Resins in Coal

A summary[11] was prepared of available information on the nature, occurrence, and possible utilization of resins found in coal, with particular reference to western coals of the United States and Canada. Two forms of resins are visible in coal. One form, usually designated as a microscopic form of resin, is present in most coals. It is visible in thin section under the microscope and consists of small particles mixed with the coal so intimately that it cannot be removed by mechanical methods. The other form, designated as lump-type resin, is visible to the naked eye and can be recovered by crushing the coal and removing the separated resins by flotation methods. Some resinous western coals contain approximately 5 percent of these lump-type resins. According to published information, attempts have been made to evaluate lump-form coal resins for varnish making, and these indicate that coal resins as recovered from certain western resinous coals by flotation methods might be suitable for making the cheaper grades of dark varnishes. One investigator has reported that lump-form resins as recovered by flotation from resinous Utah coals contain waxes and asphaltic substances, which, if removed, give a purified resin suitable for making light varnishes.

COAL MINING

Experimental Mine and Dust Explosions

Technical Assistance and Service to Others

The Experimental Coal Mine and Dust Explosions Section assisted other sections of the Bureau of Mines, the War Department, and other Federal Agencies, and many national safety groups and industries. These activities included the preparation of coal for special tests by the Synthetic Fuels Division; lectures and demonstrations on dust explosibility and on mine-roof problems to groups of inspectors of the Coal Mines Inspection Division; assistance in designs of portable equipment for testing flame safety lamps, gas-flow equipment, and low-pressure manometers by the Safety Division and other sections; supplying of new information through reports on dust explosion research and assisting members of the Safety Division in miscellaneous field problems to facilitate plant inspections; and providing information to the Safety Division in connection with preparation of safety instruction manuals on coal mining. Consulting advice was given to military agencies on test methods and on precautions for preventing ignitions of various dust mixtures. Information was supplied to interested laboratories on special instruments used in dust-explosion studies, and to industrial companies on particle-size distribution and measurements and on means for reducing dust explosions. During the year an increasing number of technical men, some from foreign nations, visited Bureau laboratories to gather information on test methods and equipment.

11/ Selvig, W. A., Resins in Coal: Bureau of Mines Tech. Paper 680, 1945, 24 pp.

Studies of Coal-Mine Roof

The experimental project of roof sealing by means of a gilsonite-base paint in the Montour No. 10 mine of the Pittsburgh Coal Co. was inspected, and possible reasons for the ineffectiveness of the paint to prevent roof disintegration were analyzed. A wax-containing wetting agent was tested and found unsuitable as a roof-sealing medium. Tests were made of core-drill samples of shale from the immediate roof overlying the No. 7 Ohio coal bed in northeastern Ohio to provide data for predicting roof difficulties that might be encountered in a proposed mine. Assistance was given a railroad company on surface subsidence problems in connection with a railroad bridge to be erected over a coal-mining area. Information on roof-convergence problems and a recorder for testing were supplied to a group at Lehigh University working on the reduction of roof accidents in the anthracite field.

Allaying Dust in Coal Mines

Increased use of rubber-tired shuttle cars and other mining equipment in coal mines has emphasized the need of compacting or otherwise allaying the loose dust on the floor of mine roadways. The presence of such dust, ground to fine size by traffic and thrown into suspension in the air, constitutes an explosion hazard, is physiologically harmful, reduces visibility, and diminishes traction for the vehicles. Some mines have attempted to treat the dust with calcium chloride, which deliquesces when exposed to the mine atmosphere and thereby wets and consolidates the dust. To study the effectiveness of this procedure, Bureau engineers made tests in two operating mines and also investigated, under controlled laboratory conditions, the rate and extent of moisture absorption and the consolidation of mixtures of mine dust with calcium chloride, with commercial-grade, granular sodium chloride, and with samples of these salts that had been sprayed with wetting agents.

Figure 4 shows the rate of moisture absorption in air at 61° F. and 89 to 91 percent relative humidity by untreated calcium chloride and by calcium chloride treated with a wetting agent, and also by similar samples of sodium chloride. Figure 5 shows the rate of moisture absorption by a road-dust sample from one mine and by mixtures of the dust covered, with 1 and 3 percent untreated calcium chloride and of untreated sodium chloride, respectively. The principle conclusions from field and laboratory studies are: (1) In roadways of normally humid mines the loose dust can be consolidated effectively by proper application of 2 to 3 percent calcium chloride or sodium chloride; (2) in locations where the humidity is high - about 90 percent - sodium chloride is at least as effective as calcium chloride; and (3) untreated salts are as effective as salts which had been treated with wetting agents. A publication[12] giving the details of the work just described was issued.

Laboratory tests were conducted to determine whether ordinary commercial-grade glycerin would be effective as a wetting agent for allaying coal dust

12/ Thomas, E., and Hartmann, I., Use of Salts to Allay Dust on Shuttle-car Roadways in Coal Mines: Bureau of Mines Rept. of Investigations 3828, 1945, 15 pp.

