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Degasification and Production of Natural Gas From an Air Shaft in the Pittsburgh Coalbed

UNITED STATES DEPARTMENT OF THE INTERIOR

Report of Investigations 8173

Degasification and Production of Natural Gas From an Air Shaft in the Pittsburgh Coalbed

By H. H. Fields, Joseph Cervik, and T. W. Goodman
Pittsburgh Mining and Safety Research Center, Pittsburgh, Pa.

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DEGASIFICATION AND PRODUCTION OF NATURAL GAS FROM AN AIR SHAFT IN THE PITTSBURGH COALBED

by

H. H. Fields,[1] Joseph Cervik,[2] and T. W. Goodman[1]

ABSTRACT

The Bureau of Mines conducted research to determine the effectiveness of long holes drilled in solid virgin coal in degasifying an area of the Pittsburgh coalbed showing that horizontal holes drilled into a virgin coalbed from the bottom of any shaft will effectively remove methane gas in commercial quantities from the Pittsburgh coalbed.

The in situ pressure at a depth of 214 feet into the coalbed and the average gas and water flows from the five degasification holes were 3 lb/in^2 gage and 860,000 ft^3/d and 1.7 gal/min, respectively. On June 19, 1975, after 593 days of degasification, a compressor was installed and pipeline quality gas was introduced into a commercial pipeline. As of June 1, 1976, after 1,022 days of degasification, over 753 million cubic feet of gas had been drained and 117 million cubic feet of gas had been purchased by the gas company for use in the local community of Wadestown, W. Va. The gas drained to date is six times the gas estimated to be in the area subtended by the holes. Methane emissions at the working face of 1 West mains, Federal No. 2 mine has been reduced by 50 pct, proving the value of methane drainage by horizontal degasification holes drilled from shaft bottoms ahead of mining.

INTRODUCTION

The Bureau of Mines has been responsible for the promotion of health and safety in mining since its establishment in 1910. Presently, in addition to other areas of research, it is engaged in methane control involving removal of methane from virgin coalbeds, from major panels being pillared, and from old gobs. Specifically, this study was designed to determine the effectiveness of long holes drilled in solid virgin coal in degasifying an area of the Pittsburgh coalbed.

Methane exists under pressure in micropores, joints, and fractures of gassy coalbeds, and also may be present in adjacent strata. A static in situ gas pressure of 275 lb/in^2g (gage) has been measured in the Pittsburgh coalbed

[1] Mining engineer.
[2] Supervisory geophysicist.

and the permeability of this bed has been found to be high compared with that of other coalbeds.[3] Dynamic gas pressure is a function of the piping system and ranges from 3 to 197 inches water gage and is regulated by hole size, collector piping system, and volume of gas available. Further, in a number of mines where gas wells are located in the Pittsburgh coalbed, significant bleed off of methane from the wells is evident.[4]

After 921 days of degasification, 596 million cubic feet of methane has been removed from the multipurpose borehole in a virgin area of the Pittsburgh coalbed.[5] As of March 15, 1975, it is still flowing at a daily rate of 500,000 ft^3/d into a commercial pipeline.[6] This indicates that a much larger area of virgin coal is being degasified than is defined by the holes. This study shows that horizontal holes drilled into a virgin coalbed from the bottom of any shaft will effectively remove methane gas in commercial quantities from the Pittsburgh coalbed.

ACKNOWLEDGMENTS

The cooperation of the managements of Eastern Associated Coal Corp., Federal No. 2 mine, Pittsburgh, Pa., and Consolidated Natural Gas Supply Corp., Clarksburg, W. Va., is greatly appreciated.

THE 18-FOOT-DIAM SHAFT SITE

The shaft utilized in this study is an 18-foot-diam, concrete-lined return air shaft located in a return airway of a projected set of 10 headings in 1 West mains of Eastern Associated Coal Corp., Federal No. 2 mine, approximately 4,000 feet from the nearest mine workings (fig. 1). The 18-foot-diam shaft is constructed with a set of four headings--one each in the north, south, east, and west directions. The Pittsburgh coalbed is 7 feet high at the shaft site.

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[3]Cervik, Joseph. An Investigation of the Behavior and Control of Methane Gas. Min. Cong. J., v. 53, No. 7, July 1967, pp. 32-37.

[4]Zabetakis, M. G., T. D. Moore, Jr., A. E. Nagel, and J. E. Carpetta. Methane Emission in Coal Mines--Effects of Oil and Gas Wells. BuMines RI 7658, 1972, 9 pp.

[5]Fields, H. H., J. H. Perry, and M. Deul. Commercial Quality Gas From the Multipurpose Borehole Located in the Pittsburgh Coalbed. BuMines RI 8025, 1975, 14 pp.

[6]Deul, Maurice, and A. G. Kim. Coal Beds: A Source of Natural Gas. Oil and Gas J., v. 73, No. 34, June 16, 1975, pp. 47-49.

