tight line check.
8-12-54
Factory approved line through IP and exhaust. Turned generator core on foundation. Installing bolts in high pressure shell. Completed tightening HP horizontal joint and taking tight line reading.
8-13-54
Continued alignment of No. 2 standard.
8-16-54
Turned generator frame. Tried to take frame out of hole but the cables were too long.
8-17-54
Brought generator frame out of hole and set on cribs over generator foundation. Started cleaning frame and getting pulling gear ready for core.
8-18-54
Started pulling generator core.
8-19-54
Pulled in generator core and started bolting trunion mounts. Factory approved line for grouting standard. Formed No. 1 and No. 2 standards for grout.
8-20-54
Made up generator spring supports on core. Grouted in middle and front standard.
8-23-54
Removed high pressure turbine front standard and started chipping grout. Lowered generator to within 3″ of foundation. Unbolted intermediate turbine.
8-24-54
Set front and medium standards after installing pipe and standard plate. Set RH stop valve in hole. Installed lower intermediate casing and made vertical joint with crane No. 425. Installed upper intermediate half of outer casing with grease at joint. Set lower outer high pressure casing and installed all keys. Set inner upper high pressure casing and made joints with grease.
8-25-54
Set and bolted upper half of high pressure shell.
8-26-54
Installed HV (high voltage) bushing extension box and started installing terminal leads. Block condenser, and removed HP outer and inner upper casings, IP outer and inner casing, turbine end upper exhaust casing and LP outer and inner upper casings.
8-27-54
Installed three gas coolers. Continued work on HV bushing job.

8-30-54
Continued work on coolers. Finished installing HP diaphragms (lower). Cleaned and installed lower LP double flow diaphragm, cleaned and installed No. 4 and No. 5 bearing rings.
8-31-54
Set No. 3 bearing. Checked IP rotor alignment of HP diaphragm and corrected as needed. Set top half of diaphragms and checked horizontal joint on HP section. Finished putting diaphragms in upper HP and LP sections. Took readings on LP double flow diaphragms. Installed inner lower end bell on TB end of generator.
9-1-54
Checked dial readings on 24th stage intermediate section. Set LP double flow diaphragms to tight lines.
9-2-54
Continued work on HV bushing. Checked low pressure diaphragms. Installed HP diaphragm packing.
9-3-54
Worked on IP diaphragm. Continued on high voltage bushings. Installed bottom half of generator end bell, turbine end. Worked on seal oil unit motor alignment.
9-7-54
Doweled No. 6 and No. 7 packing boxes. Checked diaphragm alignment on IP section. Worked on LP diaphragms. Installed lower half of No. 1 and No. 2 bearings. Checked LP diaphragms.
9-8-54
Completed diaphragm alignment. Set oil pump in front standard. Completed alignment on main oil pump. Run final tight line through low pressure diaphragm.
9-9-54
Checked and corrected radial pin clearance on HP diaphragms. The high pressure diaphragms are ready for the rotor.
9-10-54
Completed welding boiler side of right hand stop valve. Started welding boiler side left hand stop valve. Put HP rotor in place. Finished packing IP diaphragms. Finished radial pin clearance in the double flow section of the low pressure turbine.
9-13-54
Put lower half of the end bell collector in place. Set up tight line for aligning generator core. Set up tight line to align generator to turbine. Completed high voltage bushings. Completed installing gas coolers.
9-14-54
Installed No. 3, No. 4 and No. 5 bearings. Installed IP rotor. Finished leak test on internal oil lines. Started installation of current transformers. Left side stop valve weld completed.
9-15-54
Finished with the generator field and removed sliding shoe and sliding pan.
9-16-54
Made air gap check on generator. Installed No. 6 bearing. Installed LP rotor. Installed lower half of the generator inner end bell (Collector end).
9-17-54
Installing large piece of bottom inner air shield on collector end. Checked bearing clearance and ring pinch on No. 1, No. 2, No. 4, No. 5 and No. 6.
9-20-54
Installed top half of inner air shield, both ends of generator. Shimmed No. 4, No. 5 and No. 6 bearings to where IP and LP coupling is ready to make up. Made up IP and LP couplings.
9-21-54
Aligned HP and IP couplings. Aligned all reflectors generator side, No. 5 bearing. Installed turning gear for turning the turbine rotor. HP and IP couplings made up tight but the turbine side of the thrust is off and the top half of No. 2 bearing is off. Removed the collector end generator end bell and doweled the oil deflector.
9-22-54
Reassembled thrust bearing. Started taking diaphragms and packing clearances. Removed temporary turning gear. Installing oil deflector TB side No. 4 bearing. Doweling top half of inner oil deflector TB end of generator. Installed all lower half packings that were left out to align shaft. Put some fan nozzle blades on collector end. Installed upper half of generator end bell collector end. Held the weight of generator field on crane while the end bell was tightened.
9-23-54
Completed diaphragm and packing clearances. Installed oil deflector generator side No. 6 bearing. Installed oil deflector generator side No. 5 bearing. Installed some fan nozzles and air baffles on TB end of generator. Installed and locked remaining fan nozzles and air baffles on collector end. Installed hydrogen seal assembly device, collector end of generator. Started modification of bucket cover of 23rd stage wheel, IP section as per factory's instructions. Removed baffle plate from turbine end on generator end bell and installed outer upper half of generator end bell. Made joint and tightened all outer bolts with the weight of field on crane. There is none of the inner bolts tight. Installed governor and started alignment.
9-24-54
Completed making up the hydrogen seal on the collector end of the generator. Aligned governor to turbine shaft. Made check on turbine and generator couplings. Worked on oil tank motor alignment.
9-27-54
Installed seal rings in main shaft oil pump. Factory approved wheel clearances. Installed HP inner casing. Installed intermediate casing and tightened bolts. Installed 24th stage IP diaphragm and second stage diaphragm (bolted and locked).
9-28-54
Installed and bolted up upper half of exhaust. Tightened inner HP shell. Heated and tightened all HP inner shell bolts. Rolled the turbine rotor a full revolution—OK.
9-29-54
Set IP case and installed bolts. Tightened inner exhaust shell. Installed HP outer shell and installed top gib key.
9-30-54
Bolting up IP casing.
10-1-54
Finished stressing HP outer horizontal bolts. Installed IP and HP coupling bolts and pulled up hand tight.
10-2-54
Fitting main steam leads to turbine.
10-4-54
Stretching HP and IP coupling bolts. Installing LP outer exhaust cover top gib keys.
10-5-54
Set, doweled and bolted speed governor.
10-6-54
Replaced oil coupling bolts in IP and LP couplings with new ones from factory. Stressed above bolts and made up couplings.
10-7-54
Completed weld on upper steam leads stop valve to turbine.
10-8-54
Completed dry packing right rear sole plates under exhaust case.
10-9-54
Aligning generator coupling.
10-10-54
Completed alignment of generator coupling with water in condenser.
10-11-54
Check generator coupling after draining condenser. Forming generator sole plates. Started wiring front standard.
10-12-54
Completed fitting generator alignment gib keys. Installed differential expansion indicator in front standard. Made up No. 4 and No. 5 bearing covers. Installed alignment pins in generator support feet.

10-13-54
Made up LP generator coupling. Grouted generator. Started making up cross over pipes and aligning exciter.
10-14-54
Install No. 7 bearing top for oil flush.
10-15-54
Install cover plates on front standard. Put gib key in mid-standard top half.
10-16-54
Started 3 men grinding boiler side opening of RH stop valves. Cleaned main oil tank. Filled turbine oil tank and seal oil tank for oil flush. Aligned exciter and checked.
10-18-54
Completed lining exciter coupling. Started oil flush. Doweled exciter in place.
10-19-54
Continued oil flush. Oil used for flush: Puroturbine Oil TVA C4204 B1676SB-54J.
10-20-54
Took couplings off RH stop valve. Checked fit of expansion joint and one extraction line in exhauster.
10-21-54
Continued oil flush.
10-22-54
Continued oil flush. Grouted exciter.
10-23-54
Completed oil flush and started cleaning oil tank. Installed turning gear.
10-24-54
Completed cleaning oil tank. Removed exciter and cleaned up grout. Replaced exciter and bolted down.
10-25-54
Checked exciter coupling and resumed oil flush.
10-26-54
Continued with oil flush.
10-27-54
Continued oil flush, blanked intercept valve for blowdown and started heat retention lagging.
10-28-54
Continued oil flush and removed stop valve heads and installed blanks for blowdown.
10-29-54
Continued oil flush. Shut oil pump off at 4:30 am and started pumping oil out of tank.
10-30-54
Removed No. 7 and No. 8 bearings—cleaned and replaced. Started cleaning oil tank.
11-1-54
Checked rotation of the main seal oil pump and seal oil vacuum pump.
11-2-54
Checked rotation of d-c seal oil pump. Checked out hydrogen control cabinet alarms. Installed partition and coupling guard on exciter.
11-3-54
Started air test on generator. Seal oil unit operated satisfactorily.
11-4-54
Continued test on generator. Checked out a-c and d-c turning gear oil pump and vapor extractor on turbine oil storage tank. Resumed oil flush.
11-5-54
Operated main stops, RH stops and intercept valves—OK. Made up exciter coupling.
11-6-54
Chipped and welded high voltage bushing extension box.
11-8-54
Made up control valve gear linkage and no load linkage. Continued air test.
11-9-54
Started installing intercept valve linkage. Checked end bells and coolers for air leaks at 30 psig—OK.
11-10-54
Installing intercept valve linkage. Continued oil flush.
11-11-54
Installing necessary lagging for start-up. Air test held perfect at 30 psig—OK. Checked water supply to oil coolers.
11-12-54
Checked generator for leaks with freon. Turning gear hooked up. Worked on intercept valve linkage.
11-13-54
Electricians completed installation of thermocouples and thrust bearing.
11-15-54
Continued work on intercept valve linkage. Placed machine on turning gear at 10:30 am. Adjusted brush holders to collector rings.
11-16-54
Installing lagging between turbine and generator, right side. Continued work on intercept valve linkage and collector ring brushes.
11-17-54
Checked out speed relay and continued work on intercept valves. Completed hydrostatic test of hydrogen coolers.
11-18-54
Continued work on intercept valve linkage. Removed top half of collector end generator oil deflection and replaced with permanent joint, tightened TB end generator oil deflection back.
11-19-54
Turbine rolled off turning gear on water through operational error.
11-20-54
Removed the blowdown valves and covers from two main stop valves. Removed the seat and stem from the left main stop valve. Removed covers from both intercept valves and RH stop valves and disconnected all valve stems from hydraulic pistons.
Blowed down main steam, RH steam and steam seals. Removed temporary seal oil piping and installed permanent piping.
11-21-54
Blued and reseated both main stop valves and both intercept valves.
11-22-54
Start-up engineer arrived on job.
11-23-54
Completed stressing inner and outer shell bolts.
11-24-54
Set up tram pointers on main steam stop valves and took cold readings. Checked out gland condenser blowers. Checked relay dump valves at oil tank. Made electrical interlock check.
11-25-54
Checked out air operated valves for controlling water to oil cooler and to hydrogen cooler. 5:45 pm—Started warming steam chest. 6:33 pm—Rolled turbine on steam, 200 RPM. Continued stretch out run through the night. Took expansion readings and oil temperature.
11-26-54
At 1800 RPM after the water sprays in the exhaust shell were turned on a loud knocking developed near the turning gear. Machine was slowed down to 800 RPM and the knock became intermittent and then disappeared. Machine was held at 800 RPMs for about 4 hours and then brought up to 1800 RPMs and water sprays turned on again. The knock was only slight and lasted only a short time and then disappeared completely. The turbine was brought up to 3600 RPMs and set low speed and high speed stop. Checked over-speed trip at 4000 RPMs. Synchronized the machine and continued to run until the electrical test was made. The machine was shut down to work on the boiler safety valves.
11-28-54
Rolled turbine at 1:35 pm, rub developed in No. 4 steam packing after unit had been at speed for awhile, unit put back on turning gear. 5:40 pm—Rolled turbine on steam. 6:35 pm—Tripped unit off to work on steam seal exhauster. 10:20 pm—Started warming steam chest. 10:25 pm—

Rolled turbine at 200 RPMs. Tested over-speed trip at 3950 RPMs. 11:56 pm—Unit went on line.
11-29-54
Continued taking expansion and temperature readings.
11-30-54
Completed first balance run and tried to set RH safety valves. Not enough flow to make setting with valves closed to within ¾". Reduced load and tripped out at 2:10 pm and came on turning gear.
12-1-54
Shut down for main safety valve repairs. Rolled off for balance shot No. 1 at 7:35 pm. Synchronized at 10:06 pm.
12-2-54
Reached 90 MW at 2:00 am. Started down at 6:25 am, off line at 7:49 am. Installed shot No. 2 which was increasing the weight of shot No. 1 to 14 oz. (Same location). Rolled turbine at 9:53 am. Reached 90 MW at 11:55 am. Started down at 4:45 pm. Off line at 5:37 pm. Installed shot No. 3 which was a static pair of 8 oz. located at L.H.H.J. with sine wave alternator stopped at 220°. Shot No. 2 was left in and not moved. Rolled off at 7:41 pm. On the line at 8:38 pm. Reached 90 MW at 10:20 pm.
12-3-54
Made balance shot No. 5.
12-4-54
Made balance shot No. 6 and No. 7.
12-5-54
Made balance shot No. 8.
12-6-54
Made balance shot No. 9.
12-7-54
Set RH safety valves.
12-8-54
Increased load to 200 MW.
12-9-54
Unit tripped off line at 8:10 am.
12-10-54
Making repairs on unit.
12-11-54
Rolled turbine at 7:06 pm. Came up to speed satisfactorily. Attempted to test over-speed trip. Trip operated at 3970 RPM, but simultaneously the whole machine went into a severe vibration. Vacuum was broken and machine was put on turning gear. It was decided to remove the weights from the single flow low pressure turbine and the turbine was rolled again while watching the speed vibration characteristics of the generator bearing.
12-12-54
The turbine came up to speed with several very sharp critical vibrations which were rather severe. When the generator came to 3600 RPMs the vibration was minimal, but the over-speed trip was not checked. The load was increased to 180 MW and then brought down to repair a leak in the economizer.
12-13-54
Turbine rolled and the speed increased to 800 RPMs. A severe vibration started in the high pressure turbine but still no rub could be detected by listening rods. Eccentricity recorder picked up to 11-12 mils. The machine was tripped and put on turning gear until the eccentricity came back to normal (hour and one half). 10:10 pm—The unit was rolled and came to speed with no difficulty.
12-16-54
Made balance shot.
12-17-54
Made balance shot.
12-18-54
Made two balance shots.
12-19-54
Down for repairs.
12-22-54
Rolled turbine and increased to 200 MW.
12-23-54
The machine operated normally at 200 MW until 4:40 am at which time a loud noise was heard and the vibration recorder showed a large increase in vibration especially at No. 6 detector (4 mils). The operators reduced load to 75-90 MW and held until inspector could get here. The eccentricity picked up only lightly, but vibration continued to increase very slowly. The load was reduced to zero and the machine tripped out. When the man hole covers were removed the damage to the generator end double flow low pressure turbine 24th stage which was observed to be a 3" portion of the tip of one of the 27" blades twisted off and another with about 1" portion of another blade missing and about a dozen blades bent and damaged at the tips. Preparations were made to remove the double flow exhaust hood. Left hand cross-over tee removed. Still working on right hand tee. Dowels hung up. GE representatives and shift engineers arrived at beginning of second shift to inspect damage.
12-24-54
Removed upper outer and upper inner IP shells.
12-26-54
Broke IP and LP coupling, and exciter coupling. Removed bolts from bearing caps and turning gear. Worked on jig for machining buckets.
12-27-54
Removed turning gear and broke LP generator coupling; LP rotor ready to be removed. Worked on jig for machining buckets.
12-28-54
Machining buckets on 23rd stage.
12-29-54
Continued machining buckets on 23rd stage.
12-30-54
Continued machining buckets on 23rd stage.
12-31-54
Completed machining wheel 23rd stage generator end. Machining wheel 23rd stage IP end. Removed LP rotor and all LP diaphragms.
1-2-55
Took wheel clearances of LP section—OK. Made coupling check from LP end to generator.
1-3-55
Assemble generator end exhaust hood and bolted up. Aligned generator to turbine coupling.
1-4-55
Put unit on turning gear and started seal oil unit. Machine rolled off turning gear at 1:36 pm. Unit off to repair leaking valve.
1-5-55
Unit back on line.
1-6-55
Off line for balance shot.
1-7-55
Making balance shot.
1-8-55
On line.
1-9-55
On line at 170 MWs.
1-10-55
Off line.
1-11-55
On line.
1-12-55
On line.
1-15-55
On line with 170 MW.
1-16-55
Off line checking for condenser leak.
1-17-55
On line.
1-18-55
On line 170 MW.

APPENDIX G

SEQUENCE OF STARTUP OPERATIONS FOR UNIT 6

The following log of startup operations for unit 6 illustrates the numerous items involved from firing of the boiler to commercial operation, a test period which varies with different units according to the problems encountered.

January 18, 1955

5:55 am	Fire in boiler (pilot torches)
7:12 am	2 main torches in each furnace
1:45 pm	All main torches in
8:00 pm	Unit 6 and unit 9 phosphate pump motors burned out—dismantled and shipped motors to Knoxville for repairs

January 19, 1955

4:15 am	Down to check noise in 6-A F.D. fan
5:30 am	Started 1st blowdown of chemical boil out
5:45 am	Finished 1st blowdown of chemical boil out
12:45 pm	6-B boiler feed pump discharge gage out 6-C boiler feed pump discharge gage out
1:10 pm	Fires out—pumps off to try to stir up dirt in boiler. Water clean up to now
7:00 pm	Issued 2 drums caustic soda and 25 bags phosphate
11:30 pm	Concentration PO_4 1500 PPM, NaOH 2300

January 20, 1955

1:22 am	Finished blowing down ¼ glass
2:00 am	Let settle with fires out and circulators off —then blowdown again
7:00 am	Boil out complete, started deconcentrating
2:15 pm	Fires out—pressure 200#
9:05 pm	Drained boiler to wash drums and headers with R.W. (raw water)
10:00 pm	Started filling S.H. (superheater) with condensate from #6 cold well

January 21, 1955

1:27 am	S.H. full
3:49 am	Started filling boiler for hydrostat
5:41 am	300# pressure reached
8:15 am	All pilots and 4 mains in
11:00 am	Temperature right to drain but hole in temporary softened water line
11:45 am	Started draining
12:30 pm	Drained
1:18 pm	Filling with acid
3:15 pm	Boiler full of acid with 30-minute delay to repair leak
9:15 pm	Draining boiler of acid under N_2 atmosphere
10:20 pm	Boiler drained
10:50 pm	Boiler filled for 1st flush
12:00 pm	Boiler drained under N_2 atmosphere

January 22, 1955

12:58 am	Boiler filled for 2nd flush
1:39 am	Started draining under N_2 atmosphere
2:41 am	Boiler drained—#6 cold well pump on to backwash S.H.
2:45 am	Dowell pumping soda solution into boiler
3:10 am	Dowell through—#7 cold well pump on to flush acid fill line
3:50 am	Boiler filled
4:13 am	Oil pump on—all pilot torches on
5:00 am	All main torches on
7:45 am	50# pressure on boiler
9:45 am	Two hour boil out time complete. Sample from main and lower drums show heavy oxides
10:40 am	Decision reached to set up blowdown schedule to clear up water. Schedule to be determined by available water. Blowing down ¼ glass at each lower drum
4:08 pm	Blowing down ¼ glass from each bottom drum
4:46 pm	Boiler pressure 75#
8:30 pm	Main oil torches and pilots off
9:10 pm	Blowing down ½ glass from front RH (reheater) and SH drum
10:27 pm	North drum vent, SH link vent, SH, OH (outlet header) vents open Cooling boiler down to drain

January 23, 1955

2:00 am	Boiler water temperature 158°
2:18 am	Draining boiler
3:46 am	Boiler drained of soda solution
3:52 am	Drain closed and filling boiler
4:24 am	Boiler filled with distilled water from #6 cold well
4:27 am	Circulators on
4:39 am	Circulators off
4:55 am	Draining boiler
5:55 am	Boiler empty—closing drains
6:06 am	Filling boiler
6:51 am	Boiler filled
7:30 am	All pilots and 4 main torches in
7:42 am	# 5, 7, 8 phosphate pumps on
8:25 am	Fires out, phosphate pumps off
8:40 am	Laboratory satisfied with water condition
9:20 am	170°F. draining boiler Opened all drums Acid wash complete

January 24, 1955

1. Changing valve stems in boiler circulating pump stop check valves.
2. Removing all temporary acid wash piping and restore permanent connections.
3. Equipment not sold — pulverizers and feeders, bunkers and coal scale dust collectors, d.c. oil pump turbine oil tank.
4. TVA design engineer on job to check high and low pressure heaters. Removed impellers from #5 and 6 heater drain pump that was taken out of service and found approximately ½″ plug lodged in section of 1st stage impeller. Removed same and assembled pump (Serial No. 1442611).
5. Installing drum nozzles and internals.

6. Working on leaks in fuel oil system.
7. Installing pilot tubes in downcomers (boilermaker work completed).
8. Cleaning elements in 6-B air preheater.
9. Place blank in run of tee at main steam stop valves to isolate cold reheat for hydrostat.

January 25, 1955

9:45 am	Started filling #6 boiler
11:00 am	100 psi on boiler—holding due to leak on B stop valve and scavenge flange below valve
12:05 pm	Increasing leak test pressure to 350 psi
1:55 pm	Draining boiler to firing level
3:05 pm	All pilot torches in boiler
4:05 pm	6-A F.D. fan tripped out due to water in SAFE stop switch
4:06 pm	All fires out of furnace
5:15 pm	Pilot torches in
6:44 pm	All pilot torches and 4 main torches in
7:25 pm	All main torches out each furnace (north reheat return water locked in temporary scavenge piping—added drain valve)
8:30 pm	Pilot torches in
9:18 pm	Two main torches in each furnace
9:25 pm	All main torches out—south link drain plugged (line cut between valves and cleared)
11:30 pm	Pilot torches in

January 26, 1955

12:00 am	All main torches in
1:15 am	Closed drum vents, link vents, and reheat drains
4:35 am	450 psi, main torches out—1st blow to 325 psi
4:46 am	Main torches in
5:10 am	450 psi, main torches out 2nd blow main steam to 350 psi
5:15 am	All main torches in
5:37 am	450 psi, main torches out 3rd blow, main steam to 350 psi
5:43 am	All main torches in
6:05 am	450 psi, main torches out 4th blow to 350 psi
6:09 am	All main torches in
6:30 am	450 psi, main torches out 5th blow to 350 psi Superheat O.K. by G.E. (General Electric service representative) Reheat stop valves being opened
6:37 am	Main torches in, pressure being held at 400 psi
9:22 am	Blowing RH 1st time (450 to 350 psig)
10:00 am	Blowing RH 2nd time (450 to 350 psig)
10:28 am	Blowing RH 3rd time (450 to 350 psig)
11:07 am	Blowing RH 4th time (450 to 350 psig)
11:38 am	Blowing RH 5th time (450 to 350 psig)
12:00 noon	Scavenging SH and RH desuperheat lines, main steam to SJAP (steam jet air pump) and hogging jet lines
3:30 pm	Scavenging all steam seals on turbine
5:40 pm	All fires out in boiler
6:15 pm	Finished steam seal scavenging
7:00 pm	Cutting out temporary piping

January 27, 1955

Temporary scavenge flanges
Removed from main steam stop valves and reheat intercept valves. Cover flange on reheat stop valves pulled

January 28, 1955

Cleaning condenser and working on stop and intercept valves

January 29, 1955

Inspected and accepted condenser after cleaning

January 30, 1955

Made final hydrostat on condenser. MSR (manufacturers service representative) arrived at 8 a.m. and reworked drum safeties (safety valves)

January 31, 1955

5:45 pm	Started filling #6 for hydrostat, pilot tube connections and caps on lower drums. Tubes on downcomers
6:55 pm	Pressure 1500 psi, caps on lower drums and pilot tube connections. Handhole clamps loose on sidewall headers, pressure dropped to 100 psi and clamps tightened
9:00 pm	Boiler being drained to firing level
11:10 pm	All pilot torches in

February 1, 1955

12:15 am	6-A F.D. fan tripped out—water in local switch—fires out
1:20 am	Boiler fired
1:45 am	Shut 6-B hotwell pump down—gland water not flowing out—grease leaking out around keeper—beginning to run hot. Removed gland water line, found gland chamber full of graphite grease. No millwrights—left pump down
2:20 am	Unstopped SH link drain by beating on valve
2:50 am	Leak in flange of south turbine oil cooler —tightened down
3:22 am	Fires out due to line not run from #2 extraction to valve stem leak off. Cold reheat is blowing back steam. Drove wood plug in extraction connection
9:05 am	Started setting drum and superheat outlet header safeties—not satisfactory
10:30 am	Leak in economizer reported
11:20 am	Off for economizer leak
9:00 pm	Leak in economizer section welded
9:35 pm	Started filling for hydrostat (hydrostatic test)
11:05 pm	1500 psi on boiler

February 2, 1955

12:13 am	Hydrostat complete—draining down
12:15	Found float in Nash valve on DW (distilled water) pump collapsed—replaced with one from #7 gland pump
1:37 am	Fire in boiler—pilots
6:30 am	1500# pressure
7:30 am	Start setting drum and superheat outlet header safeties
4:30 pm	Quit setting safeties—not satisfactory
6:30 pm	Hogger on
7:05 pm	Rolled turbine off turning gear
7:10 pm	Increasing speed to 200 RPM
8:10 pm	Increasing speed to 400 RPM
9:10 pm	Increasing speed to 800 RPM
11:20 pm	Holding 25″ ± for 1 hour Speed 800 RPM—no load SH 675#, 670°F, reheat 580°—fire-oil—Note #6 low pressure heater drain line safety valve is blanked off
11:30 pm	Holding 20″ Hg vacuum for 1 hour

February 3, 1955

1:00 am	Holding 15″ Hg vacuum for 1 hour
2:00 am	Holding 10″ Hg vacuum for 30 minutes
2:00 am	Removed blanks in #6 heater drain safety valve and cold well to hot well drag line
2:30 am	Increased vacuum to 15″ Hg holding for 1 hour. Both hot well pumps on recirculation
3:30 am	Increased vacuum to 20″ Hg, holding for 1 hour
4:30 am	Increased vacuum to 25″ Hg, holding for 1 hour

5:30 am	Increased vacuum to maximum, holding for 1 hour
	Exhaust shell temp high—240°F. Temp climbed during ½-hour run at 10" Hg vacuum
	Air operated hand valve on #4 extraction reverse current valve E28274 installed backwards—had fitters reverse brass lines
6:55 am	Stretch out complete
7:30 am	1800 RPM
2:00 pm	Increasing speed to 3600 RPM, 10 a minute
5:00 pm	3600 RPM
6:57 pm	Synchronized and increasing to 20 MW
8:20 pm	#6 off line to make amplidyne adjustment
9:20 pm	On line, increasing to 20 MW
10:20 pm	Increasing to 30 MW
February 4, 1955	
12:00 am	Increasing load to 40 MW
1:00 am	Increasing load to 50 MW
2:00 am	Increasing load to 60 MW
3:00 am	Increasing load to 70 MW
3:39 am	Cutting high pressure heaters in service
4:00 am	Increasing load to 80 MW
5:10 am	Increasing load to 90 MW
8:10 am	Decreasing load to 60 MW
9:30 am	Started setting reheat safeties
2:15 pm	Completed setting reheat safeties—all set satisfactorily
3:10 pm	Decreasing load from 60 MW
4:48 pm	Fires out to repair drum safeties
4:57 pm	Turbine tripped
5:10 pm	Turbine on turning gear
8:00 pm	All vents open
February 5, 1955	
1:30 am	Consolidated safety valve service men reported to check 4 drum safeties
3:00 am	Repaired oil leak on lighting off oil board
4:00 am	Welded joint in vapor extractor vent line, El. 843.0
4:00 am	Boilermakers started work on buckstays at El. 801. Trimming outer web of channel 1½" and welding 1" x 4" bar stiffener on. Doing this to two buckstays. One superheat and one reheat boiler, both too close to building steel
5:00 am	Installed 8 flange bolts in s.v. (safety valve) on evaporator
5:00 am	Replaced gasket in flange joint of vacuum drag line at hot well
5:30 am	Cleaned injection water strainers—found one strainer crimped holes in fine mesh
5:30 am	Completed work on 4 drum s.v.
9:00 am	Repaired air leak in main supply to superheat torches
11:18 am	Torches in boiler
12:50 pm	Drum vents closed
1:00 pm	G.E. tested turbine oil coolers—no leaks found
	Oil from #6 res. being centrifuged Started at 11:40 am
1:50 pm	"C" mill on
2:10 pm	"C" feeder on—firing 5 out of 20 minutes
	Grout in condenser base plates on units 6, 7, and 8
4:00 pm	Pressure 1750 psi—feeder out, holding pressure
5:25 pm	Safeties gagged, feeder in increasing pressure to 2100 psi Started setting drum safeties
7:00 pm	Cleaned turbine oil storage tank—OK'd by P.O.
8:15 pm	Started pumping oil from dirty lub oil tank to turbine lub oil tank through centrifuge
8:20 pm	Completed setting drum pressure safeties All set satisfactorily
8:25 pm	Checked automatic position on power relief valve
	Opened 1995 psi—seated 1960 psi
8:40 pm	"C" mill off—one main torch in each furnace—decreasing pressure to 800#
10:00 pm	Purged with CO_2 (6 cyl) and filled generator with hydrogen (33 cyl)
February 6, 1955	
2:00 am	Approximately 2500 gallons oil returned to turbine lub oil tank, still cloudy (had G.E. check). Returning oil to oil room, heating to 170°F and centrifuging again. Called the mechanical engineer to inform him of condition of oil and approximately 14 hours delay—4 hours to heat and 10 hours to centrifuge
2:30 am	Started cleaning turbine lub oil tank
5:00 am	Completed
5:30 am	Oil temp in new dirty tank 168°
	Oil temp in old dirty tank 128°
8:30 am	Started filling lub oil tank with new oil
11:30 am	Millwrights reported a barrel of fuel oil had been found among new oil and pumped into front standard (42 barrels in reservoir when found)
1:25 pm	Pumping oil from turbine oil reservoir back in drums
2:15 pm	Filling clean oil storage tank with clean turbine oil from drums
2:40 pm	Turbine oil reservoir empty—millwrights started cleaning
4:30 pm	Turbine oil reservoir cleaned—started pumping oil from drums through front standard of turbine
4:50 pm	Started filling turbine oil reservoir from clean oil storage tank
5:00 pm	Pure Oil Company MSR arrived on the job. Samples of (1) the oil which was in No. 6 on initial run, (2) the oil which was taken from tank today which we knew was contaminated, (3) sample from bottom of tank with oil going in now, and (4) of the black oil
7:35 pm	Turbine oil reservoir full to operating level
7:40 pm	Main turbine oil pump on
7:45 pm	Turbine on turning gear
8:00 pm	Main torches in SH and RH furnaces, bringing to 1000 psi
8:15 pm	Turbine oil reservoir full
8:35 pm	Steam seal regulator in service
9:17 pm	Steam to turbine
February 7, 1955	
12:04 am	On the line 20 MW
12:39 am	Increasing to 40 MW
2:00 am	Increasing to 100 MW
3:00 am	Turbine oil sample from top of lub tank clear
6:00 am	Turbine oil sample from top of lub tank clear
9:00 am	Tightened BFP (boiler feed pump) suction flange under DA (deaerator) storage tank
9:30 am	Tightened 2" plug in condensate line behind #4 heater
1:40 pm	High pressure heaters in service
7:45 pm	Repaired leaks on coal piping at mills "A" and "D". Burned RH safety valve drain loose from grating
10:00 pm	Welded evaporation safety drain to main
February 8, 1955	
	Load 100 MW steam flow 625,000 #/hr
2:30 am	Completed soot blower drains
3:00 am	Blew air preheaters

TVA-00020364

4:00 am Soot blowing system safety valve popped at 780 psig on test. Started blowing A and B air preheaters

Unit 5 down to change out 3″ M.O. (motor operated) bypass valve in boiler fill line

4:30 am Started cutting evaporator in service

1-2 Flange on level control to evaporator broken

2 Level controller on evaporator shell connected in reverse

3 Hole in top of evaporator preheater (thermometer not installed)

4 Coil vent line on evaporator head leaking

1:45 pm 6-A I.D. fan inboard bearing vibrating

6:20 pm Evaporator in service

9:30 pm Gas dryer in service

10:30 pm "D" circulator isolated to repair plug leaks

11:30 pm Unable to isolate "D" circulator—repair on shutdown

February 9, 1955

Load 100 MW S.F. (steam flow) 625,000 #/hr

1:45 am Bearing next to fan running rough on coal scale dust collector—tagged out to millwrights

2:00 am C.E. (Combustion Engineering representative) investigating S.H. furnace water wall for leak. Small water seepage on buckstay S.H. furnace east side approximately 6′ from north burner, El. 765. Removed 2 casing panels, found moisture but no leak

3:30 am 6-A F.D. fan bearing next to motor vibrating inside bearing housing. Top snugging shoe loose vibration reduced when tightened down. Millwright standing watch on 6-A I.D. and F.D.

4:15 am Air pressure down to 20 psig on RH furnace pilot torches—cleaned torches and strainers but pressure still low

4:30 am Coal dust collector bearing bad, replaced with one from collector on unit 8

6:30 am Coal dust collector in service

9:10 am 6-D circulator isolated to stop leaks around two threaded plugs in housing

4:40 am Injection water pump isolated to stop plug leak in pump housing

5:05 am Injection water pump in service

9:30 am Removed water column gage #1 heater to blow out lines and free gage valve stem. Replaced valve with one from unit 7—due to hard packing

12:00 noon 6-B I.D. fan inboard bearing leaking oil around gasket seal—seal being tightened

1:10 pm 6-B I.D. fan outboard bearing temp has increased from 140° at 10:00 am to 152° at present, cooling water being cut on

1:25 pm Cooling water on 6-B I.D. fan outboard bearing—temp dropped below normal

1:30 pm Oil level low in 6-A I.D. fan inboard bearing—oil being added

5:05 pm Leak in economizer, A and D feeders off

5:15 pm A and D mills off—decreasing load to come off line

5:55 pm Main torches out

6:01 pm Turbine tripped

6:16 pm Turbine on turning gear

10:00 pm Hoppers under air heaters full of fly ash and water. Plug valve removed and hoppers being cleaned (reheat furnace)

10:10 pm Millwrights working on 6-A I.D. fan inboard bearing. Moving collars from .023″ thrust clearance to .015″ per Westinghouse erector. Removing bottom half of bearing. Bearing scored

February 10, 1955

12:00 am NAVCO (National Valve Company) standing by to change out 3″ M.O. boiler fill bypass valve when economizer drained

12:45 am Draining economizer section

Leak located—3 tubes, 13th, 14th, and 15th from east end of 10¼″ O.D. economizer inlet header on south side of reheat furnace. These tubes have holes in edge of field weld

3:00 am 6-A I.D. fan bearing bottom half scored. Called in factory service representative

3:30 am NAVCO cut 3″ MO valve out at line

4:00 am Removed C.I. plug in condensate line entering #4 heater and replaced with steel plug

6:00 am 3″ MO valve welded in, stress relieved and wrapped

9:40 am 3″ MO valve limits set and released to DPO (Division of Power Operations)

10:00 am Cleaned air line to pilot torches by blowing sections. Also cleaned all strainers and torches

11:00 am Cleaned both air preheater ash collectors and all fly ash collectors

12:35 pm Welding complete on economizer tubes

1:15 pm Cleared #6 for hydrostat

1:25 pm 6-A boiler feed on to fill and raise pressure to 1500# for hydrostat

2:46 pm 1500 psi on #6

2:50 pm Economizer leak OK

3:00 pm Check 3″ MO bypass valve on boiler fill line at 1500 psi—OK

3:05 pm Draining boiler to firing level

4:20 pm Cleared to light off

4:30 pm Igniters on

8:58 pm Rolling turbine, 17″ vacuum 650 psi drum, 475°F, 600 psi superheat at 560°F

9:23 pm Turbine tripped at G.E.'s request. High eccentricity, 3 mills at 400 RPM

9:38 pm Turbine on turning gear

10:05 pm Hogger back in service, rolling turbine

10:30 pm Pulling maximum vacuum 800 RPM, eccentricity normal

11:20 pm 6-B I.D. fan inboard bearing has a slight vibration

11:45 pm Leveled off 3600 RPM

11:48 pm Turbine on line 20 MW

February 11, 1955

Load 150 MW

10:00 pm Pressure gage lines to hotwell pumps and raw water pumps frozen

10:45 pm Telephone being installed from control room to north end #6 boiler

February 12, 1955

Load 150 MW

Outside temp reached low of 5°F and during this period much difficulty was encountered with frozen lines

12:45 am Superheater outlet header pressure gage frozen—in service 2:30 am

1:50 am Unit 6 transformer sprinkler system opened up due to frozen pilot. Cut off and drained

1:50 am Boiler feedwater regulator on hand—regulator freezing

3:00 am Outside temp 6°F

4:35 am Right side intercept valve would not go fully closed on test.

5:30 am BFP discharge pressure gage frozen up

7:40 am Injection water pressure "Low Annunciation" frozen up

8:05 am Steam to reheat pressure transmitter frozen

8:15 am Knock in 6-B condenser circulating water pump reported
10:00 am Ash sluice nozzles froze up on reheat furnace—thawing with torches
10:15 am Shift engineer and instrument mechanic OK'd keeping only following instrumentation in service:
1. Injection water diff.
2. Boiler feed water transmitter and regulator
3. Steam flow meter
4. Drum level transmitter
5. Boiler master regulator
6. Feedwater regulator
7. Drum pressure
8. Superheat pressure
9. Extraction recorders
10. Hotwell level
11. Manometers on boiler circulating pumps
12. Condensate flow
10:30 am More temperature protection requested
10:55 am Temp 15°F
2:15 pm Started filling transmitters with anti-freeze, per Republic Flowmeters Co.

February 13 and 14, 1955
Load 150 MW
Outside temp reached low of 5°F and during this period much difficulty was encountered with frozen lines

February 15 and 16, 1955
Load 150 MW—steam flow 900,000 #/hr

February 17, 1955
Steam flow 900,000—load 147 MW
B-1 slag blower in superheat furnace hangs up before going all the way in
8:27 am 4160V bus #2 tripped out due to secondary pot fuse (6 amp) blowing. Load 90 MW

February 18, 1955
12:33 pm Increasing load to 160 MW at rate 1 per minute and holding 1 hour
2:47 pm Increasing load to 175 MW at rate 1 MW/min
3:48 pm Increasing load to 185 MW at rate 1 MW/min
4:45 pm Increasing load to 200 MW at rate 1 MW/min
5:15 pm Leveled off at 200 MW

February 19, 1955
5:00 pm Borrowed 20 bottles CO_2 and hydrogen (each) from DPO for purging and refilling generator in the morning
5:30 pm Reducing load to 150 MW for G.E. to take balance readings
7:45 pm Reducing load to 90 MW for G.E. to take balance reading
8:25 pm 90 MW load—holding for G.E.
10:45 pm G.E.completed balance readings on 90 MW load
11:00 pm Increasing load to 200 MW
11:55 pm Load at 150 MW—increasing at 1 to 2 MW/min

February 20, 1955
12:00 am Load at 160 MW—increasing at 1 to 2 MW/min
12:40 am Load at 200 MW—holding
4:30 am Reducing load from 200 MW—coming off the line
4:40 am Water from leaking check valve on injection water line running down coal pipe and into B feeder
6:10 am Turbine off the line. Boiler pressure 500 psi, oil trip on turbine did not operate
Interceptor valves failed to close when tripped at turbine. Had to be tripped by vacuum breaker
12:45 pm Rolled turbine off turning gear
3:40 pm Load at 90 MW—G.E. taking balance checks
10:17 pm Decreasing load to "0" for G.E.
11:34 pm Turbine tripped with oil trip

February 21, 1955
1:00 am Completed balance shot on #7 and 8 bearings
2:20 pm 3600 RPM
3:38 am Leveled off at 90 MW, holding for G.E. balance data #8 bearing, 1⅛ mills
9:50 am Turbine off line
10:00 am All bolts removed from main steam stop and reheat intercept valve
10:10 am Turbine on turning gear. Decreasing pressure on boiler to make repairs
12:00 pm Unit down to remove fine mesh strainers in stop and intercept valves and complete jobs on work list

February 22, 1955
10:30 pm Unit released for fire
Note: South drum gage cut out of service due to leak
6-A, 6-B, 6-C, BFP recirculating valves are in open position by cutting off d-c supply. Annunciation did not come on and test valves failed to open every time
False annunciation—"DA overflow valve open"
11:06 pm Torches in
11:25 pm Fires out, testing reverse current valve by overflowing DA tank
11:25 pm Oil leak on line to burner box left hand rear, reheat furnace

February 23, 1955
12:55 am Oil leak repaired on SW corner reheat furnace
1:00 am All main torches in
4:17 am Steam to turbine
8:55 am Leveled off at 90 MW, holding for G.E. to take balance data—1¾ mills vib amp
2:25 pm Reducing load 1 MW per min. for balance shot and empty 6-A coal pipe
6:06 pm On the line increasing to 90 MW

February 24, 1955
12:15 am Decreasing load to "0" for G.E. to make balance shot
12:53 am Turbine tripped off line
4:22 am Turbine rolled—increased to 90 MW
5:25 am Leveled off at 90 MW for G.E. to obtain balance data
8:47 am Decreasing load to "0" at rate of 2MW/min, #8 bearing, 1½ mills vib amp—#4 bearing ½ mill, vib amp
9:28 am Turbine tripped
12:15 pm Turbine rolled
1:45 pm Load 90 MW
7:33 pm Decreasing load to "0" for balance shot
8:25 pm Off the line for balance shot
11:02 pm Rolling turbine
11:15 pm On the line

February 25, 1955
12:00 am Holding 90 MW for G.E. balance data
Note: Leak in line to sampling coil at #4 heaters, el. 809.0, 23 and F lines
2:55 am Dropping load to "0" for G.E. to make balance shot
3:23 am Turbine off line
6:45 am Holding 90 MW for G.E. to obtain balance data
2:02 pm Turbine tripped for balancing shot
7:01 pm Turbine rolled

7:14 pm On the line
11:23 pm Turbine tripped for balance shot

February 26, 1955
1:30 am Turbine rolled (balance shot)
2:20 am Load 90 MW (holding)
11:12 am Tripped for G.E. to take shot No. 8 on balancing
1:23 pm Turbine on line
2:30 pm Load 90 MW
8:19 pm Turbine tripped for balance shot
10:45 pm Rolling turbine

February 27, 1955
12:30 am Load 90 MW
3:49 am Tripped turbine for balance shot
4:50 am Rolling turbine
5:08 am On line with 20 MW
7:00 am Load 90 MW, 330,000 #/hr S.F.
9:30 am Repairing 6-B boiler feed pump bypass valve
1:30 pm Load back to 90 MW—holding due to trouble with unit 1-A F.D. fan
11:49 pm Turbine tripped for G.E. balance shot

February 28, 1955
2:15 am Purging air from generator—15 bottles CO_2
3:10 am Started filling generator with hydrogen
5:35 am Finished filling generator with hydrogen—27 bottles
5:55 am Rolling turbine
6:25 am Load 25 MW
7:00 am Load 90 MW—425,000 #/hr S.F.
10:45 am Increasing load to 180 MW
4:45 pm Load 150 MW
9:07 pm Load 180 MW

March 1, 1955
Load 180 MW 1,100,000 #/hr S.F.
12:20 pm Started increasing load to 200 MW
12:30 pm Load 200 MW
2:17 pm Decreasing to "0" load for G.E.
4:25 pm Off line
6:50 pm On line—10 MW
9:00 pm Increasing to 200 MW

March 2, 1955
Load 200 MW—1,300,000 #/hr S.F.
10:00 am 5 and 6 heater drain pumps taken apart—found three pieces of metal lodged in 1st stage impeller.

March 3, 1955
12:01 am Commercial Operation

DRAWINGS
FOR THE
KINGSTON STEAM PLANT
UNITS 1-9

A selected group of drawings are included with this Technical Report No. 34 in lieu of a separate bound volume. The drawings are representative of major engineering and technical features of the plant, but are not intended to serve as a set of construction drawings. There is included a complete index of drawings for the Kingston Steam Plant, Units 1-9, from which particular drawings may be selected for reference.

DRAWINGS
FOR THE
KINGSTON STEAM PLANT
UNITS 1-9

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Steel Lockers, Stools, and Hook - Lyon Metal Products, Incorporated C53-19346
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Aluminum Louvers and Grilles - Aluminum Structures, Incorporated C53-26843
Millwork, Cabinets, and Chalkboard - D. M. Rose and Company C54-15754
Wire Mesh Partitions - Kentucky Metal Products Company C54-20661
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Metal Brackets, Angle Supports, and Closet Rods - Newman Brothers, Inc C54-24850
Portable Aluminum Ladders - Aluminum Ladder Company C54-27142
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  - Portable Pipe Threading Machine - C. M. McClung and Company — C51-21992
  - Wheel Press, Arbor Press, and Metal Bending Brake - Noland Company — C51-22254
  - Metal Bending Roll - Webb Corporation — C51-24012
  - Surface Plate - George M. Merriwether — C51-26833
  - Valve Grinding Machine - R. T. Clapp Company — C51-26974
  - Induction Heater - Electric Arc, Inc — C51-27117
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  - Forging Hammer - Chambersburg Engineering Company — C51-27686
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  - Universal Milling Machine - Noland Co — C52-1837
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  - Metal Shears - Tidewater Supply Co — 56-821535
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- Electrostatic Collectors - Research-Cottrell, Incorporated — 59-34559
- Dry Fly Ash Handling System - Allen-Sherman-Hoff Company — 61-41064
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Steam Cleaners
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Speed Reducing Units - Infilco, Inc — C51-27004

Closed Feedwater Heaters
- Lummus Company — C51-27095
- Griscom-Russell Company — C53-19323

Evaporators and Evaporator Preheaters
- Graham Manufacturing Company — C51-27634
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- Chattanooga Boiler and Tank Company — C53-21964

Raw Water Strainers
- Grey-Hodges Corporation — C52-10020
- J. A. Zurn Manufacturing Company — C54-18753

Clam Shell Coal Valves - Columbus Conveyor Company — C52-10280 and C53-18652

Coal Scales
- Richardson Scale Company — C52-10600
- Stock Equipment Company — C53-20364

Heat Exchangers
- Lummus Company — C52-10635
- Downington Iron Works, Incorporated — C53-21343

Insulating and Lubricating Oil Purifying Units - Buford, Hall, and Smith — C52-10793

Portable Oil Purifier Units - U. S. Hoffman Machinery Corporation — C52-10794

Special Cast Iron Fittings
- Hardie-Tynes Manufacturing Company — C52-10920
- Thomas Foundries, Incorporated — C53-21316

Forced and Induced Draft Fans - Westinghouse Electric Corporation — C52-11130 and C53-20560

Condensate Return Pumps
- Carver Pump Company — C52-11472
- Economy Pumps, Incorporated — C53-21632

Vacuum Cleaning Equipment - Lamson Corporation — C52-12111 and C53-17869

Boiler Feedwater System Pumps - Worthington Corporation — C52-12117 and C53-19398

Heater Drainers - Fisher Governor Co — C52-12419

Oil Pumping Units - Worthington Corp — C52-13091

Control Boards, Control, and Metering Equipment - Republic Flow Meters Co — C52-13194

Conductivity and pH Recorders - Minneapolis-Honeywell Regulator Co — C52-13290 and C53-22410

Tank Level Gauges
- Gray-Hodges Corp — C52-13716
- Jones-Sylar Supply Co — C53-19334

Vertical Turbine Pumps - Worthington Corporation — C52-13838 and C53-22409

Automatic Elevators - Otis Elevator Co — C52-14562

Vacuum Priming Pumps - Nash Engineering Company — C52-14565 and C53-21230

Sump Pumps - Yeomans Brothers Company — C52-15154

Float Switches, Pressure Switches, and Temperature Controls - Leinart Engineering Company — C52-15197

Pressure Switches - Gray-Hodges Corp — C52-15198

Bottom Ash Sluice Water Pumps
- Units 1-4 - Byron Jackson Company — C52-17244
- Units 5-8 - Byron Jackson Company — C53-3549
- Units 1-9 - Byron Jackson Company — C55-25324

Fire Hose Cabinets - Grinnell Company — C52-19154

Float Trap Strainers - American Radiator and Standard Sanitary Corporation — C52-19302

Float Switches
- Leinart Engineering Company — C52-19922
- Rittlemeyer and Company — C54-18457

Pressure Gauges and Pulsation Dampeners
- J. E. Lonergan Company — C52-20109
- Mills and Lupton Supply Company — C54-18806

Test Wells - Gray-Hodges Corporation — C52-20110

Deaerating Feedwater Heaters - Worthington Corporation — C53-17814

Butterfly Valves - Henry Pratt Company — C53-18030

Lubricating Oil Pumping Units - Worthington Corporation — C53-18031

Dirty Lubricating Oil Transfer Pump - Worthington Corporation — C54-2531

Fire Hose and Racks - Gray-Hodges Corp — C54-17049

Fire Hose Carts, Nozzles, and Playpipes - Grinnell Company — C54-17050

Soft Water Booster Pump - Peerless Pump Division — C54-17129

Pressure Switches and Temperature Gauges - Leinart Engineering Company — C54-18458

Injection Water Pumps - Ingersoll-Rand Co — C54-21224

Additional Lube Oil Heaters - Gray-Hodges Corporation — C54-21398

Level Controllers for Gland Seal Water Storage Tanks - Leinart Engineering Co — C54-23432

Fire Protection Equipment
- Leinart Engineering Company — C54-23543
- Associated Engineers — C54-23544

Sprinkler Nozzles - Binks Manufacturing Co — C54-23545

Float Switches for Continuous Blow-down Tanks - Rittlemeyer and Company — C54-23994

Industrial Thermometers and Test Wells
- American Machine and Metals, Inc — C54-28574
- Manning, Maxwell, and Moore, Inc — C55-17984

Differential Pressure Switches - Republic Flow Meters Company — C55-15430

Desuperheating Equipment - Continental Foundry and Machine Company — C55-15538

Manometers - Meriam Instrument Company — C55-16117

Spare Stators for Forced and Induced Draft Fan Motors - Westinghouse Electric Co — C55-16267

Special Chemical Feed Pumps - Proportioneers, Incorporated — C55-24082

Differential Pressure Indicators for Injection Water - Republic Flow Meters Company — C55-25100

Wired Television Equipment
- Thompson Products — 56-677176
- Diamond Power Specialties Corporation — 56-836927

Portable Emergency Sump Pumps - Tidewater Supply Company — 56-821534

Turbine Thrust Bearing Temperature Recorders - Minneapolis-Honeywell Regulator Company — 57-53026

Freight Elevator Capacity Increase - Otis Elevator Company — 57-53294

Mill Temperature Control - Leeds and Northrup Company — 58-57241

Replacement and Additional Thrust Bearing Thermocouples - Thermal Harness Divn — 59-34689

Gas Ducts - Connery Construction Company — 59-34760

Pressure Switches for Lighting-off Oil and Air Failures - Leinart Engineering Company — 59-58032

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Drive Assembly for Cross Flow Air Duct - Republic Flow Meters Company 59-58192
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Scroll Housing and Inlet Box - Drains
Induced Draft Fan
Flexible coupling - Bearings to Cooling Water Pipe 47B10616
Side Wall Stiffening 47B10680
Work Bench for Oil Purification Room 47K10622
Chemical Solution Tanks - Level Indicator Scale 47B10624
Sampling Pail and Trident for Dissolved Oxygen Test 47A10638
Rewind Roll for Republic Flow Recorder 47A10657
Drip Pans
Pulverizer Main Drive 47A10660
Vulcan Wall Blowers 47A10713 and 47B10839
Retractible Soot Blowers 47C10734
Circulating Pump Suction Valves 47B10819
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Surface Condensers - Test Manometer Connections across Water Box 47K10667
Heater Water Level Gages - Additional Valves 47A10690
Deaerator Storage Tanks - Support under 3-Inch Water Column 47A10691
Aspirator 47A10698
Mechanical Controls - Alterations 47A10712
Cross-over Connection between Phosphate Pumps 47C10726
Pulverizer Exhauster Damper Positioner - Location and Linkage 47N10745
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Softened Water Booster Pumps - Packing Leak-off Drain 47B10777
Continuous Blow-down Valve - Extension 47B10786
Sump Drain Screens 47A10787
Forced Draft Ducts - Alterations 47B10793
Amplifier - Relocation 47A10800
Hi-Level By-pass Control - Bracing 47B10802
Ash Hopper Gage Boards - Relocation 47B10817
Soot Blower Relief Valve Vent Extension 47B10850

PIPING - HIGH PRESSURE
High Pressure Steam and Safety Valve Vents
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Units 5-9 47W5400 through 47W5406
Extraction Steam Piping
Units 1-4 47W410 through 47W414
Units 5-9 47W5410 through 47W5414
Desuperheater for Number 1 Extraction Line 47W415 and 47W416
Boiler Feedwater Piping
Units 1-4 47W420 through 47W425
Units 5-9 47W5420 through 47W5426
Condensate Piping
Units 1-4 47W430 through 47W434
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Heater Drains and Vents and Miscellaneous Piping
Units 1-4 47W440 through 47W455
Units 5-9 47W5440 through 47W5458
Miscellaneous Connections to Turbines
Units 1-4 47W460 through 47W463
Units 5-9 47W5460 through 47W5465
Blow-off and Miscellaneous Drains
Units 1-4 47W465 through 47W471
Units 5-9 47W5467 through 47W5474
Principal Piping Systems - National Valve and Manufacturing Company Tv-8206-A
Back Pressure Valves - Tidewater Supply Co C52-15726
Safety Valves - Manning, Maxwell, and Moore, Incorporated C52-15727
Special Valves and Controllers - Leinart Engineering Company C53-23445
Pneumatic Controllers - Leinart Engineering Company C54-20430

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Units 1-9 47W475 through 47W477
TVA Piping 47W585 and 47W586
Units 5-9 47W5475 through 47W5477
Distilled Water Piping
Units 1-4 47W480 and 47W481
Units 5-9 47W5480 and 47W5481
Cooling Water, Gland Seal, and Vacuum Priming
Units 1-4 47W482 through 47W489
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Lighting-off Oil and Air Piping
Units 1-4 47W490 through 47W492
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Connections for Fly Ash Removal in Boiler Dead Air Spaces
Units 1-4 47W493 and 47W494
Units 5-9 47W5493 and 47W5494
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Units 1-4 47W495 through 47W497
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Units 1-4 47W498 and 47W499
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Units 1-4 47W500 through 47W502
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Units 1-4 47W505 through 47W509
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Embedded Piping - El 725.0 Fill Slab
Units 1-4 47W512 through 47W516
Units 5-9 47W5512 through 47W5516
Acid Cleaning System
Units 1-4 47W518
Units 5-9 47W5518
Condenser Water Piping
Units 1-4 47W519
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Units 5-9 47W5558 and 47W5559
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Units 1-4 47W560 through 47W569
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Permanent Bench Marks - Main and Reheat Steam Piping
Units 1-4 47W590
Units 5-9 47W5590
Hydrogen System for Generator Cooling
Units 1-4 47W593 and 47W594
Units 5-9 47W5593 through 47W5595
Automatic Fire Detectors - J. H. Scharff, Incorporated 56-50564-5
Hydrogen Meters - Rockwell Manufacturing Company 56-50564-6
Roof and Floor Sleeves
Units 5-8 47W5572 through 47W5576
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Rubber Expansion Joints
C. D. Genter Company C52-10403 and C52-20725
U. S. Rubber Company C53-18479 and C55-19333
Garlock Packing Company C54-18287
Power Control Valves
Manning, Maxwell, and Moore, Inc C52-11495
I. Burrack, Incorporated C53-22387
Special Valves and Controllers
Leinart Engineering Company C52-15228
Swartwout Company C52-15229 and C53-23446
Fisher Governor Company C52-15230
Valves - Gray-Hodges Corp C52-17407 and C52-17978
Pressure Regulating Valves - Grinnell Co C52-17979
Indicating Flowmeters - New Jersey Meter Company C52-18510
Pressure Reducing Valves - Gray-Hodges Corporation C52-19915
Temperature Control Valve for Service Bay - Manning, Maxwell, and Moore, Inc C52-18568
Temperature-Pressure Control Valves - Spence Engineering Company C52-19916
Temperature Control Valves
Manning, Maxwell, and Moore, Inc C52-19917
Gray-Hodges Corporation C54-17256
Solenoid Valves - I. Burrack, Inc C52-19918
Thermometers - Gray-Hodges Company C52-20585 and C54-16823
Electro-Dryer Units - C. M. Kemp Manufacturing Company C52-20885
Safety Valves - American Radiator and Standard Sanitary Corporation C53-15970
Temperature Regulating Valves
Gray-Hodges Corporation C53-16343
Hajoca Corporation C54-19055
Dual Heat Transfer Coils - Leinart Engineering Company C53-16347
Solenoid-Operated Valves
Leinart Engineering Co C53-21455 and C54-27358
Manhattan Lighting Equipment Company C54-15117
Leinart Engineering Co C55-22292 and 56-50564-3
Hajoca Corporation C55-25653
Air Filters
Jones-Sylar Supply Company C53-22273
Felix J. Commager C54-21123
Pressure Switches
Leinart Engineering Co C53-22277 and 56-50453-5
Leinart Engineering Company 56-50678-4
Control Air Filters and Pads - Dollinger Corporation C53-22278
Extension-Stem Operated Valves
American Radiator and Standard Sanitary Corporation C54-17092
Gray-Hodges Corporation C54-27355
Pressure Reducing Valves and Combination Pressure-Temperature Control Valves - O. C. Keckley Company C54-17259

Filters - Gray-Hodges Corporation C54-21117
Pressure Reducing Relief Valves - Crane Company C54-21119
Differential Pressure Control Switches and Expansion Joints - American Radiator and Standard Sanitary Corporation C54-18128
Cooling Water Control Valves - Rittelmeyer and Company C54-22105
Expansion Joints - American District Steam Company C54-26752 and C55-19081
Low Water Controls - Stokes Electric Co C55-18150
Industrial Thermometers
Mills and Lupton Supply Company C55-18393
Gray-Hodges Corporation C55-25894
Temperature Regulators - Gray-Hodges Corp C55-18696
Combustion Temperature Pressure Control Valves - O. C. Keckley Company C55-18700
Pressure Regulating and Relief Valves - Rittelmeyer and Company C55-19514
Special Sampling Coils - Leinart Engineering Company C55-23895
Temperature Switches - Leinart Engineering Company C55-25893
Motor Operated Valves - Chapman Valve Manufacturing Company 56-50325
Swing Check Valve - Norwalk Valve Co 56-50453-2
Pressure Reducing and Regulating Valves - Grinnell Company 56-50564
Piston Operated Check Valve - Coppus Engineering Corporation 56-50564-1
Pneumatically Actuated Hydrogen Control Valves - Gray-Hodges Corporation 56-50564-2
Manual Air Loading Controls - A. W. Cash Company 56-50564-4
Pressure Transmitters and Gauges - Tidewater Supply Company 56-50678-7
Pressure Control Switches for Fuel Oil Interlocks - Leinart Engineering Co 56-50710-1
Sampling Coils - Dickey Engineering Co 56-50711
Motor Operators for Valves in Ash Sluice Water System
Chapman Valve Manufacturing Company 56-836917
Charles F. Guyon, Incorporated 56-836919
William Powell Company 56-836920
Rotary Discharge Gate Valves - Ducon Co 58-53993
Plug Valves
Leinart Engineering Company 58-57279-4
Grinnell Company 60-40146-3
Boiler Acid Cleaning Valve - Keystone Valve Corporation 58-57338-4
Instrument Control Air Dryers - C. M. Kemp Manufacturing Company 60-35108
Valves, Fittings, Pipe, and Accessories for Fly Ash Reclaiming System - Tate and Roe Incorporated 61-66097-9
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Ash Hoppers
Additional 4-Inch Filling Line 47B10649
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Jones-Sylar Supply Company C52-12734
Hajoca Corporation C53-22983
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Cleveland Heater Company C52-12735
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American Radiator and Standard Sanitary Corporation C52-12736 and C54-21805
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Battery Room Sink - Hajoca Corporation C54-1110
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Chicago Blower Corp	C52-29834 and C54-22053
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Blast Heater - Wesix Electric Heater Co	C52-29317
Steam Convectors and Unit Heaters - Gray-Hodges Corporation	C52-29354
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Barber-Colman Company	C53-15106
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SELECTED DRAWINGS

The following exhibits are representative drawings prepared in connection with the steam plant and appurtenant structures.

EXHIBIT 1

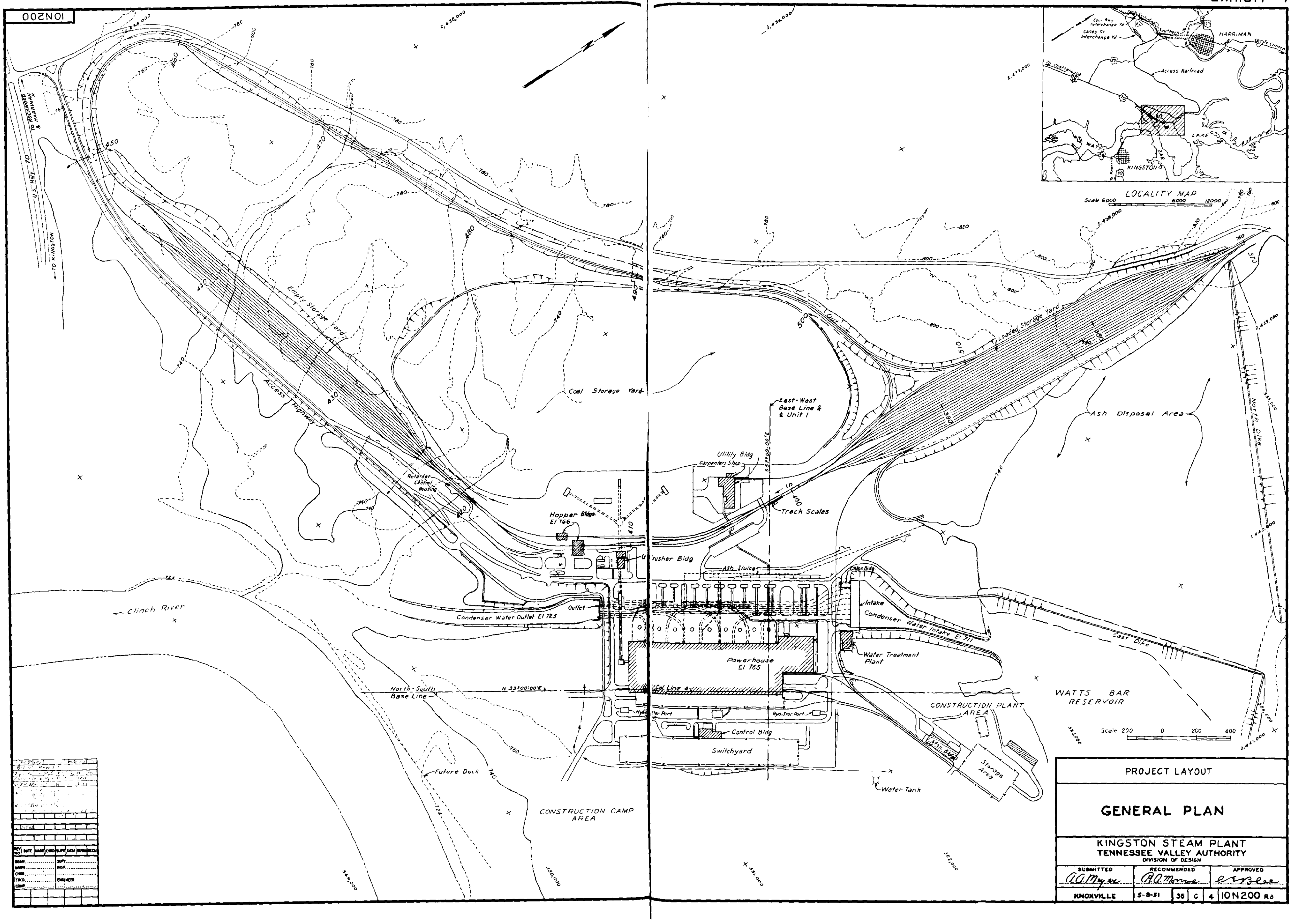

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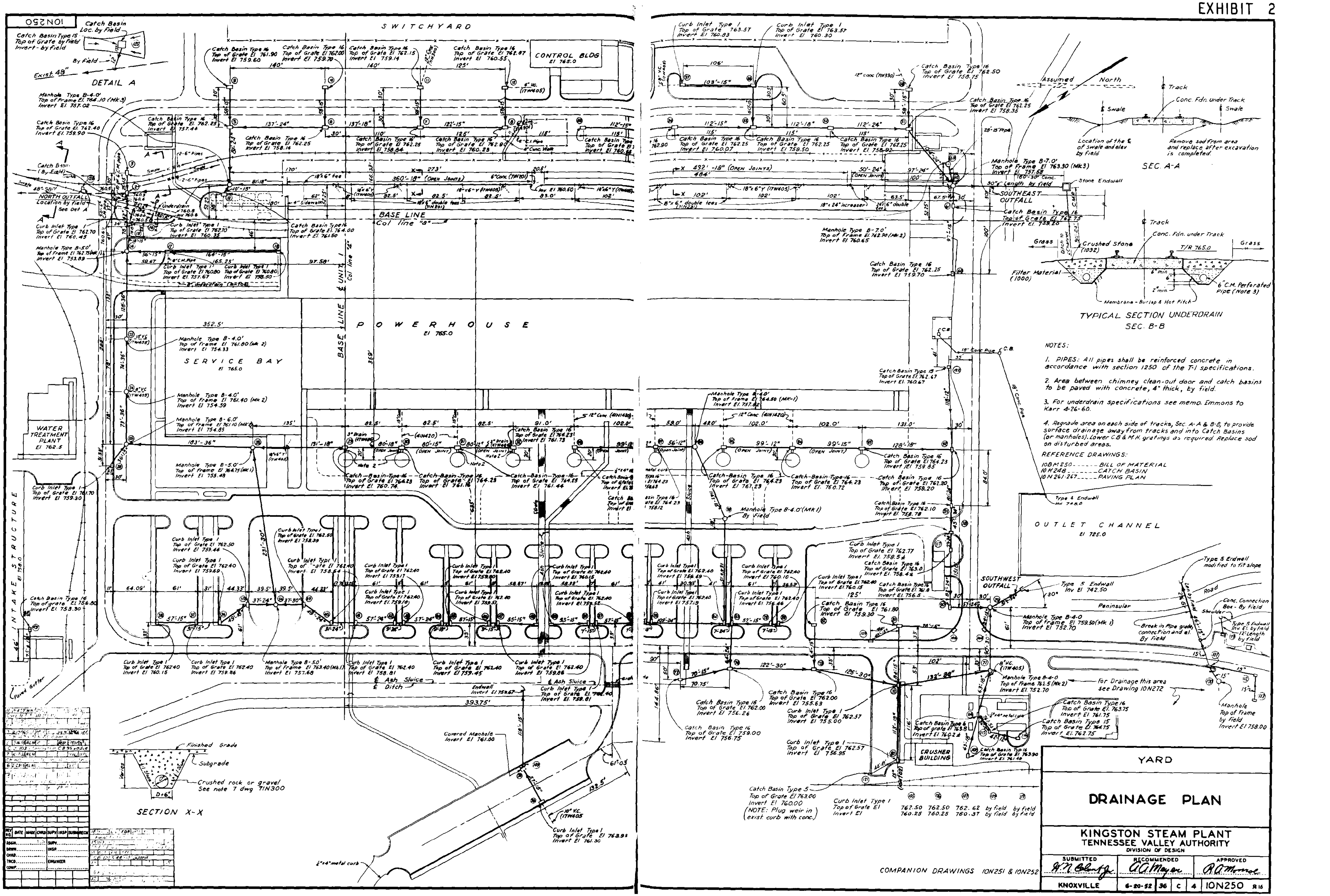
EXHIBIT 2



10N250
SWITCHYARD
CONTROL BLDG
El 765.0
DETAIL A
NORTH OUTFALL
BASE LINE
POWERHOUSE
El 765.0
SERVICE BAY
El 765.0
WATER TREATMENT PLANT
El 762.5
INTAKE STRUCTURE
SOUTHEAST OUTFALL
OUTLET CHANNEL
El 725.0
SOUTHWEST OUTFALL
CRUSHER BUILDING
SEC. A-A
TYPICAL SECTION UNDERDRAIN
SEC. B-B
SECTION X-X
Assumed North
NOTES:
1. PIPES: All pipes shall be reinforced concrete in accordance with section 1250 of the T-1 specifications.
2. Area between chimney clean-out door and catch basins to be paved with concrete, 4" thick, by field.
3. For underdrain specifications see memo. Emmons to Karr 4-26-60.
4. Regrade area on each side of tracks, Sec. A-A & B-B, to provide surface drainage away from tracks and into Catch Basins (or manholes). Lower C.B & M.H. gratings as required. Replace sod on disturbed areas.
REFERENCE DRAWINGS:
10BM250 BILL OF MATERIAL
10H248 CATCH BASIN
10N261, 267 PAVING PLAN
COMPANION DRAWINGS 10N251 & 10N252
YARD
DRAINAGE PLAN
KINGSTON STEAM PLANT
TENNESSEE VALLEY AUTHORITY
DIVISION OF DESIGN
SUBMITTED
RECOMMENDED
APPROVED
KNOXVILLE
6-20-52
36
C
4
10N250
R16

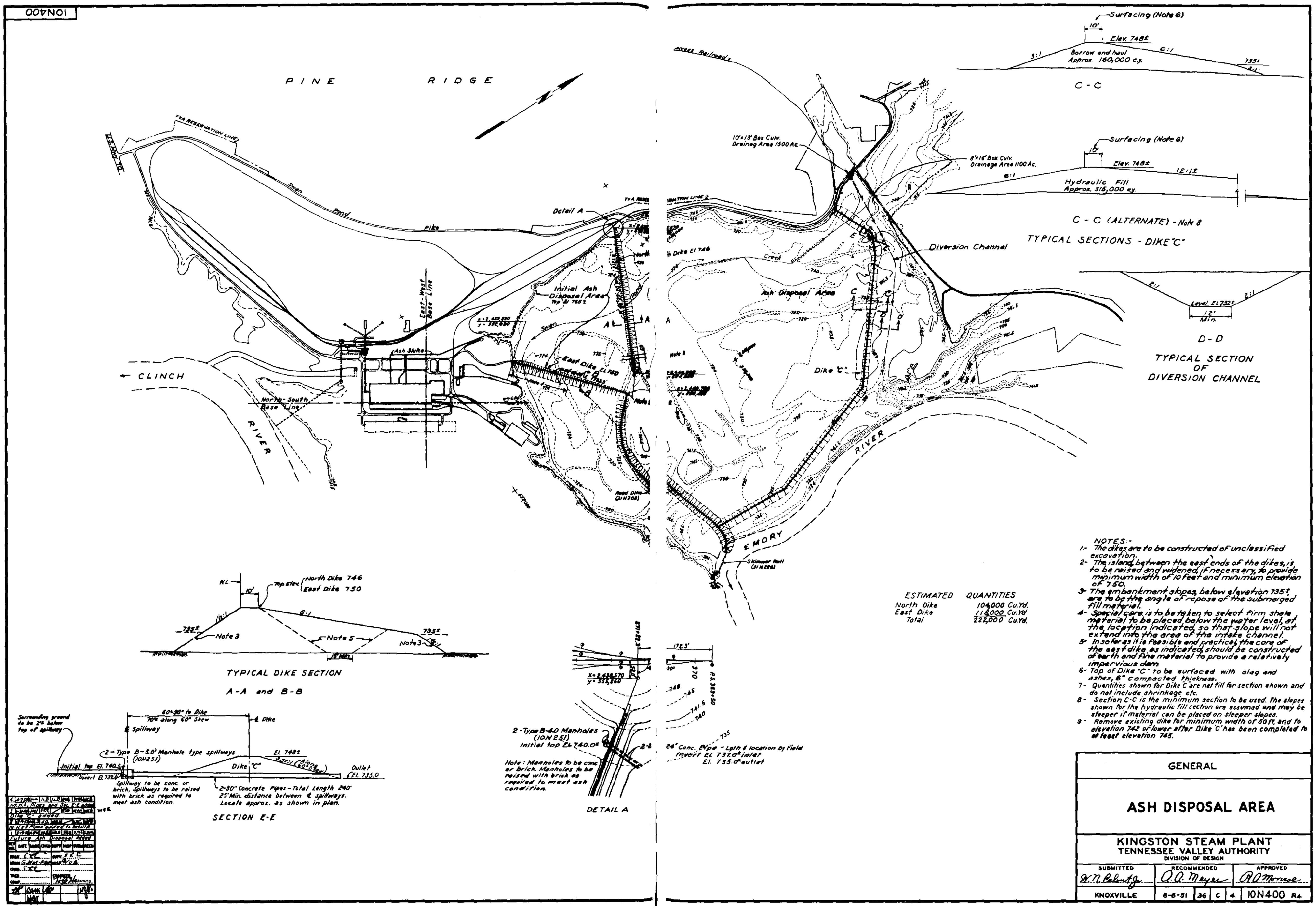
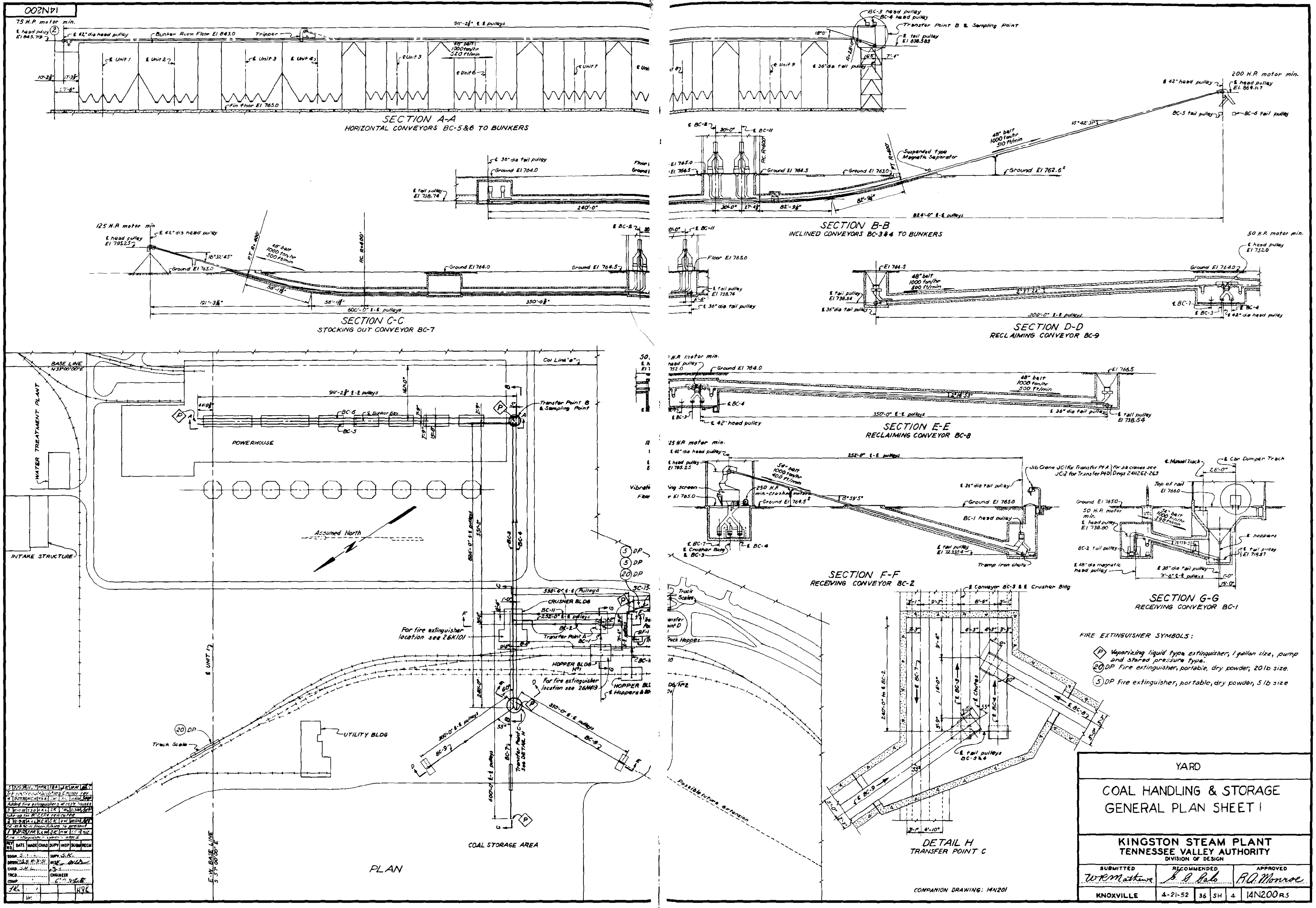
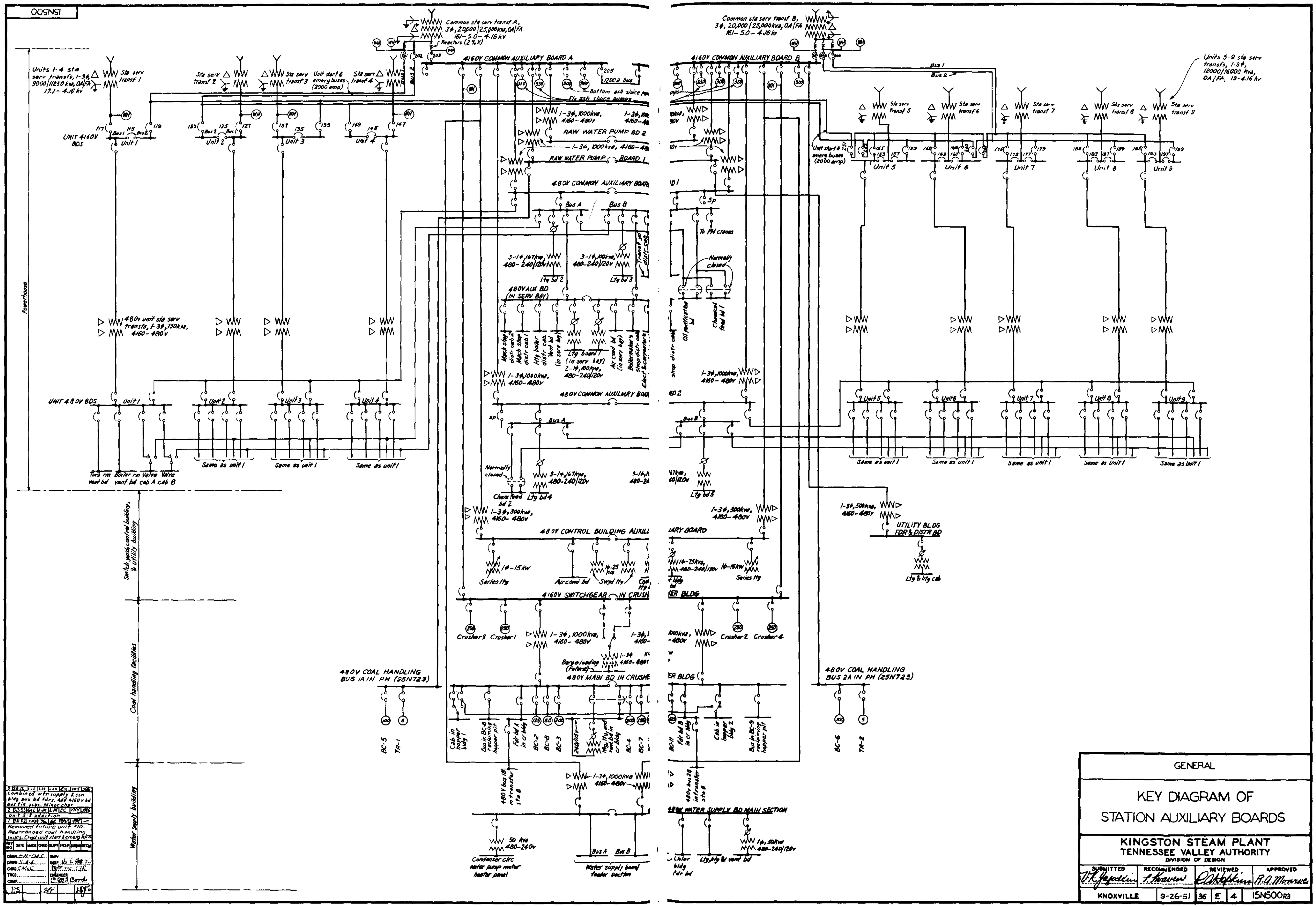