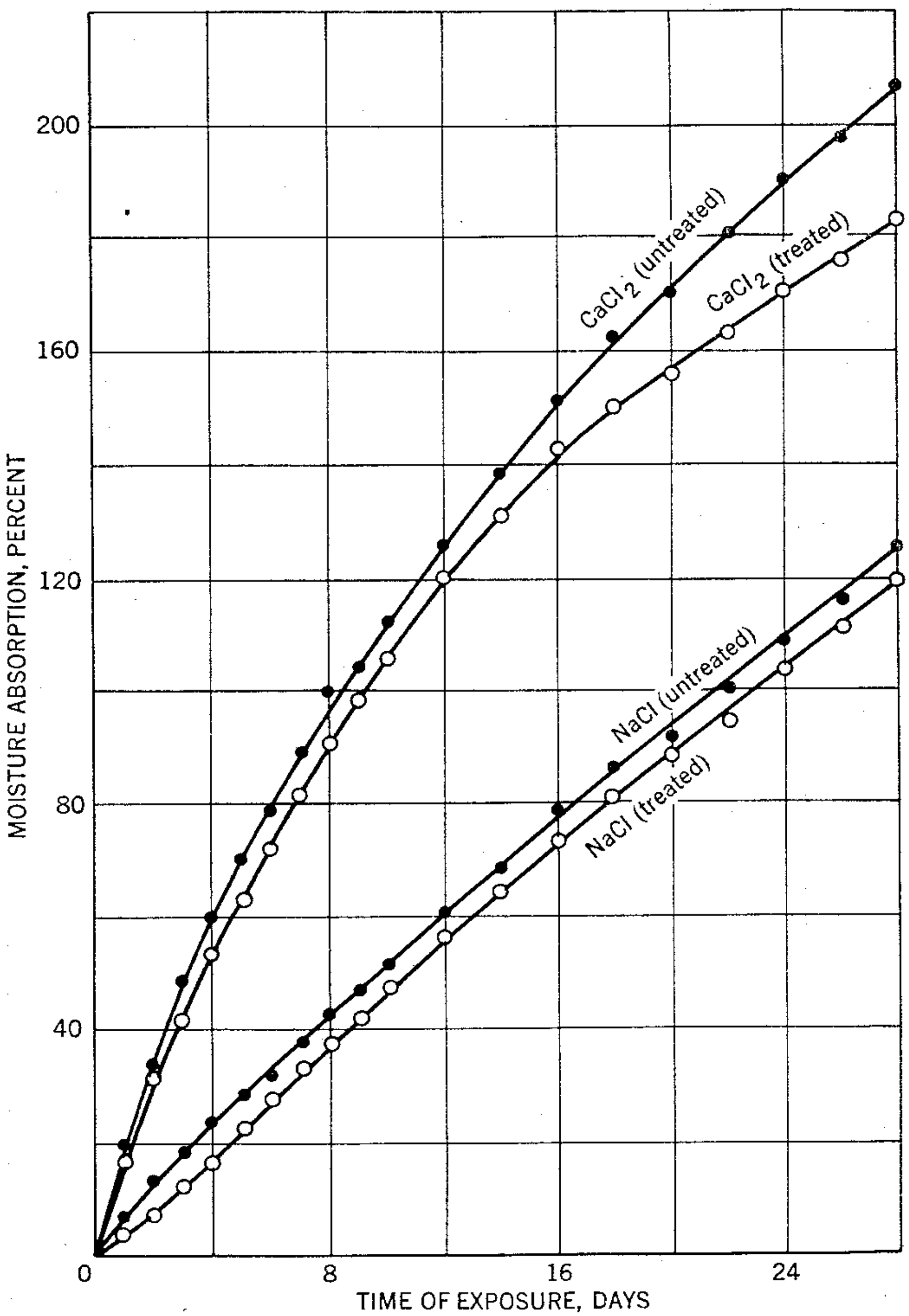

Figure 4. - Moisture absorption of calcium chloride and sodium chloride at 61 F. and 89 to 91 percent relative humidity.

