CONTROL OF FIRES IN INACTIVE COAL DEPOSITS IN WESTERN UNITED STATES, INCLUDING ALASKA, 1948-58

BY T. R. JOLLEY AND H. W. RUSSELL

* * * * * * * * * Information Circular 7932

UNITED STATES DEPARTMENT OF THE INTERIOR
Fred A. Seaton, Secretary
BUREAU OF MINES
Marling J. Ankeny, Director

1959

This publication has been cataloged as follows:

Jolley, Theodore R

Control of fires in inactive coal deposits in western United States, including Alaska, 1948-58, by T. R. Jolley and H. W. Russell. [Washington] U. S. Dept. of the Interior, Bureau of Mines, 1959.

ii, 22 p. illus., tables. 27 cm. (U. S. Bureau of Mines. Information circular, 7932)

1. Fires–The West. 2. Coal mines and mining–Fires and fire prevention. I. Russell, H. W., joint author. II. Title. (Series)

[TN23.U71 no. 7932] 622.06173

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CONTROL OF FIRES IN INACTIVE COAL DEPOSITS IN WESTERN UNITED STATES, INCLUDING ALASKA, 1948-58[1]

by

T. R. Jolley[2] and H. W. Russell[3]

SUMMARY

This publication describes the control of fires in inactive coal deposits in the Western United States, including Alaska by the Bureau of Mines. Material presented should contribute to a better understanding of the purpose, process, and benefits of the program.

Forty fires were extinguished or controlled in the Western United States and Alaska from 1948 to 1958 under a national program directed by the Bureau's Health and Safety activity. Thirty-five fires were controlled by smothering; three were controlled by the isolation method; and two were extinguished by removing the burning coal, smothering it with incombustible material, and backfilling the fire zone. The fire-control projects were distributed as follows: Alaska 2, Arizona 1, Colorado 9, Montana 9, New Mexico 4, Utah 2, and Wyoming 13.

The total cost of the 40 fires extinguished or controlled was $1,203,957. Of this cost, 12.8 percent was engineering and administrative and 87.2 percent was contractual services.

The quantity of coal exposed to each fire cannot be determined accurately, but the occurrence of numerous scoria beds in coal formations indicate that uncontrolled fires in the past have destroyed a tremendous quantity of coal. The beds ranged in thickness from 3 to 84 feet, and the coal ranged in classification from lignite to bituminous but was mostly subbituminous. The calorific value ranged from 5,590 to 12,580 B.t.u.

Conservation of coal resources and preservation of other property justify continuing this program for control of coal-formation fires.

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INTRODUCTION

Numerous fires throughout the Western United States are continually burning along coal outcrops. A few of them have been burning for over a hundred years, whereas others are recent. The fires have different origins. Many were started by Indians or sheepherders, who camped on the coal outcrop and neglected to extinguish their camp fires. Lightning and forest fires have also ignited trees or brush along the outcrop. During the process of mining coal, fires have been started by spontaneous combustion and other causes and then left burning when the mines were abandoned. Later, the fire was found to have spread through the mine workings and progressed along the coalbed to the outcrop.

These fires seldom extinguish themselves. In places where the dip of the coalbed was such that the overburden increased rapidly, fires progressed to considerable depths as they continued burning along the coal outcrop. In flat deposits many acres of coal have been destroyed, and the progress of the burning was due mostly to caving of the ground after the coal burned, which opened cracks to the surface. Through these cracks air was supplied and the burning continued. In figure 1 the caved, settled area can be seen in the foreground, and crevices supplying air are clearly shown in the center of the picture.

The fires have burned millions of tons of coal, destroyed thousands of acres of grazing land, and in some instances started brush and forest fires. Figure 2 shows the result of a forest fire that was started by a burning outcrop and destroyed over 3,000 acres of forest. Fire areas also present a hazard to cattle and wildlife. Many animals bedding on the fire area in winter have been trapped in crevices or overcome by noxious gases.

Control of fires in inactive coal deposits in the Western United States and Alaska was begun by the Bureau of Mines in 1948. U. S. Department of the Interior Appropriation Acts[4/] authorized the Bureau of Mines to control fires in inactive coal formations in land owned as follows:

1. Federal land.

2. Government-owned coal deposits in privately owned surface land.

3. Privately owned land that endangers adjacent Government-owned coal deposits.

4. In privately owned coal deposits, if the owner of the coal rights contributes 50 percent of the cost.

4/ Public Law 841, 80th Cong., 2d sess., Act of 1948, Fiscal Year 1949.
Public Law 350, 81st Cong., 1st sess., Act of 1949, Fiscal Year 1950.
Public Law 759, 81st Cong., 2d sess., Act of 1950, Fiscal Year 1951.
Public Law 136, 82d Cong., 1st sess., Act of 1951, Fiscal Year 1952.
Public Law 470, 82d Cong., 2d sess., Act of 1952, Fiscal Year 1953.
Public Law 172, 83d Cong., 1st sess., Act of 1953, Fiscal Year 1954.
Public Law 465, 83d Cong., 2d sess., Act of 1954, Fiscal Year 1955.
Public Law 78, 84th Cong., 1st sess., Act of 1955, Fiscal Year 1956.
Public Law 573, 84th Cong., 2d sess., Act of 1956, Fiscal Year 1957.
Public Law 87-77, 85th Cong., 1st sess., Act of 1957, Fiscal Year 1958.
Public Law 85-439, 85th Cong., 2d sess., Act of 1958, Fiscal Year 1959.

FIGURE 1. - Two Trees Fire Area in Montana, Showing Subsidence and Cracks.

FIGURE 2. - Vicinity of Dugger Rollins Fire Area in Colorado, Showing Results of Fire That Damaged Over 3,000 Acres of Timber.

From 1948 through 1958 $1,203,957 was spent on this program in Alaska, Arizona, Colorado, Montana, New Mexico, Utah, and Wyoming. Detailed reports of each fire-control project are available for inspection by interested parties in the office of the District Supervisor, District H, Health and Safety Activity, Building 20, Federal Center, Denver, Colo.

ACKNOWLEDGMENT

The assistance and cooperation of land owners and officials of companies, State, and Federal agencies, who have provided information and made records available, are gratefully acknowledged.

SCOPE OF PROGRAM

The fire-control activities discussed herein embrace the Western United States (west of the Mississippi River), including Alaska. To date, work has been done in seven States. Table 1 lists by States the known fires, fires controlled or extinguished, and the total amount of money spent for contractual services for the various projects in each State.

TABLE 1. - Known and controlled fires by States

State	Fires reported	Controlled fires	Amount spent for contractual services
Alaska	2	2	$38,914.09
Arizona	3	1	17,989.49
California	1	0	
Colorado	35	9	236,573.13
Montana	66	9	178,019.46
New Mexico	13	4	76,434.91
North Dakota	6	0	
South Dakota	3	0	
Utah	12	1/2	86,459.30
Wyoming	36	13	415,038.36
Total	177	40	1,049,428.74

1/ Includes Hoffman Creek (incomplete).

The average cost on this basis of completed projects is $26,235.72. Actually, the cost of individual projects ranges from $4,789.76, (Three Forks in Montana), to an estimated $150,000 (Hoffman Creek in Utah). Because of this wide variation, the estimated cost of a project is often the determining factor in deciding whether a fire should be controlled.