10N400
PINE RIDGE
TVA RESERVATION LINE
Swan Pond Pike
Access Railroad
Detail A
Initial Ash Disposal Area Top El. 765±
East-West Base Line
North-South Base Line
Ash Sluice
East Dike El. 750
North Dike
CLINCH RIVER
EMORY RIVER
Ash Disposal Area
Dike "C"
Diversion Channel
10'x13' Box Culv. Drainag Area 1500 Ac.
8'x16' Box Culv. Drainage Area 1100 Ac.
Skimmer Wall (31N226)
Surfacing (Note 6)
Elev. 748±
Borrow and haul Approx. 160,000 c.y.
C - C
Hydraulic Fill Approx. 315,000 c.y.
C - C (ALTERNATE) - Note 8
TYPICAL SECTIONS - DIKE "C"
Level El. 732±
12' Min.
D - D
TYPICAL SECTION OF DIVERSION CHANNEL
Top Elev. North Dike 746 East Dike 750
Note 3
Note 5
TYPICAL DIKE SECTION
A-A and B-B
60°-90° to Dike
70± along 60° Skew
℄ Spillway
℄ Dike
2 - Type B-5.0' Manhole type spillways (10N251)
Initial top El. 740.5±
Invert El. 737.0±
El. 748±
Dike "C"
Outlet El. 735.0
Spillway to be conc. or brick. Spillways to be raised with brick as required to meet ash condition.
2-30" Concrete Pipes - Total Length 240' 25' Min. distance between ℄ spillways. Locate approx. as shown in plan.
SECTION E-E
2 - Type B-4.0 Manholes (10N251) Initial top El. 740.0±
Note: Manholes to be conc. or brick. Manholes to be raised with brick as required to meet ash condition.
24" Conc. Pipe - Lgth. & location by Field Invert El. 737.0± inlet El. 735.0± outlet
DETAIL A
ESTIMATED QUANTITIES
North Dike 104,000 Cu.Yd.
East Dike 118,000 Cu.Yd.
Total 222,000 Cu.Yd.
NOTES:-
1- The dikes are to be constructed of unclassified excavation.
2- The island between the east ends of the dikes, is to be raised and widened, if necessary, to provide minimum width of 10 feet and minimum elevation of 750.
3- The embankment slopes, below elevation 735±, are to be the angle of repose of the submerged fill material.
4- Special care is to be taken to select firm shale material to be placed below the water level, at the location indicated, so that slope will not extend into the area of the intake channel.
5- Insofar as it is feasible and practical, the core of the east dike as indicated, should be constructed of earth and fine material to provide a relatively impervious dam.
6- Top of Dike "C" to be surfaced with slag and ashes, 6" compacted thickness.
7- Quantities shown for Dike C are net fill for section shown and do not include shrinkage etc.
8- Section C-C is the minimum section to be used. The slopes shown for the hydraulic fill section are assumed and may be steeper if material can be placed on steeper slopes.
9- Remove existing dike for minimum width of 50 ft. and to elevation 742 or lower after Dike C has been completed to at least elevation 745.
GENERAL
ASH DISPOSAL AREA
KINGSTON STEAM PLANT
TENNESSEE VALLEY AUTHORITY
DIVISION OF DESIGN
SUBMITTED
RECOMMENDED
APPROVED
KNOXVILLE
8-8-51
36
C
4
10N400 R4

EXHIBIT 4


14N200
SECTION A-A
HORIZONTAL CONVEYORS BC-5&6 TO BUNKERS
SECTION B-B
INCLINED CONVEYORS BC-3&4 TO BUNKERS
SECTION C-C
STOCKING OUT CONVEYOR BC-7
SECTION D-D
RECLAIMING CONVEYOR BC-9
SECTION E-E
RECLAIMING CONVEYOR BC-8
SECTION F-F
RECEIVING CONVEYOR BC-2
SECTION G-G
RECEIVING CONVEYOR BC-1
DETAIL H
TRANSFER POINT C
PLAN
POWERHOUSE
WATER TREATMENT PLANT
INTAKE STRUCTURE
UTILITY BLDG
COAL STORAGE AREA
CRUSHER BLDG
HOPPER BLDG
Assumed North
FIRE EXTINGUISHER SYMBOLS:
P Vaporizing liquid type extinguisher, 1 gallon size, pump and stored pressure type.
20 DP Fire extinguisher, portable, dry powder, 20 lb size.
5 DP Fire extinguisher, portable, dry powder, 5 lb size
COMPANION DRAWING: 14N201
YARD
COAL HANDLING & STORAGE
GENERAL PLAN SHEET 1
KINGSTON STEAM PLANT
TENNESSEE VALLEY AUTHORITY
DIVISION OF DESIGN
SUBMITTED
RECOMMENDED
APPROVED
KNOXVILLE
4-21-52
14N200 R5


15N500
Common sta serv transf A, 3φ, 20,000 | 25,000 kva, OA/FA 161-5.0-4.16 kv
Reactors (2½% X)
Common sta serv transf B, 3φ, 20,000 | 25,000 kva, OA/FA 161-5.0-4.16 kv
4160V COMMON AUXILIARY BOARD A
4160V COMMON AUXILIARY BOARD B
Units 1-4 sta serv transfs, 1-3φ, 9000 | 11250 kva, OA/FA 17.1-4.16 kv
Units 5-9 sta serv transfs, 1-3φ, 12000 | 16000 kva, OA/FA, 19-4.16 kv
UNIT 4160V BDS
Unit 1
Unit 2
Unit 3
Unit 4
Unit 5
Unit 6
Unit 7
Unit 8
Unit 9
Unit start & emerg buses (2000 amp)
Bottom ash sluice pumps
Fly ash sluice pumps
RAW WATER PUMP BD 2
RAW WATER PUMP BOARD 1
480V COMMON AUXILIARY BOARD 1
Bus A
Bus B
To PH cranes
Normally closed
480V AUX BD (IN SERV BAY)
480V unit sta serv transfs, 1-3φ, 750 kva, 4160-480v
UNIT 480V BDS
Same as unit 1
Turb rm vent bd
Boiler rm vent bd
Valve cab A
Valve cab B
480V COMMON AUXILIARY BOARD 2
Chem feed bd 2
Ltg bd 4
Ltg bd 5
480V CONTROL BUILDING AUXILIARY BOARD
Series ltg
Air cond bd
Swyd ltg
1-3φ, 500 kva, 4160-480v
UTILITY BLDG FDR & DISTR BD
Ltg & htg cab
4160V SWITCHGEAR IN CRUSHER BLDG
Crusher 3
Crusher 1
Crusher 2
Crusher 4
Barge loading (Future)
480V MAIN BD IN CRUSHER BLDG
480V COAL HANDLING BUS 1A IN PH (25N723)
480V COAL HANDLING BUS 2A IN PH (25N723)
BC-5
TR-1
BC-6
TR-2
480V WATER SUPPLY BD MAIN SECTION
Condenser circ water pump motor heater panel
Water supply board feeder section
Chlor bldg fdr bd
Ltg, htg & vent bd
Powerhouse
Switchyards, control building, & utility building
Coal handling facilities
Water supply building
GENERAL
KEY DIAGRAM OF STATION AUXILIARY BOARDS
KINGSTON STEAM PLANT
TENNESSEE VALLEY AUTHORITY
DIVISION OF DESIGN
SUBMITTED
RECOMMENDED
REVIEWED
APPROVED
KNOXVILLE
9-26-51
36
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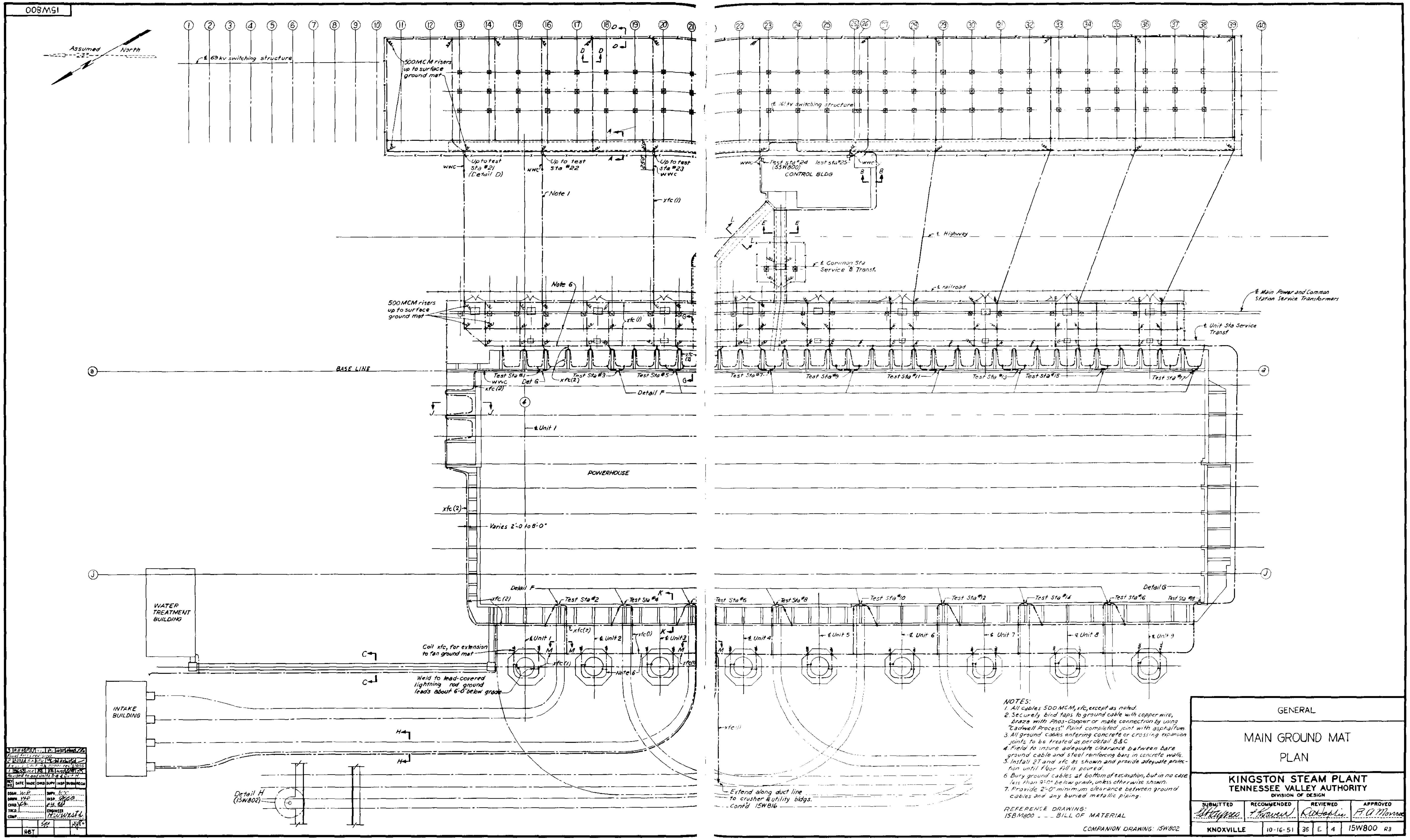
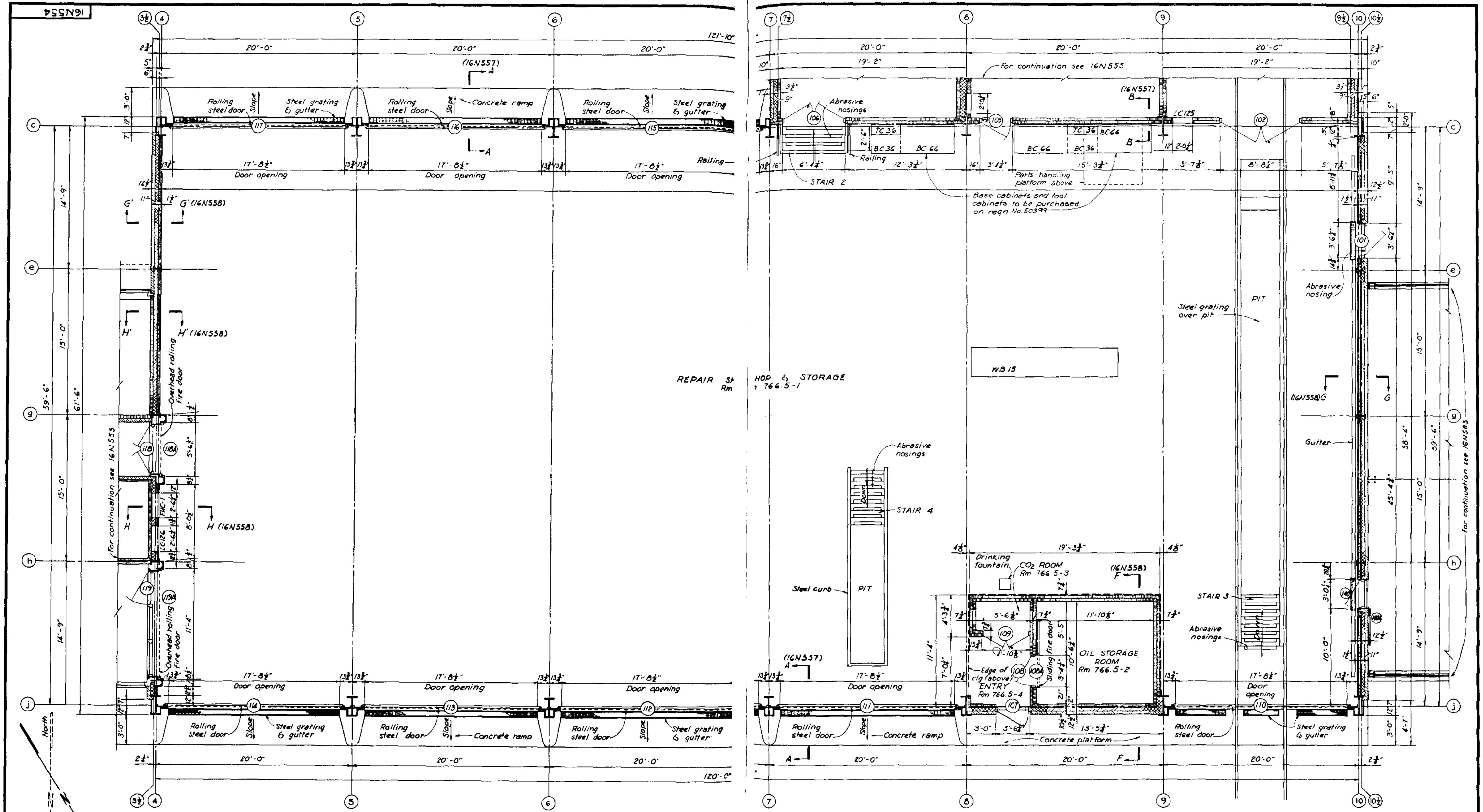
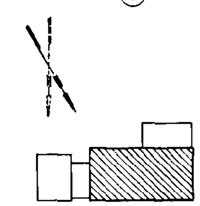

15W800
Assumed North
℄ 69 kv switching structure
500MCM risers up to surface ground mat
℄ 161 kv switching structure
Up to test sta #21 (Detail D)
Up to test sta #22
Up to test sta #23
Test Sta #24 (15W800)
Test Sta #25
CONTROL BLDG
Note 1
℄ Highway
℄ Common Sta Service Transf.
℄ railroad
℄ Main Power and Common Station Service Transformers
℄ Unit Sta Service Transf
Note 6
BASE LINE
Detail F
Detail G
POWERHOUSE
℄ Unit 1
Varies 2'-0 to 8'-0"
WATER TREATMENT BUILDING
INTAKE BUILDING
Coil xfc, for extension to fan ground mat
Weld to lead-covered lightning rod ground leads about 6-0 below grade
Detail H (15W802)
Extend along duct line to crusher & utility bldgs. Cont'd 15W816
NOTES:
1. All cables 500 MCM, xfc, except as noted.
2. Securely bind taps to ground cable with copper wire, braze with Phos-Copper or make connection by using "Cadwell Process." Paint completed joint with asphaltum.
3. All ground cables entering concrete or crossing expansion joints to be treated as per detail B&C
4. Field to insure adequate clearance between bare ground cable and steel reinforcing bars in concrete walls.
5. Install 2T and xfc as shown and provide adequate protection until floor fill is poured.
6. Bury ground cables at bottom of excavation, but in no case less than 9'-0" below grade, unless otherwise shown.
7. Provide 2'-0" minimum clearance between ground cables and any buried metallic piping.
REFERENCE DRAWING:
15BM800 - - - BILL OF MATERIAL
COMPANION DRAWING: 15W802
GENERAL
MAIN GROUND MAT
PLAN
KINGSTON STEAM PLANT
TENNESSEE VALLEY AUTHORITY
DIVISION OF DESIGN
SUBMITTED
RECOMMENDED
REVIEWED
APPROVED
KNOXVILLE
10-16-51
36
E
4
15W800 R3

EXHIBIT 7



ROOM NUMBER	ROOM NAME	FLOOR	BASE	WALLS	SUSP CEILING FINISH	SUSP CEILING ELEV	REMARKS	ROOM NUMBER	ROOM NAME	FLOOR	BASE	WALLS	SUSP CEILING FINISH	SUSP CEILING ELEV	REMARKS
766.5-1	Repair shop & storage	Masterplate	Mstr pl	Facing tile	—	—	Stairs to pits & compr rm cem trds & rsrs—feralun nosings	766.5-14	Assembly & lunch rm	Cem…ent	Cement	Facing tile	—	—	Keenes cem plstr wall & susp clg El 773'-7½" at kitn recesses
766.5-2	Oil storage room	Masterplate	Mstr pl	Facing tile	—	774'-0¾"	Exposed metal roof deck ceiling	766.5-15	Toilet	Terr…azzo	Terrazzo	Glazed tile	S. fin. plstr	774'-10½"	
766.5-3	CO_2 room	Masterplate	Mstr pl	Facing tile	—	774'-0¾"	Exposed metal roof deck ceiling	766.5-16	Locker room / Showers & drying rooms	Terr…azzo	Terrazzo	Glazed tile	S. fin. plstr	774'-0½" / 774'-10½"	N. shower at Clg El 777'-0½"
766.5-4	Entry	Masterplate	Mstr pl	Facing tile	—	774'-0¾"	Exposed metal roof deck ceiling	766.5-17	Toilet	Terr…azzo	Terrazzo	Glazed tile	S. fin. plstr	774'-10½"	
766.5-5	Track mntnce tools	Masterplate	Mstr pl	Facing tile	—	—		766.5-18	Locker room / Showers & drying rooms	Terr…azzo	Terrazzo	Glazed tile	S. fin. plstr	774'-0½" / 774'-10½"	N. shower at Clg El 777'-0½"
766.5-6	Mechanics tools	Cement	Cement	Facing tile & wire mesh	—	—		766.5-19	Vestibule	Cem…ent	Cement	Facing tile & wire mesh	—	—	
766.5-7	Parts storage rm	Cement	Cement	Facing tile & wire mesh	—	—	Stairs - feralun treads & steel risers								
766.5-8	Janitor	Cement	Cement	Facing tile	—	—									
766.5-9	Storage room	Cement	Cement	Facing tile	S. fin. plstr	775'-1½"		764.0-1	Air compressor rm	Cem…ent	—	Facing tile & concrete	—	—	
766.5-10	Raincoat room	Cement	Cement	Facing tile	S. fin. plstr	775'-1½"		774.35-1	Elec. equipment rm	Cem…ent	Cement	Facing tile	—	—	Stair landing - cem fin. floor & base
766.5-11	Foremans room	Cement	Cement	Facing tile & steel panels	S. fin. plstr	775'-1½"		776.17-1	Parts storage rm	Cem…ent	Cement	Facing tile	—	—	Parts handling platform cement float finish
766.5-12	Corridor	Cement		Face brick	S. fin. plstr	775'-1½"	Cem. plaster at marquee soffits								
766.5-13	Passage	Cement		Face Brick	S. fin. plstr	775'-1½"									



KEY PLAN

REV NO.	DATE	MADE	CHKD	SUPV	INSP
3		CRC	MC		
Removed reference to Care Shop					
2		CRC			
Moved Stair 3 added Carpenter shop					
1	1-28-53	OCK	RTC	RTC	
Added note					

DSGN. ____ SUPV. ____
DRWN. TLC INSP. ____
CHKD. ____
TRCD. ____ ENGINEER R.T.Ca
COMP. ____

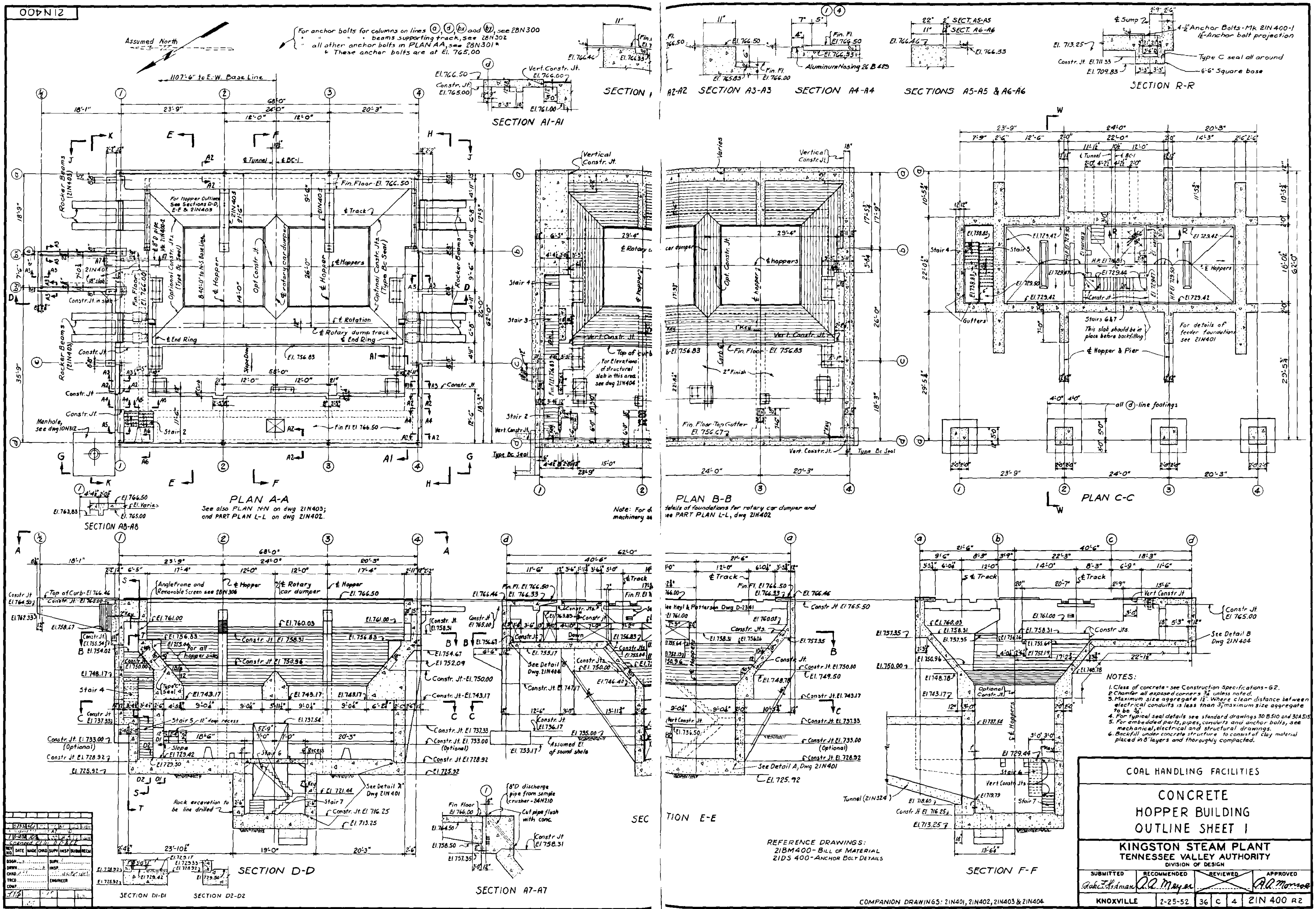
UTILITY BUILDING

ARCHITECTURAL PLAN - EL 766.5

KINGSTON STEAM PLANT
TENNESSEE VALLEY AUTHORITY
DIVISION OF DESIGN

SUBMITTED	RECOMMENDED	APPROVED
H. H. Ostrander	Henry B. Tinner	R. A. Monroe

KNOXVILLE | 6-17-53 | 36 | A | 4 | 16N554 R3


21N400
Assumed North
PLAN A-A
See also PLAN N-N on dwg 21N403; and PART PLAN L-L on dwg 21N402.
SECTION A1-A1
SECTION A2-A2
SECTION A3-A3
SECTION A4-A4
SECTIONS A5-A5 & A6-A6
SECTION R-R
SECTION A8-A8
PLAN B-B
PLAN C-C
SECTION D-D
SECTION D1-D1
SECTION D2-D2
SECTION E-E
SECTION A7-A7
SECTION F-F
NOTES:
1. Class of concrete - see Construction Specifications - G2.
2. Chamfer all exposed corners 3/4" unless noted.
5. For embedded parts, pipes, conduits and anchor bolts, see mechanical, electrical and structural drawings.
6. Backfill under concrete structure to consist of clay material placed in 8" layers and thoroughly compacted.
REFERENCE DRAWINGS:
21BM400 - BILL OF MATERIAL
21DS 400 - ANCHOR BOLT DETAILS
COMPANION DRAWINGS: 21N401, 21N402, 21N403 & 21N404
COAL HANDLING FACILITIES
CONCRETE
HOPPER BUILDING
OUTLINE SHEET 1
KINGSTON STEAM PLANT
TENNESSEE VALLEY AUTHORITY
DIVISION OF DESIGN
SUBMITTED
RECOMMENDED
REVIEWED
APPROVED
KNOXVILLE
2-25-52
21N 400 R2

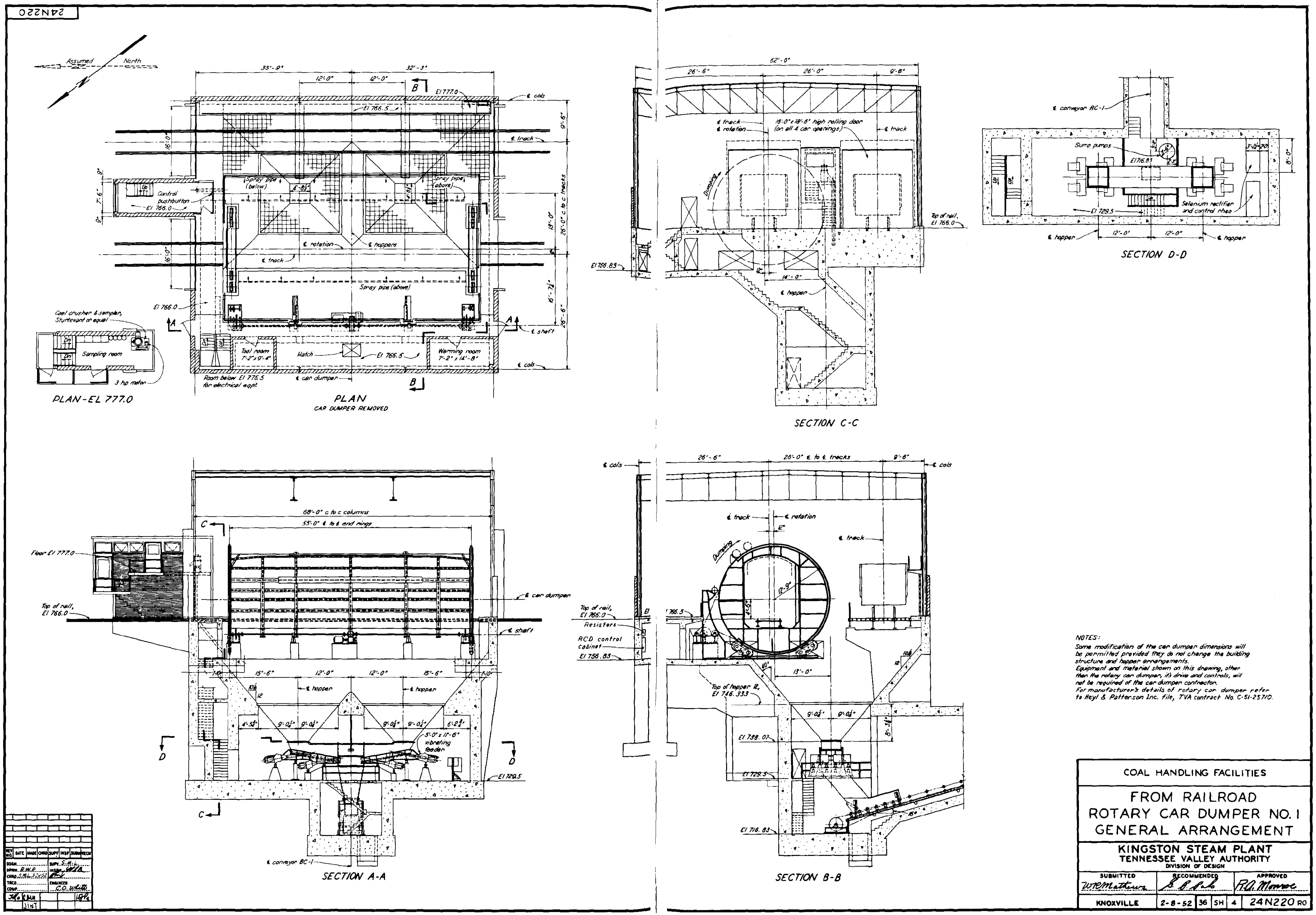
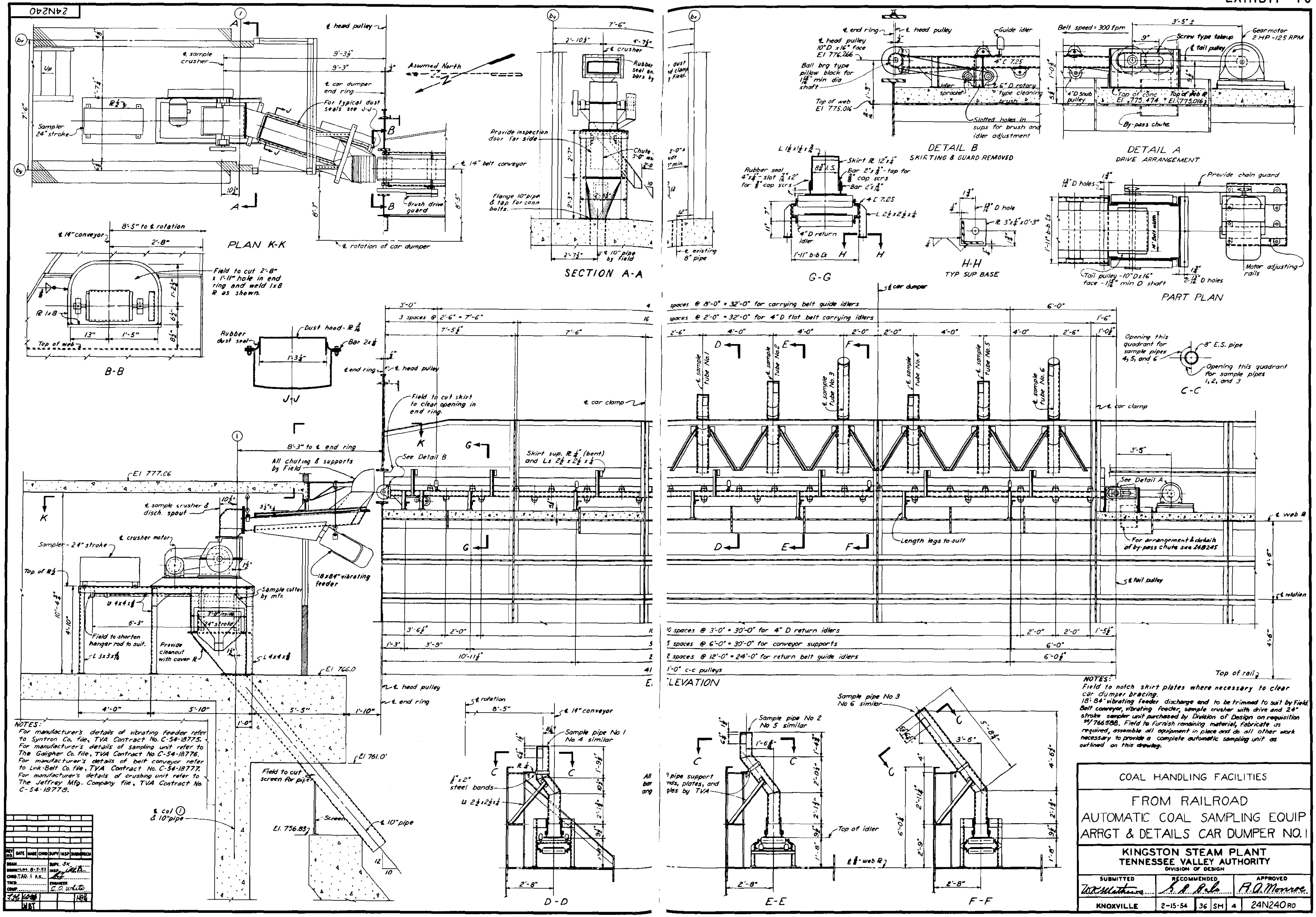
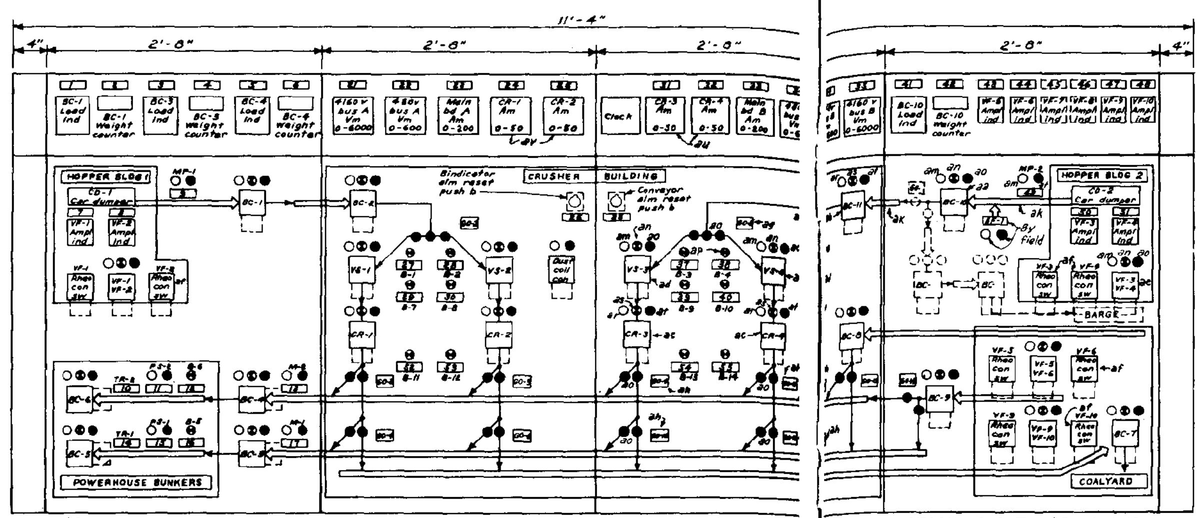

24N220
Assumed North
PLAN
CAR DUMPER REMOVED
PLAN - EL 777.0
Coal crusher & sampler, Sturtevant or equal
Sampling room
3 hp motor
Control pushbutton
El 766.0
El 777.0
El 766.5
Spray pipe (below)
Spray pipe (above)
℄ rotation
℄ hoppers
℄ track
℄ cols
℄ shaft
℄ car dumper
Tool room 7'-2" x 9'-4"
Hatch
Warming room 7'-2" x 14'-8"
Room below El 776.5 for electrical eqpt.
26'-0" c to c tracks
SECTION C-C
16'-0" x 18'-6" high rolling door (on all 4 car openings)
Dumping
Top of rail, El 766.0
El 758.83
℄ hopper
SECTION D-D
℄ conveyor BC-1
Sump pumps
Selenium rectifier and control rheo
El 729.5
El 716.83
℄ hopper
SECTION A-A
68'-0" c to c columns
55'-0" ℄ to ℄ end rings
Floor El 777.0
Top of rail, El 766.0
5'-0" x 11'-6" vibrating feeder
El 729.5
℄ conveyor BC-1
SECTION B-B
26'-0" ℄ to ℄ tracks
Resistors
RCD control cabinet
El 756.83
Top of hopper ℄, El 746.333
El 738.07
El 729.5
El 716.83
NOTES:
Some modification of the car dumper dimensions will be permitted provided they do not change the building structure and hopper arrangements.
Equipment and material shown on this drawing, other than the rotary car dumper, it's drive and controls, will not be required of the car dumper contractor.
For manufacturer's details of rotary car dumper refer to Heyl & Patterson Inc. file, TVA contract No. C-51-25710.
COAL HANDLING FACILITIES
FROM RAILROAD
ROTARY CAR DUMPER NO. 1
GENERAL ARRANGEMENT
KINGSTON STEAM PLANT
TENNESSEE VALLEY AUTHORITY
DIVISION OF DESIGN
SUBMITTED
RECOMMENDED
APPROVED
KNOXVILLE
2-8-52
36
SH
4
24N220 RO

EXHIBIT 10



TVA-00020403

25N750



POWERHOUSE & CAR DUMPING PANEL 1 | CRUSHERS, CR-1 & CR-2 PANEL 2 | CRUSHERS, CR-3 & CR-4 PANEL 3 | STOCKING OUT, RECLAIMING, CAR DUMPING & BARGE LOADING PANEL 4

BENCH

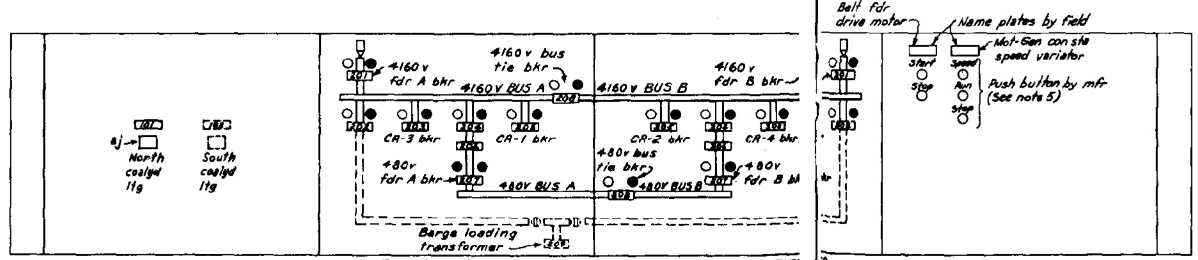
EQUIPMENT DESIGNATIONS

VF-1 - Car dumping vibrating feeder
VF-2 - Car dumping vibrating feeder
BC-1 - Inclined car dumping belt conveyor
BC-3 - Inclined powerhouse belt conveyor
BC-4 - Inclined powerhouse belt conveyor
BC-5 - Horizontal powerhouse belt conveyor
BC-6 - Horizontal powerhouse belt
M-1 - Magnet for BC-3
M-2 - Magnet for BC-4
MP-1 - Magnetic pulley for BC-1
TR-1 - Tripper for BC-5
TR-2 - Tripper for BC-6
PS-1 - Primary sampler for BC-5
PS-2 - Primary sampler for BC-6
B-5 - Bindicator for PS-1 hopper
B-6 - Bindicator for PS-2 hopper

GO-2 - Dividing gate operator for cr's 1 & 2
GO-3 - Gate operator for crusher 1
GO-4 - Gate operator for crusher 1
GO-5 - Gate operator for crusher 2
GO-6 - Gate operator for crusher 2
VS-1 - Vibrating screen above crusher 1
VS-2 - Vibrating screen above crusher 2
CR-1 - Coal crusher 1
CR-2 - Coal crusher 2
BC-2 - Inclined cr's 1 & 2 belt conveyor
B-1 - Bindicator for crusher 1
B-2 - Bindicator for crusher 2
B-7 - Bindicator for crusher 1
B-8 - Bindicator for crusher 2
B-11 - Bindicator for crusher 1
B-12 - Bindicator for crusher 2

GO-8 - Dividing ga[...]te operator for cr's 3 & 4
GO-9 - Gate opera[...]tor for crusher 3
GO-10 - Gate opera[...]tor for crusher 3
GO-11 - Gate opera[...]tor for crusher 4
GO-12 - Gate opera[...]tor for crusher 4
GO-13 - Gate opera[...]tor for BC-8
VS-3 - Vibrating s[...]creen above crusher 3
VS-4 - Vibrating s[...]creen above crusher 4
CR-3 - Coal crush[...]er 3
CR-4 - Coal crush[...]er 4
BC-8 - Inclined re[...]claiming belt conveyor
BC-11 - Inclined cr['s] 3 & 4 belt conveyor
B-3 - Bindicator [...] for crusher 3
B-4 - Bindicator [...] for crusher 4
B-9 - Bindicator f[...]or crusher 3
B-10 - Bindicator f[...]or crusher 4
B-13 - Bindicator f[...]or crusher 3
B-14 - Bindicator f[...]or crusher 4

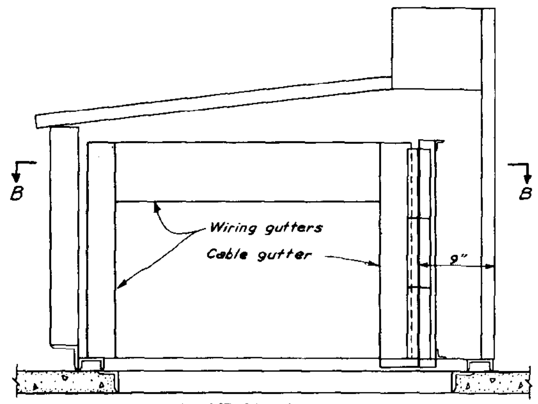
VF-3 - Car dumping vibrating feeder
VF-4 - Car dumping vibrating feeder
VF-5 - Reclaiming vibrating feeder
VF-6 - Reclaiming vibrating feeder
VF-7 - Reclaiming vibrating feeder (Fut)
VF-8 - Reclaiming vibrating feeder (Fut)
VF-9 - Reclaiming vibrating feeder
VF-10 - Reclaiming vibrating feeder
BC-7 - Inclined stocking out belt conveyor
BC-9 - Inclined reclaiming belt conveyor
BC-10 - Inclined car dumping belt conveyor
BC- - (Fut)
BC- - (Fut)
GO-14 - Gate operator for BC-9
GO- - (Fut)
MP-2 - Magnetic pulley for BC-10
BF-1 - Belt feeder 1



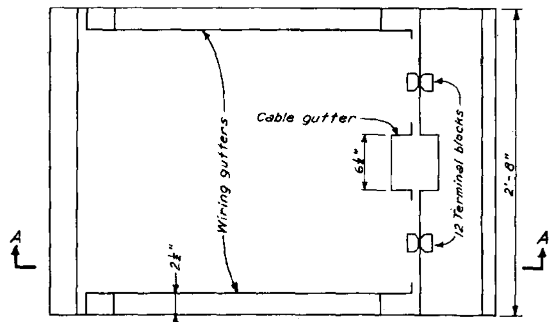
PANEL 1 | BUS & FDR SYSTEM FOR COAL HANDLING FACILITIES PANEL 2 | PANEL 3 | PANEL 4

APRON

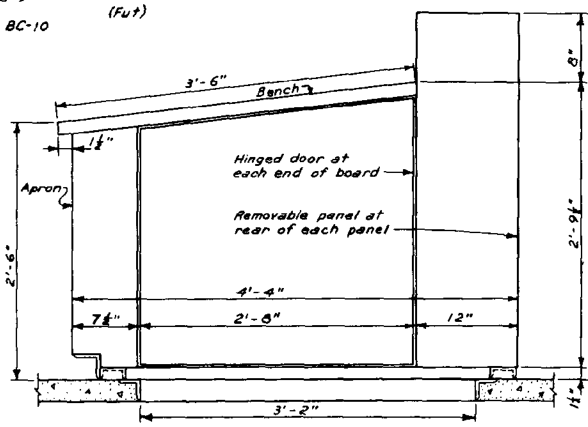
BENCHBOARD



SECTION A-A



SECTION B-B



END ELEVATION

SYMBOLS:
- ○ --- Green indicating light
- ◉ --- White indicating light
- ● --- Red indicating light
- ◉ --- Amber indicating light
- ☐ -- Control switch
- ▭ --- Selector switch

NOTES:
1. Dotted equipment is future.
2. 12-12 point terminal blocks required for each panel.
3. 1-115v a-c bell for conveyor alarm and 1-115v a-c buzzer for bindicator alarm required.
4. Double letters aa, ab, etc, refer to items on Bill of Material 25BM750.
5. Remove pb's from case supplied by mfr & flush mount on apron.

REFERENCE DRAWING:
25BM750 ------- BILL OF MATERIAL

COAL HANDLING FACILITIES
CRUSHER BUILDING

SWITCHBOARDS
COAL HANDLING CON BNCHBD
FRONT ELEVATION

KINGSTON STEAM PLANT
TENNESSEE VALLEY AUTHORITY
DIVISION OF DESIGN

SUBMITTED	RECOMMENDED	REVIEWED	APPROVED
V.K. Yagodkin	S. Kravec	R.A. Hopkins	R.O. Monroe

KNOXVILLE	11-29-51	36	E	4	25N750 R5

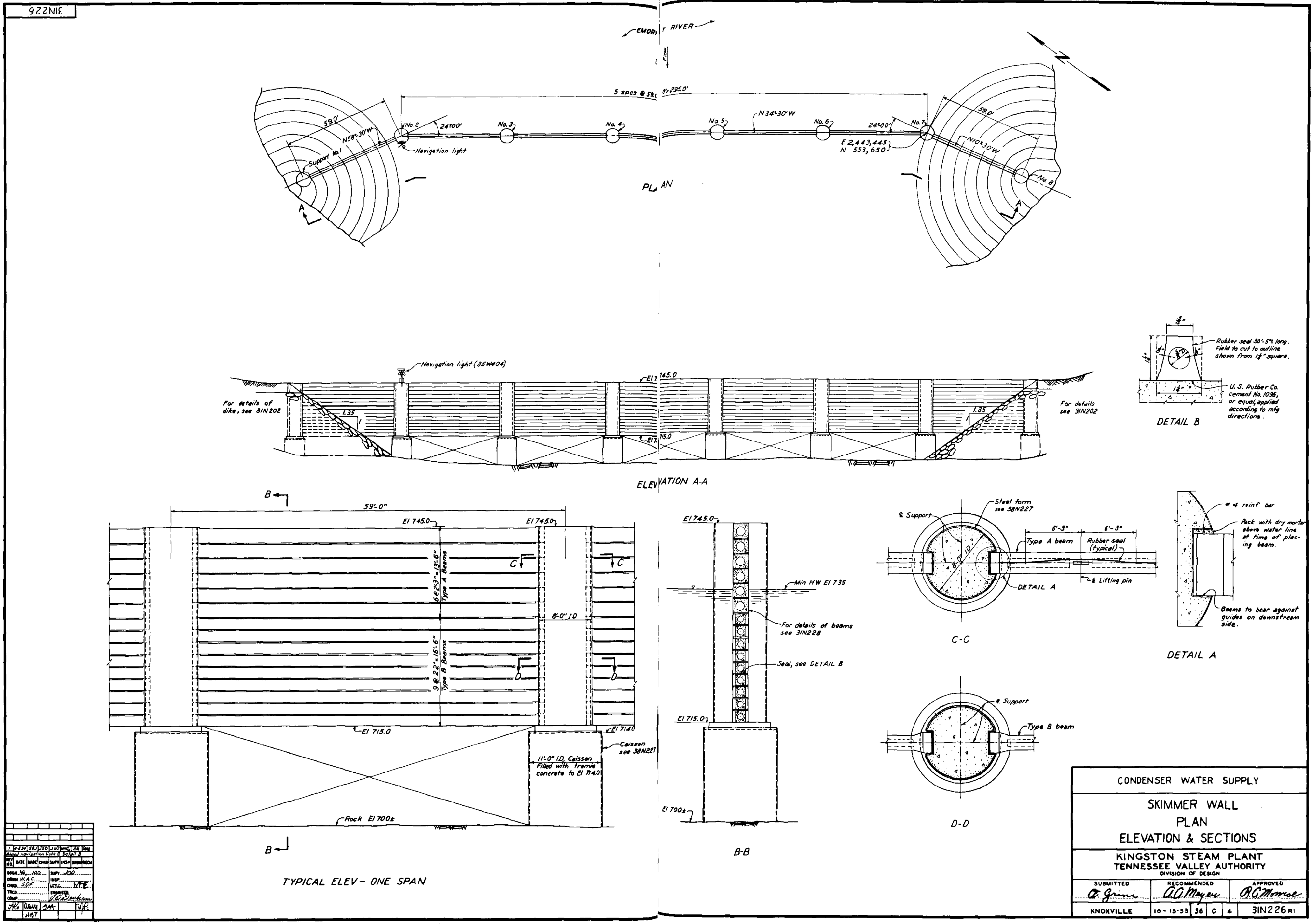
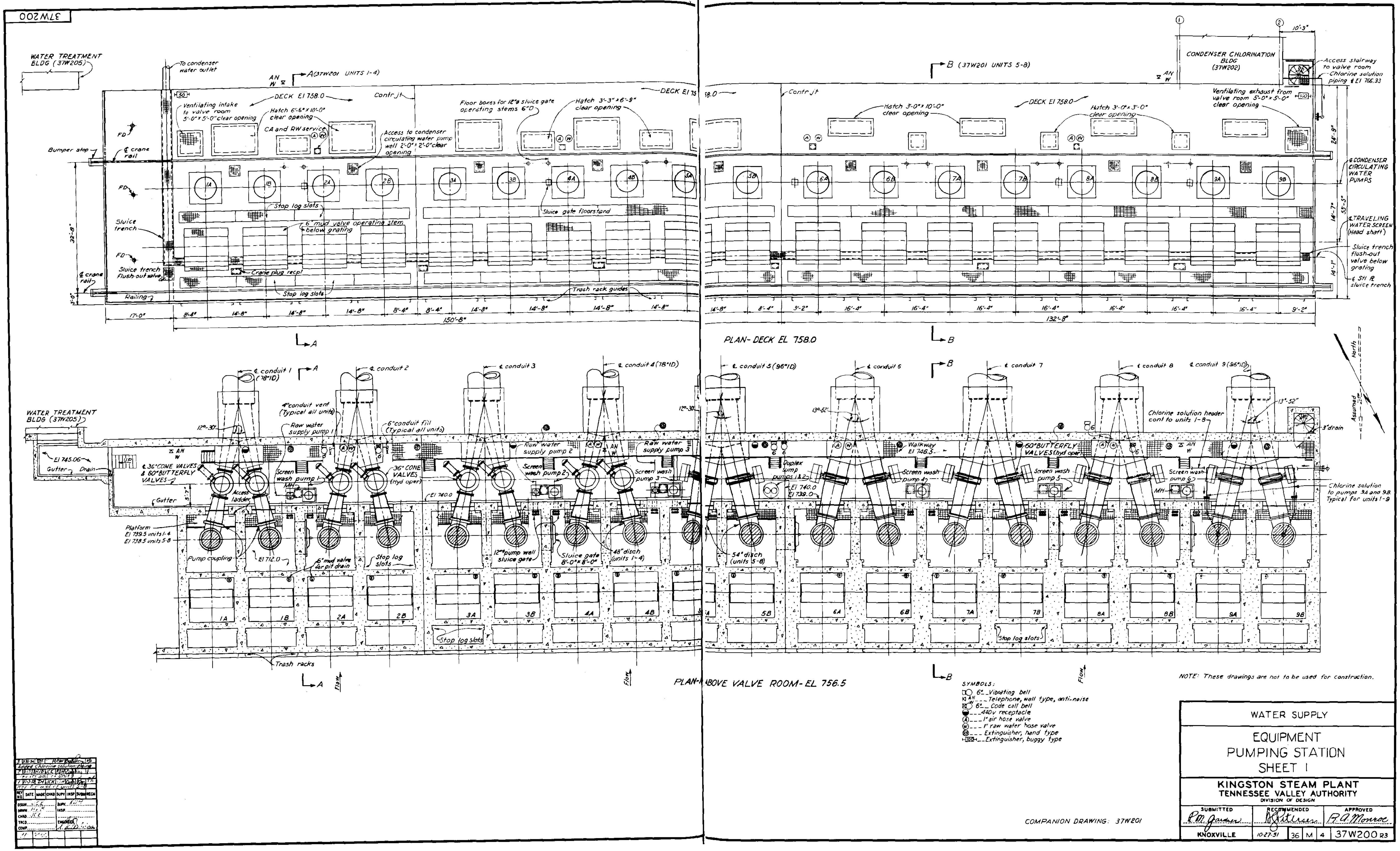
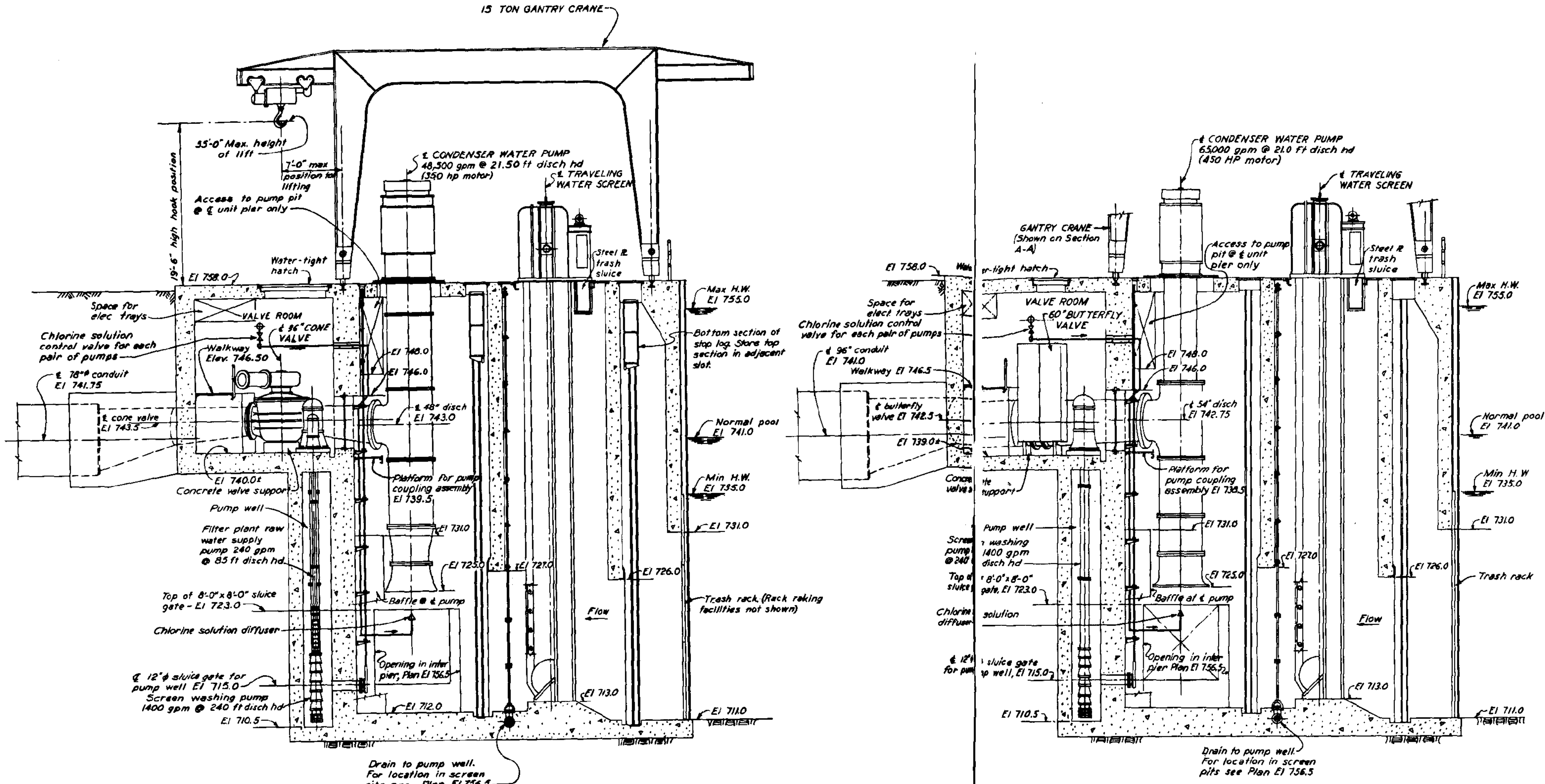

31N226
EMORY RIVER
5 spcs @ 59.0' = 295.0'
Support No. 1
N58°30'W
No. 2
24°00'
Navigation light
No. 3
No. 4
No. 5
N34°30'W
No. 6
No. 7
E 2,443,445
N 553,650
N10°30'W
No. 8
PLAN
Navigation light (35W404)
El 745.0
El 715.0
For details of dike, see 31N202
For details see 31N202
ELEVATION A-A
DETAIL B
Rubber seal 50'-5" long. Field to cut to outline shown from 1¼" square.
U. S. Rubber Co. cement No. 1096, or equal, applied according to mfg directions.
59'-0"
El 745.0
6 @ 2¼" = 13'-6" Type A Beams
9 @ 22" = 16'-6" Type B Beams
8'-0" I.D.
El 715.0
El 714.0
Caisson see 38N227
11'-0" I.D. Caisson Filled with tremie concrete to El 714.0
Rock El 700±
TYPICAL ELEV - ONE SPAN
Min HW El 735
For details of beams see 31N228
Seal, see DETAIL B
El 700±
B-B
Support
Steel form see 38N227
Type A beam
Rubber seal (typical)
6'-3"
DETAIL A
Lifting pin
C-C
Support
Type B beam
D-D
#4 reinf bar
Pack with dry mortar above water line at time of placing beam.
Beams to bear against guides on downstream side.
DETAIL A
CONDENSER WATER SUPPLY
SKIMMER WALL
PLAN
ELEVATION & SECTIONS
KINGSTON STEAM PLANT
TENNESSEE VALLEY AUTHORITY
DIVISION OF DESIGN
SUBMITTED
RECOMMENDED
APPROVED
KNOXVILLE
10-15-53
31N226 R1

EXHIBIT 13

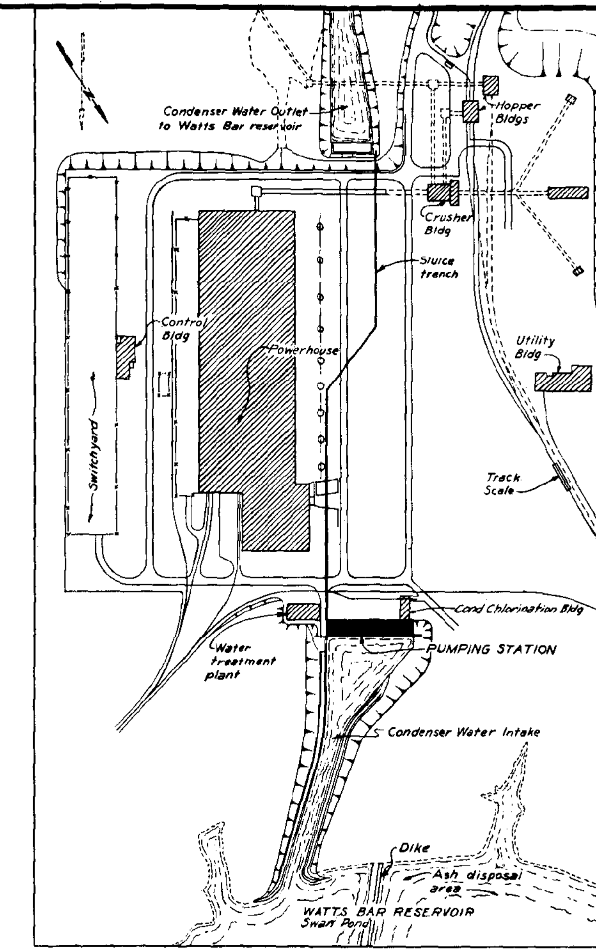

37W200
WATER TREATMENT BLDG (37W205)
To condenser water outlet
DECK El 758.0
Contr jt
Ventilating intake to valve room 5'-0" x 5'-0" clear opening
Hatch 6'-6" x 10'-0" clear opening
CA and RW service
Access to condenser circulating water pump well 2'-0" x 2'-0" clear opening
Floor boxes for 12"φ sluice gate operating stems 6"O
Hatch 3'-3" x 6'-9" clear opening
Hatch 3'-0" x 10'-0" clear opening
Hatch 3'-0" x 3'-0" clear opening
CONDENSER CHLORINATION BLDG (37W202)
Access stairway to valve room
Chlorine solution piping ℄ El 756.33
Ventilating exhaust from valve room 5'-0" x 5'-0" clear opening
Bumper stop
℄ crane rail
Sluice trench
Sluice trench flush-out valve
Stop log slots
6" mud valve operating stem below grating
Sluice gate floorstand
Crane plug recpl
Trash rack guides
Railing
℄ CONDENSER CIRCULATING WATER PUMPS
℄ TRAVELING WATER SCREEN (Head shaft)
Sluice trench flush-out valve below grating
℄ Sll R sluice trench
150'-8"
132'-8"
PLAN- DECK EL 758.0
North
Assumed
℄ conduit 1 (78"ID)
℄ conduit 2
℄ conduit 3
℄ conduit 4 (78"ID)
℄ conduit 5 (96"ID)
℄ conduit 6
℄ conduit 7
℄ conduit 8
℄ conduit 9 (96"ID)
4" conduit vent (Typical all units)
Raw water supply pump 1
6" conduit fill (Typical all units)
36" CONE VALVES & 60" BUTTERFLY VALVES
36" CONE VALVES (hyd oper)
Screen wash pump 1
Access ladder
Gutter
Drain
El 745.06
Platform El 739.5 units 1-4 El 738.5 units 5-8
Pump coupling
El 712.0
6" mud valve for pit drain
Stop log slots
12" pump well sluice gate
Sluice gate 8'-0" x 8'-0"
48" disch (units 1-4)
54" disch (units 5-8)
Raw water supply pump 2
Raw water supply pump 3
Screen wash pump 2
Screen wash pump 3
Duplex sump pumps 1 & 2
El 740.0
El 739.0
Walkway El 746.5
60" BUTTERFLY VALVES (hyd oper)
Screen wash pump 4
Screen wash pump 5
Screen wash pump 6
Chlorine solution header cont to units 1-8
Chlorine solution to pumps 9A and 9B Typical for units 1-9
3" drain
Trash racks
Flow
PLAN- ABOVE VALVE ROOM- EL 756.5
SYMBOLS:
6" Vibrating bell
Telephone, wall type, anti-noise
6" Code call bell
440v receptacle
1" air hose valve
1" raw water hose valve
Extinguisher, hand type
Extinguisher, buggy type
NOTE: These drawings are not to be used for construction.
COMPANION DRAWING: 37W201
WATER SUPPLY
EQUIPMENT
PUMPING STATION
SHEET 1
KINGSTON STEAM PLANT
TENNESSEE VALLEY AUTHORITY
DIVISION OF DESIGN
SUBMITTED
RECOMMENDED
APPROVED
KNOXVILLE
10-27-51
36 M 4
37W200 R3

37W201



SECTION A-A
(UNITS 1-4)

SECTION B-B
(UNITS 5-9)



KEY PLAN

NOTE:
For notes see 37W200.

COMPANION DRAWING: 37W200

WATER SUPPLY

EQUIPMENT
PUMPING STATION
SHEET 2

KINGSTON STEAM PLANT
TENNESSEE VALLEY AUTHORITY
DIVISION OF DESIGN

SUBMITTED	RECOMMENDED	APPROVED
P.M. Gardner	[signature]	R.A. Monroe

KNOXVILLE	10-27-51	36	M	4	37W201 R3

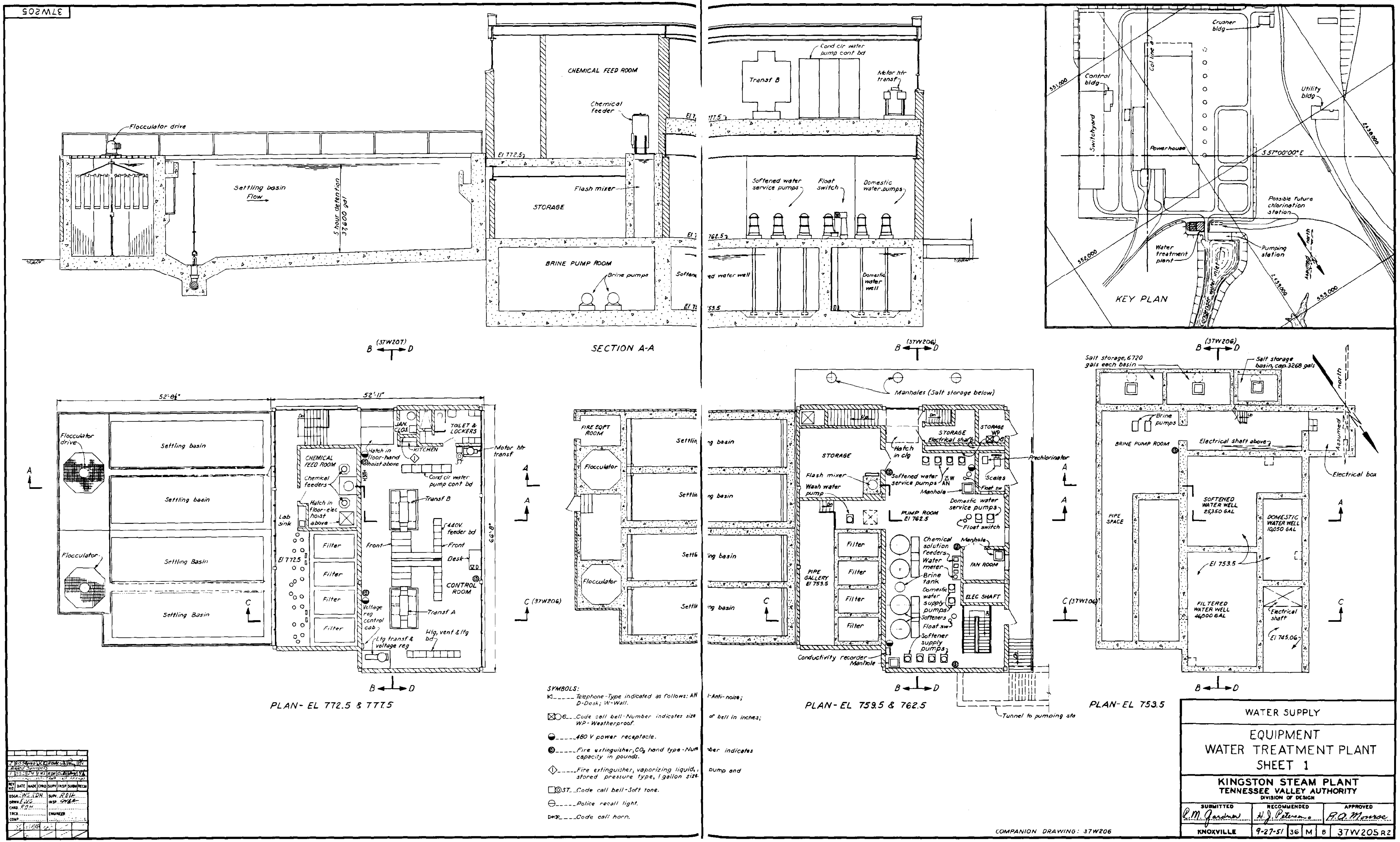
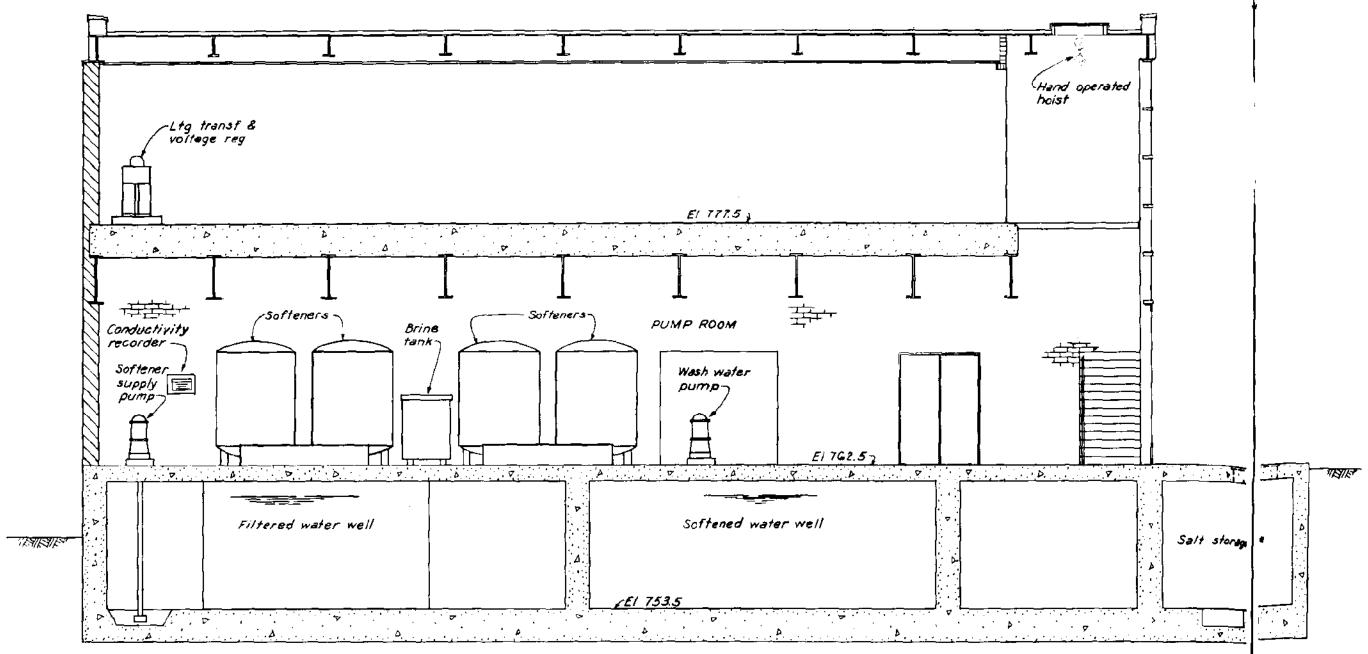
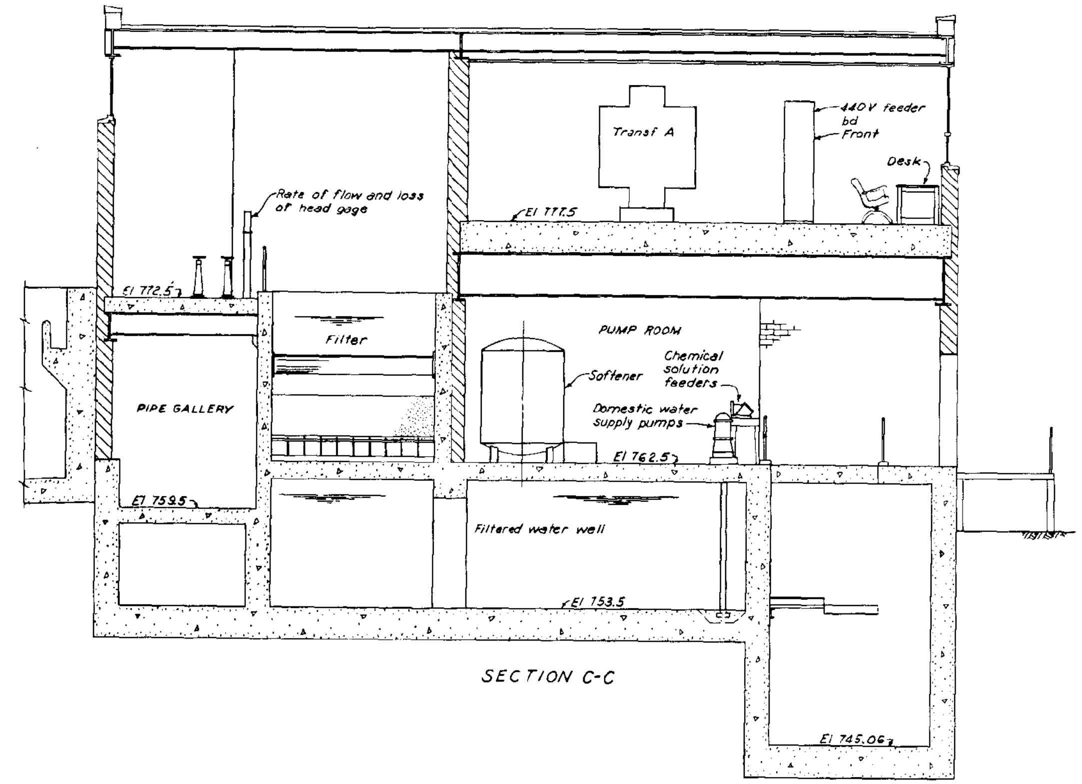

37W205
Flocculator drive
Settling basin
Flow
5 hour detention 37,600 gal
CHEMICAL FEED ROOM
Chemical feeder
El 772.5
Flash mixer
STORAGE
BRINE PUMP ROOM
Brine pumps
Transf B
Cond cir water pump cont bd
Motor htr transf
Softened water service pumps
Float switch
Domestic water pumps
Domestic water well
SECTION A-A
KEY PLAN
Crusher bldg
Control bldg
Utility bldg
Switchyard
Powerhouse
S 57°00'00" E
Possible future chlorination station
Water treatment plant
Pumping station
Assumed north
PLAN- EL 772.5 & 777.5
PLAN- EL 759.5 & 762.5
PLAN- EL 753.5
Settling basin
Flocculator
Filter
CONTROL ROOM
TOILET & LOCKERS
KITCHEN
Transf A
Transf B
440V feeder bd
Lab sink
FIRE EQPT ROOM
Manholes (Salt storage below)
STORAGE
PUMP ROOM El 762.5
PIPE GALLERY El 753.5
Wash water pump
Chemical solution feeders
Water meter
Brine tank
Domestic water supply pumps
Softeners
Softener supply pumps
Conductivity recorder
FAN ROOM
ELEC SHAFT
Prechlorinator
Scales
Tunnel to pumping sta
Salt storage, 6720 gals each basin
Salt storage basin, cap. 3268 gals
Brine pumps
BRINE PUMP ROOM
Electrical shaft above
Electrical box
PIPE SPACE
SOFTENED WATER WELL 25,350 GAL
DOMESTIC WATER WELL 10,050 GAL
El 753.5
FILTERED WATER WELL 46,000 GAL
Electrical shaft
El 745.06
SYMBOLS:
Telephone-Type indicated as follows: AN-Anti-noise; D-Desk; W-Wall.
Code call bell-Number indicates size of bell in inches; WP-Weatherproof.
480 V power receptacle.
Fire extinguisher, CO2 hand type-Number indicates capacity in pounds.
Fire extinguisher, vaporizing liquid, pump and stored pressure type, 1 gallon size.
Code call bell-Soft tone.
Police recall light.
Code call horn.
COMPANION DRAWING: 37W206
WATER SUPPLY
EQUIPMENT
WATER TREATMENT PLANT
SHEET 1
KINGSTON STEAM PLANT
TENNESSEE VALLEY AUTHORITY
DIVISION OF DESIGN
SUBMITTED
RECOMMENDED
APPROVED
KNOXVILLE
9-27-51
36
M
8
37W205 R2

EXHIBIT 16

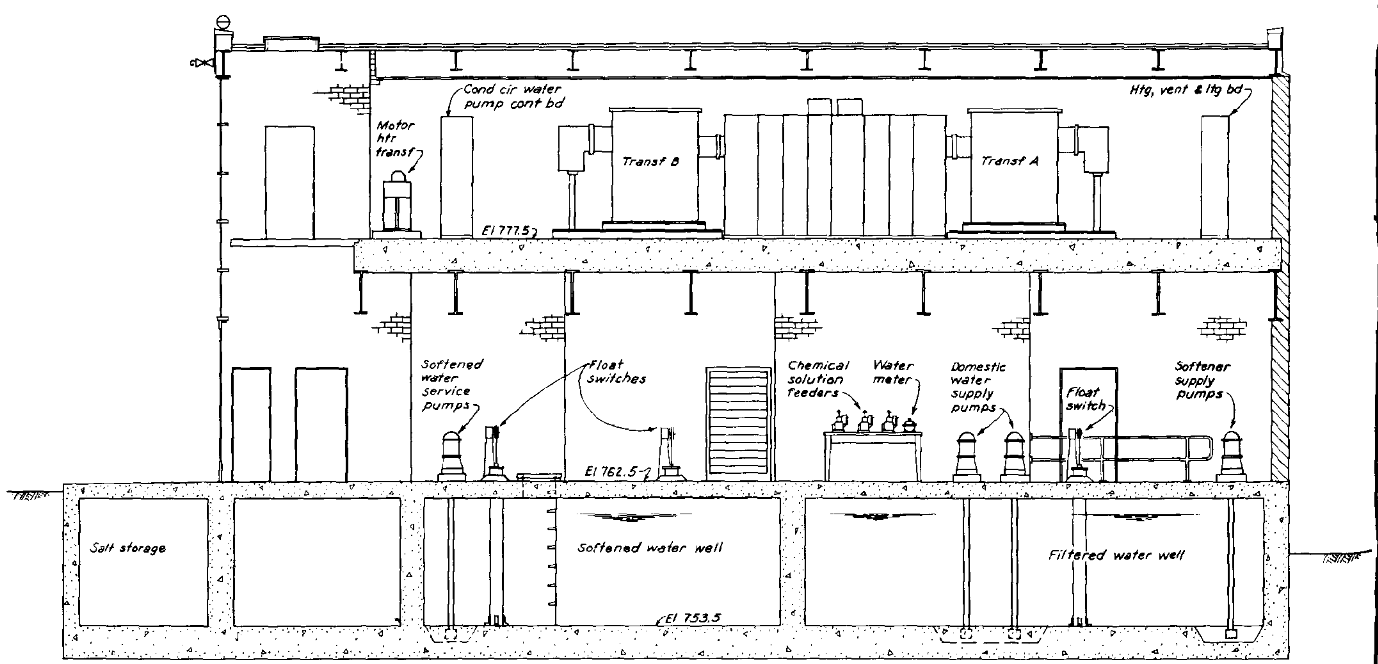
37W206



SECTION B-B



SECTION C-C

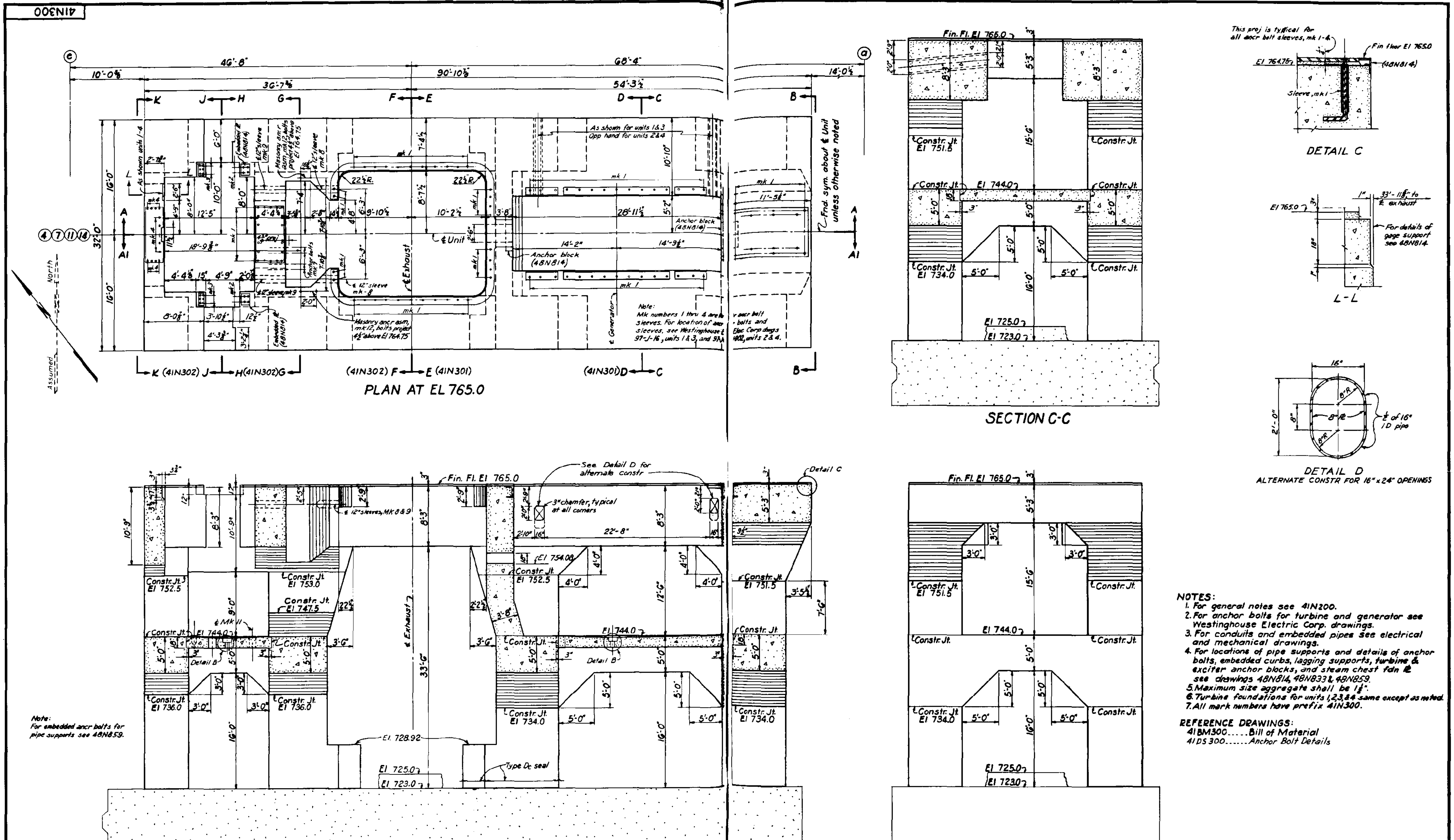


SECTION D-D

COMPANION DRAWING: 37W205

WATER SUPPLY	
EQUIPMENT WATER TREATMENT PLANT SHEET 2	
KINGSTON STEAM PLANT TENNESSEE VALLEY AUTHORITY DIVISION OF DESIGN	
SUBMITTED: R.M. Gardner	RECOMMENDED: H.J. Petersen · APPROVED: R.A. Monroe
KNOXVILLE	9-27-51 · 36 · M · 8 · 37W206 R2

TVA-00020409



NOTES:

1. For general notes see 41N200.
2. For anchor bolts for turbine and generator see Westinghouse Electric Corp. drawings.
3. For conduits and embedded pipes see electrical and mechanical drawings.
4. For locations of pipe supports and details of anchor bolts, embedded curbs, lagging supports, turbine & exciter anchor blocks, and steam chest fdn ℞ see drawings 48N814, 48N833 & 48N859.
5. Maximum size aggregate shall be 1½".
6. Turbine foundations for units 1,2,3,&4 same except as noted.
7. All mark numbers have prefix 41N300.

