APPENDICES

A P P E N D I C E S

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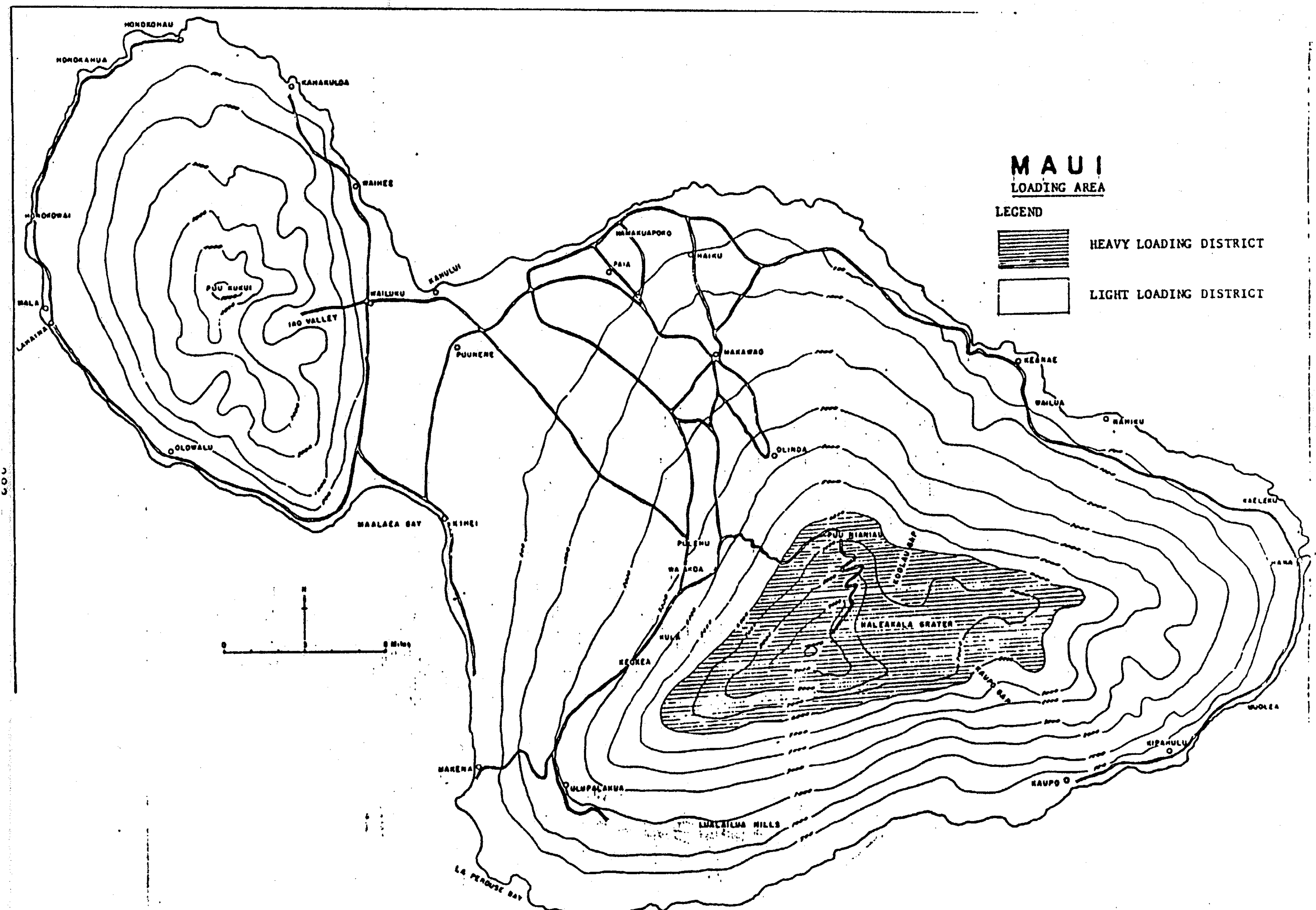
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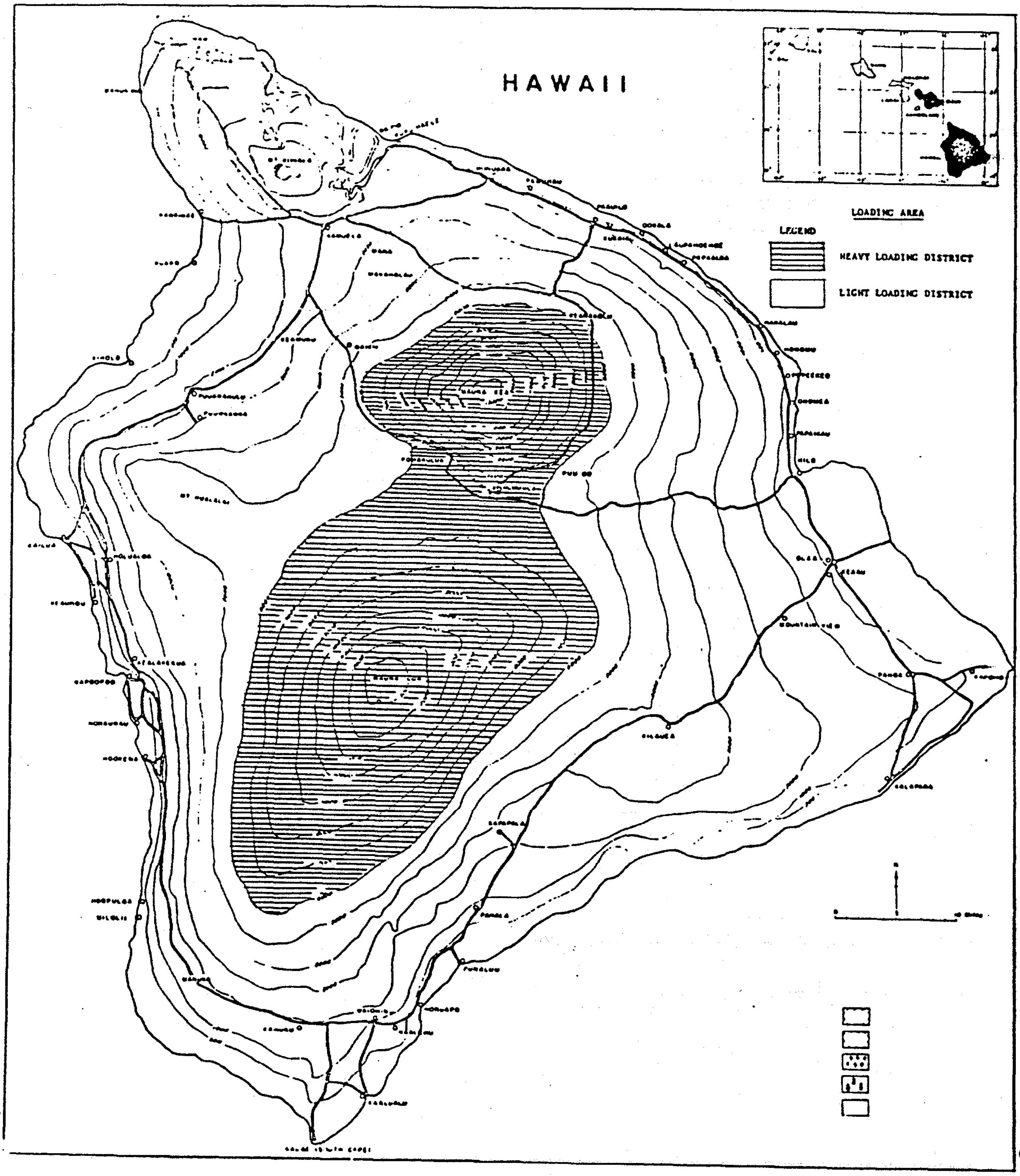

HAWAII
LOADING AREA
LEGEND
HEAVY LOADING DISTRICT
LIGHT LOADING DISTRICT

APPENDIX B

MECHANICAL AND LOADING DATA FOR CONDUCTORS

The tables included in Appendix B contain mechanical data for conductors commonly used in supply and communication lines. The ultimate strengths and other data for copper, steel and iron wires are those contained in specifications of the American Society for Testing Materials or are ultimate strengths based upon such specifications. For other types and kinds of conductors the ultimate strengths and other data used have been taken from manufacturers' specifications.

The requirements of Rule 43 were used to calculate the loaded conductor conditions.

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TABLE 17

COPPER WIRE—BARE—SOLID—CHARACTERISTICS AND LOADING

Characteristics of conductor: Gage number, AWG	Characteristics of conductor: Gage number, NBS	Characteristics of conductor: Diameter, inch	Characteristics of conductor: Area, square inch	Ultimate tensile strength, pounds: Hard drawn*	Ultimate tensile strength, pounds: Medium hard drawn**	Loading per linear foot of conductor, pounds: Light loading district: Vertical load, conductor only	Light loading district: Horizontal load, wind of 8 lbs. per sq. ft. on conductor	Light loading district: Resultant load	Heavy loading district: Vertical load, conductor with ½ inch of ice	Heavy loading district: Horizontal load, wind of 8 lbs. per sq. ft. on conductor with ½ inch of ice	Heavy loading district: Resultant load
--------	--------	0.165	0.02138	1,326	1,078	0.0825	0.1100	0.137	0.4960	0.5825	0.765
--------	9	.144	.01629	1,026	832	.0628	.0960	.115	.4632	.5720	.736
--------	--------	.134	.01410	894	720	.0544	.0893	.105	.4486	.5670	.723
--------	10	.128	.01287	820	662	.0496	.0853	.099	.4401	.5640	.715
9	--------	.1144	.01028	661	532	.0396	.0763	.086	.4216	.5572	.699
--------	--------	.114	.01021	656	528	.0394	.0760	.086	.4212	.5570	.698
--------	12	.104	.00850	551	440	.0327	.0693	.077	.4083	.5520	.687
12	--------	.0808	.00513	337	271	.0198	.0539	.057	.3809	.5404	.661
--------	14	.080	.00503	330	265	.0194	.0533	.057	.3800	.5400	.660

* Minimum ultimate strengths of ASTM Specification, B 1-39.
** Minimum ultimate strengths of ASTM Specification, B 2-39, plus ¼ the difference between minimum and maximum.