Total costs charged against each project are slightly higher than those shown in table 1. The engineering, supervisory, and administrative costs are included with contractual services. (See table 2.) These additional costs average about 12.8 percent of the total. Projects are distributed among the States on the basis of highest rank coal and thickest coalbeds. Fires that are most accessible and fit allotted funds are given preference. Table 2 also gives information on the coalbeds.

Because of the immense destruction, control of large fires is essential from a conservation standpoint. However, control of smaller fires to prevent their spread is more desirable because funds are more readily available for such projects and the consequent savings are greater. Control of large and costly fires has been considered and has been tried by extending the work over several years. For example, the Hoffman Creek fire in Utah was partly controlled during the summer of 1958. This project is expected to be completed by the end of 1959. However owing to funds and time involved, some work may be carried over to 1960.

All projects thus far have involved fires in inactive Federal coal deposits or fires endangering such deposits. Although fires are burning in privately owned coal and are endangering active mines, none has been controlled under the cooperative arrangement in the West. Under this arrangement, the owner of the coal rights, where the fire is burning would have to assume 50 percent of the cost.

CONTROL AND EXTINGUISHMENT

Since 1948, when the Federal control and extinguishment of coal-crop fires was begun, 126 of the 177 known fires have been investigated, 66 mapped, and 40 controlled or extinguished. The work comprises:

1. Preliminary investigation.

2. Topographic mapping.

3. Filling and covering, removal, or isolation.

Table 3 lists completed projects chronologically and gives information on location, method used, and contractor.

Preliminary Investigation

The first step in preliminary investigation is to determine ownership. Surface and coal rights are examined in county assessor's records and plats, patents, and Bureau of Land Management records of surface and coal rights land status. The tract or lot section, township, range, county, and State in which a fire is burning is determined from existing stone or brass-capped land-survey markers. This procedure involves a transit survey to confirm the exact location of the fire area. Location and ownership are very important because partial cost must be borne by the owner, if the fire is on privately owned coal.

The burning coalbed and overlying and underlying stratum (where possible), are measured and identified. Whether the coalbed is adequate in thickness and quality to be mined profitably in the area is also determined. The overlying or underlying stratum or adjacent alluvium must be suitable for use as covering material.

The history of mining in the area and of the fire is obtained from nearby residents or existing records. An attempt is made to determine the origin of the fire and whether the coal has been used as fuel.

Topographic Mapping

A topographic map is made of the fire and surrounding areas to show all physical features. The map shows: Surface area of the fire, elevations, subsidence, hot spots or vents, cracks, mine openings, dumps, roads, drainage, buildings, fences, vegetation, borrow pits, and other pertinent information. The slope of the terrain can be obtained by marking cross sections on the map and projecting the cross sections into a vertical plane. Borrow-pit areas can be marked on the map then laid out in the field. The contour lines show points of equal elevation and are used to lay out roadways and berms for the cover.

These maps are useful for estimating the amount of work required for miscellaneous bulldozing, exploratory drilling, and test-hole drilling in order to determine the number of cubic yards of material needed for compacted filling and covering. The estimate is used to allocate funds, to select projects for the summer season, and to prepare invitations to bid on work to be done.

Methods

Methods used to control and extinguish coalbed fires in the Western United States and Alaska are: (1) Removal, (2) isolation, and (3) smothering.

A discussion of each method and its advantages and disadvantages follows.

Removal

The removal method consists of excavating the burning mass, placing it in an incombustible area, and extinguishing the burning coal by smothering. The excavation is backfilled to prevent rekindling. Removal of the burning coal is a direct approach, and further destruction of coal is stopped. Use of this method presents a health and safety hazard because of attendant heat, fumes, and dust. Two fires, the I.H.I. Nos. 1 and 2 in Colorado, were controlled by the removal method. Figure 3 shows drilling operations and removal of overburden at I.H.I. No. 2 fire area. The success of smothering the burning coal with a mantle of incombustible material at the I.H.I. projects in approximately 1 year showed that smothering was effective in extinguishing coal fires.

Isolation

The isolation method consists of separating the burning mass from the main coal formation by establishing a barrier that stops the fire from spreading or advancing into the main coalbed. In this method a trench of suitable dimensions is excavated from the surface through the overburden, the coalbed, and the carbonaceous shale that usually underlies the coalbed. The trench is subsequently backfilled with compacted incombustible material to an adequate height above the coalbed. The isolated mass continues to burn toward the barrier, and burning stops when the isolated coal is burned out. This method was used to control three fires: Skull Creek, near Massadona, Colo.; North Park, near Coalmont, Colo.; and Ranger Station in Alaska.