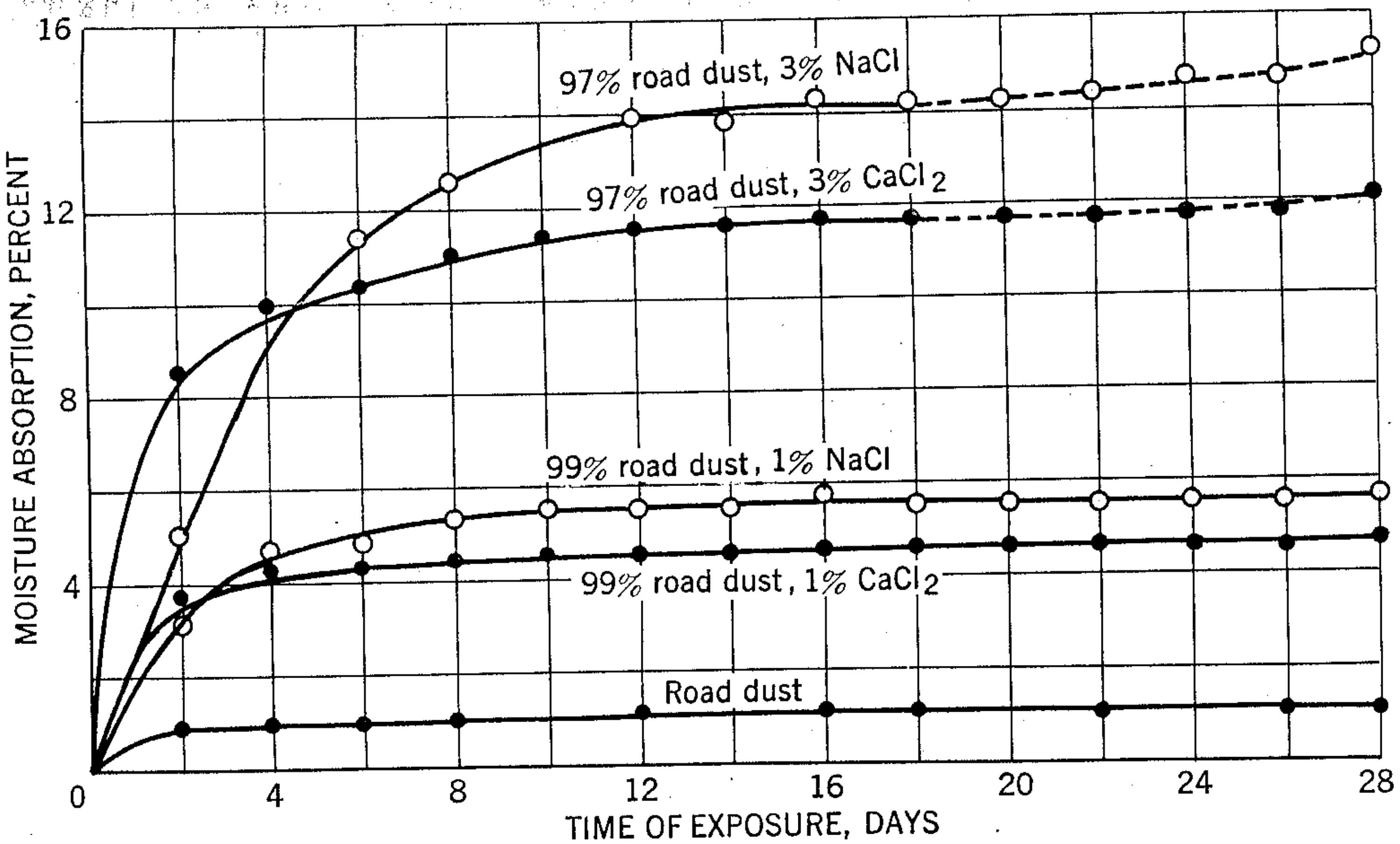

Figure 5. - Moisture absorption of No. 30 mine dust and untreated salt mixtures at 61 F. and 89 to 91 percent relative humidity.

with water in mines. Coal dust is quite resistant to wetting by water alone. Concentrations as high as 1 part of glycerin to 10 parts of water proved to be no better than water alone.

Application of Rock Dust in Coal Mines

Results were reported last year of tests with an automatic device designed to provide protection against propagation of coal-dust explosions near the working faces and in trackless entries of coal mines. The device consists of a wire-mesh basket with a drop bottom, which is opened by the pressure wave preceding the explosion flame, allowing the rock dust in the basket to be dispersed into the mine entry in the path of the explosion. During the year additional tests were made with these baskets and also with cardboard containers with a hinged bottom which function in the same manner as the baskets. Preliminary tests indicate that the cardboard containers are about as effective and are easier to install than the wire baskets. Further tests will be required to determine the value and limitations of these two devices.

Inflammability and Explosibility of Industrial Dusts and Powders

A potential dust-explosion hazard exists in some 28,000 industrial plants in the United States which employ an estimated 1,000,000 persons.[13] Many of these plants produce powders or dusts as primary products, and in other plants the dust is a byproduct of manufacturing operations.

Formerly only carbonaceous dusts, such as coal, grain, sugar, and wood flour, were known to be capable of forming explosive mixtures with air. Recent experiences and laboratory studies have shown that some metal powders are more hazardous than carbonaceous dusts. At present, over 50 types of metals, metal alloys, metal hydrides, metal phosphides, and mixtures containing metals are produced and used in powdered form, some of them in huge amounts. This increased production was accompanied by an increase in the number of metal-dust explosions and fires. Between March 1939 and February 1944 at least 32 severe explosions, in which 19 persons were killed, were officially reported in commercial plants. A recent publication[14] lists the types of powders, their methods of production, and their principal applications in industry and in the military field; discusses ignition sources, factors affecting explosibility, and the fineness and concentration of the dust entering into an explosion; classifies the more than 100 metal-dust samples studied into three groups; and suggests means of reducing the explosion hazard through certain preventative measures.