TABLE 18

COPPER WIRE—BARE—STRANDED AND SOLID—CHARACTERISTICS AND LOADING

Characteristics of conductor							Loading per linear foot of conductor, pounds					
Size of cable or wire, cir mils or AWG	Component wires (strands)		Diameter, inch	Area, square inch	Ultimate tensile strength, pounds		Light loading district			Heavy loading district		
	Number	Diameter, inch			Hard drawn*	Medium hard drawn**	Vertical load, conductor only	Horizontal load, wind of 8 lbs. per sq. ft. on conductor	Resultant load	Vertical load, conductor with ½ inch of ice	Horizontal load, wind of 6 lbs. per sq. ft. on conductor with ½ inch of ice	Resultant load
500,000	37	0.1162	0.813	0.3927	22,510	18,726	1.544	0.5420	1.636	2.3604	0.9065	2.528
350,000	19	.1357	.679	.2749	15,590	13,024	1.081	.4523	1.172	1.8141	.8395	1.998
250,000	19	.1147	.574	.1964	11,365	9,366	0.7719	.3827	0.862	1.4397	.7870	1.641
0000	7	.1739	.527	.1662	9,154	7,772	.6533	.3514	.742	1.2919	.7635	1.500
000	7	.1548	.464	.1318	7,366	6,204	.5181	.3093	.604	1.1175	.7320	1.334
00	7	.1379	.414	.1045	5,925	4,952	.4109	.2760	.495	0.9792	.7070	1.208
0	7	.1228	.368	.0829	4,753	3,953	.3258	.2453	.408	.8655	.6840	1.103
1	7	.1093	.328	.0657	3,802	3,154	.2584	.2187	.338	.7733	.6640	1.019
2	7	.0974	.292	.0521	3,042	2,517	.2049	.1947	.283	.6974	.6460	0.950
2	3	.1487	.320	.0521	2,913	2,453	.2029	.2133	.294	.7128	.6600	.971
4	7	.0772	.232	.0328	1,940	1,604	.1289	.1547	.201	.5841	.6160	.849
4	3	.1180	.254	.0328	1,879	1,564	.1276	.1693	.212	.5964	.6270	.865
4	1		.2043	.03278	1,970	1,642	.1264	.1360	.185	.5641	.6020	.825
6	3	.0935	.201	.0206	1,204	995	.0825	.1340	.157	.5184	.6005	.793
6	1		.1620	.02062	1,280	1,046	.0795	.1080	.134	.4911	.5810	.759
8	1		.1285	.01297	826	667	.0500	.0853	.099	.4406	.5640	.716

* Minimum ultimate strengths of ASTM Specifications, B 1-39.

** For stranded conductors, 90% minimum ultimate strengths of ASTM Specifications, B 2-39, plus ½ of the difference between maximum and 90% of minimum ASTM values; for solid conductors, minimum ultimate strengths of ASTM Specifications, B 2-39, plus ½ of the difference between minimum and maximum.

TABLE 19

COPPER WIRE—STRANDED AND SOLID—DOUBLE BRAID WEATHERPROOF—CHARACTERISTICS AND LOADING

Characteristics of conductor							Loading per linear foot of conductor, pounds					
	Component wires (strands)				Ultimate tensile strength, pounds		Light loading district			Heavy loading district		
Size of cable or wire, cir mils or AWG	Number	Diameter, inch	Diameter with covering, inches***	Area without covering, square inch	Hard drawn*	Medium hard drawn**	Vertical load, conductor only	Horizontal load, wind of 8 lbs. per sq. ft. on conductor	Resultant load	Vertical load, conductor with ½ inch of ice	Horizontal load, wind of 6 lbs. per sq. ft. on conductor with ½ inch of ice	Resultant load
1,000,000	61	0.1280	1.430	0.7854	45,030	37,210	3.456	0.9534	3.585	4.6561	1.2150	4.812
750,000	61	.1109	1.195	.5890	34,090	28,272	2.635	.7967	2.753	3.6890	1.0975	3.849
500,000	37	.1162	1.081	.3927	22,510	18,726	1.765	.7207	1.906	2.7481	1.0405	2.938
350,000	19	.1357	0.867	.2749	15,590	13,024	1.248	.5780	1.375	2.0980	0.9335	2.296
250,000	19	.1147	.740	.1964	11,365	9,366	0.9070	.4934	1.032	1.6780	.8700	1.890
0000	7	.1739	.685	.1662	9,154	7,772	.7450	.4567	0.874	1.4818	.8425	1.704
000	7	.1548	.640	.1318	7,366	6,204	.6040	.4267	.740	1.3128	.8200	1.548
00	7	.1379	.560	.1045	5,925	4,952	.4820	.3734	.610	1.1411	.7800	1.382
0	7	.1228	.546	.0829	4,753	3,953	.3880	.3640	.532	1.0384	.7730	1.294
1	7	.1093	.445	.1657	3,802	3,154	.3030	.2967	.424	0.8906	.7225	1.147
2	7	.0974	.415	.0521	3,042	2,517	.2460	.2767	.370	.8149	.7075	1.079
4	7	.0772	.344	.0328	1,940	1,604	.1550	.2293	.277	.6798	.6720	0.956
4	1		.337	.03278	1,970	1,642	.1535	.2247	.272	.6739	.6685	.949
6	1		.290	.0206	1,280	1,046	.1030	.1933	.219	.5942	.6450	.877
8	1		.246	.01297	826	667	.0680	.1640	.178	.5319	.6230	.819

* Minimum ultimate strengths of ASTM Specifications, B 1-39.

** For stranded conductors, 90% minimum ultimate strengths of ASTM Specifications, B 2-39, plus ¼ of the difference between maximum and 90% of minimum ASTM values; for solid conductors, minimum ultimate strengths of ASTM Specifications, B 2-39, plus ¼ of the difference between minimum and maximum.

*** Average outside diameter [illegible] commercially.

TABLE 20

COPPER WIRE—STRANDED AND SOLID—TRIPLE BRAID WEATHERPROOF—CHARACTERISTICS AND LOADING

Characteristics of conductor							Loading per linear foot of conductor, pounds					
	Component wires (strands)				Ultimate tensile strength, pounds		Light loading district			Heavy loading district		
Size of cable or wire, cir mils or AWG	No.	Diameter, inch	Diameter with covering, inches***	Area without covering, square inch	Hard drawn*	Medium hard drawn**	Vertical load, conductor only	Horizontal load, wind of 8 lbs. per sq. ft. on conductor	Resultant load	Vertical load, conductor with ½ inch of ice	Horizontal load, wind of 6 lbs. per sq. ft. on conductor with ½ inch of ice	Resultant load
1,000,000	61	0.1280	1.656	0.7854	45,030	37,210	3.764	1.1041	3.836	5.0146	1.3280	5.188
750,000	61	.1109	1.380	.5890	34,090	28,272	2.822	0.9200	2.968	3.9910	1.1900	4.165
500,000	37	.1162	1.250	.3927	22,510	18,726	1.894	.8334	2.069	2.9822	1.1250	3.187
350,000	19	.1357	1.000	.2749	15,590	13,024	1.345	.6667	1.501	2.2777	1.0000	2.488
250,000	19	.1147	0.850	.1964	11,365	9,366	0.9850	.5667	1.136	1.8244	0.9250	2.045
0000	7	.1739	.805	.1662	9,154	7,772	.8000	.5367	0.963	1.6114	.9025	1.847
000	7	.1548	.710	.1318	7,366	6,204	.6530	.4734	.807	1.4054	.8550	1.645
00	7	.1379	.660	.1045	5,925	4,952	.5220	.4400	.683	1.2433	.8300	1.495
0	7	.1228	.610	.0829	4,753	3,953	.4240	.4067	.588	1.1142	.8050	1.375
1	7	.1093	.509	.0657	3,802	3,154	.3280	.3394	.472	0.9554	.7545	1.217
2	7	.0974	.488	.0521	3,042	2,517	.2700	.3253	.423	.8843	.7440	1.156
4	7	.0772	.390	.0328	1,940	1,604	.1700	.2600	.311	.7234	.6950	1.003
4	1		.387	.03278	1,970	1,642	.1665	.2580	.307	.7180	.6935	0.998
6	1		.347	.0206	1,280	1,046	.1136	.2313	.258	.6403	.6735	.929
8	1		.294	.01297	826	667	.0760	.1960	.210	.5697	.6470	.862

* Minimum ultimate strengths of ASTM Specifications, B 1-39.

** For stranded conductors, 90% minimum ultimate strengths of ASTM Specifications, B 2-39, plus ¼ of the difference between maximum and 90% of minimum ASTM values; for solid conductors, minimum ultimate strengths of ASTM Specifications, B 2-39, plus ¼ of the difference between minimum and maximum.