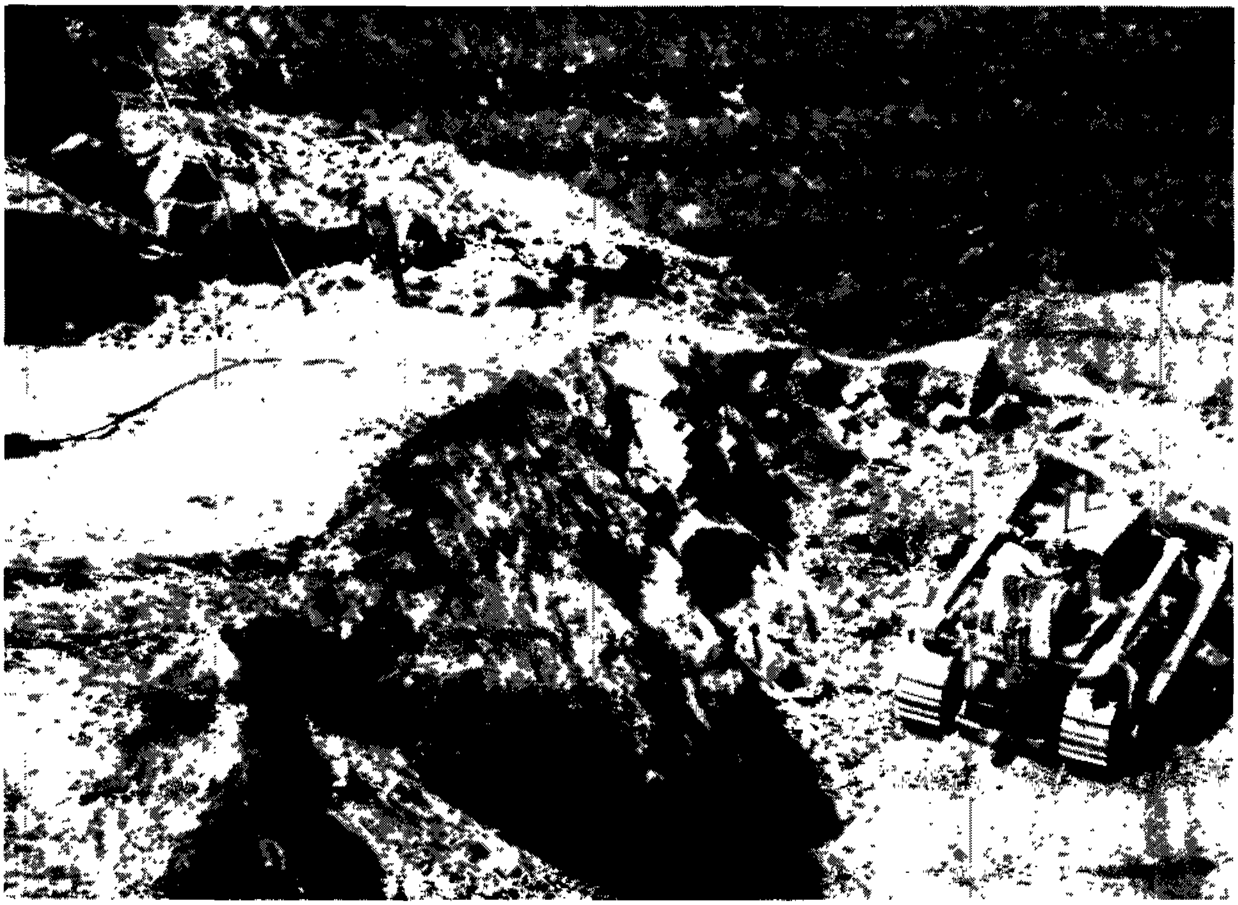


FIGURE 3. - Overburden Removal at I.H.I. No. 2 Fire Area in Colorado.

The Skull Creek fire was burning in a narrow ridge of the coal formation that could be separated from the main mass of coal by digging a trench across the ridge. The coalbed was 16 feet thick. Figure 4 shows work in progress in the trench dug across the ridge. The isolated fire has continued to burn for 8 years after being controlled by the barrier.

The North Park fire was burning in the unmined top coal and pillars of an abandoned underground mine in a 28-foot coalbed. The overlying stratum sagged over the rooms, and it was hazardous to place filling and covering material over the voids. This fire was isolated by digging a trench around it and enclosing the burning area. The isolated fire has continued to burn for 10 years.

The Ranger Station fire was burning in a coalbed, near the top of an escarpment at Katchemak Bay, Alaska, comprising alternating bands of interbedded coal, shale, and soft sandstone. The coalbed was about 4 feet thick near the top of the escarpment and about 400 feet above the beach of Katchemak Bay, which was washed continually by waves at high tide. As the burning coalbed was at the top of this precipitous escarpment it could not be smothered. Five years after control the fire had not reached the barrier.

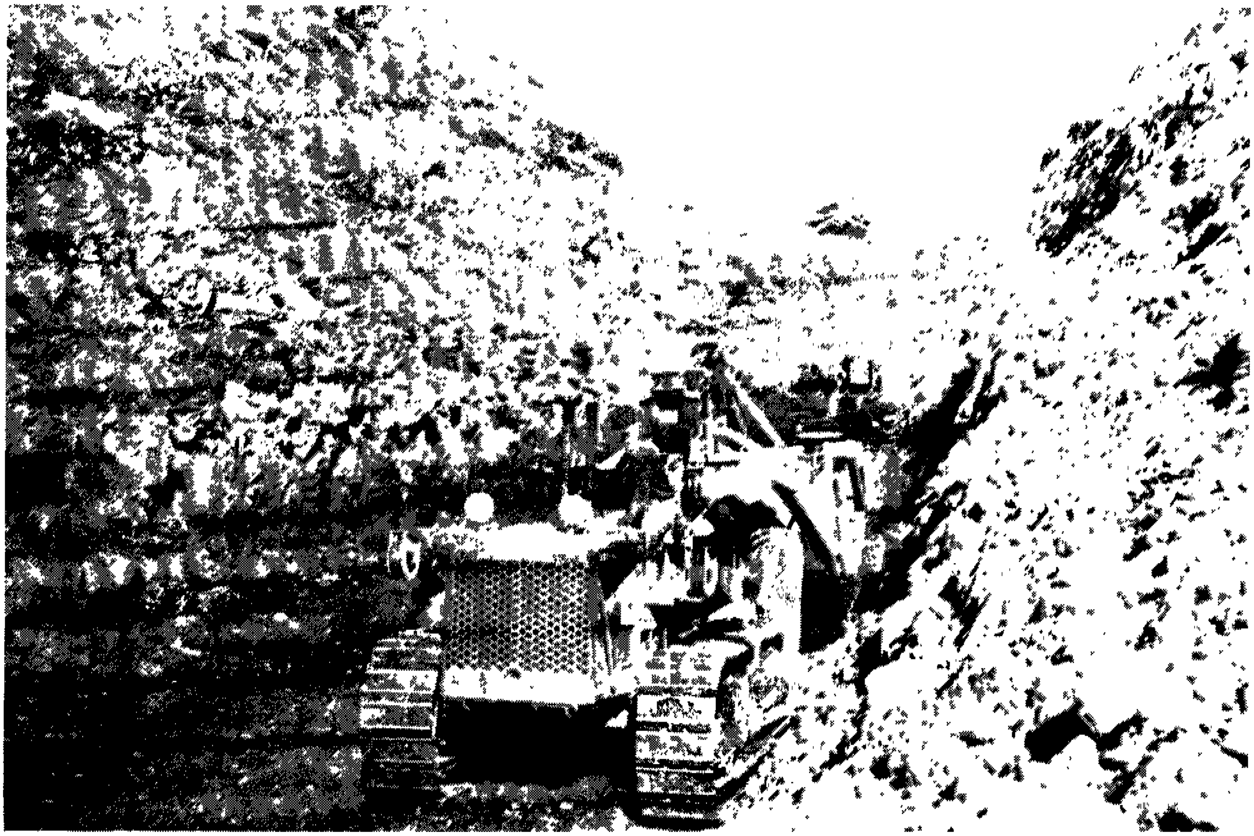


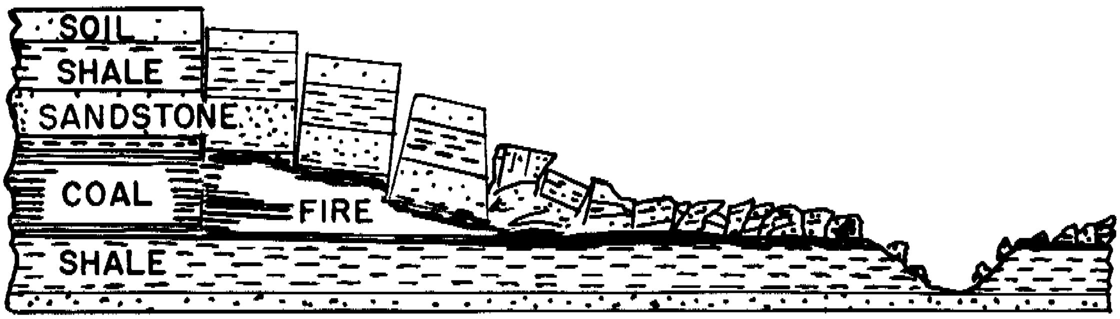
FIGURE 4. - Skull Creek Fire Area in Colorado, Showing Equipment Working in Isolation Trench.

The three fires controlled by isolation were unusual because of the relation of the burning coalbed to the main coal formation and adjacent terrain. The isolating trenches were about 60 feet deep at Skull Creek, 100 feet deep at North Park, and 30 feet deep at Ranger Station. The trenches isolated fires in coalbeds 16 feet, 28 feet, and about 4 feet thick, respectively.