Additional information was furnished to a subcommittee of the National Fire Protective Association, working on the problem of preventing dust

13/ Brown, R. H., Industrial-Dust Explosions: Bureau of Mines Inf. Circ. 7309, 1945, 7 pp.
14/ Hartmann, I., and Greenwald, H. P., The Explosibility of Metal-Powder Dust Clouds: Min. and Met., vol. 26, 1945, pp. 331-335.

explosions in the plastics industry. These data are incorporated in the safety code[15] prepared by the subcommittee.

Material was prepared for a new book on Industrial Hygiene and Toxicology which is to include the subject, Explosion and Fire Hazards from dusts.[16]

New useful experimental data on dust explosibility were obtained during the year for 123 samples submitted by industries and military agencies. The samples included 34 metal powders and powders containing metals and their compounds, 24 food and other agricultural dusts, 22 incendiary, smoke, and other pyrotechnic mixtures used in chemical warfare, 18 powders used in the plastics industry, and coal, coke, rubber, and other dusts. Tests of 11 atomized aluminum powders of about equal fineness, submitted by 6 manufacturers through the War Production Board, showed that slight variation in manufacturing procedure or in purity of the powders had little effect on the explosibility of the final products. Comparison of test data for 3 atomized-magnesium and 1 atomized-magnesium-aluminum alloy powders with test data for milled and stamped powders of these metals showed that the atomized powders are the least explosive and the stamped powders most explosive, However, it must be kept in mind that atomization is a continuous process involving large quantities of powder at all times, whereas milling and stamping operations are generally performed with limited batches.

New Gallery Tests of Dust Explosions

The pressures developed by violent dust explosions in a confined space are so great that few manufacturing structures can withstand them without serious damage. One means for reducing such destruction is by providing, in the enclosing walls or roof, rapidly opening explosion-relieving devices or vents through which the pressure of an incipient explosion can be dissipated. To provide technical information on which the design of pressure-relief vents can be based and to furnish data on violent dust explosions, an extensive investigation of this problem was started. A 64-cubic foot gallery was designed and built, which has adjustable rectangular and square openings on three sides and on top, and in which dust explosions can be studied under controlled conditions. The gallery is housed in a shed 12 by 12 feet in area and 12 feet in height, whose sides are opened during tests. During the year, 377 explosion tests were made with dust clouds of pulverized coal, corn starch, soy bean protein, wood flour, phenolic resin, atomized aluminum, and stamped or flaked aluminum powder. In most tests no diaphragms or other restrictions were placed on the vent. Figure 6 shows an explosion of an atomized aluminum-powder dust cloud of 0.200 ounce per cubic foot concentration being vented through four openings having a combined area of 2.25 square feet or a relief ratio of 3.52 square feet per 100 cubic feet of volume of

15/ Jones, W. M., Forney, R. L., Hartmann, I., Hirst, H. S., and Merrill, J. W., Code for the Prevention of Dust Explosions in the Plastics Industry: Nat. Fire Protec. Assoc. Quart., vol. 38, pt. 2, April 1945, pp. 11-28.

16/ Hartmann, I., Explosion and Fire Hazard from Dusts: Industrial Hygiene and Toxicology (F. A. Patty, ed.), Interscience Publishers, Inc. (In press.)