*** Average outside diameter obtained commercially.

TABLE 21

GALVANIZED STEEL AND IRON WIRE—BARE—SOLID—CHARACTERISTICS AND LOADING

Characteristics of conductor						Loading per linear foot of conductor, pounds					
			Ultimate tensile strength, pounds*			Light loading district			Heavy loading district		
Size of wire, BWG	Diameter, inch	Area, square inch	EBB grade	BB grade	Steel grade	Vertical load, conductor only	Horizontal load, wind of 8 lbs. per sq. ft. on conductor	Resultant load	Vertical load, conductor with ½ inch of ice	Horizontal load, wind of 6 lbs. per sq. ft. on conductor with ½ inch of ice	Resultant load
4	0.238	0.0445	2,028	2,270	2,433	.1530	0.1587	0.220	0.6119	0.6190	0.870
6	.203	.0324	1,475	1,650	1,770	.1120	.1353	.176	.5491	.6015	.814
8	.165	.0214	975	1,090	1,170	.0740	.1100	.133	.4875	.5825	.760
9	.148	.0172	785	880	942	.0600	.09867	.116	.4629	.5740	.737
10	.134	.0141	645	720	774	.0490	.08934	.102	.4432	.5670	.720
11	.120	.0113	515	575	618	.0390	.08000	.089	.4245	.5600	.703
12	.109	.0093	425	475	510	.0320	.07267	.079	.4107	.5545	.690
14	.083	.0054	247	275	297	.0190	.05533	.058	.3815	.5415	.662

* All ultimate tensile strengths are from ASTM Specification A 111-33.

TABLE 22

COPPER COVERED STEEL—STRAND, SOLID AND COMPOSITE—CHARACTERISTICS AND LOADING

Characteristics of conductor								Loading per linear foot of conductor, pounds					
Nominal diameter, inch	Strands		Actual diameter, inch	Area of conductor, square inch	Ultimate tensile strength, pounds			Light loading district			Heavy loading district		
	No.	Size AWG			High strength 40% Cond.	High strength 30% Cond.	Extra high strength 30% Cond.	Vertical load, conductor only	Horizontal load, wind of 8 lbs. per sq. ft. on conductor	Resultant load	Vertical load, conductor with ½ inch of ice	Horizontal load, wind of 8 lbs. per sq. ft. on conductor with ½ inch of ice	Resultant load
1/2	7	6	0.486	0.1443	15,330	16,890	20,460	0.5150	0.3240	0.608	1.1281	0.7430	1.351
7/16	7	7	.433	.1145	12,670	13,910	16,890	.4084	.2887	.500	0.9885	.7165	1.221
3/8	7	8	.385	.0908	10,460	11,440	13,890	.3239	.2567	.413	.8742	.6925	1.115
5/16	7	10	.306	.0571	7,121	7,758	9,196	.2037	.2040	.288	.7049	.6530	0.961
	3	6	.349	.0618	6,204	6,835	8,281	.2203	.2327	.320	.7482	.6745	1.007
	3	8	.277	.0389	4,232	4,629	5,621	.1385	.1847	.231	.6216	.6385	0.891
	3	9	.247	.0308	3,488	3,802	4,565	.1099	.1647	.198	.5744	.6235	.848
	3	10	.220	.0245	2,882	3,140	3,722	.08713	.1467	.171	.5348	.6100	.811
	1	6	.1620	.0206	2,433	2,680	3,247	.07285	.1080	.130	.4844	.5810	.756
	1	8	.1285	.0130	1,660	1,815	2,204	.04581	.08567	.097	.4366	.5642	.713
	1	9	.1144	.0103	1,368	1,491		.03633	.07627	.084	.4183	.5572	.697
	1	10	.1019	.00816	1,130	1,231		.02881	.06794	.074	.4031	.5510	.683
	1	12	.08081	.00513	711	800		.01812	.05388	.057	.3792	.5404	.660
	3	*	.366	.0680			5,876	.2568	.2440	.354	.7953	.6830	1.048
	3	**	.290	.0428			3,938	.1615	.1933	.252	.6527	.6450	0.918
	3	***	.230	.0269			2,585	.1016	.1533	.184	.5555	.6150	.829

NOTES—Items marked with asterisks are composite conductors of 1 copper covered steel and 2 hard drawn copper wires.
Copper conductance equivalents: * = No. 2 AWG, ** = No. 4 AWG, *** = No. 6 AWG.

TABLE 23

ALUMINUM CABLE STEEL REINFORCED—BARE—CHARACTERISTICS AND LOADING

Characteristics of Conductor							Loading per linear foot of conductor, pounds					
							Light loading district			Heavy loading district		
A.C.S.R. size, cir mils or AWG	Copper equivalent conductivity size, cir mils or AWG	Number of strands: Aluminum	Number of strands: Steel	Diameter, inches	Area, square inch	Ultimate tensile strength, pounds	Vertical load, conductor only	Horizontal load, wind of 8 lbs. per sq. ft. on conductor	Resultant load	Vertical load, conductor with ½ inch of ice	Horizontal load, wind of 6 lbs. per sq. ft. on conductor with ½ inch of ice	Resultant load
795,000	500,000	30	19	1.140	0.7668	38,400	1.234	0.7600	1.449	2.2538	1.0700	2.495
795,000	500,000	26	7	1.108	.7261	31,200	1.093	.7387	1.319	2.0928	1.0540	2.343
795,000	500,000	54	7	1.093	.7053	28,500	1.023	.7287	1.256	2.0135	1.0465	2.269
397,500	250,000	30	7	0.806	.3850	19,980	0.6206	.5374	.821	1.4327	0.9030	1.694
397,500	250,000	26	7	.783	.3630	16,190	.5464	.5220	.756	1.3442	.8915	1.613
266,800	000	26	7	.642	.2436	11,250	.3668	.4280	.564	1.0769	.8210	1.354
0000	00	6	1	.563	.1939	8,420	.2921	.3754	.476	0.9531	.7815	1.232
000	0	6	1	.502	.1538	6,675	.2316	.3347	.407	.8546	.7510	1.138
00	1	6	1	.447	.1219	5,345	.1837	.2980	.350	.7725	.7235	1.058
0	2	6	1	.398	.0967	4,280	.1456	.2653	.303	.7040	.6990	0.992
2	4	7	1	.325	.0653	3,525	.1072	.2167	.242	.6202	.6625	.907
2	4	6	1	.316	.0608	2,790	.0916	.2107	.230	.5990	.6580	.890
4	6	7	1	.257	.0411	2,288	.0674	.1713	.184	.5381	.6285	.827
4	6	6	1	.250	.0383	1,830	.0576	.1667	.176	.5240	.6250	.816
6	8	6	1	.198	.0240	1,170	.0362	.1320	.137	.4702	.5990	.762

All data "Characteristics of Conductor" from manufacturer specifications.

TABLE 24

MECHANICAL CHARACTERISTICS OF GALVANIZED STEEL STRAND

Diameter, inch (nominal)	Weight per 1,000 ft. in pounds (approx.)	Ultimate tensile strength, pounds			
		Common	Siemens-Martin	High strength	Extra high strength
5/8	813	11,600	19,100	29,600	42,400
9/16	671	9,600	15,700	24,500	35,000
1/2	517	7,400	12,100	18,800	26,900
7/16	399	5,700	9,350	14,500	20,800
3/8	273	4,250	6,950	10,800	15,400
5/16	205	3,200	5,350	8,000	11,200
9/32	164	2,570	4,250	6,400	8,950
1/4	121	1,900	3,150	4,750	6,650
3/16	73	1,150	1,900	2,850	3,990

NOTE—All data from ASTM Specification A 122-33 for 7 strand cable.

APPENDIX C

CONDUCTOR SAGS

(a) Basis of Sag Curves for Supply Conductors

Data are presented in Appendix C in the form of curves in Charts numbers 1 to 9 inclusive, showing conductor sags which produce tensions that do not exceed either 35% of ultimate strength of the conductor at 60°F and no wind, or 50% of ultimate strength (safety factor of 2) of the conductor under the maximum loading conditions specified for Light or Heavy Loadings in Rule 43. These sags are considered particularly applicable to the stringing of new wire (i.e. they should be considered initial sags for conductors which have not been prestressed) and are not recommended in the case of used or so-called prestressed wire.

The curves of the sag charts were drawn from computations made under the following conditions:

1. Sag curves in the Light Loading charts are based on 35% of conductor ultimate tensions at 60°F and no wind.
2. Sag curves in the Heavy Loading charts show sags which will obtain at 60°F and no wind, in conductors which are so strung that under heavy loading conditions the conductor tension will be one-half of the ultimate tension.
3. The sag curves for weatherproof wire are for conductors having a triple-braid-weatherproof covering.
4. Conductor dimensions, weights and loadings were taken from the tables in Appendix B.
5. Modulus of Elasticity—lbs. per sq. in.

Copper	17,000,000
Steel and iron, solid	29,000,000
Steel, stranded	21,000,000
Copper-covered steel, solid	24,000,000
Copper-covered steel, stranded	23,000,000

6. Coefficient of Linear Thermal Expansion—per degree F.

Copper	.0000094
Steel and iron	.0000065
Copper-covered steel	.0000072

(b) Communication Conductor Sags

The safety factors of Rule 44 and the conductor sizes of Rule 49.4 are the minimum requirements applicable to communication conductors. Conductors having sags not less than those specified in Table 25 will meet the minimum requirements of these rules for Grade "F" construction. The sag values given in Table 25 are greater than are required by the minimum requirements, but are considered to be in accordance with good practice.

(c) Sags for Unequal Spans, Level Supports and Normal Conditions

When a crossing span and its adjoining spans are of different lengths it is not possible to string the conductors so as to make both the normal tension and the loaded tension balance in the several spans. This condition should be met by selecting a sag for the longest span not less than that shown in the accompanying curves, pages 299 to 304, inclusive.

The sags for the other spans should then be determined as follows: For each span multiply the sag for the longest span by the square of the ratio of the length of the span under consideration to that of the longest span. The total normal tension in each of the spans will then balance and the total tension under loaded conditions will be slightly less in the short spans than in the longest span.