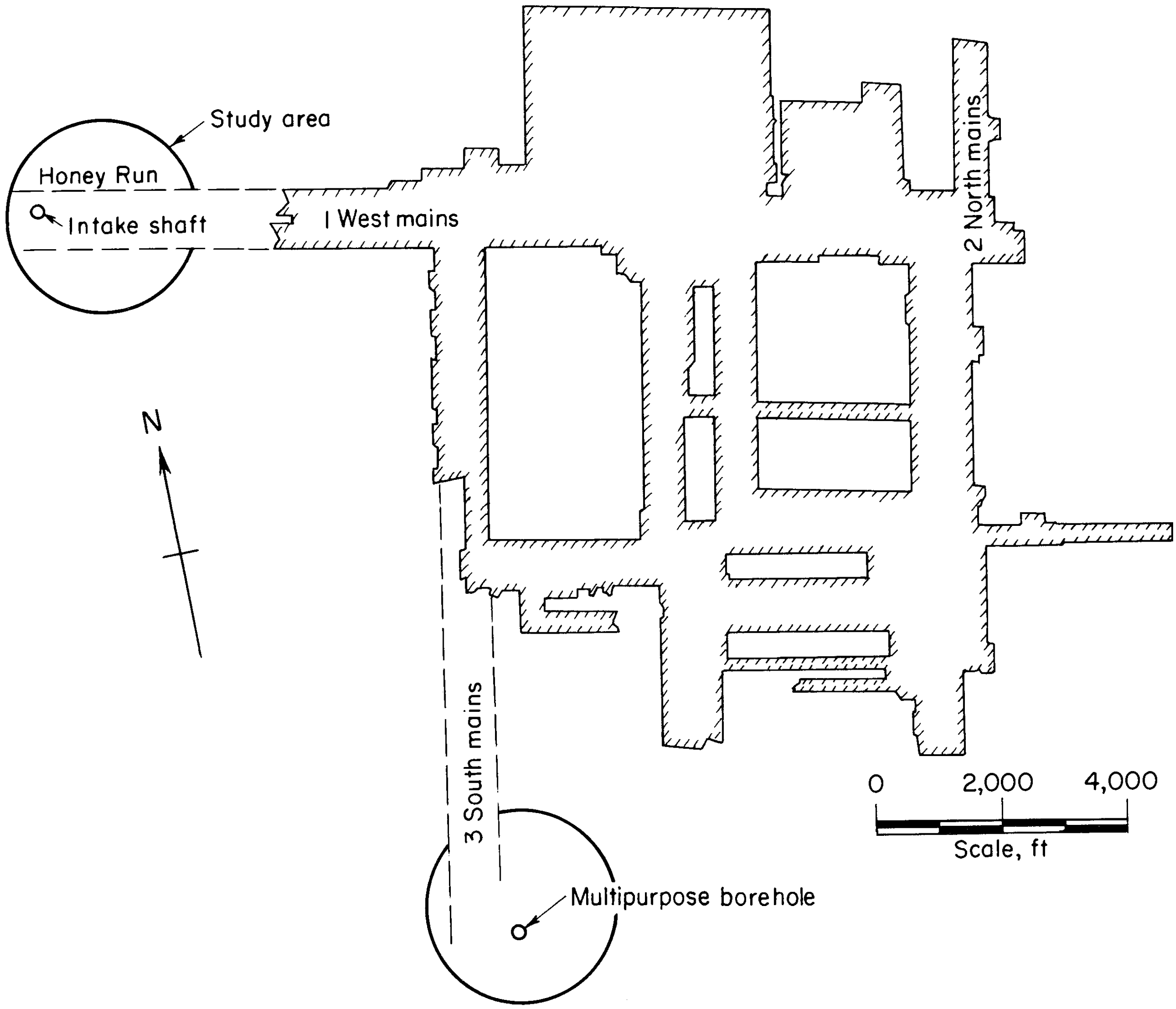

FIGURE 1. - Location of shaft site in virgin Pittsburgh coalbed.

HORIZONTAL HOLES

Five 3-1/2-inch-diam horizontal degasification and one in situ pressure hole were drilled: Two degasification and one pressure hole in the North heading and one degasification hole in each of the other three headings. The degasification holes were drilled ranging in depth from 670 to 2,126 feet and the pressure hole was drilled to a depth of 214 feet. The direction of holes with respect to face and butt cleats, relationships of shaft to a projected set of entries being driven toward the shaft, location of gas wells, and length of holes are shown in figure 2.

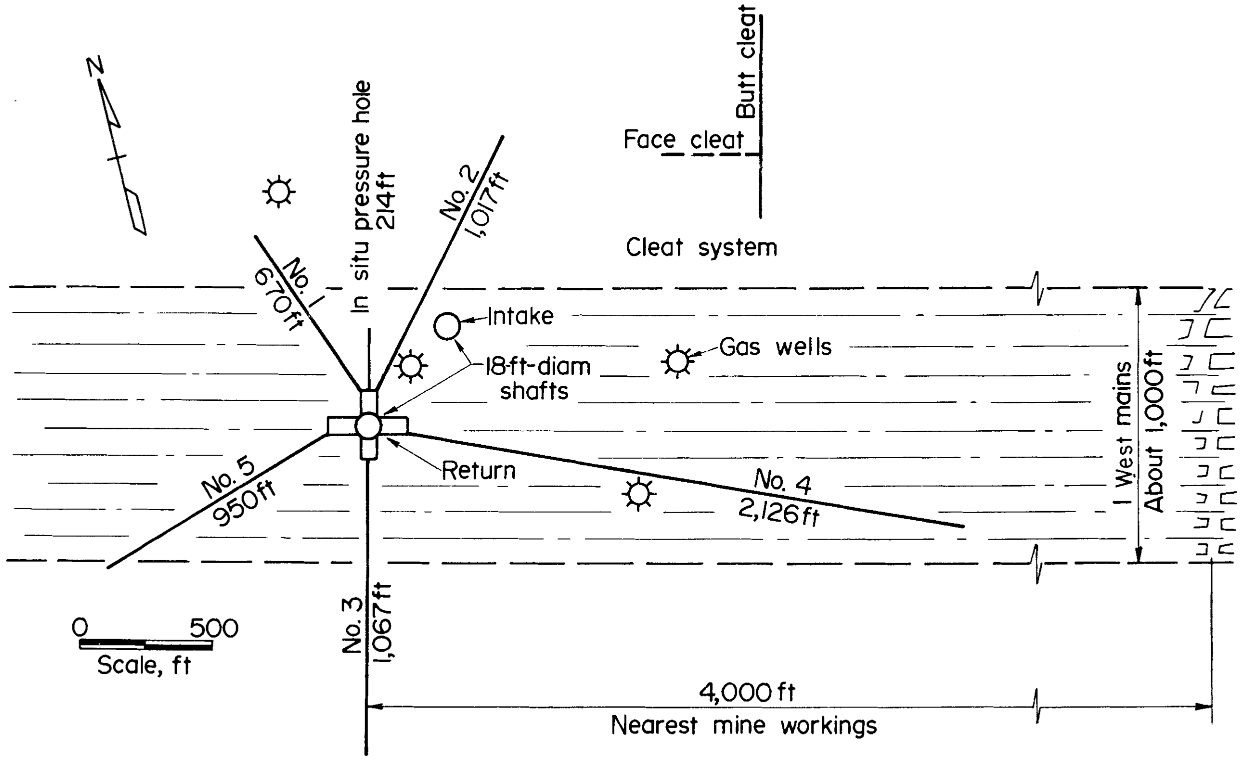

FIGURE 2. - Location of degasification holes underground with respect to closest mine workings, to projected main headings, and to face cleats.

A 30-hp, electrohydraulic horizontal drill was used to drill the 3-1/2-inch-diam degasification holes. Gas flow during drilling was controlled at the face by drilling through a Bureau-designed stuffing box which separated the gas from water and drill cuttings (figs. 3-6). Both during and after drilling, gas was piped to an 18-inch-diam, 7-foot-high receiver tank and then to the surface through an 8-inch-diam pipe. The stuffing box was attached to a 4-inch-diam pipe fitted with a 4-inch valve so the hole could be shut in, if necessary. The 4-inch-diam, 21-foot-long steel pipe was grouted into a 25-foot-deep, 6-inch-diam hole drilled into the coalbed (fig. 7).[7]

[7]Cervik, J., H. H. Fields, and G. N. Aul. Rotary Drilling of Holes in Coalbeds for Degasification. BuMines RI 8097, 1975, 21 pp.