REFERENCE DRAWINGS:

41BM300.....Bill of Material
41DS300......Anchor Bolt Details

COMPANION DRAWINGS 41N301 & 41N302

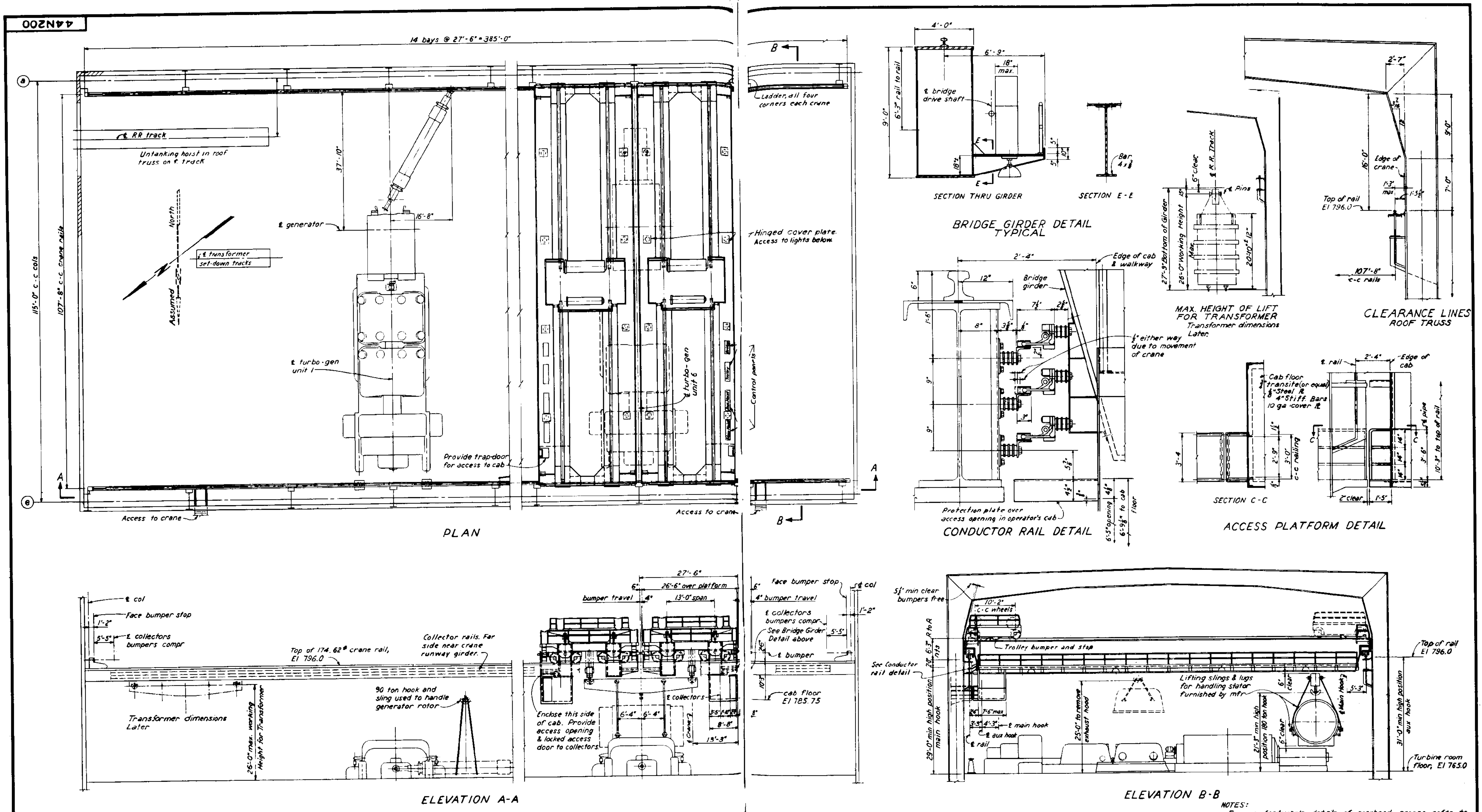
POWERHOUSE SUBSTRUCTURE
UNITS 1,2,3 & 4

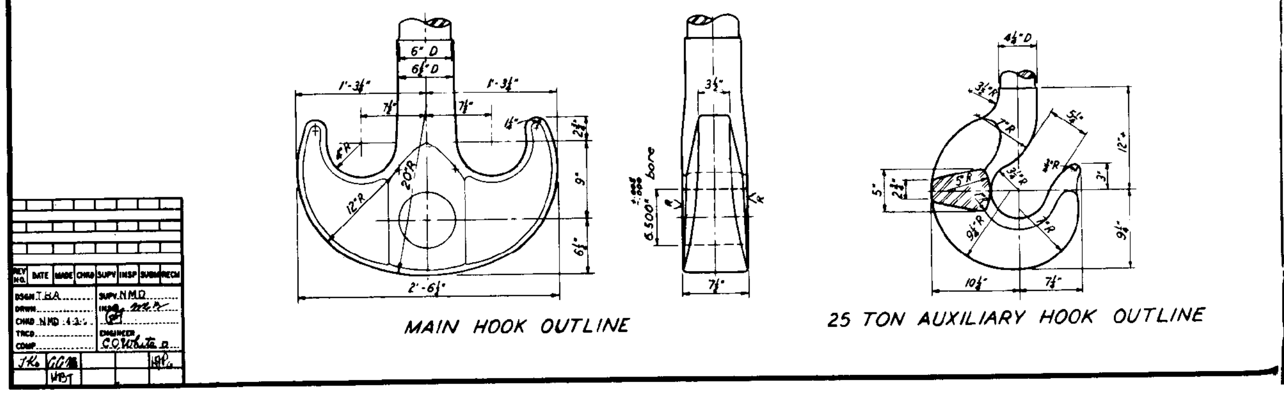
CONCRETE
TURBINE FOUNDATION
OUTLINE-SHEET 1

KINGSTON STEAM PLANT
TENNESSEE VALLEY AUTHORITY
DIVISION OF DESIGN

SUBMITTED	RECOMMENDED	APPROVED
A. Grissi	A.A. Meyer	R.A. Monroe

KNOXVILLE	2-25-52	36	C	4	41N300R6





NOTES:
For manufacturer's details of overhead cranes refer to Cyclops Iron Works file, TVA Contract No. C-51-27122.

MAIN EQUIPMENT HANDLED BY CRANE:

Turbine:
H.P. cylinder cover ...... 52,000#
I.P. cylinder cover ...... 63,000#
L.P. cylinder cover ...... 50,000#
L.P. blade ring ...... 33,000#
H.P. rotor ...... 16,500#
I.P. rotor ...... 45,000#
L.P. rotor ...... 33,000#
Exhaust chamber base ...... 85,000#

Generator:
Rotor ...... 105,000#
Stator-Frame ctr sect. ...... 343,000#
Stator-ctr sect & 2 end sects 393,000# vert lift only
Main transformer no oil ... 345,000# } ±10%
Main transformer untanking ... 32,000 }

CAPACITIES & SPEEDS - PER CRANE

Main hoist.
Max lift ...... 62'-0"
Rated capacity at hook ...... 180,000#
Tested load at hook ...... 225,000#
Hoisting speed ...... 4 to 6 FPM
Motor (min size) ...... 40 hp, 900 RPM, syn speed

Aux hoist:
Max lift ...... 70'-0"
Rated capacity at hook ...... 50,000#
Tested load at hook ...... 64,000#
Hoisting speed ...... 20 to 30 FPM
Motor (min size) ...... 40 hp, 900 RPM, syn speed

Bridge travel speed ...... 100 to 120 FPM
Bridge travel motor (min size) ... 2-30 hp, 900 RPM, syn speed

Trolley travel speed ...... 25 to 35 FPM
Trolley travel motor (min size) 10 hp, gearmotor 280± RPM full load

All truck wheels - 27" min tread diameter

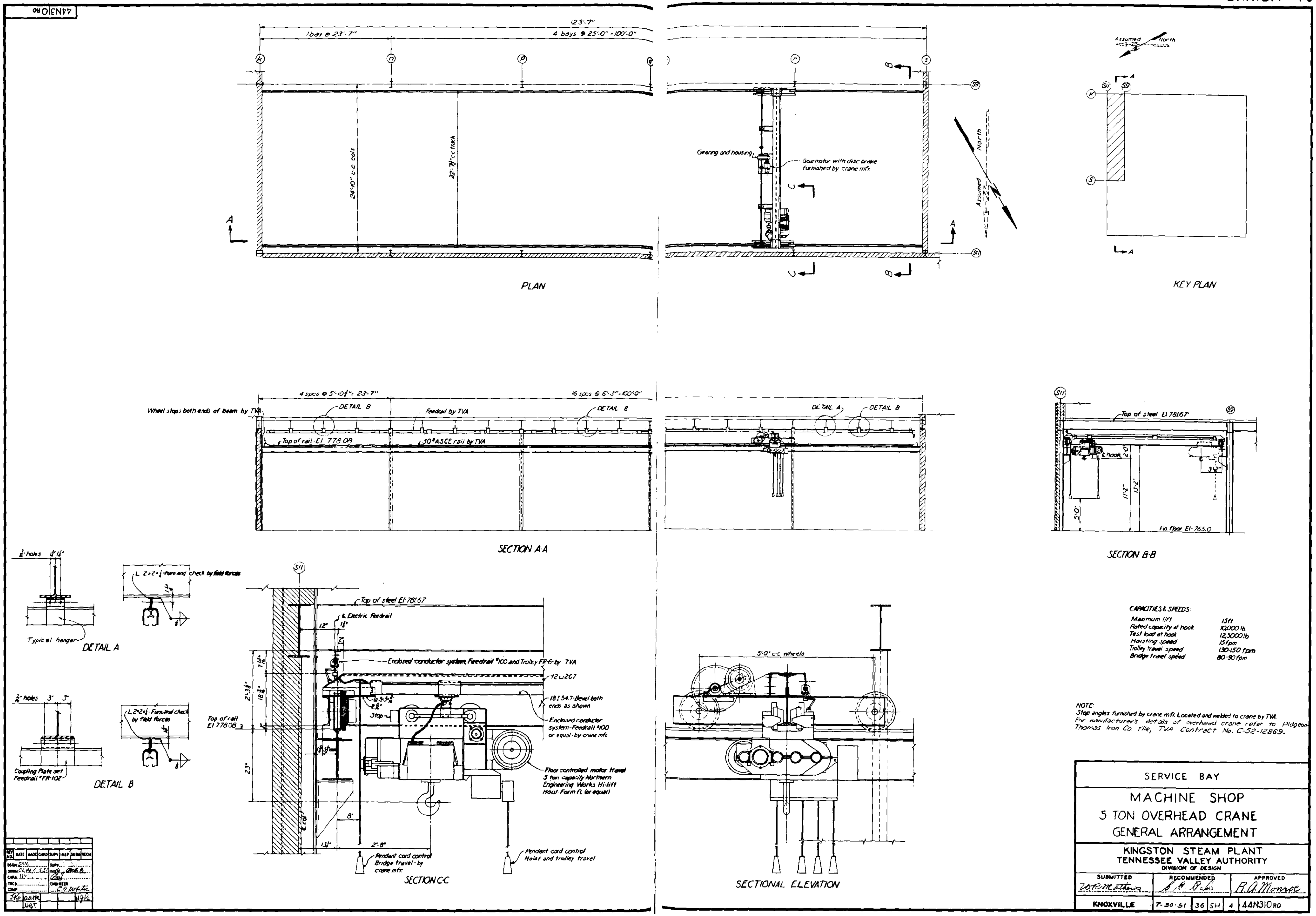
POWERHOUSE

TURBINE ROOM OVERHEAD CRANES ARRANGEMENT

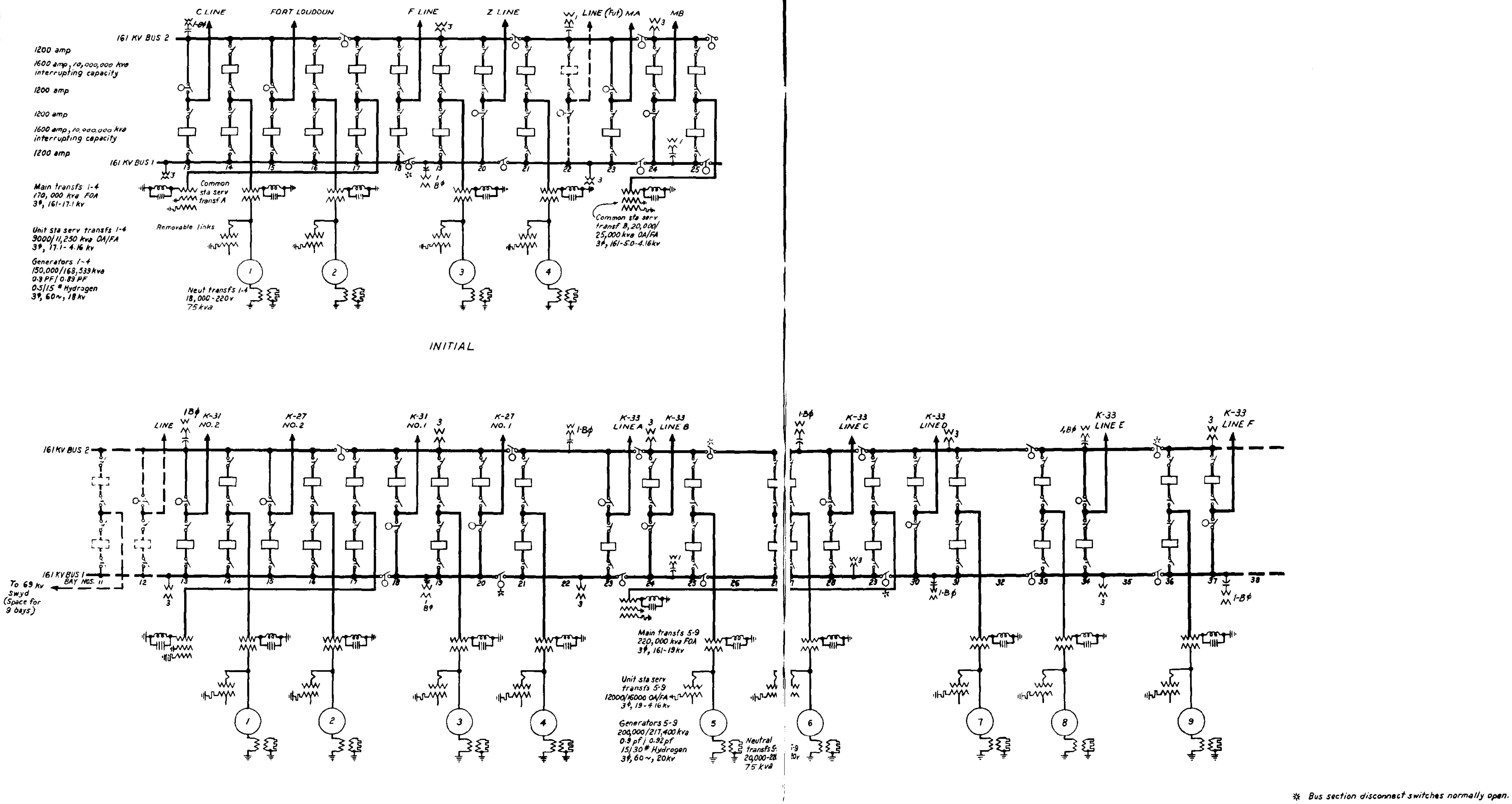
KINGSTON STEAM PLANT
TENNESSEE VALLEY AUTHORITY
DIVISION OF DESIGN

SUBMITTED	RECOMMENDED	APPROVED
[signature]	[signature]	R.O. Monroe

KNOXVILLE | 4-3-51 | 36 | SH | 4 | 44N200 R0


44N310 R0
123'-7"
1 bay @ 23'-7"
4 bays @ 25'-0" = 100'-0"
24'-10" c-c cols
22'-7½" c-c track
Gearing and housing
Gearmotor with disc brake furnished by crane mfr.
Assumed North
PLAN
KEY PLAN
4 spcs @ 5'-10¾" = 23'-7"
16 spcs @ 6'-3" = 100'-0"
Wheel stops both ends of beam by TVA
DETAIL B
Feedrail by TVA
DETAIL A
Top of rail - El 778.08
30# ASCE rail by TVA
SECTION A-A
Top of steel El 781.67
Fin floor El 765.0
SECTION B-B
DETAIL A
Typical hanger
DETAIL B
Coupling Plate set Feedrail # FR-102
Top of steel El 781.67
Electric Feedrail
Enclosed conductor system, Feedrail #100 and Trolley FR-6 by TVA
12 ⊔ 20.7
18 I 54.7 - Bevel both ends as shown
Enclosed conductor system - Feedrail #100 or equal - by crane mfr.
Top of rail El 778.08
Stop
Floor controlled motor travel 5 ton capacity Northern Engineering Works Hi-lift Hoist Form FL (or equal)
Pendant cord control Bridge travel - by crane mfr.
Pendant cord control Hoist and trolley travel
SECTION C-C
5'-0" c-c wheels
SECTIONAL ELEVATION
CAPACITIES & SPEEDS:
Maximum lift 15ft
Rated capacity at hook 10,000 lb.
Test load at hook 12,5000 lb
Hoisting speed 15 fpm
Trolley travel speed 130-150 fpm
Bridge travel speed 80-90 fpm
NOTE:
Stop angles furnished by crane mfr. Located and welded to crane by TVA.
For manufacturer's details of overhead crane refer to Pidgeon-Thomas Iron Co. file, TVA Contract No. C-52-12869.
SERVICE BAY
MACHINE SHOP
5 TON OVERHEAD CRANE
GENERAL ARRANGEMENT
KINGSTON STEAM PLANT
TENNESSEE VALLEY AUTHORITY
DIVISION OF DESIGN
SUBMITTED
RECOMMENDED
APPROVED
R.A. Monroe
KNOXVILLE
7-30-51
36 SH 4
44N310 R0

45N500



STATION No. 135

POWERHOUSE

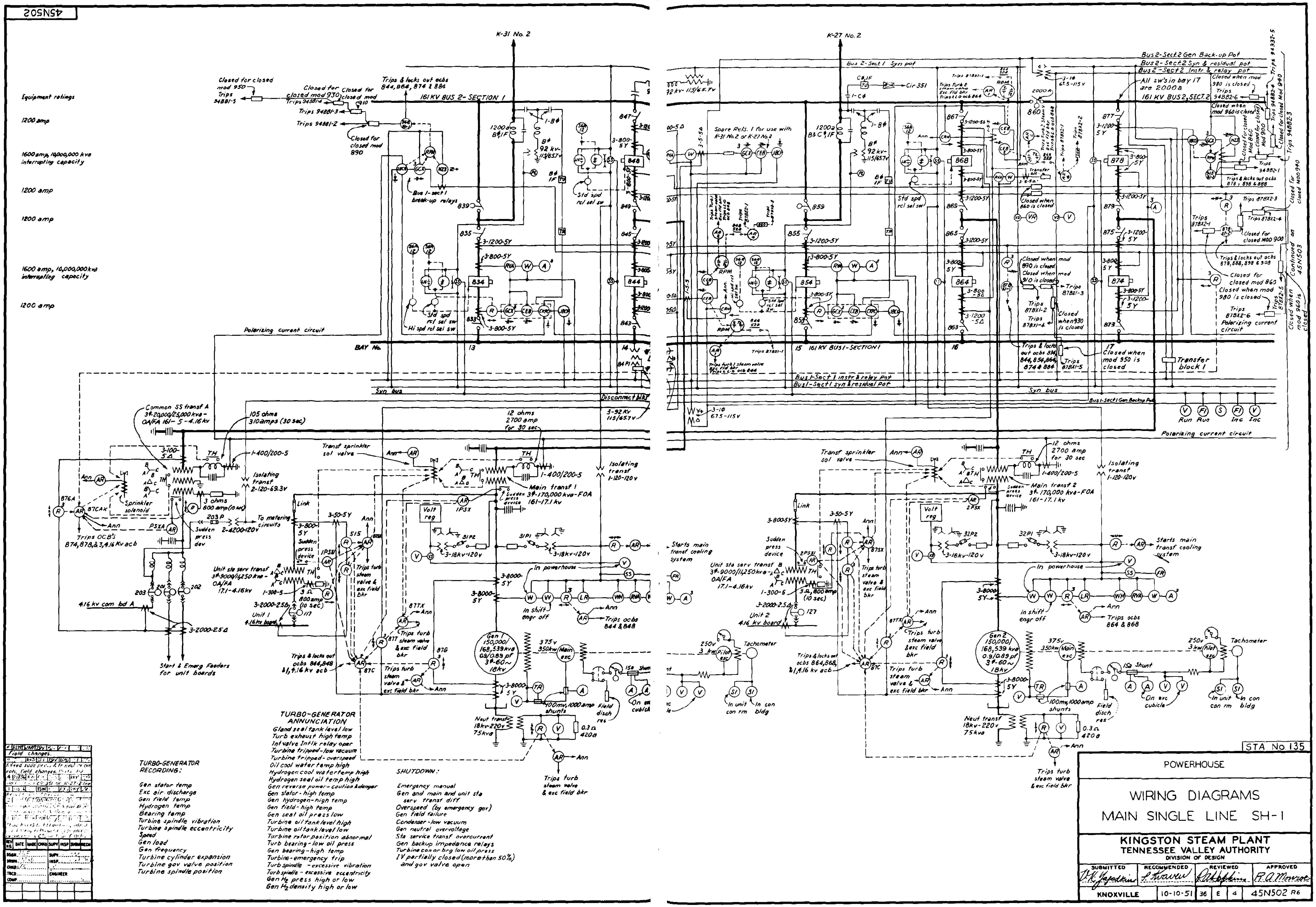
WIRING DIAGRAMS
DEVELOPMENT SINGLE LINE

KINGSTON STEAM PLANT
TENNESSEE VALLEY AUTHORITY
DIVISION OF DESIGN

SUBMITTED	RECOMMENDED	REVIEWED	APPROVED
KNOXVILLE	7-12-51	36 E 4	45N500R7

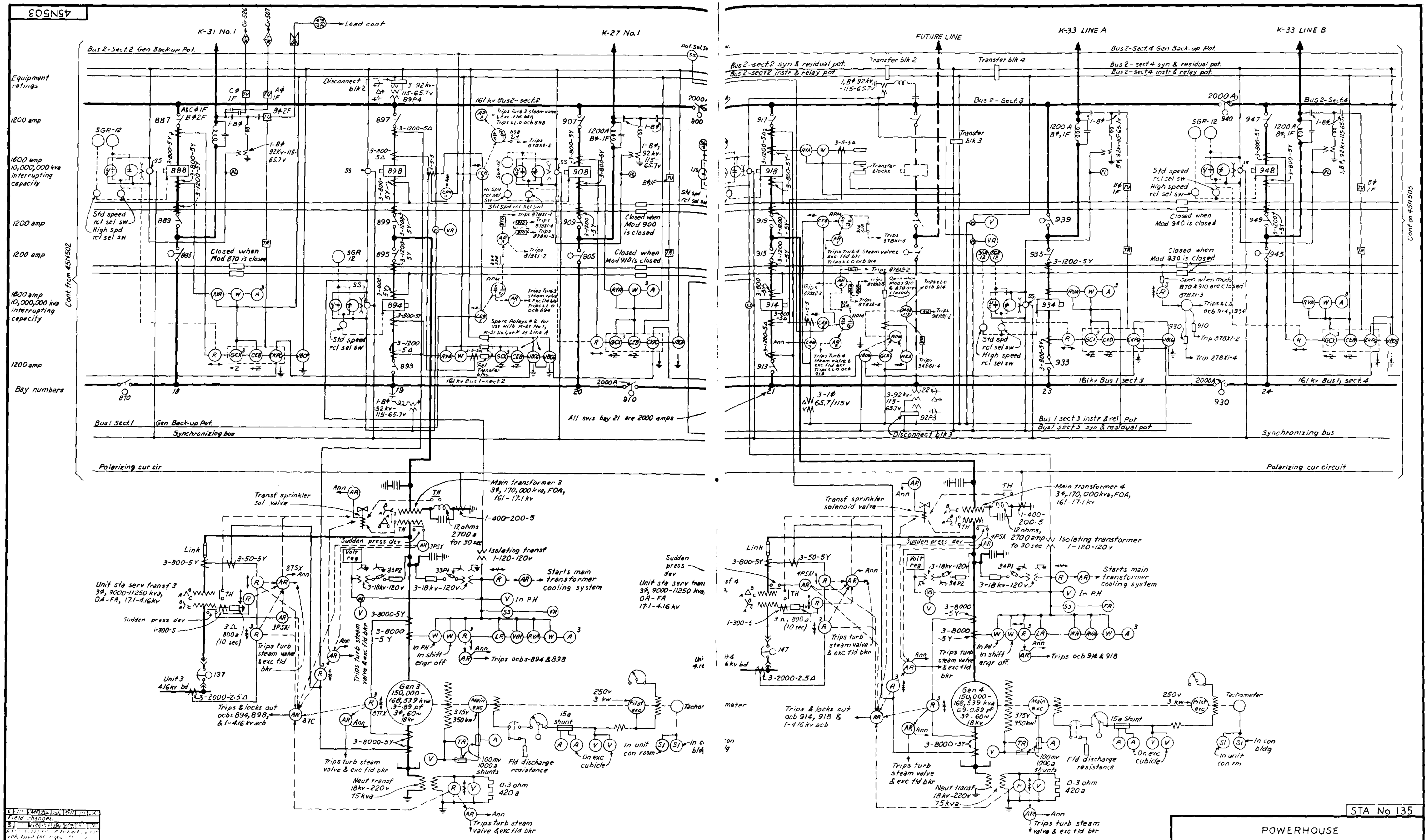
PROJECT MANAGER

EXHIBIT 21



TVA-00020414

EXHIBIT 22



TURBO-GENERATOR RECORDING:

Gen stator temp
Exc air discharge
Gen field temp
Hydrogen temp
Bearing temp
Turbine spindle vibration
Turbine spindle eccentricity
Speed
Turbine spindle position
Gen frequency
Gen load
Turbine cylinder expansion
Turbine gov valve position

TURBO-GENERATOR ANNUNCIATION:

Gland seal tank level low
Gen stator-high temp
Gen hydrogen-high temp
Gen field-high temp
Gen seal oil press low
Turbine oil tank level high
Turbine oil tank level low
Turbine rotor position abnormal
Turbine bearing-low oil press.
Gen bearing-high temp
Turbine emergency trip
Turbine spindle-excessive vibration
Turbine spindle excessive eccentricity

SHUTDOWN:

Emergency manual
Gen and main and unit sta serv transf diff
Overspeed (by emergency gov)
Gen field failure
Condenser-low vacuum
Gen neutral overvoltage
Sta serv transf overcurrent
Gen back-up impedance relays
Turbine con or low oil press
IV partially closed (more than 5 0%) and gov valve open

TURBO-GENERATOR ANNUNCIATION

Turbine exhaust high temp
Int valve intlk relay oper
Turbine tripped-low vacuum
Turbine tripped-overspeed
Oil cooling water temp high
Hydrogen cool water temp high
Hydrogen seal oil temp high
Gen reverse power-caution & danger
Gen H_2 press high or low
Gen H_2 density high or low

STA No 135

POWERHOUSE

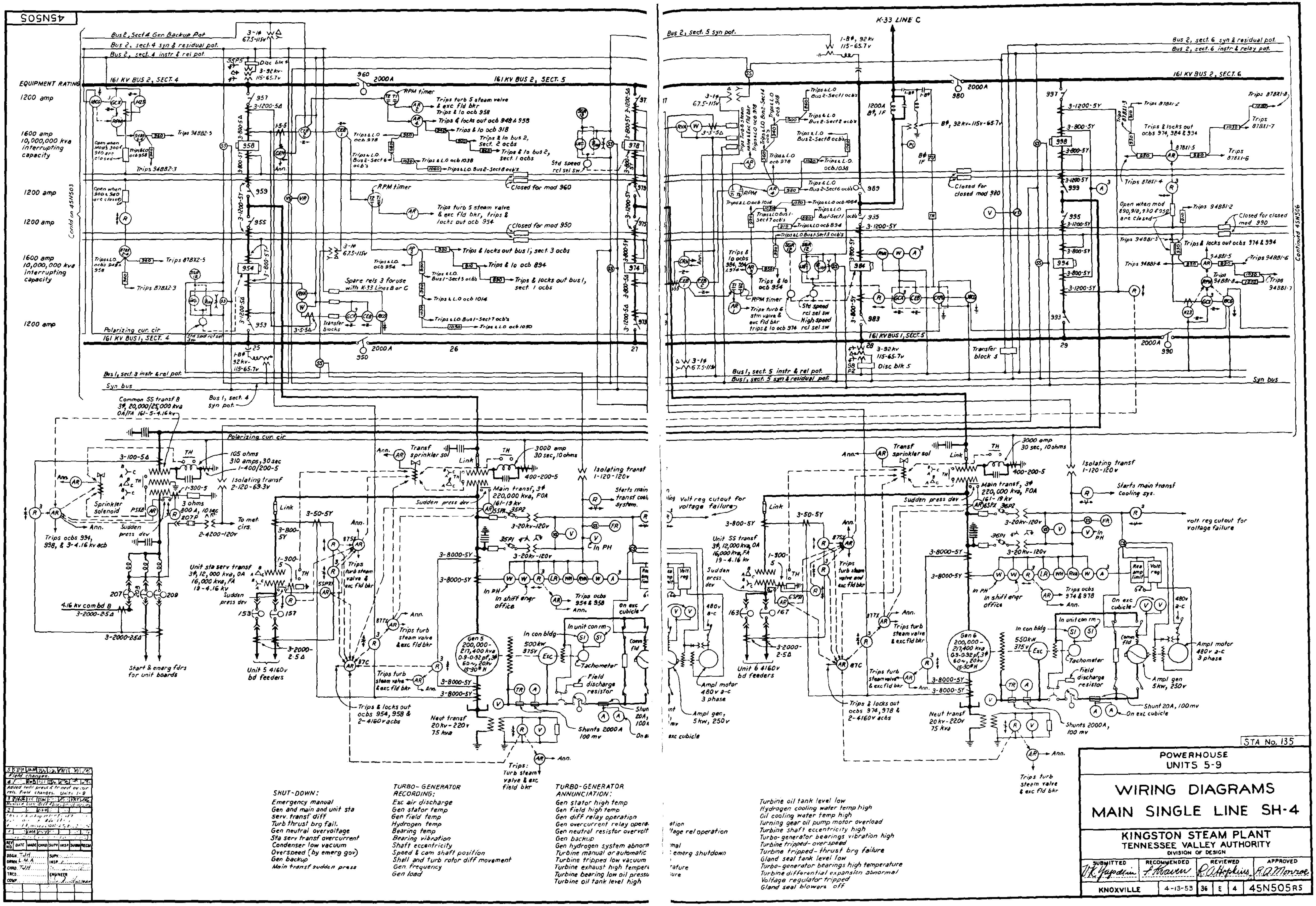
WIRING DIAGRAMS

MAIN SINGLE LINE - SH 2

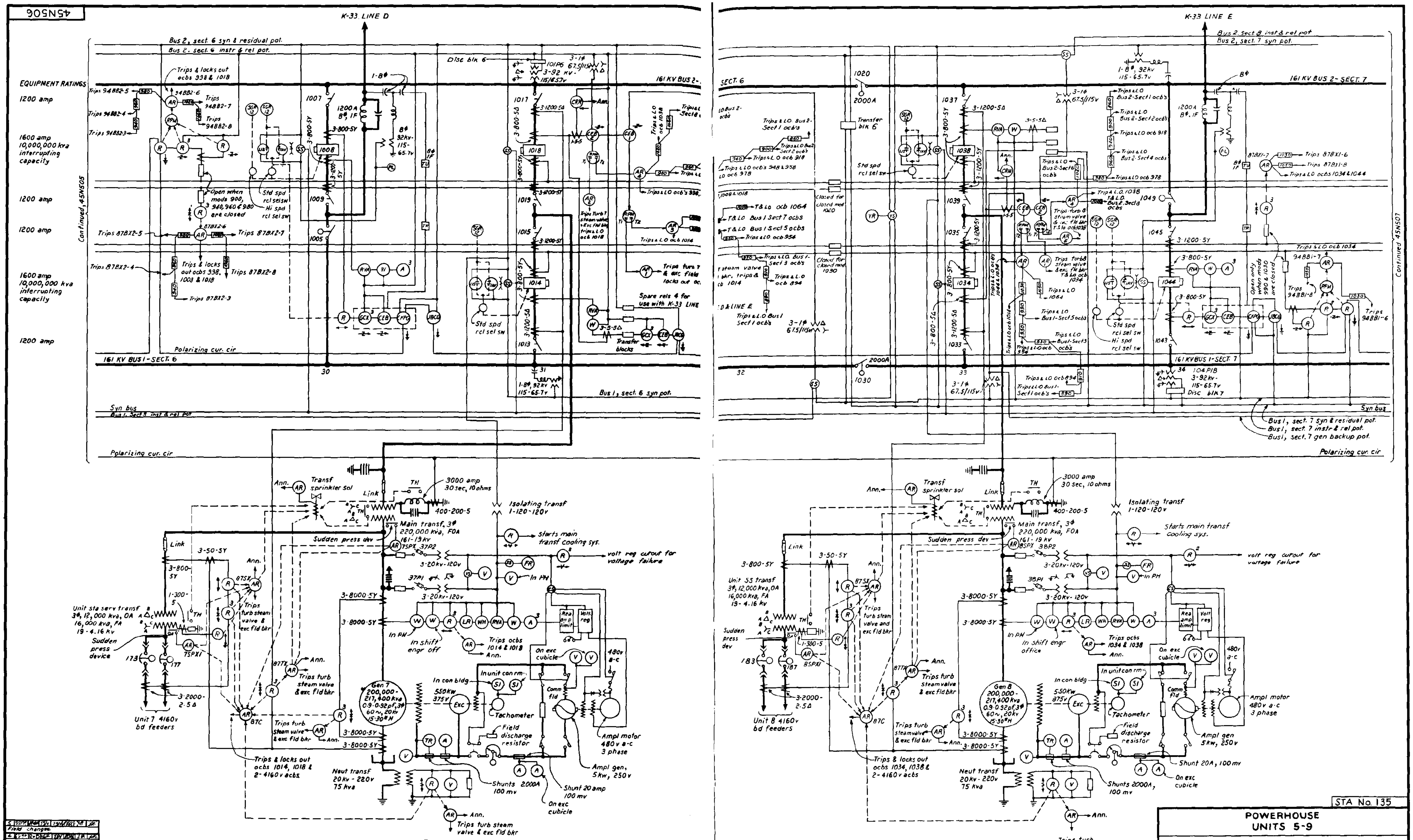
KINGSTON STEAM PLANT
TENNESSEE VALLEY AUTHORITY
DIVISION OF DESIGN

SUBMITTED	RECOMMENDED	REVIEWED	APPROVED
V.K. Yagodkin	[signature]	R.D. Hopkins	R.A. Monroe
KNOXVILLE	10-10-51	36 E 4	45N503 R6

EXHIBIT 23



POWERHOUSE
UNITS 5-9
WIRING DIAGRAMS
MAIN SINGLE LINE SH-4
KINGSTON STEAM PLANT
TENNESSEE VALLEY AUTHORITY
DIVISION OF DESIGN
SUBMITTED
RECOMMENDED
REVIEWED
APPROVED
KNOXVILLE
4-13-53
45N505 RS
STA No. 135
K-33 LINE C
161 KV BUS 2, SECT. 4
161 KV BUS 2, SECT. 5
161 KV BUS 2, SECT. 6
161 KV BUS 1, SECT. 4
161 KV BUS 1, SECT. 5
EQUIPMENT RATING
SHUT-DOWN:
Emergency manual
Gen and main and unit sta serv. transf diff
Turb thrust brg fail.
Gen neutral overvoltage
Sta serv transf overcurrent
Condenser low vacuum
Overspeed (by emerg gov)
Gen backup
Main transf sudden press
TURBO-GENERATOR RECORDING:
Exc air discharge
Gen stator temp
Gen field temp
Hydrogen temp
Bearing temp
Shaft eccentricity
Speed & cam shaft position
Shell and turb rotor diff movement
Gen frequency
Gen load
TURBO-GENERATOR ANNUNCIATION:
Gen stator high temp
Gen field high temp
Gen diff relay operation
Gen overcurrent relay operation
Gen neutral resistor overvolt
Gen backup
Gen hydrogen system abnormal
Turbine manual or automatic
Turbine tripped low vacuum
Turbine exhaust high temperature
Turbine bearing low oil pressure
Turbine oil tank level high
Turbine oil tank level low
Hydrogen cooling water temp high
Oil cooling water temp high
Turning gear oil pump motor overload
Turbine shaft eccentricity high
Turbo-generator bearings vibration high
Turbine tripped-over speed
Turbine tripped-thrust brg failure
Gland seal tank level low
Turbo-generator bearings high temperature
Turbine differential expansion abnormal
Voltage regulator tripped
Gland seal blowers off



SHUT-DOWN:
Emergency manual
Gen and main and unit sta
Serv transf diff
Turb thrust brg fail
Gen neutral overvoltage
Sta serv transf overcurrent
Condenser low vacuum
Overspeed (by emerg gov)
Gen backup
Main transf sudden press

TURBO-GENERATOR RECORDING:
Exc air discharge
Gen stator temp
Gen field temp
Hydrogen temp
Bearing temp
Bearing vibration
Shaft eccentricity
Speed & cam shaft position
Shell & turbine rotor diff movement
Gen frequency
Gen load

TURBO-GENERATOR ANNUNCIATION:
Gen stator high temp
Gen field high temp
Gen diff relay operation
Gen overcurrent relay opera
Gen neutral resistor overvolt
Gen back up
Gen hydrogen system abnor
Turbine manual or automatic
Turbine tripped low vacuum
Turbine exhaust high temp
Turbine bearing low oil pres
Turbine oil tank level high

tion
tage rel operation
rmal
emerg shutdown
ssure

Turbine oil tank level low
Hydrogen cooling water temp high
Oil cooling water temp high
Turning gear oil pump motor overload
Turbine shaft eccentricity high
Turbo-generator bearings vibration high
Turbine tripped overspeed
Turbine tripped-thrust brg failure
Gland seal tank level low
Turbo-generator bearings high temp
Turbine differential expansion abnormal
Voltage regulator tripped
Gland seal blowers off

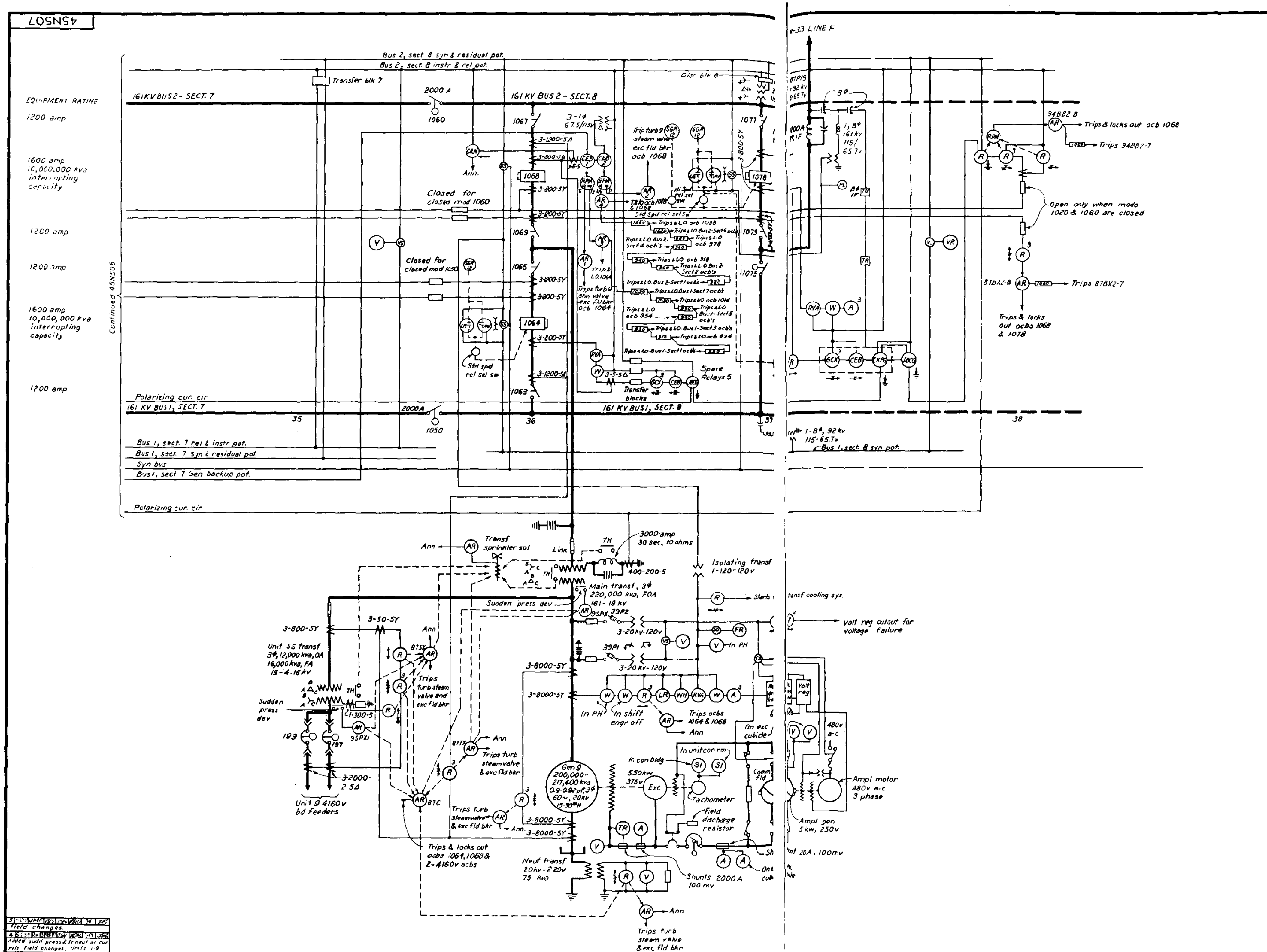
POWERHOUSE
UNITS 5-9

WIRING DIAGRAMS
MAIN SINGLE LINE SH-5

KINGSTON STEAM PLANT
TENNESSEE VALLEY AUTHORITY
DIVISION OF DESIGN

SUBMITTED	RECOMMENDED	REVIEWED	APPROVED
V.K. Yajodin	L. Kravin	R.A. Hopkins	R.A. Monroe

KNOXVILLE | 4-13-53 | 36 | E | 4 | 45N506R5



SHUT-DOWN:

- Emergency manual
- Gen and main and unit sta serv transf diff
- Turb thrust brg failure
- Gen neutral overvoltage
- Sta serv transf overcurrent
- Condenser low vacuum
- Overspeed (by emerg gov)
- Gen backup
- Main transf sudden press

TURBO-GENERATOR RECORDING:

- Exc air discharge
- Gen stator temp
- Gen field temp
- Hydrogen temp
- Bearing temp
- Bearing vibration
- Shaft eccentricity
- Speed & cam shaft position
- Shell & turbine rotor diff movement
- Gen frequency
- Gen load

TURBO-GENERATOR ANNUNCIATION:

- Gen stator high temp
- Gen field high temp
- Gen diff relay operation
- Gen overcurrent relay operation
- Gen neutral resistor overvoltage rel oper
- Gen back up
- Gen hydrogen system abnormal
- Turbine manual or automatic emerg shut down
- Turbine tripped low vacuum
- Turbine exhaust high temp
- Turbine bearing low oil pressure
- Turbine oil tank level high
- Gland seal blowers off
- Turbine oil tank level low
- Hydrogen cooling water temp high
- Oil cooling water temp high
- Turning gear oil pump motor overload
- Turbine shaft eccentricity high
- Turbo-generator bearings vibration high
- Turbine tripped-overspeed
- Turbine tripped-thrust brg failure
- Gland seal tank level low
- Turbo-generator bearings high temp
- Turbine differential expansion-abnormal
- Voltage regulator tripped

STA No. 135

POWERHOUSE
UNITS 5-9

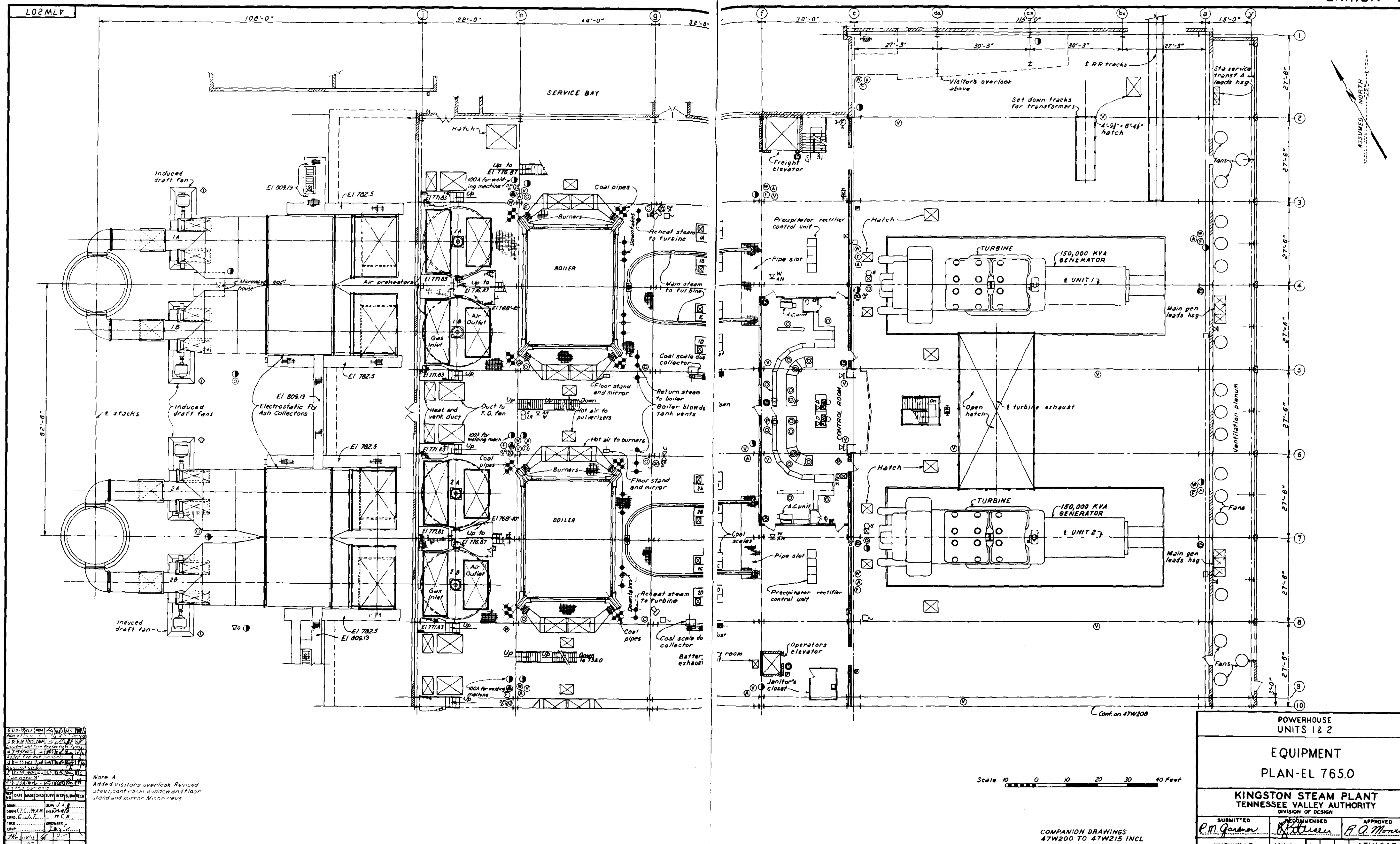
WIRING DIAGRAMS
MAIN SINGLE LINE SH-6

KINGSTON STEAM PLANT
TENNESSEE VALLEY AUTHORITY
DIVISION OF DESIGN

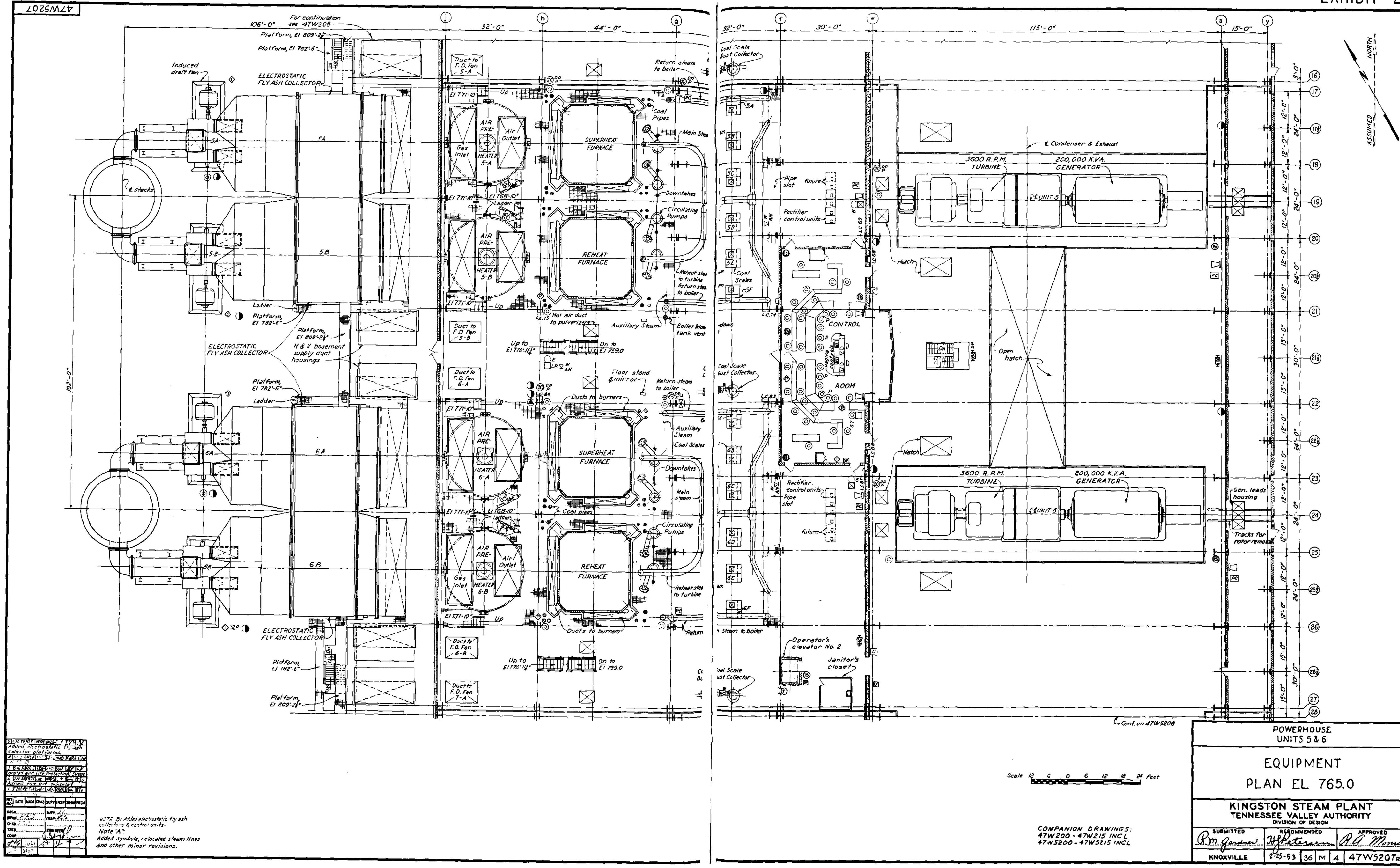
SUBMITTED	RECOMMENDED	REVIEWED	APPROVED
V.K. Yafredin	F. Kraven	R.A. Hopkins	R.A. Monroe

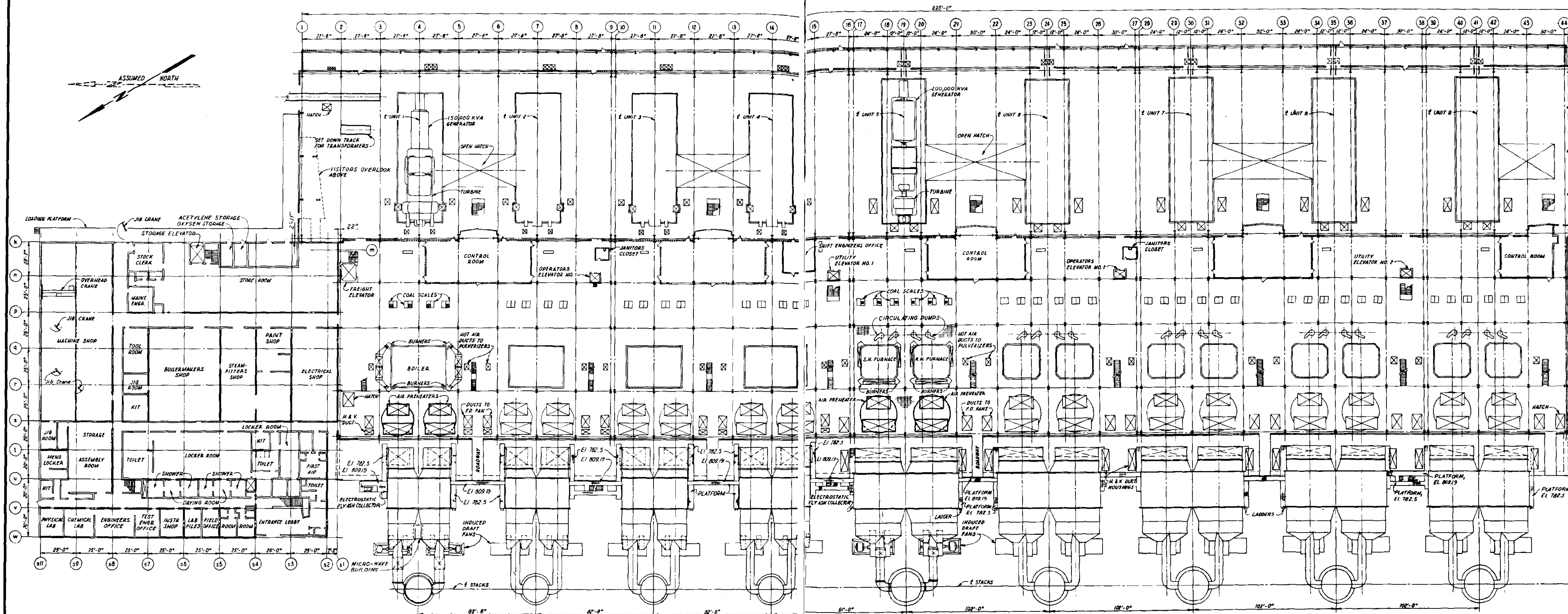
KNOXVILLE	4-13-53	36	E	4	45N507 R5

EXHIBIT 26



47W207
SERVICE BAY
Induced draft fan
Induced draft fans
Electrostatic Fly Ash Collectors
Air preheaters
Microwave eqpt house
℄ stacks
Heat and vent. duct
Duct to F.D. fan
Hot air to pulverizers
Hot air to burners
Gas Inlet
Air Outlet
BOILER
Burners
Coal pipes
Downtakes
Reheat steam to turbine
Main steam to turbine
Coal scale dust collector
Floor stand and mirror
Return steam to boiler
Boiler blowdown tank vents
Hatch
Freight elevator
Operators elevator
Janitor's closet
Precipitator rectifier control unit
Pipe slot
Coal scales
A.C. unit
CONTROL ROOM
Open hatch
℄ turbine exhaust
TURBINE
150,000 KVA GENERATOR
℄ UNIT 1
℄ UNIT 2
Main gen leads hsg
Fans
Ventilation plenum
Sta service transf A leads hsg
℄ RR tracks
Set down tracks for transformers
Visitors overlook above
ASSUMED NORTH
Note A
Added visitors overlook Revised steel, cont room window and floor stand and mirror Minor revs
Cont on 47W208
Scale 10 0 10 20 30 40 Feet
COMPANION DRAWINGS 47W200 TO 47W215 INCL
POWERHOUSE UNITS 1 & 2
EQUIPMENT
PLAN-EL 765.0
KINGSTON STEAM PLANT
TENNESSEE VALLEY AUTHORITY
DIVISION OF DESIGN
SUBMITTED
RECOMMENDED
APPROVED
KNOXVILLE
12-1-51
47W207R6


47W5207
For continuation see 47W208
Platform, El 809'-2½"
Platform, El 782'-6"
Induced draft fan
ELECTROSTATIC FLY ASH COLLECTOR
℄ stacks
Ladder
H & V basement supply duct housings
AIR PRE-HEATER 5-A
AIR PRE-HEATER 5-B
AIR PRE-HEATER 6-A
AIR PRE-HEATER 6-B
Gas Inlet
Air Outlet
SUPERHEAT FURNACE
REHEAT FURNACE
Duct to F.D. Fan 5-A
Duct to F.D. Fan 5-B
Duct to F.D. Fan 6-A
Duct to F.D. Fan 6-B
Duct to F.D. Fan 7-A
Hot air duct to pulverizer
Ducts to burners
Coal pipes
Return steam to boiler
Main Steam
Downtakes
Circulating Pumps
Reheat steam to turbine
Auxiliary Steam
Boiler blow tank vent
Floor stand ℄ mirror
Coal Scales
Coal Scale Dust Collector
Pipe slot
Rectifier control units
future
CONTROL ROOM
Hatch
Open hatch
Operator's elevator No. 2
Janitor's closet
℄ Condenser & Exhaust
3600 R.P.M. TURBINE
200,000 K.V.A. GENERATOR
℄ UNIT 5
℄ UNIT 6
Gen. leads housing
Tracks for rotor removal
ASSUMED NORTH
Cont. on 47W5208
Scale 12 6 0 6 12 18 24 Feet
COMPANION DRAWINGS: 47W200 - 47W215 INCL 47W5200 - 47W5215 INCL
NOTE B - Added electrostatic fly ash collectors & control units.
Note "A" Added symbols, relocated steam lines and other minor revisions.
POWERHOUSE UNITS 5 & 6
EQUIPMENT
PLAN EL 765.0
KINGSTON STEAM PLANT
TENNESSEE VALLEY AUTHORITY
DIVISION OF DESIGN
SUBMITTED
RECOMMENDED
APPROVED
KNOXVILLE 2-25-53 36 M 4 47W5207RS



Scale: 0 10 20 30 40 50 Feet

COMPANION DRAWINGS
47W200 - 47W215 INCL
47W5200 - 47W5218 INCL

POWERHOUSE UNITS 1-9					
EQUIPMENT PLAN - EL 765.0					
KINGSTON STEAM PLANT TENNESSEE VALLEY AUTHORITY DIVISION OF DESIGN					
SUBMITTED R.M. Gardner	RECOMMENDED H.J. Petersen			APPROVED R.A. Monroe	
KNOXVILLE	4-22-54	36	M	4	47W5216 R4

Added Electrostatic Fly Ash Collectors - Units 1-4. Added Electrostatic Fly Ash Collector platforms - Units 1-9.
Added Elect. Fly ...
As constructed
Removed H₂ storage

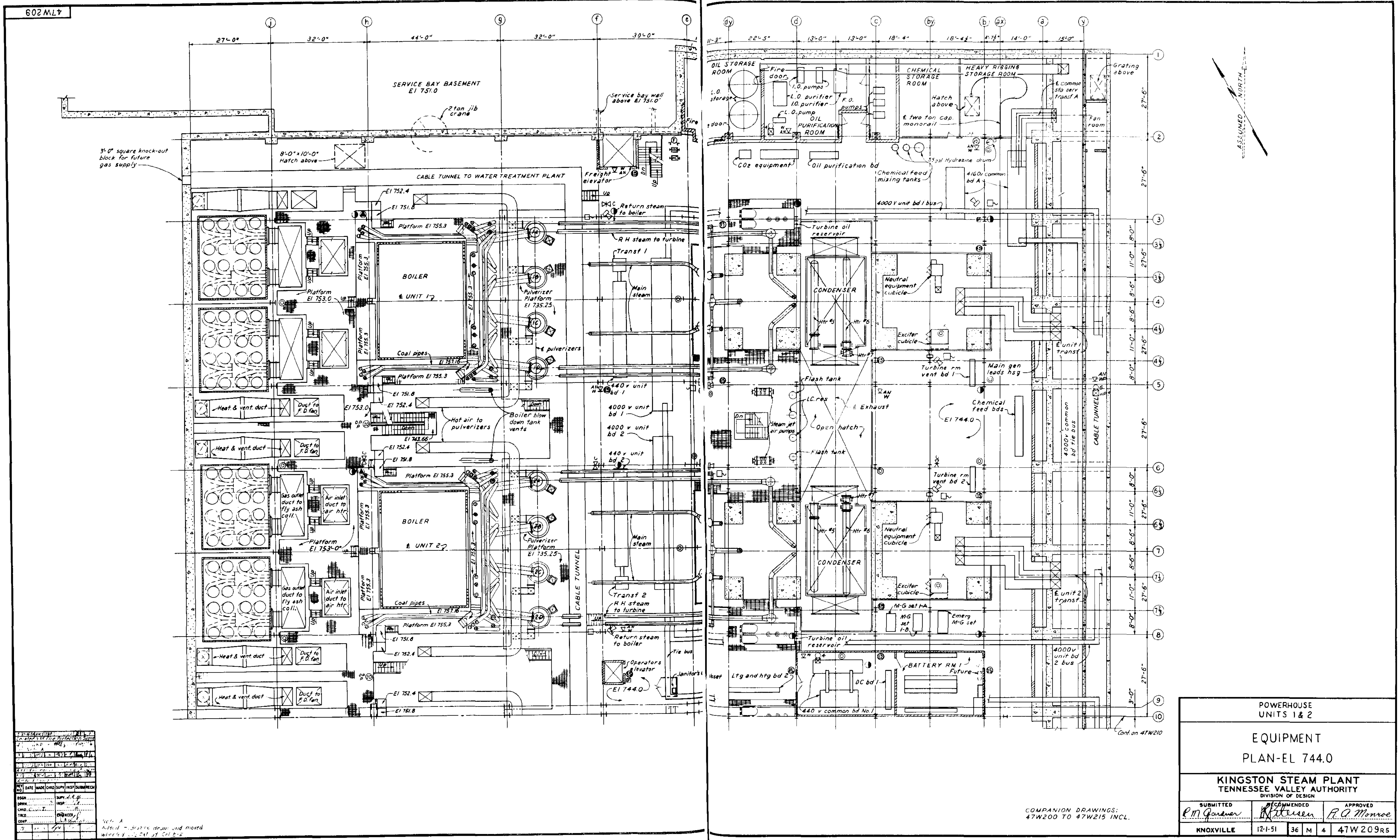
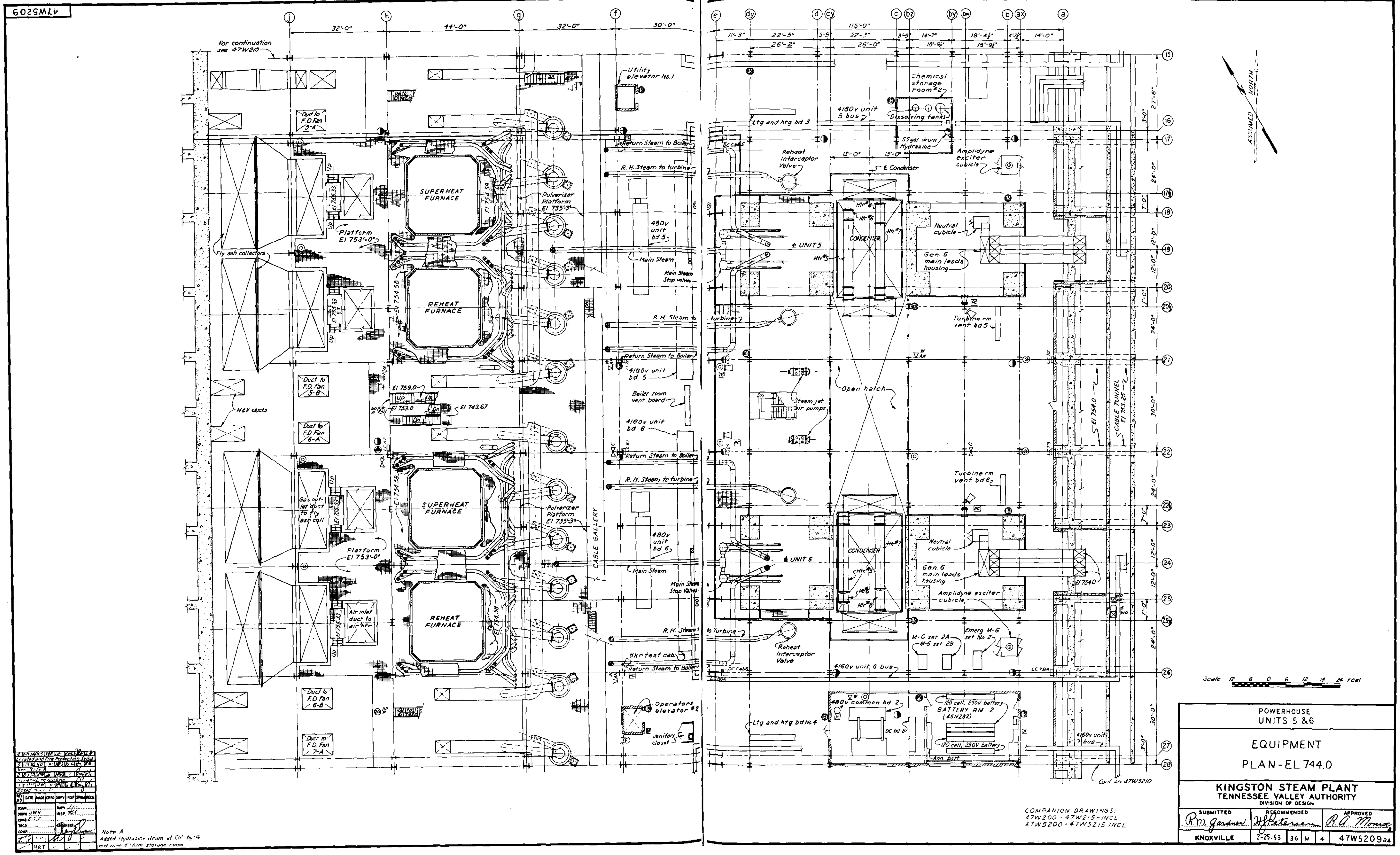
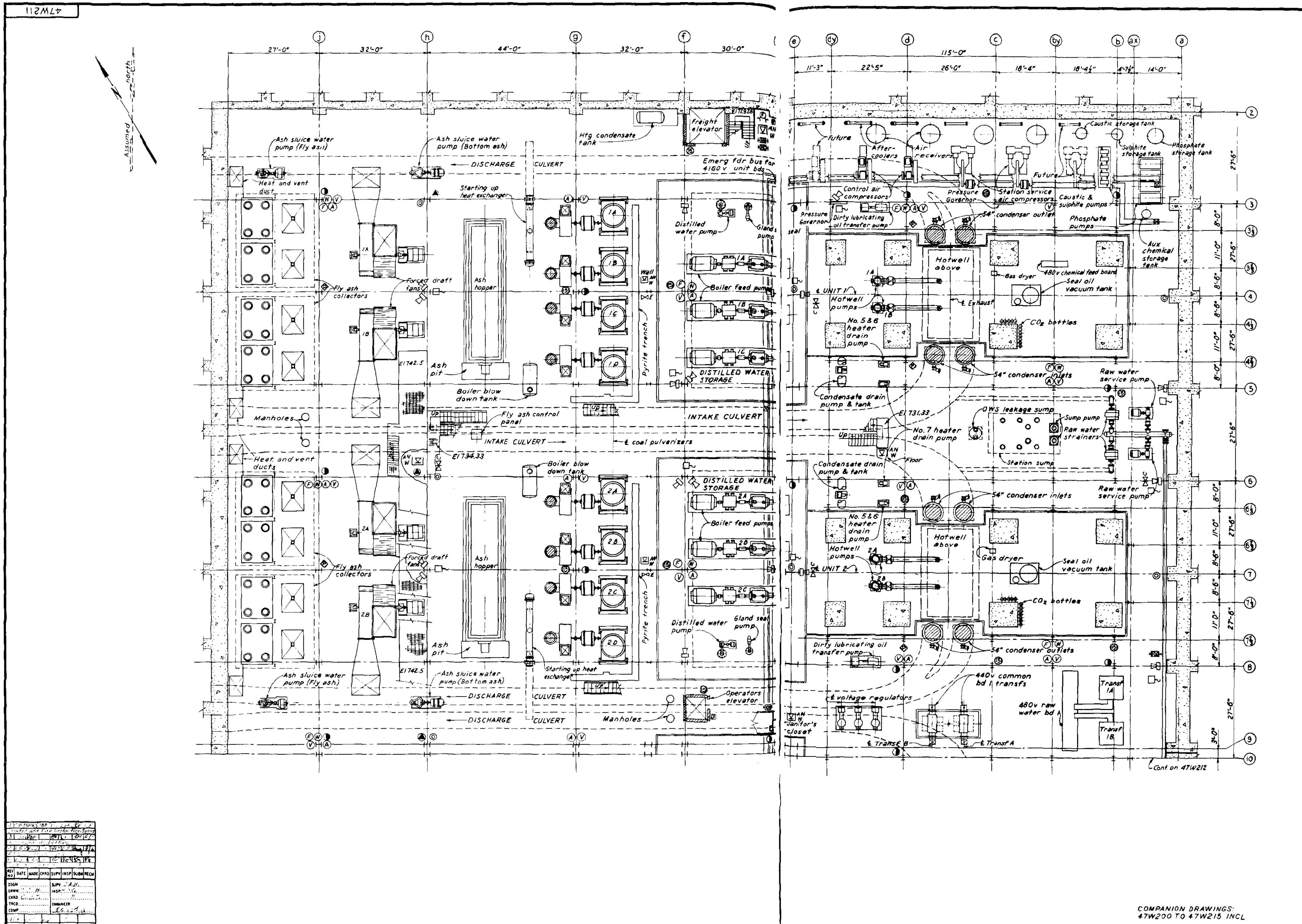

47W209
SERVICE BAY BASEMENT
El 751.0
CABLE TUNNEL TO WATER TREATMENT PLANT
3'-0" square knock-out block for future gas supply
8'-0" x 10'-0" Hatch above
2 ton jib crane
Service bay wall above El 751.0'
Freight elevator
OIL STORAGE ROOM
L.O. storage
L.O. pumps
L.O. purifier
I.O. purifier
L.O. pump
OIL PURIFICATION ROOM
F.O. pumps
CHEMICAL STORAGE ROOM
HEAVY RIGGING STORAGE ROOM
Hatch above
℄ two ton cap monorail
Grating above
Fan room
CO2 equipment
Oil purification bd
Chemical feed mixing tanks
4160v common bd A
4000 V unit bd I bus
ASSUMED NORTH
BOILER
℄ UNIT 1
BOILER
℄ UNIT 2
Platform El 755.3
Platform El 753.0
Platform El 753-0"
Pulverizer Platform El 735.25
℄ pulverizers
Coal pipes
Heat & vent. duct
Duct to F.D. fan
Gas outlet duct to fly ash coll.
Air inlet duct to air htr
Hot air to pulverizers
Boiler blow down tank vents
Return steam to boiler
R H steam to turbine
Transf 1
Transf 2
Main steam
440 v unit bd 1
4000 v unit bd 1
4000 v unit bd 2
440 v unit bd 2
CABLE TUNNEL
Operators elevator
El 744.0
Janitor's closet
Tie bus
Turbine oil reservoir
CONDENSER
Neutral equipment cubicle
Exciter cubicle
Flash tank
L.C. res
℄ Exhaust
Steam jet air pumps
Open hatch
Turbine rm vent bd 1
Turbine rm vent bd 2
Main gen leads hsg
Chemical feed bds
El 744.0
4000v common bd tie bus
℄ unit 1 transf
℄ unit 2 transf
M-G set I-A
M-G set 1-B
Emerg M-G set
4000v unit bd 2 bus
Ltg and htg bd 2
DC bd 1
BATTERY RM 1
Future
440 v common bd No. 1
Cont. on 47W210
COMPANION DRAWINGS: 47W200 TO 47W215 INCL.
POWERHOUSE UNITS 1 & 2
EQUIPMENT
PLAN-EL 744.0
KINGSTON STEAM PLANT
TENNESSEE VALLEY AUTHORITY
DIVISION OF DESIGN
SUBMITTED
RECOMMENDED
APPROVED
R. O. Monroe
KNOXVILLE
12-1-51
36
M
4
47W209R5

EXHIBIT 30



TVA-00020423



NOTES
For symbols see 47W200

COMPANION DRAWINGS:
47W200 TO 47W215 INCL

POWERHOUSE
UNITS 1 & 2

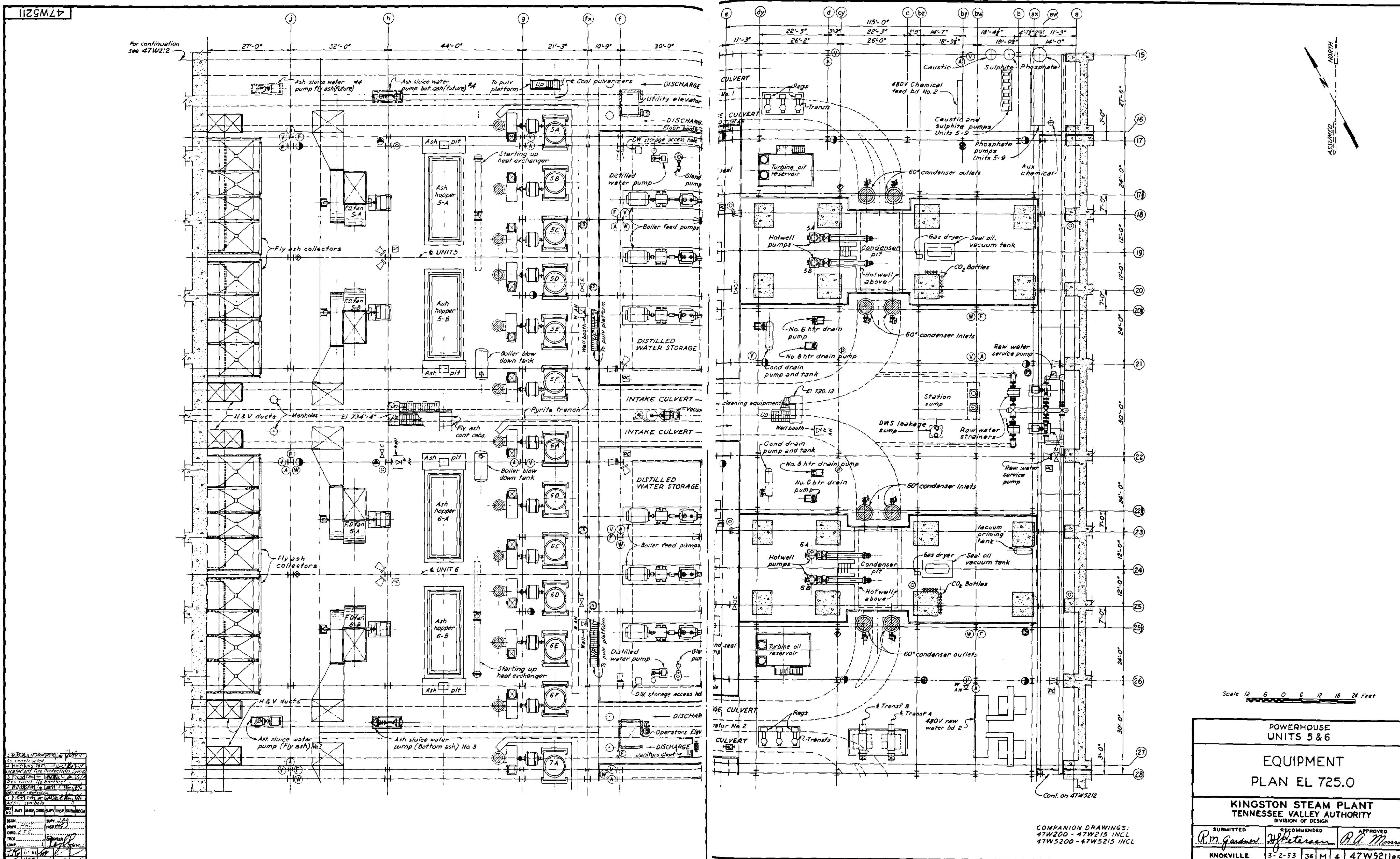
EQUIPMENT
PLAN EL 725.0

KINGSTON STEAM PLANT
TENNESSEE VALLEY AUTHORITY
DIVISION OF DESIGN

SUBMITTED	RECOMMENDED	APPROVED
R M Gardner	[illegible]	R A Monroe

KNOXVILLE | 12-1-51 | 36 | M | 4 | 47W211R4

EXHIBIT 32


47W5211
For continuation See 47W212
Ash sluice water #4 pump fly ash (future)
Ash sluice water pump bot. ash (future) #4
To pulv platform
Coal pulverizers
DISCHARGE
Utility elevator
Starting up heat exchanger
Ash hopper 5-A
Ash hopper 5-B
Ash hopper 6-A
Ash hopper 6-B
F.D. fan 5-A
F.D. fan 5-B
F.D. fan 6-A
F.D. fan 6-B
Fly ash collectors
UNIT 5
UNIT 6
Boiler blow down tank
Distilled water pump
Boiler feed pumps
DISTILLED WATER STORAGE
INTAKE CULVERT
H & V ducts
Manholes
El 734'-4"
Fly ash cont cabs.
Pyrite trench
To pulv platform
D.W. storage access hole
Operators Elev
Janitors closet
Ash sluice water pump (Fly ash) No. 3
Ash sluice water pump (Bottom ash) No. 3
Caustic
Sulphite
Phosphate
480V Chemical feed bd No. 2
Caustic and sulphite pumps Units 5-9
Phosphate pumps Units 5-9
Aux chemical
Regs
Transfs
Turbine oil reservoir
60" condenser outlets
60" condenser inlets
Hotwell pumps
Condenser pit
Hotwell above
Gas dryer
Seal oil vacuum tank
CO_2 Bottles
No. 6 htr drain pump
No. 8 htr drain pump
Cond drain pump and tank
El 730.13
Station sump
DWS leakage sump
Raw water service pump
Raw water strainers
Vacuum priming tank
Transf B
Transf A
480V raw water bd 2
Cont. on 47W5212
NORTH
ASSUMED
Scale 12 6 0 6 12 18 24 Feet
COMPANION DRAWINGS: 47W200 - 47W215 INCL 47W5200 - 47W5215 INCL
POWERHOUSE UNITS 5 & 6
EQUIPMENT PLAN EL 725.0
KINGSTON STEAM PLANT
TENNESSEE VALLEY AUTHORITY
DIVISION OF DESIGN
SUBMITTED
RECOMMENDED
APPROVED
KNOXVILLE 3-2-53 36 M 4 47W5211 R5
As constructed
General revisions

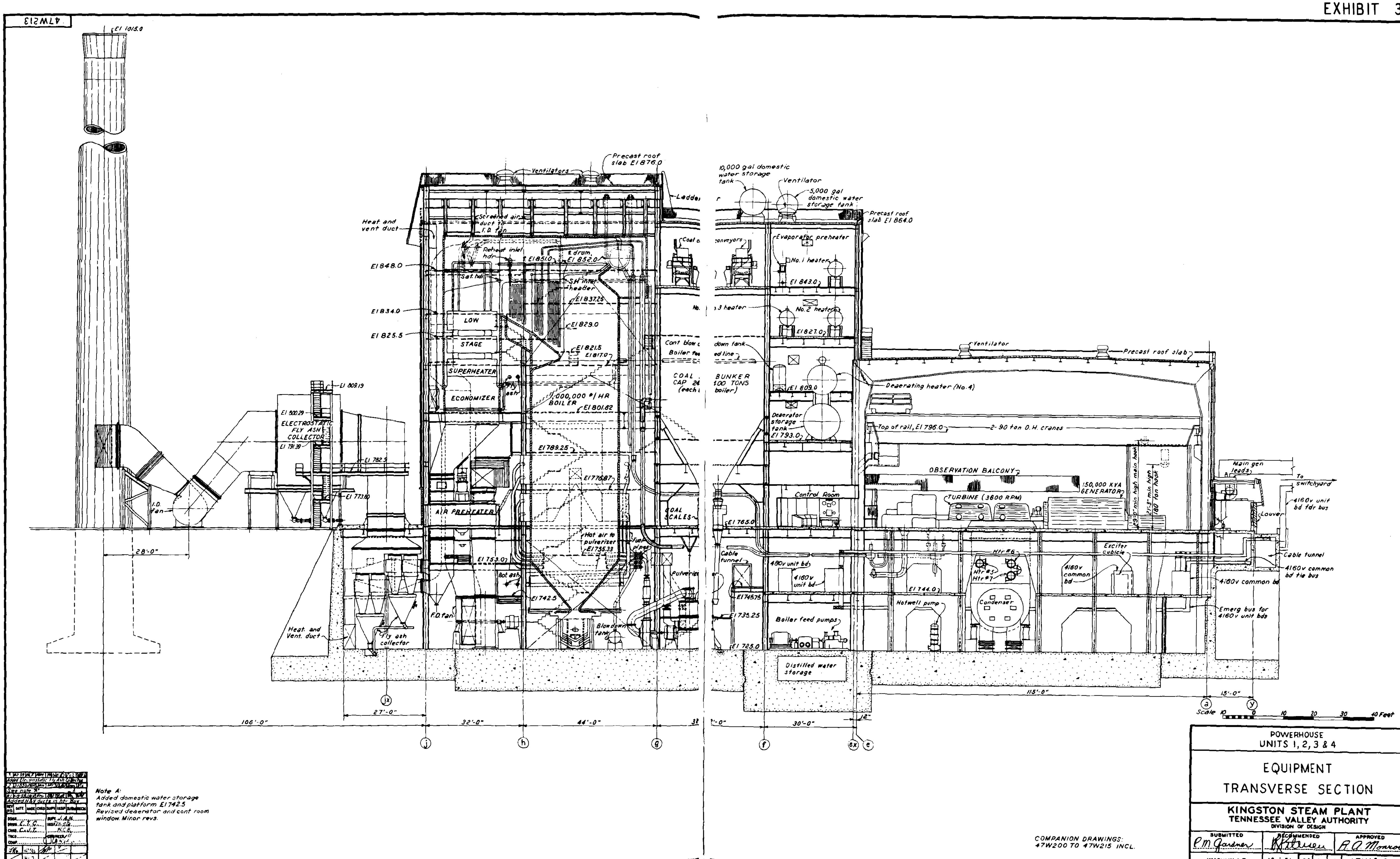
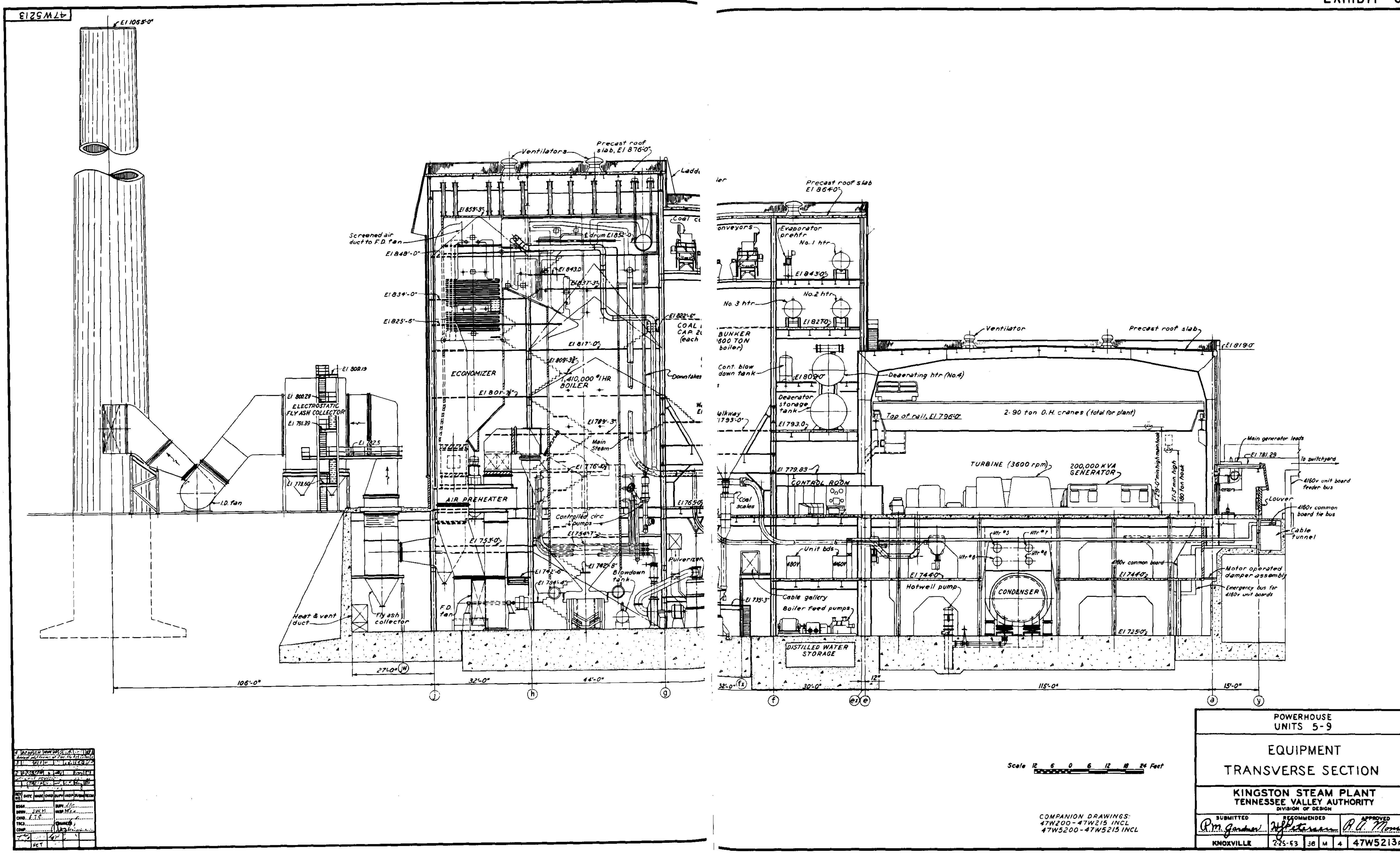