Example

Assume—A crossing span length of 250 feet—Heavy Loading District.
Adjoining spans of 300 feet and 200 feet, respectively.
Conductors No. 0, AWG copper, medium-hard-drawn, stranded, bare.
Sag from curve on page 302, for a 300-foot span is 5.30 feet.

Making the sags in the other spans proportional to the squares of their length, the sag in the 250-foot span will be,

$$\frac{(250)^2}{(300)^2} \times 5.30 = 3.68 \text{ feet}$$

The sag in the 200-foot span will be,

$$\frac{(200)^2}{(300)^2} \times 5.30 = 2.36 \text{ feet}$$

(d) Sag Correction for Temperature

The curves, on page 305, cover the correction of sags for stringing temperatures other than that for which the sag curves were calculated. These figures cover the normal range of stringing conditions for temperatures at time of stringing, varying between 0°F and 130°F, and for spans of from 100 feet to 1000 feet, inclusive, in 100-foot steps, with the exception that the 150-foot span has also been included. They represent average values for each degree F. difference between actual stringing temperature and the temperature for which the curves were calculated, that is 60°F. The corrections for temperatures greater than 60°F are to be added to the normal sags while the corrections for temperatures less than 60°F are to be subtracted. The correction for a given difference of temperature from the base value is considered the same whether the stringing temperature is greater or less than the base value.

The use of these corrections may be illustrated by assuming a specific case:

Example

Assume—A span of 300 feet—Heavy Loading District.

Conductors No. 0, AWG copper, medium-hard-drawn, stranded, bare.
Stringing temperature 80°F.
Minimum normal sag, page 302, is 5.30 feet.
Difference between stringing temperature and normal temperature is 20°F.

The ratio for sag divided by span is 0.0177. From the curve on page 305, the correction per degree F for this ratio for a span of 300 feet is 0.024 feet.

The total correction for 20°F difference is,

$$20 \times 0.024 = 0.48 \text{ feet}$$

Then the corrected sag is 5.30+0.48 equals 5.78 feet.

If some other span than those covered by specific curves is used the correction may be obtained by interpolation between curves.

(e) Sags for Supports at Different Elevations

The sag curves have been based on the supports being at the same elevation. The curve on page 306 covers the correction of the sag to care for the difference of elevation of supports.

The use of this correction may best be illustrated by taking a concrete case:

Example

Assume—A span of 300 feet—Heavy Loading District.

A difference in level of supports of 5 feet.
Conductors No. 0, AWG copper, medium-hard-drawn, stranded, bare.
The curve, page 302, requires a sag of 5.30 feet.

The ratio of difference in level of supports divided by the sag is 5.0 divided by 5.30 which equals 0.94 and is the ratio marked h/S on curve, page 306. The multiplier C for this ratio is 0.58. Therefore the sag below the lower point of support is,

$$0.58 \times 5.30 = 3.07 \text{ feet}$$

If the sag is to be measured from the higher support, the sag below the lower support may be obtained as above and the difference in elevation of supports added thereto, which gives the sag below the higher support as 3.07+5.00 which equals 8.07 feet. The difference of levels may be such that the resultant pull is upward at the lower support; that is, the lowest point in the span is at the support. To cover this condition, and also as an alternative method of solving cases like that just considered, use may be made of the following approximate rule which is sufficiently accurate for all ordinary situations,—"The apparent sag, or the vertical distance between a straight line joining supports and the tangent to the span, parallel thereto, equals the sag for a normal span of the same length."

(f) Determination of Amount of Sag for Various Points in a Span.

The sag curves on pages 299 to 304, inclusive, show for wires of different sizes and materials the value of the center sag at which these wires should be strung under normal conditions to have the assumed factors of safety under the designated load conditions. At times it is desirable to know, not only the amount of sag at the center of the span, but also the amount of sag at some other point in the span.

This is necessary, for example, in obtaining the clearance over other wires where the point of crossing between the crossing span and the wires crossed, occurs, not at the center of the crossing span, but at some other point.

On page 307 a curve is given by means of which, given the amount of center sag, the amount of the sag at any other point in the span can be determined. This curve gives the value of the sag at all points on the catenary curve expressed in per cent of the center sag. The use of this curve is shown by the following example:

Example

Assume—A span of 300 feet—Heavy Loading District.
A center sag, determined from the sag curves, of 5.30 feet.
The crossing span crosses over a Class C line, on which the top wire at the point of this crossing has an elevation of 25 feet.
This point of crossing to be 105 feet from the nearest support of the crossing conductor, and a minimum vertical clearance of 6 feet is required at the point of crossing.

Required—At what height must the crossing conductor be supported in order that this required vertical clearance shall be obtained?

As the span length is 300 feet, and the distance from the nearest support to the point of crossing is 105 feet, this distance is 35 per cent of the span length. From the curve, page 307, the value of the sag at this point is 91 per cent of the center sag. The sag at this point, therefore, equals 5.30x0.91=4.82 feet.

Therefore, the required elevation of the crossing conductor at its point of support is equal to the height of the Class C wires crossed (25 feet), plus the minimum vertical clearance required (6 feet), plus the sag of the conductor at the point of crossing (4.82 feet).

25 feet+6 feet+4.82 feet=35.82 feet

(g) Charts of Conductor Sag Curves

The following list includes charts of sags of various sizes and kinds of copper conductors, adjustment curves for temperature changes, sag adjustment curve for supports at different elevations, and a table of sags for communication conductors in Grade "F" construction:

CHART NO. 1. LIGHT LOADING

Sags at 60° F and No Wind

Bare Copper—Hard Drawn and Medium Hard Drawn

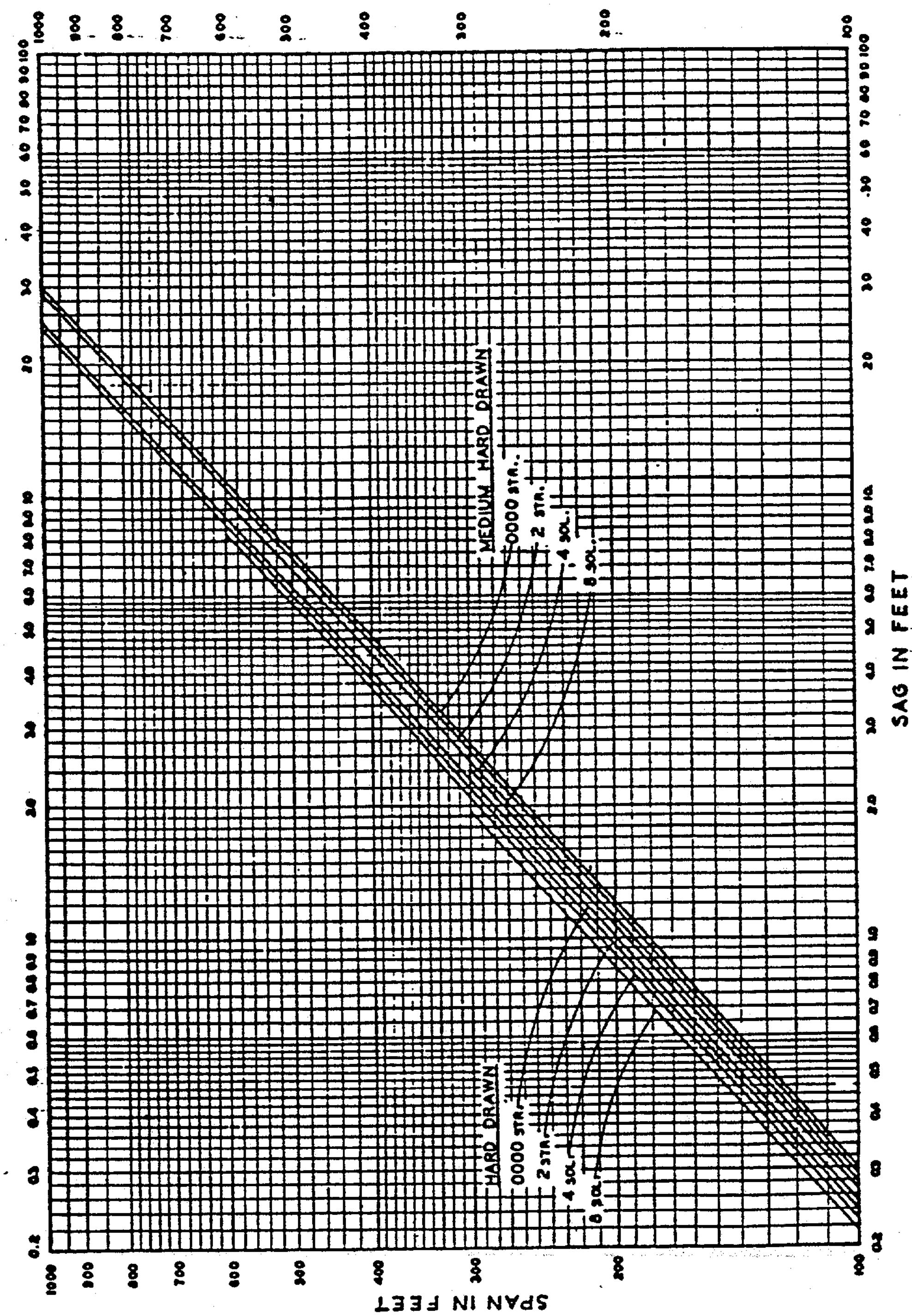

CHART NO. 2. LIGHT LOADING

Sags at 60° F and No Wind

Weatherproof Copper—Hard Drawn and Medium Hard Drawn

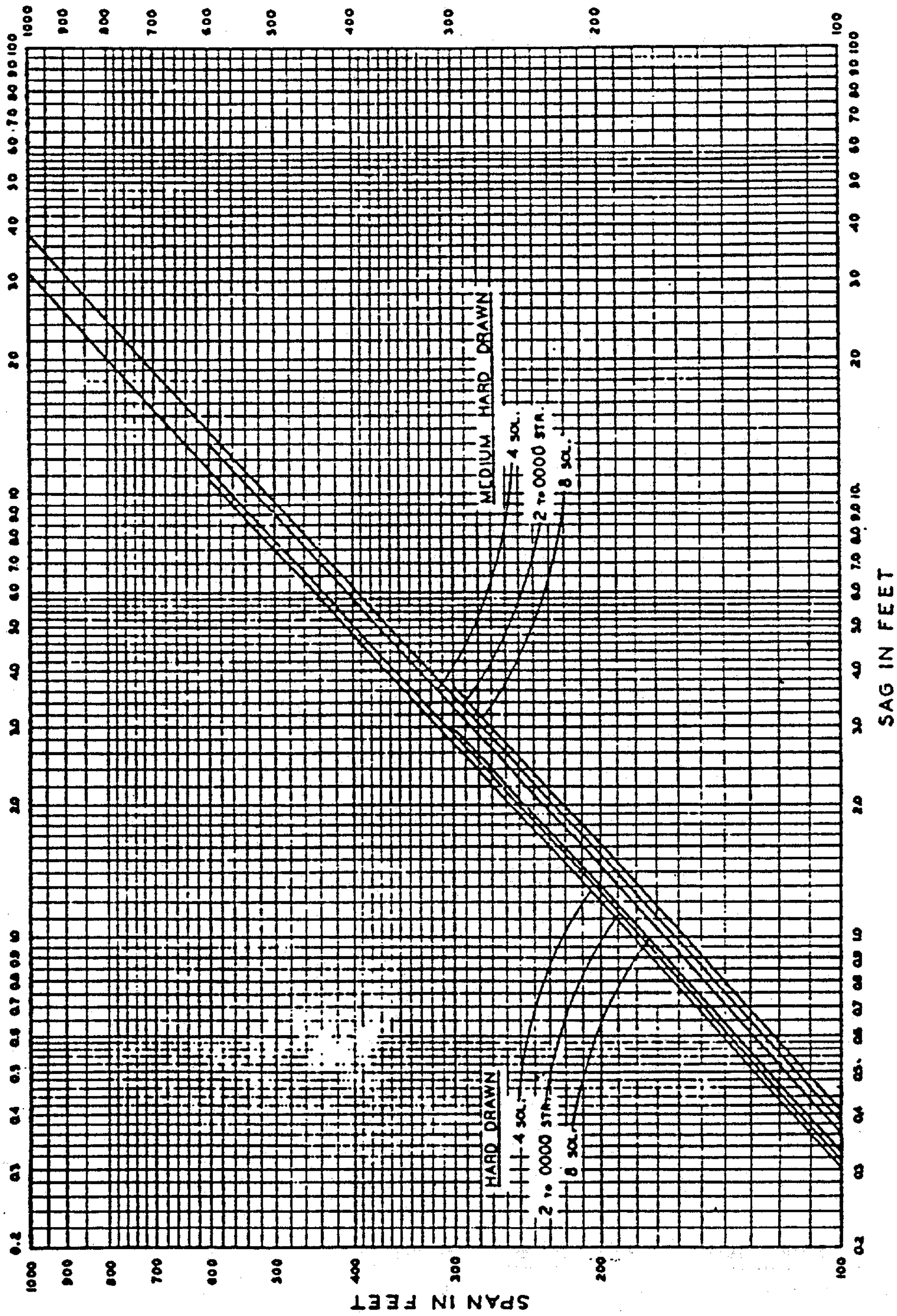

CHART NO. 3. HEAVY LOADING

Sags at 60° F and No Wind

Bare Copper—Hard Drawn