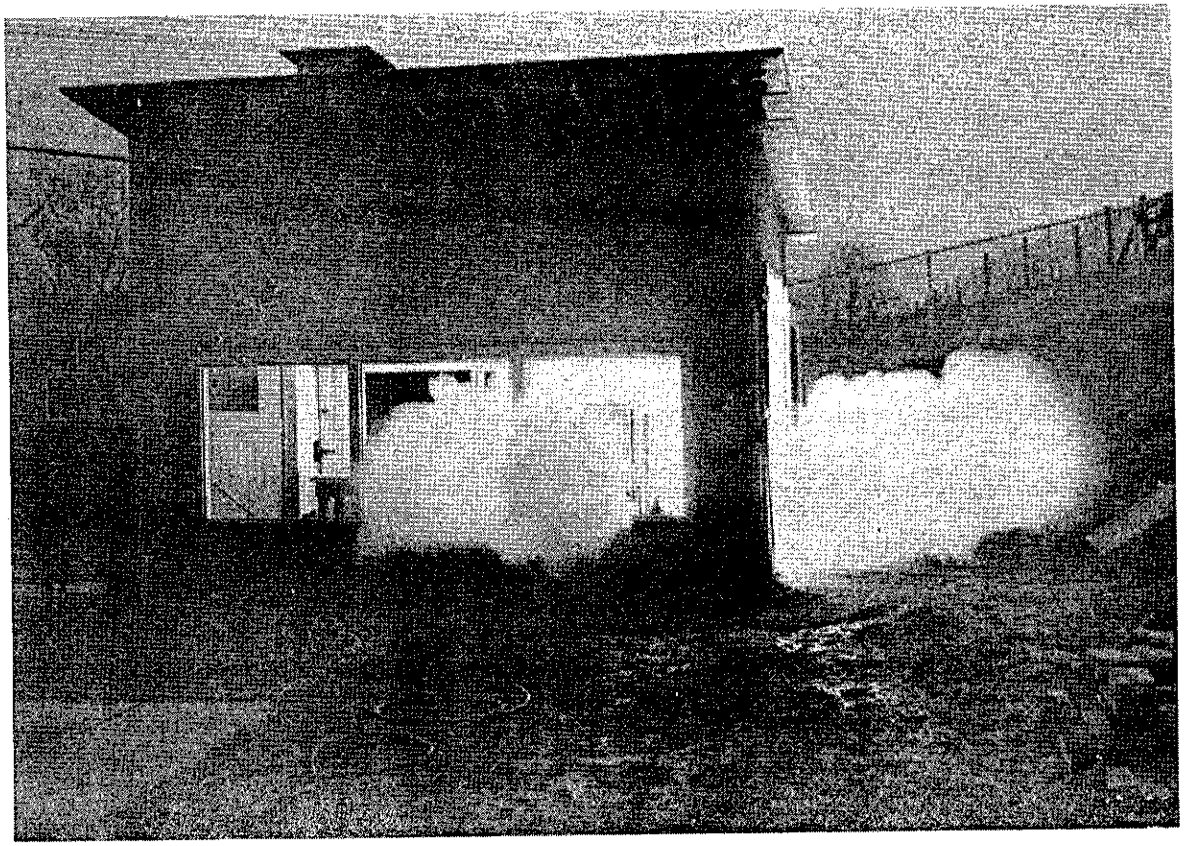

Figure 6. - Explosion of atomized aluminum-powder dust cloud in 64-cubic foot gallery vented through opening at top and on three sides of gallery.

enclosure. Much of the interior of the shed surrounding the test gallery is obscured by the flame of the explosion. Most explosions were initiated by the flame of a small amount of guncotton, whose ignition was timed with the formation of the dust cloud; in other tests ignition was effected by a high-voltage induction spark. To date, the most violent explosions were developed by clouds of stamped-aluminum powder. To prevent the development of a pressure greater than 300 pounds per square foot with this powder, the unrestricted relief area had to exceed 7.5 square feet per 100 cubic feet. The same pressure reduction for wood flour and for pulverized coal could be accomplished with a relief-vent ratio of only 1.5 square feet per 100 cubic feet. A preliminary publication of the completed work is being prepared. Two additional galleries of different sizes have been designed and are under construction. Studies of various factors involved in this problem are being continued.

Exploration of Coal Deposits

Exploration for coal deposits by Bureau engineers of the Coal Mining Section during the past fiscal year will be considered under two headings: (1) Coking coals, and (2) coal reserves in areas of critical fuel supplies.

Coking Coals

The erection of steel plants in the West to augment production of steel for war made it advisable to seek additional nearby sources of coking coals. The only known source of metallurgical coal west of the Continental Divide available to these plants before the war was the Lower Sunnyside bed in Carbon County, Utah. The reserves in that area are reported to be extensive, but the outlet is restricted to one railroad which, if cut off for any reason, would seriously curtail steel production in western plants. Explorations therefore, were made in other western coal fields.

A reserve of high-volatile A bituminous coking coal was proved in Oyster Ridge, near Kemmerer, Lincoln County, Wyo. Results of the exploration, carbonization properties of the coal, and plans for development of this coal were published.[17]

The area explored comprises 12 sections; except for a few small tracts, the coal and mining rights are owned by the Government. The southern limit of the area is about 3.5 miles north of the end of a standard-gage railroad and about 12 miles north of Kemmerer, a station on the Union Pacific Railroad. The thickness, physical characteristics, and extent of this Willow Creek-bed coal and underlying and overlying strata were determined by 18 diamond-drill holes, which yielded 2-1/4-inch cores. Chemical and petrographic analyses (see p. 12) were made of these cores, and the dip and strike of the bed were computed from the drilling data. Two diamond-drill holes to recover 8-inch