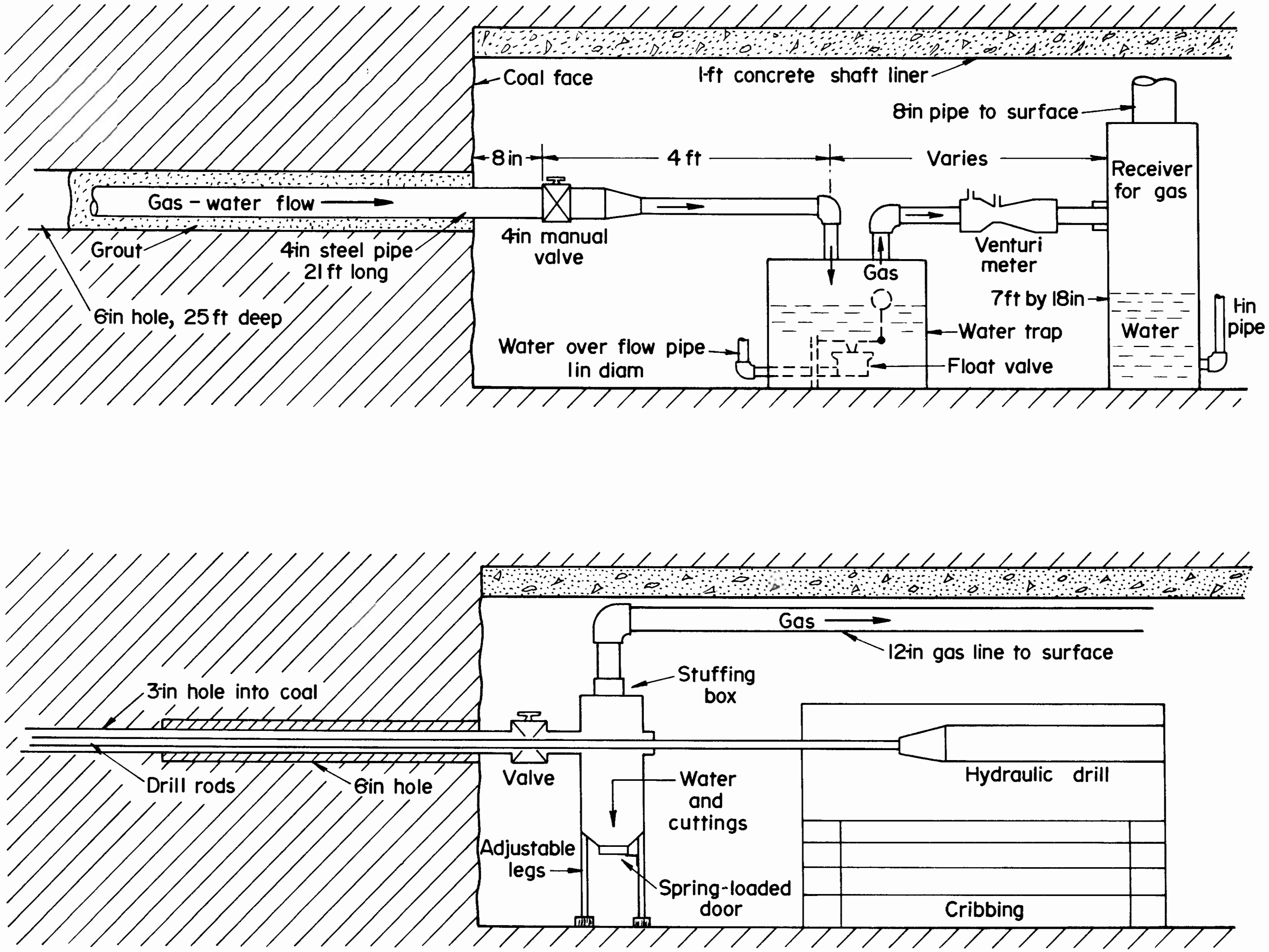

FIGURE 3. - Degasification hookup, during and after drilling.

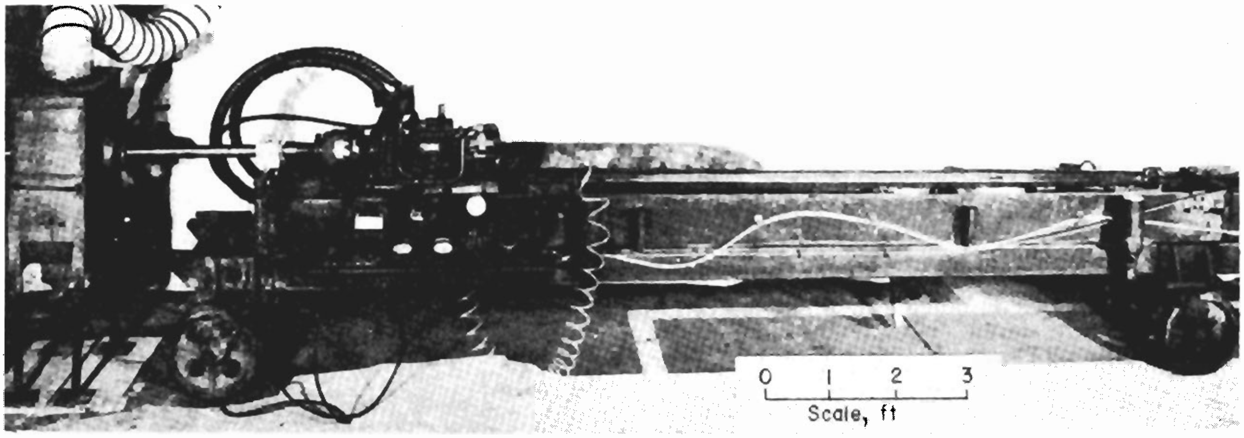

FIGURE 4. - View of drill.