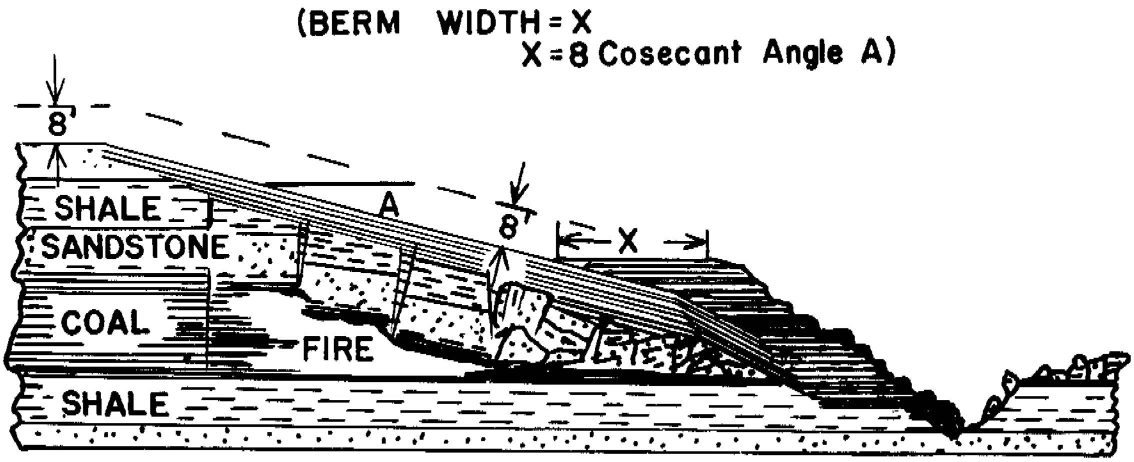
Obviously, use of the removal and isolation methods is limited by the overburden and terrains. Therefore, these methods have been used only a few times. Their main disadvantage is that they cannot be used when the overburden is excessive.

Smothering

The smothering method is used most frequently and consists of covering burning-coal formations with an 8- to 10-foot mantle of compacted, incombustible earthen material that prevents admission of air to propagate combustion. The mantled area is extended 35 feet beyond the periphery of the actively burning fire area. The fire area is prepared for covering by sloping the cracked and subsided surface with a bulldozer to a smooth, even plane. Figure 5 shows a cross section of a fire area before sloping (part A) and the method of control (part B). Some cracks are closed during the sloping operation, and smothering of the fire begins even before the area is covered. A berm or roadway is started below the burning coalbed or in the lowest part of the fire basin, and incombustible material is hauled from borrow pits outside the fire area. This material is compacted in contour



PART A DIAGRAM OF COAL BURNING AND OVERBURDEN CRACKING AND SUBSIDING



PART B DIAGRAM OF SLOPED FIRE AREA AND COVERING FIRE WITH INCOMBUSTIBLE MATERIAL

FIGURE 5. - Cross-Sectional Diagrams, Showing Fire Area and Method of Covering.

layers 8 inches thick. The contour layers are built horizontally and longitudinally until 8 feet of incombustible material has been added perpendicular to the slope of the surface. (See fig. 5, part B.) The width of the berm changes proportionately to the angle of the sloped surface because the fire area usually is not at the same constant slope. The width of the berm or horizontal distance is 8 feet times the cosecant of the angle of the sloped surface with the horizontal. Slope tables are prepared for guidance and control. The thickness of the filling and covering material on flat areas is controlled by setting 8-foot-grade stakes. The berm or roadway width is marked as each layer is added. At the beginning of the program, 10-foot cover normal to the surface was used; however, it was found that satisfactory results could be obtained with 8 feet of material.

Work stages of a project using the filling and covering method are shown by selected photographs, which illustrate the appearance of fires before, during, and at completion of control. Figure 6 shows the Deer Creek fire in Montana as it appeared before control work was begun. The peripheral cracks in the overburden are caused by subsidence from the burning of a 16-foot coalbed. Figure 7 shows sloping and preparing the Padlock Ranch fire with two bulldozers. Combustion vapors from the burning coalbed can be seen ahead and to the left of the distant bulldozer.

Building up the smothering mantle of incombustible material with a crawler tractor and scraper at the Virgil Weidner fire in Montana is shown in figure 8. The roadway or berm was begun with a bulldozer; then, succeeding contour layers were added, building the sealing mantle up and over each contour layer. (See fig. 9.) The ridges of the contour strips reduce water erosion. It is often necessary, however, to cut diversion ditches to prevent washing out cover material. Normally, washing out is prevented by the natural contour of the surface on the upper side of the fill; however, if a large drainage area is involved, diversion ditches are cut. Figure 10 is a view of a diversion ditch of this type at Moyer Gulch project. In one instance a small earthen dam (fig. 11) had to be erected. This dam proved to be a big asset to ranchers, as it greatly improved the range by retaining water for livestock.

CONTRACTS

Standard Government construction contracts are let to the lowest qualified competitive bidder, and work is guaranteed under a standard performance bond. Wages of contractor's employees, in accordance with fair labor practices, are guaranteed by a payment bond. Costs of bid items are compared with those of similar projects to ascertain whether a fair unit cost was bid. The work has been performed under the supervision of Bureau of Mines personnel.

RESULTS AND BENEFITS

Excellent results have been obtained to date on all projects. Repairs and maintenance have been negligible. Only in very few instances has it been necessary to fill cracks in the cover resulting from settling or washing out of material.

The time necessary for the complete extinguishing and cooling of a fire cannot be estimated. The time varies with the fire intensity, its extent, the cover, the type of formation, and whether it is in a solid coalbed or abandoned mine workings. On some projects test holes were drilled and cased in the fire area before covering. These holes were subsequently used for air sampling and temperature measurements to determine rate of cooling.

FIGURE 6. - Deer Creek Fire Area in Montana, Showing Subsidence.