47W213
El 1015.0
Precast roof slab El 876.0
Ventilators
Heat and vent duct
Screened air duct to F.D. fan
Reheat inlet hdr
Sat. hdr
El 851.0
Drum El 852.0
SH inter heater
El 848.0
El 837.25
El 834.0
LOW
El 829.0
El 825.5
STAGE
El 821.5
El 817.0
SUPERHEATER
ECONOMIZER
1,000,000 #/HR BOILER
El 801.62
El 809.19
El 800.29
ELECTROSTATIC FLY ASH COLLECTOR
El 791.39
El 782.5
El 789.25
El 776.87
El 773.80
I.D. fan
AIR PREHEATER
Hot air to pulverizer El 735.33
Fuel pipes
El 753.0
Bot ash
El 742.5
F.D. fan
Blowdown tank
Pulverizer
Heat and Vent. duct
Fly ash collector
COAL SCALES
COAL BUNKER CAP 24 100 TONS (each boiler)
Cont blow down tank
Boiler feed line
Coal conveyors
Ladder
10,000 gal domestic water storage tank
Ventilator
5,000 gal domestic water storage tank
Precast roof slab El 864.0
Evaporator preheater
No. 1 heater
El 843.0
No. 3 heater
No. 2 heater
El 827.0
El 809.0
Deaerating heater (No. 4)
Deaerator storage tank
El 793.0
Ventilator
Precast roof slab
Top of rail, El 796.0
2-90 ton O.H. cranes
OBSERVATION BALCONY
150,000 KVA GENERATOR
TURBINE (3600 RPM)
29'-0" min high main hook
21'-3" min high 180 ton hook
Control Room
El 765.0
Cable tunnel
480v unit bd
4160v unit bd
El 745.75
El 735.25
Boiler feed pumps
El 725.0
Distilled water storage
El 744.0
Hotwell pump
Htr #6
Htr #5
Htr #7
Condenser
Exciter cubicle
4160v common bd
Main gen leads
To switchyard
4160v unit bd fdr bus
Louver
Cable tunnel
4160v common bd tie bus
4160v common bd
Emerg bus for 4160v unit bds
28'-0"
106'-0"
27'-0"
32'-0"
44'-0"
30'-0"
12'
115'-0"
15'-0"
j h g f ex e a y jx
Scale 10 0 10 20 30 40 Feet
Note A:
Added domestic water storage tank and platform El 742.5
Revised deaerator and cont room window. Minor revs.
COMPANION DRAWINGS: 47W200 TO 47W215 INCL.
POWERHOUSE
UNITS 1, 2, 3 & 4
EQUIPMENT
TRANSVERSE SECTION
KINGSTON STEAM PLANT
TENNESSEE VALLEY AUTHORITY
DIVISION OF DESIGN
SUBMITTED
RECOMMENDED
APPROVED
P.M. Gardner
R.A. Monroe
KNOXVILLE
12-1-51
47W213R3

EXHIBIT 34



POWERHOUSE
UNITS 5-9

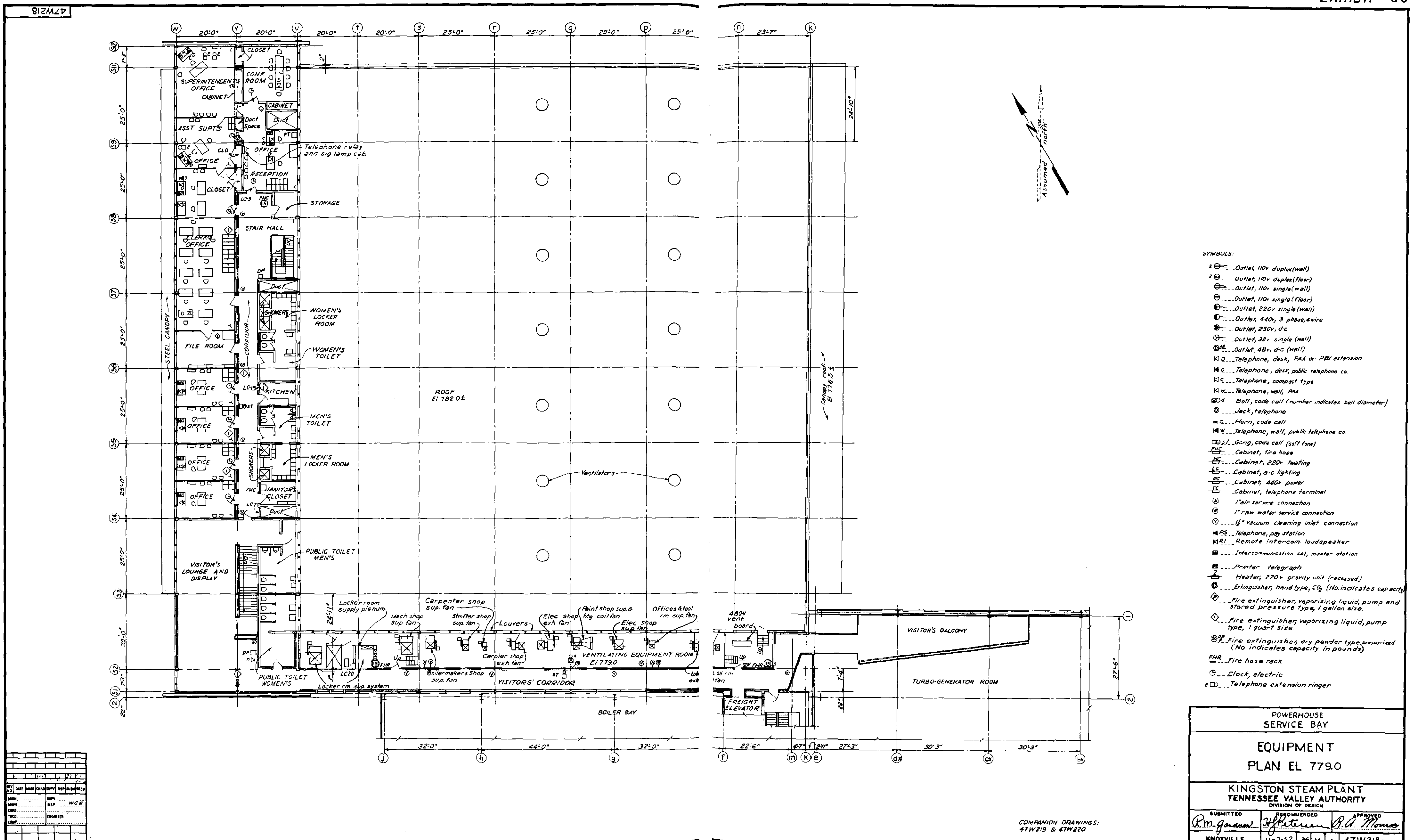
EQUIPMENT
TRANSVERSE SECTION

KINGSTON STEAM PLANT
TENNESSEE VALLEY AUTHORITY
DIVISION OF DESIGN

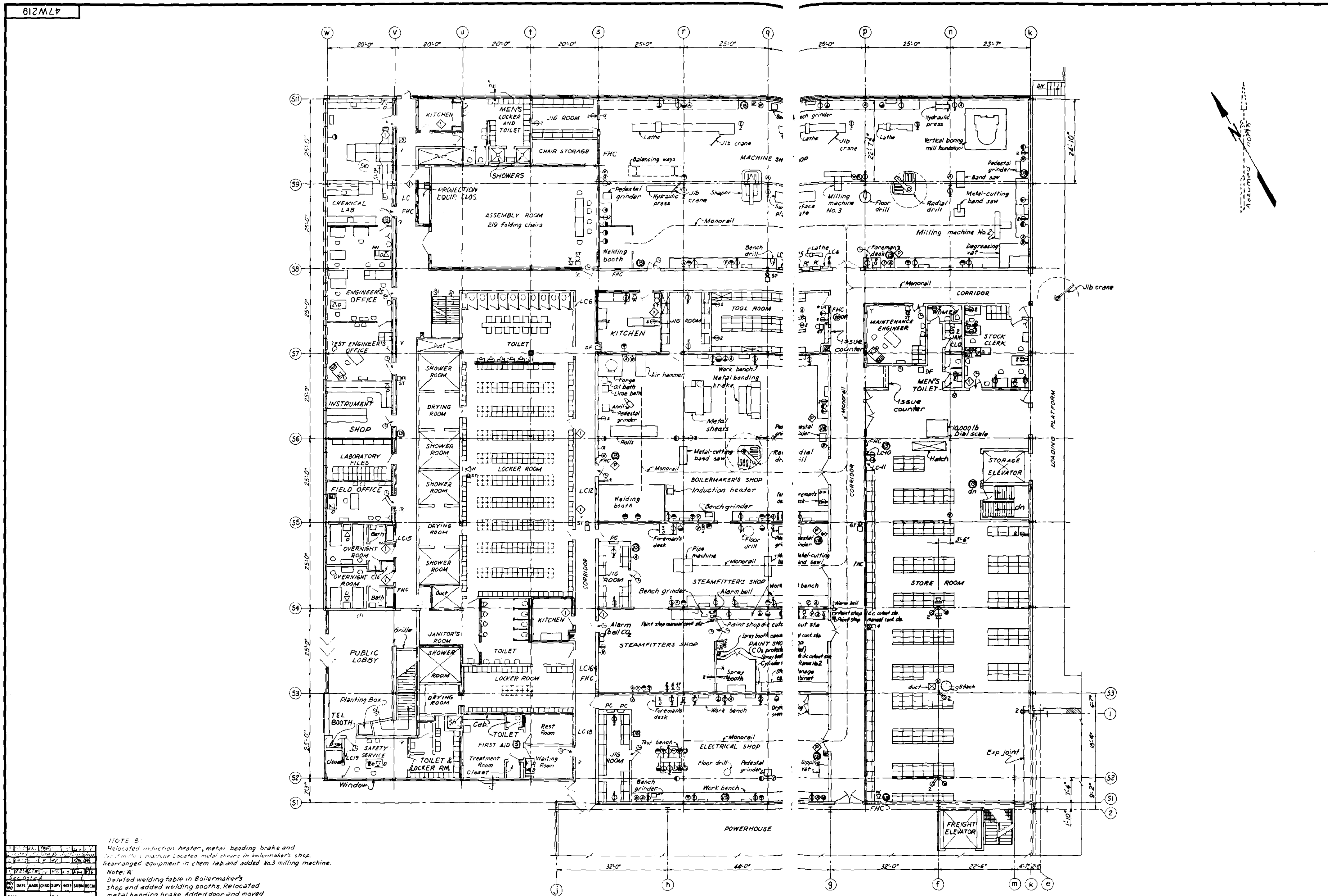
SUBMITTED	RECOMMENDED	APPROVED
R.M. Gardner	H.J. Petersen	R.A. Monroe

KNOXVILLE	2-25-53	38	M	4	47W5213 R4

EXHIBIT 35



TVA-00020428



NOTE B:
Relocated induction heater, metal bending brake and No. 2 milling machine. Located metal shears in boilermaker's shop.
Rearranged equipment in chem lab. and added No.3 milling machine.

Note: 'A'
Deleted welding table in Boilermaker's shop and added welding booths. Relocated metal bending brake. Added door and moved cabinets in Steamfitter shop. Deleted Carpenter's shop eqpt DPO items 1-6.

REV NO	DATE	MADE	CHKD	SUPV	INSP	SUBM	RECM
See note A							

DSGN. / DRWN. / CHKD. / TRCD. / COMP. — SUPV. / INSP. WCB / ENGINEER

COMPANION DRAWINGS: 47W218 & 47W220

POWERHOUSE SERVICE BAY

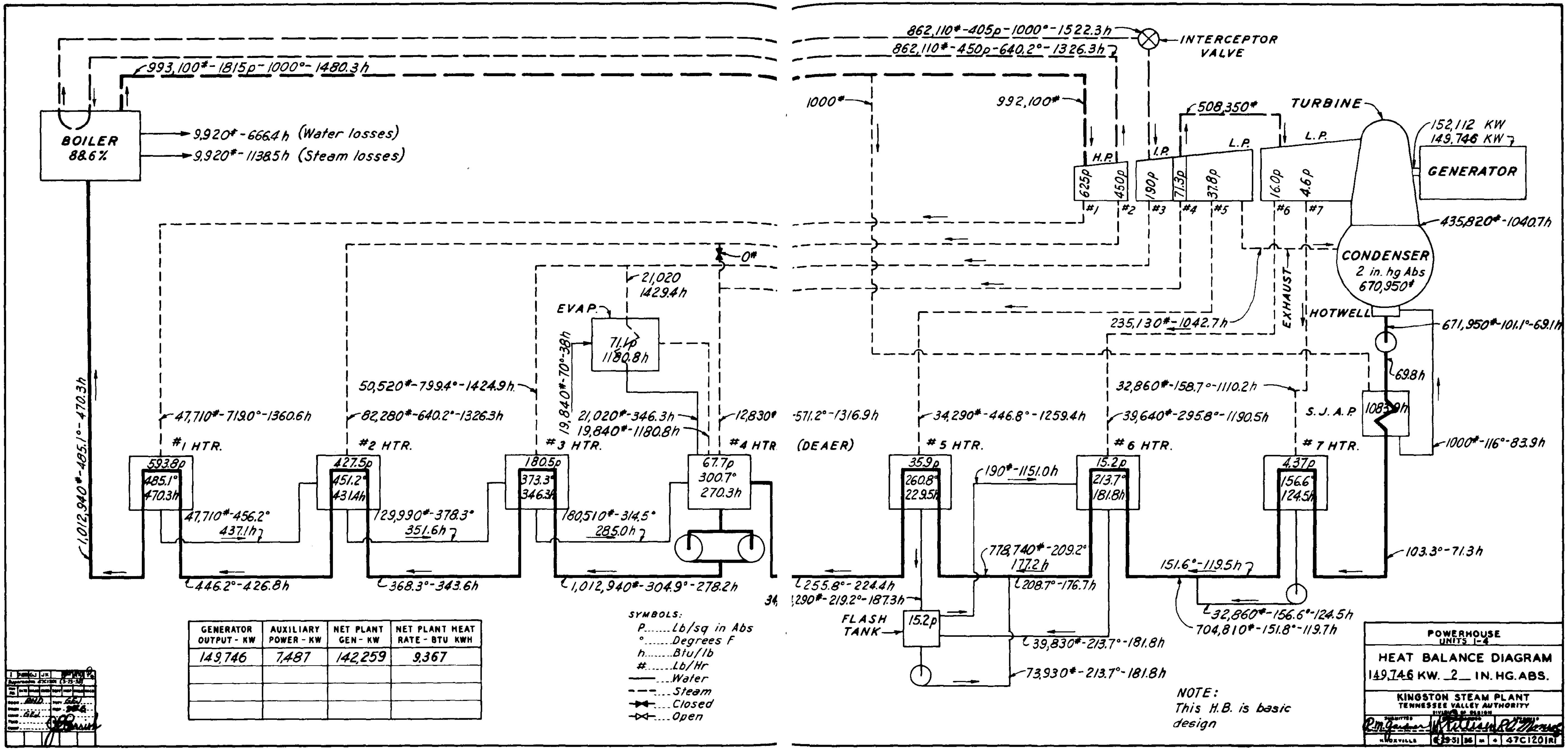
EQUIPMENT

PLAN-EL 765.0

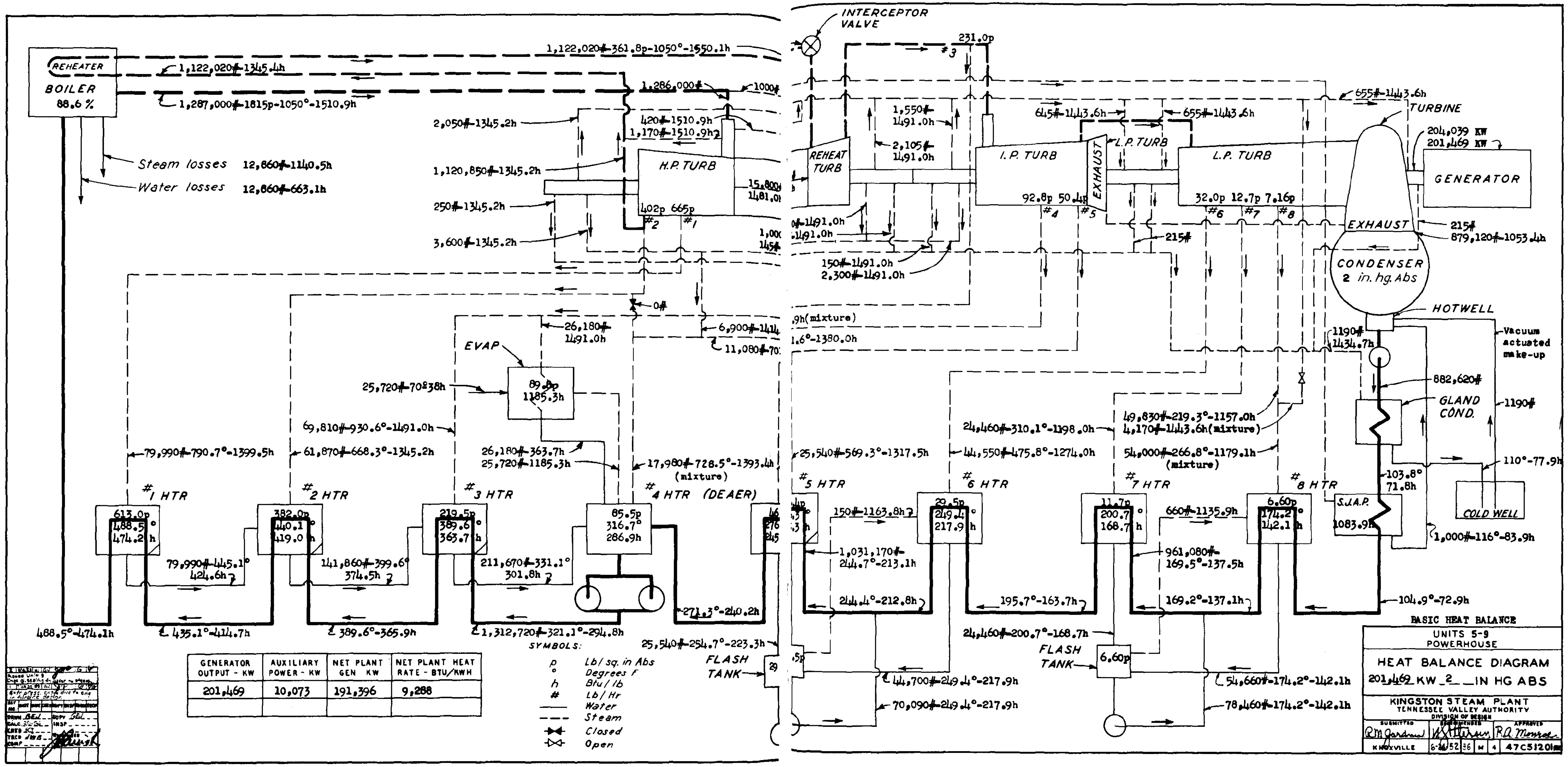
KINGSTON STEAM PLANT
TENNESSEE VALLEY AUTHORITY
DIVISION OF DESIGN

SUBMITTED	RECOMMENDED	APPROVED
R.M. Gardner	H. Petersen	R.A. Monroe

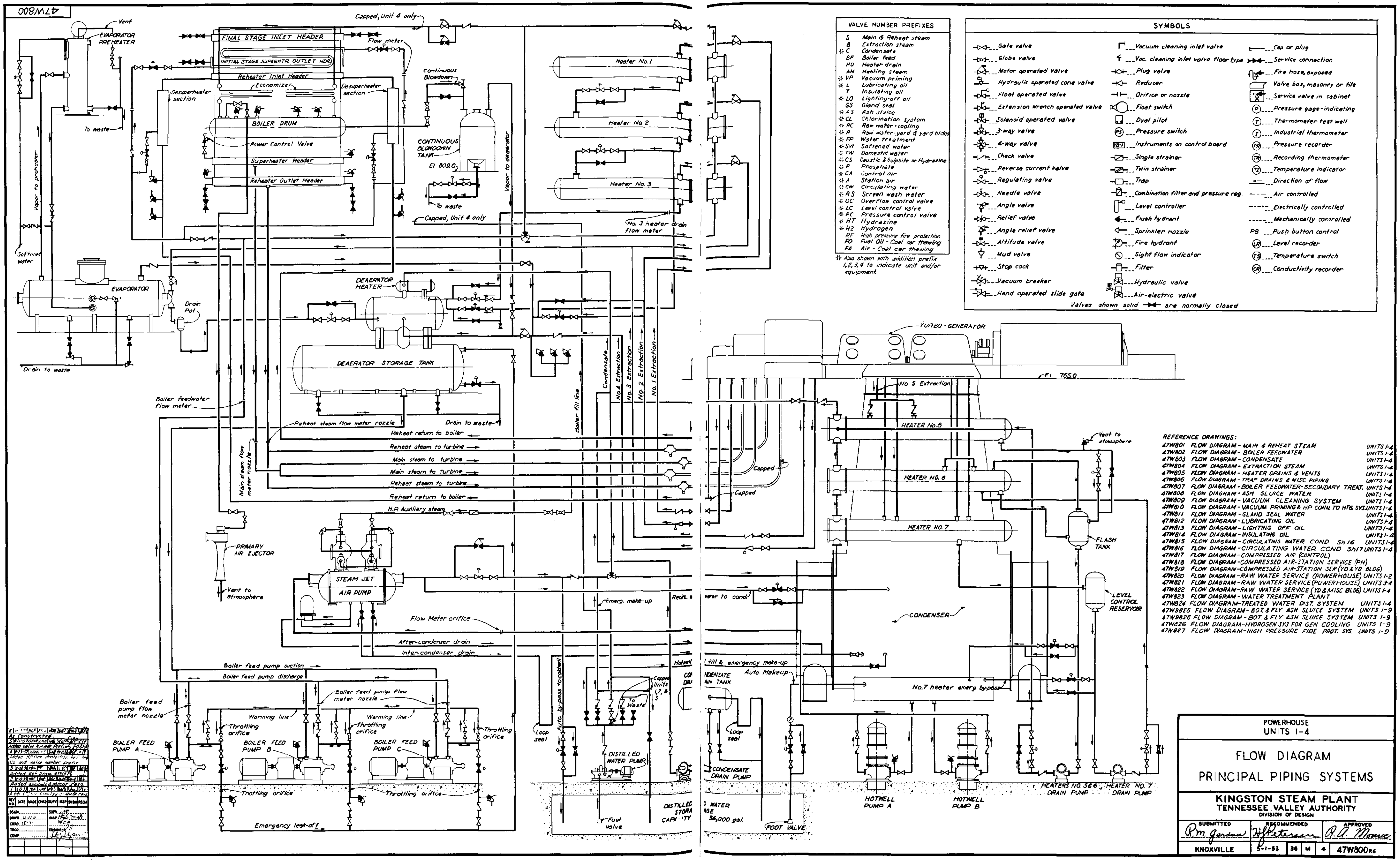
KNOXVILLE	11-4-52	36	M	4	47W219R3

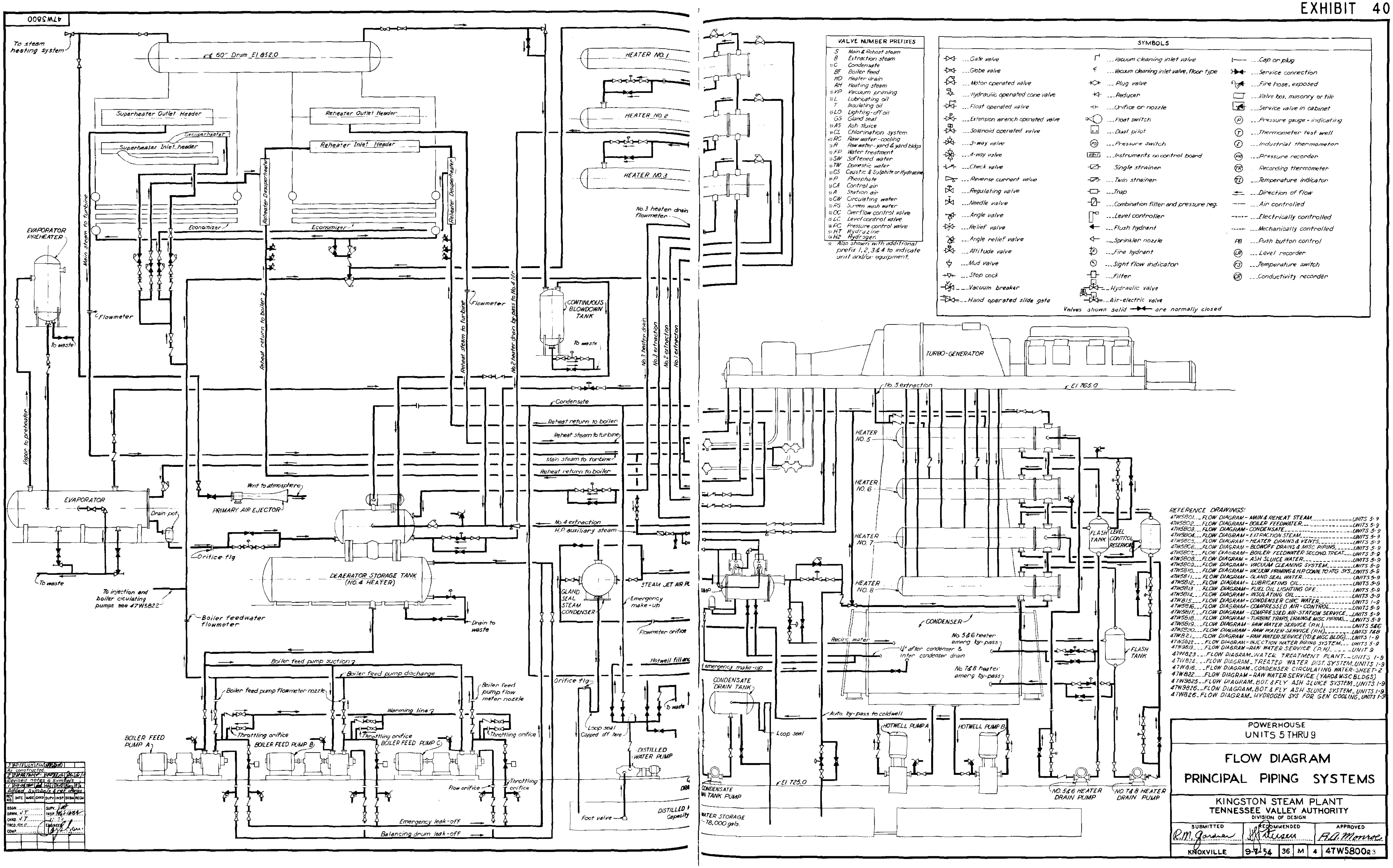


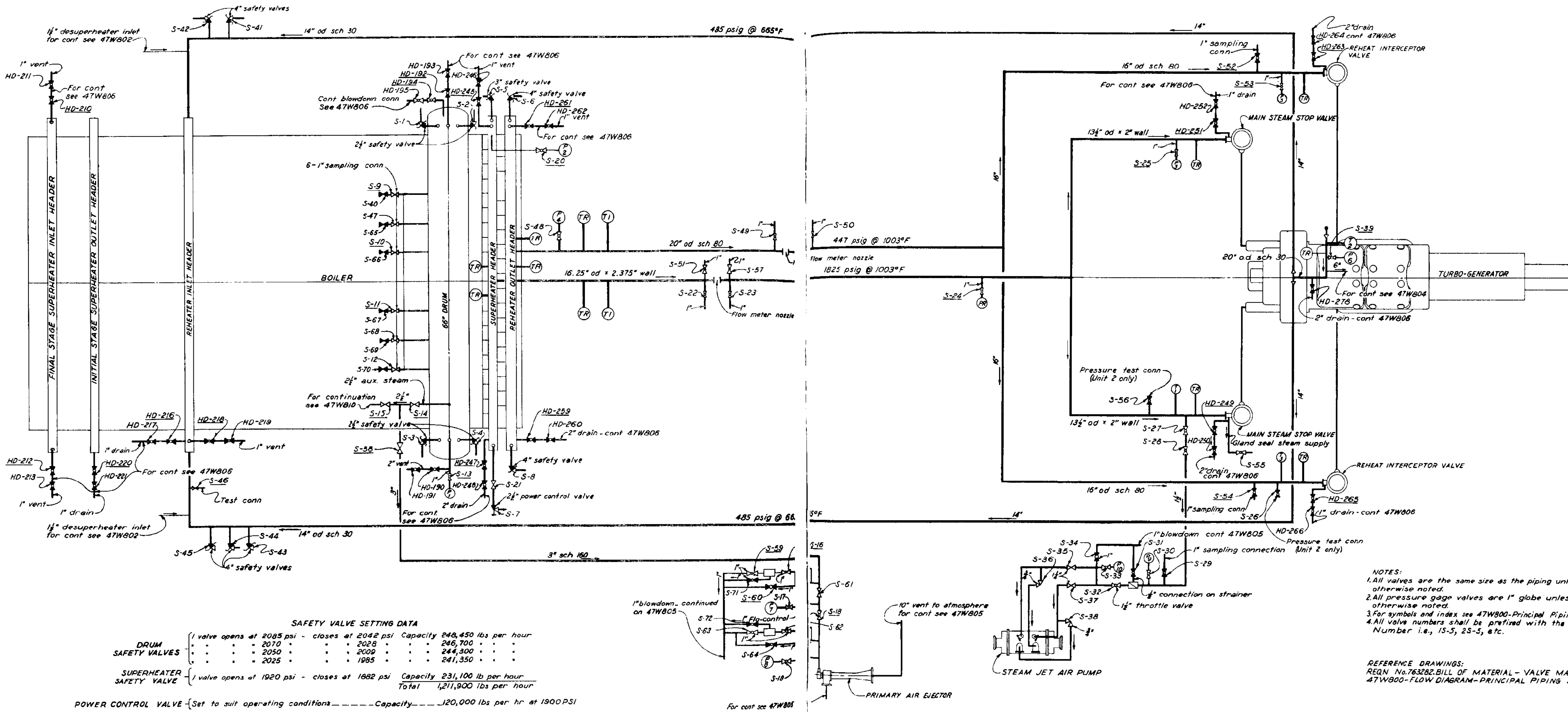
GENERATOR OUTPUT - KW	AUXILIARY POWER - KW	NET PLANT GEN - KW	NET PLANT HEAT RATE - BTU KWH
149,746	7,487	142,259	9,367



GENERATOR OUTPUT - KW	AUXILIARY POWER - KW	NET PLANT GEN KW	NET PLANT HEAT RATE - BTU/KWH
201,469	10,073	191,396	9,288


47W800
FINAL STAGE INLET HEADER
INITIAL STAGE SUPERHTR OUTLET HDR
Reheater Inlet Header
Economizer
BOILER DRUM
Power Control Valve
Superheater Header
Reheater Outlet Header
EVAPORATOR PREHEATER
EVAPORATOR
CONTINUOUS BLOWDOWN TANK
DEAERATOR HEATER
DEAERATOR STORAGE TANK
Heater No. 1
Heater No. 2
Heater No. 3
HEATER No. 5
HEATER NO. 6
HEATER NO. 7
TURBO-GENERATOR
CONDENSER
FLASH TANK
LEVEL CONTROL RESERVOIR
STEAM JET AIR PUMP
PRIMARY AIR EJECTOR
BOILER FEED PUMP A
BOILER FEED PUMP B
BOILER FEED PUMP C
DISTILLED WATER PUMP
CONDENSATE DRAIN PUMP
HOTWELL PUMP A
HOTWELL PUMP B
HEATERS NO. 5 & 6 DRAIN PUMP
HEATER NO. 7 DRAIN PUMP
Main steam to turbine
Reheat steam to turbine
Reheat return to boiler
Boiler feed pump suction
Boiler feed pump discharge
Emergency leak-off
VALVE NUMBER PREFIXES
S Main & Reheat steam
B Extraction steam
C Condensate
BF Boiler feed
HD Heater drain
AH Heating steam
VP Vacuum priming
L Lubricating oil
T Insulating oil
LO Lighting-off oil
GS Gland seal
AS Ash sluice
CL Chlorination system
RC Raw water-cooling
R Raw water-yard & yard bldgs
FP Water treatment
SW Softened water
TW Domestic water
CS Caustic & Sulphite or Hydrazine
P Phosphate
CA Control air
A Station air
CW Circulating water
RS Screen wash water
OC Overflow control valve
LC Level control valve
PC Pressure control valve
HT Hydrazine
H2 Hydrogen
PF High pressure fire protection
FO Fuel Oil - Coal car thawing
FA Air - Coal car thawing
SYMBOLS
Valves shown solid are normally closed
REFERENCE DRAWINGS:
47W801 FLOW DIAGRAM - MAIN & REHEAT STEAM UNITS 1-4
47W802 FLOW DIAGRAM - BOILER FEEDWATER UNITS 1-4
47W803 FLOW DIAGRAM - CONDENSATE UNITS 1-4
47W804 FLOW DIAGRAM - EXTRACTION STEAM UNITS 1-4
47W805 FLOW DIAGRAM - HEATER DRAINS & VENTS UNITS 1-4
47W806 FLOW DIAGRAM - TRAP DRAINS & MISC. PIPING UNITS 1-4
47W807 FLOW DIAGRAM - BOILER FEEDWATER-SECONDARY TREAT. UNITS 1-4
47W808 FLOW DIAGRAM - ASH SLUICE WATER UNITS 1-4
47W809 FLOW DIAGRAM - VACUUM CLEANING SYSTEM UNITS 1-4
47W810 FLOW DIAGRAM - VACUUM PRIMING & HP CONN. TO HTG. SYS. UNITS 1-4
47W811 FLOW DIAGRAM - GLAND SEAL WATER UNITS 1-4
47W812 FLOW DIAGRAM - LUBRICATING OIL UNITS 1-4
47W813 FLOW DIAGRAM - LIGHTING OFF OIL UNITS 1-4
47W814 FLOW DIAGRAM - INSULATING OIL UNITS 1-4
47W815 FLOW DIAGRAM - CIRCULATING WATER COND Sh16 UNITS 1-4
47W816 FLOW DIAGRAM - CIRCULATING WATER COND Sh17 UNITS 1-4
47W817 FLOW DIAGRAM - COMPRESSED AIR (CONTROL)
47W818 FLOW DIAGRAM - COMPRESSED AIR-STATION SERVICE (PH)
47W819 FLOW DIAGRAM - COMPRESSED AIR-STATION SER. (YD & YD BLDG)
47W820 FLOW DIAGRAM - RAW WATER SERVICE (POWERHOUSE) UNITS 1-2
47W821 FLOW DIAGRAM - RAW WATER SERVICE (POWERHOUSE) UNITS 3-4
47W822 FLOW DIAGRAM - RAW WATER SERVICE (YD & MISC BLDG) UNITS 1-4
47W823 FLOW DIAGRAM - WATER TREATMENT PLANT
47W824 FLOW DIAGRAM - TREATED WATER DIST. SYSTEM UNITS 1-4
47W9825 FLOW DIAGRAM - BOT. & FLY ASH SLUICE SYSTEM UNITS 1-9
47W9826 FLOW DIAGRAM - BOT. & FLY ASH SLUICE SYSTEM UNITS 1-9
47W826 FLOW DIAGRAM - HYDROGEN SYS FOR GEN COOLING UNITS 1-9
47W827 FLOW DIAGRAM - HIGH PRESSURE FIRE PROT. SYS. UNITS 1-9
POWERHOUSE
UNITS 1-4
FLOW DIAGRAM
PRINCIPAL PIPING SYSTEMS
KINGSTON STEAM PLANT
TENNESSEE VALLEY AUTHORITY
DIVISION OF DESIGN
SUBMITTED
RECOMMENDED
APPROVED
KNOXVILLE
5-1-53
47W800R6


47W5800
To steam heating system
60" Drum El 852.0
Superheater Outlet Header
Desuperheater
Superheater Inlet header
Reheater Outlet Header
Reheater Inlet Header
Reheater Desuperheater
Economizer
EVAPORATOR PREHEATER
Main steam to turbine
Flowmeter
To waste
Vapor to preheater
Reheat return to boiler 2
Reheat steam to turbine
No.2 heater drain by-pass to No.4 htr
CONTINUOUS BLOWDOWN TANK
HEATER NO.1
HEATER NO.2
HEATER NO.3
No.3 heater drain Flowmeter
No.1 heater drain
No.3 extraction
No.2 extraction
No.1 extraction
Condensate
Reheat return to boiler
Reheat steam to turbine
Main steam to turbine
Reheat return to boiler
Vent to atmosphere
PRIMARY AIR EJECTOR
EVAPORATOR
Drain pot
Orifice flg
To waste
No.4 extraction
H.P. auxiliary steam
DEAERATOR STORAGE TANK (NO.4 HEATER)
To injection and boiler circulating pumps see 47W5822
Boiler feedwater flowmeter
Drain to waste
GLAND SEAL STEAM CONDENSER
STEAM JET AIR
Emergency make-up
Flowmeter orifice
Hotwell fill
Boiler feed pump suction
Boiler feed pump discharge
Boiler feed pump flowmeter nozzle
Boiler feed pump flow meter nozzle
Warming line
Throttling orifice
BOILER FEED PUMP A
BOILER FEED PUMP B
BOILER FEED PUMP C
Flow orifice
Emergency leak-off
Balancing drum leak-off
Orifice flg
Loop seal Capped off here
To waste
DISTILLED WATER PUMP
Foot valve
DISTILLED Capacity
As constructed
Revised notes & symbols
Added symbols
VALVE NUMBER PREFIXES
S Main & Reheat steam
B Extraction steam
*C Condensate
BF Boiler feed
HD Heater drain
AH Heating steam
*VP Vacuum priming
*L Lubricating oil
T Insulating oil
*LO Lighting-off oil
GS Gland seal
*AS Ash sluice
*CL Chlorination system
*RC Raw water-cooling
*R Raw water-yard & yard bldgs
*FP Water treatment
*SW Softened water
*TW Domestic water
*CS Caustic & Sulphite or Hydrazine
*P Phosphate
*CA Control air
*A Station air
*CW Circulating water
*RS Screen wash water
*OC Overflow control valve
*LC Level control valve
*PC Pressure control valve
*HT Hydrazine
*H2 Hydrogen
* Also shown with additional prefix 1,2,3 & 4 to indicate unit and/or equipment.
SYMBOLS
...Gate valve
...Globe valve
...Motor operated valve
...Hydraulic operated cone valve
...Float operated valve
...Extension wrench operated valve
...Solenoid operated valve
...3-way valve
...4-way valve
...Check valve
...Reverse current valve
...Regulating valve
...Needle valve
...Angle valve
...Relief valve
...Angle relief valve
...Altitude valve
...Mud valve
...Stop cock
...Vacuum breaker
...Hand operated slide gate
...Vacuum cleaning inlet valve
...Vacuum cleaning inlet valve, floor type
...Plug valve
...Reducer
...Orifice or nozzle
...Float switch
...Dual pilot
...Pressure switch
...Instruments on control board
Single strainer
...Twin strainer
...Trap
...Combination filter and pressure reg.
...Level controller
...Flush hydrant
...Sprinkler nozzle
...Fire hydrant
...Sight flow indicator
...Filter
...Hydraulic valve
...Air-electric valve
...Cap or plug
...Service connection
...Fire hose, exposed
...Valve box, masonry or tile
...Service valve in cabinet
...Pressure gauge - indicating
...Thermometer test well
...Industrial thermometer
...Pressure recorder
Recording thermometer
...Temperature indicator
...Direction of flow
...Air controlled
...Electrically controlled
...Mechanically controlled
...Push button control
...Level recorder
...Temperature switch
...Conductivity recorder
Valves shown solid are normally closed
TURBO-GENERATOR
No.5 extraction
El 765.0
HEATER NO.5
HEATER NO.6
HEATER NO.7
HEATER NO.8
FLASH TANK
LEVEL CONTROL RESERVOIR
CONDENSER
Recirc water
1½" after condenser & inter condenser drain
No.5&6 heater emerg by-pass
No.7&8 heater emerg by-pass
emergency make-up
CONDENSATE DRAIN TANK
Auto by-pass to coldwell
Loop seal
HOTWELL PUMP A
HOTWELL PUMP B
El 725.0
CONDENSATE DRAIN TANK PUMP
WATER STORAGE 78,000 gals.
NO.5&6 HEATER DRAIN PUMP
NO.7&8 HEATER DRAIN PUMP
FLASH TANK
REFERENCE DRAWINGS:
47W5801__FLOW DIAGRAM - MAIN & REHEAT STEAM__UNITS 5-9
47W5802__FLOW DIAGRAM - BOILER FEEDWATER__UNITS 5-9
47W5803__FLOW DIAGRAM - CONDENSATE__UNITS 5-9
47W5804__FLOW DIAGRAM - EXTRACTION STEAM__UNITS 5-9
47W5805__FLOW DIAGRAM - HEATER DRAINS & VENTS__UNITS 5-9
47W5806__FLOW DIAGRAM - BLOWOFF DRAINS & MISC. PIPING__UNITS 5-9
47W5807__FLOW DIAGRAM - BOILER FEEDWATER SECOND. TREAT.__UNITS 5-9
47W5808__FLOW DIAGRAM - ASH SLUICE WATER__UNITS 5-9
47W5809__FLOW DIAGRAM - VACUUM CLEANING SYSTEM__UNITS 5-9
47W5810__FLOW DIAGRAM - VACUUM PRIMING & H.P. CONN. TO HTG SYS__UNITS 5-9
47W5811__FLOW DIAGRAM - GLAND SEAL WATER__UNITS 5-9
47W5812__FLOW DIAGRAM - LUBRICATING OIL__UNITS 5-9
47W5813__FLOW DIAGRAM - FUEL OIL LIGHTING OFF__UNITS 5-9
47W5814__FLOW DIAGRAM - INSULATING OIL__UNITS 5-9
47W815__FLOW DIAGRAM - CONDENSER CIRC WATER__UNITS 1-9
47W5816__FLOW DIAGRAM - COMPRESSED AIR - CONTROL__UNITS 5-9
47W5817__FLOW DIAGRAM - COMPRESSED AIR-STATION SERVICE__UNITS 5-9
47W5818__FLOW DIAGRAM - TURBINE TRAPS, DRAINS & MISC PIPING__UNITS 5-9
47W5819__FLOW DIAGRAM - RAW WATER SERVICE (P.H.)__UNITS 5&6
47W5820__FLOW DIAGRAM - RAW WATER SERVICE (P.H.)__UNITS 7&8
47W821__FLOW DIAGRAM - RAW WATER SERVICE (YD & MISC BLDG)__UNITS 1-9
47W5822__FLOW DIAGRAM - INJECTION WATER PIPING SYSTEM__UNITS 5-9
47W9819__FLOW DIAGRAM - RAW WATER SERVICE (P.H.)__UNIT 9
47W823__FLOW DIAGRAM_WATER TREATMENT PLANT__UNITS 1-9
47W824__FLOW DIAGRAM_TREATED WATER DIST. SYSTEM_UNITS 1-9
47W816__FLOW DIAGRAM_CONDENSER CIRCULATING WATER-SHEET-2
47W822__FLOW DIAGRAM - RAW WATER SERVICE (YARD & MISC BLDGS)
47W9825__FLOW DIAGRAM_BOT. & FLY ASH SLUICE SYSTEM_UNITS 1-9
47W9826__FLOW DIAGRAM_BOT. & FLY ASH SLUICE SYSTEM_UNITS 1-9
47W826_FLOW DIAGRAM_HYDROGEN SYS FOR GEN COOLING_UNITS 1-9
POWERHOUSE
UNITS 5 THRU 9
FLOW DIAGRAM
PRINCIPAL PIPING SYSTEMS
KINGSTON STEAM PLANT
TENNESSEE VALLEY AUTHORITY
DIVISION OF DESIGN
SUBMITTED
R.M. Gardner
RECOMMENDED
APPROVED
R.A. Monroe
KNOXVILLE
9-7-54
36
M
4
47W5800R3



SAFETY VALVE SETTING DATA

DRUM SAFETY VALVES	1 valve opens at 2085 psi - closes at 2042 psi	Capacity	248,450 lbs per hour
	" " " " 2070 " " " 2028 "	" "	246,700 " " "
	" " " " 2050 " " " 2009 "	" "	244,300 " " "
	" " " " 2025 " " " 1985 "	" "	241,350 " " "
SUPERHEATER SAFETY VALVE	1 valve opens at 1920 psi - closes at 1882 psi	Capacity	231,100 lb per hour
		Total	1,211,900 lbs per hour
POWER CONTROL VALVE	Set to suit operating conditions	Capacity	120,000 lbs per hr at 1900 PSI
REHEAT RETURN TO BOILER SAFETY VALVES	1-Valve opens at 550 psi closes at 539 psi	Capacity	227,600 lbs per hour
	" " " " 545 " " " 534 "	"	225,550 " " "
	" " " " 540 " " " 529 "	"	223,500 " " "
	" " " " 525 " " " 515 "	"	217,500 " " "
	" " " " 500 " " " 490 "	"	207,400 " " "
REHEAT STEAM TO TURBINE SAFETY VALVES	1 Valve opens at 480 psi closes at 470 psi	Capacity	174,100 lbs per hour
	" " " " 470 " " " 460 "	"	170,550 " " "
		Total	1,445,600 lbs per hour

NOTES:
1. All valves are the same size as the piping unless otherwise noted.
2. All pressure gage valves are 1" globe unless otherwise noted.
3. For symbols and index see 47W800-Principal Piping Systems.
4. All valve numbers shall be prefixed with the Unit Number i.e., 1S-5, 2S-5, etc.

REFERENCE DRAWINGS:
REQN No.763282.BILL OF MATERIAL - VALVE MARKER TAGS
47W800-FLOW DIAGRAM-PRINCIPAL PIPING SYSTEMS.

REV NO.	DATE	MADE	CHKD	SUPV	INSP	SUBM	RECM
4	[illegible]	HLF	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
As Constructed.							
3	[illegible]	[illegible]	LK	LK	[illegible]	[illegible]	[illegible]
Field changes							
2	[illegible]	ETW	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Added shut-off valve S-69							
1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
Minor revisions							

DSGN.
DRWN. W.E.B.
CHKD. [illegible]
TRCD.
COMP.
SUPV. [illegible]
INSP. [illegible]
WCB
ENGINEER [signature]

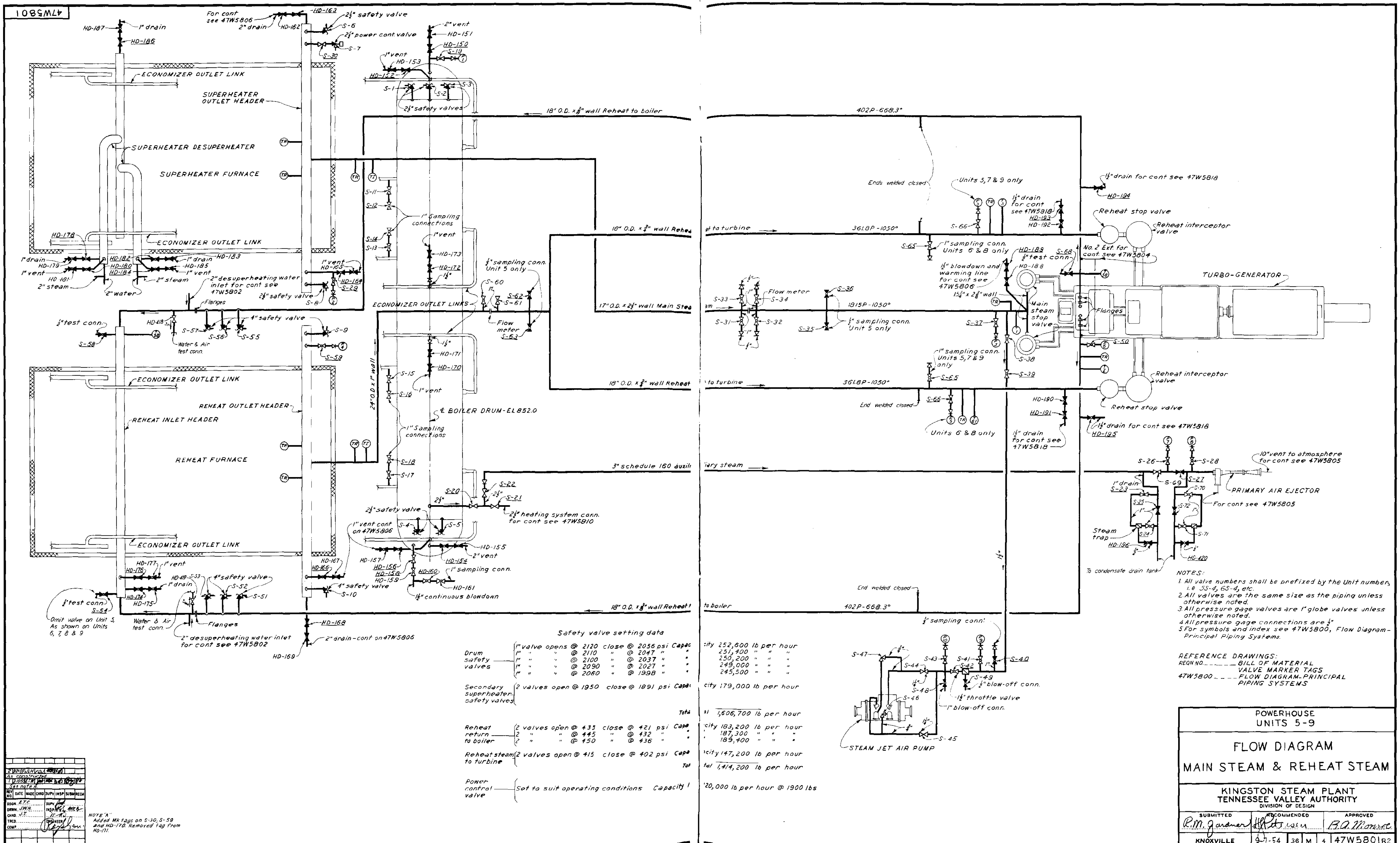
POWERHOUSE
UNITS 1, 2, 3 & 4

FLOW DIAGRAM MAIN STEAM & REHEAT STEAM

KINGSTON STEAM PLANT
TENNESSEE VALLEY AUTHORITY
DIVISION OF DESIGN

SUBMITTED	RECOMMENDED	APPROVED
[signature]	[signature]	[signature]

KNOXVILLE	5-1-53	36	M	4	47W801R4


47W5801
ECONOMIZER OUTLET LINK
SUPERHEATER OUTLET HEADER
SUPERHEATER DESUPERHEATER
SUPERHEATER FURNACE
ECONOMIZER OUTLET LINK
REHEAT OUTLET HEADER
REHEAT INLET HEADER
REHEAT FURNACE
ECONOMIZER OUTLET LINKS
℄ BOILER DRUM-EL 852.0
18" O.D. x 3/8" wall Reheat to boiler
18" O.D. x 3/4" wall Reheat to turbine
17" O.D. x 2 1/4" wall Main Steam
3" schedule 160 auxiliary steam
402P-668.3°
3618P-1050°
1815P-1050°
TURBO-GENERATOR
Reheat stop valve
Reheat interceptor valve
Main steam stop valve
PRIMARY AIR EJECTOR
STEAM JET AIR PUMP
Safety valve setting data
Drum safety valves: 1" valve opens @ 2120 close @ 2056 psi Capacity 252,600 lb per hour; 1" @ 2110 close @ 2047 251,400; 1" @ 2100 close @ 2037 250,200; 1" @ 2090 close @ 2027 249,000; 1" @ 2060 close @ 1998 245,500
Secondary superheater safety valves: 2 valves open @ 1950 close @ 1891 psi Capacity 179,000 lb per hour
Total 1,606,700 lb per hour
Reheat return to boiler: 2 valves open @ 433 close @ 421 psi Capacity 183,200 lb per hour; 2 @ 445 @ 432 187,300; 2 @ 450 @ 436 189,400
Reheat steam to turbine: 2 valves open @ 415 close @ 402 psi Capacity 147,200 lb per hour
Total 1,414,200 lb per hour
Power control valve: Set to suit operating conditions Capacity 120,000 lb per hour @ 1900 lbs
NOTES:
1. All valve numbers shall be prefixed by the Unit number, i.e. 5S-4, 6S-4, etc.
2. All valves are the same size as the piping unless otherwise noted.
3. All pressure gage valves are 1" globe valves unless otherwise noted.
4. All pressure gage connections are 1/2".
5. For symbols and index see 47W5800, Flow Diagram-Principal Piping Systems.
REFERENCE DRAWINGS:
REQN NO. — BILL OF MATERIAL, VALVE MARKER TAGS
47W5800 — FLOW DIAGRAM-PRINCIPAL PIPING SYSTEMS
NOTE "A" Added Mk tags on S-30, S-59 and HD-170. Removed tag from HD-171.
POWERHOUSE UNITS 5-9
FLOW DIAGRAM
MAIN STEAM & REHEAT STEAM
KINGSTON STEAM PLANT
TENNESSEE VALLEY AUTHORITY
DIVISION OF DESIGN
SUBMITTED R.M. Gardner RECOMMENDED APPROVED B.O. Monroe
KNOXVILLE 9-1-54 36 M 4 47W5801R2

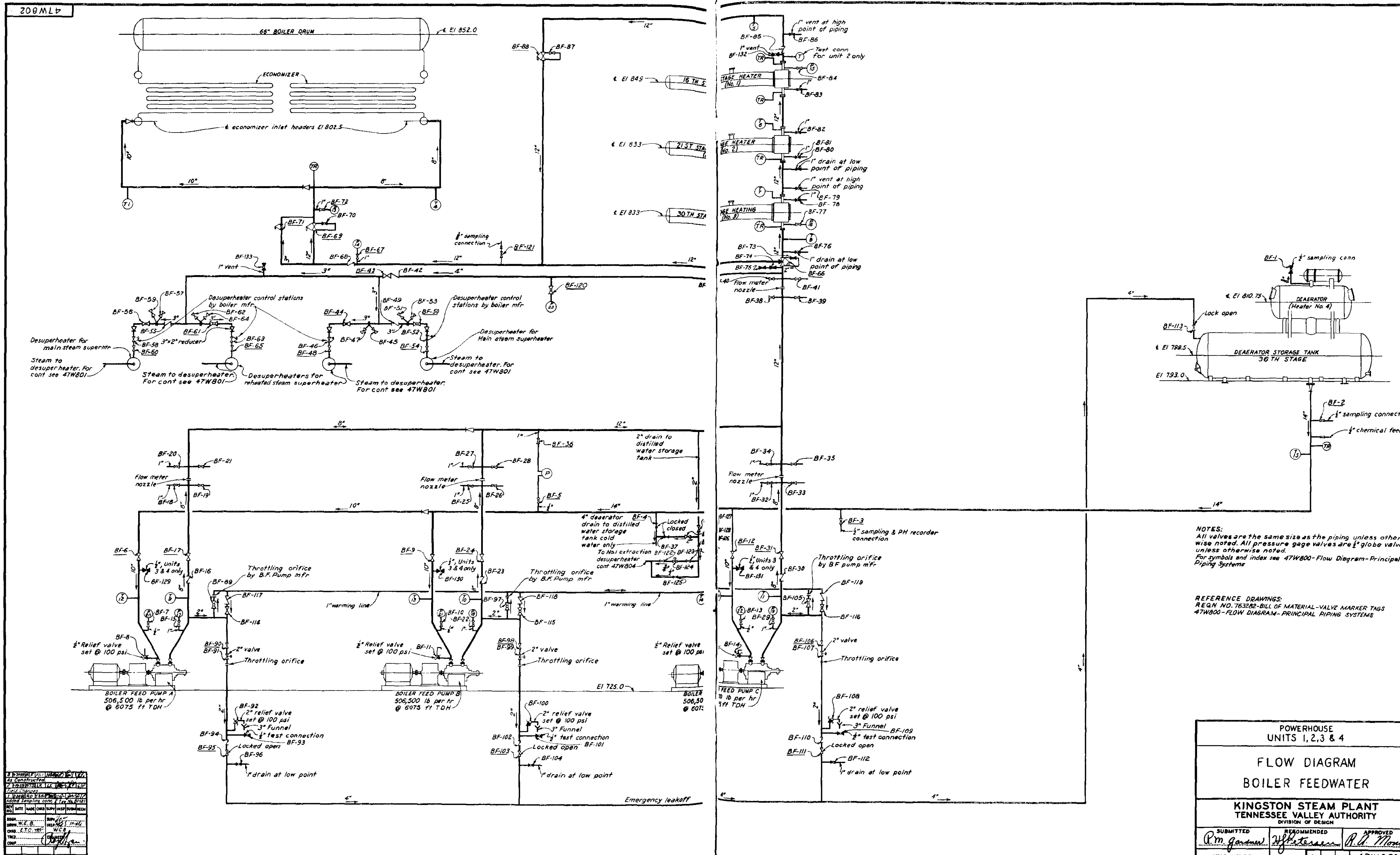
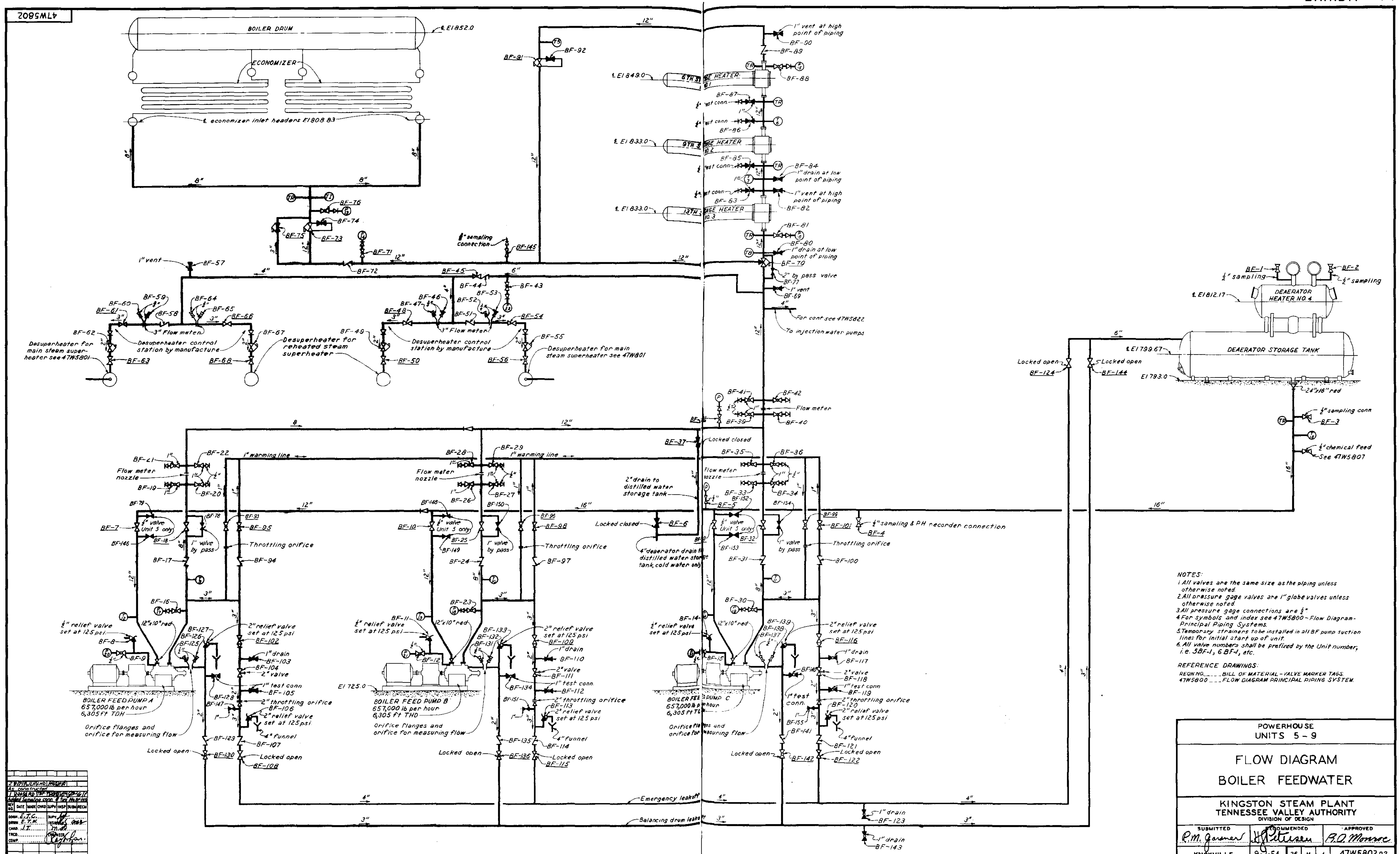

47W802
66" BOILER DRUM
℄ El 852.0
ECONOMIZER
℄ economizer inlet headers El 802.5
Desuperheater control stations by boiler mfr
Desuperheater for main steam superhtr
Steam to desuperheater. For cont see 47W801
Desuperheaters for reheated steam superheater
Desuperheater for Main steam superheater
Stage Heater (No. 1)
Stage Heater (No. 2)
Stage Heating (No. 3)
1" vent at high point of piping
Test conn. for unit 2 only
1" drain at low point of piping
Flow meter nozzle
℄ El 810.75
DEAERATOR (Heater No. 4)
Lock open
℄ El 798.5
DEAERATOR STORAGE TANK 36 TH STAGE
El 793.0
1/2" sampling connection
1/2" chemical feed
2" drain to distilled water storage tank
4" deaerator drain to distilled water storage tank cold water only
Locked closed
To No. 1 extraction desuperheater cont 47W804
1/2" sampling & PH recorder connection
Throttling orifice by B.F. Pump mfr
1" warming line
1/2" Relief valve set @ 100 psi
2" valve
Throttling orifice
BOILER FEED PUMP A 506,500 lb per hr @ 6075 ft TDH
BOILER FEED PUMP B 506,500 lb per hr @ 6075 ft TDH
BOILER FEED PUMP C
El 725.0
2" relief valve set @ 100 psi
3" Funnel
1/2" test connection
Locked open
1" drain at low point
Emergency leakoff
NOTES:
All valves are the same size as the piping unless otherwise noted. All pressure gage valves are 1/2" globe valves unless otherwise noted.
For symbols and index see 47W800-Flow Diagram-Principal Piping Systems
REFERENCE DRAWINGS:
REQN NO. 763282-BILL OF MATERIAL-VALVE MARKER TAGS
47W800-FLOW DIAGRAM-PRINCIPAL PIPING SYSTEMS
POWERHOUSE
UNITS 1,2,3 & 4
FLOW DIAGRAM
BOILER FEEDWATER
KINGSTON STEAM PLANT
TENNESSEE VALLEY AUTHORITY
DIVISION OF DESIGN
SUBMITTED
RECOMMENDED
APPROVED
KNOXVILLE
5-1-53
47W802R3

EXHIBIT 44



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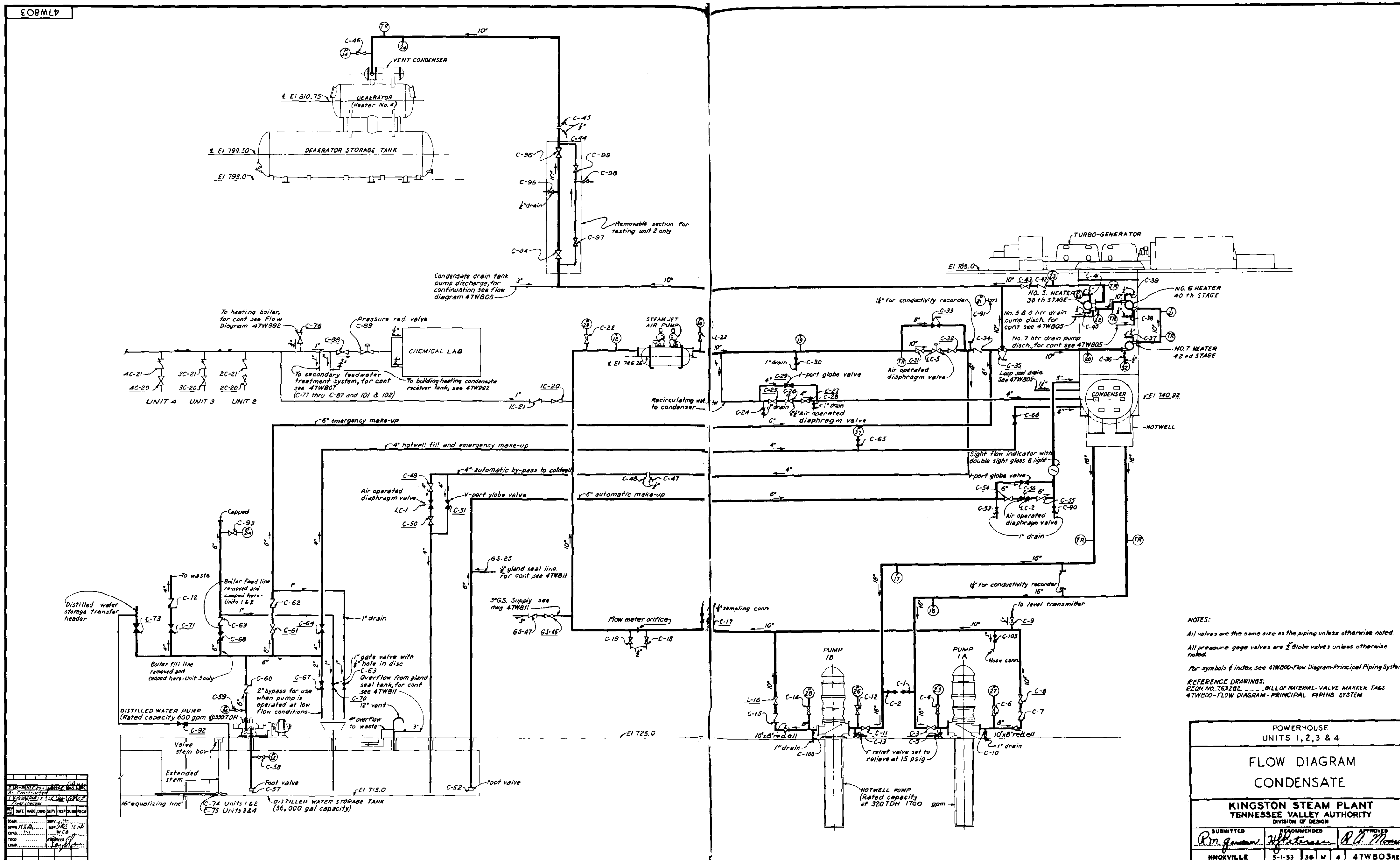

VENT CONDENSER
DEAERATOR (Heater No. 4)
DEAERATOR STORAGE TANK
℄ El 810.75
℄ El 799.50
El 793.0
Removable section for testing unit 2 only
Condensate drain tank pump discharge, for continuation see flow diagram 47W805
To heating boiler, for cont see Flow Diagram 47W992
Pressure red. valve C-89
CHEMICAL LAB
To secondary feedwater treatment system, for cont see 47W807 (C-77 thru C-87 and 101 & 102)
To building-heating condensate receiver tank, see 47W992
UNIT 4
UNIT 3
UNIT 2
STEAM JET AIR PUMP
℄ El 746.26
Recirculating wat. to condenser
6" emergency make-up
4" hotwell fill and emergency make-up
4" automatic by-pass to coldwell
6" automatic make-up
Air operated diaphragm valve
V-port globe valve
Capped
To waste
Boiler Feed line removed and capped here-Units 1 & 2
Distilled water storage transfer header
Boiler fill line removed and capped here-Unit 3 only
1" drain
2" bypass for use when pump is operated at low flow conditions
1" gate valve with 1/8" hole in disc
Overflow from gland seal tank, for cont see 47W811
12" vent
4" overflow to waste
DISTILLED WATER PUMP (Rated capacity 600 gpm @ 350 TDH)
Valve stem box
Extended stem
16" equalizing line
C-74 Units 1 & 2
C-75 Units 3 & 4
Foot valve
DISTILLED WATER STORAGE TANK (56,000 gal capacity)
El 725.0
El 715.0
1/2" gland seal line. For cont see 47W811
3" G.S. Supply see dwg 47W811
Flow meter orifice
1/2" sampling conn
TURBO-GENERATOR
El 765.0
NO. 5 HEATER 38 th STAGE
NO. 6 HEATER 40 th STAGE
NO. 7 HEATER 42 nd STAGE
No. 5 & 6 htr drain pump disch. for cont see 47W805
No. 7 htr drain pump disch., for cont see 47W805
1 1/2" for conductivity recorder
Loop seal drain. See 47W805
CONDENSER
El 740.92
HOTWELL
Sight flow indicator with double sight glass & light
Air operated diaphragm valve
1" drain
To level transmitter
Hose conn.
PUMP 1B
PUMP 1A
10"x8" red. ell
1" relief valve set to relieve at 15 psig
HOTWELL PUMP (Rated capacity at 320 TDH 1700 gpm)
NOTES:
All valves are the same size as the piping unless otherwise noted.
All pressure gage valves are 1/2" Globe valves unless otherwise noted.
For symbols & index see 47W800-Flow Diagram-Principal Piping System.
REFERENCE DRAWINGS:
REQN. NO. 763282 ____ BILL OF MATERIAL-VALVE MARKER TAGS
47W800-FLOW DIAGRAM-PRINCIPAL PIPING SYSTEM
POWERHOUSE
UNITS 1, 2, 3 & 4
FLOW DIAGRAM
CONDENSATE
KINGSTON STEAM PLANT
TENNESSEE VALLEY AUTHORITY
DIVISION OF DESIGN
SUBMITTED
RECOMMENDED
APPROVED
KNOXVILLE
5-1-53
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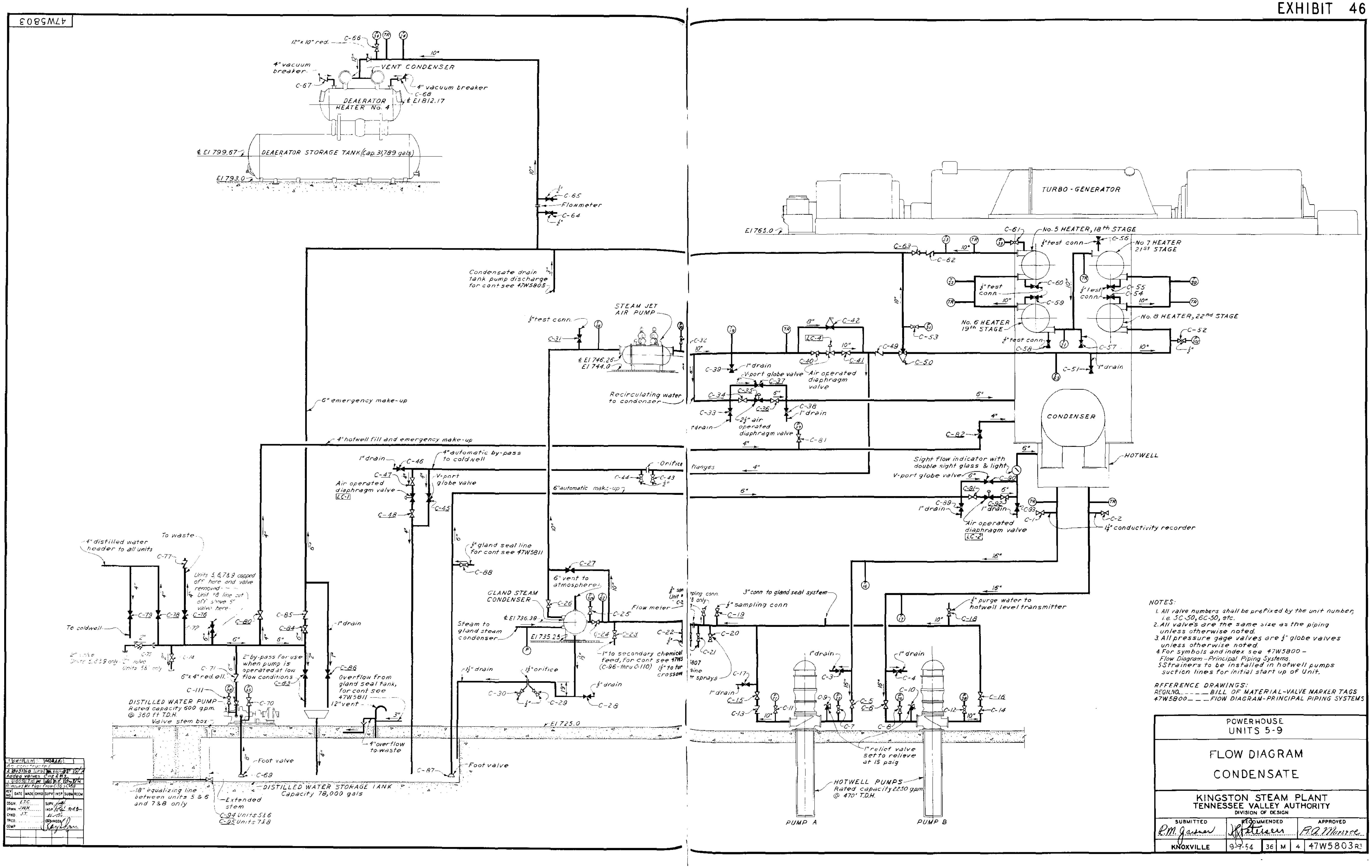
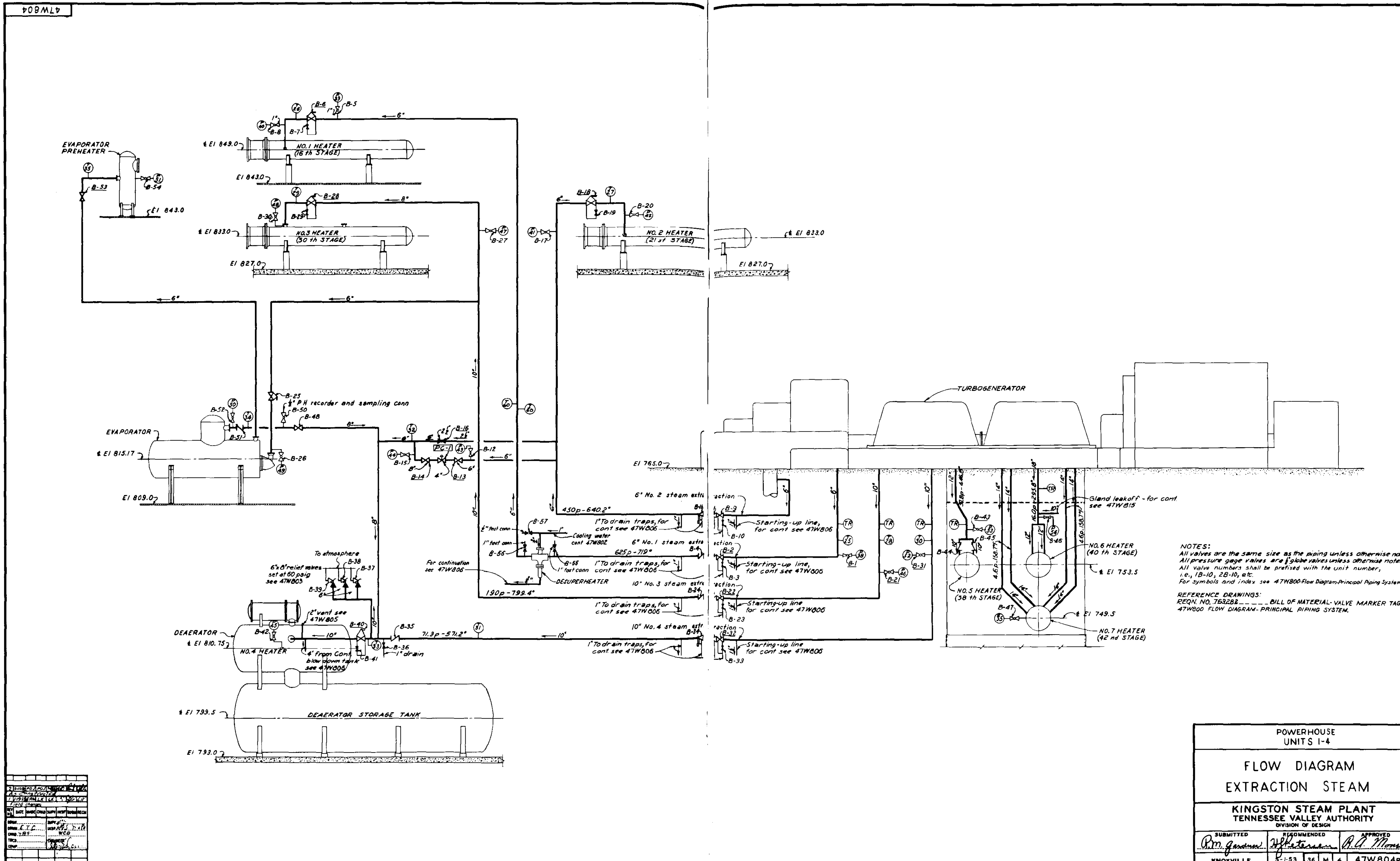
47W803R2



47W5803
VENT CONDENSER
4" vacuum breaker
DEAERATOR HEATER No. 4
DEAERATOR STORAGE TANK (Cap. 31,789 gals)
Flowmeter
TURBO-GENERATOR
No. 5 HEATER, 18th STAGE
No. 7 HEATER 21st STAGE
No. 6 HEATER 19th STAGE
No. 8 HEATER, 22nd STAGE
Condensate drain tank pump discharge for cont see 47W5805
STEAM JET AIR PUMP
Recirculating water to condenser
6" emergency make-up
4" hotwell fill and emergency make-up
4" automatic by-pass to coldwell
Air operated diaphragm valve
V-port globe valve
CONDENSER
HOTWELL
Sight flow indicator with double sight glass & light
1½" conductivity recorder
GLAND STEAM CONDENSER
6" vent to atmosphere
Flow meter
Steam to gland steam condenser
1" to secondary chemical feed, for cont see 47W5
3" conn to gland seal system
½" sampling conn
½" purge water to hotwell level transmitter
4" distilled water header to all units
To waste
To coldwell
DISTILLED WATER PUMP Rated capacity 600 g.p.m. @ 360 ft T.D.H.
Valve stem box
Overflow from gland seal tank, for cont see 47W5811
4" overflow to waste
Foot valve
DISTILLED WATER STORAGE TANK Capacity 78,000 gals
18" equalizing line between units 5 & 6 and 7 & 8 only
Extended stem
C-94 Units 5 & 6
C-95 Units 7 & 8
1" relief valve set to relieve at 15 psig
HOTWELL PUMPS Rated capacity 2250 gpm @ 470' T.D.H.
PUMP A
PUMP B
NOTES:
1. All valve numbers shall be prefixed by the unit number, i.e. 5C-50, 6C-50, etc.
2. All valve's are the same size as the piping unless otherwise noted.
3. All pressure gage valves are ½" globe valves unless otherwise noted.
4. For symbols and index see 47W5800 - Flow Diagram - Principal Piping Systems.
5. Strainers to be installed in hotwell pumps suction lines for initial start up of Unit.
REFERENCE DRAWINGS:
REQN.NO. BILL OF MATERIAL-VALVE MARKER TAGS
47W5800 FLOW DIAGRAM-PRINCIPAL PIPING SYSTEMS
POWERHOUSE UNITS 5-9
FLOW DIAGRAM CONDENSATE
KINGSTON STEAM PLANT
TENNESSEE VALLEY AUTHORITY
DIVISION OF DESIGN
SUBMITTED
RECOMMENDED
APPROVED
KNOXVILLE
9-7-54
36 M 4 47W5803 R3