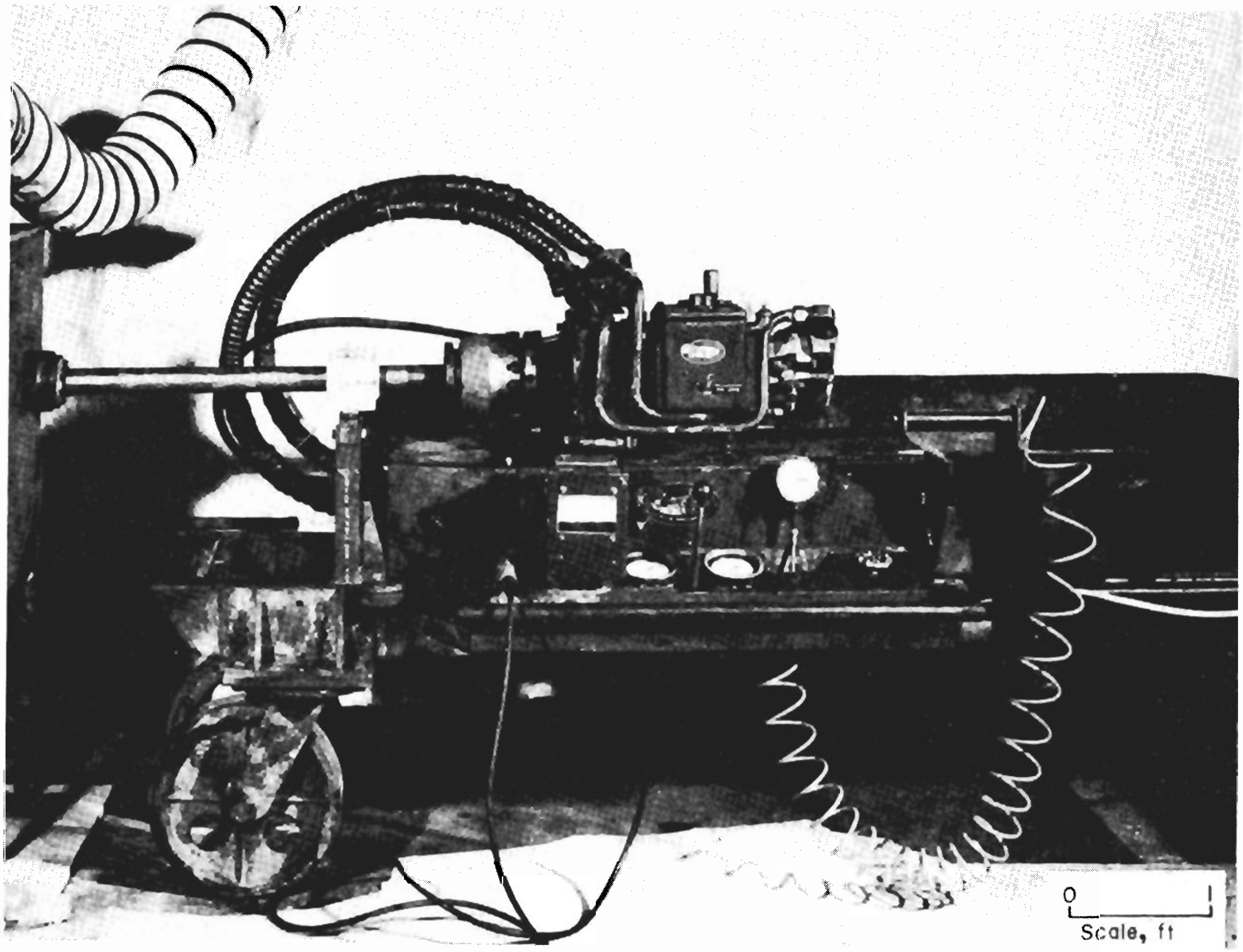

FIGURE 5. - View of drill controls.

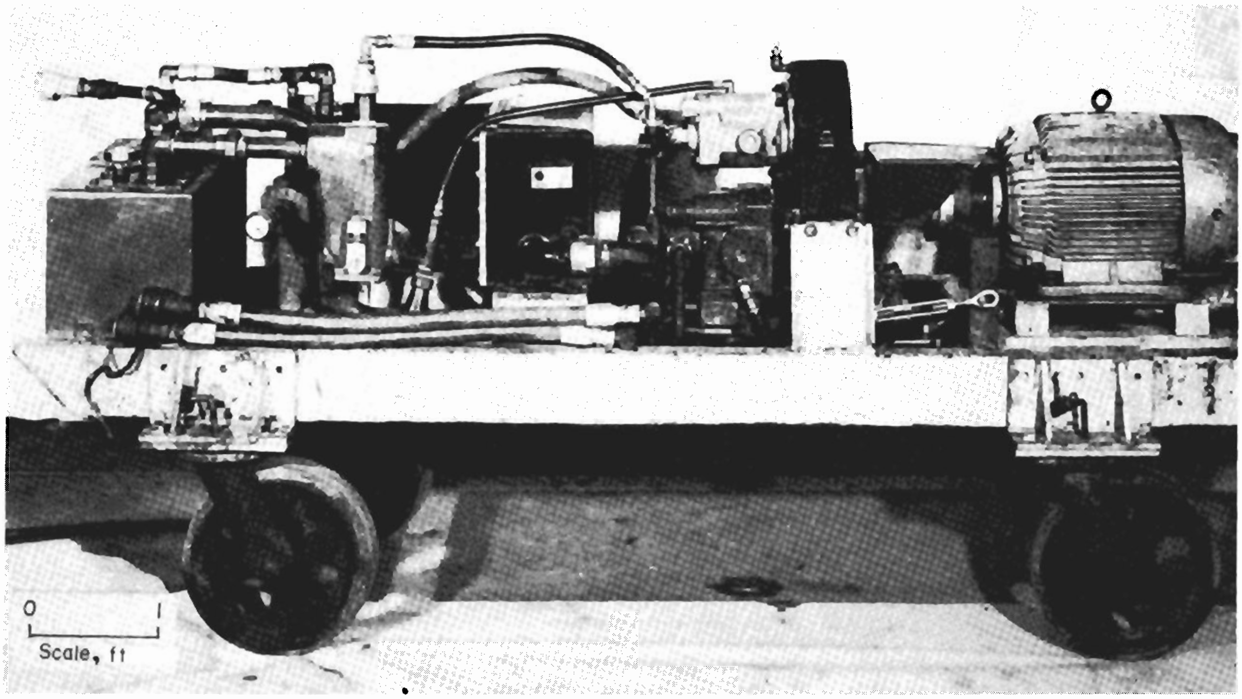

FIGURE 6. - View of drill powerpack unit (electrohydraulic).

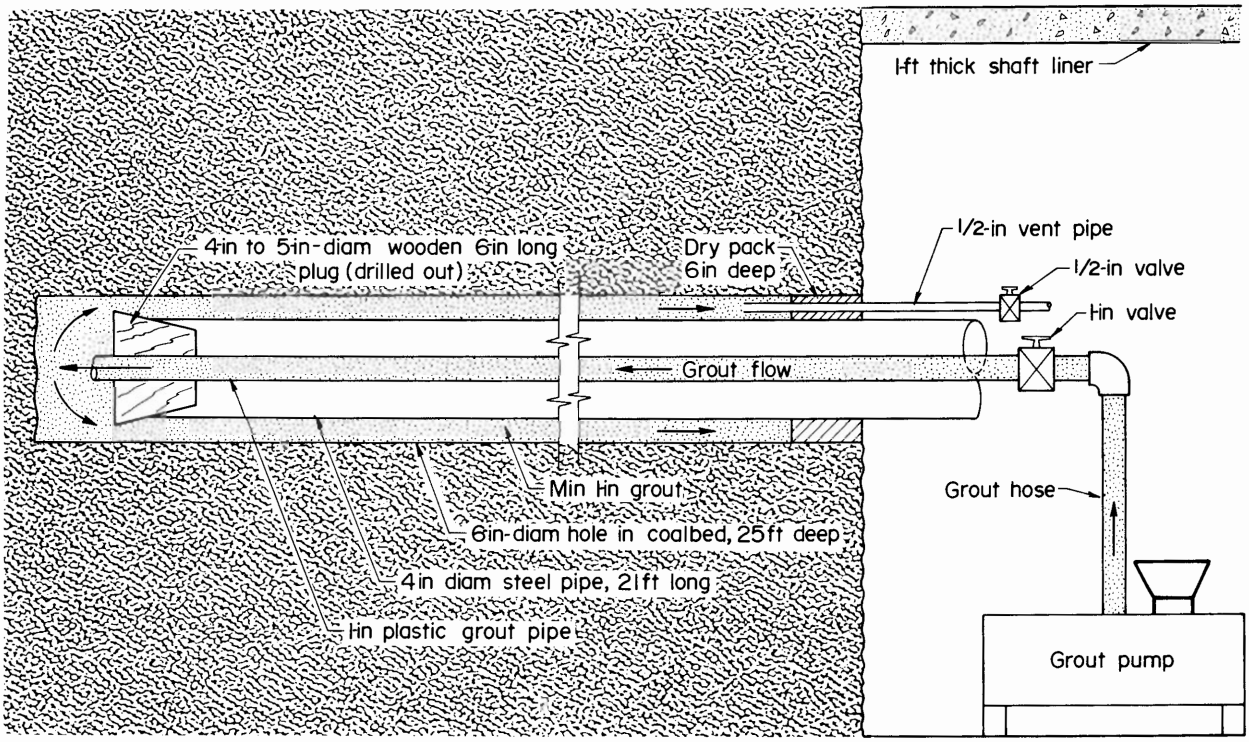

FIGURE 7. - Arrangement for grouting 4-inch-diam steel pipe into coalbed.