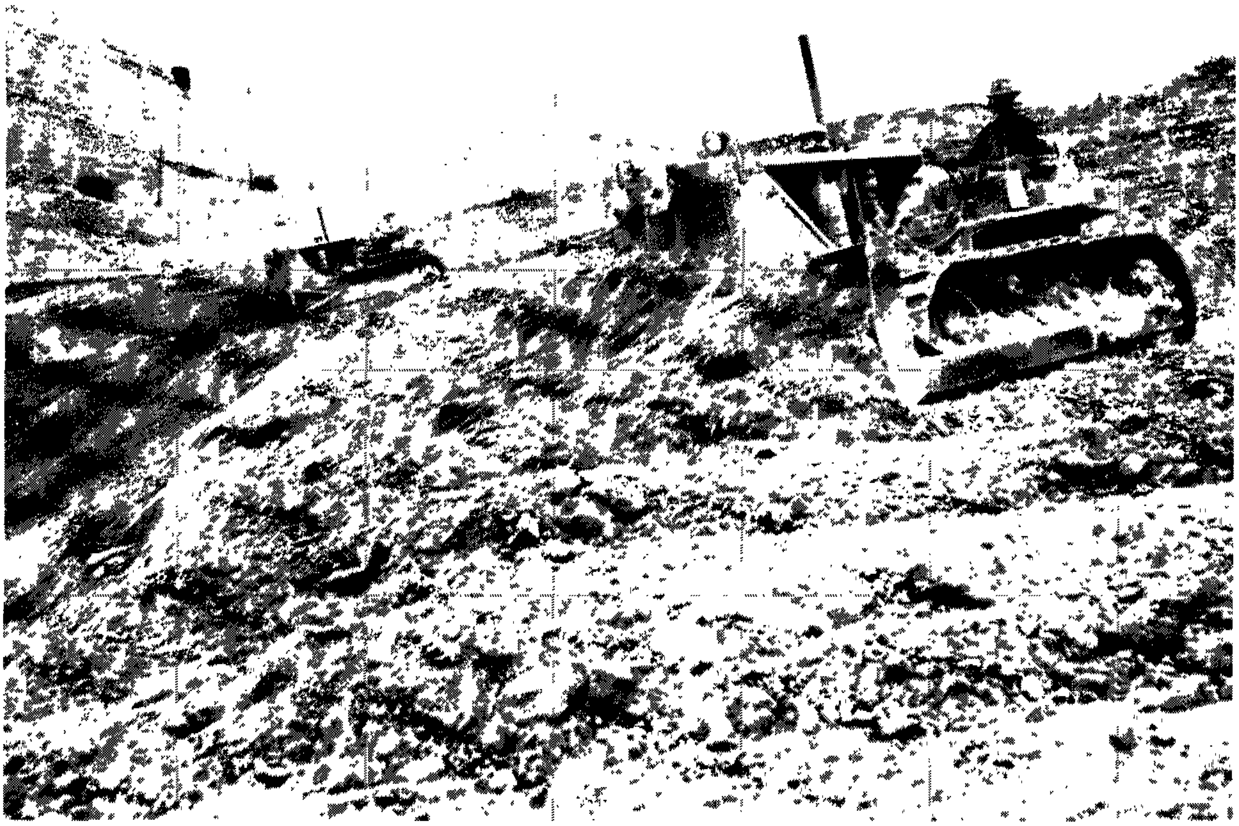


FIGURE 7. - Sloping Operation on Padlock Ranch Fire Area in Wyoming.

Typical temperature-time differential curves for three test holes on the Terry No. 2 fire are shown in figure 12. A definite cooling trend is apparent in all three test-hole areas which denotes a decrease in combustion. Leveling of the curves when temperatures are constant indicates that the fire has been controlled in the borehole area. If these temperatures are near the normal temperature of the strata, the fire is assumed to be no longer active. Measurements are made at approximately the same depth; however, variation in temperature readings can be observed with only 1 or 2 feet difference in depth. In some places it has been noticed that surface temperature affects the test-hole measurements.

In some fire areas, tests made several years after completion of the project indicate that complete cooling has not taken place, whereas fires in other areas are extinguished and cooled in a relatively short time. For example, the Moose Creek fire in Alaska was extinguished completely in less than 1 year, and mining was begun the following year. Obviously, in addition to the actual saving of coal there are benefits from the coal-availability standpoint.

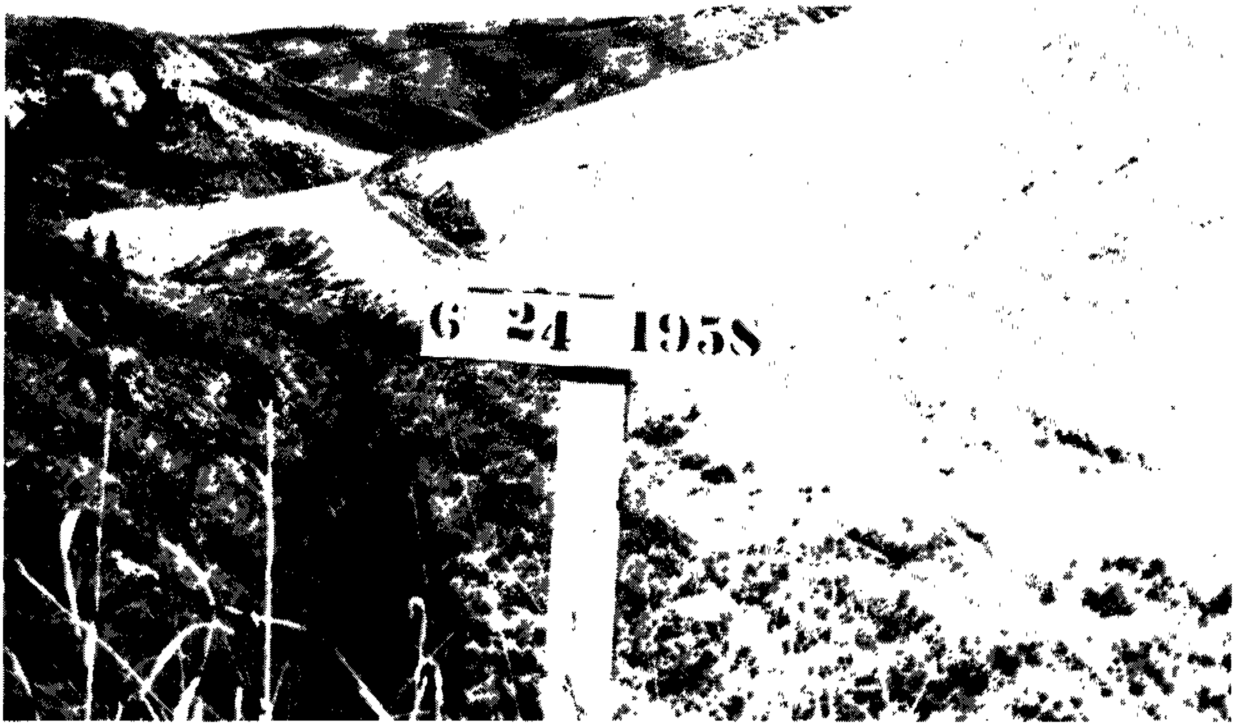


FIGURE 8. - Starting Berm at Bottom of Sloped Area for Building Up Smothering Mantle at Virgil Weidner Fire.

The quantity of coal exposed to a coal-formation fire cannot be accurately determined. The coal within the fire area can be determined and classified as measured coal, as defined by the Bureau of Mines and Geological Survey.[5]

The amount of coal exposed has not been included in this report because numerous indefinite factors may affect the burning rate. Some of these factors are:

1. The length of time each fire has burned.

2. The effect of rainfall and inherent moisture.

3. The effect of variable dip and thickness of coalbeds.

4. The effect of poorly consolidated overlying strata compared with strongly consolidated strata, also the thickness of the overlying strata.

5/ Dowd, James J., Turnbull, Louis A., Toenges, Albert L., Cooper, H. M. Abernethy, R. F., Reynolds, D. A., and Fraser, Thomas, Estimate of Known Recoverable Reserves of Coking in Cambria County, Pa.: Bureau of Mines Rept. of Investigation 4734, 1950, pp. 3-5.