47W804
EVAPORATOR PREHEATER
El 843.0
NO. 1 HEATER (16 th STAGE)
El 849.0
El 843.0
NO. 3 HEATER (30 th STAGE)
El 833.0
El 827.0
NO. 2 HEATER (21 st STAGE)
El 833.0
El 827.0
PH recorder and sampling conn
EVAPORATOR
El 815.17
El 809.0
El 765.0
TURBOGENERATOR
6" No. 2 steam extraction
450p-640.2°
1" To drain traps, for cont see 47W806
Starting-up line, for cont see 47W806
6" No. 1 steam extraction
625p-719°
1" To drain traps, for cont see 47W806
Starting-up line, for cont see 47W806
10" No. 3 steam extraction
190p-799.4°
1" To drain traps, for cont see 47W806
Starting-up line, for cont see 47W806
10" No. 4 steam extraction
71.3p-571.2°
1" To drain traps, for cont. see 47W806
Starting-up line for cont see 47W806
Cooling water cont 47W802
DESUPERHEATER
For continuation see 47W806
To atmosphere
6"x8" relief valves set at 60 psig see 47W803
2" vent see 47W805
DEAERATOR
El 810.75
NO. 4 HEATER
4" From Cont blow down tank see 47W806
1" drain
El 799.5
DEAERATOR STORAGE TANK
El 793.0
Gland leakoff - for cont see 47W815
NO. 6 HEATER (40 th STAGE)
El 753.5
NO. 5 HEATER (38 th STAGE)
El 749.5
NO. 7 HEATER (42 nd STAGE)
NOTES:
All valves are the same size as the piping unless otherwise noted.
All pressure gage valves are ¼" globe valves unless otherwise noted.
All valve numbers shall be prefixed with the unit number, i.e., 1B-10, 2B-10, etc.
For symbols and index see 47W800-Flow Diagram-Principal Piping System.
REFERENCE DRAWINGS:
REQN. NO. 763282 _ _ _ _ _ BILL OF MATERIAL - VALVE MARKER TAGS
47W800 FLOW DIAGRAM - PRINCIPAL PIPING SYSTEM.
POWERHOUSE
UNITS 1-4
FLOW DIAGRAM
EXTRACTION STEAM
KINGSTON STEAM PLANT
TENNESSEE VALLEY AUTHORITY
DIVISION OF DESIGN
SUBMITTED
R.M. Gardner
RECOMMENDED
H.J. Petersen
APPROVED
R.A. Monroe
KNOXVILLE
5-1-53
36
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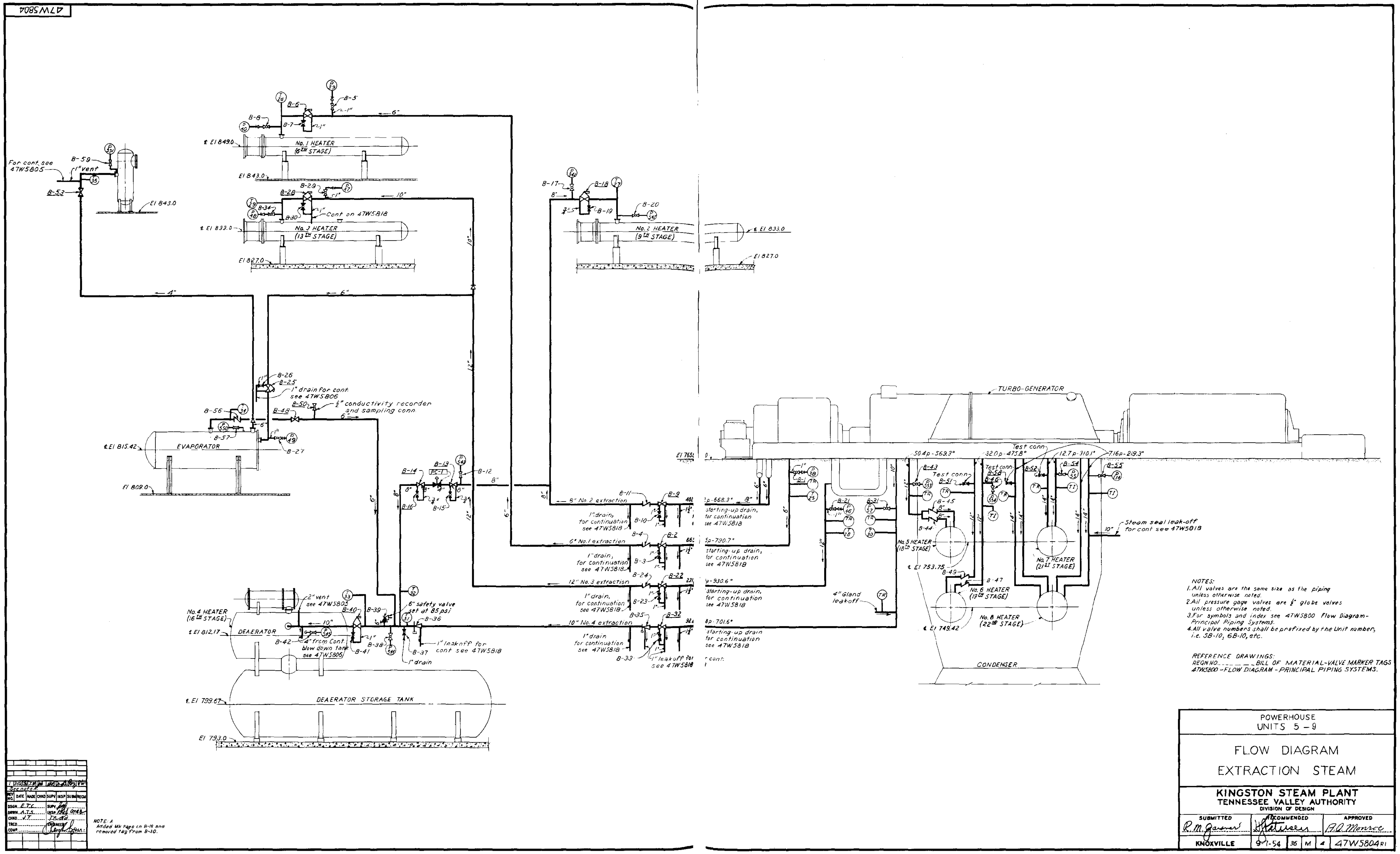
47W804R2


47W5804
No. 1 HEATER (6TH STAGE)
No. 3 HEATER (13TH STAGE)
No. 2 HEATER (9TH STAGE)
EVAPORATOR
No. 4 HEATER (16TH STAGE)
DEAERATOR
DEAERATOR STORAGE TANK
TURBO-GENERATOR
No. 5 HEATER (18TH STAGE)
No. 6 HEATER (19TH STAGE)
No. 7 HEATER (21ST STAGE)
No. 8 HEATER (22ND STAGE)
CONDENSER
8" No. 2 extraction
6" No. 1 extraction
12" No. 3 extraction
10" No. 4 extraction
6" safety valve set at 85 psi
Steam seal leak-off for cont see 47W5818
NOTES:
1. All valves are the same size as the piping unless otherwise noted.
2. All pressure gage valves are ½" globe valves unless otherwise noted.
3. For symbols and index see 47W5800 Flow Diagram-Principal Piping Systems.
4. All valve numbers shall be prefixed by the Unit number, i.e. 5B-10, 6B-10, etc.
REFERENCE DRAWINGS:
REQN NO. _ _ _ _ _ _ _ BILL OF MATERIAL-VALVE MARKER TAGS
47W5800 - FLOW DIAGRAM - PRINCIPAL PIPING SYSTEMS.
NOTE: A Added Mk tags on B-16 and removed tag from B-30.
POWERHOUSE
UNITS 5 – 9
FLOW DIAGRAM
EXTRACTION STEAM
KINGSTON STEAM PLANT
TENNESSEE VALLEY AUTHORITY
DIVISION OF DESIGN
SUBMITTED
RECOMMENDED
APPROVED
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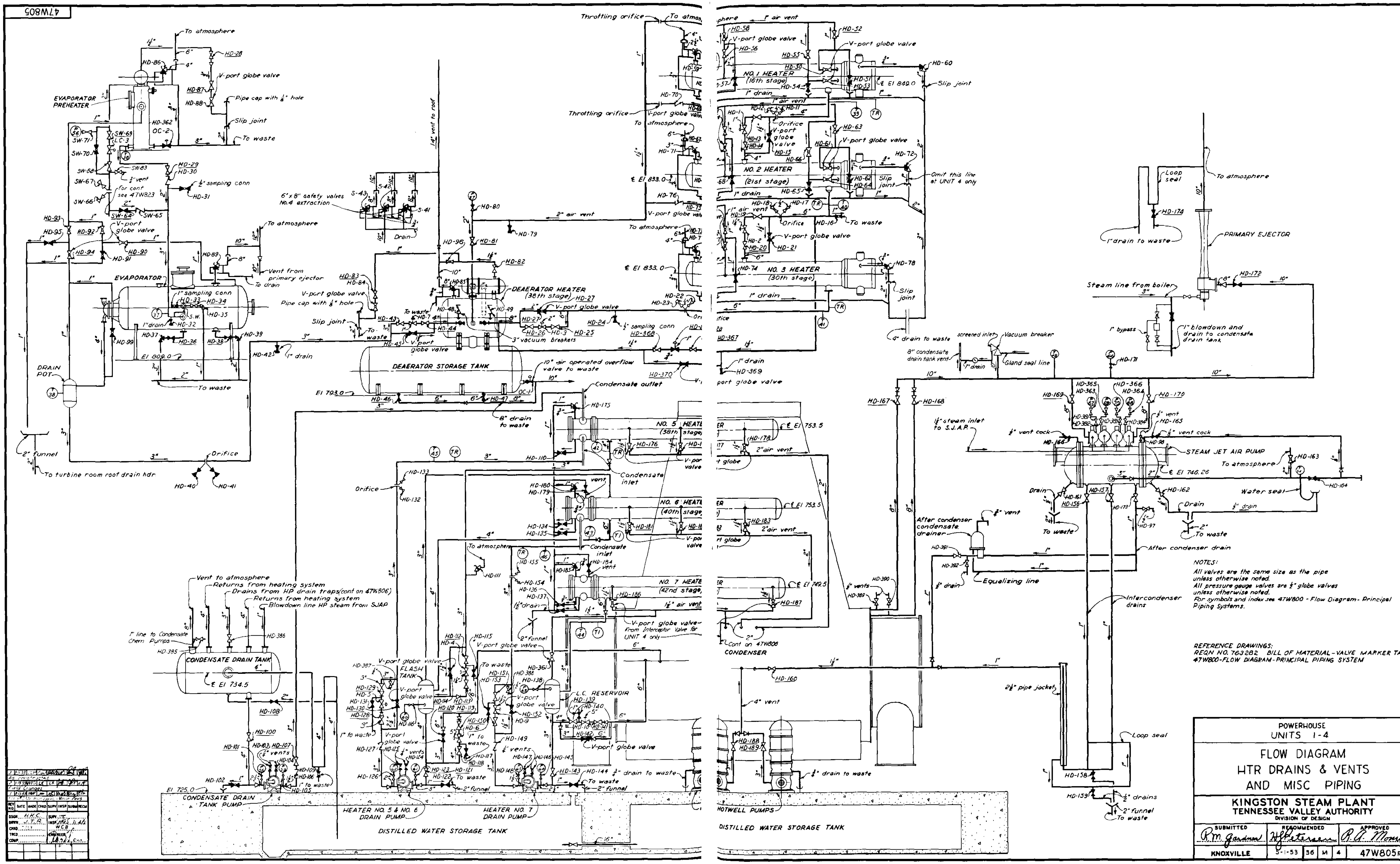
47W5804 R1

EXHIBIT 49



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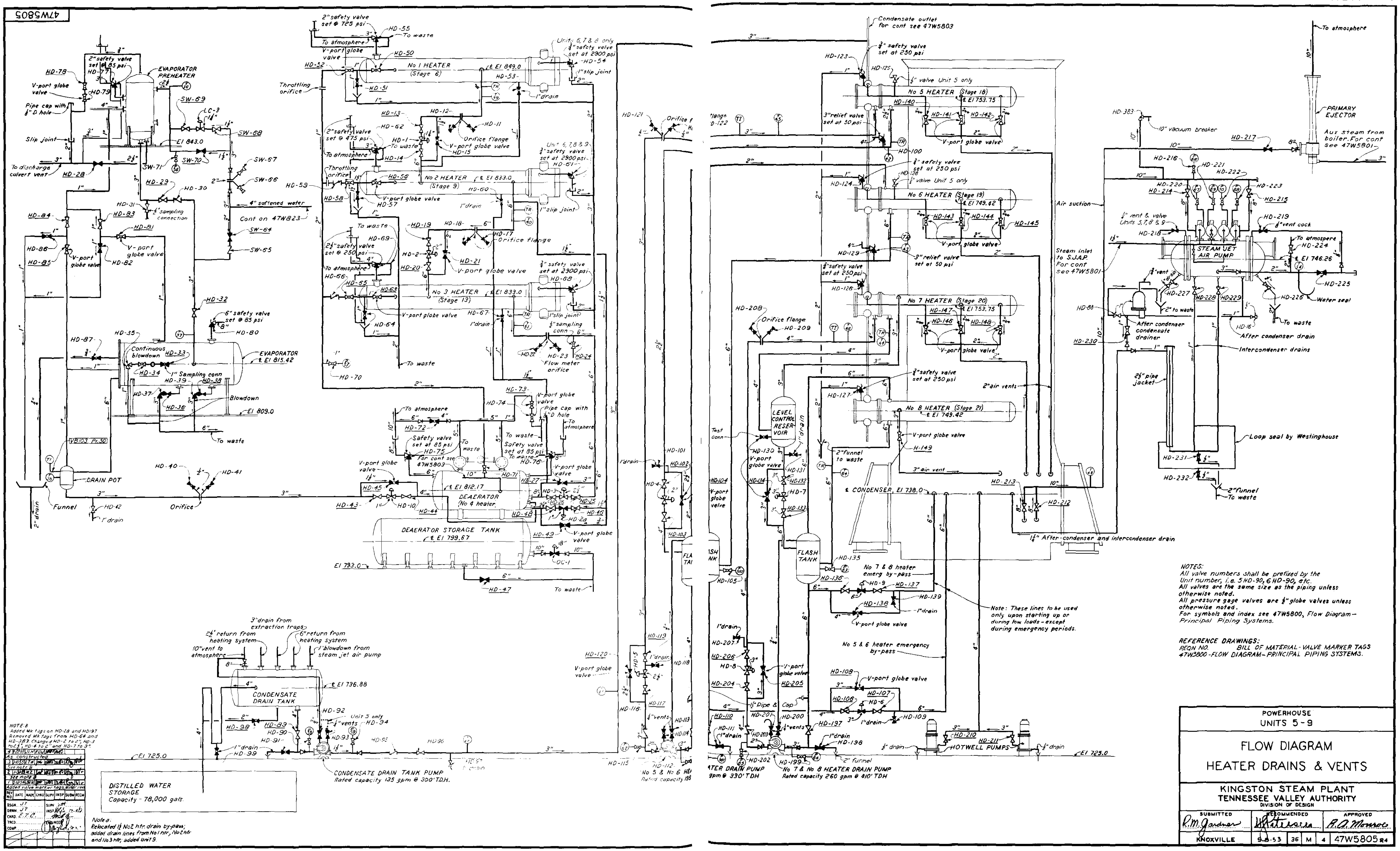
47W5805
EVAPORATOR PREHEATER
EVAPORATOR
DRAIN POT
No 1 HEATER (Stage 6)
No 2 HEATER (Stage 9)
No 3 HEATER (Stage 13)
DEAERATOR (No 4 heater)
DEAERATOR STORAGE TANK
CONDENSATE DRAIN TANK
CONDENSATE DRAIN TANK PUMP
Rated capacity 135 gpm @ 300' T.D.H.
DISTILLED WATER STORAGE
Capacity - 78,000 gals.
No 5 HEATER (Stage 18)
No 6 HEATER (Stage 19)
No 7 HEATER (Stage 20)
No 8 HEATER (Stage 21)
LEVEL CONTROL RESERVOIR
FLASH TANK
CONDENSER, El 738.0
STEAM JET AIR PUMP
PRIMARY EJECTOR
HOTWELL PUMPS
No 7 & No 8 HEATER DRAIN PUMP
Rated capacity 260 gpm @ 410' TDH
Loop seal by Westinghouse
Note: These lines to be used only upon starting up or during low loads - except during emergency periods.
Note a:
Relocated 1½ No2 htr. drain by-pass; added drain lines from No1 htr, No2 htr and No3 htr; added unit 9.
NOTES:
All valve numbers shall be prefixed by the Unit number, i.e. 5HD-90, 6HD-90, etc.
All valves are the same size as the piping unless otherwise noted.
All pressure gage valves are ½" globe valves unless otherwise noted.
For symbols and index see 47W5800, Flow Diagram - Principal Piping Systems.
REFERENCE DRAWINGS:
REQN NO. BILL OF MATERIAL - VALVE MARKER TAGS
47W5800 - FLOW DIAGRAM - PRINCIPAL PIPING SYSTEMS.
POWERHOUSE
UNITS 5-9
FLOW DIAGRAM
HEATER DRAINS & VENTS
KINGSTON STEAM PLANT
TENNESSEE VALLEY AUTHORITY
DIVISION OF DESIGN
SUBMITTED
RECOMMENDED
APPROVED
KNOXVILLE
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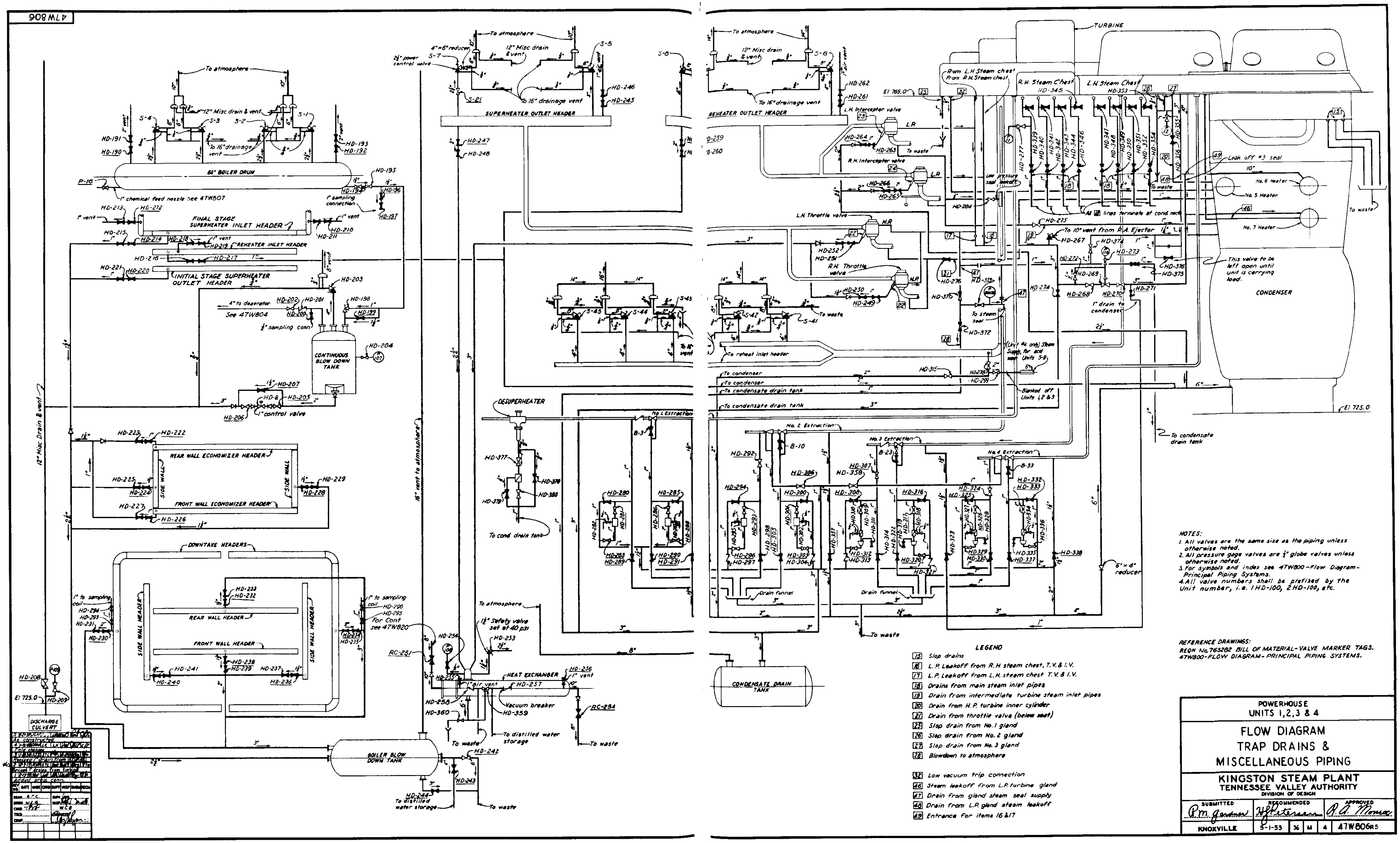
47W5805 R4


47W806
TURBINE
R.H. Steam Chest
L.H. Steam Chest
CONDENSER
66" BOILER DRUM
FINAL STAGE SUPERHEATER INLET HEADER
REHEATER INLET HEADER
INITIAL STAGE SUPERHEATER OUTLET HEADER
SUPERHEATER OUTLET HEADER
REHEATER OUTLET HEADER
CONTINUOUS BLOW DOWN TANK
REAR WALL ECONOMIZER HEADER
FRONT WALL ECONOMIZER HEADER
DOWNTAKE HEADERS
REAR WALL HEADER
FRONT WALL HEADER
SIDE WALL HEADER
DESUPERHEATER
HEAT EXCHANGER
BOILER BLOW DOWN TANK
CONDENSATE DRAIN TANK
No. 6 Heater
No. 5 Heater
No. 7 Heater
NOTES:
1. All valves are the same size as the piping unless otherwise noted.
2. All pressure gage valves are ½" globe valves unless otherwise noted.
3. For symbols and index see 47W800-Flow Diagram-Principal Piping Systems.
4. All valve numbers shall be prefixed by the Unit number, i.e. 1HD-100, 2HD-100, etc.
REFERENCE DRAWINGS:
REQN No. 763282 BILL OF MATERIAL-VALVE MARKER TAGS.
47W800-FLOW DIAGRAM-PRINCIPAL PIPING SYSTEMS.
LEGEND
15 Slop drains
16 L.P. Leakoff from R.H. steam chest, T.V. & I.V.
17 L.P. Leakoff from L.H. steam chest T.V. & I.V.
18 Drains from main steam inlet pipes
19 Drain from intermediate turbine steam inlet pipes
20 Drain from H.P. turbine inner cylinder
21 Drain from throttle valve (below seat)
25 Slop drain from No. 1 gland
26 Slop drain from No. 2 gland
27 Slop drain from No. 3 gland
28 Blowdown to atmosphere
32 Low vacuum trip connection
46 Steam leakoff from L.P. turbine gland
47 Drain from gland steam seal supply
48 Drain from L.P. gland steam leakoff
49 Entrance for items 16 & 17
POWERHOUSE
UNITS 1, 2, 3 & 4
FLOW DIAGRAM
TRAP DRAINS &
MISCELLANEOUS PIPING
KINGSTON STEAM PLANT
TENNESSEE VALLEY AUTHORITY
DIVISION OF DESIGN
SUBMITTED
RECOMMENDED
APPROVED
KNOXVILLE
5-1-53
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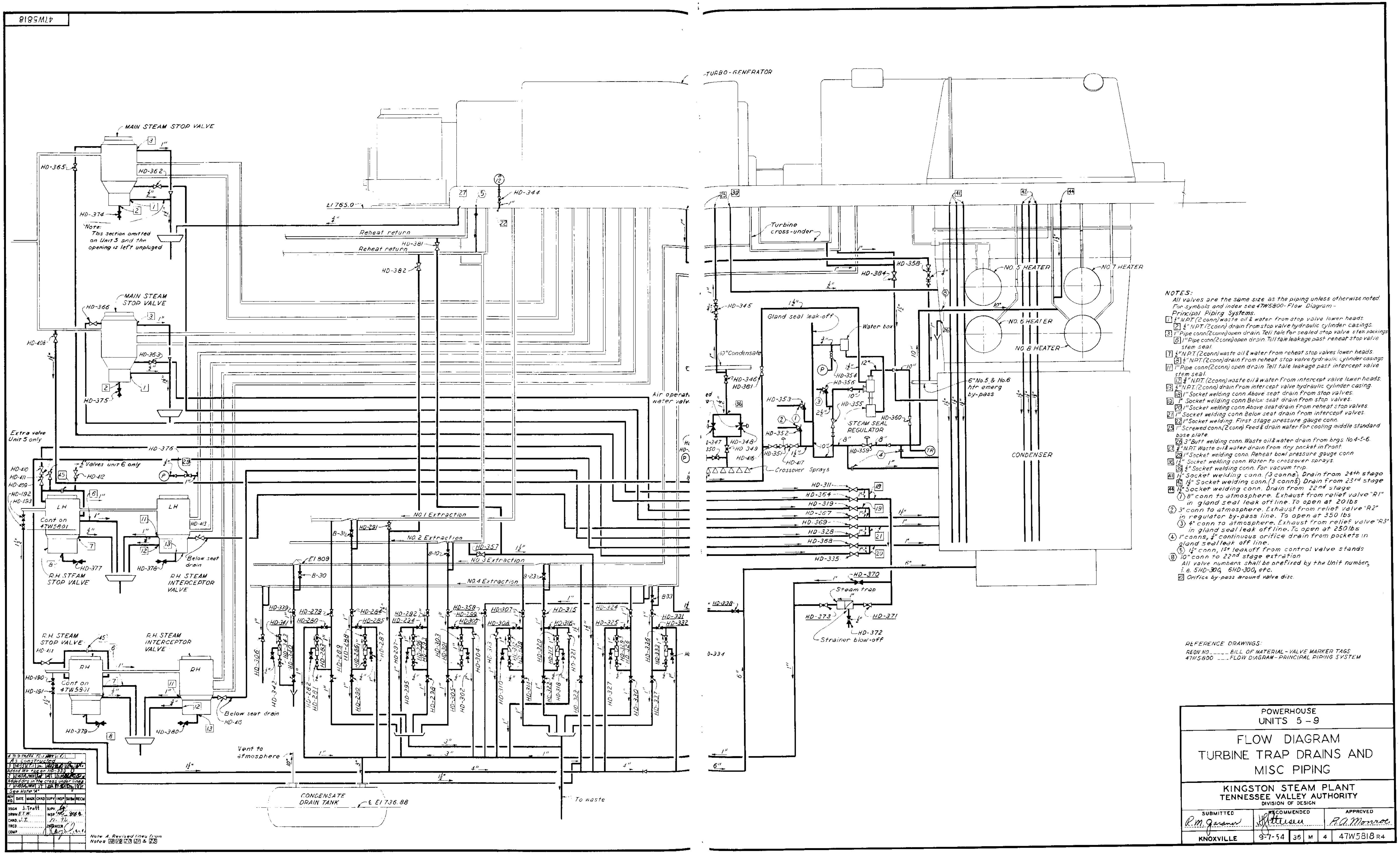
47W5818
MAIN STEAM STOP VALVE
RH STEAM STOP VALVE
RH STEAM INTERCEPTOR VALVE
TURBO-GENERATOR
Reheat return
Turbine cross-under
NO. 5 HEATER
NO. 6 HEATER
NO. 7 HEATER
NO. 8 HEATER
CONDENSER
Gland seal leak-off
Water box
STEAM SEAL REGULATOR
Crossover Sprays
Steam trap
Strainer blow-off
NO. 1 Extraction
NO. 2 Extraction
NO. 3 Extraction
NO. 4 Extraction
CONDENSATE DRAIN TANK
El 736.88
Vent to atmosphere
To waste
NOTES:
All valves are the same size as the piping unless otherwise noted.
For symbols and index see 47W5800 - Flow Diagram - Principal Piping Systems.
1 ½" N.P.T. (2 conn) waste oil & water from stop valve lower heads.
2 ½" N.P.T. (2 conn) drain from stop valve hydraulic cylinder casings.
3 1" Pipe conn (2 conn) open drain. Tell tale for sealed stop valve stem packings
6 1" Pipe conn (2 conn) open drain. Tell tale leakage past reheat stop valve stem seal.
7 ½" N.P.T. (2 conn) waste oil & water from reheat stop valves lower heads.
8 ½" N.P.T. (2 conn) drain from reheat stop valve hydraulic cylinder casings
11 1" Pipe conn (2 conn) open drain Tell tale leakage past intercept valve stem seal.
12 ¾" N.P.T. (2 conn) waste oil & water from intercept valve lower heads.
13 ½" N.P.T. (2 conn) drain from intercept valve hydraulic cylinder casing.
18 1" Socket welding conn. Above seat drain from stop valves.
19 1" Socket welding conn. Below seat drain from stop valves.
20 1" Socket welding conn. Above seat drain from reheat stop valves.
21 1" Socket welding conn. Below seat drain from intercept valves.
22 1" Socket welding. First stage pressure gauge conn.
25 1" Screwed conn. (2 conn) Feed & drain water for cooling middle standard base plate.
26 3" Butt welding conn. Waste oil & water drain from brgs. No. 4-5-6.
27 ¾" N.P.T. Waste oil & water drain from dry pocket in front.
29 1" Socket welding conn. Reheat bowl pressure gauge conn
36 1½" Socket welding conn. Water to crossover sprays.
39 ½" Socket welding conn. For vacuum trip.
41 1½" Socket welding conn. (3 conns) Drain from 24th stage
42 1½" Socket welding conn. (3 conns) Drain from 23rd stage
44 1½" Socket welding conn. Drain from 22nd stage
(1) 8" conn to atmosphere. Exhaust from relief valve "R1" in gland seal leak off line. To open at 20 lbs
(2) 3" conn to atmosphere. Exhaust from relief valve "R2" in regulator by-pass line. To open at 350 lbs
(3) 4" conn to atmosphere. Exhaust from relief valve "R3" in gland seal leak off line. To open at 250 lbs
(4) 1" conns, ¼" continuous orifice drain from pockets in gland seal leak off line.
(5) 1¼" conn, 1st leakoff from control valve stands
(8) 10" conn to 22nd stage extration
All valve numbers shall be prefixed by the Unit number, i.e. 5HD-300, 6HD-300, etc.
45 Orifice by-pass around valve disc.
REFERENCE DRAWINGS:
REQN NO. ____ BILL OF MATERIAL - VALVE MARKER TAGS
47W5800 ___ FLOW DIAGRAM - PRINCIPAL PIPING SYSTEM
POWERHOUSE
UNITS 5 - 9
FLOW DIAGRAM
TURBINE TRAP DRAINS AND
MISC PIPING
KINGSTON STEAM PLANT
TENNESSEE VALLEY AUTHORITY
DIVISION OF DESIGN
SUBMITTED
RECOMMENDED
APPROVED
KNOXVILLE
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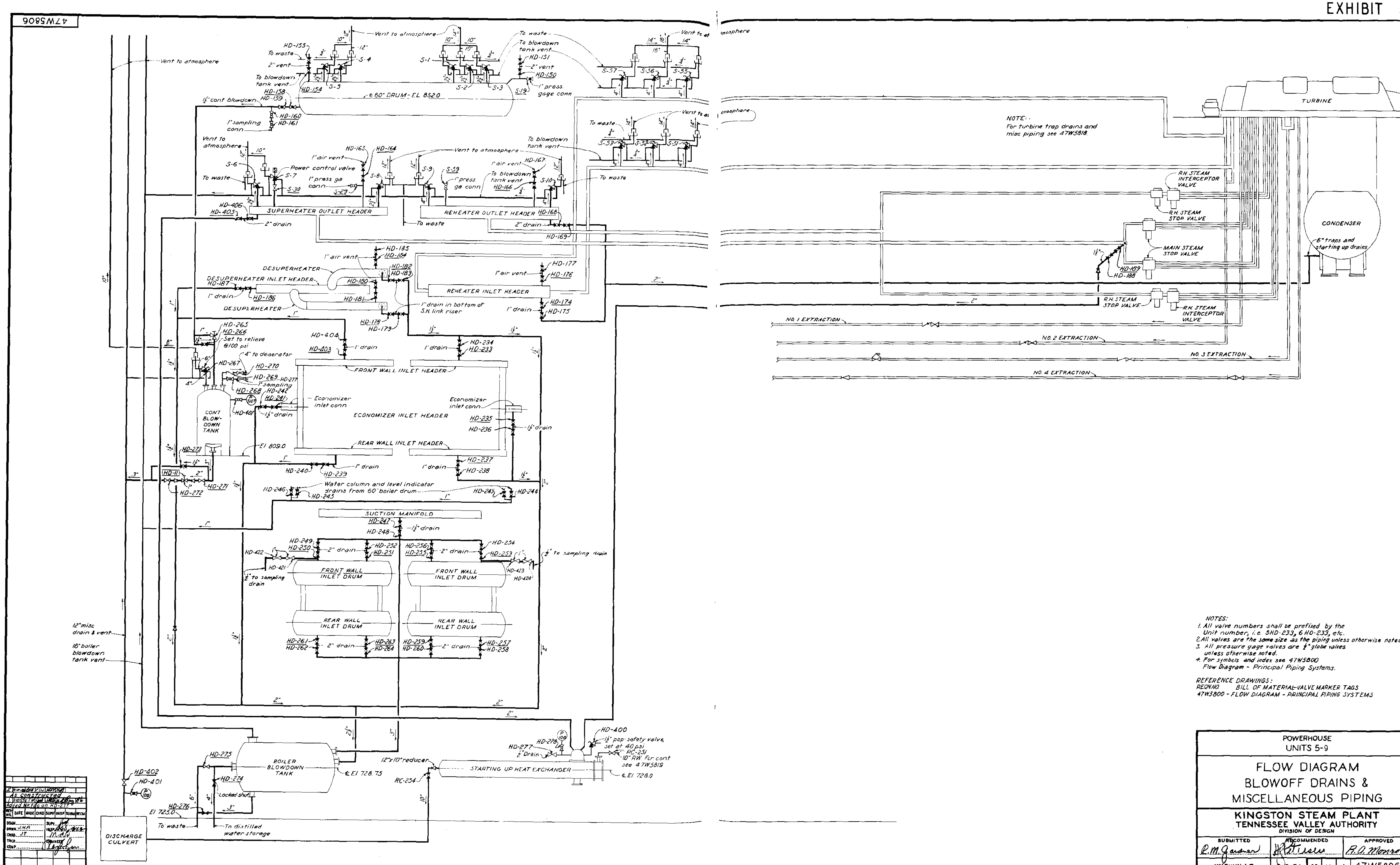
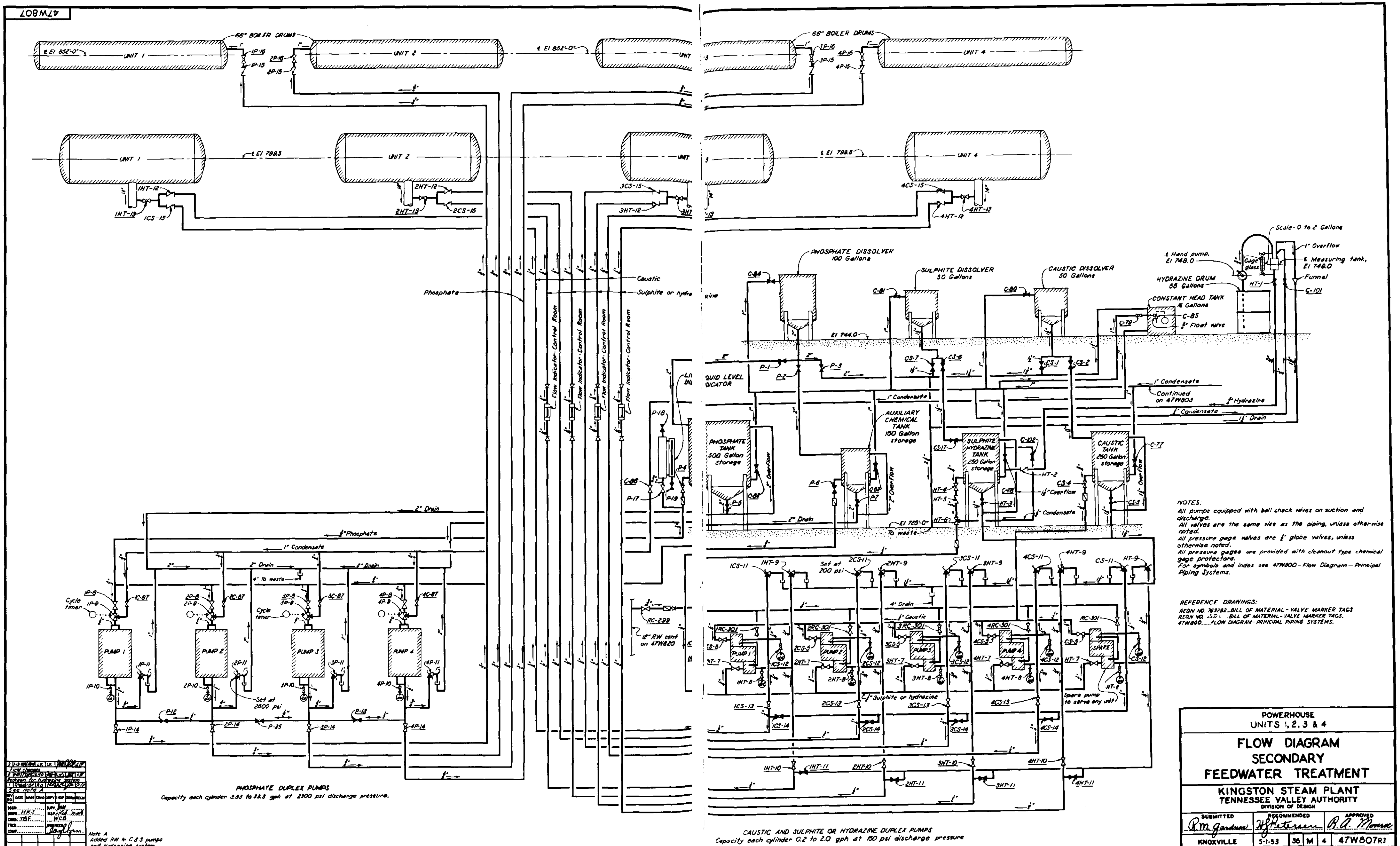
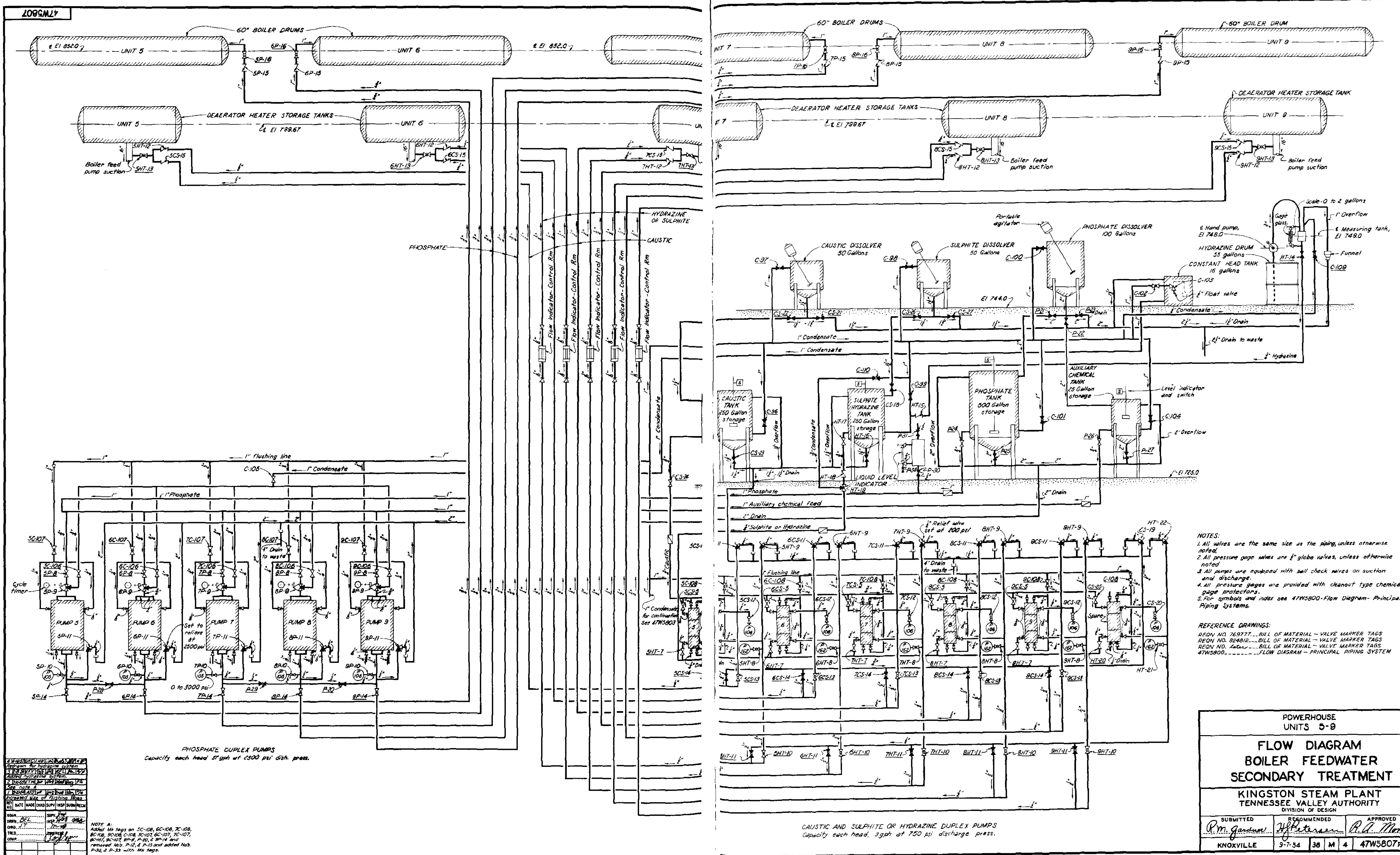
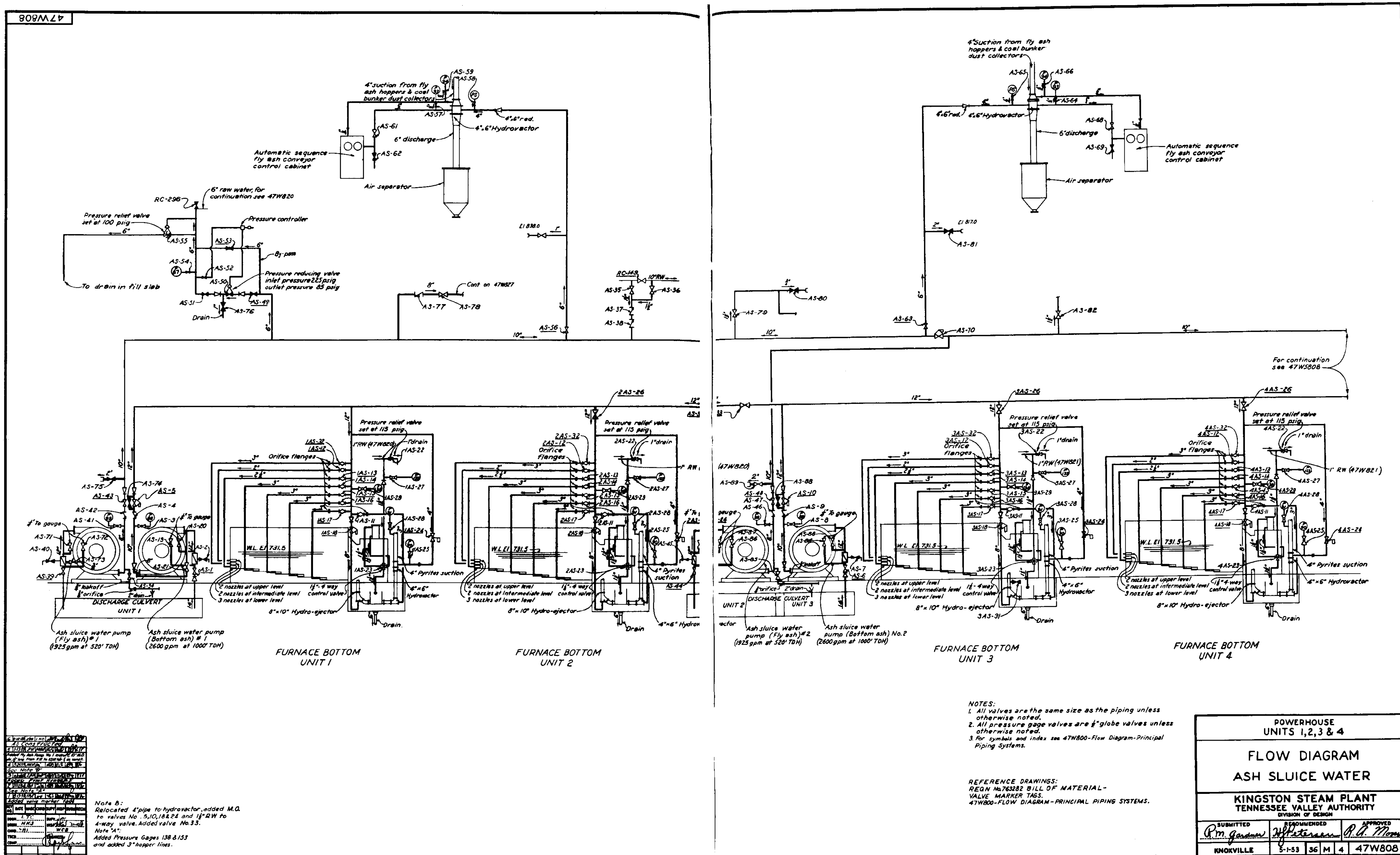

47W5806
60" DRUM-EL 852.0
SUPERHEATER OUTLET HEADER
REHEATER OUTLET HEADER
DESUPERHEATER
DESUPERHEATER INLET HEADER
REHEATER INLET HEADER
FRONT WALL INLET HEADER
ECONOMIZER INLET HEADER
REAR WALL INLET HEADER
CONT BLOW-DOWN TANK
SUCTION MANIFOLD
FRONT WALL INLET DRUM
REAR WALL INLET DRUM
BOILER BLOWDOWN TANK
STARTING UP HEAT EXCHANGER
DISCHARGE CULVERT
TURBINE
CONDENSER
R.H. STEAM INTERCEPTOR VALVE
R.H. STEAM STOP VALVE
MAIN STEAM STOP VALVE
NO. 1 EXTRACTION
NO. 2 EXTRACTION
NO. 3 EXTRACTION
NO. 4 EXTRACTION
NOTE: For turbine trap drains and misc piping see 47W5818.
Water column and level indicator drains from 60" boiler drum
NOTES:
1. All valve numbers shall be prefixed by the Unit number, i.e. 5HD-233, 6HD-233, etc.
2. All valves are the same size as the piping unless otherwise noted.
3. All pressure gage valves are ¼" globe valves unless otherwise noted.
4. For symbols and index see 47W5800 Flow Diagram - Principal Piping Systems.
REFERENCE DRAWINGS:
REDNHO BILL OF MATERIAL-VALVE MARKER TAGS
47W5800 - FLOW DIAGRAM - PRINCIPAL PIPING SYSTEMS
POWERHOUSE UNITS 5-9
FLOW DIAGRAM
BLOWOFF DRAINS &
MISCELLANEOUS PIPING
KINGSTON STEAM PLANT
TENNESSEE VALLEY AUTHORITY
DIVISION OF DESIGN
SUBMITTED
RECOMMENDED
APPROVED
KNOXVILLE
47W5806 R2


47W807
66" BOILER DRUMS
UNIT 1
UNIT 2
UNIT 4
PHOSPHATE DISSOLVER
100 Gallons
SULPHITE DISSOLVER
50 Gallons
CAUSTIC DISSOLVER
50 Gallons
HYDRAZINE DRUM
55 Gallons
CONSTANT HEAD TANK
15 Gallons
Scale - 0 to 2 Gallons
1" Overflow
Funnel
AUXILIARY CHEMICAL TANK
150 Gallon storage
PHOSPHATE TANK
500 Gallon storage
SULPHITE HYDRAZINE TANK
250 Gallon storage
CAUSTIC TANK
250 Gallon storage
Caustic
Phosphate
Flow Indicator - Control Room
PUMP 1
PUMP 2
PUMP 3
PUMP 4
SPARE
Cycle timer
Set at 2500 psi
Set at 200 psi
Spare pump to serve any unit
PHOSPHATE DUPLEX PUMPS
Capacity each cylinder 3.33 to 33.3 gph at 2500 psi discharge pressure.
CAUSTIC AND SULPHITE OR HYDRAZINE DUPLEX PUMPS
Capacity each cylinder 0.2 to 2.0 gph at 150 psi discharge pressure
NOTES:
All pumps equipped with ball check valves on suction and discharge.
All valves are the same size as the piping, unless otherwise noted.
All pressure gage valves are ¼" globe valves, unless otherwise noted.
All pressure gages are provided with cleanout type chemical gage protectors.
For symbols and index see 47W800 - Flow Diagram - Principal Piping Systems.
REFERENCE DRAWINGS:
47W800....FLOW DIAGRAM - PRINCIPAL PIPING SYSTEMS.
Note A
Added RW to C & S pumps and Hydrazine system.
POWERHOUSE
UNITS 1, 2, 3 & 4
FLOW DIAGRAM
SECONDARY
FEEDWATER TREATMENT
KINGSTON STEAM PLANT
TENNESSEE VALLEY AUTHORITY
DIVISION OF DESIGN
SUBMITTED
RECOMMENDED
APPROVED
KNOXVILLE
5-1-53
47W807R3


60" BOILER DRUMS
UNIT 5
UNIT 6
UNIT 7
UNIT 8
UNIT 9
DEAERATOR HEATER STORAGE TANKS
DEAERATOR HEATER STORAGE TANK
Boiler feed pump suction
PHOSPHATE
HYDRAZINE OR SULPHITE
CAUSTIC
Flow Indicator-Control Rm
CAUSTIC DISSOLVER 50 Gallons
SULPHITE DISSOLVER 50 Gallons
PHOSPHATE DISSOLVER 100 Gallons
HYDRAZINE DRUM 55 gallons
CONSTANT HEAD TANK 16 gallons
CAUSTIC TANK 250 Gallon storage
SULPHITE HYDRAZINE TANK 250 Gallon storage
PHOSPHATE TANK 500 Gallon storage
AUXILIARY CHEMICAL TANK 25 Gallon storage
LIQUID LEVEL INDICATOR
PUMP 5
PUMP 6
PUMP 7
PUMP 8
PUMP 9
PHOSPHATE DUPLEX PUMPS
Capacity each head 57 gph at 2500 psi disch. press.
CAUSTIC AND SULPHITE OR HYDRAZINE DUPLEX PUMPS
Capacity each head, 3gph at 750 psi discharge press.
NOTES:
1. All valves are the same size as the piping, unless otherwise noted.
2. All pressure gage valves are ½" globe valves, unless otherwise noted
3. All pumps are equipped with ball check valves on suction and discharge.
4. All pressure gages are provided with cleanout type chemical gage protectors.
5. For symbols and index see 47W5800-Flow Diagram- Principal Piping Systems.
REFERENCE DRAWINGS:
REQN NO. 769777...BILL OF MATERIAL — VALVE MARKER TAGS
REQN NO. 824812...BILL OF MATERIAL — VALVE MARKER TAGS
REQN NO. Later...BILL OF MATERIAL — VALVE MARKER TAGS
47W5800...FLOW DIAGRAM — PRINCIPAL PIPING SYSTEM
POWERHOUSE
UNITS 5-9
FLOW DIAGRAM
BOILER FEEDWATER
SECONDARY TREATMENT
KINGSTON STEAM PLANT
TENNESSEE VALLEY AUTHORITY
DIVISION OF DESIGN
SUBMITTED
RECOMMENDED
APPROVED
KNOXVILLE
9-7-54
47W5807 R4



NOTES:
1. All valves are the same size as the piping unless otherwise noted.
2. All pressure gage valves are ½" globe valves unless otherwise noted.
3. For symbols and index see 47W800-Flow Diagram-Principal Piping Systems.

REFERENCE DRAWINGS:
REQN No. 763282 BILL OF MATERIAL-VALVE MARKER TAGS.
47W800-FLOW DIAGRAM-PRINCIPAL PIPING SYSTEMS.

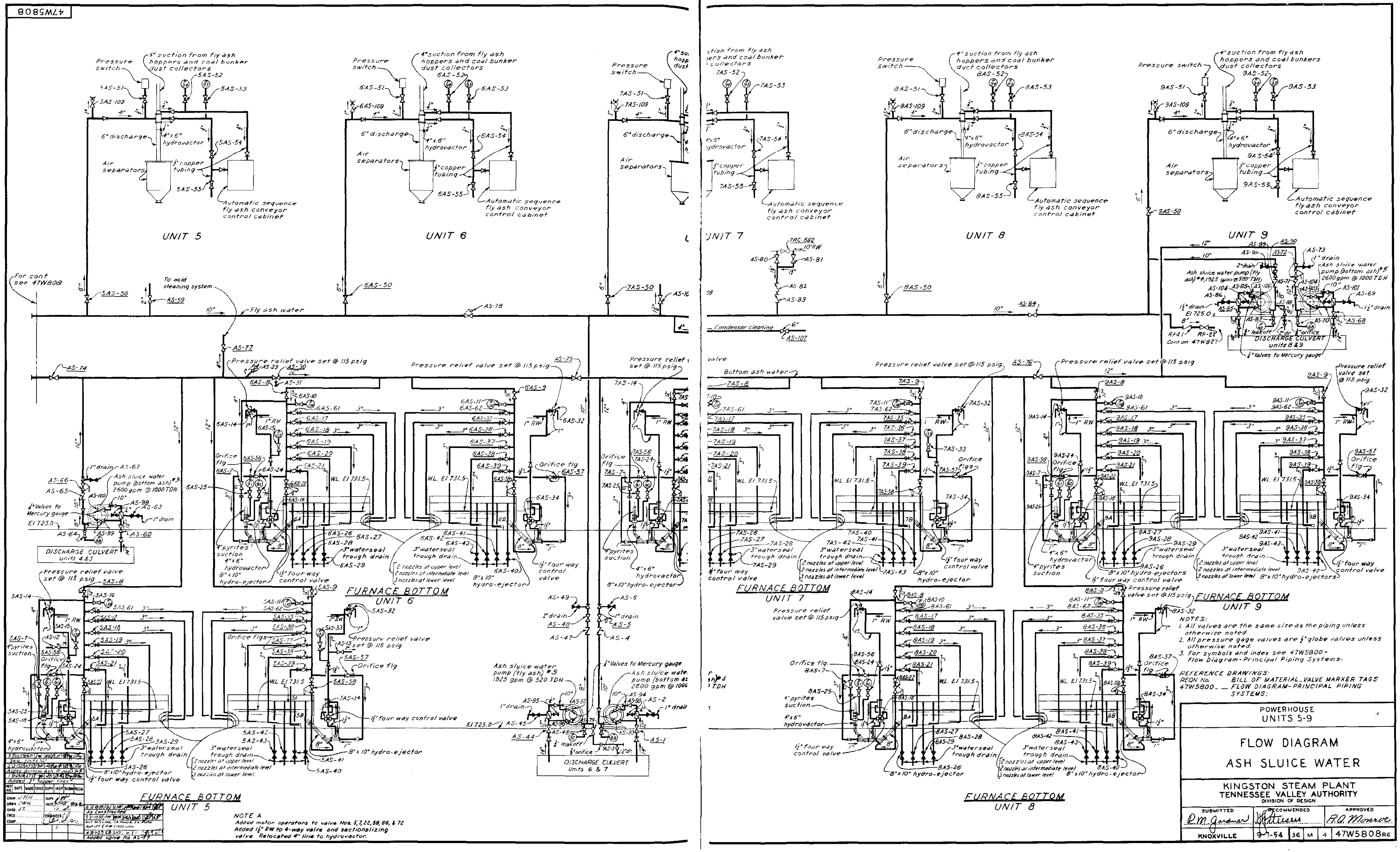
POWERHOUSE
UNITS 1,2,3 & 4

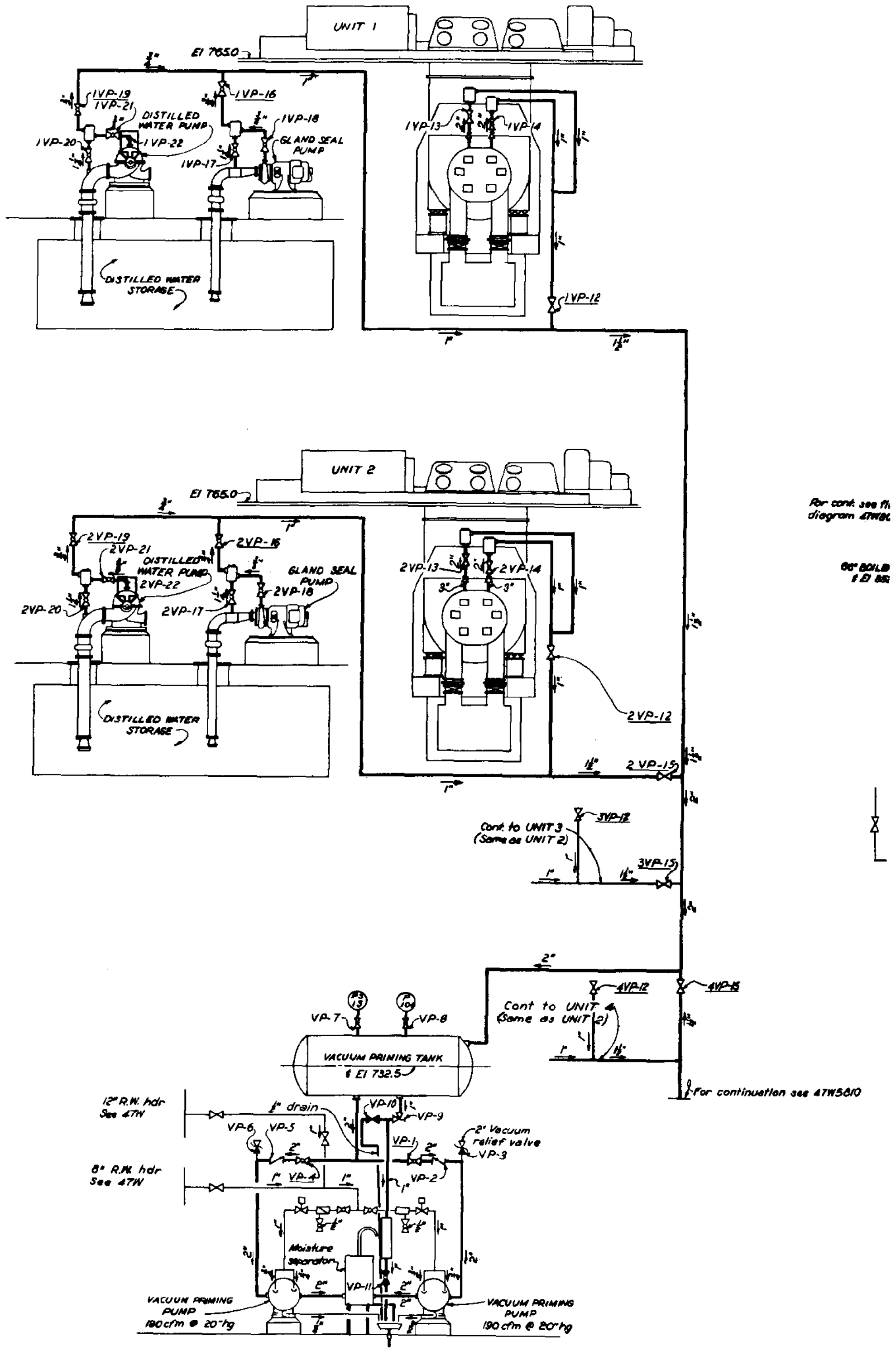
FLOW DIAGRAM
ASH SLUICE WATER

KINGSTON STEAM PLANT
TENNESSEE VALLEY AUTHORITY
DIVISION OF DESIGN

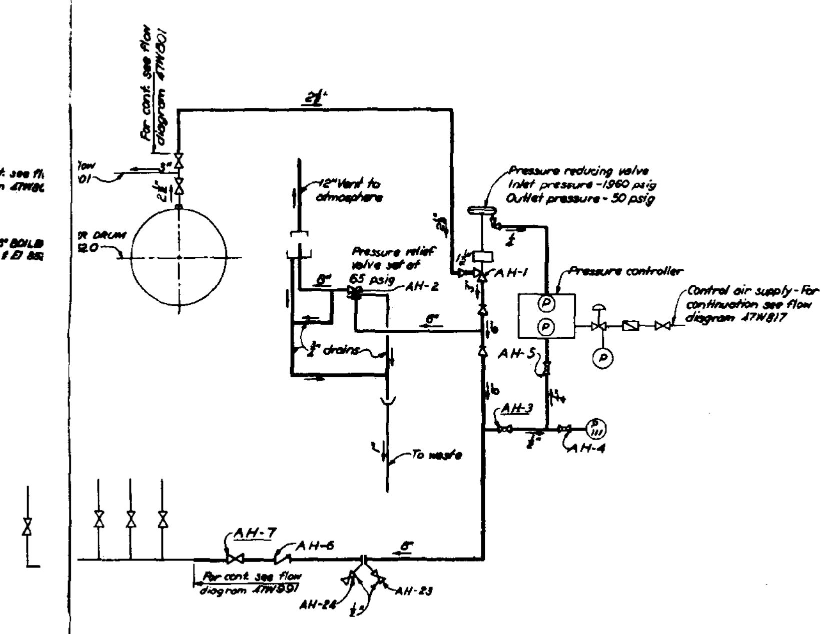
SUBMITTED | RECOMMENDED | APPROVED

KNOXVILLE | 5-1-53 | 36 | M | 4 | 47W808 R6


47W5808
UNIT 5
UNIT 6
UNIT 7
UNIT 8
UNIT 9
Fly ash water
Bottom ash water
Condenser cleaning
DISCHARGE CULVERT units 4 & 5
DISCHARGE CULVERT Units 6 & 7
DISCHARGE CULVERT units 8 & 9
FURNACE BOTTOM UNIT 5
FURNACE BOTTOM UNIT 6
FURNACE BOTTOM UNIT 7
FURNACE BOTTOM UNIT 8
FURNACE BOTTOM UNIT 9
NOTE A
Added motor operators to valve Nos. 5,7,22,58,66, & 72
Added 1½" RW to 4-way valve and sectionalizing valve. Relocated 4" line to hydrovactor.
NOTES:
1. All valves are the same size as the piping unless otherwise noted.
2. All pressure gage valves are ½" globe valves unless otherwise noted.
3. For symbols and index see 47W5800-Flow Diagram-Principal Piping Systems.
REFERENCE DRAWINGS:
REQN No. BILL OF MATERIAL_VALVE MARKER TAGS
47W5800 FLOW DIAGRAM-PRINCIPAL PIPING SYSTEMS:
POWERHOUSE
UNITS 5-9
FLOW DIAGRAM
ASH SLUICE WATER
KINGSTON STEAM PLANT
TENNESSEE VALLEY AUTHORITY
DIVISION OF DESIGN
SUBMITTED
RECOMMENDED
APPROVED
KNOXVILLE
9-1-54
36
M
4
47W5808 R6



VACUUM PRIMING SYSTEM - POWERHOUSE



HIGH PRESSURE CONNECTION TO HEATING SYSTEM - POWERHOUSE

NOTES:
1. All valves are the same size as the piping unless otherwise noted.
2. All pressure gage valves are ½" globe valves unless otherwise noted.
3. For symbols and index see 47W800-Flow Diagram-Principal Piping Systems.

REFERENCE DRAWINGS:
REQN NO.763282 BILL OF MATERIAL - VALVE MARKER TAGS.
47W800-FLOW DIAGRAM-PRINCIPAL PIPING SYSTEMS.

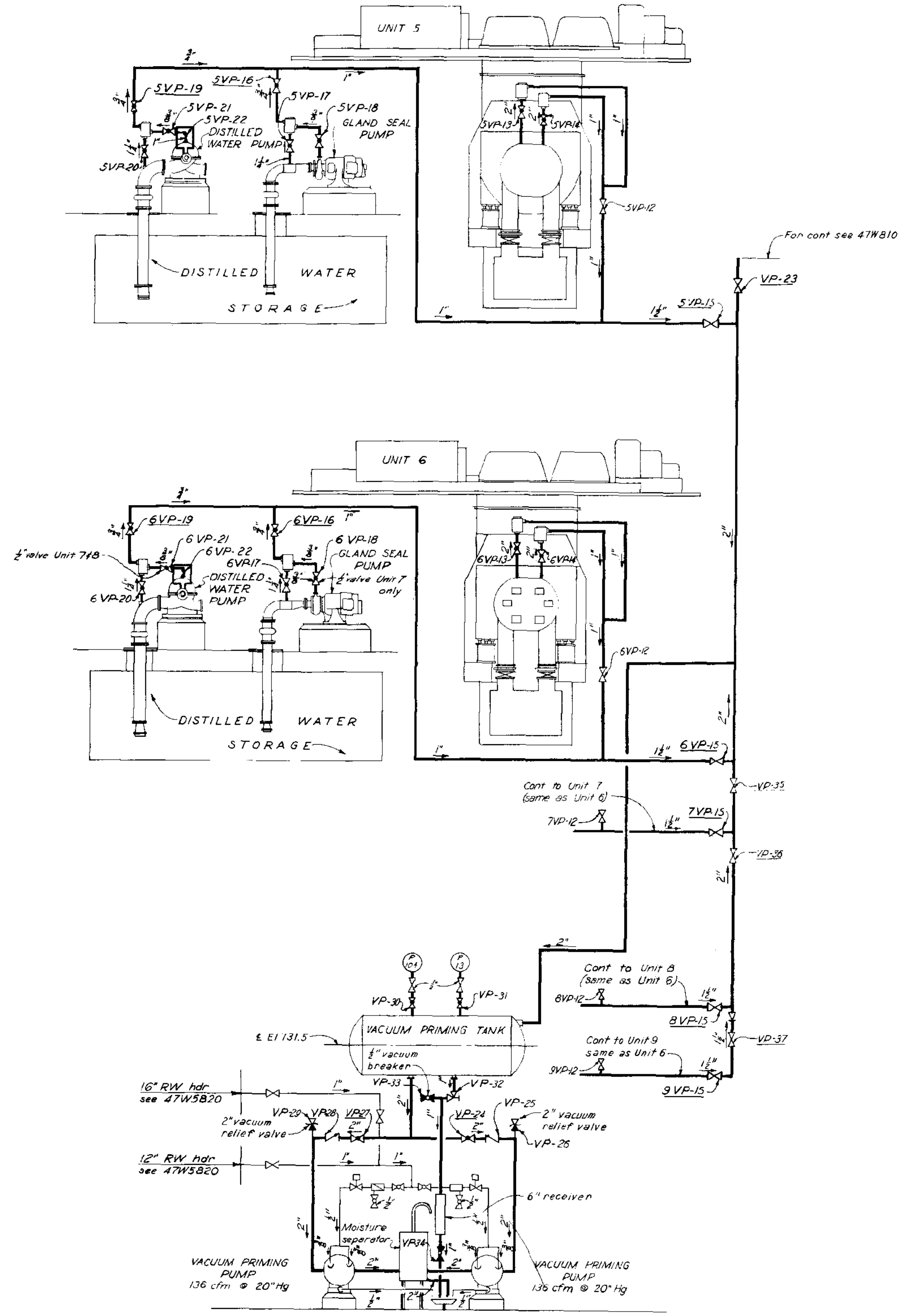
POWERHOUSE
UNITS 1 THRU 4

FLOW DIAGRAMS
VACUUM PRIMING SYSTEMS
HP CONN TO HTG SYSTEM

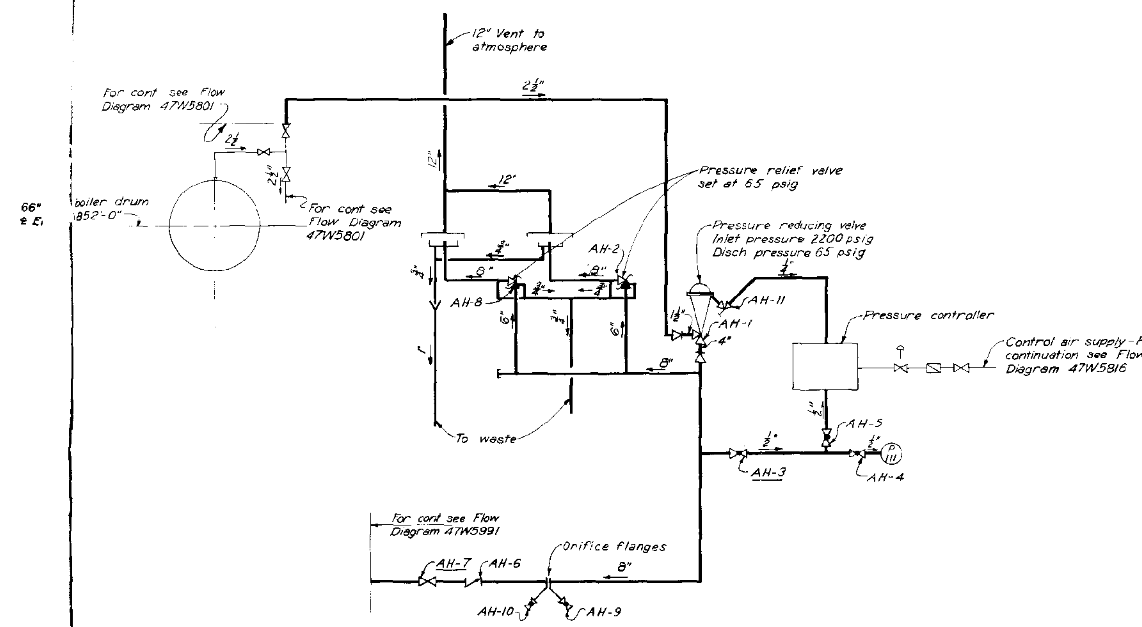
KINGSTON STEAM PLANT
TENNESSEE VALLEY AUTHORITY
DIVISION OF DESIGN

SUBMITTED	RECOMMENDED	APPROVED
R.M. Gardner	H.J. Petersen	R.A. Monroe
KNOXVILLE	5-1-53 · 36 · M · 4	47W810 R2

47W5810



VACUUM PRIMING SYSTEM - POWERHOUSE



HIGH PRESSURE CONNECTION TO HEATING SYSTEM - POWERHOUSE

NOTES:
1. All valves are the same size as the piping unless otherwise noted.
2. All pressure gage valves are 1/2" globe valves unless otherwise noted.
3. For symbols and index see 47W5800 Flow Diagram Principal Piping Systems.
4. All valve numbers shall be prefixed with the Unit number i.e., 5VP-12, 6VP-12, etc.

REFERENCE DRAWINGS:
REQN NO BILL OF MATERIAL - VALVE MARKER TAGS. 47W5800 - FLOW DIAGRAM - PRINCIPAL PIPING SYSTEMS.

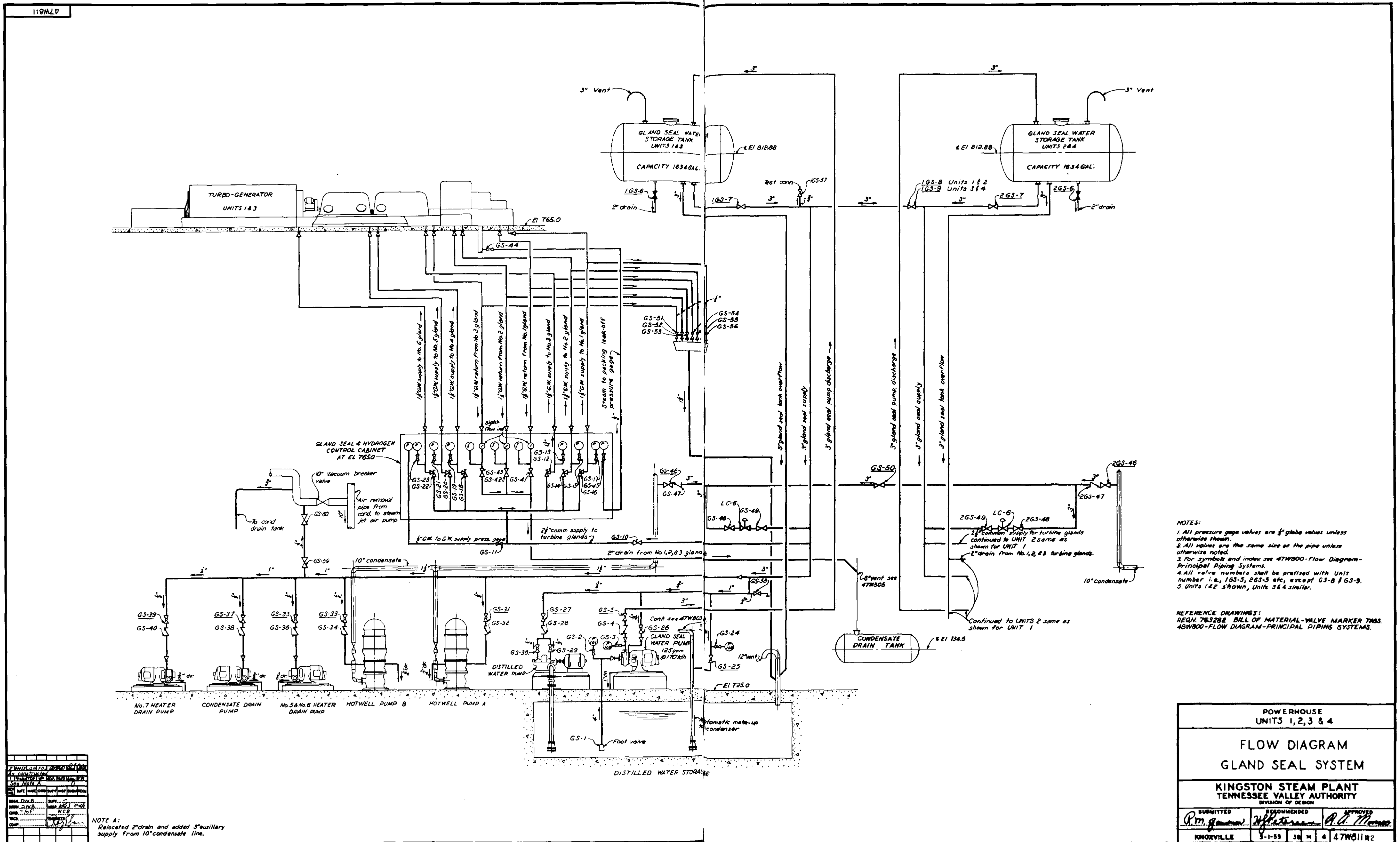
POWERHOUSE
UNITS 5 - 9

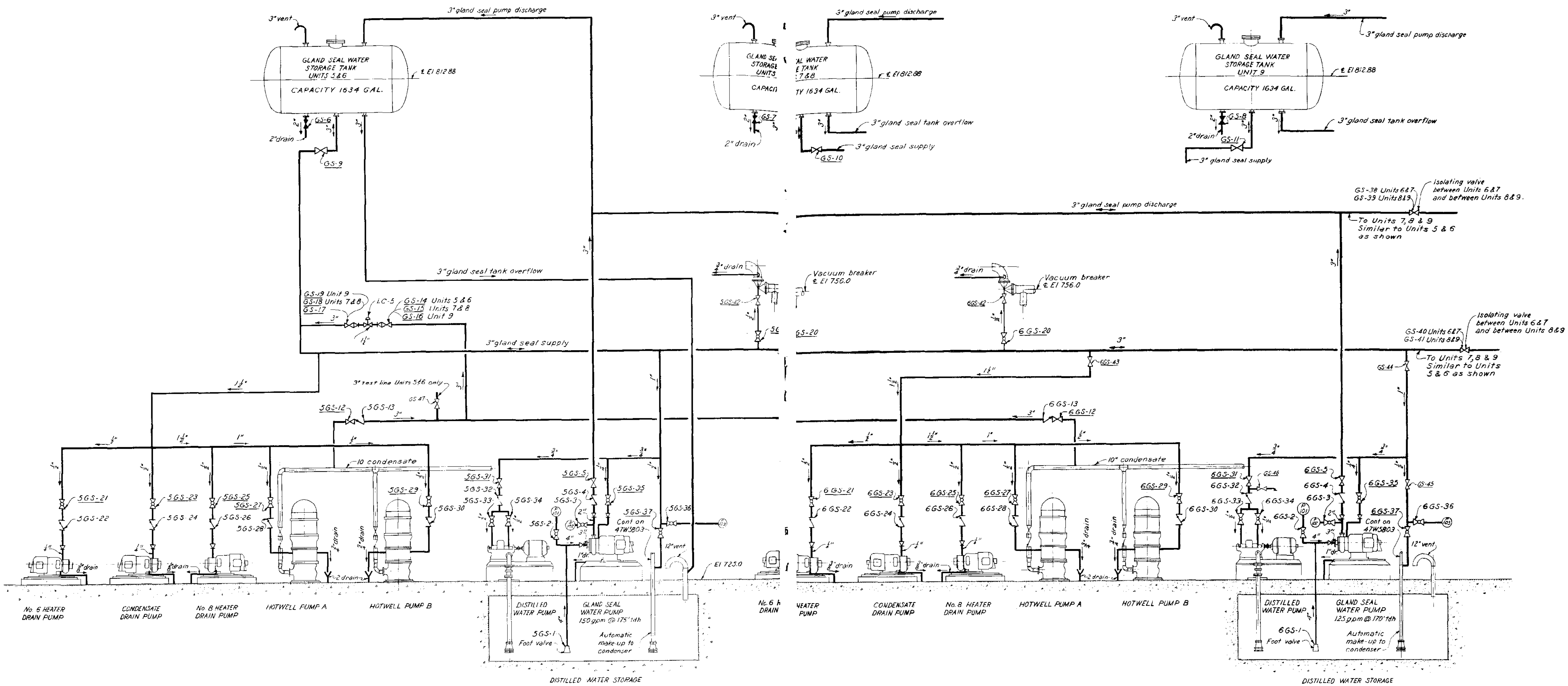
FLOW DIAGRAM
VACUUM PRIMING SYSTEM
HP CONN TO HTG SYSTEM

KINGSTON STEAM PLANT
TENNESSEE VALLEY AUTHORITY
DIVISION OF DESIGN

SUBMITTED	RECOMMENDED	APPROVED
R.M. Gardner	H. J. Peterson	R.A. Monroe
KNOXVILLE	9-7-54 36 M 4	47W5810 R1

As constructed
DSGN. J.L.G.
DRWN. J.L.G.
CHKD. J.T.


47W811
3" Vent
GLAND SEAL WATER STORAGE TANK UNITS 1&3
CAPACITY 1634 GAL.
El 812.88
GLAND SEAL WATER STORAGE TANK UNITS 2&4
CAPACITY 1634 GAL.
TURBO-GENERATOR UNITS 1&3
El 765.0
GLAND SEAL & HYDROGEN CONTROL CABINET AT EL 765.0
10" Vacuum breaker valve
Air removal pipe from cond. to steam jet air pump
To cond drain tank
2½" comm supply to turbine glands
2" drain from No.1,2,&3 glands
10" condensate
3" gland seal tank over-flow
3" gland seal supply
3" gland seal pump discharge
8" vent see 47W805
CONDENSATE DRAIN TANK
El 734.5
Continued to UNITS 2 same as shown for UNIT 1
10" condensate
No.7 HEATER DRAIN PUMP
CONDENSATE DRAIN PUMP
No.5 & No.6 HEATER DRAIN PUMP
HOTWELL PUMP B
HOTWELL PUMP A
DISTILLED WATER PUMP
GLAND SEAL WATER PUMP 125 gpm @ 170' hh
Foot valve
Automatic make-up to condenser
DISTILLED WATER STORAGE
El 725.0
NOTES:
1. All pressure gage valves are ¼" globe valves unless otherwise shown.
2. All valves are the same size as the pipe unless otherwise noted.
3. For symbols and index see 47W800-Flow Diagram-Principal Piping Systems.
4. All valve numbers shall be prefixed with Unit number i.e., 1GS-5, 2GS-5 etc, except GS-8 & GS-9.
5. Units 1&2 shown, Units 3&4 similar.
REFERENCE DRAWINGS:
REQN. 763282 BILL OF MATERIAL-VALVE MARKER TAGS.
48W800-FLOW DIAGRAM-PRINCIPAL PIPING SYSTEMS.
NOTE A:
Relocated 2" drain and added 3" auxiliary supply from 10" condensate line.
POWERHOUSE UNITS 1, 2, 3 & 4
FLOW DIAGRAM
GLAND SEAL SYSTEM
KINGSTON STEAM PLANT
TENNESSEE VALLEY AUTHORITY
DIVISION OF DESIGN
SUBMITTED
RECOMMENDED
APPROVED
KNOXVILLE
3-1-53
47W811 R2



NOTES:
1. All pressure gage valves are ½" globe valves unless otherwise shown.
2. All valves are the same size as the pipe unless otherwise noted.
3. For symbols and index see 47W5800 Flow Diagram - Principal Piping Systems.
4. All valve numbers shall be prefixed with the Unit number i.e., 5GS-5, 6GS-5 etc.