DEGASIFICATION AND DEWATERING

Each hole after completion was connected to a Bureau-designed water-gas separator. A Venturi gas flow measuring device was installed in the pipe between the water-gas separator and the 18-inch-diam by 7-foot-high receiver tank. Gas is piped to the surface through an 8-inch-diam pipe located behind the shaft liner (fig. 8). The gas at present is being purchased by a gas company having commercial gaslines nearby. Previously, the gas was vented to the atmosphere.

The in situ pressure and gas and water volume measurements are made at approximately 10-day intervals (figs. 9-17).

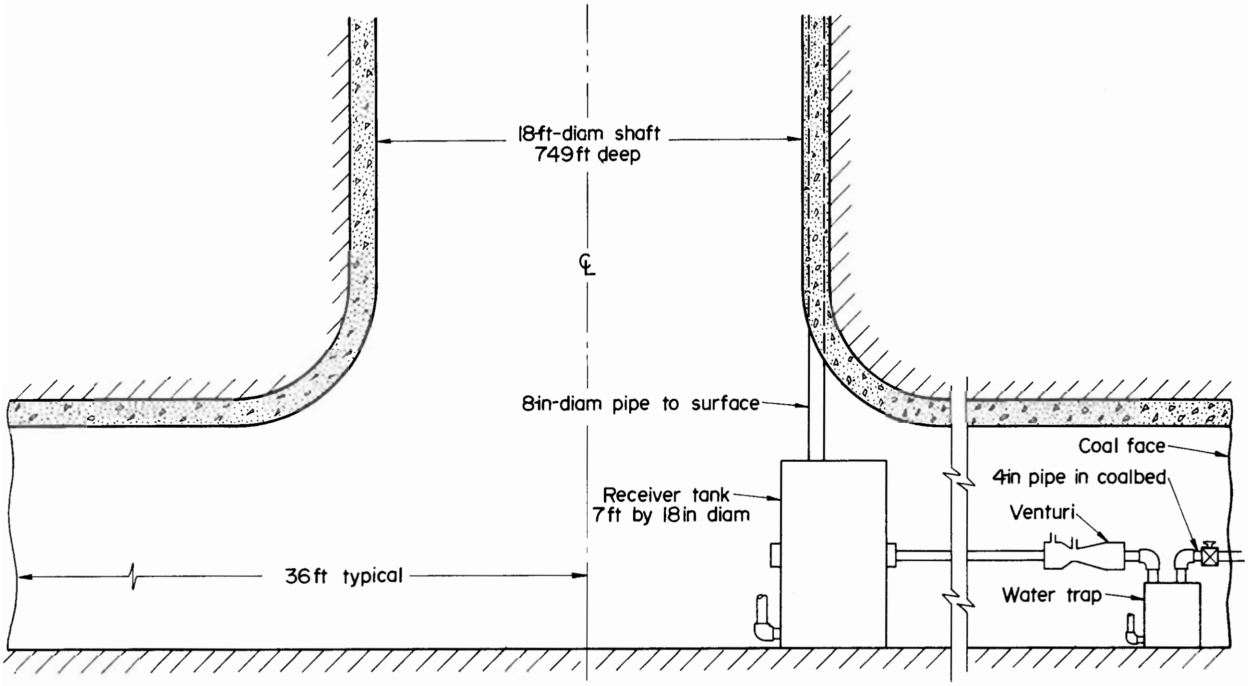

FIGURE 8. - Typical degasification setup for each of the four headings in the 18-foot return air shaft.

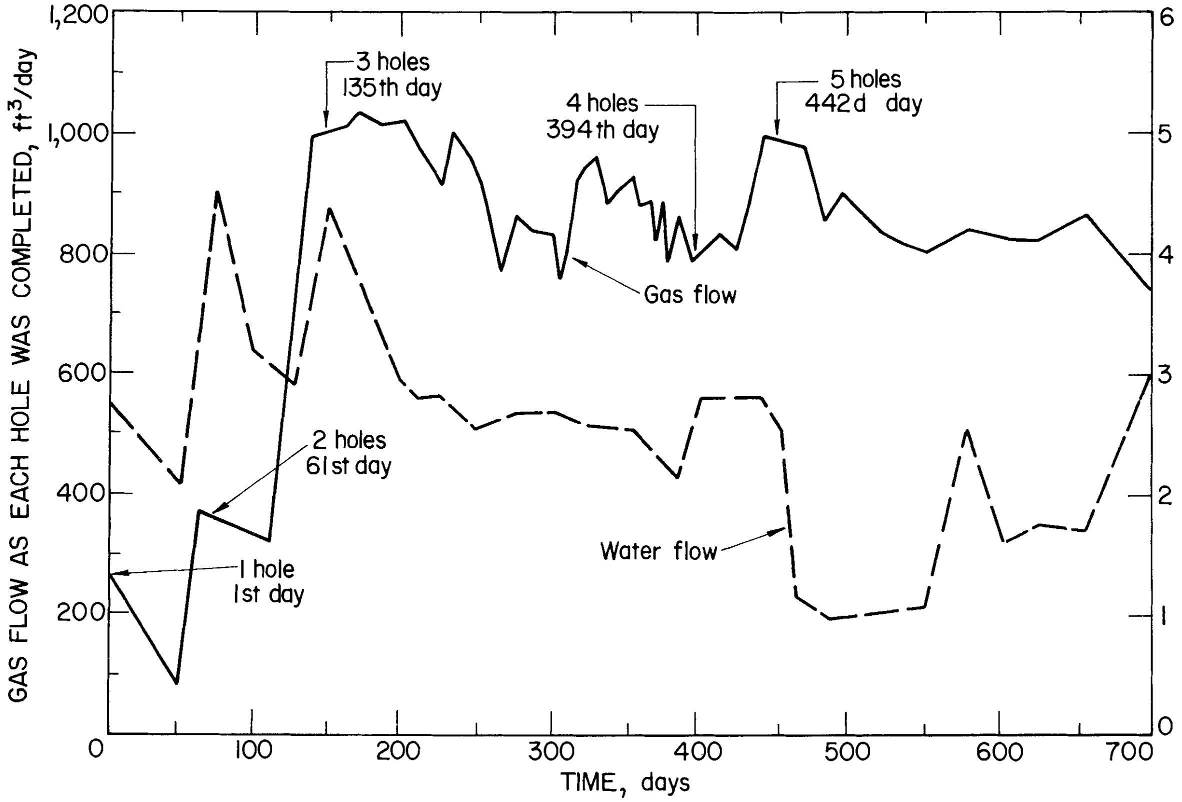

FIGURE 9. - Total gas and water flow rates.