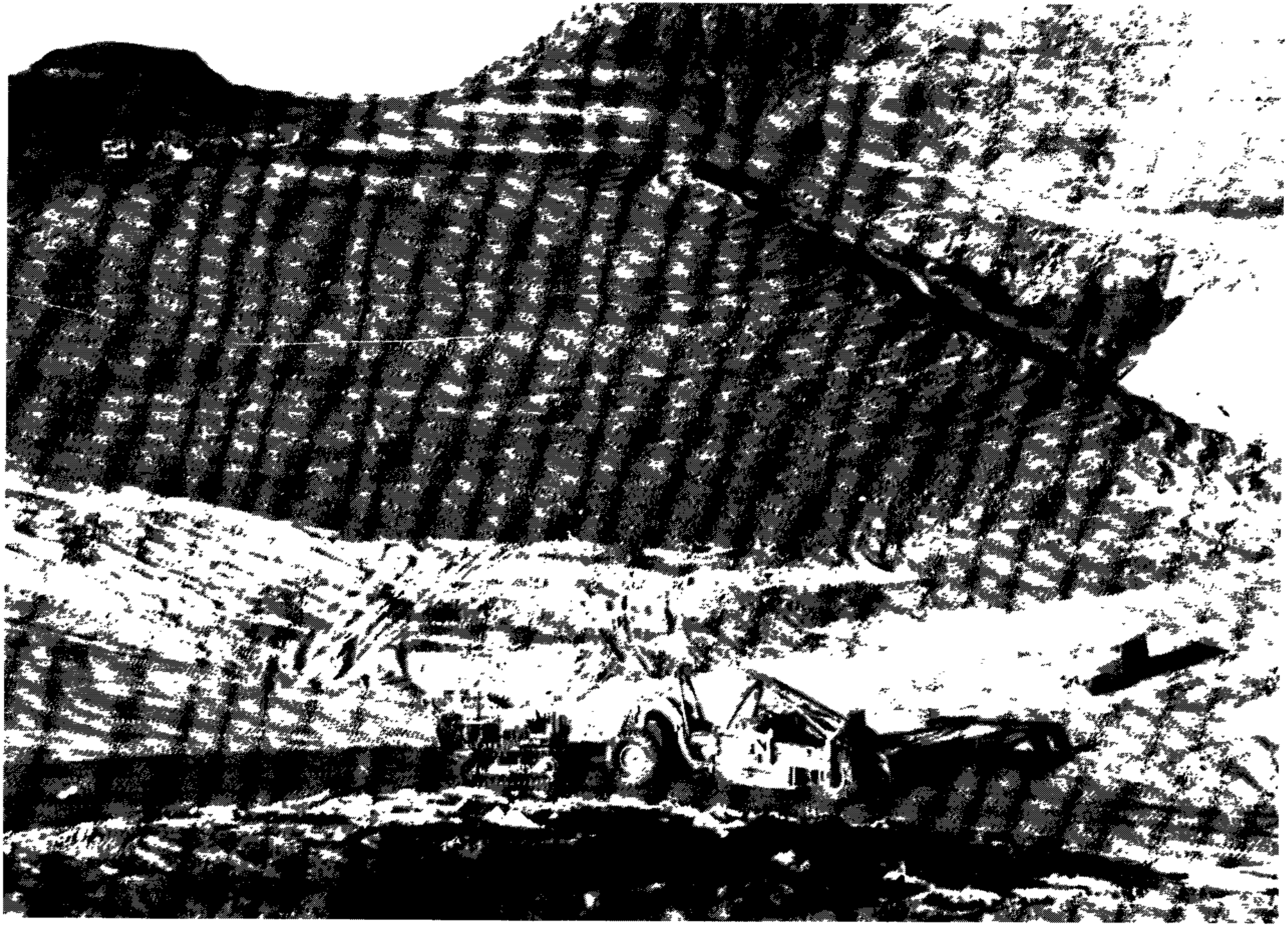


FIGURE 9. - Deer Creek Fire Project in Montana, Showing Cover of Incombustible Material.

5. The effect of the direction of burning in relation to prevailing winds.

6. The effect of sulfur and other impurities .

FIGURE 10. - Diversion Ditch at Moyer Gulch Project in Wyoming.

Large scoria beds, formed by the burning of underlying coalbeds are evidence that these fires have destroyed enormous quantities of coal. The most typical area of widespread occurrence of scoria beds is in northeastern Wyoming near Moorcroft, Gillette, Buffalo, and Sheridan, where the upper parts of many small monadnock-type hills are scoria.

Perhaps one of the most important indirect benefits of this fire-control program is the prevention of forest, grass, and brush fires. Preserving and improving grazing land and preventing destruction of cattle and wildlife are also important benefits in some fire areas.

CONCLUSIONS

The smothering method of control and extinguishment of coal-formation fires is the most adaptable method in the Western United States. This method requires less earth-moving equipment, and the work usually can be performed rapidly and relatively cheaply.

FIGURE 11. - Dam Protecting Smothering Cover at Deer Creek Project in Montana. (Water was beneficial to livestock.)

The isolation method may be adaptable to thin beds at shallow depths, but thick coalbeds at greater depths require deep isolating trenches and thus cost more. The fire is not extinguished until all isolated coal is burned, which usually takes many years. Frequently, excavating equipment is required in addition to earth-moving equipment.

The removal method creates a health and safety hazard, as hot coals, ashes, and overlying strata are dry and dusty. The excavation needed for this method is apt to be large, deep, and costly. Removal is the most direct method but is undesirable except in very small fires near the surface.

All fire-control projects require patrolling, inspection, and maintenance for at least 3 years or until extinguishment of the fire is assured. The mantle sealing the fire must exclude oxygen and retain all combustion products throughout the cooling period.

The conservation of coal resources and the preservation of life and property justify continuing control and extinguishment of coal-formation fires.