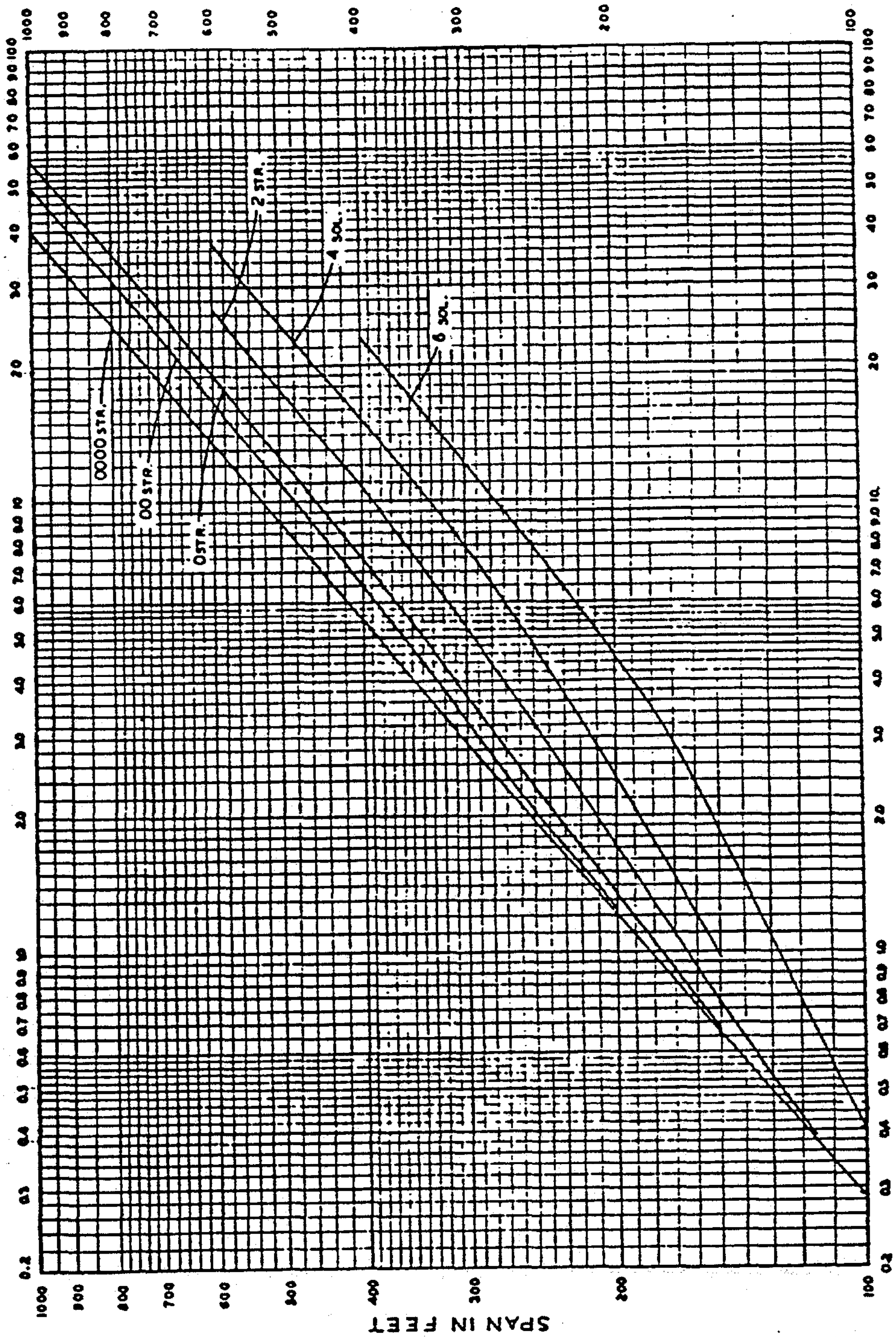

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CHART NO. 4. HEAVY LOADING

Sags at 60° F and No Wind

Bare Copper—Medium Hard Drawn

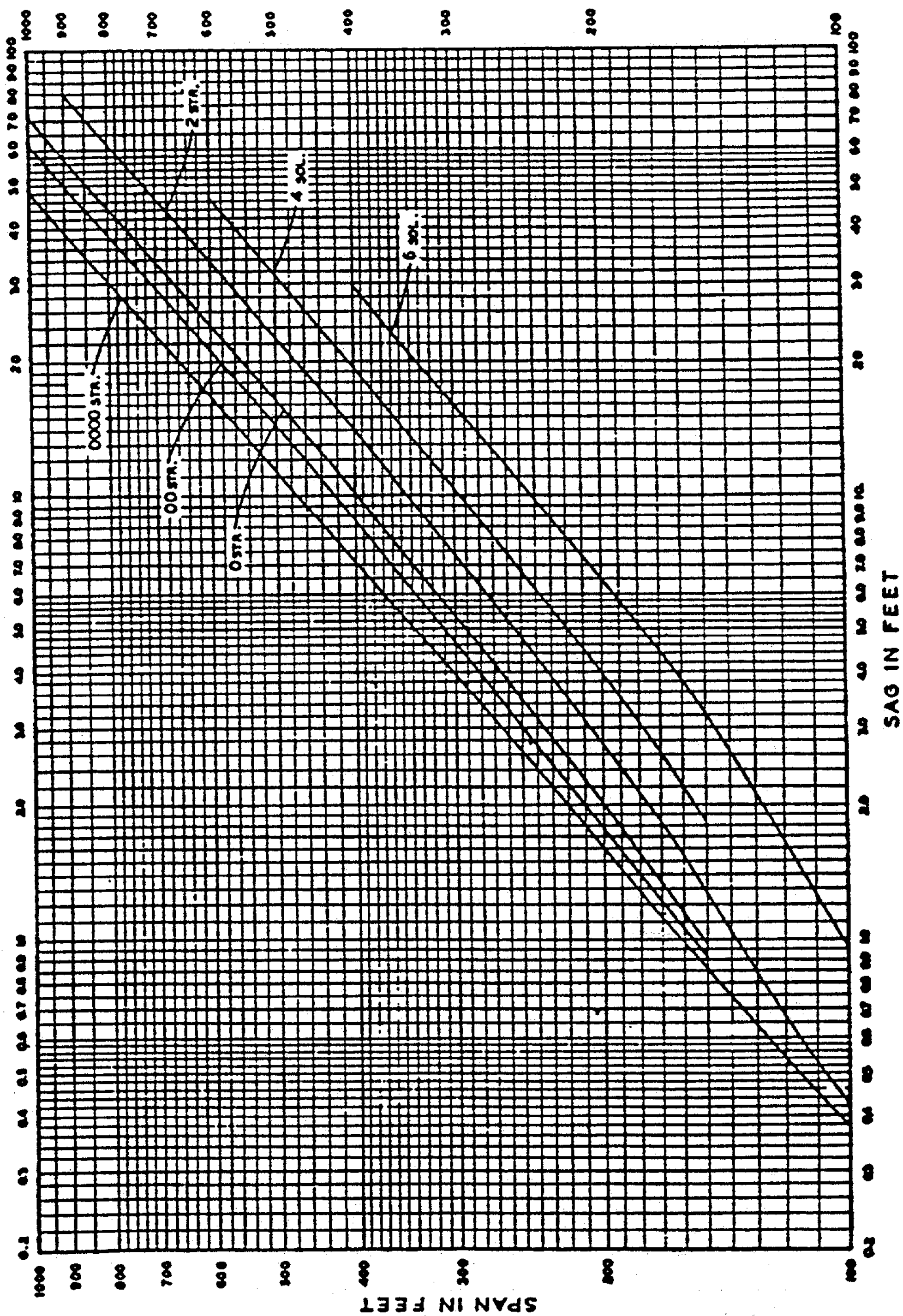

CHART NO. 5. HEAVY LOADING

Sags at 60° F and No Wind

Weatherproof Copper—Hard Drawn

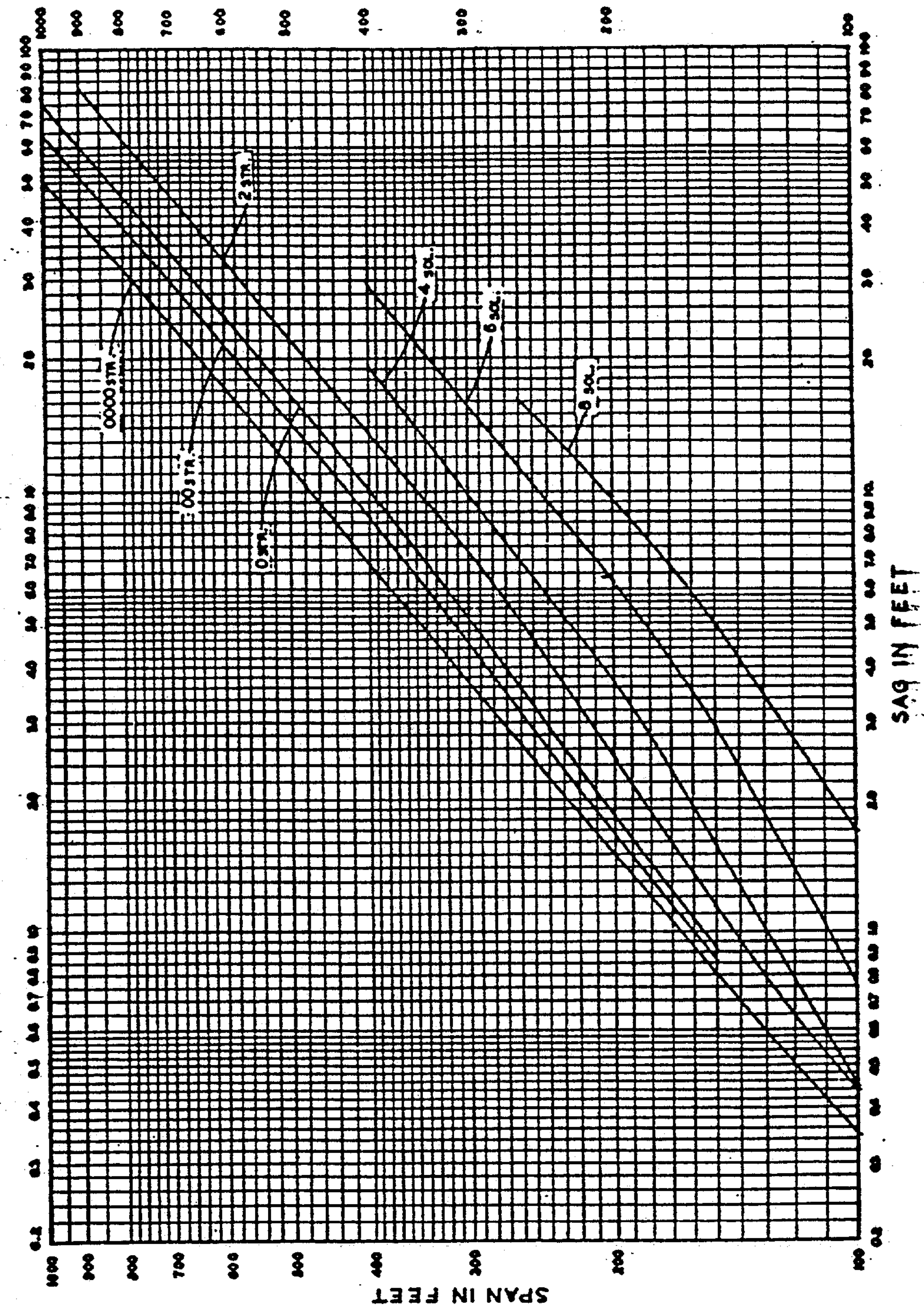

CHART NO. 6. HEAVY LOADING