REFERENCE DRAWINGS:
REQN. No. BILL OF MATERIAL - VALVE MARKER TAGS
47W5800 - FLOW DIAGRAM - PRINCIPAL PIPING SYSTEMS

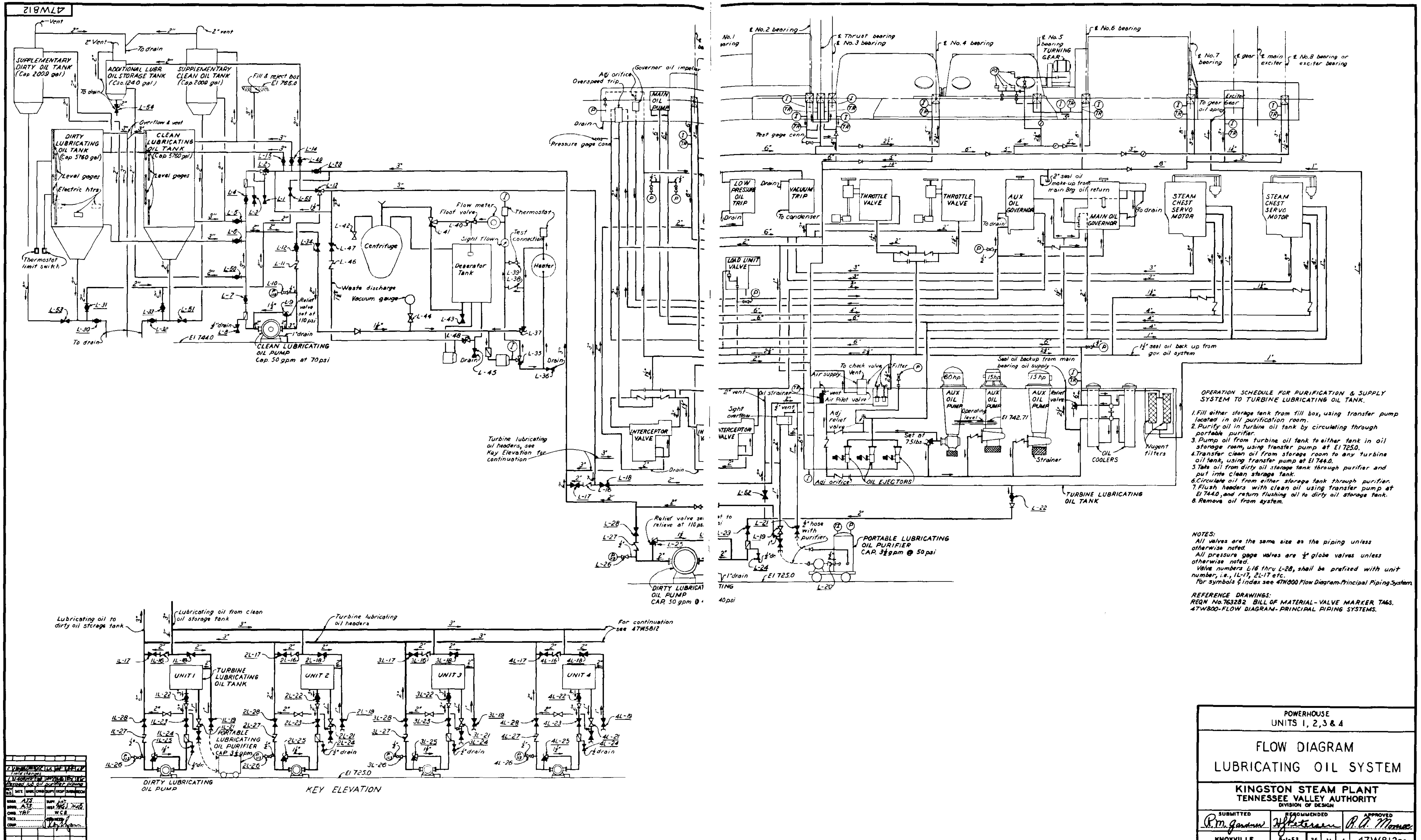
POWERHOUSE
UNITS 5-9

FLOW DIAGRAM
GLAND SEAL SYSTEM

KINGSTON STEAM PLANT
TENNESSEE VALLEY AUTHORITY
DIVISION OF DESIGN

SUBMITTED	RECOMMENDED	APPROVED
R.M. Gardner	[signature]	R.A. Monroe

KNOXVILLE | 9-7-54 | 36 | M | 4 | 47W5811 R2



OPERATION SCHEDULE FOR PURIFICATION & SUPPLY SYSTEM TO TURBINE LUBRICATING OIL TANK.

1. Fill either storage tank from fill box, using transfer pump located in oil purification room.
2. Purify oil in turbine oil tank by circulating through portable purifier.
3. Pump oil from turbine oil tank to either tank in oil storage room, using transfer pump at El 725.0.
4. Transfer clean oil from storage room to any turbine oil tank, using transfer pump at El 744.0.
5. Take oil from dirty oil storage tank through purifier and put into clean storage tank.
6. Circulate oil from either storage tank through purifier.
7. Flush headers with clean oil using transfer pump at El 744.0, and return flushing oil to dirty oil storage tank.
8. Remove oil from system.

NOTES:
All valves are the same size as the piping unless otherwise noted.
All pressure gage valves are ½" globe valves unless otherwise noted.
Valve numbers L-16 thru L-28, shall be prefixed with unit number, i.e., 1L-17, 2L-17 etc.
For symbols & index see 47W800 Flow Diagram-Principal Piping System.

REFERENCE DRAWINGS:
REQN No. 763282 BILL OF MATERIAL-VALVE MARKER TAGS.
47W800-FLOW DIAGRAM-PRINCIPAL PIPING SYSTEMS.

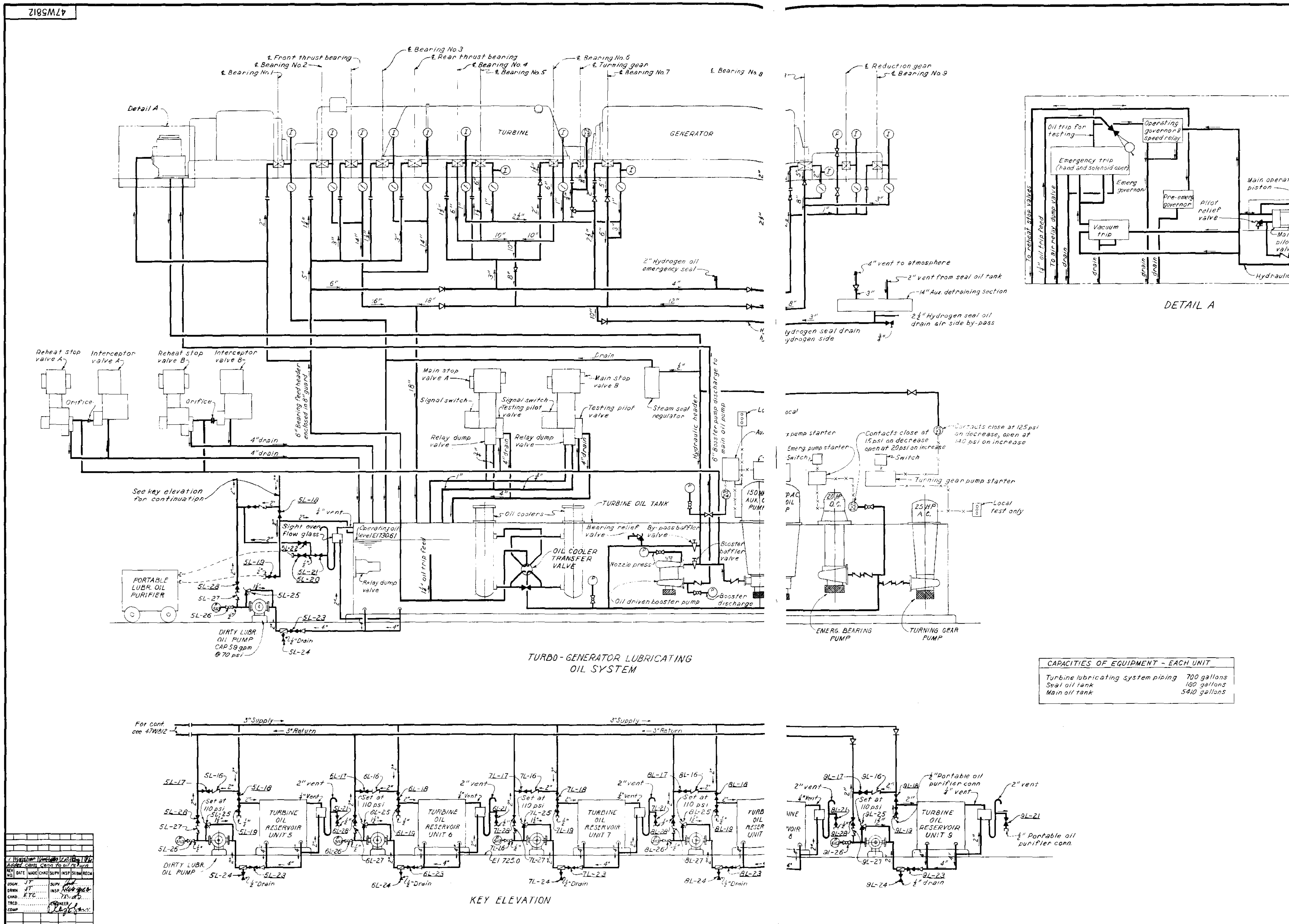
POWERHOUSE
UNITS 1, 2, 3 & 4

FLOW DIAGRAM
LUBRICATING OIL SYSTEM

KINGSTON STEAM PLANT
TENNESSEE VALLEY AUTHORITY
DIVISION OF DESIGN

SUBMITTED	RECOMMENDED	APPROVED
R. M. Gardner	H. J. Petersen	R. A. Monroe

KNOXVILLE | 5-1-53 | 36 | M | 4 | 47W812R2



CAPACITIES OF EQUIPMENT - EACH UNIT

Turbine lubricating system piping	700 gallons
Seal oil tank	180 gallons
Main oil tank	5410 gallons

OPERATION SCHEDULE FOR PURIFICATION & SUPPLY SYSTEM TO TURBINE LUBRICATING OIL TANK

1. Fill either storage tank from fill box using transfer pump located in oil purification room.
2. Purify oil in turbine oil tank by circulating through portable oil purifier.
3. Pump oil from turbine oil tank to either tank in oil storage room using transfer pump at El 725.0.
4. Transfer clean oil from storage room to any turbine oil tank using transfer pump at El 744.0 .
5. Take oil from dirty oil storage tank through purifier and put into clean storage tank.
6. Circulate oil from either storage tank through purifier.
7. Flush headers with clean oil, using transfer pump at El 744.0 and return flushing oil to dirty oil storage tank.
8. Remove oil from system.

NOTES:

1. All valves are the same size as the piping unless otherwise noted.
2. All pressure gage valves are ½" globe valves unless otherwise noted.
3. Valve numbers L-16 thru L-28 shall be prefixed with UNIT number, i.e. 5L-16, 6L-16, etc.
4. For symbols and index see 47W5800-Flow Diagram-Principal Piping Systems.

REFERENCE DRAWINGS:

REQN. NO. BILL OF MATERIAL - VALVE MARKER TAGS

47W5800 - FLOW DIAGRAM-PRINCIPAL PIPING SYSTEM

47W812 - FLOW DIAGRAM-LUBRICATING OIL SYSTEM

POWERHOUSE
UNITS 5-9

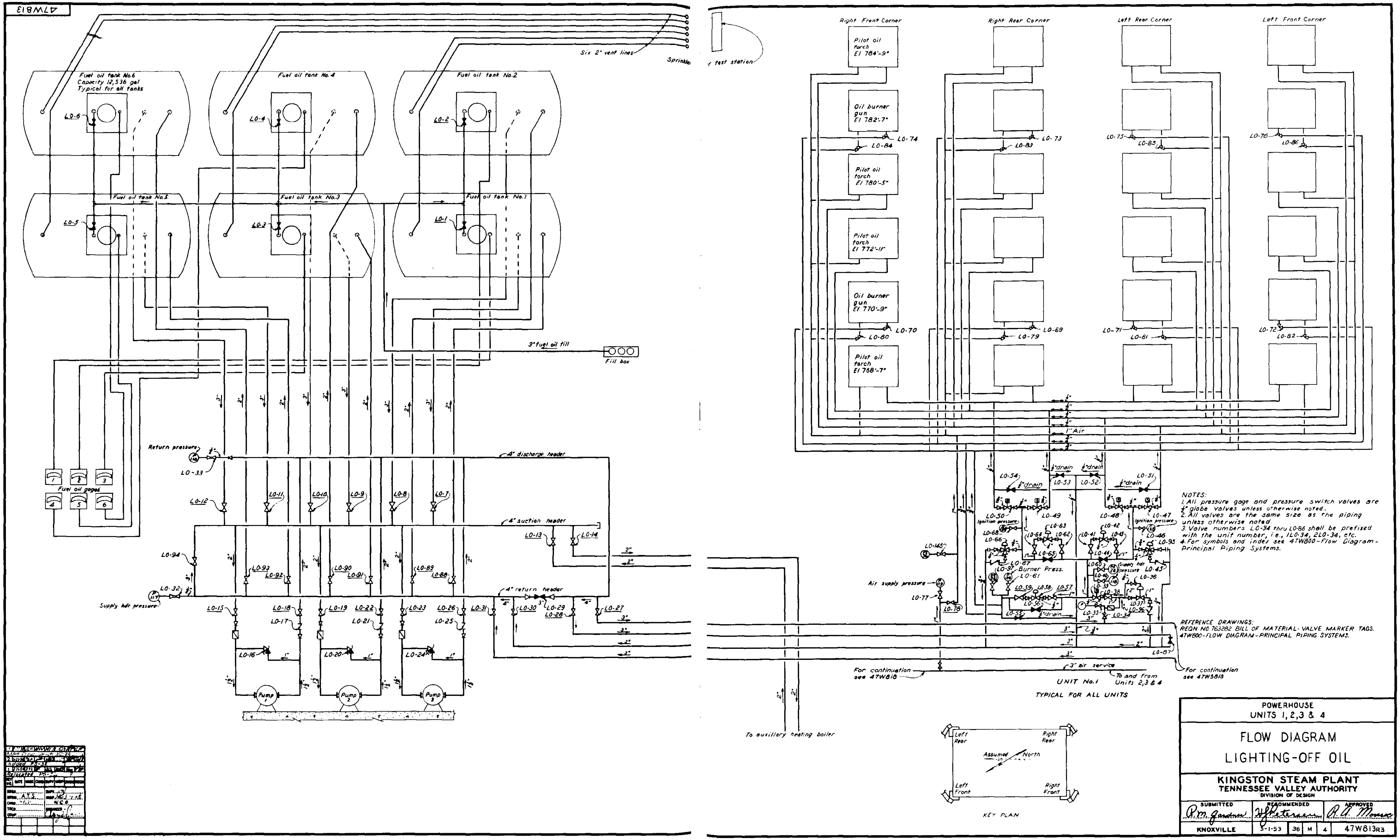
FLOW DIAGRAM

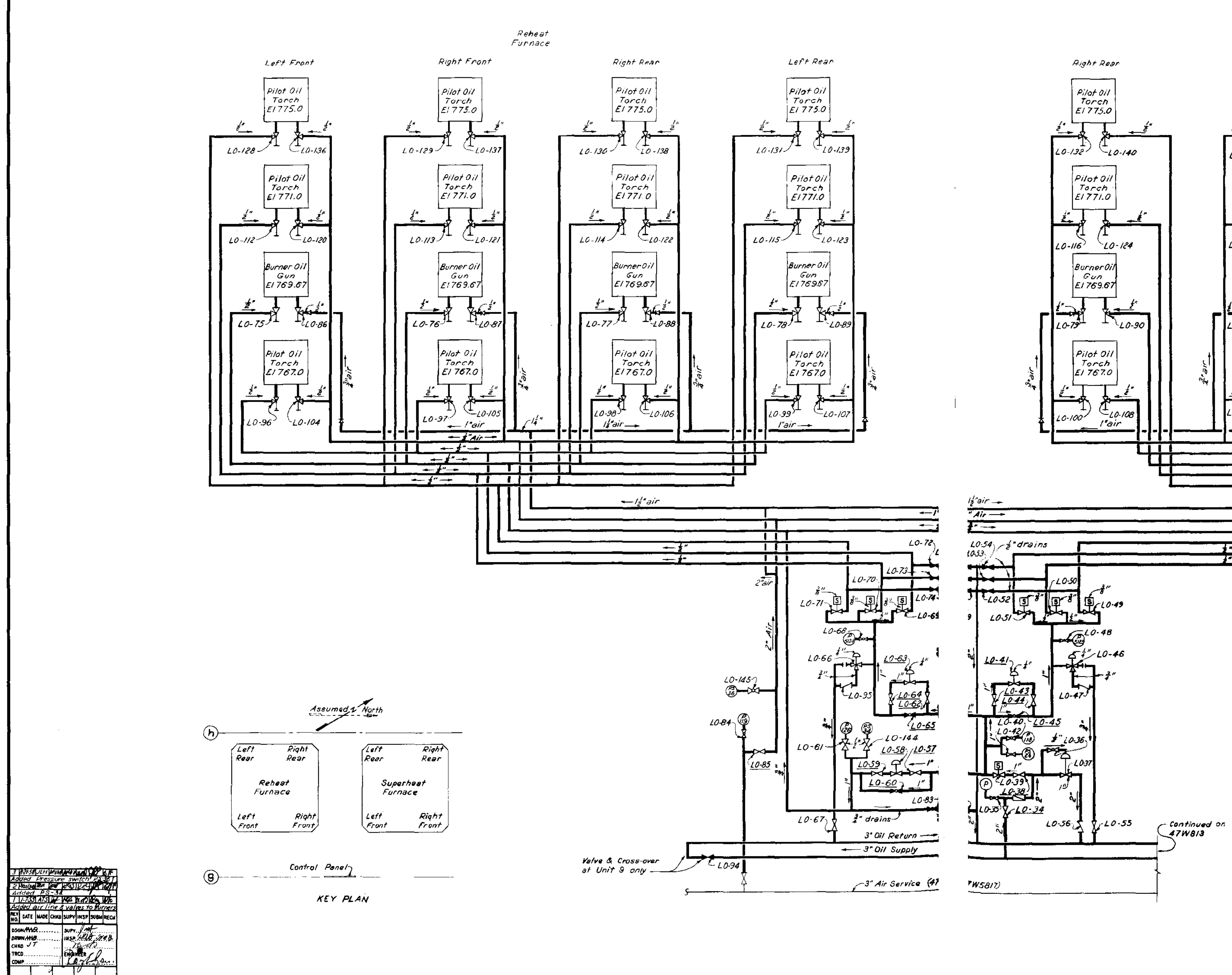
LUBRICATING OIL SYSTEM

KINGSTON STEAM PLANT
TENNESSEE VALLEY AUTHORITY
DIVISION OF DESIGN

SUBMITTED	RECOMMENDED	APPROVED
R.M. Gardner	H.J. Petersen	R.A. Monroe

KNOXVILLE | 9-7-54 | 36 | M | 4 | 47W5812R1


47W813
Fuel oil tank No.6
Capacity 12,536 gal
Typical for all tanks
Fuel oil tank No.4
Fuel oil tank No.2
Fuel oil tank No.5
Fuel oil tank No.3
Fuel oil tank No.1
Six 2" vent lines
3" fuel oil fill
Fill box
Fuel oil gages
Return pressure
4" discharge header
4" suction header
4" return header
Supply hdr pressure
Pump 1
Pump 2
Pump 3
Right Front Corner
Right Rear Corner
Left Rear Corner
Left Front Corner
Pilot oil torch El 784'-9"
Oil burner gun El 782'-7"
Pilot oil torch El 780'-5"
Pilot oil torch El 772'-11"
Oil burner gun El 770'-9"
Pilot oil torch El 768'-7"
1" Air
Ignition pressure
Burner Press.
Air supply pressure
3" air service
For continuation see 47W818
To and from Units 2,3 & 4
For continuation see 47W5818
UNIT No.1
TYPICAL FOR ALL UNITS
To auxiliary heating boiler
NOTES:
1. All pressure gage and pressure switch valves are 1/4" globe valves unless otherwise noted.
2. All valves are the same size as the piping unless otherwise noted.
3. Valve numbers LO-34 thru LO-86 shall be prefixed with the unit number, i.e., 1LO-34, 2LO-34, etc.
4. For symbols and index see 47W800-Flow Diagram-Principal Piping Systems.
REFERENCE DRAWINGS:
REQN NO 763282 BILL OF MATERIAL-VALVE MARKER TAGS.
47W800-FLOW DIAGRAM-PRINCIPAL PIPING SYSTEMS.
Left Rear
Right Rear
Assumed North
Left Front
Right Front
KEY PLAN
POWERHOUSE
UNITS 1, 2, 3 & 4
FLOW DIAGRAM
LIGHTING-OFF OIL
KINGSTON STEAM PLANT
TENNESSEE VALLEY AUTHORITY
DIVISION OF DESIGN
SUBMITTED
RECOMMENDED
APPROVED
KNOXVILLE
3-1-53
36
M
4
47W813R3



NOTES:

1. All pressure gage and pressure switch valves are ½" globe valves unless otherwise noted.
2. All valves are the same size as the piping except as noted.
3. All valve numbers shall be prefixed with the Unit number, i.e. 5LO-82, 6LO-82, etc.
4. For symbols and index see 47W5800 - Flow Diagram Principal Piping Systems.

REFERENCE DRAWINGS:

47BM5800 _ _ _ BILL OF MATERIAL - VALVE MARKER TAGS
47W5800 _ _ _ FLOW DIAGRAM - PRINCIPAL PIPING SYSTEMS

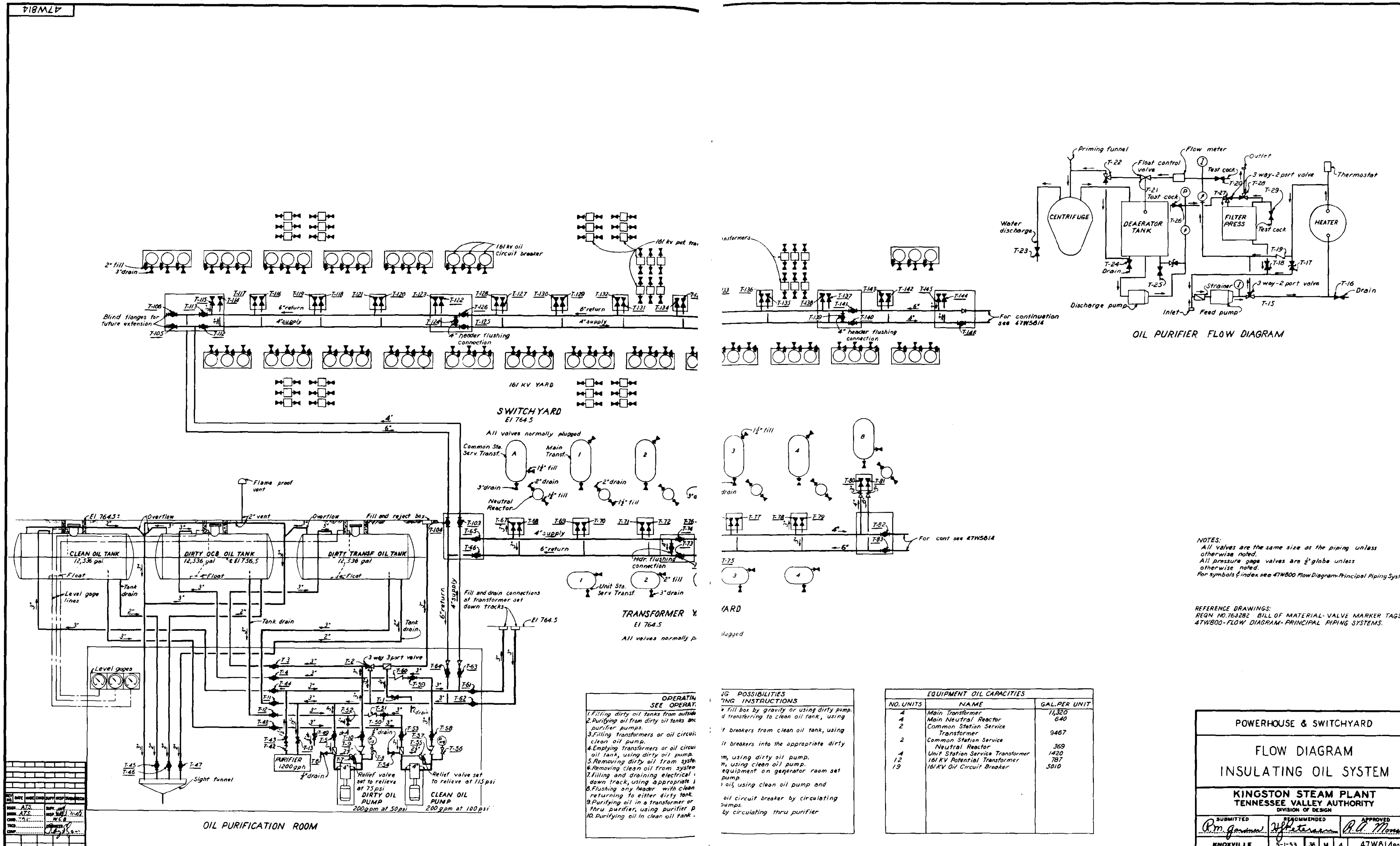
POWERHOUSE
UNITS 5-9

FLOW DIAGRAM
LIGHTING-OFF OIL

KINGSTON STEAM PLANT
TENNESSEE VALLEY AUTHORITY
DIVISION OF DESIGN

SUBMITTED	RECOMMENDED	APPROVED
R.M. Gardner	[illegible]	R.A. Monroe

KNOXVILLE | 9-7-54 | 36 | M | 4 | 47W5813 R3



NOTES:
All valves are the same size as the piping unless otherwise noted.
All pressure gage valves are ½" globe unless otherwise noted.
For symbols & index see 47W800 Flow Diagram-Principal Piping System.

REFERENCE DRAWINGS:
REQN NO. 763282 BILL OF MATERIAL-VALVE MARKER TAGS
47W800-FLOW DIAGRAM-PRINCIPAL PIPING SYSTEMS.

OPERATIN JG POSSIBILITIES
SEE OPERAT TING INSTRUCTIONS

1.Filling dirty oil tanks from outside e fill box by gravity or using dirty pump.
2.Purifying oil from dirty oil tanks and d transferring to clean oil tank, using
purifier pumps.
3.Filling transformers or oil circui t breakers from clean oil tank, using
clean oil pump.
4.Emptying transformers or oil circui it breakers into the appropriate dirty
oil tank, using dirty oil pump.
5.Removing dirty oil from syste m, using dirty oil pump.
6.Removing clean oil from system n, using clean oil pump.
7.Filling and draining electrical equipment on generator room set
down track, using appropriate pump.
8.Flushing any header with clean oil, using clean oil pump and
returning to either dirty tank.
9.Purifying oil in a transformer or oil circuit breaker by circulating
thru purifier, using purifier p umps.
10.Purifying oil in clean oil tank by circulating thru purifier

EQUIPMENT OIL CAPACITIES		
NO. UNITS	NAME	GAL. PER UNIT
4	Main Transformer	11,320
4	Main Neutral Reactor	640
2	Common Station Service Transformer	9467
2	Common Station Service Neutral Reactor	369
4	Unit Station Service Transformer	1420
12	161 KV Potential Transformer	787
19	161 KV Oil Circuit Breaker	5010

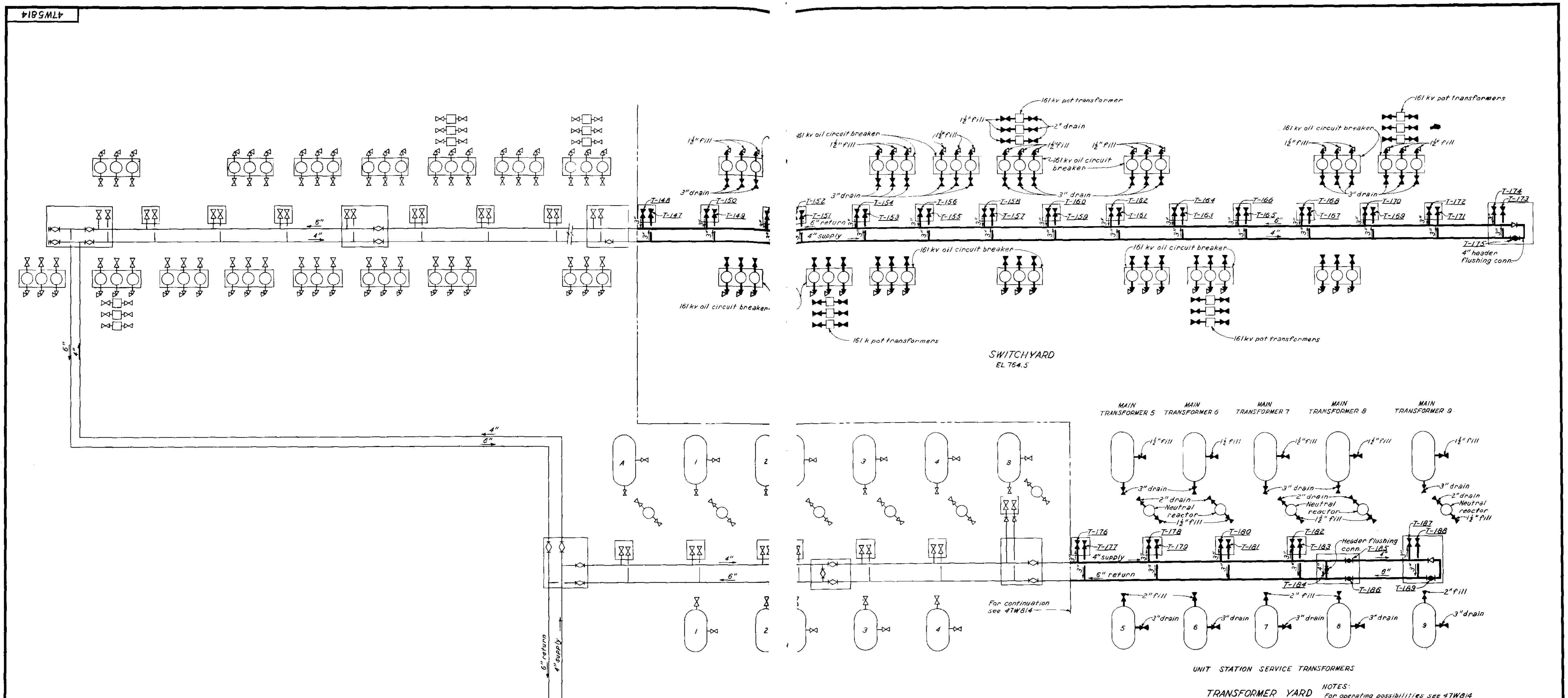
POWERHOUSE & SWITCHYARD

FLOW DIAGRAM
INSULATING OIL SYSTEM

KINGSTON STEAM PLANT
TENNESSEE VALLEY AUTHORITY
DIVISION OF DESIGN

SUBMITTED: R.M. Gardner | RECOMMENDED: H.J. Peterson | APPROVED: R.A. Monroe

KNOXVILLE 5-1-53 36 M 4 47W814R0



TRANSFORMER YARD
EL 764.5

NOTES:
For operating possibilities see 47W814
All valves are the same size as the piping unless otherwise noted.
All pressure gage valves are ½" globe unless otherwise noted
For symbols & index see 47W5800. Flow Diagram - Principal Piping Systems.

REFERENCE DRAWINGS:
REQN NO.______BILL OF MATERIAL - VALVE MARKER TAGS
47W5800______FLOW DIAGRAM - PRINCIPAL PIPING SYSTEM
47W814______FLOW DIAGRAM - INSULATING OIL SYSTEM

EQUIPMENT OIL CAPACITIES

NO. UNITS	NAME	GAL. PER UNIT
5	Main Transformer	11,900
5	Main Neutral Reactor	720
5	Unit Station Service Transformer	2,340
12	161 KV Potential Transformer	787
14	161 KV Oil Circuit Breaker	5,010

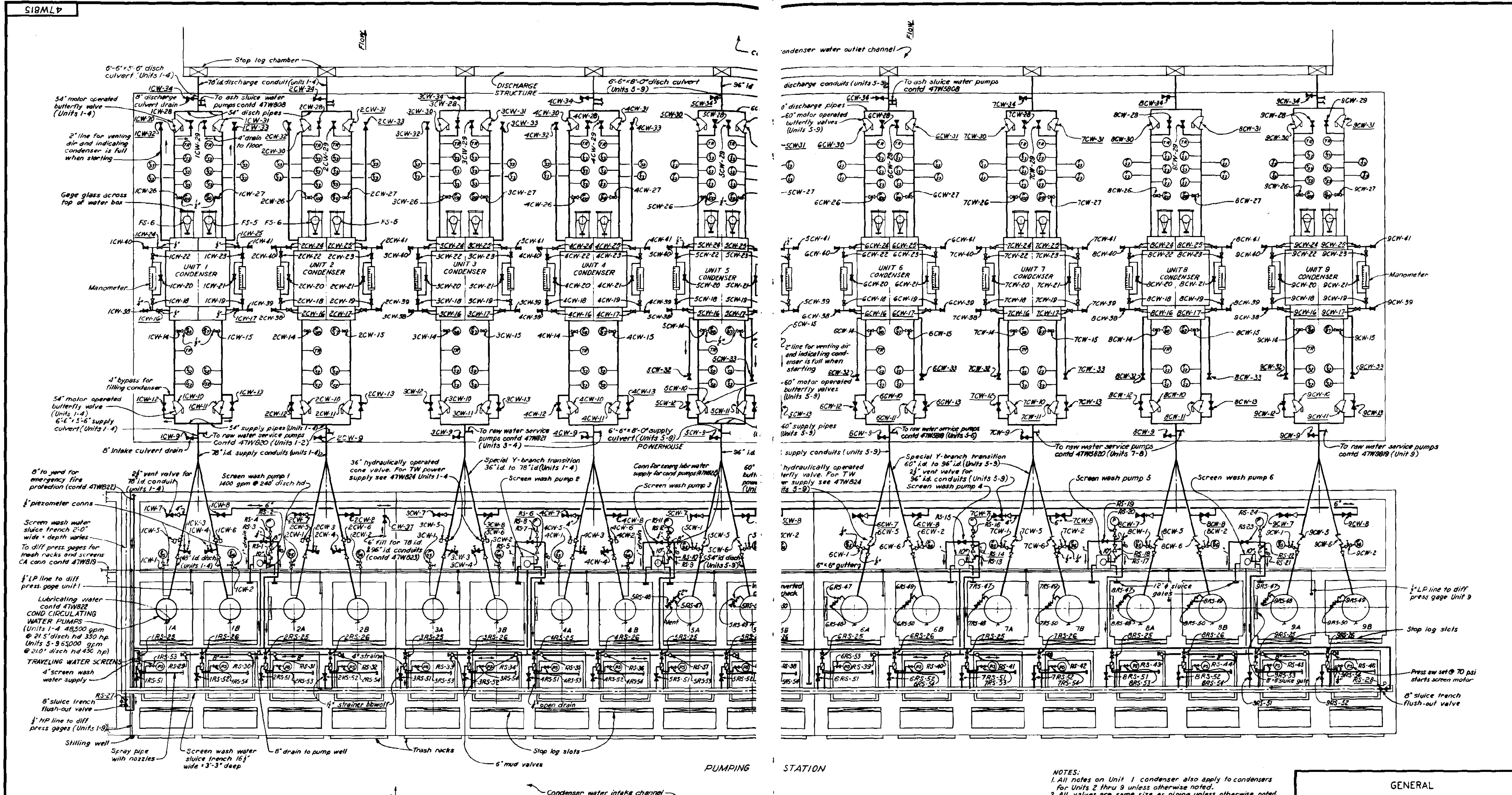
POWERHOUSE & SWITCHYARD
UNITS 5 - 9

FLOW DIAGRAM
INSULATING OIL SYSTEM

KINGSTON STEAM PLANT
TENNESSEE VALLEY AUTHORITY
DIVISION OF DESIGN

SUBMITTED	RECOMMENDED	APPROVED
R.M. Gardner	H. Petersen	R.A. Monroe

KNOXVILLE | 9-7-54 | 36 | M | 4 | 47W5814



NOTES:
1. All notes on Unit 1 condenser also apply to condensers for Units 2 thru 9 unless otherwise noted.
2. All valves are same size as piping unless otherwise noted.

REFERENCE DRAWINGS:
REQN NO. 763282 - BILL OF MATERIAL - VALVE MARKER TAGS - UNITS 1-4
REQN NO. 769777 - BILL OF MATERIAL - VALVE MARKER TAGS - UNITS 5-8
REQN NO. 824812 - BILL OF MATERIAL - VALVE MARKER TAGS - UNIT 9
FOR SYMBOLS & INDEX SEE 47W800 - FLOW DIAGRAM PRINCIPAL PIPING SYSTEMS

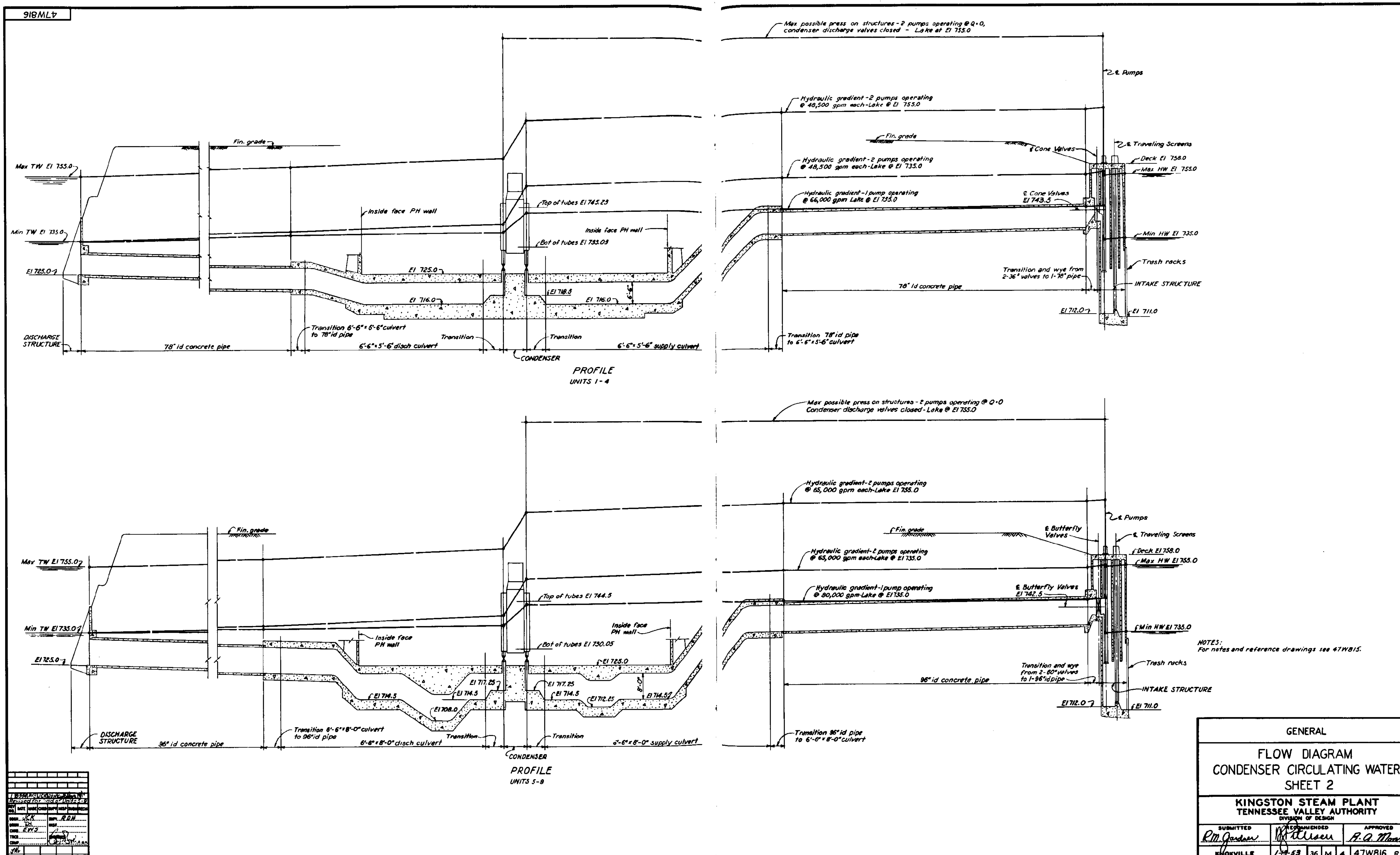
GENERAL

FLOW DIAGRAM
CONDENSER CIRCULATING WATER
SHEET 1

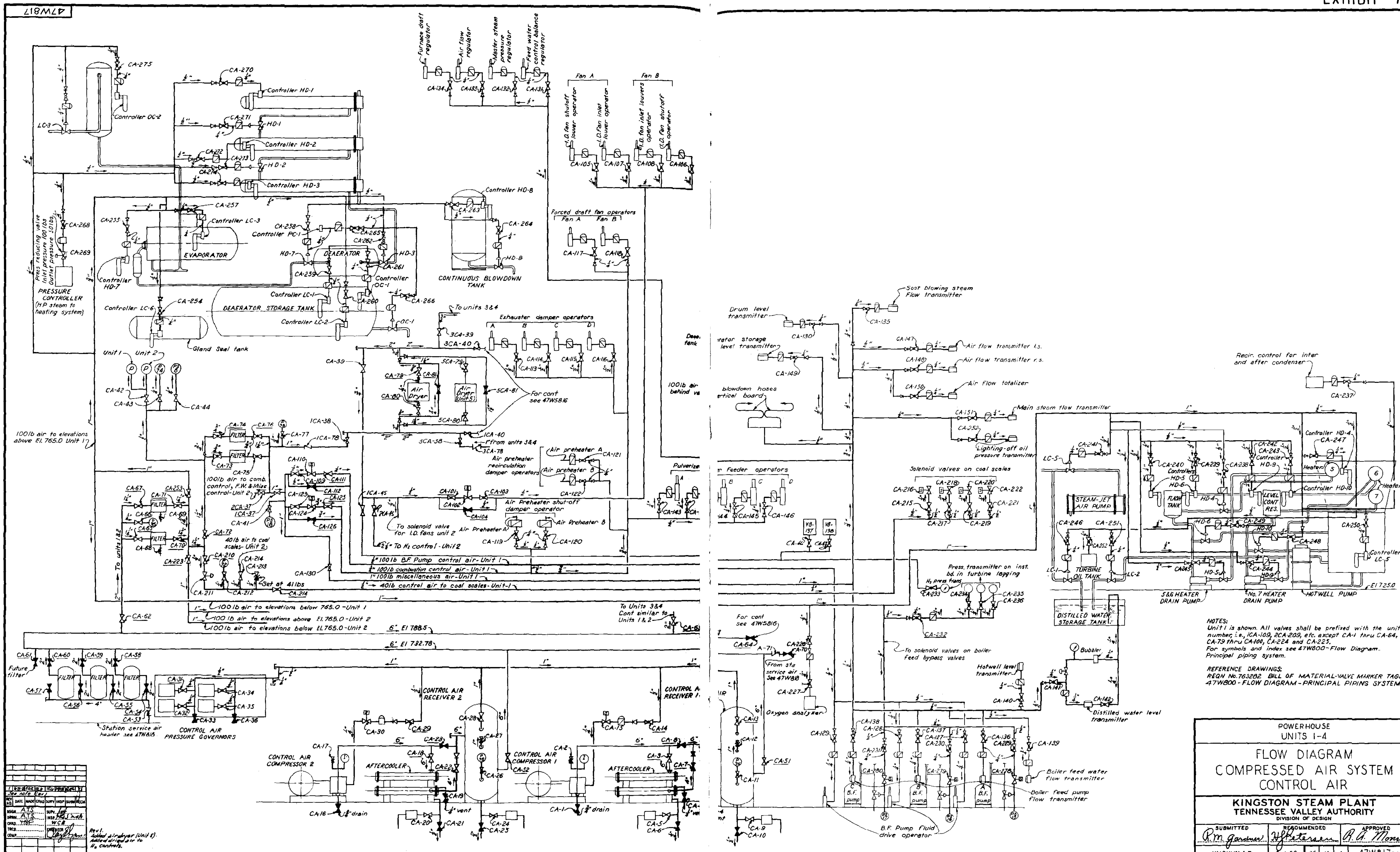
KINGSTON STEAM PLANT
TENNESSEE VALLEY AUTHORITY
DIVISION OF DESIGN

SUBMITTED	RECOMMENDED	APPROVED
R.M. Gardner	[signature]	R.A. Monroe

KNOXVILLE | 1-13-53 | 36 | M | 4 | 47W815 R4



47W816
Max possible press on structures - 2 pumps operating @ Q=0, condenser discharge valves closed - Lake at El 755.0
℄ Pumps
Hydraulic gradient - 2 pumps operating @ 48,500 gpm each-Lake @ El 755.0
Fin. grade
℄ Cone Valves
℄ Traveling Screens
Deck El 758.0
Max HW El 755.0
Hydraulic gradient - 2 pumps operating @ 48,500 gpm each-Lake @ El 735.0
Hydraulic gradient - 1 pump operating @ 66,000 gpm Lake @ El 735.0
℄ Cone Valves El 743.5
Min HW El 735.0
Trash racks
Transition and wye from 2-36" valves to 1-78" pipe
INTAKE STRUCTURE
78" id concrete pipe
El 712.0
El 711.0
Transition 78"id pipe to 6'-6"×5'-6" culvert
Max TW El 755.0
Min TW El 735.0
El 725.0
Inside face PH wall
Top of tubes El 745.23
Bot of tubes El 733.03
El 725.0
El 716.0
El 718.5
DISCHARGE STRUCTURE
78" id concrete pipe
Transition 6'-6"×5'-6" culvert to 78"id pipe
6'-6"×5'-6" disch culvert
Transition
CONDENSER
6'-6"×5'-6" supply culvert
PROFILE
UNITS 1-4
Max possible press on structures - 2 pumps operating @ Q=0 Condenser discharge valves closed - Lake @ El 755.0
Hydraulic gradient - 2 pumps operating @ 65,000 gpm each-Lake @ El 755.0
℄ Butterfly Valves
Hydraulic gradient - 2 pumps operating @ 65,000 gpm each-Lake @ El 735.0
Hydraulic gradient - 1 pump operating @ 80,000 gpm-Lake @ El 735.0
℄ Butterfly Valves El 742.5
Min HW El 735.0
NOTES:
For notes and reference drawings see 47W815.
Transition and wye from 2-60" valves to 1-96"id pipe
96" id concrete pipe
Transition 96"id pipe to 6'-6"×8'-0" culvert
Top of tubes El 744.5
Bot of tubes El 730.05
Inside face PH wall
El 717.25
El 714.5
El 708.0
El 712.25
El 714.5
8'-0"
96" id concrete pipe
Transition 6'-6"×8'-0" culvert to 96"id pipe
6'-6"×8'-0" disch culvert
6'-6"×8'-0" supply culvert
PROFILE
UNITS 5-8
GENERAL
FLOW DIAGRAM
CONDENSER CIRCULATING WATER
SHEET 2
KINGSTON STEAM PLANT
TENNESSEE VALLEY AUTHORITY
DIVISION OF DESIGN
SUBMITTED
RECOMMENDED
APPROVED
KNOXVILLE
1-15-53
36 M 4 47W816 R1


47W817
Controller OC-2
CA-275
CA-270
Controller HD-1
CA-271
HD-1
Controller HD-2
CA-272
CA-273
HD-2
CA-274
Controller HD-3
LC-3
Controller HD-8
CA-263
CA-264
HD-8
CONTINUOUS BLOWDOWN TANK
CA-257
CA-255
Controller LC-3
CA-268
CA-269
Press reducing valve Inlet pressure 100 lbs Outlet pressure 50 lbs
PRESSURE CONTROLLER (HP steam to heating system)
EVAPORATOR
Controller HD-7
HD-7
CA-258
Controller PC-1
CA-265
CA-262
DEAERATOR
HD-3
CA-261
Controller OC-1
CA-259
Controller LC-1
CA-260
CA-266
OC-1
Controller LC-6
CA-254
DEAERATOR STORAGE TANK
Controller LC-2
Gland Seal tank
Furnace draft regulator
Air flow regulator
Master steam pressure regulator
Feed water control balance regulator
CA-134
CA-133
CA-132
CA-131
Fan A
Fan B
F.D. fan shutoff louver operator
I.D. fan inlet louver operator
I.D. fan inlet louvers operator
I.D. fan shutoff operator
CA-105
CA-107
CA-108
CA-106
Forced draft fan operators
CA-117
CA-118
To units 3&4
3CA-39
3CA-40
Exhauster damper operators
CA-114
CA-113
CA-115
CA-116
Unit 1
Unit 2
CA-42
CA-43
CA-44
CA-39
CA-78
CA-80
Air Dryer
5CA-79
Air Dryer (Unit 5)
5CA-81
5CA-80
For cont see 47W816
100 lb air to elevations above El. 765.0 Unit 1
CA-74
CA-76
FILTER
CA-77
1CA-38
1CA-78
3CA-38
1CA-40
from units 3&4
3CA-78
Air preheater recirculation damper operators
Air preheater A
Air preheater B
CA-121
CA-73
CA-75
100 lb air to comb. control, F.W. & Misc. control - Unit 2
CA-110
CA-109
CA-111
CA-112
CA-125
CA-123
CA-124
CA-126
1CA-45
2CA-45
CA-101
CA-102
CA-103
CA-104
CA-122
Air Preheater shut-off damper operator
Air Preheater A
Air Preheater B
CA-119
CA-120
To solenoid valve for I.D. fans unit 2
To H2 control - Unit 2
CA-67
CA-253
CA-71
CA-69
CA-66
CA-65
CA-68
CA-70
CA-72
2CA-37
1CA-37
CA-41
40 lb air to coal scales - Unit 2
To units 1&2
CA-223
CA-210
CA-214
CA-213
CA-211
CA-212
Set at 41 lbs
CA-130
100 lb B.F. Pump control air - Unit 1
100 lb combustion control air - Unit 1
100 lb miscellaneous air - Unit 1
40 lb control air to coal scales - Unit 1
CA-62
100 lb air to elevations below 765.0 - Unit 1
100 lb air to elevations above El.765.0 - Unit 2
100 lb air to elevations below El.765.0 - Unit 2
To Units 3&4 Cont similar to Units 1&2
6" El 788.5
6" El 732.78
CA-61
CA-60
CA-59
CA-58
Future filter
CA-57
CA-56
CA-55
CA-54
CA-53
Station service air header see 47W815
CA-31
CA-34
CA-35
CA-32
CA-33
CA-36
CONTROL AIR PRESSURE GOVERNORS
CONTROL AIR RECEIVER 2
CA-30
CA-29
CA-28
CA-27
CA-26
CA-17
CA-23
CA-18
CA-22
CA-19
CONTROL AIR COMPRESSOR 2
AFTERCOOLER
CA-16
drain
vent
CA-20
CA-21
CA-24
CA-25
CONTROL AIR COMPRESSOR 1
CA-52
CA-2
CA-1
drain
CA-15
CA-14
CA-8
CA-3
CA-7
CA-5
CA-6
CONTROL AIR RECEIVER 1
Rev 1. Added air dryer (Unit 1). Added dried air to H2 controls.
Soot blowing steam flow transmitter
Drum level transmitter
CA-135
CA-130
Deaerator storage level transmitter
CA-149
CA-147
Air flow transmitter l.s.
CA-148
Air flow transmitter r.s.
CA-150
Air Flow totalizer
Blowdown hoses vertical board
CA-151
Main steam flow transmitter
CA-252
Lighting-off oil pressure transmitter
Recir. control for inter and after condenser
CA-237
Feeder operators
CA-144
CA-145
CA-146
CA-143
Pulverizer
Solenoid valves on coal scales
CA-216
CA-218
CA-220
CA-222
CA-215
CA-217
CA-219
CA-221
VB-137
VB-138
CA-42
CA-43
Press. transmitter on inst. bd. in turbine lagging
H2 press. trans.
CA-233
CA-234
CA-235
CA-236
CA-232
To solenoid valves on boiler feed bypass valves
For cont see 47W816
CA-64
A-71
CA-226
CA-70
From sta service air See 47W815
CA-227
Oxygen analyzer
CA-13
CA-12
CA-11
CA-51
CA-9
CA-10
CA-129
CA-138
CA-128
CA-231
CA-280
CA-137
CA-127
CA-230
CA-279
CA-136
CA-229
CA-278
CA-139
B.F. pump
Boiler feed water flow transmitter
Boiler feed pump flow transmitter
B.F. Pump fluid drive operator
Hotwell level transmitter
CA-140
CA-141
Bubbler
CA-142
Distilled water level transmitter
LC-5
CA-241
STEAM-JET AIR PUMP
CA-246
CA-251
CA-252
LC-1
TURBINE OIL TANK
LC-2
DISTILLED WATER STORAGE TANK
CA-240
Controller HD-5
HD-6
FLASH TANK
CA-239
CA-238
HD-4
CA-242
CA-243
Controller HD-9
LEVEL CONT. RES.
Controller HD-4
CA-247
Heater
Controller HD-10
CA-249
HD-10
CA-248
CA-250
Controller LC-5
CA-245
HD-5
CA-244
HD-9
5&6 HEATER DRAIN PUMP
No. 7 HEATER DRAIN PUMP
HOTWELL PUMP
El 725.0
NOTES:
Unit 1 is shown. All valves shall be prefixed with the unit number, i.e., 1CA-109, 2CA-209, etc. except CA-1 thru CA-64, CA-79 thru CA-100, CA-224 and CA-225.
For symbols and index see 47W800-Flow Diagram-Principal piping system.
REFERENCE DRAWINGS:
REQN No.763282 BILL OF MATERIAL-VALVE MARKER TAGS
47W800-FLOW DIAGRAM-PRINCIPAL PIPING SYSTEM.
POWERHOUSE
UNITS 1-4
FLOW DIAGRAM
COMPRESSED AIR SYSTEM
CONTROL AIR
KINGSTON STEAM PLANT
TENNESSEE VALLEY AUTHORITY
DIVISION OF DESIGN
SUBMITTED R.M. Gardner
RECOMMENDED H.J. Petersen
APPROVED R.A. Monroe
KNOXVILLE
5-1-53
36
M
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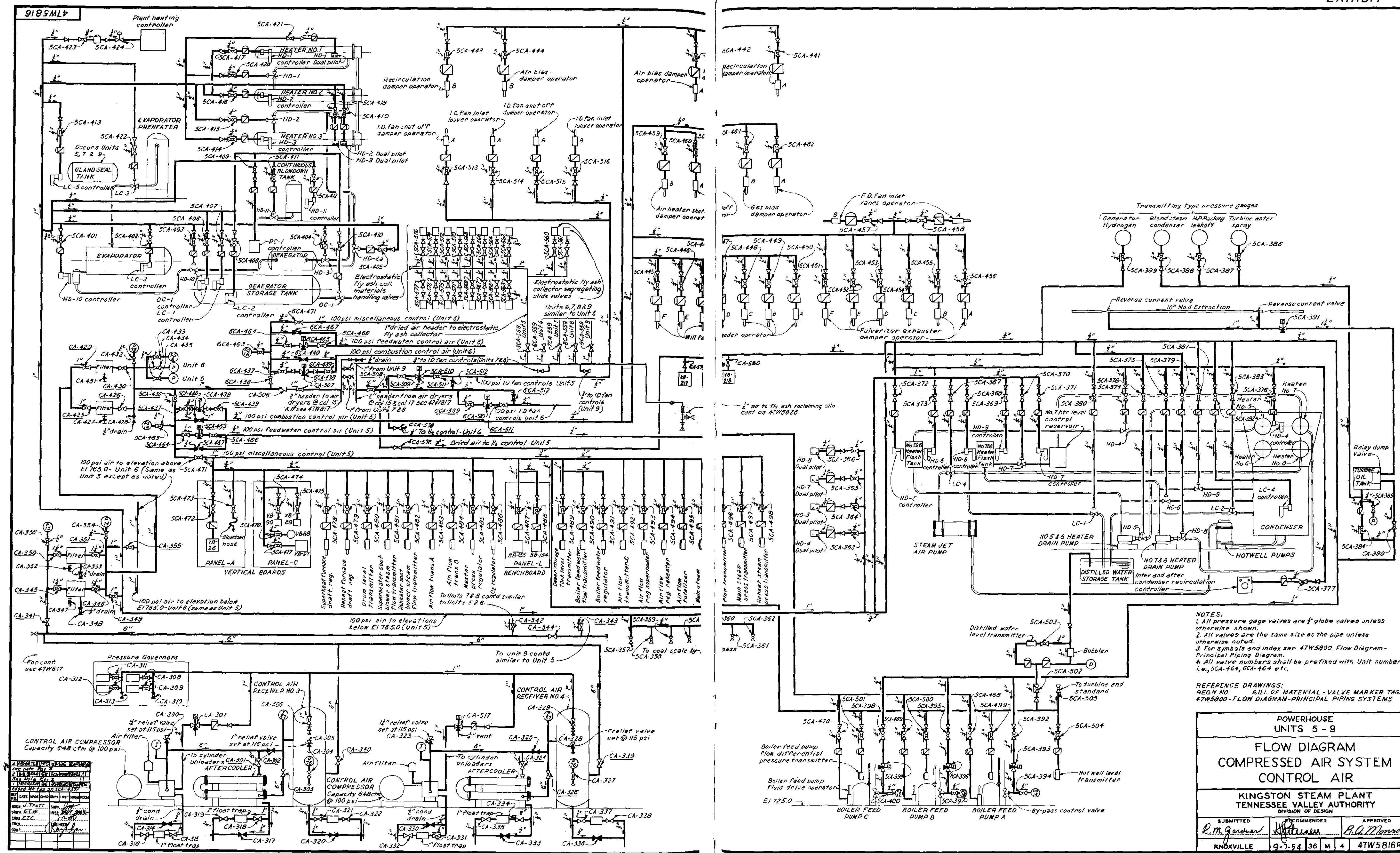
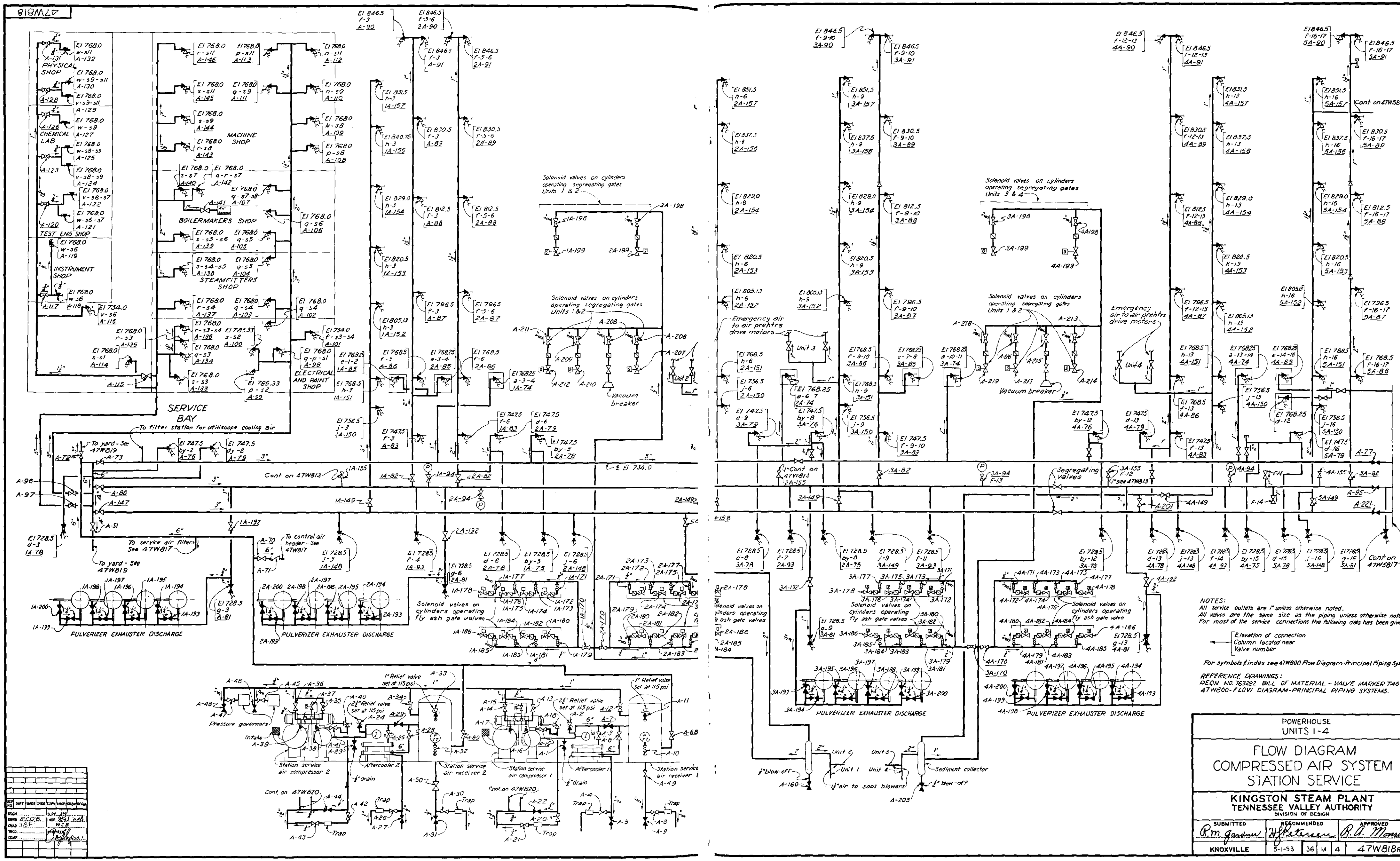
47W817R1


4TW5816
CONTROL AIR COMPRESSOR
Capacity 648 cfm @ 100 psi
CONTROL AIR RECEIVER NO. 3
CONTROL AIR RECEIVER NO. 4
AFTERCOOLER
Pressure Governors
EVAPORATOR
EVAPORATOR PREHEATER
DEAERATOR STORAGE TANK
CONTINUOUS BLOWDOWN TANK
GLAND SEAL TANK
PANEL-A
PANEL-C
PANEL-L
VERTICAL BOARDS
BENCHBOARD
Transmitting type pressure gauges
Pulverizer exhauster damper operator
F.D. fan inlet vanes operator
STEAM JET AIR PUMP
NO. 5 & 6 HEATER DRAIN PUMP
NO. 7 & 8 HEATER DRAIN PUMP
DISTILLED WATER STORAGE TANK
HOTWELL PUMPS
CONDENSER
TURBINE OIL TANK
BOILER FEED PUMP C
BOILER FEED PUMP B
BOILER FEED PUMP A
NOTES:
1. All pressure gage valves are ¼" globe valves unless otherwise shown.
2. All valves are the same size as the pipe unless otherwise noted.
3. For symbols and index see 47W5800 Flow Diagram - Principal Piping Diagram.
4. All valve numbers shall be prefixed with Unit number i.e., 5CA-464, 6CA-464 etc.
REFERENCE DRAWINGS:
REQN NO. BILL OF MATERIAL - VALVE MARKER TAGS
47W5800 - FLOW DIAGRAM - PRINCIPAL PIPING SYSTEMS
POWERHOUSE
UNITS 5 - 9
FLOW DIAGRAM
COMPRESSED AIR SYSTEM
CONTROL AIR
KINGSTON STEAM PLANT
TENNESSEE VALLEY AUTHORITY
DIVISION OF DESIGN
SUBMITTED
RECOMMENDED
APPROVED
KNOXVILLE
9-1-54
36 M 4
4TW5816R3
Rev 2. Added dried air lines to electrostatic fly ash coll. & to H₂ control
Rev 3. Added dry air to fly ash reclaiming silo.


47W818
PHYSICAL SHOP
CHEMICAL LAB
TEST ENG SHOP
INSTRUMENT SHOP
MACHINE SHOP
BOILERMAKERS SHOP
STEAMFITTERS SHOP
ELECTRICAL AND PAINT SHOP
SERVICE BAY
To filter station for utiliscope cooling air
To yard - See 47W819
To service air filters See 47W817
To control air header - See 47W817
Solenoid valves on cylinders operating segregating gates Units 1 & 2
Solenoid valves on cylinders operating segregating gates Units 3 & 4
Vacuum breaker
Emergency air to air prehtrs drive motors
Segregating valves
Solenoid valves on cylinders operating fly ash gate valves
PULVERIZER EXHAUSTER DISCHARGE
Pressure governors
Intake
Station service air compressor 2
Aftercooler 2
Station service air receiver 2
Station service air compressor 1
Aftercooler 1
Station service air receiver 1
1" Relief valve set at 115 psi
Trap
drain
Cont on 47W820
Cont on 47W813
Cont on 47W5817
Sediment collector
blow-off
air to soot blowers
NOTES:
All service outlets are 1" unless otherwise noted.
All valves are the same size as the piping unless otherwise noted.
For most of the service connections the following data has been given:
Elevation of connection
Column located near
Valve number
For symbols & index see 47W800 Flow Diagram-Principal Piping System
REFERENCE DRAWINGS:
REQN NO. 763282 BILL OF MATERIAL - VALVE MARKER TAGS
47W800-FLOW DIAGRAM-PRINCIPAL PIPING SYSTEMS.
POWERHOUSE
UNITS 1-4
FLOW DIAGRAM
COMPRESSED AIR SYSTEM
STATION SERVICE
KINGSTON STEAM PLANT
TENNESSEE VALLEY AUTHORITY
DIVISION OF DESIGN
SUBMITTED R.M. Gardner
RECOMMENDED H.J. Petersen
APPROVED R.A. Monroe
KNOXVILLE
5-1-53
36
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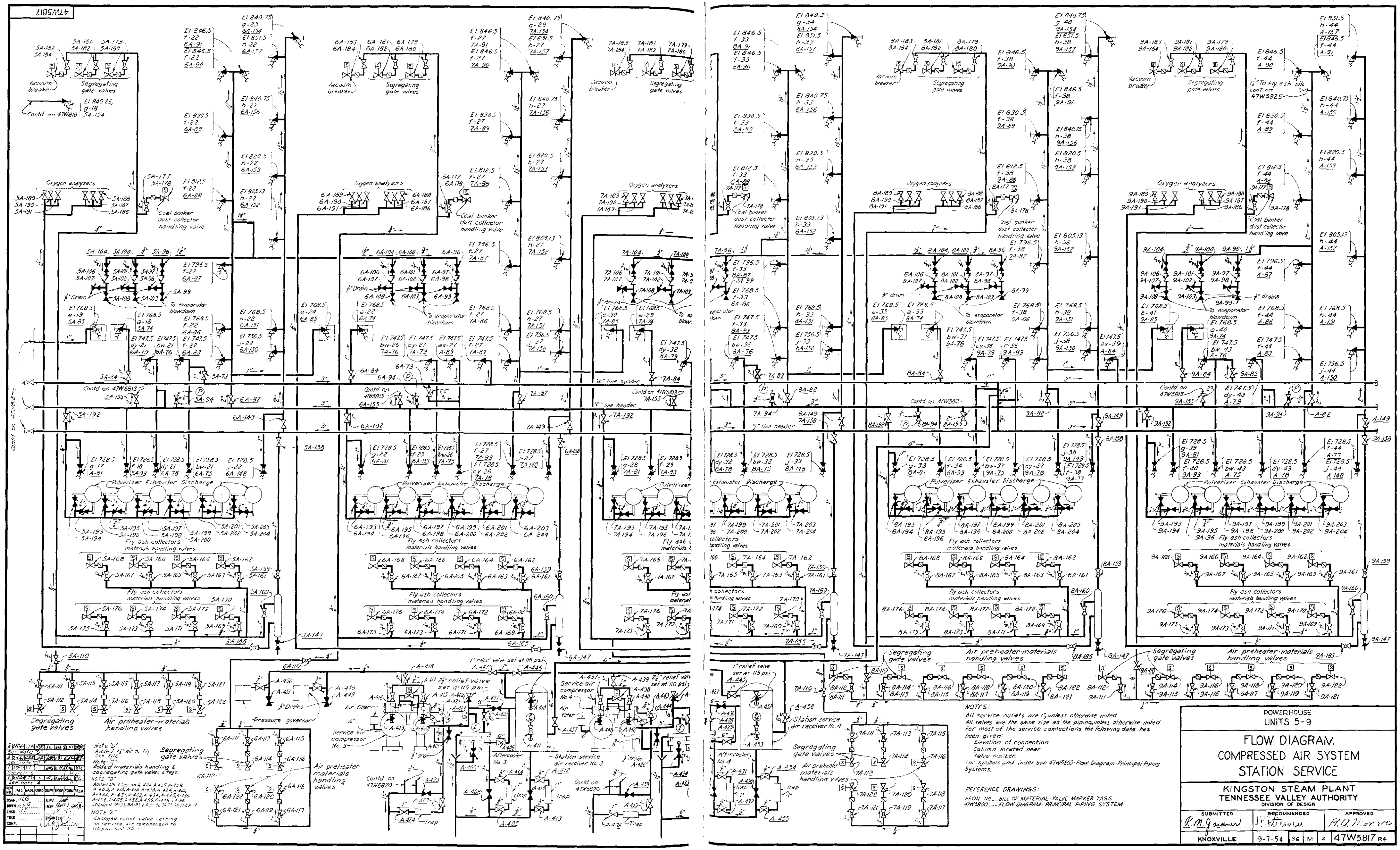
47W818R0


Oxygen analyzers
Coal bunker dust collector handling valve
Vacuum breaker
Segregating gate valves
Pulverizer Exhauster Discharge
Fly ash collectors materials handling valves
Air preheater-materials handling valves
Service air compressor No. 3
Service air compressor No. 4
Aftercooler No. 3
Aftercooler No. 4
Station service air receiver No. 3
Station service air receiver No. 4
Pressure governor
Air filter
Trap
Drains
"F" line header
"J" line header
Contd on 47W5813
Contd on 47W5820
Contd on 47W818
Contd on 47W5825
NOTES:
All service outlets are 1½" unless otherwise noted.
All valves are the same size as the piping, unless otherwise noted.
For most of the service connections the following data has been given:
Elevation of connection.
Column located near.
Valve number.
For symbols and index see 47W5800-Flow Diagram-Principal Piping Systems.
REFERENCE DRAWINGS:
REQN NO.__BILL OF MATERIAL-VALVE MARKER TAGS.
47W5800___FLOW DIAGRAM-PRINCIPAL PIPING SYSTEM.
POWERHOUSE
UNITS 5-9
FLOW DIAGRAM
COMPRESSED AIR SYSTEM
STATION SERVICE
KINGSTON STEAM PLANT
TENNESSEE VALLEY AUTHORITY
DIVISION OF DESIGN
SUBMITTED
RECOMMENDED
APPROVED
KNOXVILLE
9-7-54
36
M
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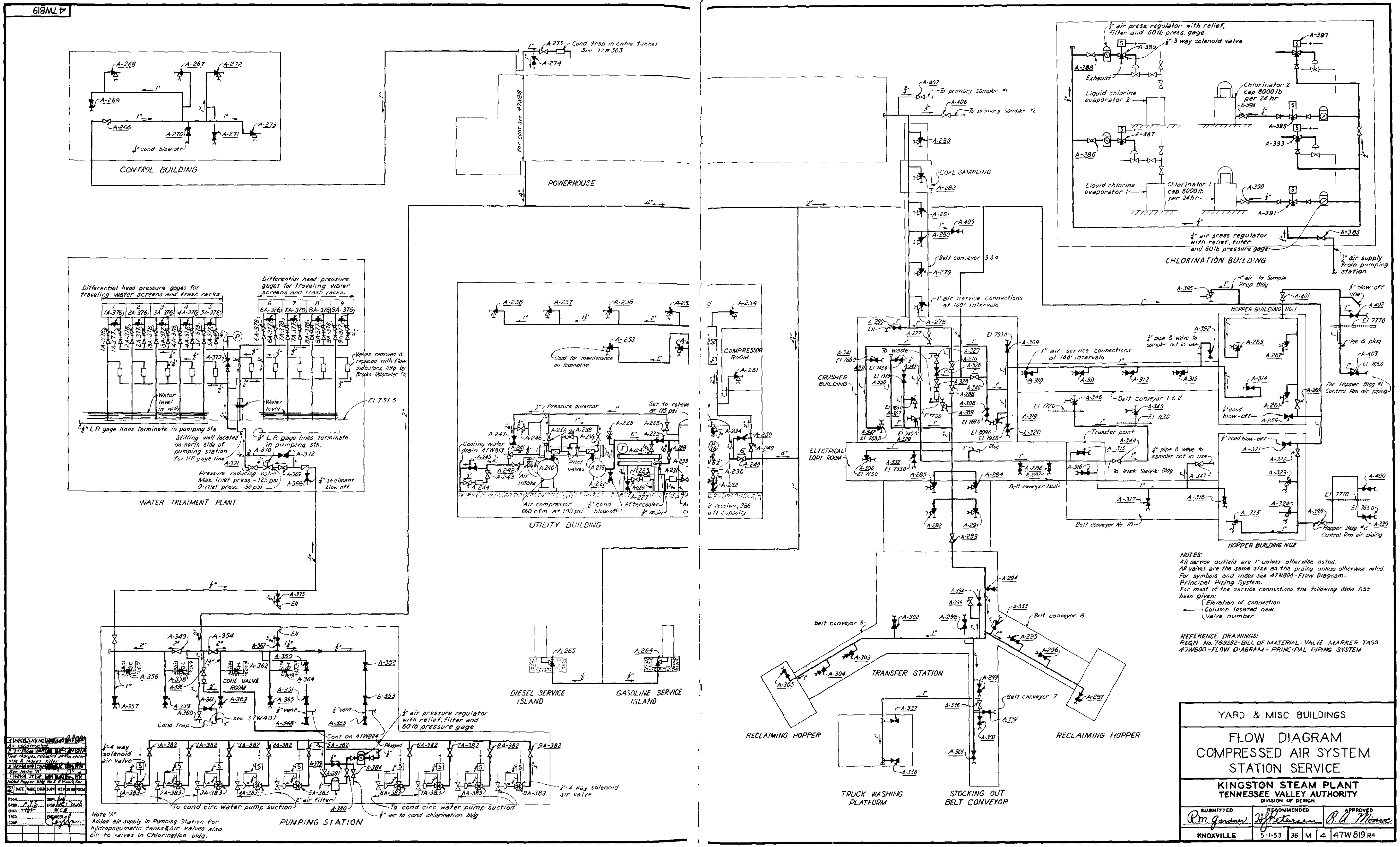
47W5817 R4


47W819
CONTROL BUILDING
POWERHOUSE
WATER TREATMENT PLANT
UTILITY BUILDING
COMPRESSOR ROOM
PUMPING STATION
CONE VALVE ROOM
DIESEL SERVICE ISLAND
GASOLINE SERVICE ISLAND
CHLORINATION BUILDING
COAL SAMPLING
CRUSHER BUILDING
ELECTRICAL EQPT ROOM
HOPPER BUILDING NO.1
HOPPER BUILDING NO.2
TRANSFER STATION
RECLAIMING HOPPER
TRUCK WASHING PLATFORM
STOCKING OUT BELT CONVEYOR
Note "A"
Added air supply in Pumping Station for hydropneumatic tanks & Air valves also air to valves in Chlorination bldg.
NOTES:
All service outlets are 1" unless otherwise noted.
All valves are the same size as the piping unless otherwise noted.
For symbols and index see 47W800-Flow Diagram-Principal Piping System.
For most of the service connections the following data has been given:
Elevation of connection
Column located near
Valve number
REFERENCE DRAWINGS:
REQN No. 763282-BILL OF MATERIAL-VALVE MARKER TAGS
47W800-FLOW DIAGRAM - PRINCIPAL PIPING SYSTEM
YARD & MISC BUILDINGS
FLOW DIAGRAM
COMPRESSED AIR SYSTEM
STATION SERVICE
KINGSTON STEAM PLANT
TENNESSEE VALLEY AUTHORITY
DIVISION OF DESIGN
SUBMITTED
RECOMMENDED
APPROVED
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5-1-53
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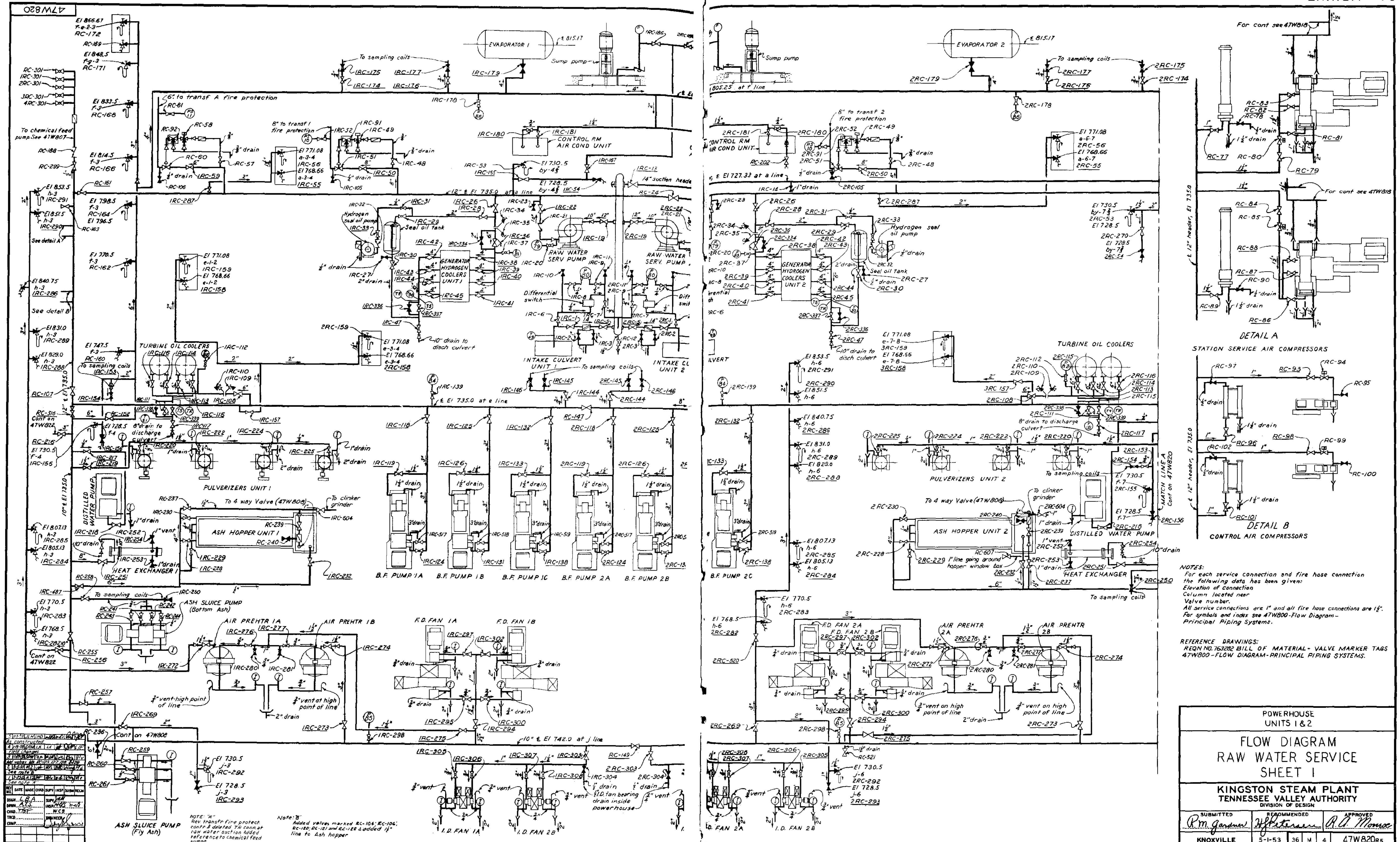
47W819 R4