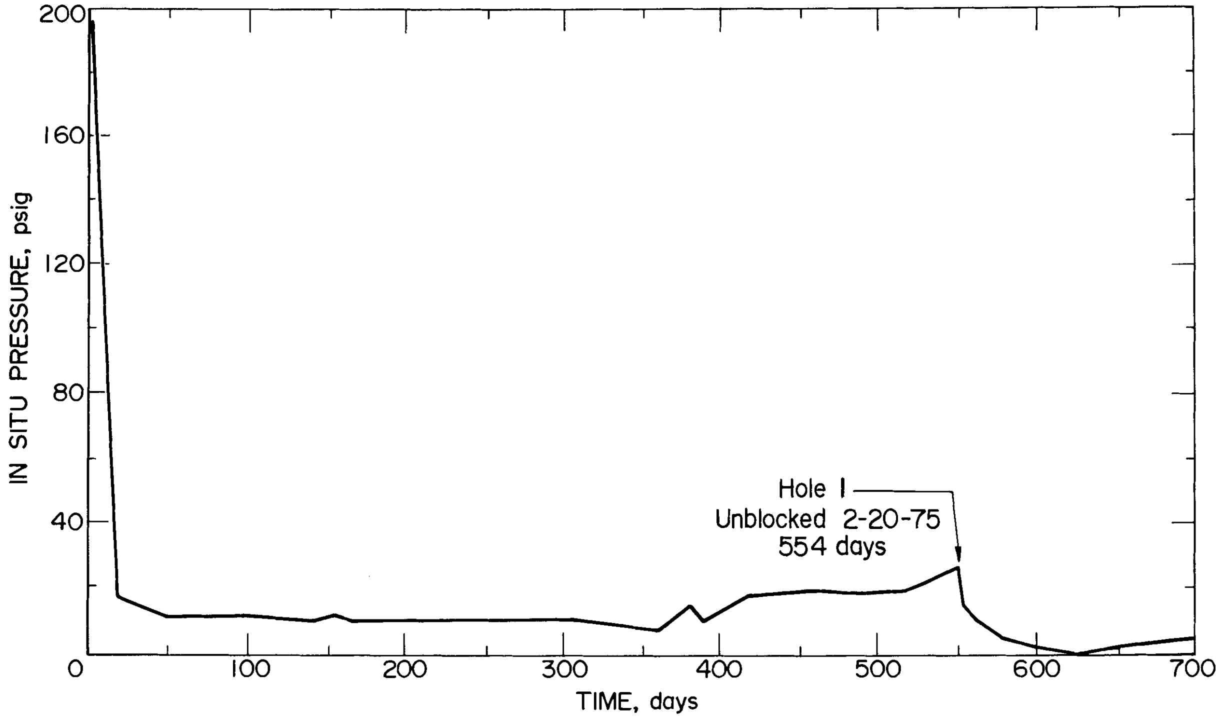

FIGURE 10. - In situ pressure.

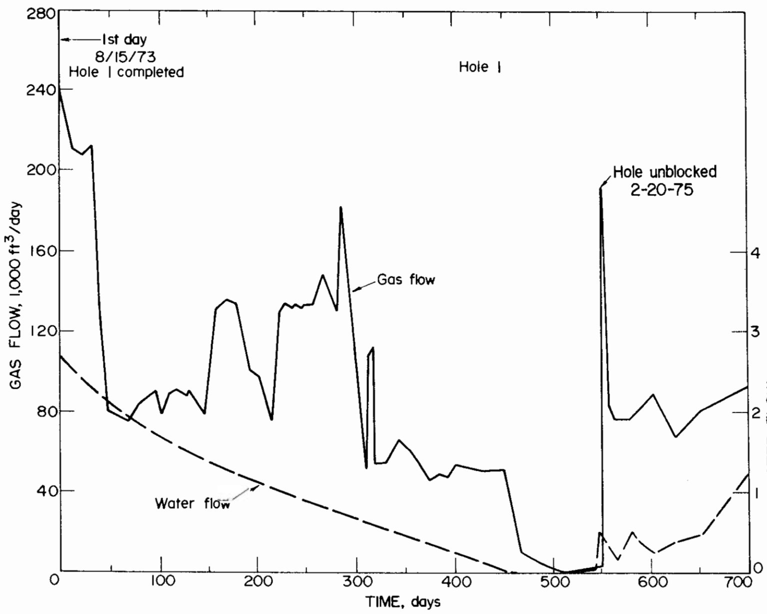

FIGURE 11. - Individual hole gas flows; hole 1.

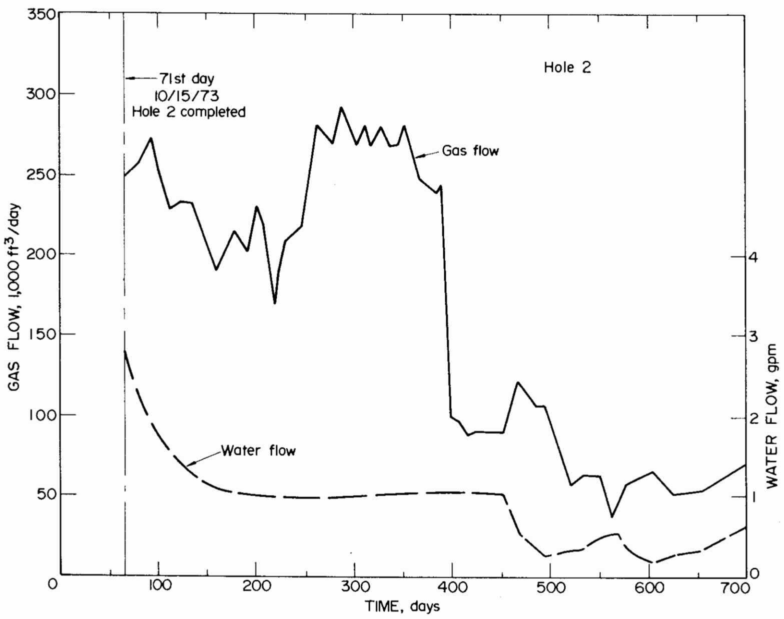

FIGURE 12. - Individual hole gas flows; hole 2.

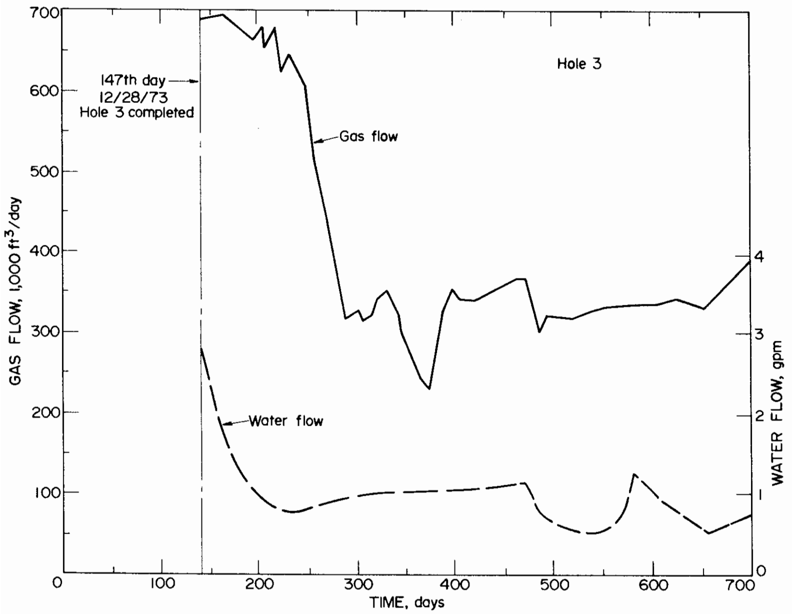

FIGURE 13. - Individual hole gas flows; hole 3.