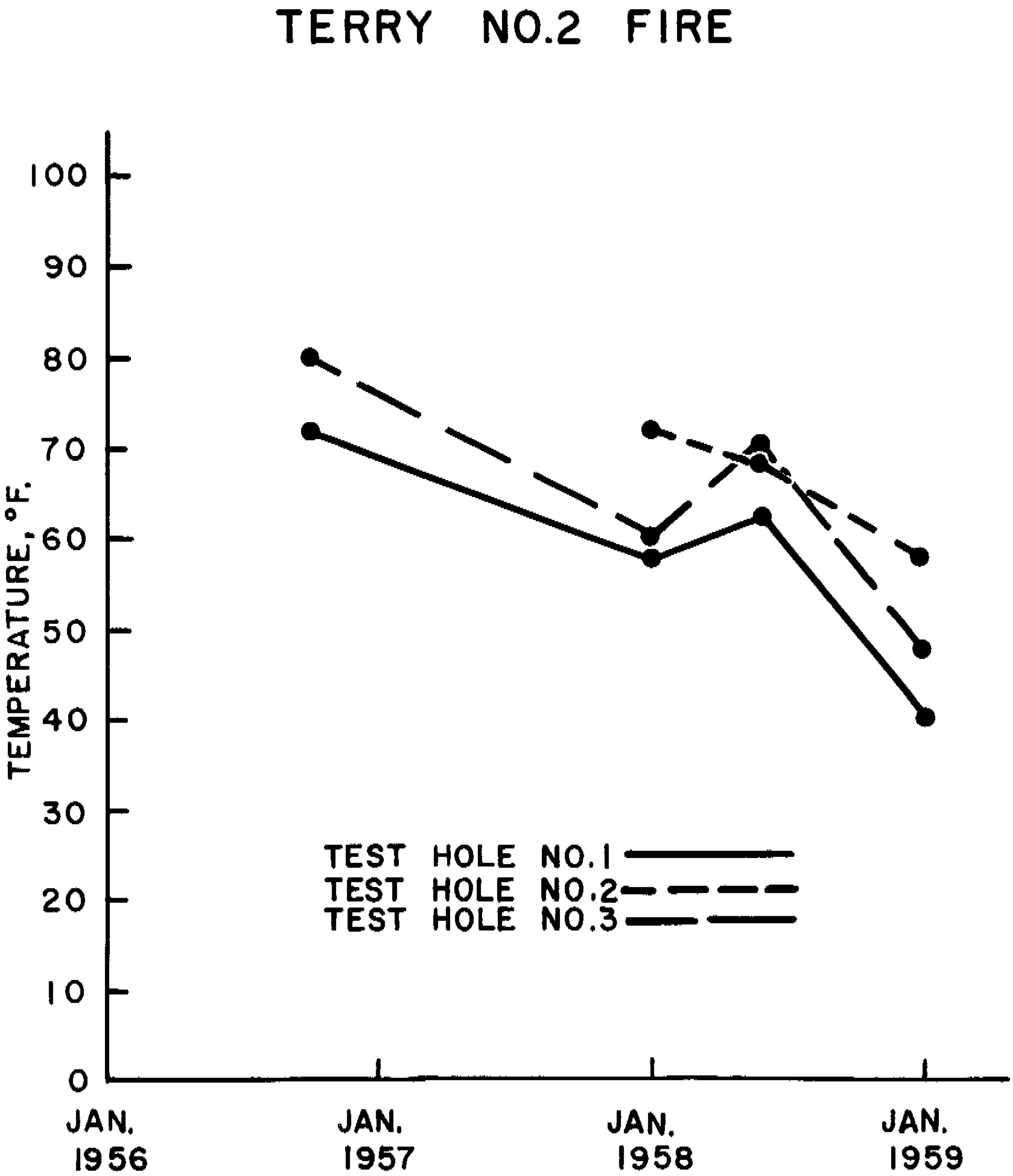


FIGURE 12. - Temperature Decline in Test Holes.

TABLE 2. - Summary of projects

State	Name	Year completed	Coal bed				Total cost
			Name	Rank	Thickness, feet	B.t.u.	
Alaska......	Moose Creek	1954	Premier No. 5	Bituminous	6	12,580	$29,233
Do........	Ranger Station	do.	Unnamed	Subbituminous	3-3/4	8,190	16,821
Arizona.....	Black Mesa	1955	do.	do.	13	11,420	23,672
Colorado....	Coal Gulch	1953	Cameo	Bituminous	14	12,120	26,767
Do........	Dugger Rollins	1952	Unnamed	Subbituminous	9	9,580	51,632
Do........	I.H.I. No. 1	1949	Rider	Bituminous	5	11,890	39,867
Do........	I.H.I. No. 2	1953	Rider No. 2	do.	3-1/2	-	10,552
Do........	North Park	1949	Riach	Subbituminous	28-1/2	9,430	57,752
Do........	Onion Lake	1955	Unnamed	do.	14	10,220	21,350
Do........	Skull Creek	1951	Williams Fork	do.	16	9,540	18,551
Do........	Slagle	1954	Unnamed	do.	7	10,220	15,228
Do........	Yellow Jacket	do.	Wesson	Bituminous	25	10,930	15,989
Montana.....	Deer Creek	1956	Unnamed	Subbituminous	16	7,160	39,614
Do........	Fuller	1955	do.	Lignite	42	5,380	37,786
Do........	Glendive Creek	1956	do.	Subbituminous	11	7,640	20,299
Do........	Reservation Creek	1958	do.	do.	26	6,080	20,303
Do........	Terry No. 1	1956	do.	Lignite	13	5,630	18,092
Do........	Terry No. 2	do.	do.	do.	12	5,630	16,509
Do........	Three Forks	1958	do.	Subbituminous	16	5,860	8,233
Do........	Two Trees	1957	do.	do.	18-1/2	8,490	51,542
Do........	Virgil Weidner	1958	do.	do.	18	7,640	10,330
New Mexico..	La Plata	1954	Carbonero	Bituminous	6	11,630	17,758
Do........	Newcomb	1956	Unnamed	do.	23	9,680	18,538
Do........	Pyle Dam	1951	Fruitland "C"	Subbituminous	12	11,660	18,011
Do........	San Juan	do.	Gibson	do.	6-3/4	10,900	35,290
Utah........	Hoffman Creek	Incomplete	do.2/	Bituminous	8-5/12	12,830	75,125
Do........	Ricci	1957	No. 1 Muddy	do.	8-1/2	8,060	30,317
Wyoming.....	Alkali Butte	1956	Signor	Subbituminous	15	7,930	62,130
Do........	Burning Coal	1950	Unnamed	do.	12-1/2	8,410	60,320
Do........	Canfield	do.	Roland1/	do.	44	8,260	78,188
Do........	Castle Garden	1954	Unnamed	Lignite	13		11,378
Do........	Elk Creek	1952	Roland	Subbituminous	12	7,420	42,125
Do........	Laur	1950	Felix	do.	10-1/2		7,471
Do........	Linwood	1954	Unnamed	do.	10		7,592
Do........	Little Thunder	1950	Roland1/	do.	45	7,420	51,333
Do........	Moyer Gulch	do.	do.	do.	84	7,730	41,384
Do........	Padlock Ranch	1951	do.	do.	37		39,221
Do........	Poposia	1957	Lander	do.	12	5,590	28,750
Do........	Snake River	1955	Unnamed	Bituminous	14	10,720	22,293
Do........	Soda Lake	1954	do.	Subbituminous	8		6,611
Total..							1,203,957

1/ Name of bed assumed.

2/ Fish Creek, Rock Canyon, and Lower Sunnyside beds also in fire area.