EVAPORATOR 1
EVAPORATOR 2
GENERATOR HYDROGEN COOLERS UNIT 1
GENERATOR HYDROGEN COOLERS UNIT 2
RAW WATER SERV PUMP
TURBINE OIL COOLERS
INTAKE CULVERT UNIT 1
INTAKE CULVERT UNIT 2
PULVERIZERS UNIT 1
PULVERIZERS UNIT 2
ASH HOPPER UNIT 1
ASH HOPPER UNIT 2
HEAT EXCHANGER 1
HEAT EXCHANGER
DISTILLED WATER PUMP
ASH SLUICE PUMP (Bottom Ash)
ASH SLUICE PUMP (Fly Ash)
AIR PREHTR 1A
AIR PREHTR 1B
AIR PREHTR 2A
AIR PREHTR 2B
F.D. FAN 1A
F.D. FAN 1B
F.D. FAN 2A
F.D. FAN 2B
I.D. FAN 1A
I.D. FAN 2B
B.F. PUMP 1A
B.F. PUMP 1B
B.F. PUMP 1C
B.F. PUMP 2A
B.F. PUMP 2B
B.F. PUMP 2C
DETAIL A
STATION SERVICE AIR COMPRESSORS
DETAIL B
CONTROL AIR COMPRESSORS
NOTES:
For each service connection and fire hose connection the following data has been given:
Elevation of connection
Column located near
Valve number.
All service connections are 1" and all fire hose connections are 1½".
For symbols and index see 47W800-Flow Diagram-Principal Piping Systems.
REFERENCE DRAWINGS:
REQN NO. 763282 BILL OF MATERIAL- VALVE MARKER TAGS
47W800-FLOW DIAGRAM-PRINCIPAL PIPING SYSTEMS.
POWERHOUSE
UNITS 1 & 2
FLOW DIAGRAM
RAW WATER SERVICE
SHEET 1
KINGSTON STEAM PLANT
TENNESSEE VALLEY AUTHORITY
DIVISION OF DESIGN
SUBMITTED
RECOMMENDED
APPROVED
KNOXVILLE
5-1-53
36
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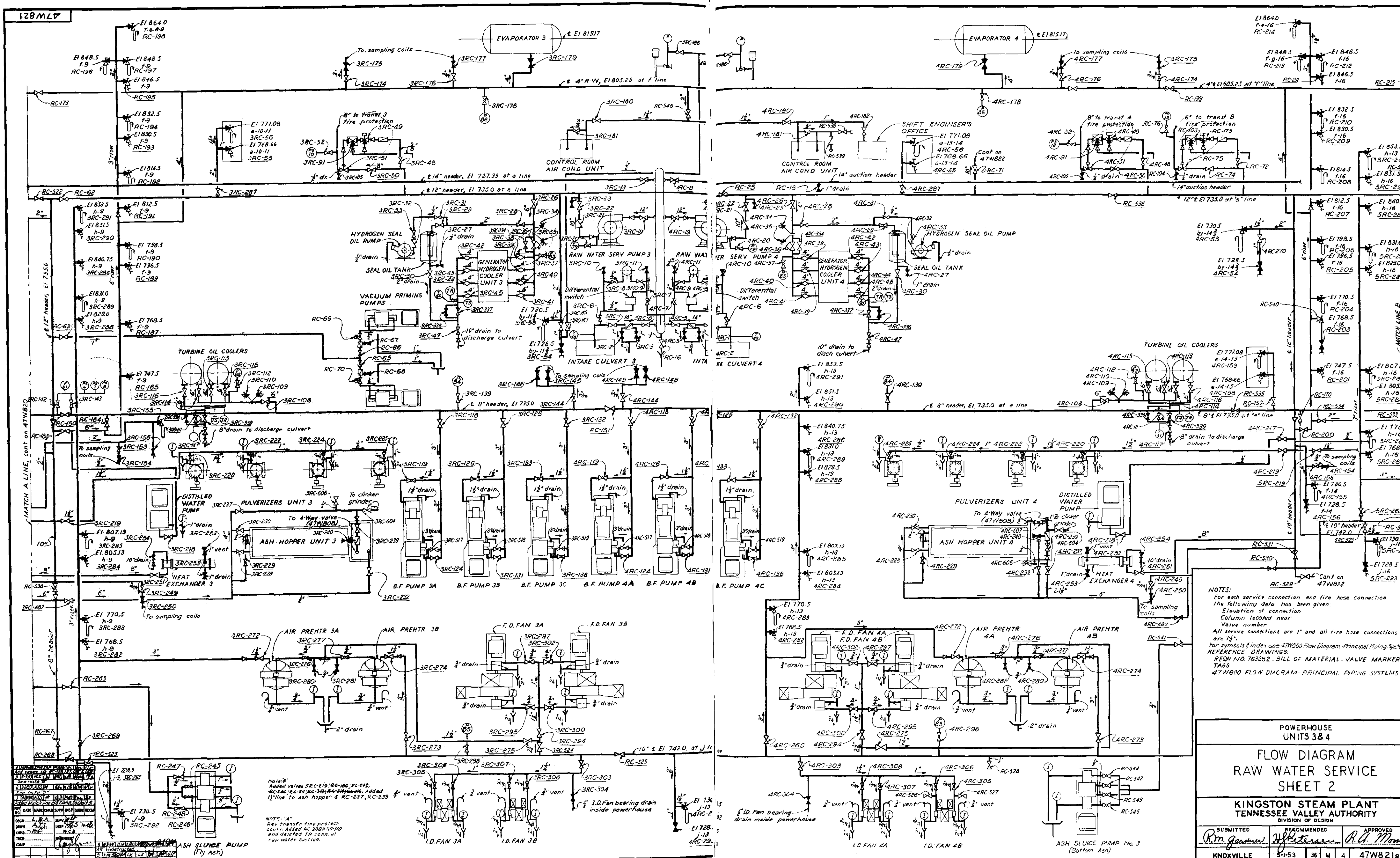
47W820R5


47W821
EVAPORATOR 3
EVAPORATOR 4
CONTROL ROOM AIR COND UNIT
SHIFT ENGINEER'S OFFICE
HYDROGEN SEAL OIL PUMP
SEAL OIL TANK
GENERATOR HYDROGEN COOLER UNIT 3
GENERATOR HYDROGEN COOLER UNIT 4
VACUUM PRIMING PUMPS
RAW WATER SERV PUMP 3
RAW WATER SERV PUMP 4
INTAKE CULVERT 3
INTAKE CULVERT 4
TURBINE OIL COOLERS
PULVERIZERS UNIT 3
PULVERIZERS UNIT 4
ASH HOPPER UNIT 3
ASH HOPPER UNIT 4
DISTILLED WATER PUMP
HEAT EXCHANGER 3
HEAT EXCHANGER 4
B.F. PUMP 3A
B.F. PUMP 3B
B.F. PUMP 3C
B.F. PUMP 4A
B.F. PUMP 4B
B.F. PUMP 4C
AIR PREHTR 3A
AIR PREHTR 3B
AIR PREHTR 4A
AIR PREHTR 4B
F.D. FAN 3A
F.D. FAN 3B
F.D. FAN 4A
F.D. FAN 4B
I.D. FAN 3A
I.D. FAN 3B
I.D. FAN 4A
I.D. FAN 4B
ASH SLUICE PUMP (Fly Ash)
ASH SLUICE PUMP No. 3 (Bottom Ash)
MATCH A LINE, cont on 47W820
MATCH LINE B cont on 47W819
NOTES:
For each service connection and fire hose connection the following data has been given:
Elevation of connection
Column located near
Valve number
All service connections are 1" and all fire hose connections are 1½".
For symbols & index see 47W800 Flow Diagram-Principal Piping System.
REFERENCE DRAWINGS:
REQN NO. 763282 - BILL OF MATERIAL - VALVE MARKER TAGS
47W800 - FLOW DIAGRAM - PRINCIPAL PIPING SYSTEMS.
POWERHOUSE
UNITS 3&4
FLOW DIAGRAM
RAW WATER SERVICE
SHEET 2
KINGSTON STEAM PLANT
TENNESSEE VALLEY AUTHORITY
DIVISION OF DESIGN
SUBMITTED R.M. Gardner
RECOMMENDED H.J. Petersen
APPROVED R.A. Monroe
KNOXVILLE
5-1-53
36
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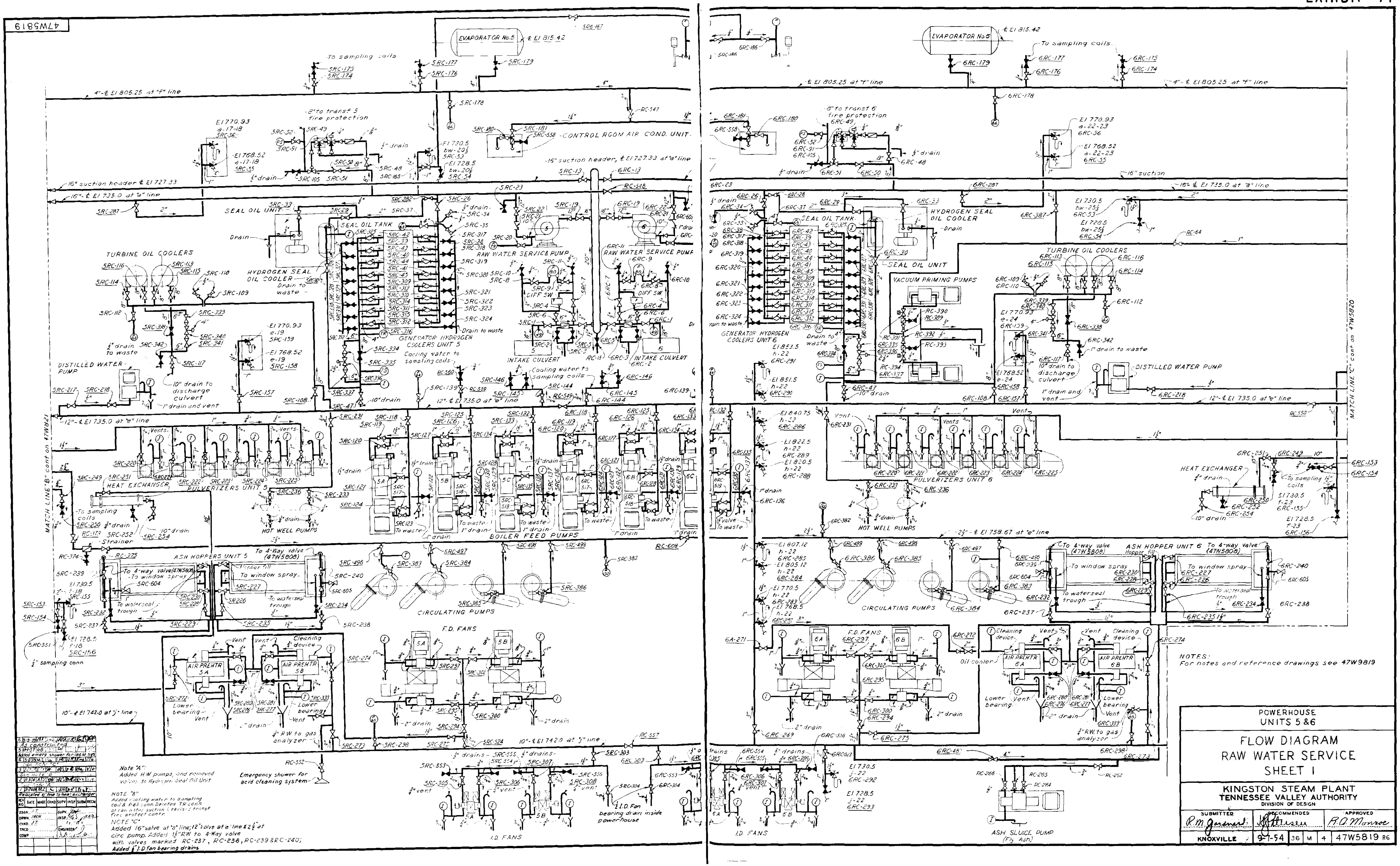
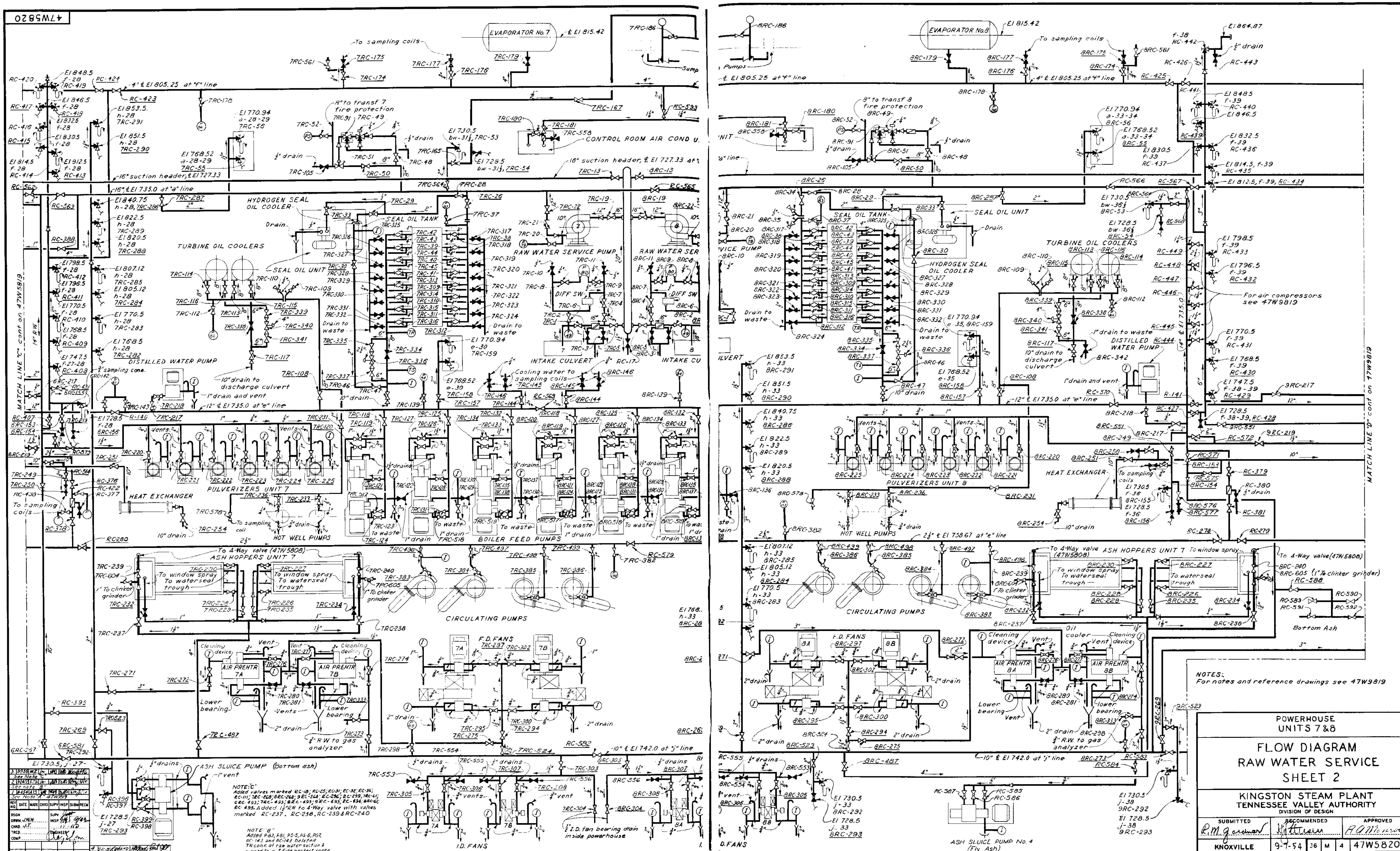
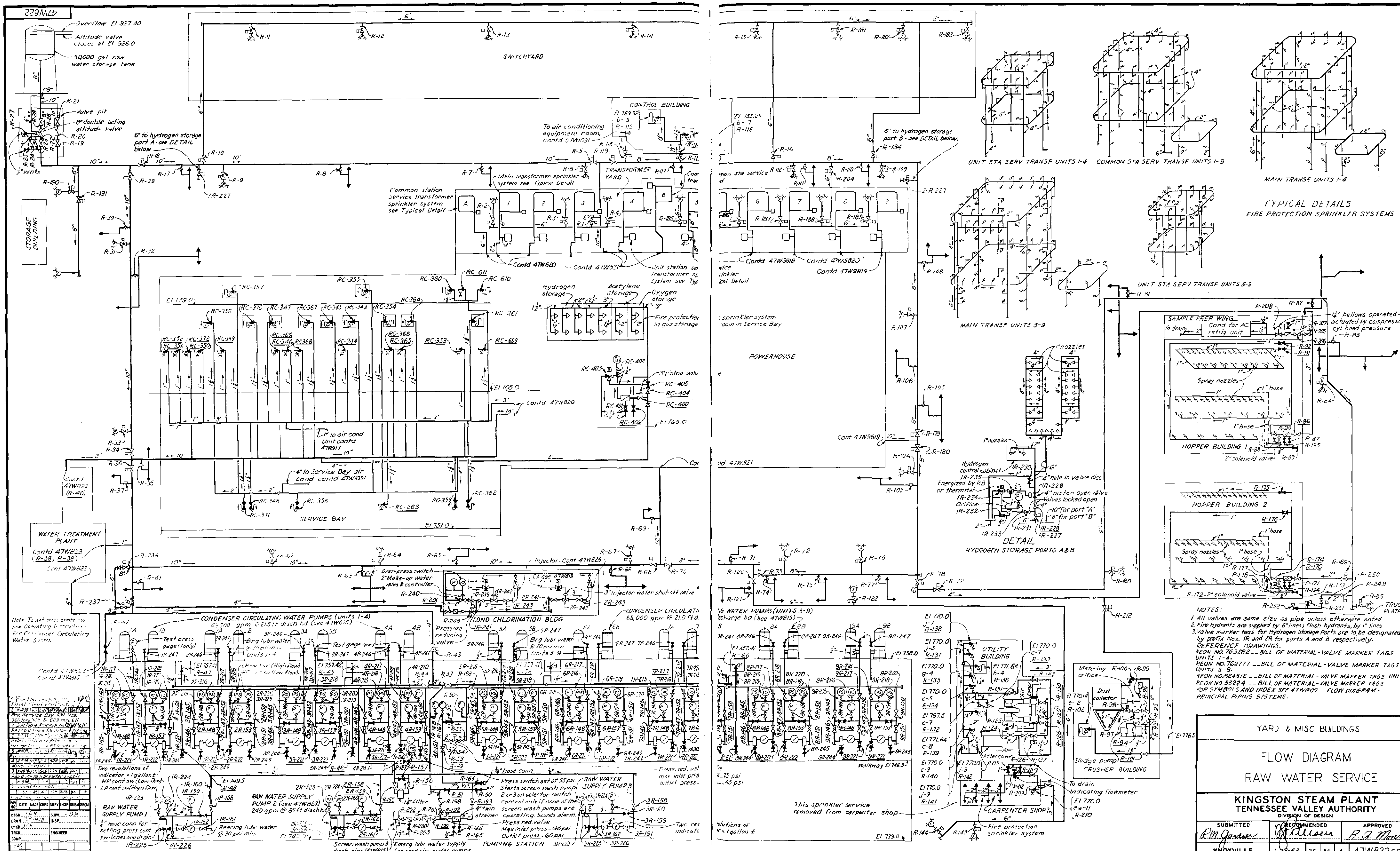
47W821 R6


47W5819
EVAPORATOR No.5
EVAPORATOR No.6
CONTROL ROOM AIR COND. UNIT
SEAL OIL UNIT
SEAL OIL TANK
HYDROGEN SEAL OIL COOLER
TURBINE OIL COOLERS
RAW WATER SERVICE PUMP
GENERATOR HYDROGEN COOLERS UNIT 5
GENERATOR HYDROGEN COOLERS UNIT 6
INTAKE CULVERT
DISTILLED WATER PUMP
VACUUM PRIMING PUMPS
HEAT EXCHANGER
PULVERIZERS UNIT 5
PULVERIZERS UNIT 6
HOT WELL PUMPS
BOILER FEED PUMPS
ASH HOPPERS UNIT 5
ASH HOPPER UNIT 6
CIRCULATING PUMPS
F.D. FANS
AIR PREHTR 5A
AIR PREHTR 5B
AIR PREHTR 6A
AIR PREHTR 6B
I.D. FANS
ASH SLUICE PUMP (Fly Ash)
MATCH LINE "B" cont on 47W1821
MATCH LINE "C" cont on 47W5820
Emergency shower for acid cleaning system
NOTES: For notes and reference drawings see 47W9819
POWERHOUSE UNITS 5 & 6
FLOW DIAGRAM
RAW WATER SERVICE
SHEET 1
KINGSTON STEAM PLANT
TENNESSEE VALLEY AUTHORITY
DIVISION OF DESIGN
SUBMITTED
RECOMMENDED
APPROVED
KNOXVILLE
9-1-54
47W5819 R6


47W5820
EVAPORATOR No.7
EVAPORATOR No.8
TURBINE OIL COOLERS
HYDROGEN SEAL OIL COOLER
SEAL OIL TANK
RAW WATER SERVICE PUMP
DISTILLED WATER PUMP
INTAKE CULVERT
PULVERIZERS UNIT 7
PULVERIZERS UNIT 8
HEAT EXCHANGER
HOT WELL PUMPS
BOILER FEED PUMPS
ASH HOPPERS UNIT 7
CIRCULATING PUMPS
F.D. FANS
AIR PREHTR 7A
AIR PREHTR 7B
AIR PREHTR 8A
AIR PREHTR 8B
I.D. FANS
ASH SLUICE PUMP (Bottom ash)
ASH SLUICE PUMP No. 4 (Fly Ash)
CONTROL ROOM AIR COND U.
MATCH LINE "C" cont on 47W5819
MATCH LINE "D" cont on 47W9819
NOTES: For notes and reference drawings see 47W9819
POWERHOUSE UNITS 7&8
FLOW DIAGRAM
RAW WATER SERVICE
SHEET 2
KINGSTON STEAM PLANT
TENNESSEE VALLEY AUTHORITY
DIVISION OF DESIGN
SUBMITTED
RECOMMENDED
APPROVED
KNOXVILLE
9-7-54
36 M 4
47W5820 R4


47W822
Overflow El 927.40
Altitude valve closes at El 926.0
50000 gal raw water storage tank
Valve pit
8" double acting altitude valve
½" vents
STORAGE BUILDING
SWITCHYARD
CONTROL BUILDING
6" to hydrogen storage port A - see DETAIL below
6" to hydrogen storage port B - see DETAIL below
To air conditioning equipment room, contd 57W1031
TRANSFORMER YARD
Main transformer sprinkler system see Typical Detail
Common station service transformer sprinkler system see Typical Detail
Unit station service transformer sprinkler system see Typical Detail
Contd 47W820
Contd 47W821
Contd 47W819
Contd 47W822
Contd 47W9819
Hydrogen storage
Acetylene storage
Oxygen storage
Fire protection in gas storage
3" piston valve
El 765.0
Contd 47W820
1" to air cond Unit contd 47W917
4" to Service Bay air cond contd 47W1031
SERVICE BAY
El 751.0
POWERHOUSE
WATER TREATMENT PLANT
Contd 47W823 (R-38, R-39)
Contd 47W823 (R-40)
Over-press. switch
2" Make-up water valve & controller
Injector. Cont 47W825
COND CHLORINATION BLDG
3" Injector water shut-off valve
CONDENSER CIRCULATING WATER PUMPS (units 1-4)
CONDENSER CIRCULATING WATER PUMPS (UNITS 5-9)
Test press gage (only)
Brg lubr water @ 75 psi min
Brg lubr water @ 20 psi min Units 5-9
Pressure reducing valve
Test gage conn
Two revolutions of indicator = 1 gallon ±
HP cont sw (Low flow)
LP cont sw (High flow)
RAW WATER SUPPLY PUMP 1
RAW WATER SUPPLY PUMP 2 (see 47W823) 240 gpm @ 85 ft disch hd
RAW WATER SUPPLY PUMP 3
½" hose conn for setting press cont switches and drain
Bearing lubr water @ 30 psi min
Screen wash pump 3 disch pipe (47W815)
Emerg lubr water supply for cond circ water pumps
PUMPING STATION
Press switch set at 55 psi. Starts screen wash pump 2 or 3 on selector switch control only if none of the screen wash pumps are operating. Sounds alarm.
Press red. valve
Max inlet press. - 130 psi
Outlet press. - 60 psi
4" twin strainer
1½" filter
¾" hose conn
Walkway El 746.5
This sprinkler service removed from carpenter shop
UTILITY BUILDING
CARPENTER SHOP
Fire protection sprinkler system
Aftercooler
Metering orifice
Dust collector
Sludge pump
CRUSHER BUILDING
To drain
Indicating flowmeter
UNIT STA SERV TRANSF UNITS 1-4
COMMON STA SERV TRANSF UNITS 1-9
MAIN TRANSF UNITS 1-4
TYPICAL DETAILS
FIRE PROTECTION SPRINKLER SYSTEMS
UNIT STA SERV TRANSF UNITS 5-9
MAIN TRANSF UNITS 5-9
1" nozzles
Hydrogen control cabinet
Energized by P.B or thermostat
Orifice
½" hole in valve disc
4" piston oper valve
Valves locked open
10" for port "A"
8" for port "B"
DETAIL
HYDROGEN STORAGE PORTS A&B
SAMPLE PREP WING
Cond for AC refrig unit
1½" bellows operated - actuated by compressor cyl. head pressure
Spray nozzles
1" hose
HOPPER BUILDING 1
2" solenoid valve
HOPPER BUILDING 2
R-172 - 2" solenoid valve
TRUCK PLATFORM
NOTES:
1. All valves are same size as pipe unless otherwise noted
2. Fire hydrants are supplied by 6" lines; flush hydrants, by 1" lines
3. Valve marker tags for Hydrogen Storage Ports are to be designated by prefix Nos. 1R and 2R for ports A and B respectively.
REFERENCE DRAWINGS:
REQN NO. 763282 - BILL OF MATERIAL - VALVE MARKER TAGS UNITS 1-4.
REQN NO. 769777 - BILL OF MATERIAL - VALVE MARKER TAGS UNITS 5-8.
REQN NO. 824812 - BILL OF MATERIAL - VALVE MARKER TAGS - UNIT 9
REQN NO. 53224 - BILL OF MATERIAL - VALVE MARKER TAGS
FOR SYMBOLS AND INDEX SEE 47W800 - FLOW DIAGRAM - PRINCIPAL PIPING SYSTEMS.
YARD & MISC BUILDINGS
FLOW DIAGRAM
RAW WATER SERVICE
KINGSTON STEAM PLANT
TENNESSEE VALLEY AUTHORITY
DIVISION OF DESIGN
SUBMITTED
RECOMMENDED
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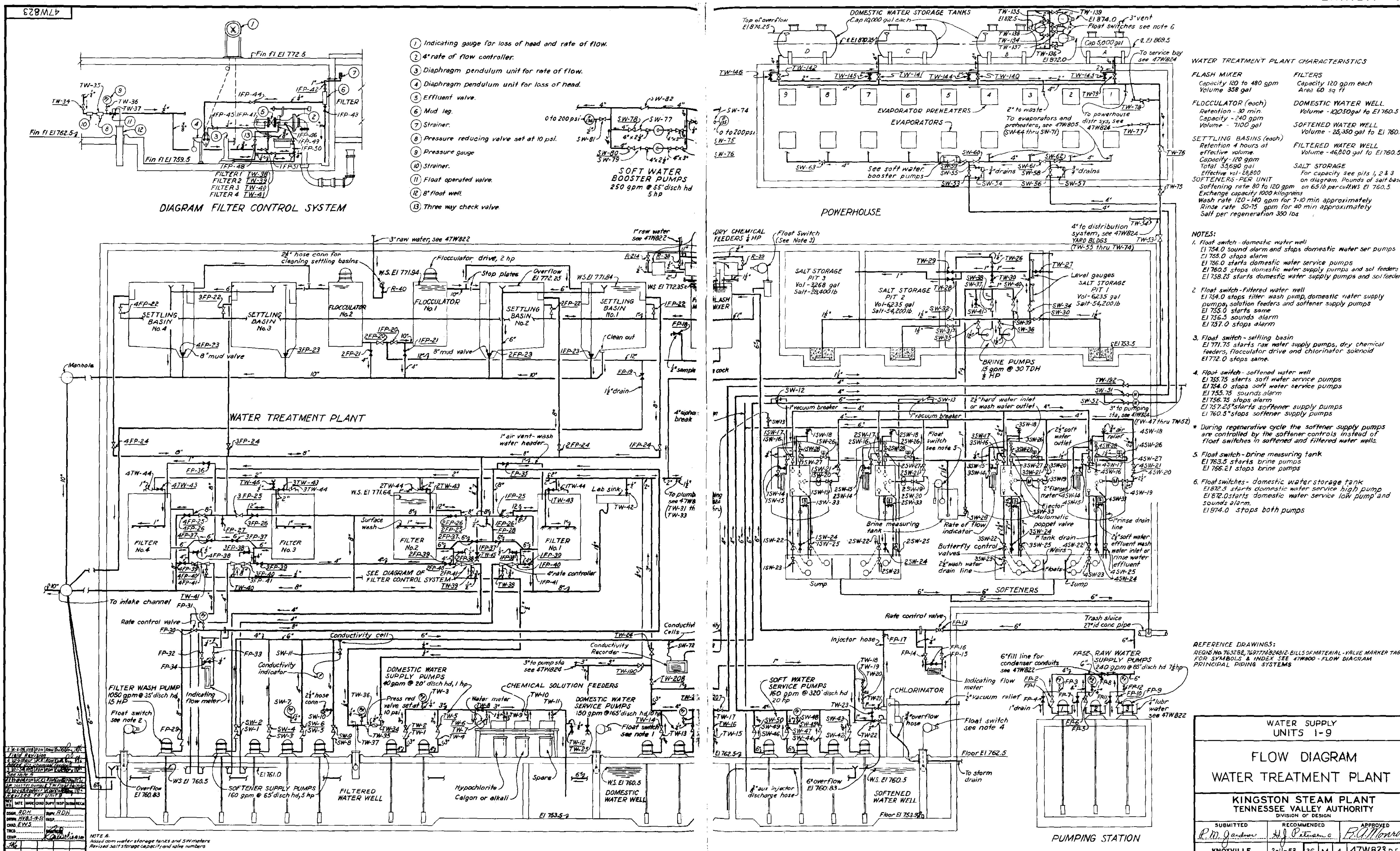
R.M. Gardner
R.A. Monroe
KNOXVILLE
1-13-53
36 M 4
47W822 R9


47W823
DIAGRAM FILTER CONTROL SYSTEM
(1) Indicating gauge for loss of head and rate of flow.
(2) 4" rate of flow controller.
(3) Diaphragm pendulum unit for rate of flow.
(4) Diaphragm pendulum unit for loss of head.
(5) Effluent valve.
(6) Mud leg.
(7) Strainer.
(8) Pressure reducing valve set at 10 psi.
(9) Pressure gauge
(10) Strainer.
(11) Float operated valve.
(12) 8" float well.
(13) Three way check valve.
SOFT WATER BOOSTER PUMPS
250 gpm @ 65' disch hd
5 hp
DOMESTIC WATER STORAGE TANKS
EVAPORATOR PREHEATERS
EVAPORATORS
POWERHOUSE
WATER TREATMENT PLANT
SETTLING BASIN No. 4
SETTLING BASIN No. 3
FLOCCULATOR No. 2
FLOCCULATOR No. 1
SETTLING BASIN No. 2
SETTLING BASIN No. 1
FILTER No. 4
FILTER No. 3
FILTER No. 2
FILTER No. 1
SEE DIAGRAM OF FILTER CONTROL SYSTEM
SALT STORAGE PIT 3
SALT STORAGE PIT 2
SALT STORAGE PIT 1
BRINE PUMPS
SOFTENERS
FILTER WASH PUMP
DOMESTIC WATER SUPPLY PUMPS
CHEMICAL SOLUTION FEEDERS
DOMESTIC WATER SERVICE PUMPS
SOFTENER SUPPLY PUMPS
FILTERED WATER WELL
DOMESTIC WATER WELL
SOFT WATER SERVICE PUMPS
CHLORINATOR
SOFTENED WATER WELL
RAW WATER SUPPLY PUMPS
PUMPING STATION
WATER TREATMENT PLANT CHARACTERISTICS
FLASH MIXER
Capacity 120 to 480 gpm
Volume 358 gal
FLOCCULATOR (each)
Retention - 30 min.
Capacity - 240 gpm
Volume - 7100 gal
SETTLING BASINS (each)
Retention 4 hours at effective volume.
Capacity - 120 gpm
Total 35,690 gal
Effective vol - 28,800
SOFTENERS - PER UNIT
Softening rate 80 to 120 gpm
Exchange capacity 1000 kilograins
Wash rate 120 - 140 gpm for 7-10 min approximately
Rinse rate 50-75 gpm for 40 min approximately
Salt per regeneration 350 lbs
FILTERS
Capacity 120 gpm each
Area 60 sq ft
DOMESTIC WATER WELL
Volume - 10,050 gal to El 760.5
SOFTENED WATER WELL
Volume - 25,350 gal to El 760.5
FILTERED WATER WELL
Volume - 46,800 gal to El 760.5
SALT STORAGE
For capacity see pits 1, 2 & 3 on diagram. Pounds of salt based on 65 lb per cu ft. WS El 760.5.
NOTES:
1. Float switch - domestic water well
El 754.0 sound alarm and stops domestic water ser pumps
El 755.0 stops alarm
El 756.0 starts domestic water service pumps
El 760.5 stops domestic water supply pumps and sol feeders
El 758.25 starts domestic water supply pumps and sol feeders
2. Float switch - filtered water well
El 754.0 stops filter wash pump, domestic water supply pumps, solution feeders and softener supply pumps
El 755.0 starts same
El 756.5 sounds alarm
El 757.0 stops alarm
3. Float switch - settling basin
El 771.75 starts raw water supply pumps, dry chemical feeders, flocculator drive and chlorinator solenoid
El 772.0 stops same.
4. Float switch - softened water well
El 755.75 starts soft water service pumps
El 754.0 stops soft water service pumps
El 755.75 sounds alarm
El 756.75 stops alarm
El 757.25* starts softener supply pumps
El 760.5* stops softener supply pumps
* During regenerative cycle the softener supply pumps are controlled by the softener controls instead of float switches in softened and filtered water wells.
5. Float switch - brine measuring tank
El 763.5 starts brine pumps
El 766.21 stops brine pumps
6. Float switches - domestic water storage tank
El 872.5 starts domestic water service high pump
El 872.0 starts domestic water service low pump and sounds alarm.
El 874.0 stops both pumps
REFERENCE DRAWINGS:
WATER SUPPLY
UNITS 1-9
FLOW DIAGRAM
WATER TREATMENT PLANT
KINGSTON STEAM PLANT
TENNESSEE VALLEY AUTHORITY
DIVISION OF DESIGN
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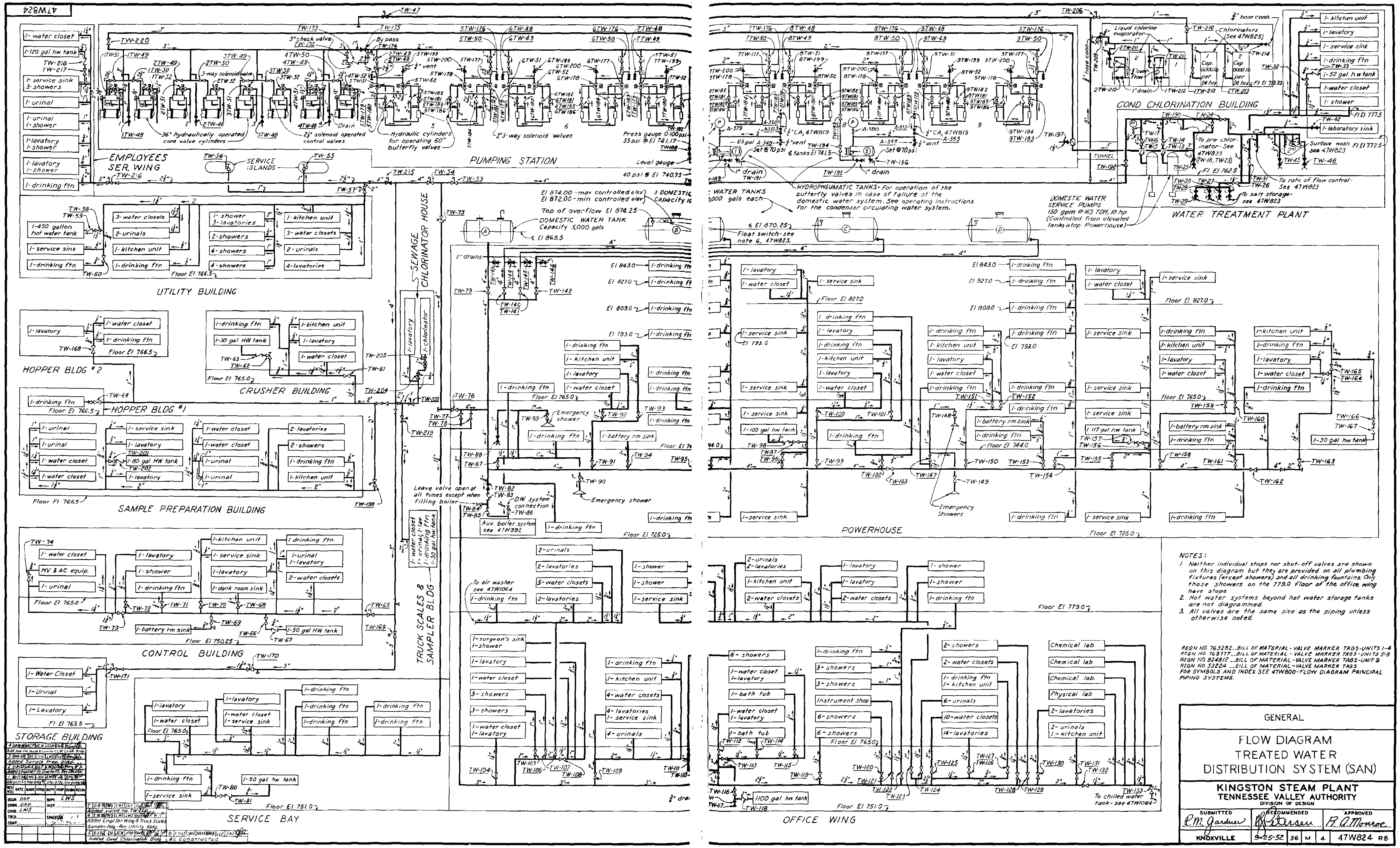
47W823 R5


47W824
EMPLOYEES SER. WING
SERVICE ISLANDS
PUMPING STATION
36" hydraulically operated cone valve cylinders
2½" solenoid operated control valves
Hydraulic cylinders for operating 60" butterfly valves
2" 3-way solenoid valves
UTILITY BUILDING
HOPPER BLDG #2
HOPPER BLDG #1
CRUSHER BUILDING
SAMPLE PREPARATION BUILDING
CONTROL BUILDING
STORAGE BUILDING
SERVICE BAY
SEWAGE CHLORINATOR HOUSE
TRUCK SCALES & SAMPLER BLDG
DOMESTIC WATER TANK Capacity 5,000 gals
HYDROPNEUMATIC TANKS - For operation of the butterfly valves in case of failure of the domestic water system. See operating instructions for the condenser circulating water system.
DOMESTIC WATER SERVICE PUMPS 150 gpm @ 165 TDH, 10 hp (Controlled from elevated tanks atop Powerhouse)
COND CHLORINATION BUILDING
WATER TREATMENT PLANT
POWERHOUSE
OFFICE WING
NOTES:
1. Neither individual stops nor shut-off valves are shown on this diagram but they are provided on all plumbing fixtures (except showers) and all drinking fountains. Only those showers on the 779.0 floor of the office wing have stops.
2. Hot water systems beyond hot water storage tanks are not diagrammed.
3. All valves are the same size as the piping unless otherwise noted.
REQN NO. 763282...BILL OF MATERIAL - VALVE MARKER TAGS - UNITS 1-4
REQN NO. 769777...BILL OF MATERIAL - VALVE MARKER TAGS - UNITS 5-8
REQN NO. 824812...BILL OF MATERIAL - VALVE MARKER TAGS - UNIT 9
REQN NO. 53224...BILL OF MATERIAL - VALVE MARKER TAGS
FOR SYMBOLS AND INDEX SEE 47W800 - FLOW DIAGRAM PRINCIPAL PIPING SYSTEMS.
GENERAL
FLOW DIAGRAM
TREATED WATER
DISTRIBUTION SYSTEM (SAN)
KINGSTON STEAM PLANT
TENNESSEE VALLEY AUTHORITY
DIVISION OF DESIGN
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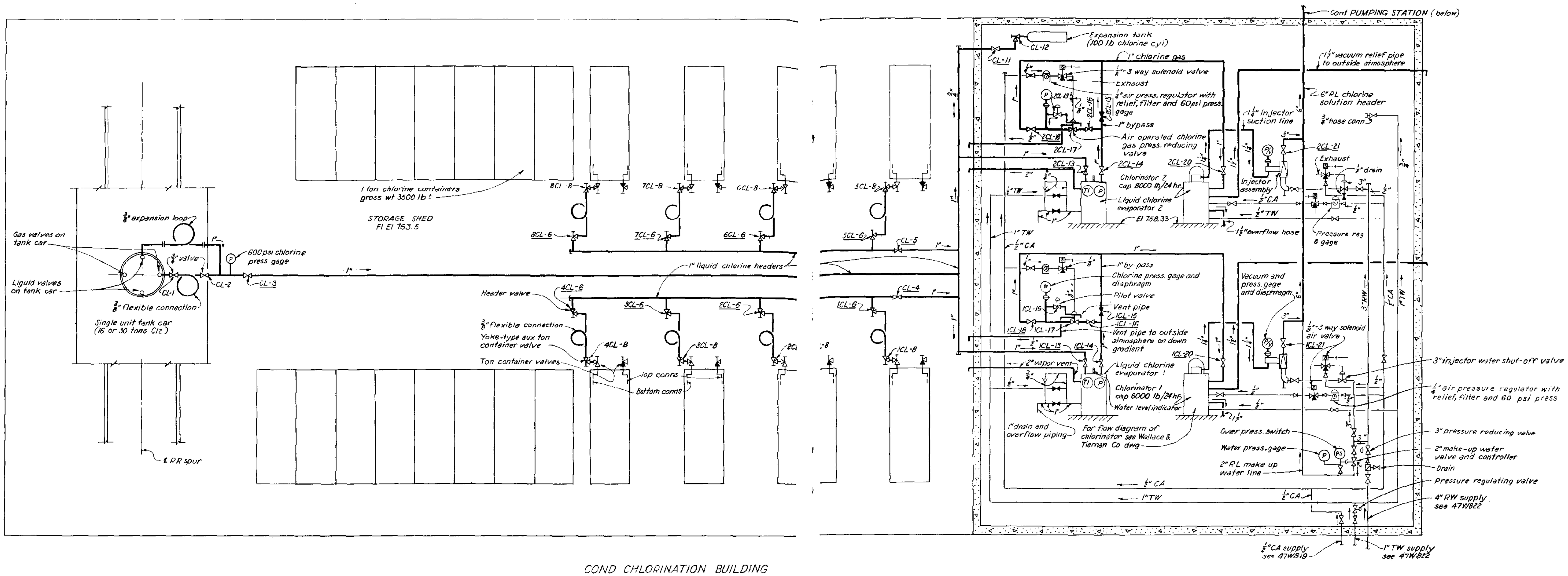
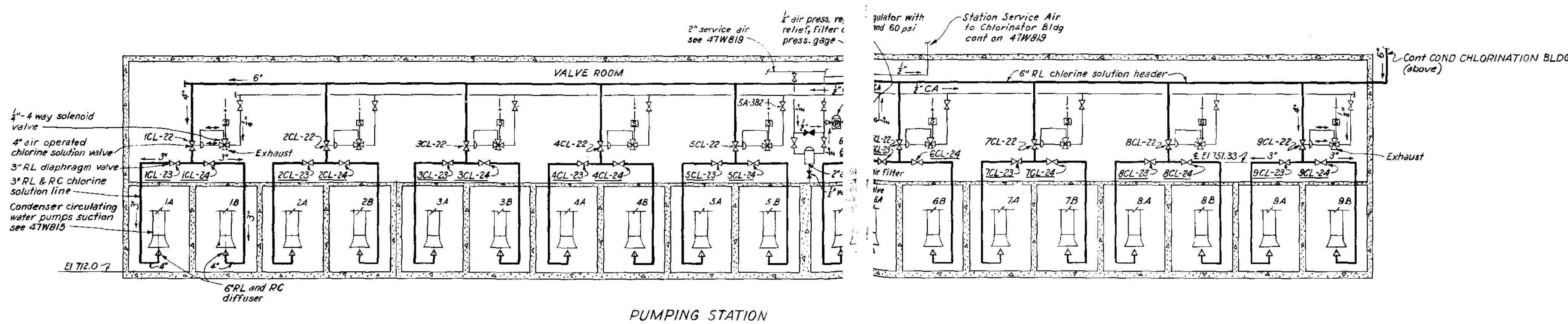
APPROVED
KNOXVILLE 9-25-52 36 M 4 47W824 R8

47W825





NOTES:

1. All valves are the same size as piping unless otherwise noted.
2. All valves are shown in the position for chlorinating.
3. The flow of water to only one pair of condenser circulating water pumps is chlorinated at a time.
4. The starting and stopping of the operating cycles and the alternation of dosing from one point of application to another is accomplished automatically by a manually adjustable program controller.
5. For operation of all chlorination equipment see manufacturer's drawings and instructions.

REFERENCE DRAWINGS:

FOR SYMBOLS AND INDEX SEE 47W800 - FLOW DIAGRAM PRINCIPAL PIPING SYSTEMS.
REQN NO. 53224 _ _ _ _ _ BILL OF MATERIAL - VALVE MARKER TAGS

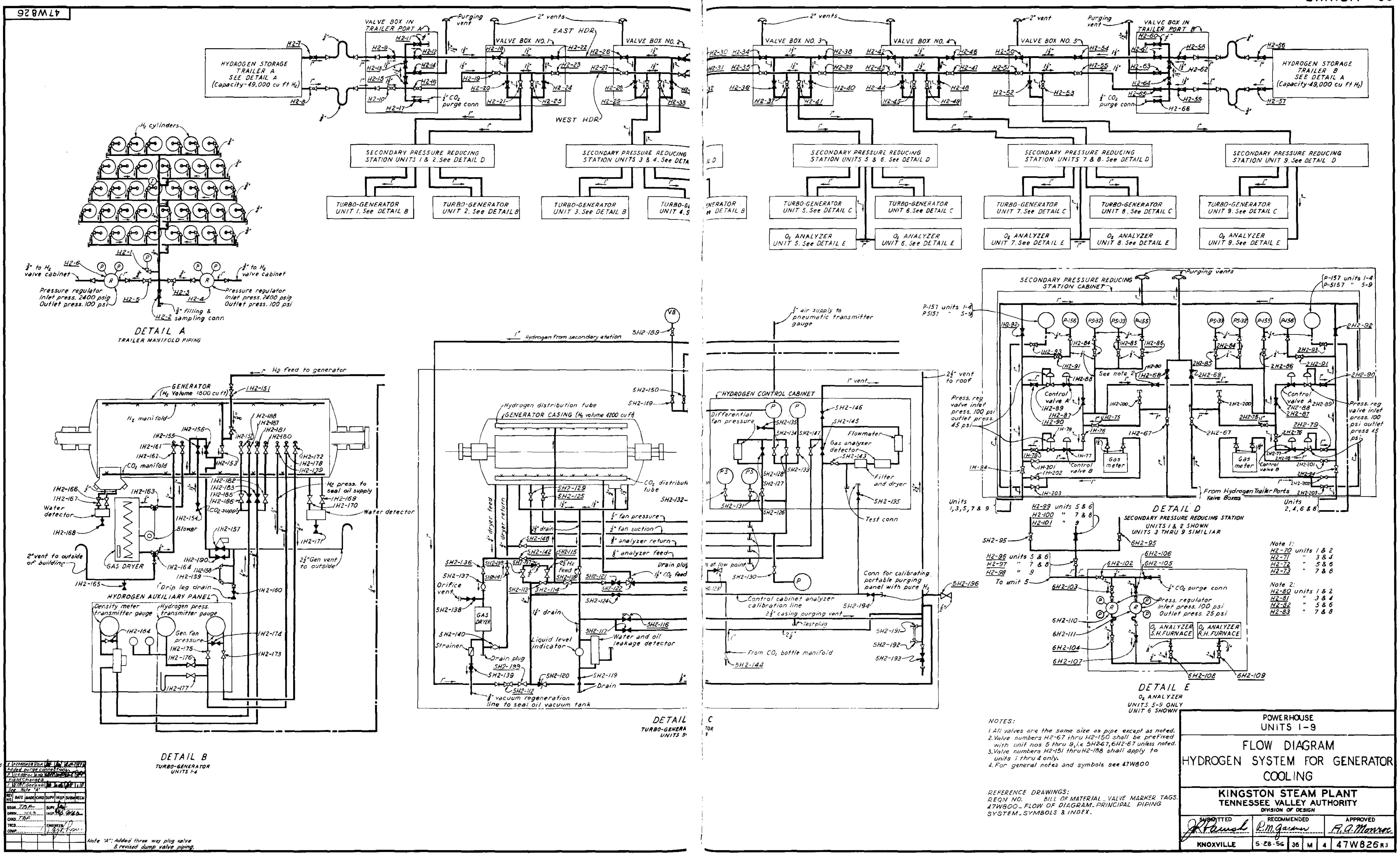
WATER SUPPLY
UNITS 1 THRU 9

FLOW DIAGRAM
CONDENSER CIRCULATING WATER
CHLORINATION SYSTEM

KINGSTON STEAM PLANT
TENNESSEE VALLEY AUTHORITY
DIVISION OF DESIGN

SUBMITTED	RECOMMENDED	APPROVED
J.K. Parrish	R.M. Gardner	R.A. Monroe
KNOXVILLE	9-18-56	36 M 4 47W825 R1

R1 As constructed


47W826
HYDROGEN STORAGE TRAILER A SEE DETAIL A (Capacity-49,000 cu ft H_2)
HYDROGEN STORAGE TRAILER B SEE DETAIL A (Capacity-49,000 cu ft H_2)
VALVE BOX IN TRAILER PORT A
VALVE BOX IN TRAILER PORT B
VALVE BOX NO. 1
VALVE BOX NO. 2
VALVE BOX NO. 3
VALVE BOX NO. 4
VALVE BOX NO. 5
EAST HDR
WEST HDR
Purging vent
2" vents
SECONDARY PRESSURE REDUCING STATION UNITS 1 & 2. See DETAIL D
SECONDARY PRESSURE REDUCING STATION UNITS 3 & 4. See DETAIL D
SECONDARY PRESSURE REDUCING STATION UNITS 5 & 6. See DETAIL D
SECONDARY PRESSURE REDUCING STATION UNITS 7 & 8. See DETAIL D
SECONDARY PRESSURE REDUCING STATION UNIT 9. See DETAIL D
TURBO-GENERATOR UNIT 1. See DETAIL B
TURBO-GENERATOR UNIT 2. See DETAIL B
TURBO-GENERATOR UNIT 3. See DETAIL B
TURBO-GENERATOR UNIT 5. See DETAIL C
TURBO-GENERATOR UNIT 6. See DETAIL C
TURBO-GENERATOR UNIT 7. See DETAIL C
TURBO-GENERATOR UNIT 8. See DETAIL C
TURBO-GENERATOR UNIT 9. See DETAIL C
O_2 ANALYZER UNIT 5. See DETAIL E
O_2 ANALYZER UNIT 6. See DETAIL E
O_2 ANALYZER UNIT 7. See DETAIL E
O_2 ANALYZER UNIT 8. See DETAIL E
O_2 ANALYZER UNIT 9. See DETAIL E
H_2 cylinders
Pressure regulator Inlet press. 2400 psig Outlet press. 100 psi
DETAIL A
TRAILER MANIFOLD PIPING
GENERATOR (H_2 Volume 1800 cu ft)
H_2 feed to generator
HYDROGEN AUXILIARY PANEL
GAS DRYER
Water detector
DETAIL B
TURBO-GENERATOR UNITS 1-4
GENERATOR CASING (H_2 volume 4200 cu ft)
Hydrogen distribution tube
HYDROGEN CONTROL CABINET
DETAIL C
TURBO-GENERATOR UNITS 5-9
SECONDARY PRESSURE REDUCING STATION CABINET
DETAIL D
SECONDARY PRESSURE REDUCING STATION UNITS 1 & 2 SHOWN UNITS 3 THRU 9 SIMILIAR
DETAIL E
O_2 ANALYZER UNITS 5-9 ONLY UNIT 6 SHOWN
O_2 ANALYZER S.H.FURNACE
O_2 ANALYZER R.H.FURNACE
NOTES:
1. All valves are the same size as pipe except as noted.
2. Valve numbers H2-67 thru H2-150 shall be prefixed with unit nos 5 thru 9, i.e. 5H2-67, 6H2-67 unless noted.
3. Valve numbers H2-151 thru H2-188 shall apply to units 1 thru 4 only.
4. For general notes and symbols see 47W800
REFERENCE DRAWINGS:
REQN NO. BILL OF MATERIAL VALVE MARKER TAGS.
47W800 - FLOW OF DIAGRAM - PRINCIPAL PIPING SYSTEM - SYMBOLS & INDEX.
POWERHOUSE UNITS 1-9
FLOW DIAGRAM
HYDROGEN SYSTEM FOR GENERATOR COOLING
KINGSTON STEAM PLANT
TENNESSEE VALLEY AUTHORITY
DIVISION OF DESIGN
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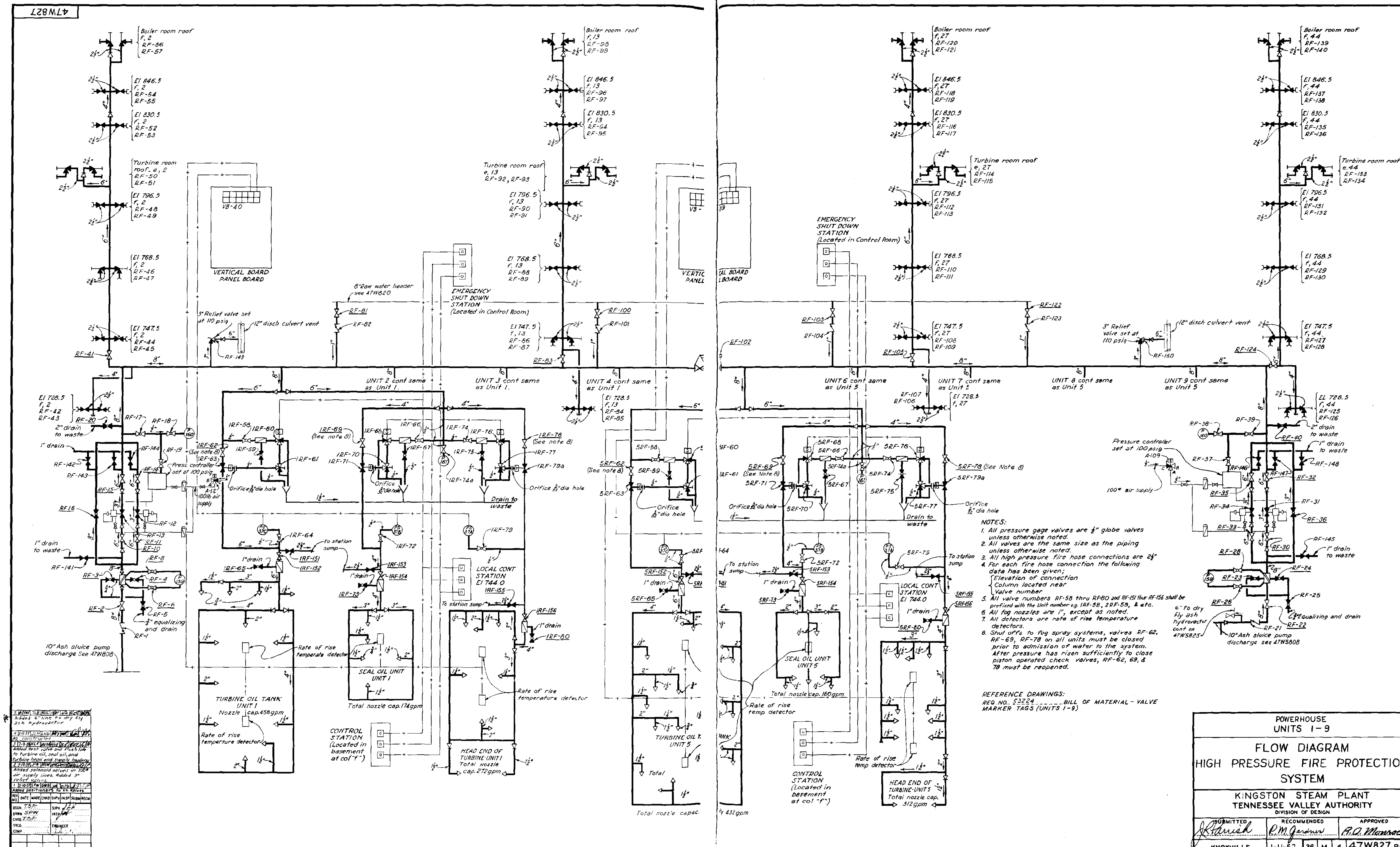
KNOXVILLE
5-28-56
47W826 R3
Note "A": Added three way plug valve & revised dump valve piping.


47W827
Boiler room roof
VERTICAL BOARD PANEL BOARD
EMERGENCY SHUT DOWN STATION (Located in Control Room)
UNIT 2 cont same as Unit 1.
UNIT 3 cont same as Unit 1.
UNIT 4 cont same as Unit 1
UNIT 6 cont same as Unit 5
UNIT 7 cont same as Unit 5
UNIT 8 cont same as Unit 5
UNIT 9 cont same as Unit 5
TURBINE OIL TANK UNIT 1
SEAL OIL UNIT UNIT 1
LOCAL CONT STATION El 744.0
HEAD END OF TURBINE UNIT 1 Total nozzle cap. 272 gpm
CONTROL STATION (Located in basement at col "F")
SEAL OIL UNIT UNIT 5
HEAD END OF TURBINE-UNIT 5 Total nozzle cap. 312 gpm
10" Ash sluice pump discharge See 47W808
NOTES:
1. All pressure gage valves are ½" globe valves unless otherwise noted.
2. All valves are the same size as the piping unless otherwise noted.
3. All high pressure fire hose connections are 2½"
4. For each fire hose connection the following data has been given; Elevation of connection, Column located near, Valve number
5. All valve numbers RF-58 thru RF-80 and RF-151 thur RF-156 shall be prefixed with the Unit number e.g. 1RF-58, 2RF-58, & etc.
6. All fog nozzles are 1", except as noted.
7. All detectors are rate of rise temperature detectors.
8. Shut offs to fog spray systems, valves RF-62, RF-69, RF-78 on all units must be closed prior to admission of water to the system. After pressure has risen sufficiently to close piston operated check valves, RF-62, 69, & 78 must be reopened.
REFERENCE DRAWINGS:
REQ. NO. 53224 ______ BILL OF MATERIAL - VALVE MARKER TAGS (UNITS 1-9)
POWERHOUSE
UNITS 1-9
FLOW DIAGRAM
HIGH PRESSURE FIRE PROTECTION SYSTEM
KINGSTON STEAM PLANT
TENNESSEE VALLEY AUTHORITY
DIVISION OF DESIGN
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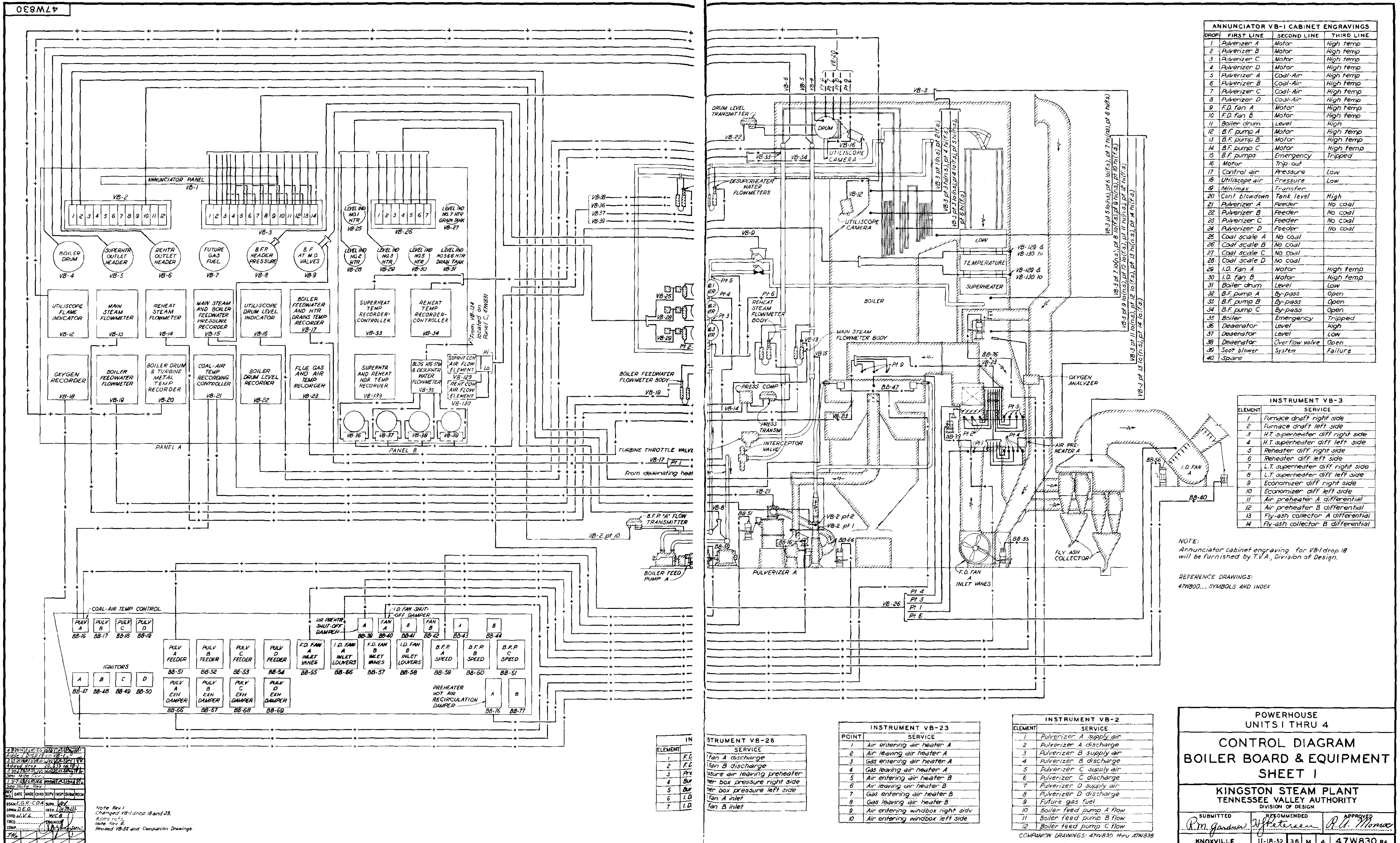
KNOXVILLE
1-11-57
36 M 4 47W827 R5



ANNUNCIATOR VB-1 CABINET ENGRAVINGS			
DROP	FIRST LINE	SECOND LINE	THIRD LINE
1	Pulverizer A	Motor	High temp
2	Pulverizer B	Motor	High temp
3	Pulverizer C	Motor	High temp
4	Pulverizer D	Motor	High temp.
5	Pulverizer A	Coal-Air	High temp
6	Pulverizer B	Coal-Air	High temp
7	Pulverizer C	Coal-Air	High temp
8	Pulverizer D	Coal-Air	High temp
9	F.D. fan A	Motor	High temp
10	F.D. fan B	Motor	High temp
11	Boiler drum	Level	High
12	B.F. pump A	Motor	High temp
13	B.F. pump B	Motor	High temp
14	B.F. pump C	Motor	High temp
15	B.F. pumps	Emergency	Tripped
16	Motor	Trip-out	
17	Control air	Pressure	Low
18	Utiliscope air	Pressure	Low
19	Minimax	Transfer	
20	Cont blowdown	Tank level	High
21	Pulverizer A	Feeder	No coal
22	Pulverizer B	Feeder	No coal
23	Pulverizer C	Feeder	No coal
24	Pulverizer D	Feeder	No coal
25	Coal scale A	No coal	
26	Coal scale B	No coal	
27	Coal scale C	No coal	
28	Coal scale D	No coal	
29	I.D. fan A	Motor	High temp
30	I.D. fan B	Motor	High temp
31	Boiler drum	Level	Low
32	B.F. pump A	By-pass	Open
33	B.F. pump B	By-pass	Open
34	B.F. pump C	By-pass	Open
35	Boiler	Emergency	Tripped
36	Deaerator	Level	High
37	Deaerator	Level	Low
38	Deaerator	Overflow valve	Open
39	Soot blower	System	Failure
40	Spare		

INSTRUMENT VB-3	
ELEMENT	SERVICE
1	Furnace draft right side
2	Furnace draft left side
3	H.T. superheater diff right side
4	H.T. superheater diff left side
5	Reheater diff right side
6	Reheater diff left side
7	L.T. superheater diff right side
8	L.T. superheater diff left side
9	Economizer diff right side
10	Economizer diff left side
11	Air preheater A differential
12	Air preheater B differential
13	Fly-ash collector A differential
14	Fly-ash collector B differential

NOTE:
Annunciator cabinet engraving for VB-1 drop 18 will be furnished by T.V.A., Division of Design.

REFERENCE DRAWINGS:
47W800... SYMBOLS AND INDEX

IN[STRUMENT VB-26]	
ELEMENT	SERVICE
1	F.D. fan A discharge
2	F.D. fan B discharge
3	Pre[ssure air leaving preheater]
4	Bur[ner box pressure right side]
5	Bur[ner box pressure left side]
6	I.D. fan A inlet
7	I.D. fan B inlet

INSTRUMENT VB-23	
POINT	SERVICE
1	Air entering air heater A
2	Air leaving air heater A
3	Gas entering air heater A
4	Gas leaving air heater A
5	Air entering air heater B
6	Air leaving air heater B
7	Gas entering air heater B
8	Gas leaving air heater B
9	Air entering windbox right side
10	Air entering windbox left side

INSTRUMENT VB-2	
ELEMENT	SERVICE
1	Pulverizer A supply air
2	Pulverizer A discharge
3	Pulverizer B supply air
4	Pulverizer B discharge
5	Pulverizer C supply air
6	Pulverizer C discharge
7	Pulverizer D supply air
8	Pulverizer D discharge
9	Future gas fuel
10	Boiler feed pump A flow
11	Boiler feed pump B flow
12	Boiler feed pump C flow

COMPANION DRAWINGS: 47W830 thru 47W838

Note Rev 1
Changed VB-1 drop 18 and 39.
Added note.
Note Rev 2.
Revised VB-35 and Companion Drawings.

POWERHOUSE
UNITS 1 THRU 4

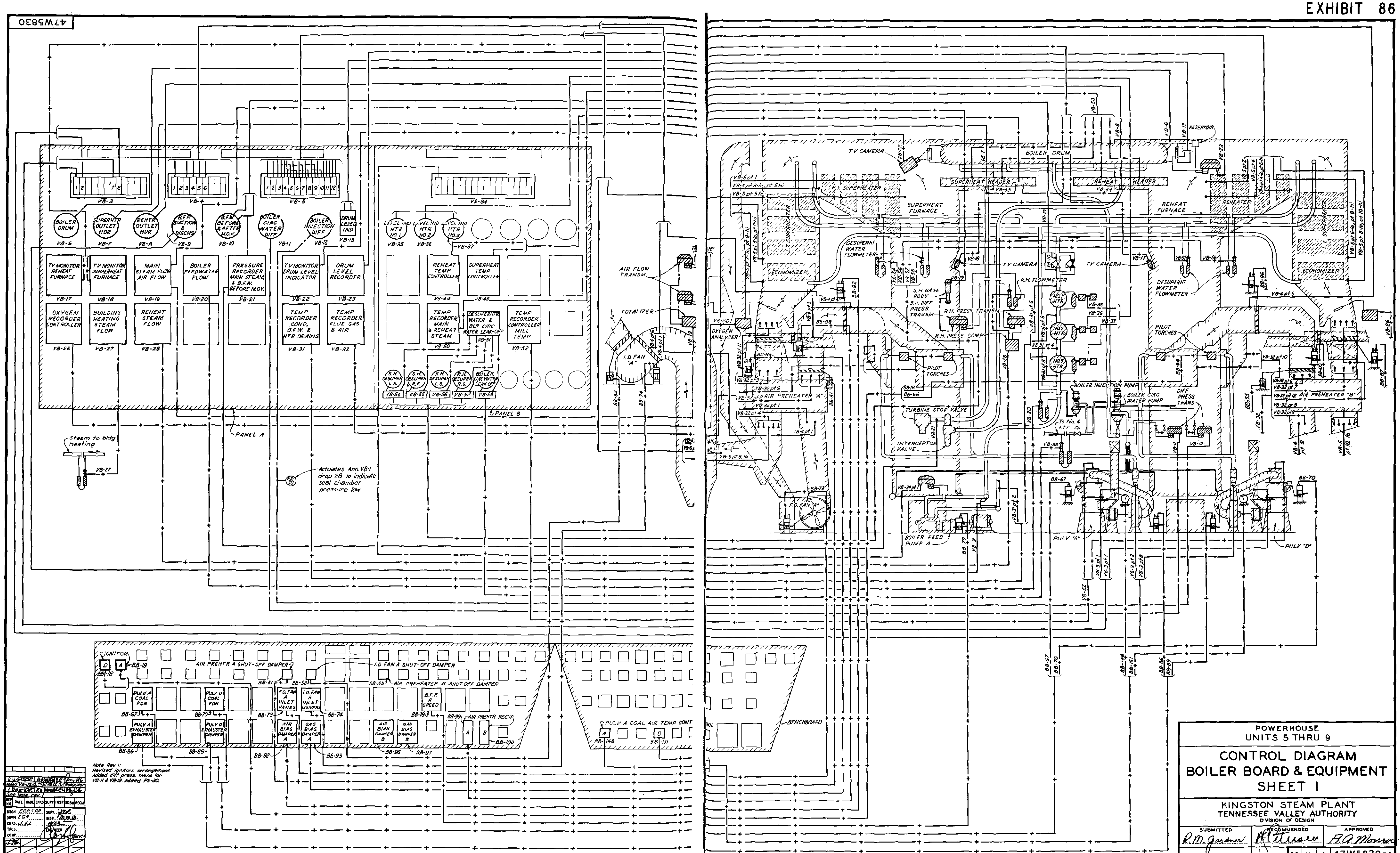
CONTROL DIAGRAM BOILER BOARD & EQUIPMENT SHEET 1

KINGSTON STEAM PLANT
TENNESSEE VALLEY AUTHORITY
DIVISION OF DESIGN

SUBMITTED / RECOMMENDED / APPROVED

KNOXVILLE | 11-18-52 | 36 | M | 4 | 47W830 R4

EXHIBIT 86


47W5830
POWERHOUSE
UNITS 5 THRU 9
CONTROL DIAGRAM
BOILER BOARD & EQUIPMENT
SHEET 1
KINGSTON STEAM PLANT
TENNESSEE VALLEY AUTHORITY
DIVISION OF DESIGN
SUBMITTED
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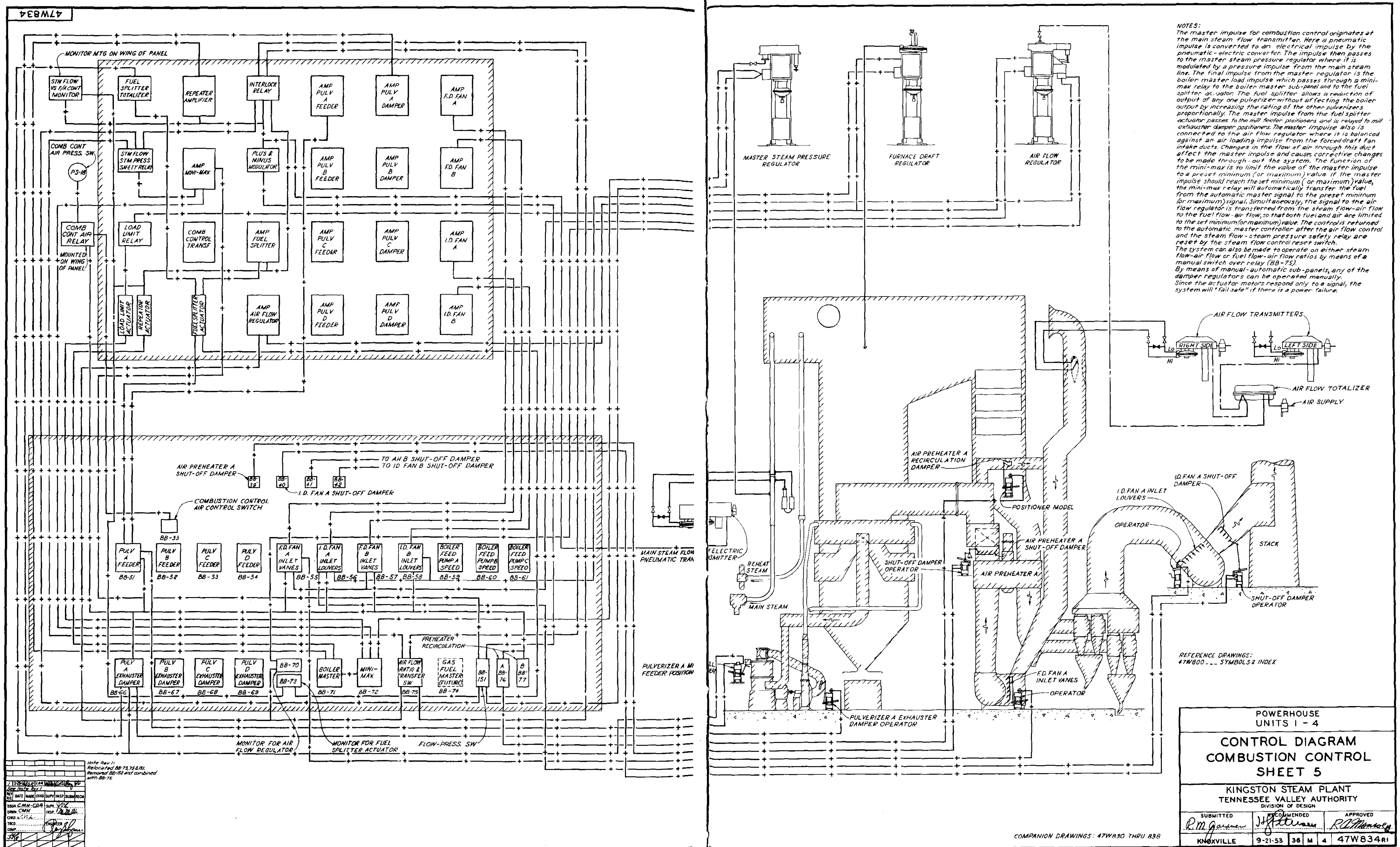
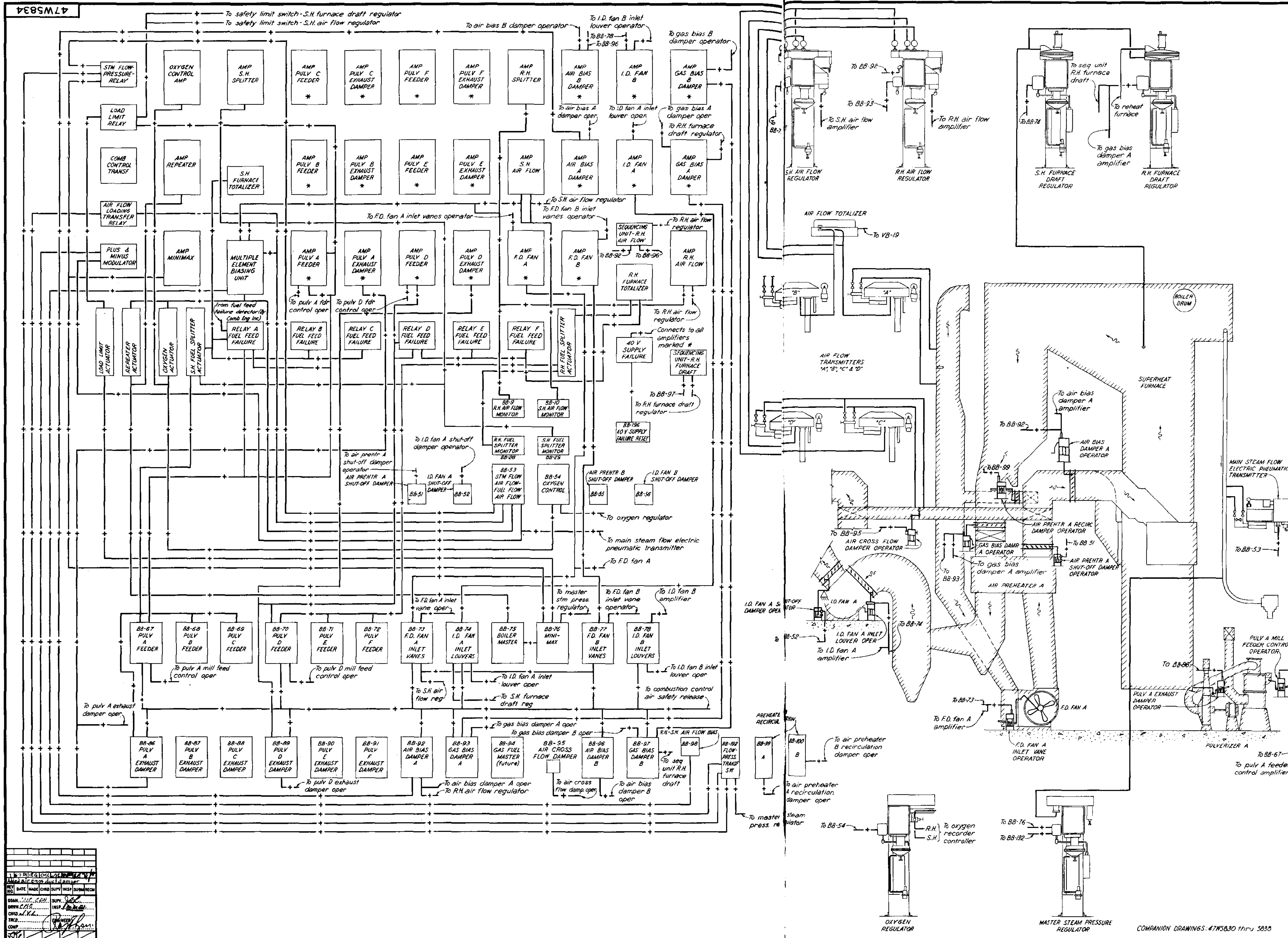
4-13-54
47W5830 R2
COMPANION DRAWINGS: 47W5830 thru 5838
PANEL A
PANEL B
BENCHBOARD
BOILER DRUM
SUPERHEAT HEADER
REHEAT HEADER
SUPERHEAT FURNACE
REHEAT FURNACE
ECONOMIZER
AIR PREHEATER "A"
AIR PREHEATER "B"
I.D. FAN "A"
F.D. FAN "A"
TURBINE STOP VALVE
INTERCEPTOR VALVE
BOILER FEED PUMP A
PULV "A"
PULV "D"
TV CAMERA
OXYGEN ANALYZER
PILOT TORCHES
BOILER INJECTION PUMP
BOILER CIRC WATER PUMP
AIR FLOW TRANSM
TOTALIZER
Steam to bldg heating
Actuates Ann. VB-1 drop 28 to indicate seal chamber pressure low
AIR PREHTR A SHUT-OFF DAMPER
I.D. FAN A SHUT-OFF DAMPER
AIR PREHEATER B SHUT-OFF DAMPER
PULV A COAL AIR TEMP CONT
AIR PREHTR RECIP.
Note Rev 1: Revised ignitors arrangement. Added diff press. trans for VB-11 & VB-12. Added PS-30.


47W834
MONITOR MTG ON WING OF PANEL
STM FLOW VS F/A CONT MONITOR
FUEL SPLITTER TOTALIZER
REPEATER AMPLIFIER
INTERLOCK RELAY
AMP PULV A FEEDER
AMP PULV A DAMPER
AMP F.D. FAN A
COMB CONT AIR PRESS SW.
PS-18
STM FLOW STM PRESS SAFETY RELAY
AMP MINI-MAX
PLUS & MINUS MODULATOR
AMP PULV B FEEDER
AMP PULV B DAMPER
AMP F.D. FAN B
COMB CONT AIR RELAY
MOUNTED ON WING OF PANEL
LOAD LIMIT RELAY
COMB CONTROL TRANSF
AMP FUEL SPLITTER
AMP PULV C FEEDER
AMP PULV C DAMPER
AMP I.D. FAN A
LOAD LIMIT ACTUATOR
REPEATOR ACTUATOR
FUEL SPLITTER ACTUATOR
AMP AIR FLOW REGULATOR
AMP PULV D FEEDER
AMP PULV D DAMPER
AMP I.D. FAN B
AIR PREHEATER A SHUT-OFF DAMPER
TO AH B SHUT-OFF DAMPER
TO ID FAN B SHUT-OFF DAMPER
I.D. FAN A SHUT-OFF DAMPER
COMBUSTION CONTROL AIR CONTROL SWITCH
BB-33
PULV A FEEDER BB-51
PULV B FEEDER BB-52
PULV C FEEDER BB-53
PULV D FEEDER BB-54
F.D. FAN A INLET VANES BB-55
I.D. FAN A INLET LOUVERS BB-56
F.D. FAN B INLET VANES BB-57
I.D. FAN B INLET LOUVERS BB-58
BOILER FEED PUMP A SPEED BB-59
BOILER FEED PUMP B SPEED BB-60
BOILER FEED PUMP C SPEED BB-61
PREHEATER RECIRCULATION
PULV A EXHAUSTER DAMPER BB-66
PULV B EXHAUSTER DAMPER BB-67
PULV C EXHAUSTER DAMPER BB-68
PULV D EXHAUSTER DAMPER BB-69
BB-70
BB-73
BOILER MASTER BB-71
MINI-MAX BB-72
AIR FLOW RATIO & TRANSFER SW BB-75
GAS FUEL MASTER (FUTURE) BB-74
BB-151
A BB-76
B BB-77
MONITOR FOR AIR FLOW REGULATOR
MONITOR FOR FUEL SPLITTER ACTUATOR
FLOW-PRESS. SW
MAIN STEAM FLOW PNEUMATIC TRAN
PULVERIZER A MI FEEDER POSITION
MASTER STEAM PRESSURE REGULATOR
FURNACE DRAFT REGULATOR
AIR FLOW REGULATOR
NOTES:
The master impulse for combustion control originates at the main steam flow transmitter. Here a pneumatic impulse is converted to an electrical impulse by the pneumatic-electric converter. The impulse then passes to the master steam pressure regulator where it is modulated by a pressure impulse from the main steam line. The final impulse from the master regulator is the boiler master load impulse which passes through a mini-max relay to the boiler master sub-panel and to the fuel splitter actuator. The fuel splitter allows a reduction of output of any one pulverizer without affecting the boiler output by increasing the rating of the other pulverizers proportionally. The master impulse from the fuel splitter actuator passes to the mill feefer positioners and is relayed to mill exhauster damper positioners. The master impulse also is connected to the air flow regulator where it is balanced against an air loading impulse from the forced draft fan intake ducts. Changes in the flow of air through this duct affect the master impulse and causes corrective changes to be made through-out the system. The function of the mini-max is to limit the value of the master impulse to a preset minimum (or maximum) value. If the master impulse should reach the set minimum (or maximum) value, the mini-max relay will automatically transfer the fuel from the automatic master signal to the preset minimum (or maximum) signal. Simultaneously, the signal to the air flow regulator is transferred from the steam flow-air flow to the fuel flow-air flow, so that both fuel and air are limited to the set minimum (or maximum) value. The control is returned to the automatic master controller after the air flow control and the steam flow-steam pressure safety relay are reset by the steam flow control reset switch.
The system can also be made to operate on either steam flow-air flow or fuel flow-air flow ratios by means of a manual switch over relay (BB-75).
By means of manual-automatic sub-panels, any of the damper regulators can be operated manually.
Since the actuator motors respond only to a signal, the system will "fail safe" if there is a power failure.
AIR FLOW TRANSMITTERS
RIGHT SIDE
LEFT SIDE
AIR FLOW TOTALIZER
AIR SUPPLY
AIR PREHEATER A RECIRCULATION DAMPER
POSITIONER MODEL
I.D. FAN A SHUT-OFF DAMPER
I.D. FAN A INLET LOUVERS
OPERATOR
STACK
AIR PREHEATER A SHUT-OFF DAMPER
SHUT-OFF DAMPER OPERATOR
AIR PREHEATER A
REHEAT STEAM
MAIN STEAM
SHUT-OFF DAMPER OPERATOR
F.D. FAN A INLET VANES
OPERATOR
PULVERIZER A EXHAUSTER DAMPER OPERATOR
REFERENCE DRAWINGS:
47W800 --- SYMBOLS & INDEX
COMPANION DRAWINGS: 47W830 THRU 838
POWERHOUSE
UNITS 1 - 4
CONTROL DIAGRAM
COMBUSTION CONTROL
SHEET 5
KINGSTON STEAM PLANT
TENNESSEE VALLEY AUTHORITY
DIVISION OF DESIGN
SUBMITTED
RECOMMENDED
APPROVED
KNOXVILLE
9-21-53
36
M
4
47W834R1



COMPANION DRAWINGS: 47W5830 thru 5838

Notes:

Under normal operating conditions the basic control impulse, for both the fuel and air, originates in the steam flow transmitter. This impulse passes through the steam pressure-load control switch, a transfer switch, air flow ratio and transfer subpanel, and air bias subpanel, to the air flow regulators for the superheat and reheat furnaces respectively.