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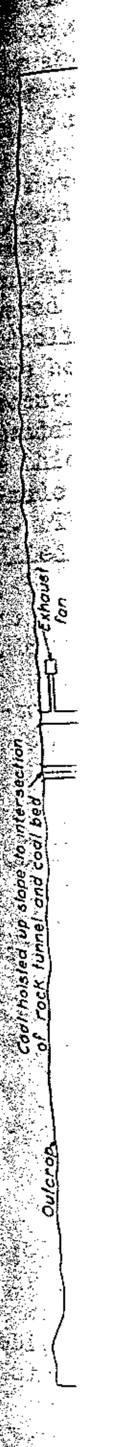
17/ Toengas, A. L., Davis, J. D., Turnbull, L. A., and Schopf, J. M., Reserves, Bed Characteristics, and Coking Properties of the Willow Creek Coal Bed, Kemmerer District, Lincoln County, Wyo.: Bureau of Mines Tech. Paper 673, 1945, 48 pp.

cores were drilled in proved areas to procure enough coal for large-scale car-bonization tests at 900° C. The Willow Creek group is composed of Lower, Mid-dle Main, and Upper (Rider) beds. The Middle Main bed, considered minable, averages 54 inches in thickness and dips west from the outcrop in Oyster Ridge into the Lazeart synclincal basin. The yields of carbonization products and the analyses and physical properties of the cokes were compared with corres-ponding data previously obtained by the Bureau of Mines on the Willow Creek bed, Gomer mine, coal and the Lower Sunnyside bed, Columbia mine, coal. In general, the shatter tests indicated that the Willow Creek cokes were as strong as the Lower Sunnyside coke, but in both the shatter and tumbler tests larger percentages of minus 1/4-inch coke resulted. Box coking tests of Willow Creek and Lower Sunnyside coals and of 60:40, 50:50, and 40:60 blends of these coals were made by the Columbia Steel Co. Results of the 50:50 blend indicated that this mixture would produce a satisfactory metallurgical coke based on Columbia Steel Co. standards. The coking properties of Middle Main Willow Creek coal can be improved by mechanical cleaning; partings in the coal bed cannot be effectively removed by hand. The exploration has in-dicated reserves of coking coal in three areas totaling 1,710 areas of sur-face. These reserves are estimated at 15,345,000 tons, of which 11,215,000 tons are considered recoverable. Physical conditions in and around the bed should not make mining problems too difficult, if modern mining practices are followed. The field can be opened in one area by the development of two mines at a cost of about $1,400,000, exclusive of road, railroad, and water supply, which are estimated at $330,000 additional. Mining costs under present con-ditions are estimated at $3.10 per ton. Figure 7 shows a proposed plan of development adaptable to conditions indicated by the exploration.

An area in Gunnison County, Colo., adjacent to Minnesota Creek was ex-plored by diamond drilling. Ownership of the land is divided about equally between Government and private interests. Paonia, a station on the Denver & Rio Grande Railroad, is about 6 miles west of the area; a dirt road extends from Paonia to the southern boundary of the land. The terrain is very moun-tainous, and access to the area is difficult. Four diamond-drill holes yielded 2-1/4-inch-diameter cores. Chemical and petrographic analyses were made of the coal cores, and the dip and strike of the beds were computed from the drilling data. A diamond-drill hole to recover 8-inch coal cores was drilled in the proved area to procure enough coal for carbonization tests. These tests showed that the coal of Minnesota Creek is not suitable for mak-ing metallurgical coke. However, the exploration indicated large areas of recoverable coal available for industrial and domestic purposes.

A reconnaissance was made of coal areas in the Coal Creek district, Colo-rado - including the Grand Mesa, Mount Carbon, and Durango-Gallop fields. The results of this survey indicate that coal having coking qualities occurs in these fields. These areas are on the western slope of the Continental Divide and could serve as sources of supply of coking coal for western steel plants should exploration prove minable reserves, should carbonization tests show that the coke is suitable for blast-furnace use. One diamond-drill hole was drilled in the Coal Creek district, Grand Mesa field, in connection with the exploration of the Minnesota Creek area, Paonia, Colo. This drilling pene-trated three minable coal beds. Table 4 gives the analyses of coal cores