Sags at 60° F and No Wind
Weatherproof Copper—Medium Hard Drawn

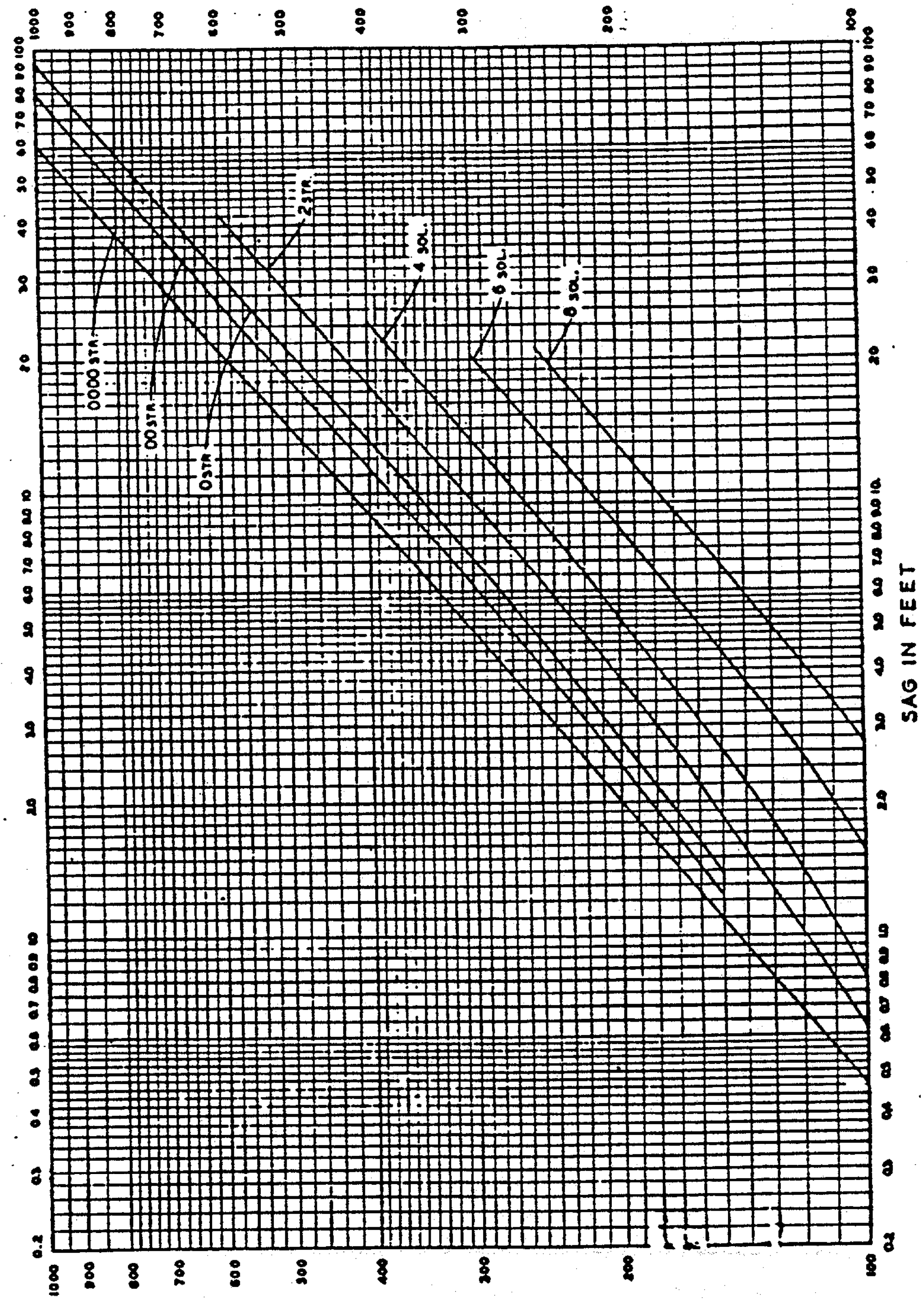

CHART NO. 7

SAG CORRECTION FOR TEMPERATURE – COPPER

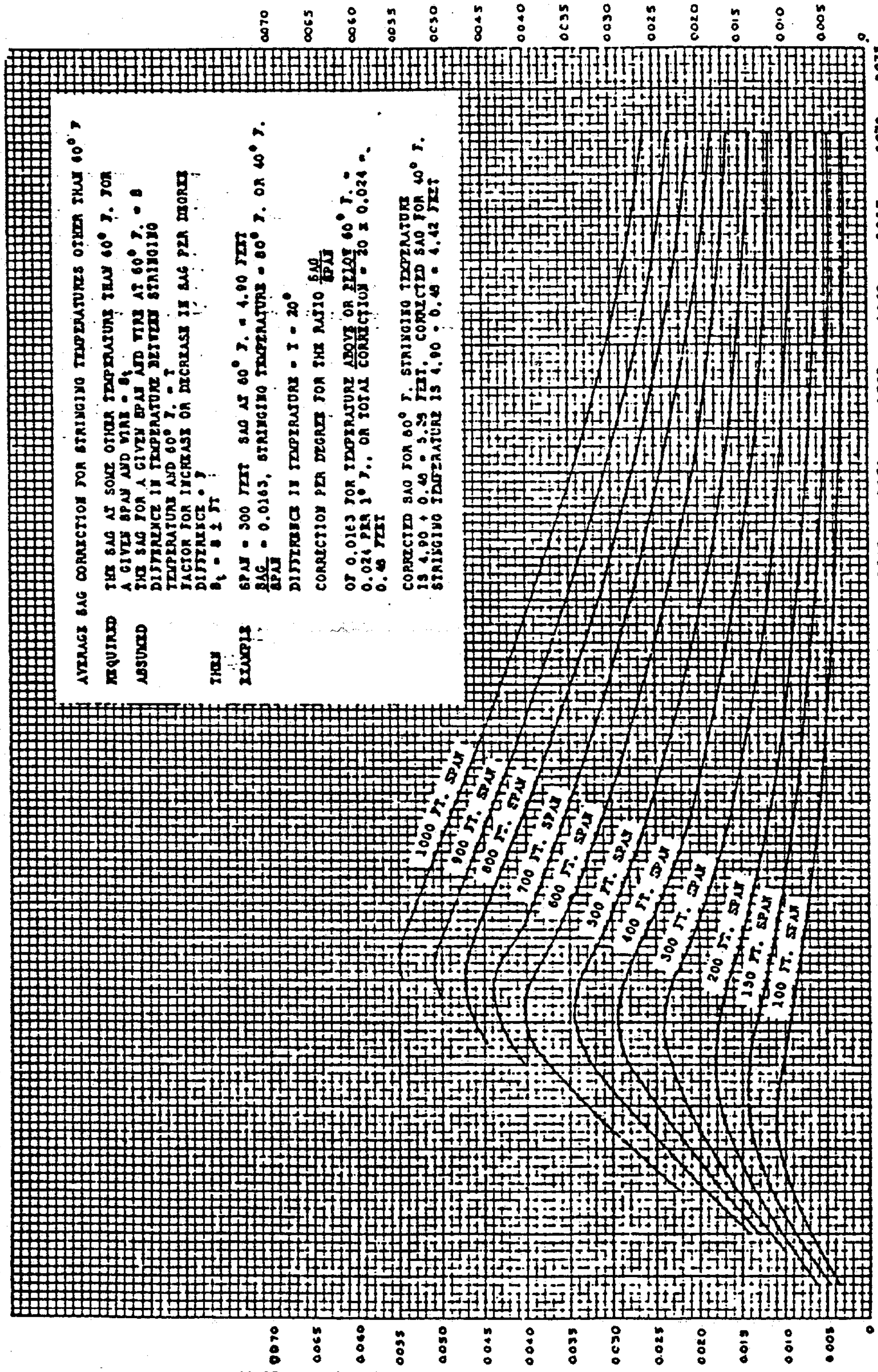

CHART NO. 8

SAG CORRECTION FACTOR – SUPPORTS AT DIFFERENT ELEVATIONS

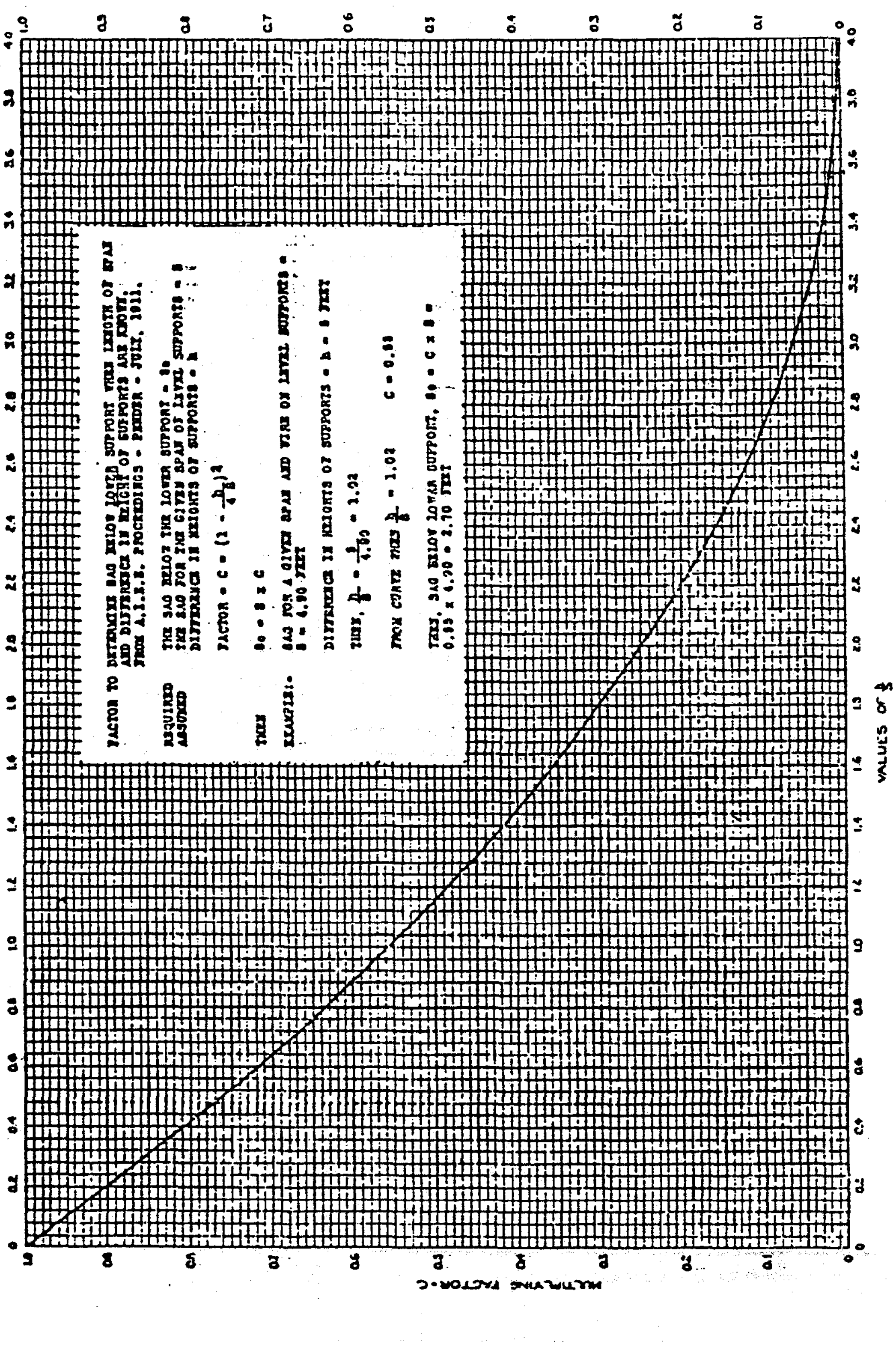

CHART NO. 9

CATENARY CURVE ORDINATES.