The air flow regulator for the superheat furnace initiates an electrical impulse through manual-automatic subpanels to operate the forced draft fan damper positioners to balance the air flow impulse from the superheat furnace with the impulse from the steam-flow transmitter.

The air flow regulator for the reheat furnace also initiates an electrical impulse through manual-automatic subpanels to operate the air bias damper positioners to balance the air flow impulse from the reheat furnace with the air flow impulse from the superheat furnace.

The control impulse from the steam flow transmitter also passes through the "Plus & Minus" modulator, where the impulse is modulated by steam pressure, the mini-max subpanel which removes the system from automatic control in case the impulse rises above a set maximum or falls below a set minimum, the repeater actuator, the fuel splitter actuators, one for the superheat furnace and one for the reheat furnace, and manual-automatic subpanels to the coal feeder positioners and exhauster damper positioners. The operator can vary the coal feeders and the exhauster dampers manually from the manual-automatic subpanels to balance or bias the firing rates for the various pulverizers. The electrical impulse to the pulverizer feeder positioners for the superheat furnace are totalized and balanced with the impulse for the reheat furnace.

Each furnace is supplied with an oxygen control to bias if necessary the fuel to the respective furnaces to maintain equal firing rates in the two furnaces.

The fuel splitter actuator splits the fuel impulse between the pulverizers for its respective furnace and corrects the rate until the total fuel flow balances the total fuel impulse.

The superheat furnace draft control transmits an impulse from the superheat furnace draft regulator through two manual-automatic subpanels to the induced draft fan damper positioners to maintain the furnace draft at a set point. The reheat furnace draft control transmits an impulse through a manual-automatic subpanel to the gas bias damper positioners to balance the furnace draft in the reheat furnace with the superheat furnace.

During start-up and shut down periods and at other times if desired, the system can be operated on steam pressure control. In this case, the fuel flow responds to steam pressure while air flow responds to total fuel.

Connections for pulverizers B & C are similar to those of pulverizer A.

Connections for pulverizers E & F are similar to those of pulverizer D.

REFERENCE DRAWINGS:

47W5800 — SYMBOLS & INDEX

V-10300-988 — REPUBLIC FLOW METERS Co-COMBUSTION CONTROL INTERCONNECTING WIRING DIAGRAM.

Not to scale

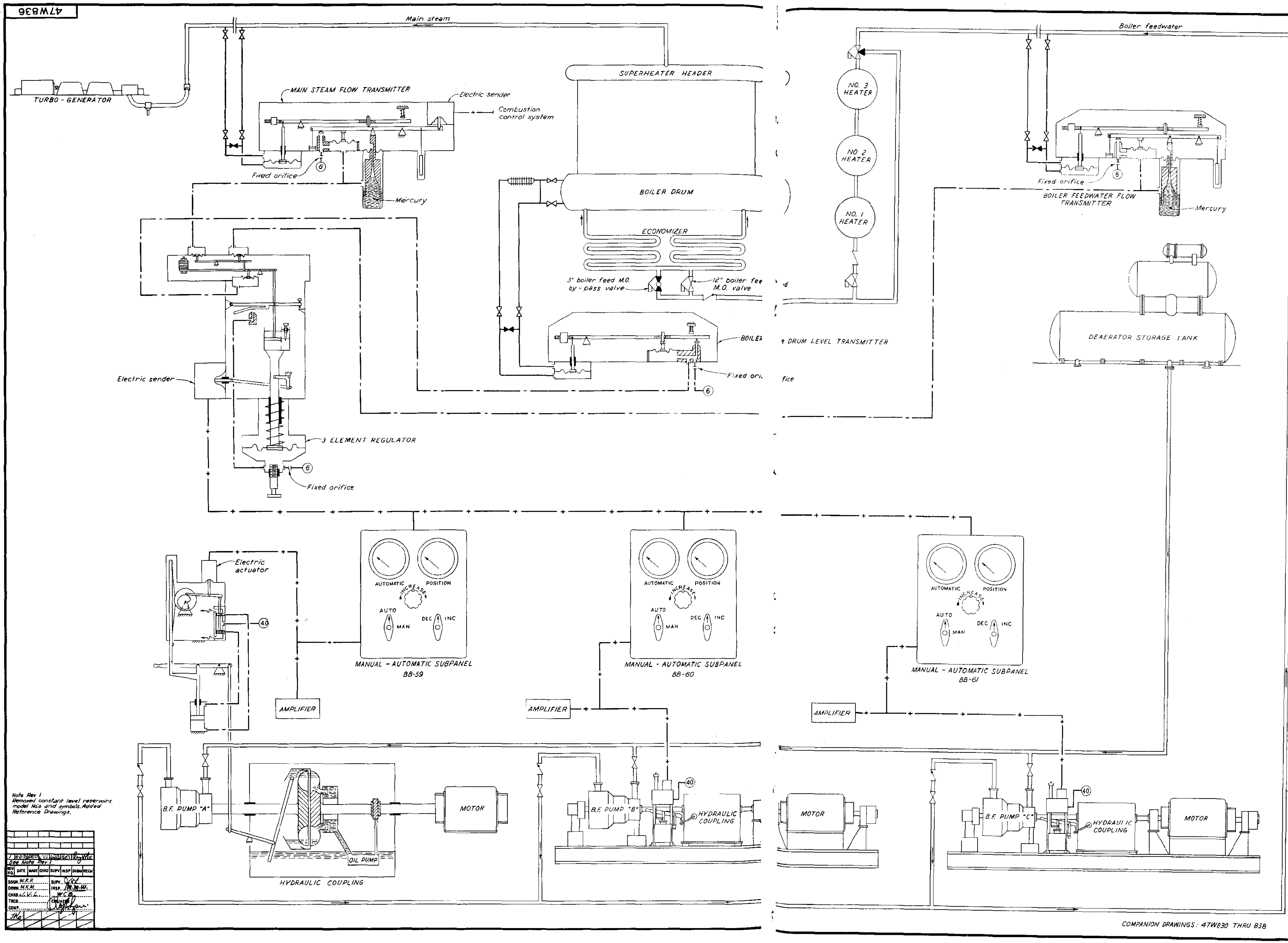
POWERHOUSE
UNITS 5 THRU 9

CONTROL DIAGRAM
COMBUSTION CONTROL
SHEET 5

KINGSTON STEAM PLANT
TENNESSEE VALLEY AUTHORITY
DIVISION OF DESIGN

SUBMITTED	RECOMMENDED	APPROVED
R.M. Gardner	D.J. Petersen	R.A. Monroe

KNOXVILLE	2-14-55	36	M	4	47W5834R1



NOTES:

The three elements by which this control system is operated are (1) steam flow from the boiler, (2) feedwater flow to the boiler and (3) water level in the boiler drum.

Pneumatic differential transmitters measure the three elements and transmit control air signals to the "3 element regulator." The "3 element regulator" combines the three control signals and mechanically positions one half of a self balancing AC wheatstone bridge (electric sender).

Any movement of the electric sender creates an unbalanced condition in the bridge circuit, and with the manual-automatic Subpanel set for automatic control, this unbalance is amplified by the amplifier and sent to a reversible induction motor in the electric actuator.

The electric actuator contains the remaining half of the self balancing AC wheatstone bridge and the electric motor, through a mechanical linkage, drives the receiver slide wire and positions the scoop tube in the fluid drive to regulate the speed of the boiler feed pump in response to the signal received from the amplifier. The control system remains active until the AC wheatstone bridge circuit is balanced.

With the subpanel set for manual control the amplifier is cut out of the circuit and the boiler feed pump fluid drive positioner is controlled by operating the increase-decrease switch.

The feed pumps ordinarily operate in parallel and respond as a unit to load change requirements. However, a bias on the control subpanel permits increasing or decreasing the response of an individual pump. The bias setter consists of a variable resistance adjustable from zero to one hundred percent load.

CAUTION: Before starting a boiler feed pump, make SURE that the hydraulic coupling is set for maximum slip. Torque should not be transmitted to the pump until the motor has come up to rated speed.

REFERENCE DRAWINGS:
47W800... SYMBOLS AND INDEX

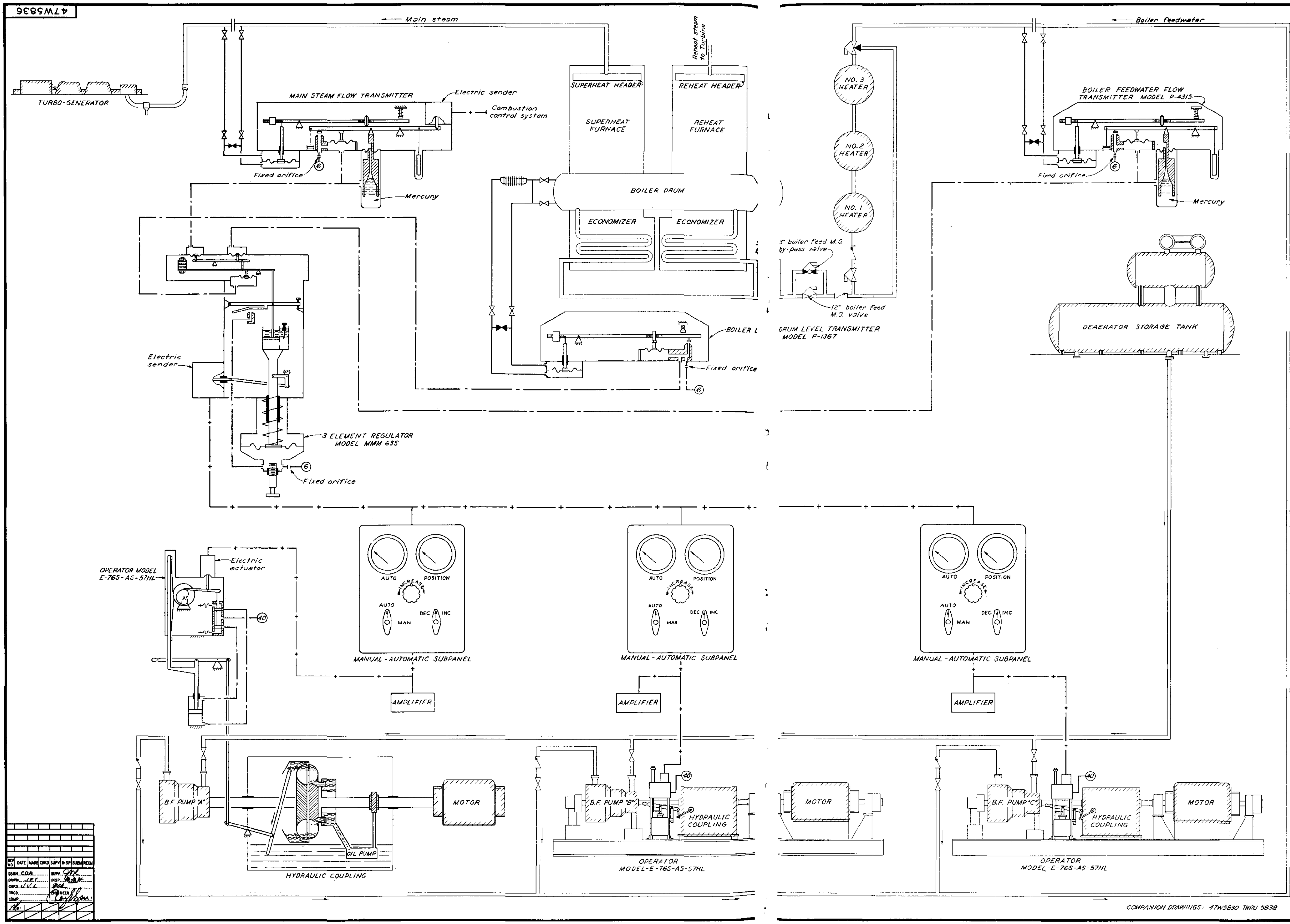
POWERHOUSE
UNITS 1 THRU 4

CONTROL DIAGRAM
BOILER FEED PUMP SYSTEM
SHEET 7

KINGSTON STEAM PLANT
TENNESSEE VALLEY AUTHORITY
DIVISION OF DESIGN

SUBMITTED	RECOMMENDED	APPROVED
R.M. Gardner	H.J. Petersen	R.A. Monroe

KNOXVILLE	4-20-53	36	M	4	47W836R1



NOTES:

The three elements by which this control system is operated are (1) steam flow from the boiler, (2) feedwater flow to the boiler and (3) water level in the boiler drum.

Pneumatic differential transmitters measure the three elements and transmit control air signals to the "3 element regulator." The "3 element regulator" combines the three control signals and mechanically positions one half of a self balancing AC wheatstone bridge (electric sender).

Any movement of the electric sender creates an unbalanced condition in the bridge circuit, and with the manual-automatic subpanel set for automatic control, this unbalance is amplified by the amplifier and sent to a reversible induction motor in the electric actuator.

The electric actuator contains the remaining half of the self balancing AC wheatstone bridge and the electric motor, through a mechanical linkage, drives the receiver slide wire and positions the scoop tube in the fluid drive to regulate the speed of the boiler feed pump in response to the signal received from the amplifier. The control system remains active until the AC wheatstone bridge circuit is balanced.

With the subpanel set for manual control, the amplifier is cut out of the circuit and the boiler feed pump fluid drive positioner is controlled by operating the increase-decrease switch.

The feed pumps ordinarily operate in parallel and respond as a unit to load change requirements. However, a bias on the control subpanel permits increasing or decreasing the response of an individual pump. The bias setter consists of a variable resistance adjustable from zero to one hundred percent load.

CAUTION: Before starting a boiler feed pump, make SURE that the hydraulic coupling is set for maximum slip. Torque should not be transmitted to the pump until the motor has come up to rated speed.

SYMBOLS:

For symbols see 47W5800

POWERHOUSE
UNITS 5 THRU 9

CONTROL DIAGRAM BOILER FEED PUMP SYSTEM SHEET 7

KINGSTON STEAM PLANT
TENNESSEE VALLEY AUTHORITY
DIVISION OF DESIGN

SUBMITTED	RECOMMENDED	APPROVED
R.M. Gardner	H.J. Petersen	R.A. Monroe

KNOXVILLE	2-3-54	36	M	4	47W5836 RO

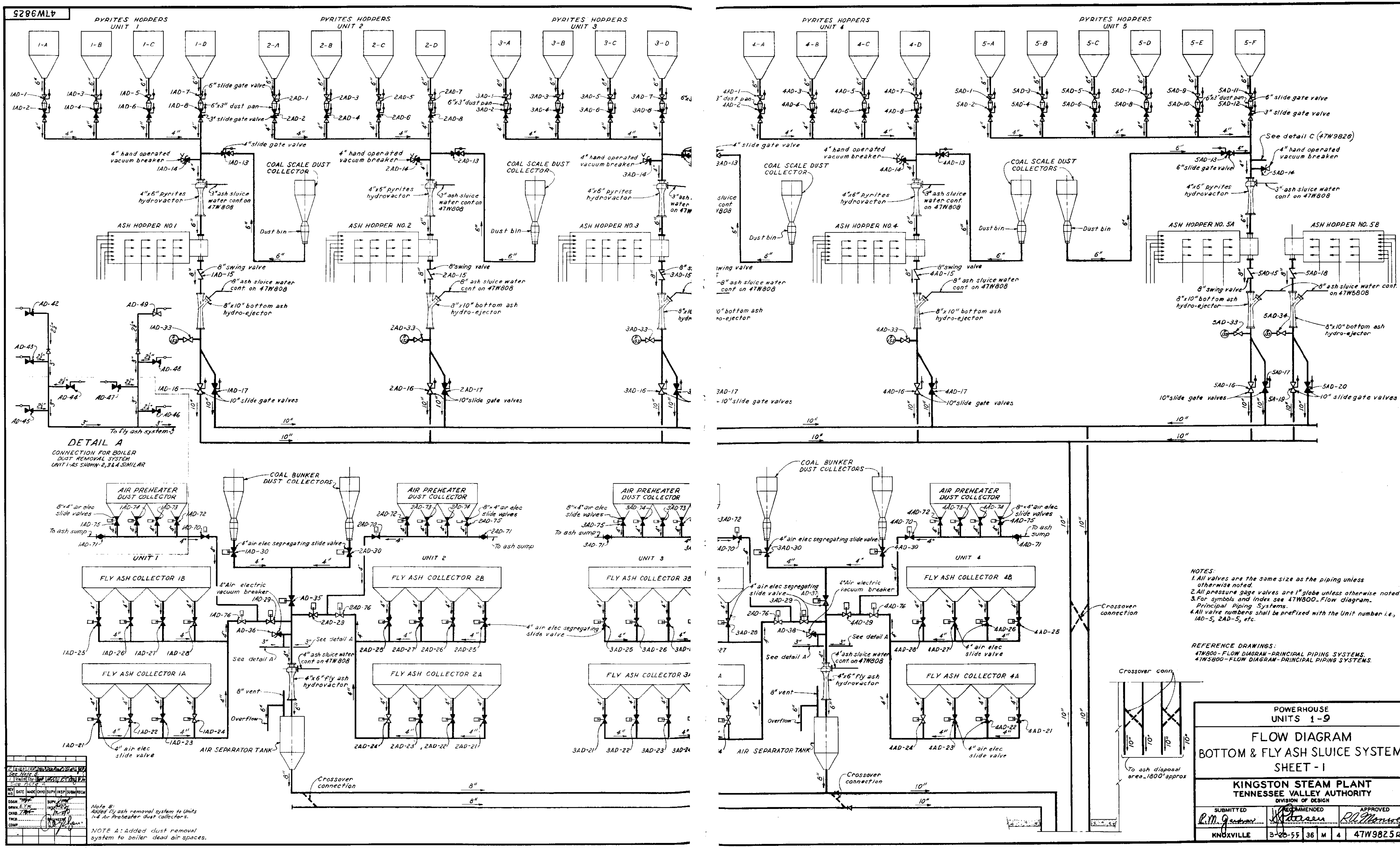
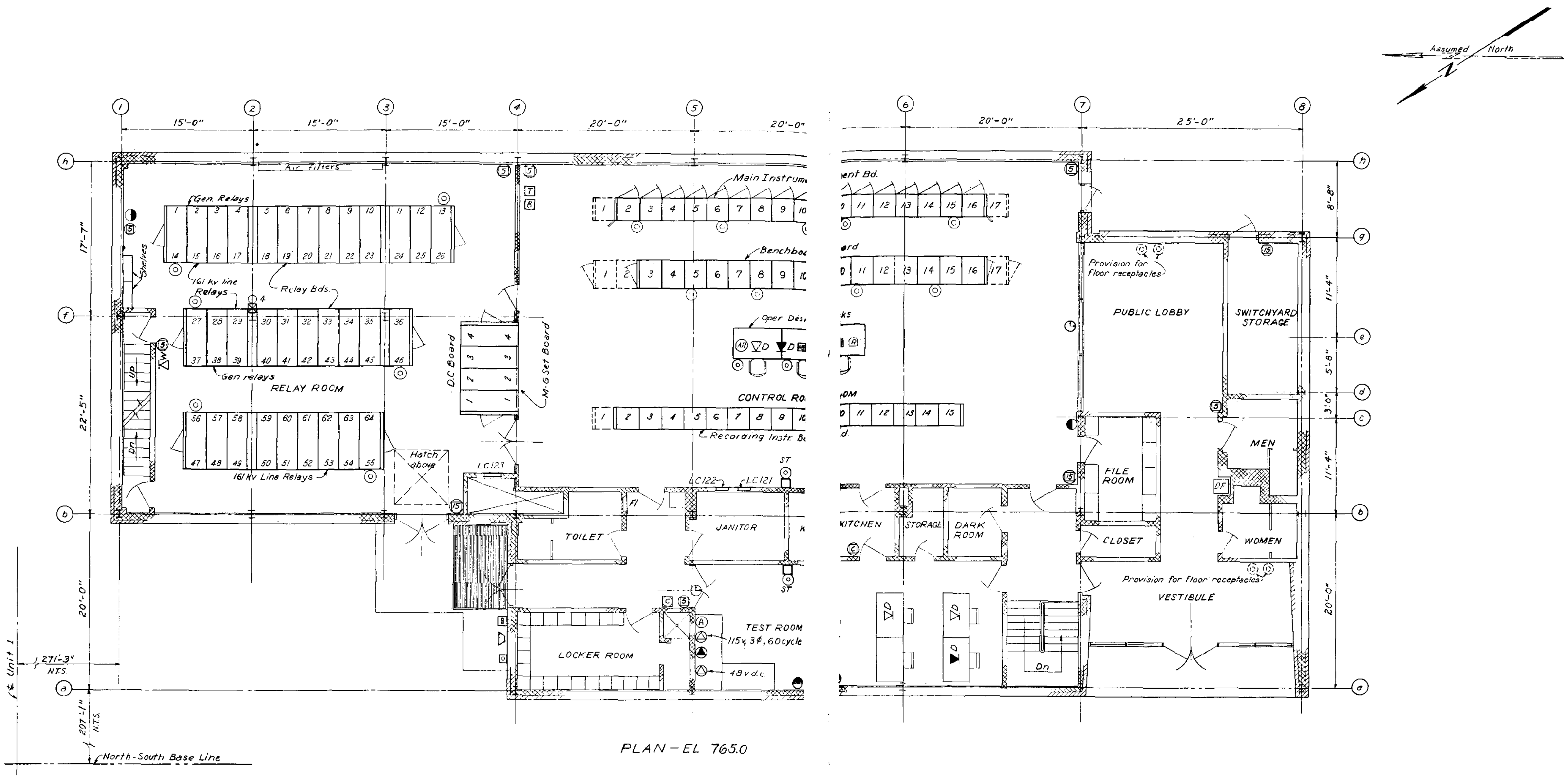

47W9825
PYRITES HOPPERS UNIT 1
PYRITES HOPPERS UNIT 2
PYRITES HOPPERS UNIT 3
PYRITES HOPPERS UNIT 4
PYRITES HOPPERS UNIT 5
ASH HOPPER NO.1
ASH HOPPER NO.2
ASH HOPPER NO.3
ASH HOPPER NO.4
ASH HOPPER NO. 5A
ASH HOPPER NO. 5B
COAL SCALE DUST COLLECTOR
COAL SCALE DUST COLLECTORS
COAL BUNKER DUST COLLECTORS
AIR PREHEATER DUST COLLECTOR
FLY ASH COLLECTOR 1B
FLY ASH COLLECTOR 1A
FLY ASH COLLECTOR 2B
FLY ASH COLLECTOR 2A
FLY ASH COLLECTOR 3B
FLY ASH COLLECTOR 4B
FLY ASH COLLECTOR 4A
AIR SEPARATOR TANK
DETAIL A
CONNECTION FOR BOILER DUST REMOVAL SYSTEM
UNIT 1-AS SHOWN-2,3 & 4 SIMILAR
Crossover connection
To ash disposal area_1800' approx
Note B: Added fly ash removal system to Units 1-4 Air Preheater dust collectors.
NOTE A: Added dust removal system to boiler dead air spaces.
NOTES:
1. All valves are the same size as the piping unless otherwise noted.
2. All pressure gage valves are 1" globe unless otherwise noted.
3. For symbols and index see 47W800-Flow diagram-Principal Piping Systems.
4. All valve numbers shall be prefixed with the Unit number i.e., 1AD-5, 2AD-5, etc.
REFERENCE DRAWINGS:
47W800-FLOW DIAGRAM-PRINCIPAL PIPING SYSTEMS.
47W5800-FLOW DIAGRAM-PRINCIPAL PIPING SYSTEMS.
POWERHOUSE
UNITS 1-9
FLOW DIAGRAM
BOTTOM & FLY ASH SLUICE SYSTEM
SHEET - 1
KINGSTON STEAM PLANT
TENNESSEE VALLEY AUTHORITY
DIVISION OF DESIGN
SUBMITTED
RECOMMENDED
APPROVED
KNOXVILLE
3-28-55
36
M
4
47W9825 R2

EXHIBIT 92

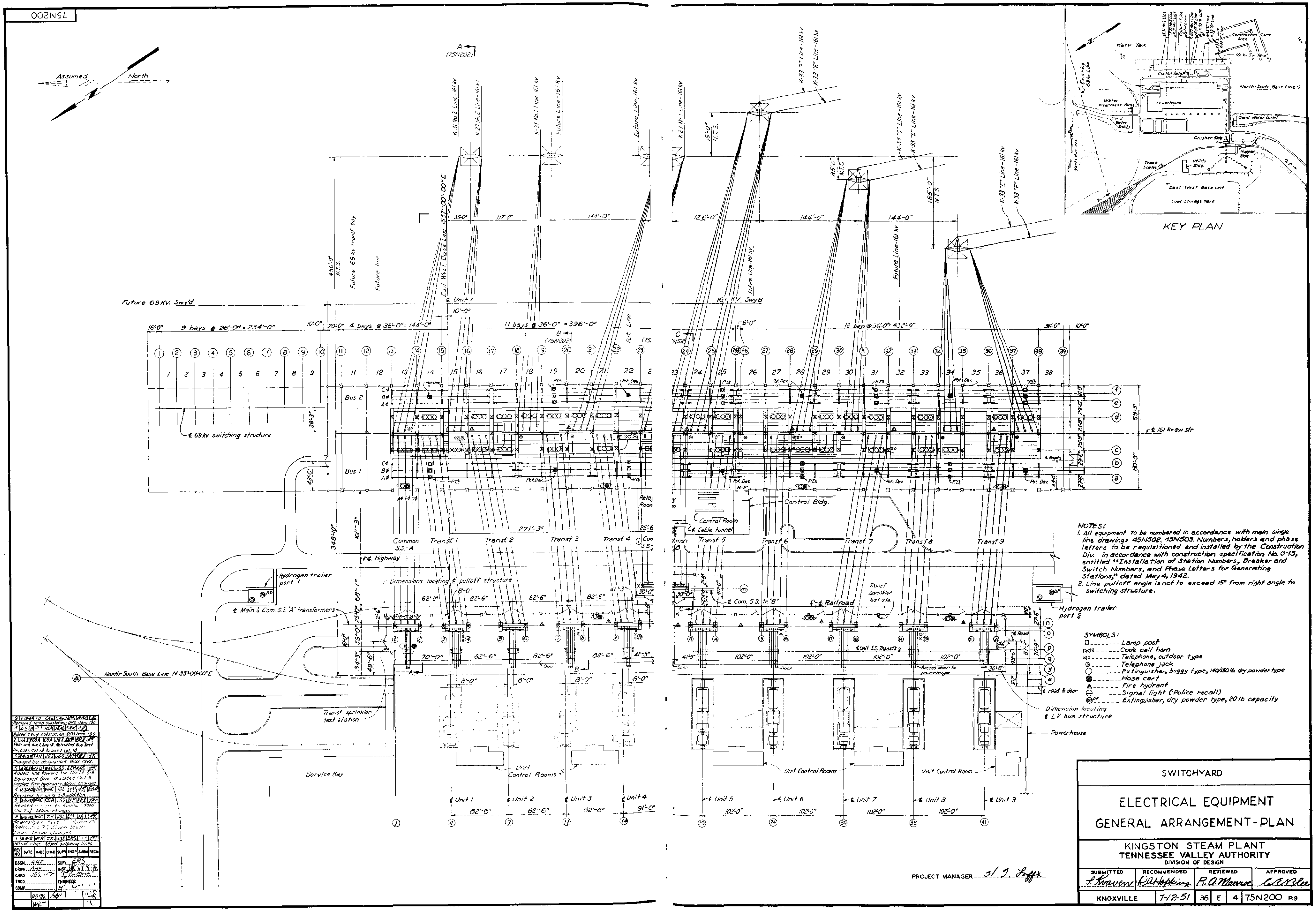


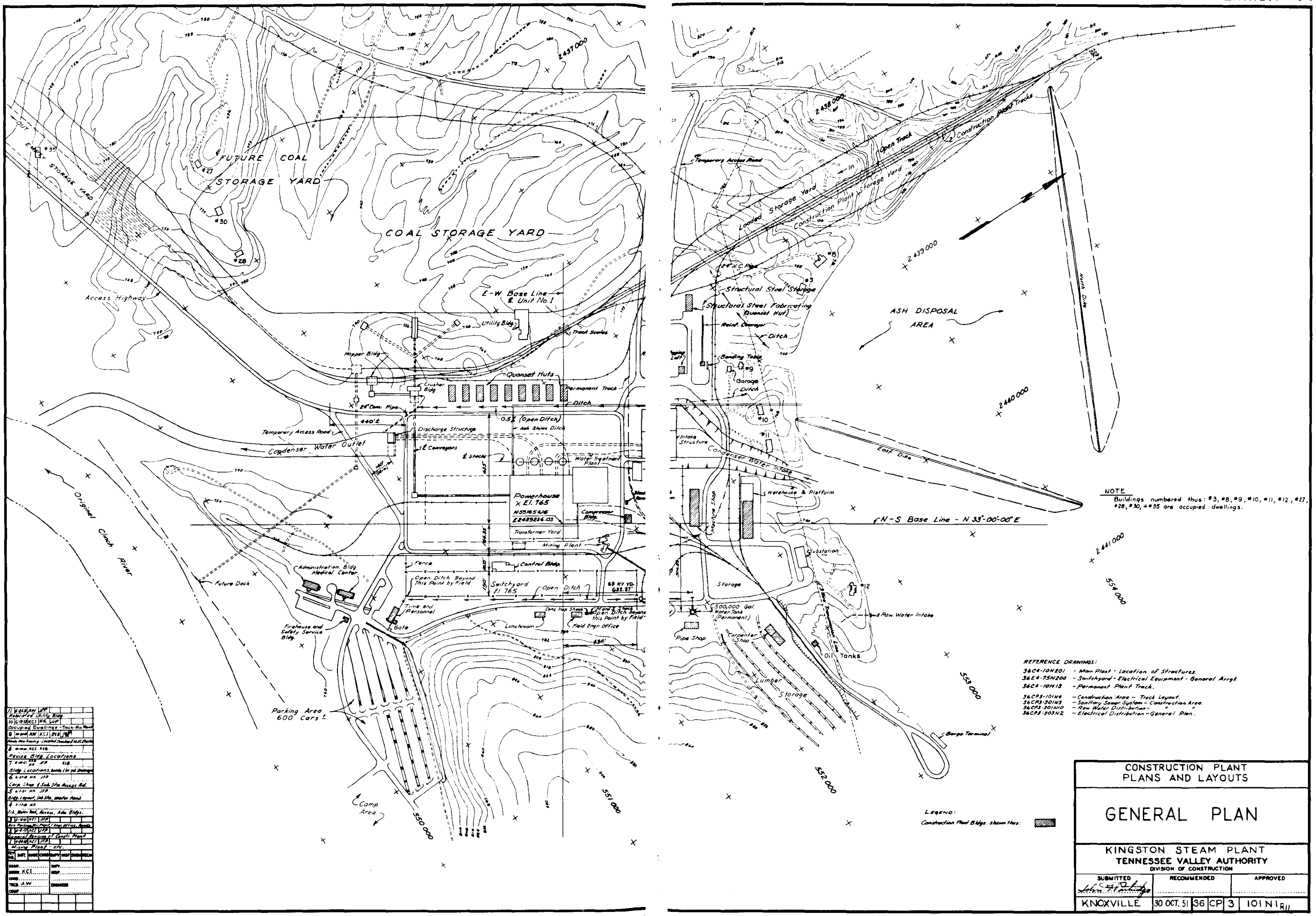
SYMBOLS:
- D — Telephone, desk (public)
- D — Telephone, desk (private)
- W — Telephone, wall (private)
- Fire extinguisher, vaporizing liquid pump type, 1 qt size
- Fire extinguisher, vaporizing liquid pump & stored pressure type, 1 gal size
- Jack, telephone
- Electric clock
- Fire extinguisher, CO_2, hand type, capacity in pounds
- Radio, remote control console
- Code call
- ST — Gong, code call (soft tone)
- Master intercom.
- Outlet, 440v, 3φ, 4-wire
- Outlet, 250v, d-c.
- Outlet, special
- Outlet, air
- Annunciator recorder
- Thermometer, recording
- Barometer, recording
- Door opener, electric
- Loudspeaker, microphone
- Pushbutton for door release signal
- LC2 — Lighting cabinet
- FH — Fire hose cabinet

COMPANION DRAWING: 55N202

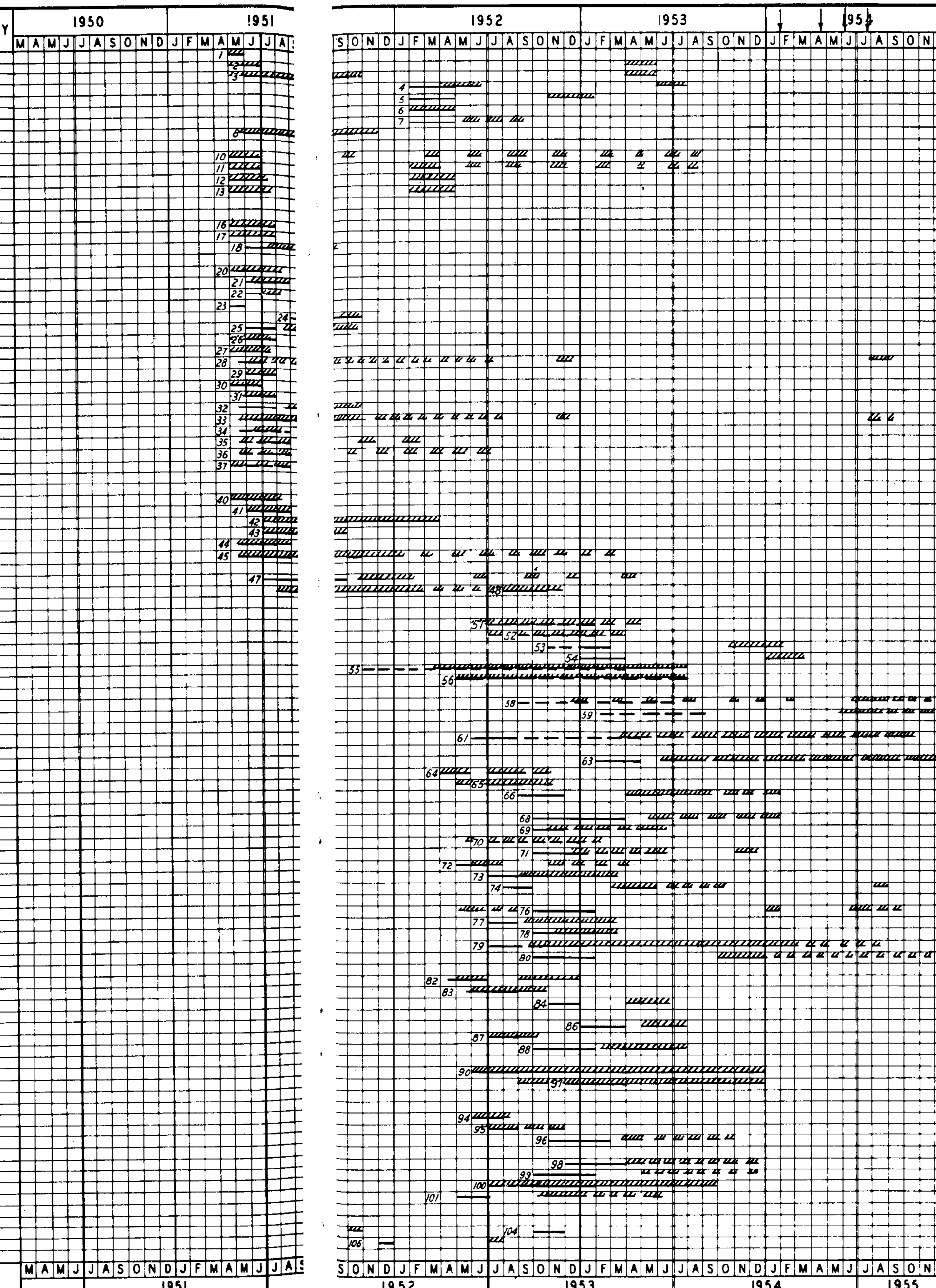
CONTROL BUILDING			
ELECTRICAL EQUIPMENT GENERAL ARRANGEMENT PLAN EL 765.0			
KINGSTON STEAM PLANT TENNESSEE VALLEY AUTHORITY DIVISION OF DESIGN			
SUBMITTED	RECOMMENDED	REVIEWED	APPROVED
E.R. Snyder	S. Kraven	R.A. Hopkins	R.A. Monroe
KNOXVILLE	12-27-51	36 E 4	55N200 R2

55N200


75N200
Assumed North
Future 69 KV. Swy'd
161 KV Swy'd
East-West Base Line S57°-00'-00"E
North-South Base Line N 33°00'-00"E
Bus 2
Bus 1
℄ 69kv switching structure
℄ 161 kv sw str
Control Bldg.
Control Room
℄ Cable tunnel
℄ Highway
℄ Railroad
Hydrogen trailer port 1
Hydrogen trailer port 2
℄ Main & Com. S.S. "A" transformers
Common S.S.-A
Transf 1
Transf 2
Transf 3
Transf 4
Transf 5
Transf 6
Transf 7
Transf 8
Transf 9
Transf sprinkler test station
Service Bay
Unit Control Rooms
Unit Control Room
Powerhouse
Dimension locating ℄ LV bus structure
KEY PLAN
NOTES:
1. All equipment to be numbered in accordance with main single line drawings 45N502, 45N503. Numbers, holders and phase letters to be requisitioned and installed by the Construction Div. in accordance with construction specification No. G-15, entitled "Installation of Station Numbers, Breaker and Switch Numbers, and Phase Letters for Generating Stations," dated May 4, 1942.
2. Line pulloff angle is not to exceed 15° from right angle to switching structure.
SYMBOLS:
Lamp post
Code call horn
Telephone, outdoor type
Telephone jack
Extinguisher, buggy type, 140/150 lb. dry powder type
Hose cart
Fire hydrant
Signal light (Police recall)
Extinguisher, dry powder type, 20 lb capacity
SWITCHYARD
ELECTRICAL EQUIPMENT
GENERAL ARRANGEMENT-PLAN
KINGSTON STEAM PLANT
TENNESSEE VALLEY AUTHORITY
DIVISION OF DESIGN
SUBMITTED
RECOMMENDED
REVIEWED
APPROVED
PROJECT MANAGER
KNOXVILLE
7-12-51
36
E
4
75N200 R9


FUTURE COAL STORAGE YARD
COAL STORAGE YARD
Access Highway
E-W Base Line
Utility Bldg.
Track Scales
Hopper Bldg.
Crusher Bldg.
Quonset Huts
Permanent Track
Ditch
24" Conc. Pipe
440'±
0.5% (Open Ditch)
Temporary Access Road
Discharge Structure
Ash Sluice Ditch
Condenser Water Outlet
Conveyors
Water Treatment Plant
Powerhouse
El. 765
Transformer Yard
Mixing Plant
Compressor Bldg.
Original Clinch River
Future Dock
Administration Bldg
Medical Center
Fence
Control Bldg.
Open Ditch Beyond This Point by Field
Switchyard El 765
Open Ditch
Time and Personnel
Gate
Firehouse and Safety Service Bldg.
Lunchroom
Field Engr Office
Parking Area 600 Cars ±
Camp Area
550 000
551 000
552 000
553 000
554 000
2 437 000
2 438 000
2 439 000
2 440 000
2 441 000
Temporary Access Road
Loaded Storage Yard
Construction Plant Storage Yard
Open Track
Construction Plant Tracks
24" V.C. Pipe
Structural Steel Storage
Structural Steel Fabricating Quonset Hut
Reinf. Conveyor
Ditch
Bending Table
Garage
ASH DISPOSAL AREA
North Dike
East Dike
Intake Structure
Condenser Water Intake
Machine Shop
Warehouse & Platform
N-S Base Line - N 33°-00'-00" E
Substation
Storage
500,000 Gal. Water Tank (Permanent)
Raw Water Intake
Pipe Shop
Carpenter Shop
Oil Tanks
Lumber Storage
Barge Terminal
NOTE
Buildings numbered thus: #3, #8, #9, #10, #11, #12, #27, #28, #30, & #35 are occupied dwellings.
REFERENCE DRAWINGS:
36C4-10N201 - Main Plant - Location of Structures.
36E4-75N200 - Switchyard - Electrical Equipment - General Arrgt.
36C4-10H13 - Permanent Plant Track.
36CP3-101N4 - Construction Area - Track Layout.
36CP3-301N3 - Sanitary Sewer System - Construction Area.
36CP3-301N10 - Raw Water Distribution - " "
36CP3-303N2 - Electrical Distribution - General Plan.
LEGEND:
Construction Plant Bldgs. shown thus:
CONSTRUCTION PLANT
PLANS AND LAYOUTS
GENERAL PLAN
KINGSTON STEAM PLANT
TENNESSEE VALLEY AUTHORITY
DIVISION OF CONSTRUCTION
SUBMITTED
RECOMMENDED
APPROVED
KNOXVILLE
30 OCT. 51
36
CP
3
101 N1 R11
Relocated Utility Bldg.
Occupied Dwellings
Revise Bldg Locations
General Revision of Constr. Plant
Mixing Plant - etc.

		NO.	ITEM	QUANTITY
CONSTRUCTION FACILITIES	CAMP	1	Clear site	
		2	Grading	
		3	Roads, curbs, & sidewalks	
		4	Buildings : bunk houses	
		5	bunk houses	
		6	camp managers office	
		7	cafeteria	
		8	houses	
		9		
		10	Telephone	
		11	Electrical distr	
		12	Sewerage system	
		13	Water system	
		14		
		15		
	CONSTRUCTION PLANT	16	Grading & temporary roads	
		17	Grading - temporary railroads	
		18	Trackage	
		19		
		20	Buildings - administration	
		21	carpenter shop	
		22	compressor bldg	
		23	garage	
		24	lunch room	
		25	machine shop	
		26	medical center	
		27	personnel & time office	
		28	quonset huts	
		29	steel yard	
		30	temp offices 20 x 20	
		31	warehouse	
		32	Mixing plant	
		33	Electrical distribution	
		34	Raw water - lines, pumps & tank	
		35	Filtered water system	
		36	Sewerage system	
		37	Telephone system	
		38		
		39		
YARD & GENERAL	CLEARING	40	Clear site	
	GRADING	41	Main plant area	
		42	Coal storage area	
		43	Roads access	
		44	Railroads - construction	
		45	" - operation	
		46		
	RAILROAD	47	Trackage - construction	
		48	Trackage - operation	
		49		
		50		
	MECHANICAL	51	Raw, treated, softened water, air & vacuum piping	
		52	Drainage & sewers	
		53	Ash sluice	
		54	Diesel oil gas tanks & piping (at island)	
	ELECTRICAL	55	Grounding	
		56	Power & lighting	
		57		
	GENERAL	58	Roads, sidewalks & curbs	
		59	Landscaping	
		60		
	OTHER	61	Transmission lines - DPO	
		62		
COAL HANDLING FACILITIES	COAL	63	Store coal	
	HOPPER BLDG	64	Excavation - cut & fill	
		65	Concrete	
		66	Structure - structural steel, siding, roofing, etc.	
		67		
		68	Mechanical - piping, heating & ventilating	
		69	car dumper & other equipment	
		70	Electrical - conduits & grounds	
		71	controls, lighting, power	
	CRUSHER BLDG	72	Excavation (cut & fill)	
		73	Concrete	
		74	Structure - structural steel, roofing, siding, etc.	
		75		
		76	Mechanical - crusher installation	
		77	piping embedded	
		78	piping & equipment exposed	
		79	Electrical - conduit, grounds	
		80	power, lighting & controls	
		81		
	STOCKING OUT & RECLAIMING STRUCTURES	82	Excavation (cut & fill)	
		83	Concrete	
		84	Structures - steel, siding, roofing, etc.	
		85		
		86	Mechanical - equipment (hoppers & feeders)	
		87	piping embedded	
		88	piping & equipment exposed	
		89		
		90	Electrical - conduits, grounds	
		91	power, lighting, controls	
		92		
		93		
	CONVEYORS	94	Excavation	
		95	Concrete	
		96	Structures (steel	
		97		
		98	Mechanical equipment	
		99	piping & controls	
		100	Electrical - conduit, lighting, power control	
	TRACK SCALE	101	Excavation - concrete & equipment	
		102		
		103		
	EQUIPMENT	104	Mobile equipment - tractors & pans	
		105	Locomotive - 80 ton	
		106		



As constructed added

INITIAL OPERATION

Unit	On Line	Commercial Operation
1	Jan 30, 1954	Feb 8, 1954
2	April 25, 1954	April 29, 1954
3	June 5, 1954	June 11, 1954
4	July 23, 1954	July 27, 1954

—— Schedule
////// As Constructed

GENERAL

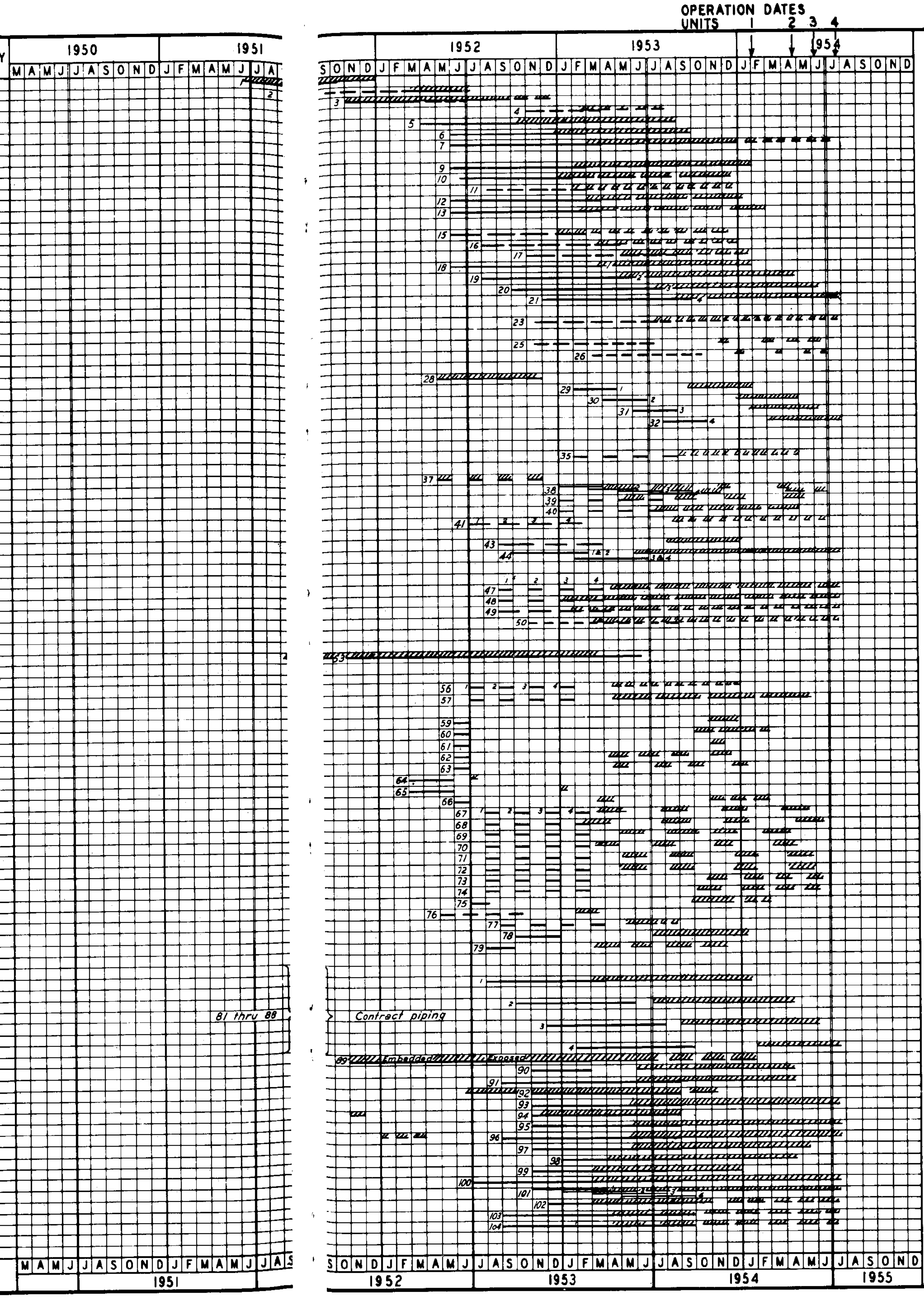
DETAILED CONSTRUCTION SCHEDULE UNITS 1, 2, 3, & 4

KINGSTON STEAM PLANT
TENNESSEE VALLEY AUTHORITY
DIVISION OF CONSTRUCTION

SUBMITTED	RECOMMENDED	RECOMMENDED	APPROVED
[signature]	[signature]	[signature]	[signature]

FIELD OFFICE 5-10-51 36 PC 4 102K10,000R1

POWERHOUSE		NO.	ITEM	QUANTITY
BUILDING	EXCAVATION & BACKFILL	1	Earth cut	
		2	Earth backfill	
	CONCRETE	3	Concrete - foundation and substructure	
		4	Floor slabs - fill (below 725)	
	STRUCTURAL	5	Steel and bunkers	
		6	Walkways, stairs & misc	
	SUPER STRUCTURE	7	Exterior walls - tile, brick, glass blocks, trim, siding,	
		8	windows, louvers, etc.	
		9	Roof - slabs - insulation - water proofing	
		10	Floors - sub floors	
		11	Finish	
		12	Partitions - tile & misc	
		13	Doors, frames	
		14		
MECHANICAL	STEAM GENERATORS	15	Air preheaters	
		16	Pulverizers	
		17	Air ducts	
		18	(1) Boiler & furnace (incl drums, supporting steel,	
		19	(2) downcomers, headers, water walls,	
		20	(3) super heaters, economizers, refractory	
		21	(4) materials, burners, lighters, casing,	
		22	doors, insulation	
		23	Soot blowers	
		24		
		25	Test	
		26	Boiling out & drying out	
		27		
	TURBO GENERATORS	28	Concrete supports & anchors	
		29	(1) Turbine & generator erection (including hydrogen	
		30	(2) and CO2 equipment etc., for	
		31	(3) complete turbine.)	
		32	(4)	
		33		
		34		
		35	Turbine stop valve	
		36		
	CONDENSERS	37	Embedded parts	
		38	Condensers	
		39	Hot well pumps	
		40	Air ejectors	
	ASH DISPOSAL	41	Wet ash & slag chamber - embedded parts & concrete	
		42	structural steel & linings	
		43	Ash sluice - trenches & covers (T.V.A.)	
		44	Pumps, piping & soot removal equipment	
		45		
		46		
	FANS	47	Forced draft	
		48	Induced draft	
		49	Air ducts, dampers, fly ash equipment	
		50	Insulation	
		51		
		52		
	STACKS	53	Excavation & concrete	
		54		
		55		
	HEATERS	56	Feed water heaters	
		57	Evaporator preheaters & evaporators	
		58		
	TANKS	59	Treated water	
		60	Boiler blow down	
		61	Continuous blow down	
		62	Gland seal	
		63	Condensate drain & flash tank	
		64	Fuel oil	
		65	Insulating oil & lubricating oil	
		66	Compressed Air & vacuum	
	PUMPS	67	Boiler feed	
		68	Distilled water	
		69	Gland seal	
		70	Raw water	
		71	Condensate drain	
		72	Extraction heater drain	
		73	Insulating oil & lubricating oil	
		74	Fuel oil & vacuum priming	
		75	Sta sump & distilled well leakage	
	FEED WATER TREATMENT	76	Deaerators & storage tank	
		77	Cold well lining	
		78	Chemical feed piping	
		79	Feedwater treatment equipment (secondary)	
		80		
	CONTRACT PIPING	81	Main steam boiler to turbine & safety valve vents	
		82	Contract pipe hangers	
		83	Boiler feed suction & discharge	
		84	Extraction steam	
		85	Heater vents & drains	
		86	Condensate	
		87	Blowoff drips & drains	
		88	Misc turbine piping	
	OTHER PIPING	89	Roof & floor drains	
		90	Cooling water	
		91	Distilled water	
		92	Fuel, insulating & lubricating oil	
		93	Sampling & FW make up	
		94	Raw & treated water service	
		95	Gland seal water	
		96	Ash sluice water	
		97	Vacuum piping	
		98	Circulating water condenser	
		99	Compressed air & vacuum cleaning systems	
		100	Control piping	
	INSULATION	101	Piping & equipment	
	HEATING & VENTILATING	102	Heating and ventilating	
		103	Air conditioning equipment	
		104	Duct - hoods, louvers, screens, dampers	
		105		
		106		



2	As constructed added
1	General revision

GENERAL

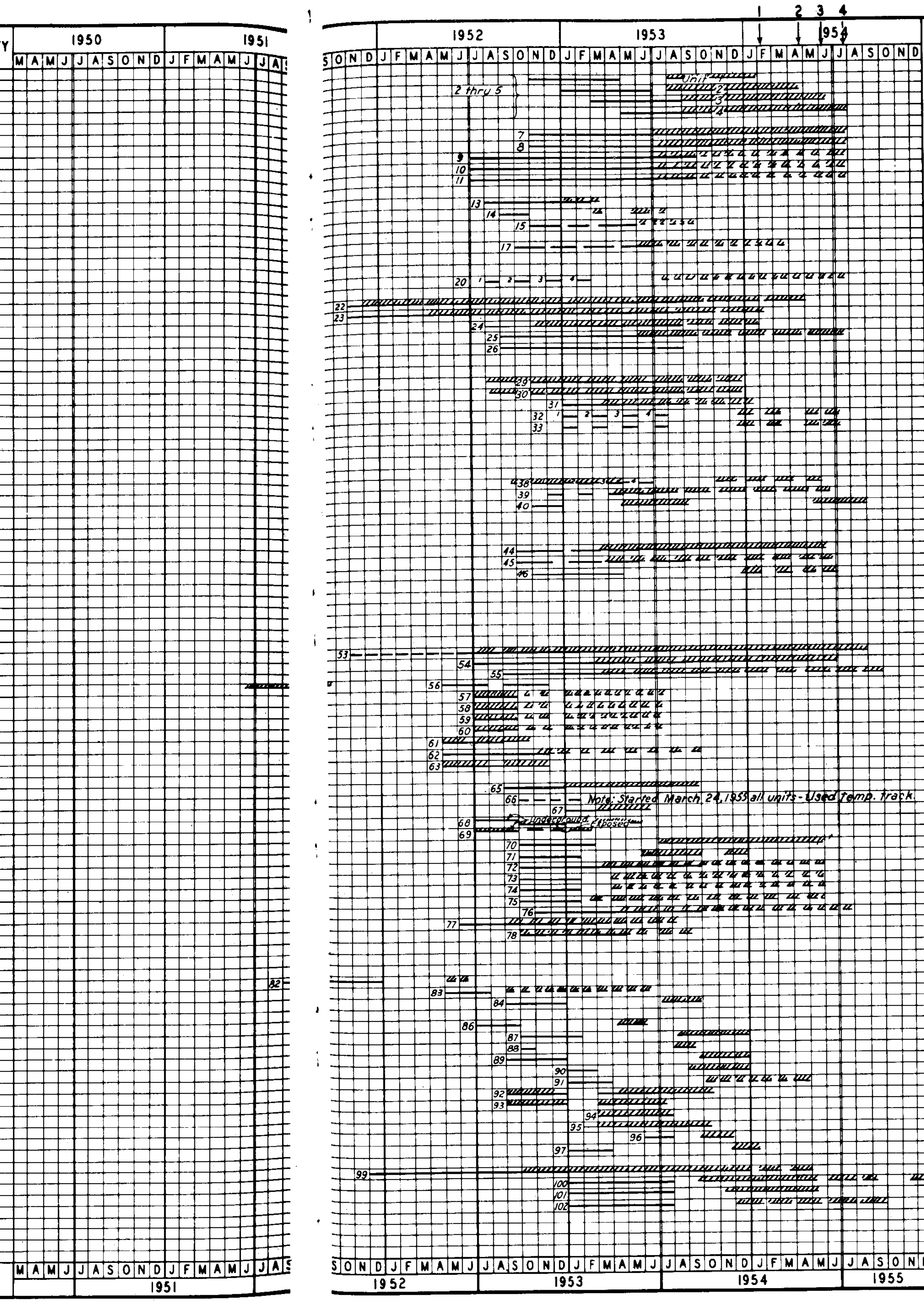
DETAILED CONSTRUCTION SCHEDULE UNITS 1, 2, 3, & 4

KINGSTON STEAM PLANT
TENNESSEE VALLEY AUTHORITY
DIVISION OF CONSTRUCTION

SUBMITTED	RECOMMENDED	RECOMMENDED	APPROVED

FIELD OFFICE 5-10-51 36 PC 4 102K10,001R2

POWERHOUSE		NO.	ITEM	QUANTITY
MECHANICAL	UNIT CONTROL BOARDS	1		
		2	Turbine gage boards & instruments	
		3	Boiler gage boards & instruments	
		4	Auxiliary boards & instruments	
		5	Bench boards & cabinets	
		6		
	OTHER CONTROLS	7	Combustion control equipment	
		8	Misc gages & controls	
	FIRE PROTECTION	9	Estinguishing equipment	
		10	piping	
		11	controls	
		12		
	CRANES	13	Crane & collector rails	
		14	Crane erection - turbine room	
		15	Misc hoists	
		16		
	ELEVATORS	17	Elevators	
		18		
		19		
	SCALES	20	Coal scales	
		21		
ELECTRICAL	GROUNDING	22	Grounding cable - boxes	
	POWER & CONTROL CONDUIT & CABLE	23	Conduits & supports	
		24	Cable trays & supports	
		25	Cable	
		26	Wiring	
		27		
		28		
	MAIN GENERATOR LEADS & EQUIPMENT	29	Generator lead structures & enclosures	
		30	Insulators & conductors	
		31	Surge prot. equip, disc sws, instrument trans.	
		32	Generator neutral reactor	
		33	Field sw breaker & accessory equip	
		34		
		35		
		36		
		37		
	AUXILIARY POWER SUPPLY	38	Station service transformers	
		39	Auxiliary power transformer	
		40	Batteries & charging equipment	
		41		
		42		
		43		
	SWITCHGEAR & LOAD CENTERS	44	Switchgear 4160v	
		45	Control centers 460/230	
		46	DC distribution panels	
		47		
		48		
		49		
	MISC POWER PLANT EQUIP	50		
		51		
		52		
	LIGHTING	53	Lighting - conduit & boxes	
		54	Lighting - cabinets	
		55	Lighting - fixtures, outlets & wiring	
TRANSFORMER YARD & SWITCHYARD	FOUNDATIONS & CABLE TUNNELS	56	Excavation & backfill	
		57	Concrete - transformer foundations	
		58	Concrete - transf yd overhead struct fdns	
		59	Concrete - switchyard " " "	
		60	Other equipment foundations	
		61	Cable tunnels	
		62	Conduits & ducts	
		63	Manholes & handholes	
		64		
	STEEL	65	Structural steel	
		66	Transformer track	
		67	Fencing	
	MECHANICAL	68	Raw water piping (fire protection)	
		69	Insulating oil & misc piping	
	ELECTRICAL	70	Main power transformers & accessories	
		71	Transformer neutral reactor	
		72	Oil circuit breakers	
		73	Disconnect switches	
		74	PTs, CTs, LAs, capacitors, etc.	
		75	Busses & supports	
		76	Power & control wiring	
		77	Grounding	
		78	Lighting	
		79		
		80		
		81		
SERVICE BAY & OFFICE WING	BUILDING	82	Excavation & backfill	
		83	Concrete foundations - wall & footings	
		84	floors	
		85		
		86	Structural steel	
		87	Super structure - exterior walls	
		88	roof	
		89	floors	
		90	partitions	
		91	doors, windows, etc.	
	MECHANICAL	92	Piping - water & air, roof & floor drains	
		93	- plumbing	
		94	Heating, ventilating & air conditioning	
		95	Station maintainance equipment	
		96	Laboratory equipment	
		97	Elevator	
		98		
	ELECTRICAL	99	Grounding & conduit	
		100	Power & lighting wire	
		101	Controls	
		102	Communication system	
		103		
		104		
		105		
		106		



2	12-28-53	JWR					
As constructed added							
1	5-26-5?	T.B.	WCA				
Nos. 65, 70, & 71 thru 78 revised							
REV NO.	DATE	MADE	CHKD	SUPV	INSP	SUBM	RECM

DSGN ....
DRWN ....
CHKD ....
TRCD ....
COMP ....
SUPV ....
INSP [illegible]
ENGINEER ....

GENERAL

DETAILED
CONSTRUCTION SCHEDULE
UNITS 1, 2, 3, & 4

KINGSTON STEAM PLANT
TENNESSEE VALLEY AUTHORITY
DIVISION OF CONSTRUCTION

SUBMITTED	RECOMMENDED	RECOMMENDED	APPROVED
[illegible]	[illegible]	[illegible]	[illegible]

FIELD OFFICE	5-10-51	36	PC	4	102K10,002R2

		NO.	ITEM	QUANTITY
CONTROL BUILDING	BUILDING	1	Excavation & backfill	
		2	Concrete - Foundation	
		3	Structural steel	
		4	Super structure - exterior walls	
		5	- roof	
		6	- floors	
		7	- partitions	
		8	- doors, windows etc.	
		9		
	MECHANICAL	10	Piping - air, water, oil, roof & floor drains	
		11	Piping - plumbing	
		12	Heating & ventilating & air conditioning	
		13	Insulating oil	
		14		
	ELECTRICAL	15	Grounding & conduits	
		16	Main control boards	
		17	Auxiliary switch board	
		18	Communication & signal board	
		19	Main switchboard & panel wiring	
		20	Auxiliary switchboard & station wiring	
		21		
UTILITY BUILDING	BUILDING	22	Excavation & backfill	
		23	Concrete foundation	
		24	Structural steel	
		25	Superstructure - exterior walls	
		26	- roof	
		27	- floors	
		28	- partitions	
		29	- misc doors, windows, etc.	
		30		
	MECHANICAL	31	Piping - air & water, roof & floor drains	
		32	Piping - plumbing	
		33	Heating & ventilating	
		34	Equipment installation	
		35		
	ELECTRICAL	36	Grounding & conduits	
		37	Power & lighting wiring, etc.	
		38		
		39		
CONDENSER WATER SUPPLY & DISCHARGE	INTAKE CANAL	40	Clearing	
		41	Excavation	
		42		
		43	Riprap	
		44		
	DISCHARGE CANAL	45	Clearing	
		46	Excavation	
		47	Concrete	
		48		
		49	Riprap	
		50		
			Clearing	
			Excavation & fill	
			Riprap	
			Coffer dam	
			Excavation	
			Concrete	
	CONDUITS		Coffer dam	
		60	Excavation - cut	
		61	- fill	
		62	Concrete cradles	
		63	Casting pipe	
		64	Laying pipe - intake	
		65	discharge	
	INTAKE STRUCTURE	67	Excavation - cut	
		68	backfill	
		69	Concrete	
		70		
		71	Mechanical - crane	
		72	- stoplogs & trash racks	
		73	- traveling screens	
		74	- pumps	
		75	- sluice gates	
		76	- piping & controls	
		77	- heating & ventilating	
		78	- valves & special fittings	
		81	Electrical - conduits & grounding	
		82	- switchboards, wiring & controls	
		83		
WATER TREATMENT	BUILDING	84	Excavation - cut & backfill	
		85	Concrete	
		86	Structural steel	
		87	Superstructure - exterior walls	
		88	- roof	
		89	- floors	
		90	- partitions	
		91	- doors windows, etc.	
		92		
		93	Mechanical - pumps	
		94	- piping	
		95	- heating & ventilating	
		96	- filter equipment	
		97		
		98		
		99		
		100	Electrical - conduits & grounds	
		101	- power & lighting wires	
		102	- fixtures	
		103		
		104		
		105		
		106		

As constructed added
Nos. 16 thru 20 revised
REV. NO. | DATE | MADE | CHKD | SUPV | INSP | SUBM | RECM
DSGN. | SUPV.
DRWN. | INSP.
CHKD. | ENGINEER
TRCD.
COMP.

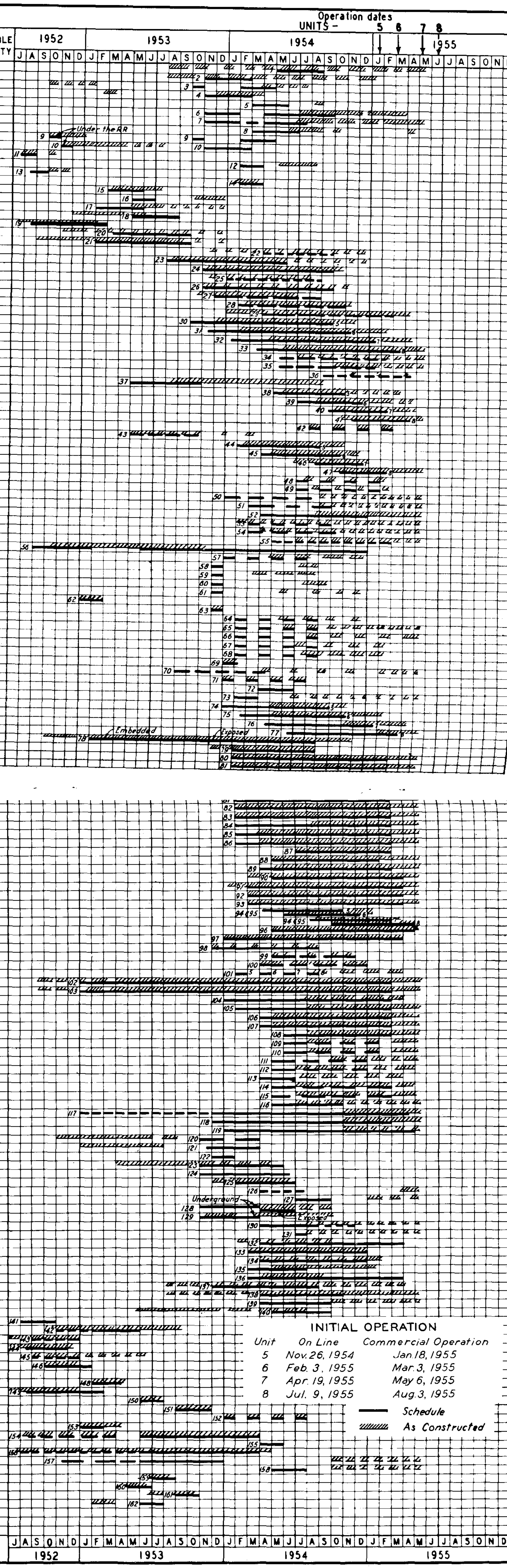
GENERAL

DETAILED CONSTRUCTION SCHEDULE UNITS 1, 2, 3, & 4

KINGSTON STEAM PLANT
TENNESSEE VALLEY AUTHORITY
DIVISION OF CONSTRUCTION

SUBMITTED	RECOMMENDED	RECOMMENDED	APPROVED
FIELD OFFICE	5-10-51	36 PC 4	102K10,003R2

Division	Category	No.	Item	Probable Quantity
YARD AND GENERAL	MECHANICAL	1	Ash disposal pipe	
		2	Water, air and sewer pipes	
COAL HANDLING FACILITIES	HOPPER BUILDING NO. 2	3	Excavation and backfill	
		4	Concrete	
		5	Structure	
		6	Mechanical	
		7	Electrical	
	CRUSHER BUILDING	8	Equipment	
	CONVEYORS	9	Conveyor 10 & 11 and transfer str excavation	
		10	" " " " " concrete	
	RAILROAD	11	Loaded coal car yard - grading	
		12	" " " " - trackage	
		13	Empty coal car yard - grading	
		14	" " " " - trackage	
		15	Southern Railway connection - grading	
		16	" " " - trackage	
		17	" " " - bridge	
	GRADING	18	Coal storage yard - excavation and fill	
POWERHOUSE BUILDING	EXCAVATION AND BACKFILL	19	Excavation	
		20	Earth backfill	
	CONCRETE	21	Concrete fdn and substructure	
		22	Fill slab below 725	
	STRUCTURAL	23	Steel, bunkers and walkways	
	SUPERSTRUCTURE	24	Walls, roof and floors	
		25	Floor finish	
		26	Partitions door and frames	
POWERHOUSE MECHANICAL	STEAM GENERATORS	27	Air preheaters	
		28	Pulverizers	
		29	Air ducts	
		30	Boiler and furnace - Unit 5	
		31	" 6	
		32	" 7	
		33	" 8	
		34	Soot blowers	
		35	Test	
		36	Boiling out and drying out	
	TURBO GENERATORS	37	Concrete supports and anchors	
		38	Turbine and generator erection - Unit 5	
		39	" 6	
		40	" 7	
		41	" 8	
		42	Turbine stop valve	
	CONDENSERS	43	Embedded parts	
		44	Condensers Unit 5	
		45	" 6	
		46	" 7	
		47	" 8	
		48	Hot well pumps	
		49	Air ejectors	
	ASH DISPOSAL	50	Wet ash and slag chamber	
		51	Ash sluice	
		52	Pumps and piping	
	FANS	53	Forced and induced draft	
		54	Air ducts, dampers, fly ash equipment	
		55	Insulation	
	STACKS	56	Excavation and concrete	
	HEATERS	57	Feed water and evaporator preheater	
	TANKS	58	Treated water	
		59	Boiler and continuous blow down	
		60	Gland seal	
		61	Condensate drain and flash tank	
		62	Fuel oil	
		63	Compressed air and vacuum	
	PUMPS	64	Boiler feed	
		65	Distilled and raw water	
		66	Gland seal	
		67	Condensate and extraction heater drains	
		68	Insulating oil, lubricating oil, fuel oil & vacuum	
		69	Sta. sump and distilled well leakage	
	FEED WATER TREATMENT	70	Deaerators and storage tank	
		71	Cold well lining	
		72	Chemical feed piping	
		73	Feedwater treatment equipment	
	CONTRACT PIPING	74	Unit 5	
		75	" 6	
		76	" 7	
		77	" 8	
		78	Roof and floor drains	
		79	Cooling water	
		80	Distilled water	
		81	Fuel, insulating and lubricating oil	
	OTHER PIPING	82	Sampling and FW make up	
		83	Raw and treated water service	
		84	Gland seal water	
		85	Ash sluice water	
		86	Vacuum piping	
		87	Circulating water condenser	
		88	Compressed air and vacuum cleaning	
		89	Control piping	
	INSULATION	90	Piping and equipment	
	HEATING AND VENTILATING	91	Heating and ventilating	
		92	Air conditioning equipment	
		93	Duct-hoods, louvers, screens, dampers	
	UNIT CONTROL BOARDS	94	Turbine gage boards and instruments	
		95	Bench boards and cabinets	
	CONTROL	96	Combustion control equipment	
	FIRE PROTECTION	97	Fire protection	
	CRANES	98	Collector rails	
		99	Misc. hoists	
	ELEVATORS	100	Elevators	
	SCALES	101	Coal scales	
POWERHOUSE ELECTRICAL	GROUNDING	102	Grounding cable-boxes	
	POWER AND CONTROL CABLE	103	Conduits and supports	
		104	Cable trays and supports	
		105	Wiring	
	MAIN GENERATOR LEADS AND EQUIPMENT	106	Generator lead structures and enclosures	
		107	Insulators and conductors	
		108	Surge prot equipment, disc sws	
		109	Generator neutral reactor	
		110	Field sw breaker and accessory equipment	
	AUXILIARY POWER SUPPLY	111	Station service transformers	
		112	Auxiliary power transformers	
		113	Batteries and charging equipment	
	SWITCHGEAR & LOAD CENTERS	114	Switchgear 4160v - auxiliary switchboards	
		115	Control centers 460/230 auxiliary swbds	
		116	DC distribution panels	
	LIGHTING	117	Lighting - conduit and boxes	
		118	Lighting - cabinets	
		119	Lighting - fixtures, outlets and wiring	
TRANSFORMER YARD AND SWITCHYARD	FOUNDATIONS AND CABLE TUNNELS	120	Excavation and backfill	
		121	Concrete foundations	
		122	Cable tunnel	
		123	Conduits and ducts	
		124	Manholes and handholes	
	STEEL	125	Structural steel	
		126	Transformer track	
		127	Fencing	
	MECHANICAL	128	Raw water piping (fire protection)	
		129	Insulating oil and misc piping	
	ELECTRICAL	130	Main power transformers and accessories	
		131	Transformer neutral reactor	
		132	Oil circuit breakers	
		133	Disconnect switches	
		134	PTs, CTs, LAs, capacitors, etc	
		135	Busses and supports	
		136	Power and control wiring	
CONTROL BUILDING		137	Grounding	
		138	Lighting	
	ELECTRICAL	139	Main control boards	
		140	Auxiliary switch board	
GENERAL – CONDENSER WATER SUPPLY	CONDUITS	141	Excavation	
		142	Backfill	
		143	Concrete cradles	
		144	Casting pipe	
		145	Laying pipe - intake	
		146	- discharge	
	INTAKE STRUCTURE	147		
		148	Backfill	
		149	Concrete	
		150	Mechanical - stoplogs and trash racks	
		151	- traveling screens	
		152	- pumps	
		153	- sluice gates	
		154	- piping and controls	
		155	- heating and ventilating	
		156	- valves and special fittings	
		157	Electrical - conduits and groundings	
		158	- switchboards, wiring	
	WATER TREATMENT BUILDING	159	Equipment	
		160	Embedded pipe	
		161	Exposed pipe	
		162	Additional settling basins	
		163		
		164		
		165		



INITIAL OPERATION

Unit	On Line	Commercial Operation
5	Nov. 26, 1954	Jan. 18, 1955
6	Feb. 3, 1955	Mar. 3, 1955
7	Apr. 19, 1955	May 6, 1955
8	Jul. 9, 1955	Aug. 3, 1955

DETAILED CONSTRUCTION SCHEDULE UNITS 5, 6, 7, & 8

KINGSTON STEAM PLANT
TENNESSEE VALLEY AUTHORITY
DIVISION OF CONSTRUCTION

SUBMITTED [signature] RECOMMENDED [signature] APPROVED [signature]

FIELD OFFICE | 8-18-52 | 36 | PC | 4 | 10 2K10.289 R1

EXHIBIT 99

TVA-00020492

EXHIBIT 100

OPERATION DATE UNIT 9

		NO	ITEM	PROBABLE QUANTITY
POWERHOUSE BUILDING	EXCAVATION & BACKFILL	1	Excavation	
		2	Earth backfill	
	CONCRETE	3	Concrete fdn and substructure	
		4	Fill slab below 725	
	STRUCTURAL	5	Steel, bunkers and walkways	
	SUPER STRUCTURE	6	Walls, roof and floors	
		7	Floor finish	
		8	Partitions door and frames	
POWERHOUSE MECHANICAL	STEAM GENERATORS	9	Air preheaters	
		10	Pulverizers	
		11	Air ducts	
		12	Boiler insulation and refractories	
		13	Boiler and furnace	
		14	Soot blowers	
		15	Test	
		16	Boiling out and drying out	
	TURBO GENERATORS	17	Concrete supports and anchors	
		18	Turbine and generator erection	
		19	Turbine stop valve	
	CONDENSERS	20	Embedded parts	
		21	Condensers	
		22	Hot well pumps	
		23	Air ejectors	
	ASH DISPOSAL	24	Wet ash and slag chamber	
		25	Ash sluice	
		26	Pumps and piping	
	FANS	27	Forced and induced draft	
		28	Airducts, dampers, fly ash equipment	
		29	Insulation	
	STACKS	30	Concrete	
	HEATERS	31	Feed water and evaporator preheater	
	TANKS	32	Boiler and continuous blow down	
		33	Gland seal	
		34	Condensate drain and flash tank	
	PUMPS	35	Boiler feed	
		36	Distilled and raw water	
		37	Gland seal	
		38	Condensate and extraction heater drains	
		39	Lubricating oil	
		40	Sta sump and distilled well leakage	
	FEED WATER TREATMENT	41	Degerators and storage tank	
		42	Cold well lining	
		43	Chemical feed piping	
		44	Feedwater treatment equipment	
	PIPING	45	Contract piping	
		46	Roof and floor drains	
		47	Plumbing	
		48	Distilled water	
		49	Fuel and lubricating oil	
		50	Sampling and FW make up	
		51	Raw and treated water service	
		52	Gland seal water, cooling water & vac. priming	
		53	Ash sluice water	
		54	Piping in fill slabs and over distilled wells	
		55	Circulating water condenser	
		56	Compressed air and vacuum cleaning	
		57	Control piping	
	INSULATION	58	Piping and equipment	
	HEATING AND VENTILATING	59	Heating and ventilating	
		60	Air conditioning equipment	
		61	Duct hoods, louvers screens, dampers	
	UNIT CONTROL BOARDS	62	Turbine gage boards and instruments	
		63	Bench boards and cabinets	
	CONTROL	64	Combustion control equipment	
	FIRE PROTECTION	65	Fire protection	
	CRANES	66	Collector rails	
		67	Misc. hoists	
	SCALES	68	Coal scales	
POWERHOUSE ELECTRICAL	GROUNDING	69	Grounding cable-boxes	
	POWER AND CONTROL CABLE	70	Conduits and supports	
		71	Cable trays and supports	
		72	Wiring	
	MAIN GENERATOR LEADS & EQUIPMENT	73	Generator lead structures and enclosures	
		74	Insulators and conductors	
		75	Surge prot equipment, disc sws	
		76	Generator neutral reactor	
		77	Field sw breaker and accessary equipment	
	AUXILIARY POWER SUPPLY	78	Station service transformers	
		79	Auxiliary power transformers	
		80	Batteries and charging equipment	
	SWITCHGEAR LOAD CENTERS	81	Switchgear 4160v auxiliary switchboards	
		82	Control centers 460/230 auxiliary switchboards	
		83	DC distribution panels	
	LIGHTING	84	Lighting - conduit and boxes	
		85	Lighting - cabinets	
		86	Lighting - fixtures, outlets and wiring	
TRANSFORMER YARD AND SWITCHYARD	FOUNDATIONS AND CABLE TUNNELS	87	Excavation and backfill	
		88	Concrete foundations	
		89	Cable tunnel	
		90	Conduits and ducts	
		91	Manholes and handholes	
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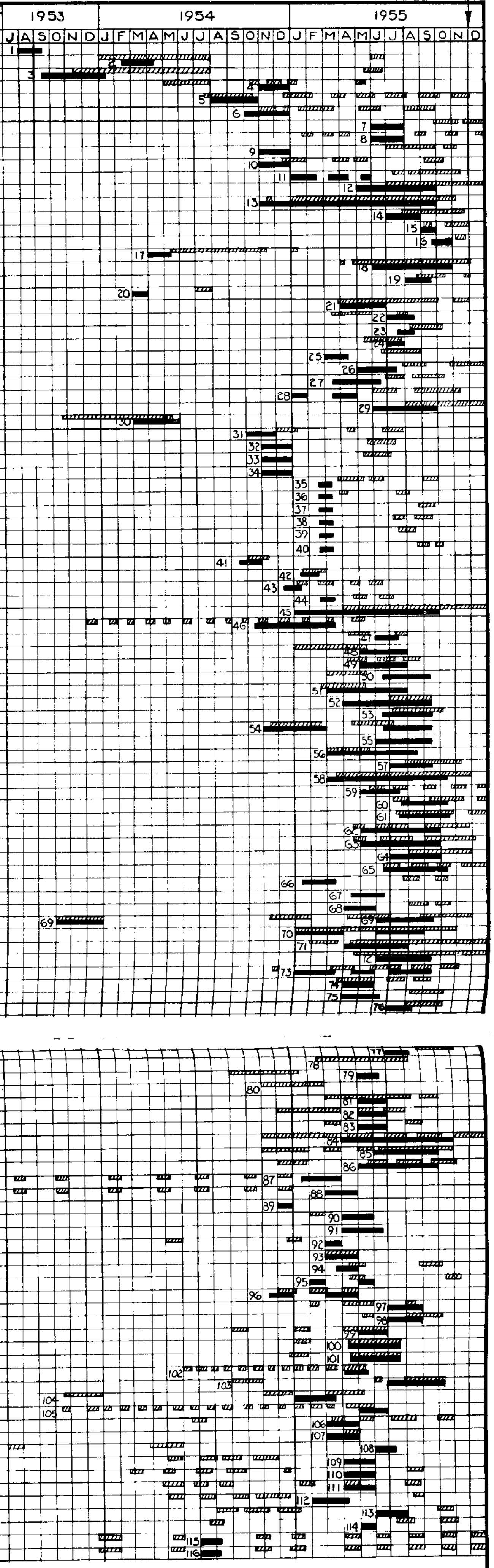

Schedule

As Constructed

INITIAL OPERATION

On Line Nov. 25, 1955

Commercial Operation Dec. 2, 1955

REV NO	DATE	MADE	CHKD	SUPV	INSP	SUBM	RECM
3	7-10-56	BC	WEF				
	As Constructed Revised						
2	6-24-55	WR					
	As constructed Added						
1	12-30-53	QRO					
	Minor Revisions in Dates						

DSGN. .... SUPV. ....
DRWN. QRO .... INSP. ....
CHKD. ....
TRCD. .... ENGINEER
COMP. ....

GENERAL

DETAILED CONSTRUCTION SCHEDULE UNIT 9

KINGSTON STEAM PLANT
TENNESSEE VALLEY AUTHORITY
DIVISION OF CONSTRUCTION

SUBMITTED: W. P. Kelleghan — RECOMMENDED: [signature] — APPROVED: 2.27.[illegible]

CONSTR. SUPT

FIELD OFFICE | 7-24-53 | 36 | PC | 4 | 102 K 10495 R3

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