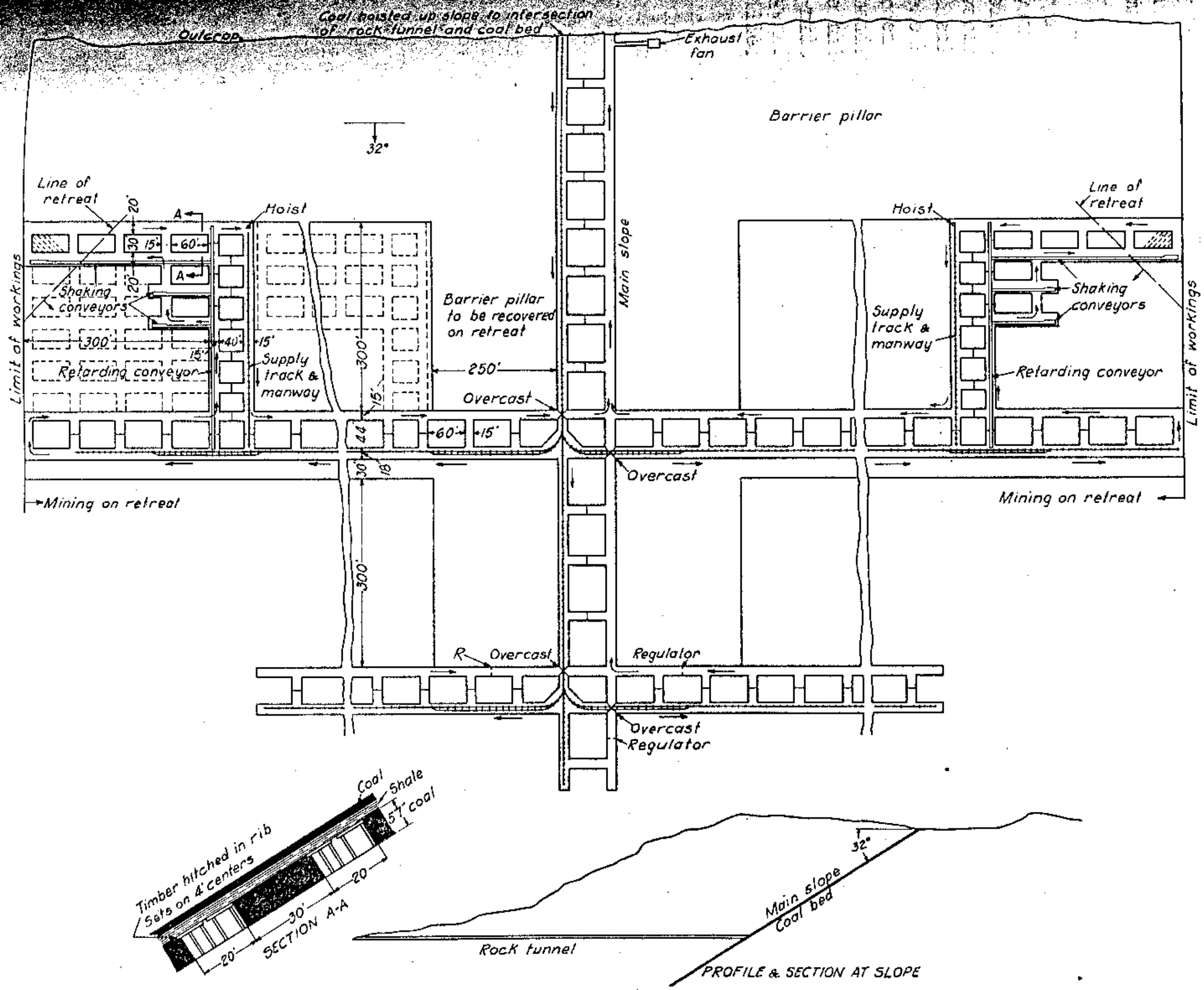


Figure 7. - Plan of development adaptable to conditions indicated by exploration of Willow Creek-bed coal.

from the 2-1/4-inch hole and indicates that the coal has coking qualities. Further exploration of the Coal Creek area will be conducted during the coming year. Should minable reserves be proved, mines that may be developed can be served by the extension of a standard-gage railroad at a distance of about 5 miles.

Seventy percent of the coal produced in the Georges Creek coal basin in Maryland is from mines operating in the Pittsburgh (Big Vein) and Sewickley (Tyson) coal beds. Reserves of recoverable coal left in these beds are limited, and mining is confined to the extraction of pillars which were not recovered in previous mining operations. Production in this field is certain to decline unless it is increased from the lower, thinner beds. Coals from these beds are low- to medium-volatile coking coals, usually containing high percentages of ash and sulfur. Based on a reconnaissance of the field, recommendations were made that it be explored by diamond drilling to determine the thickness and extent of the lower coal beds and that washability tests be made to determine the extent to which the coals can be improved by washing. The exploration to date indicates that the coal beds in the area drilled are thicker in the east than in the west limb of the synclinal basin.

TABLE 4. - Analyses of coal cores from Coal Creek district, Grand Mesa field

Laboratory number	Conditions 1/	Agglomerating index	Agglutinating value	Percent									Calorific value, B.t.u.	Fusability of ash, °F. 2/		Bed
				Moisture	Volatile matter	Fixed carbon	Ash	Sulfur	Hydrogen	Carbon	Nitrogen	Oxygen				
C-26870	1	CF	4.0	2.9	40.2	52.3	4.6	1.4	5.8	76.3	1.6	10.3	13,760	2,060	ID	A
	2				41.4	53.9	4.7	1.5	5.7	78.5	1.7	7.9	14,170	2,210	S	
	3				43.5	56.5	-	1.5	6.0	82.4	1.8	8.3	14,880	2,420	F	
C-26950	1	CF	4.1	3.1	38.0	50.5	8.4	.9	5.6	72.7	1.6	10.3	13,110	2,440	ID	B
	2				39.2	52.1	8.7	1.0	5.4	75.0	1.7	8.2	13,530	2,550	S	
	3				42.9	57.1	-	1.1	5.9	82.1	1.8	9.1	14,820	2,720	F	
C-26952	1	CF	4.1	2.8	38.3	51.5	7.4	.5	5.6	74.3	1.6	10.6	13,320	2,570	ID	C
	2				39.4	53.0	7.6	.5	5.5	76.4	1.6	8.4	13,700	2,710	S	
	3				42.6	57.4	-	.5	5.9	82.7	1.8	9.1	14,830	2,840	F	

1/ 1, Sample as received; 2, dried at 105° C.; 3, moisture-and-ash free.
2/ ID, initial deformation; S, softening; F, fluid.