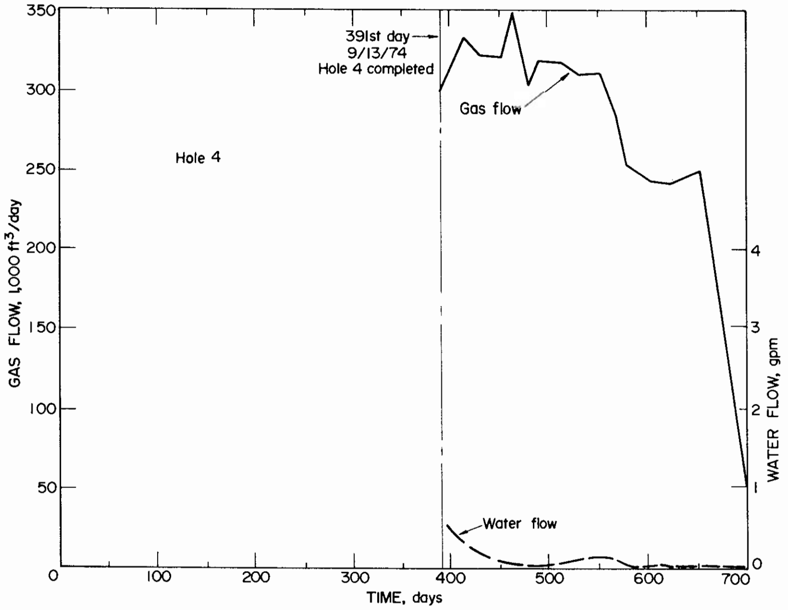

FIGURE 14. - Individual hole gas flows; hole 4.

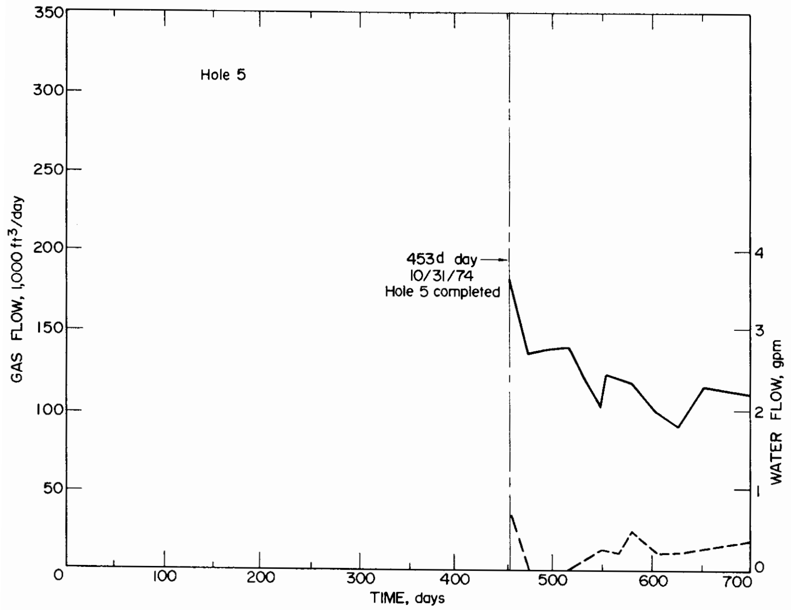

FIGURE 15. - Individual hole gas flows; hole 5.

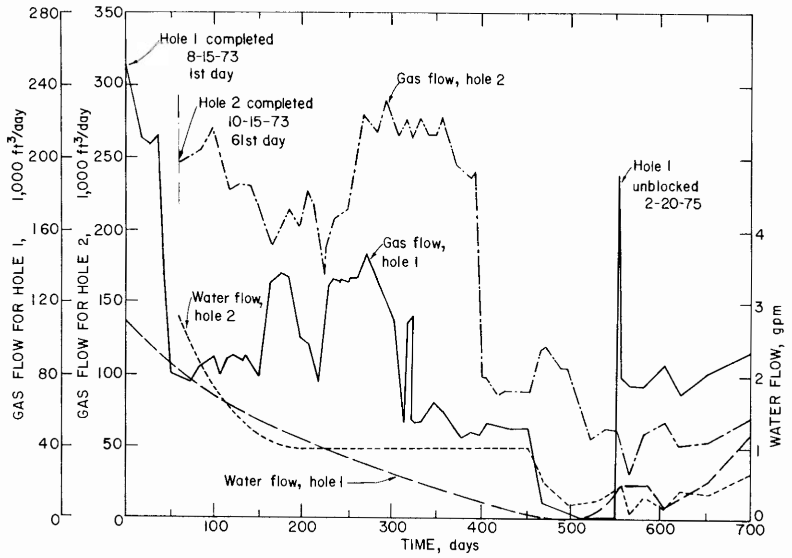

FIGURE 16. - Gas flows; holes 1 and 2.

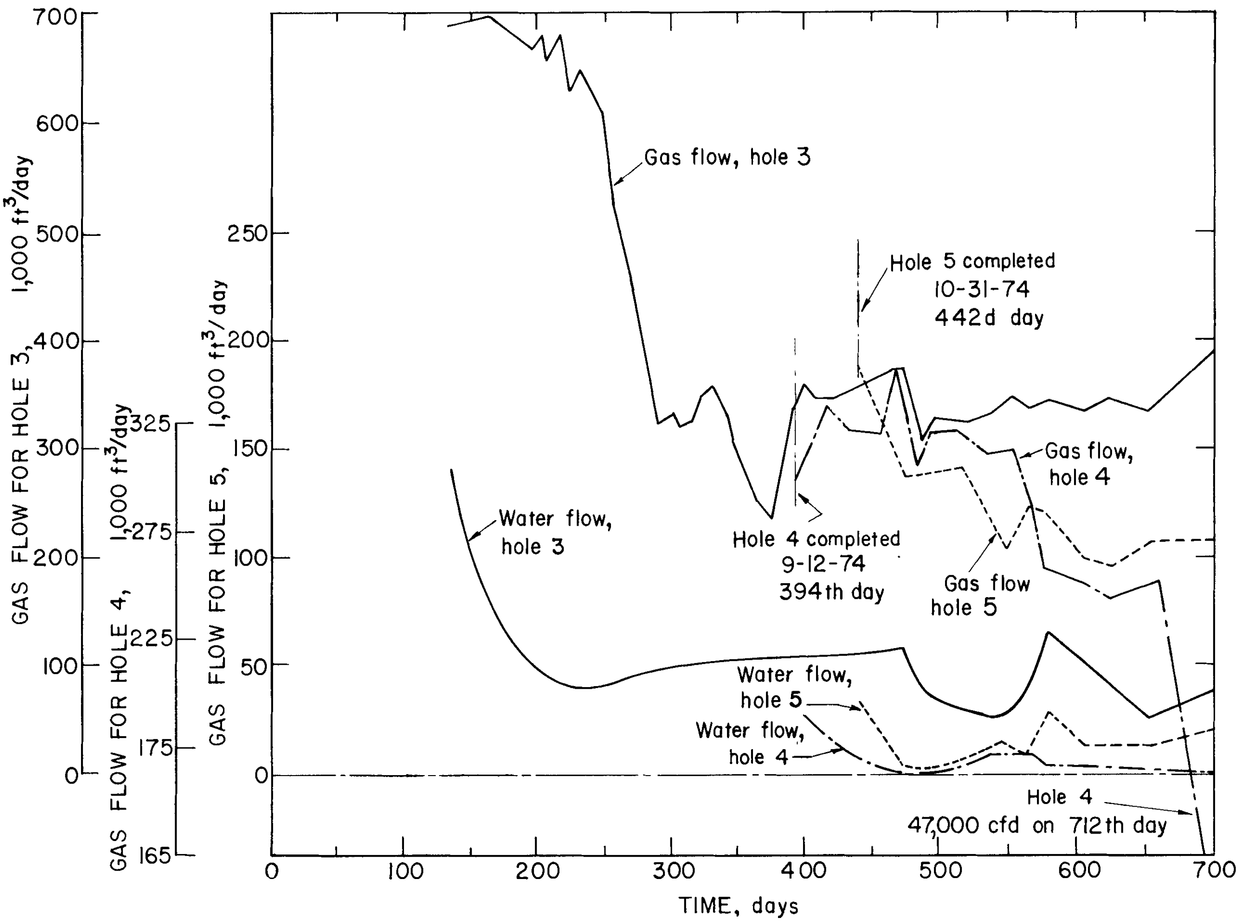

FIGURE 17. - Gas flows; holes 3, 4, and 5.