TABLE 3. - Chronological listing of completed and controlled projects

No.	Date	Name	Method	Contractor	Location--legal description
1	April-July 1949	I.H.I. No. 1	Removal	Louie Pinello Contracting Co.	Sec. 16, T. 5 S., R. 92 W., 6 P.M., 7 miles northeast of Rifle, Garfield County, Colo.
2	July-October 1949	North Park	Isolation	Nugget Coal Co.	Sec. 26, T. 7 N., R. 81 W., 6 P.M., 1 mile southwest of Coalmont, Jackson County, Colo.
3	November 1949-May 1950	Moyer Gulch	Smothering	do.	Sec. 10, T. 51 N., R. 72 W., 6 P.M., 8 miles north of Gillette, Campbell County, Wyo.
4	June-August 1950	Canfield	do.	Knisely-Moore Co.	Sec. 14, T. 41 N., R. 70 W., 6 P.M., 12 miles southeast of Teckla, Campbell County, Wyo.
5	July-September 1950	Laur	do.	Leon White	Sec. 11, T. 49 N., R. 72 W., 6 P.M., 4 miles south of Gillette, Campbell County, Wyo.
6	July-November 1950	Burning Coal	do.	Brasel & Whitehead and Asbell Bros.	Sec. 22, T. 39 N., R. 68 W., 6 P.M., 22 miles northeast of Bill, Converse County, Wyo.
7	January-March 1951	San Juan	do.	Alvis F. Denison	Sec. 31, T. 19 N., R. 1 W., N.M.P.M., 3/4 mile west of La Ventana, Sandoval County, N. Mex.
8	April-September 1951	Pyle Dam	do.	O. D. Smithhart and Alvis F. Denison	Sec. 28, T. 30 N., R. 15 W., N.M.P.M., 4 miles west of Fruitland, San Juan County, N. Mex.
9	July-September 1951	Little	do.	Doyle H. Moore	Sec. 13 and 14, T. 43 N., R. 70 W., 6 P.M., 22 miles southeast of Hilight, Campbell County, Wyo.
10	April-September 1951	Padlock Ranch	do.	J. D. White and Nugget Coal Co.	Sec. 24 and 25, T. 55 N., R. 73 W., 6 P.M., 9 miles southeast of Recluse, Campbell County, Wyo.
11	September-December 1951	Skull Creek	Isolation	Hunt Construction Co.	Sec. 35 and 36, T. 3 N., R. 102 W., 6 P.M., 13 miles southwest of Massadona, Rio Blanco County, Colo.
12	July-October 1952	Dugger Rollins	Smothering	Minerals Engineering Co. and Homer N. Gerbaz	Sec. 35, T. 13 S., R. 96 W., 6 P.M., 12 miles north of Delta, Delta County, Colo.
13	June-December 1952	Elk Creek	do.	Doyle H. Moore and Leon White	Sec. 22 and 23, T. 56 N., R. 72 W., 6 P.M., 12 miles northwest of Weston, Campbell County, Wyo.

14	June-July 1953	Coal Gulch	do.	Homer N. Gerbaz	Sec. 18, T. 8 S., R. 101 W., 6 P.M., 20 miles north of Fruita, Mesa County, Colo.
15	June-September 1953	Snake River	do.	Doyle H. Moore	Sec. 9, T. 12 N., R. 89 W., 6 P.M., 2 miles east of Savery, Carbon County, Wyo.
16	June-August 1953	I.H.I. No. 2	Removal	Hunt Construction Co.	Sec. 16, T. 5 S., R. 92 W., 6 P.M., 7 miles northeast of Rifle, Garfield County, Colo.
17	January-June 1954	La Plata	Smothering	Alvis F. Denison and Burnett Construction Co.	Sec. 13, T. 32 N., R. 13 W., N.M.P.M., 25 miles north of Farmington, San Juan County, N. Mex.
18	June-July 1954	Linwood	do.	Conrad's Construction Co.	Sec. 24, T. 12 N., R. 109 W., 6 P.M., 45 miles south of Green River, Sweetwater County, Wyo.
19	May-June 1954	Slagle	do.	Wallace Beard	Sec. 5, T. 46 N., R. 7 W., N.M.P.M., 10 miles east of Dallas, Ouray County, Colo.
20	June-July 1954	Soda Lake	do.	Nugget Coal Co.	Sec. 18, T. 25 N., R. 89 W., 6 P.M., 30 miles north of Rawlins, Carbon County, Wyo.
21	July-August 1954	Castle Garden	do.	do.	Lot 3, S. 5, T. 34 N., R. 90 W., and S. 32, T. 35 N., R. 90 W., 6 P.M., 18 miles southeast of Moneta, Fremont County, Wyo.
22	June-August 1954	Yellow Jacket	do.	Hunt Construction Co.	Sec. 19, T. 2 N., R. 92 W., 6 P.M., 15 miles northeast of Meeker, Rio Blanco County, Colo.
23	August-November 1954	Ranger Station	Isolation	Bureau of Mines, Bureau of Land Management, and Bureau of Public Roads	Sec. 15, T. 6 S., R. 14 W., S.M., 3-1/2 miles west of Homer, Kenai Peninsula, Alaska.
24	October-December 1954	Moose Creek	Smothering	Wilson Excavating Co.	Sec. 27, T. 19 N., R. 2 E., S.M., 11 miles northeast of Palmer, Matanuska Valley (Moose Creek), Alaska.
25	June-July 1955	Fuller	do.	G. E. Marshall	Sec. 28, T. 20 N., R. 56 E., M.P.M., 16 miles west of Savage, Dawson County, Mont.
26	July-August 1955	Black Mesa	do.	Alvis F. Denison	Not surveyed--Navajo Indian Reservation, 13 to 17 miles southwest of Kayenta, Navajo County, Ariz.

TABLE 3. - Chronological listing of completed and controlled projects (Con.)

No.	Date	Name	Method	Contractor	Location--legal description
27	July-September 1955	Onion Lake	Smothering	Homer N. Gerbaz	Sec. 3, T. 47 N., R. 7 W., N.M.P.M., 16 miles southeast of Montrose, Montrose County, Colo.
28	June-July 1956	Terry No. 1	do.	Darold C. Jones	Sec. 10, T. 12 N., R. 51 E., M.P.M., 2 miles northeast of Terry, Prairie County, Mont.
29	July-August 1956	Terry No. 2	do.	do.	Sec. 11, T. 12 N., R. 51 E., M.P.M., 2-1/2 miles northeast of Terry, Prairie County, Mont.
30	do.	Glendive Creek	do.	Law Construction Co.	Sec. 22, T. 16 N., R. 56 E., M.P.M., 6 miles east of Glendive, Dawson County, Mont.
31	June-October 1956	Deer Creek	do.	Darold C. Jones	Sec. 4, T. 16 N., R. 55 E., M.P.M., 11 miles northwest of Glendive, Dawson County, Mont.
32	July-October 1956	Alkali Butte	do.	Boatright-Smith	Sec. 25, T. 34 N., R. 95 W., 6 P.M., 13 miles south of Riverton, Fremont County, Wyo.
33	October-December 1956	Newcomb	do.	Ray L. Atchison	Sec. 31, T. 25 N., R. 17 W., N.M.P.M., 40 miles southeast of Shiprock, San Juan County, N. Mex.
34	May-June-1957	Ricci	do.	H. J. Wimmer	Sec. 35, T. 20 S., R. 5 E., S.L.P.M., 20 miles southwest of Ferron, Sevier County, Utah.
35	June-September 1957	Two Trees	do.	James A. Vaughn	Sec. 14 and 15, T. 4 S., R. 48 E., P.M.M., 20 miles west of Broadus, Powder River County, Mont.
36	August-October 1957	Poposia	do.	Larson & Skivington	Sec. 3 and 4, T. 33 N., R. 98 W., 6 P.M., 3 miles south of Hudson, Fremont County, Wyo.
37	June 1958	Three Forks	do.	L. P. Anderson	Sec. 7 and S. 6, T. 5 S., R. 49 E., M.P.M., 20 miles southwest of Broadus, Powder River County, Mont.
38	June-July 1958	Reservation Creek	do.	do.	Sec. 14, T. 2 S., R. 43 E., M.P.M., 10 miles northwest of Ashland, Rosebud County, Mont.
39	June-July 1958	Virgin Weidner	do.	do.	Sec. 9, T. 16 N., R. 56 E., M.P.M., 8 miles northeast of Glendive, Dawson County, Mont.
40	July-October 1958	Hoffman Creek	do.	H. J. Wimmer	Sec. 9, T. 13 S., R. 11 E., S.L.M., 14 miles northeast of Price, Carbon County, Utah.