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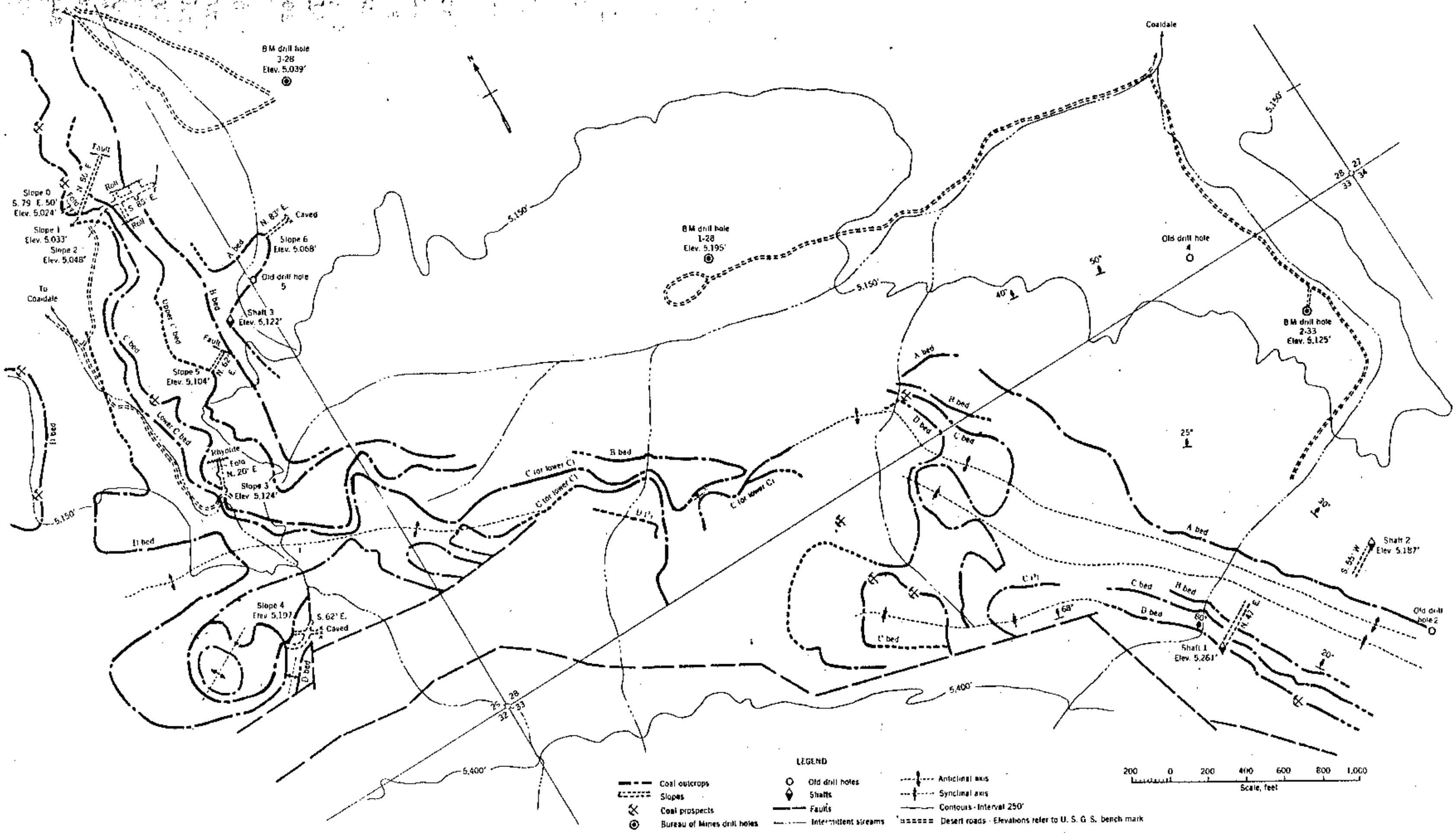

Figure 8. - Exploration in sec. 28, 29, and 33, T. 2 N., R. 37 E., M. D. M., near Coaldale, Esmeralda County, Nev.
(Prepared from map compiled by Geology of Fuels Section, Geological Survey)