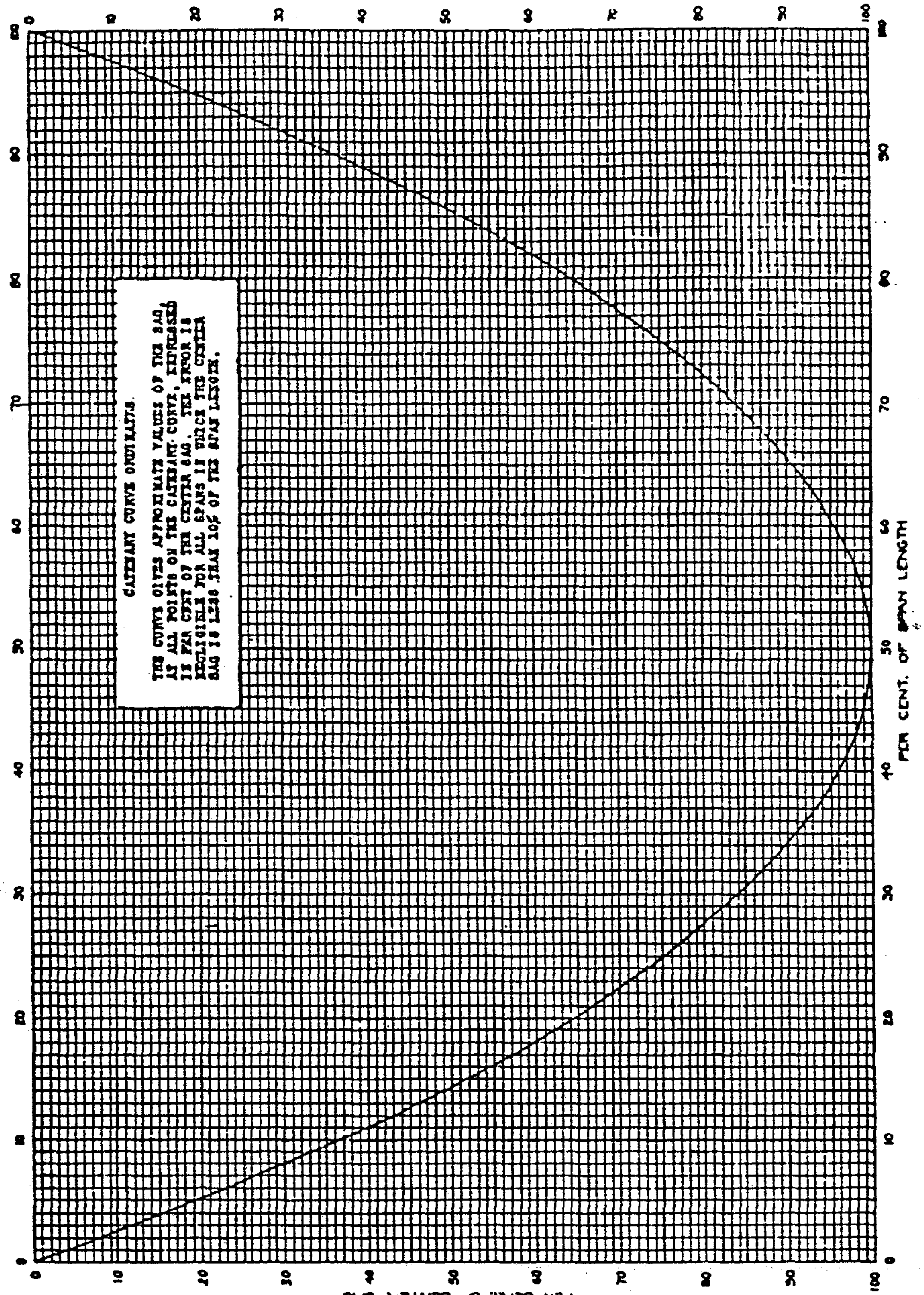

TABLE 25

STRINGING SAGS IN INCHES FOR COMMUNICATION CONDUCTORS IN GRADE F CONSTRUCTION

Span length, feet	Light loading					Heavy loading*					
	Temperature, degrees Fahrenheit					Temperature, degrees Fahrenheit					
	100	80	60	40	20	100	80	60	40	20	0
100	7	6	4.5	4	3.5	9.5	7.5	6	5	4	3.5
120	10.5	8.5	7	5.5	5	13.5	10.5	8.5	7	5.5	4.5
140	14	11	9	7.5	6.5	18.5	14.5	11.5	9.5	7.5	6.5
160	18	15	12	10	8.5	21	18	15	12.5	10.5	9
180	22	18.5	15.5	13	11	26.5	23	19	15.5	13	11
200	27	23	19	16.5	13.5	--------	--------	--------	--------	--------	--------
220	32.5	27.5	23	20	16.5	--------	--------	--------	--------	--------	--------
240	36	31.5	27	23.5	20.5	--------	--------	--------	--------	--------	--------
260	42	37	32	27.5	24	--------	--------	--------	--------	--------	--------
280	49	42.5	37	32	27.5	--------	--------	--------	--------	--------	--------
300	56	49	42.5	36.5	32	--------	--------	--------	--------	--------	--------

* In heavy loading districts, sags of the given values are inadequate for the following conductors and must be increased to meet the safety factor requirements:
Hard-drawn copper, No. 12 AWG in spans greater than 130 feet.
Galvanized iron, EBB, No. 9 BWG in spans greater than 170 feet.
Galvanized iron, EBB, No. 10 BWG in spans greater than 140 feet.
Galvanized iron, EBB, No. 12 and No. 14 BWG in spans of any length.
Galvanized iron, BB, No. 10 BWG in spans greater than 170 feet.
Galvanized iron, BB, No. 12 BWG in spans greater than 115 feet.
Galvanized iron, BB, No. 14 BWG in spans of any length.

APPENDIX D

TYPICAL COMMUNICATION LINE CONSTRUCTION

For a communication line carrying from approximately 6 to 20 conductors in a Light Loading area, the following specifications adequately meet all intents and requirements of this order:

POLES

Round, wood, butt-treated, 25 feet in length, minimum top circumference of 15 inches, and set to a minimum depth of 4.5 feet in firm soil.

CROSSARMS

3¼"x4¼"x10'. Attached by means of through bolts and washers, with a 15 inch center line of pole clearance to nearest conductors. Standard 30 inch quarter braces installed on the face of the crossarm with ⅜-inch bolts and ½-inch drive screw at the pole.

PINS

1¼"x8" wood pins.

INSULATORS

Pin type insulators to be of design that will engage the thread of the pin for not less than two and one-half turns.

CONDUCTORS

Size and material dependent upon the class of circuit involved. Sags as specified in Appendix C, Table 25. The average span length is 150 feet.

GUYS

For guying at angles or dead ends, it is recommended that a "Lead over Height" (ratio of the horizontal distance from the face of the pole to the point of entrance of anchor rod in the ground to the vertical height above the ground of the attachment of said guy wire to the pole) of 1 be used. At angles in the line where the pull of the line exceeds 4 feet, i.e., the angle of departure exceeds 5 degrees, a guy strand having a strength of 1900 lbs. (¼") or greater shall be used with the necessary pole shims, hook bolts, etc. (See App. G, Fig. 85)

HARDWARE

All line hardware to be galvanized or of other corrosion resisting material.

TABLE 26

REPLACEMENT GROUND LINE CIRCUMFERENCES IN INCHES OF SOUND SOLID WOOD FOR COMMUNICATION POLES IN GRADE "F" CONSTRUCTION

This table is suitable for poles supporting cables; interexchange lines (toll trunk and telegraph way wire); and exchange or local distribution lines of more than 10 wires. The circumferences given in this table are based on a safety factor of one-half, a modulus of rupture in bending of 5600 pounds per square inch, and the maximum number of wires (.104 inches in diameter) shown in the headings of the respective columns.

Length of pole (feet)	Span length (feet)	Load in number of wires											
		1-4		5-10		11-20		21-30		31-40		41-50	
		L. L.	H. L.	L. L.	H. L.	L. L.	H. L.	L. L.	H. L.	L. L.	H. L.	L. L.	H. L.
20	100	12	12	12	15	-------	-------	-------	-------	-------	-------	-------	-------
	125	12	12	12	16	-------	-------	-------	-------	-------	-------	-------	-------
	150	12	12	12	17	-------	-------	-------	-------	-------	-------	-------	-------
	175	12	13	12	18	-------	-------	-------	-------	-------	-------	-------	-------
25	100	12	12	12	16	12	17	12	20	-------	-------	-------	-------
	125	12	13	12	17	12	18	12	21	-------	-------	-------	-------
	150	12	14	12	18	12	20	13	22	-------	-------	-------	-------
	175	12	14	12	19	12	21	14	23	-------	-------	-------	-------
	200	12	15	12	20	13	22	14	24	-------	-------	-------	-------
30	100	12	13	12	17	12	18	13	21	14	23	14	24
	125	12	14	12	18	12	20	14	23	14	25	15	26
	150	12	15	12	19	13	21	14	24	15	26	16	28
	175	12	15	12	20	14	22	15	25	16	27	17	29
	200	12	16	12	21	14	23	16	26	17	28	18	30

35	100	12	14	12	18	13	20	14	22	15	25	16	26
	125	12	15	12	20	13	21	15	24	16	26	17	28
	150	12	16	12	21	14	23	15	25	16	28	17	30
	175	12	16	12	22	15	24	16	27	17	30	18	31
	200	12	17	13	23	15	25	17	28	18	31	19	32

L.L.—Refers to Light Loading District, Rule 43.2.
H.L.—Refers to Heavy Loading District, Rule 43.1.

TABLE 27

REPLACEMENT GROUND LINE CIRCUMFERENCES IN INCHES OF SOUND SOLID WOOD FOR COMMUNICATION POLES IN GRADE "F" CONSTRUCTION

This table is suitable for poles supporting exchange or local distribution lines of 10 or less open wires. The circumferences given in this table are based on a safety factor of one-half, a modulus of rupture in bending of 5,600 pounds per square inch, and the maximum number of wires (.104 inches in diameter) shown in the headings of the respective columns.

Length of pole, (feet)	Span length, (feet)	Load in number of wires			
		1-4		5-10	
		L. L.	H. L.	L. L.	H. L.
20	100	9	11	9	15
	125	9	12	9	16
	150	9	12	9	17
	175	9	13	9	18
25	100	9	12	9	16
	125	9	13	10	17
	150	9	14	10	18
	175	9	14	10	19
	200	9	15	11	20
30	100	9	13	10	17
	125	9	14	11	18
	150	9	15	11	19
	175	10	15	11	20
	200	10	16	12	21
35	100	10	14	11	18
	125	10	15	12	20
	150	10	16	12	21
	175	11	16	12	22
	200	11	17	13	23

L.L.—Refers to Light Loading District, Rule 43.2.
H.L.—Refers to Heavy Loading District, Rule 43.1.