DISCUSSION OF FLOW DATA

When all the holes were completed, the initial total gas flow, the in situ pressure, and total waterflow after the first 24 hours of operation from the five 3-1/2-inch-diam holes were 994,000 ft^3/d, 18 lb/in^2g, and 2.95 gal/min, respectively. Waterflow averaged 0.6 gal/min/hole. Initial measurements were influenced by the long drilling period.

Gas Analysis

The methane gas is of pipeline quality and is not expected to require remedial treatment for acceptance into the gas company's supply line (table 1).

TABLE 1. - Comparative gas analysis, pct

	Multipurpose borehole	18-ft-diam shaft
Ethane (C_2H_6)........	0.16	0.05
Carbon dioxide (CO_2).	9.06	10.7
Oxygen (O_2)..........	.34	.12
Nitrogen (N_2)........	1.24	0.0
Methane (CH_4)........	89.10	88.6

Interference Effect

Table 2 summarizes the comparative data on the degasification holes at the 18-foot shaft and the multipurpose borehole. Table 1 shows a comparison of gas composition from the multipurpose borehole and the 18-foot shaft. At both locations the gas emitted contains about 9 pct carbon dioxide. Gas compositions are comparable at these sites, about 2.6 miles apart.

Average gas flow per 100 feet of hole (table 2) is higher at the 18-foot shaft than the multipurpose borehole. This is to be expected. Seven holes were drilled from the bottom of the multipurpose borehole, and because of the length of the holes (average length 618 feet), gas flow from any one hole is soon affected by the adjacent holes. This effect is called "interference." One hole robs gas that would flow into the adjacent holes which are interconnected by the fracture system of the coalbed. The interference effect is more pronounced on adjacent holes drilled at an angle of 25° or more to the face cleat.

TABLE 2. - Initial gas flow data for degasification holes of the 18-foot shaft (set 1) and multipurpose borehole (set 2)

Description	Hole 1	2	3	4	5	6	7	8	Total
Length, ft:									
Set 1	670	1,017	1,067	2,126	950	-	-	-	5,830
Set 2	646	850	-	549	500	616	608	556	4,325
Gas flow, 1,000 ft^3/d:									
Set 1	52	92	345	320	185	-	-	-	994
Set 2	201	257	-	159	171	104	79	150	1,121
Sq ft of coal surface (less 25 ft grouted in 18-ft shaft):									
Set 1	591	909	955	1,925	847	-	-	-	5,227
Set 2	507	668	-	431	393	484	477	437	3,397
Angle of hole with face cleat, degree:									
Set 1	55	63	90	8	32	-	-	-	-
Set 2	83.5	28	-	35	61	12	28.5	59	-
Distance from gas well, ft:									
Set 1	160	60	-	70	-	-	-	-	-
Set 2	-	180	-	160/400	130/370	300	-	-	-
Waterflow, after holes completed, av/gal/min:									
Set 1	0	1.25	1.1	0	0.6	-	-	-	2.95
Set 2	6.5	6.8	-	5.6	8.0	5.0	5.0	6.2	43.1
Initial in situ pressure, lb/in^2:									
Set 1	-	-	-	-	-	-	-	-	197
Set 2	-	-	-	-	-	-	-	-	203
In situ pressure after holes completed, lb/in^2:									
Set 1	-	-	-	-	-	-	-	-	18
Set 2	-	-	-	-	-	-	-	-	18
Initial gas flow/100 ft of hole, ft^3/d:									
Set 1	-	-	-	-	-	-	-	-	20,583
Set 2	-	-	-	-	-	-	-	-	25,919
Average gas flow/100 ft of hole after 442 days:									
Set 1	-	-	-	-	-	-	-	-	17,000
Set 2	-	-	-	-	-	-	-	-	13,000
Average gas flow/sq ft of coal surface, ft^3/d:									
Set 1	-	-	-	-	-	-	-	-	190
Set 2	-	-	-	-	-	-	-	-	330
Hole, diam inches:									
Set 1	-	-	-	-	-	-	-	-	3-1/2
Set 2	-	-	-	-	-	-	-	-	3

SHUT-IN EFFECT

The use of underground pipelines in coal mines to transport methane to the surface is being considered because air required to dilute large quantities of methane produced during and after drilling is not available generally. In addition, diluting methane with air to permissible levels underground is a waste of a natural resource.

Piping methane from underground locations to the surface is not a new concept and the earliest attempts at work of this nature were made in Great Britain about 200 years ago.[8] Large-scale operations, which did not occur until after 1943, were applied at many collieries in the Ruhr, the Saar, Belgium, France, and Great Britain. However, in the United States, no large-scale operations were undertaken during this period until recently.

Many problems relating to the operation of underground pipelines must be solved before the system will be operational. One of these problems is leakage caused by improper installation or alinement of the pipeline. Leakage can be prevented or minimized by pressure testing (hydraulic or pneumatic) before the line is placed in service. A method for determining a reasonable test pressure which will vary from one coalbed to another or within the same coalbed is outlined in the paragraphs that follow.

Most coalbeds have an associated gas reservoir pressure. In the Pocahontas No. 3 coalbed, the reservoir pressure is 650 lb/in^2g;[9] and in the Pittsburgh coalbed, the reservoir pressure is 275 lb/in^2g.[10] Gas pressure gradients are known to exist around mine openings.[11] These gradients are steeper near active face areas in sections advancing into virgin coal compared to rib areas in the returns that have been exposed for months. In the Pittsburgh coalbed, measurements at an active face show that the gas pressure at a depth of 175 feet is 34 lb/in^2g. At the collar of the hole, the gas pressure in the coalbed is near atmospheric. Therefore, the gas pressure gradient is 0.19 $lb/in^2g/ft$. A horizontal hole must be drilled at least 1,450 feet to reach a point in the coalbed where gas pressure is approaching the reservoir gas pressure (275 lb/in^2g) of the coalbed. The gas pressure versus depth curve approaches reservoir pressure asymptotically. Therefore, in order to reach reservoir pressure drilling must exceed a depth of 1,450 feet.

Several tests were conducted in the Honey Run shaft to determine gas pressure increase at the collar of the hole when the hole is shut-in or when the main underground pipeline is blocked. When either occurs, gas flows

[8] Bromilow, J. G., and J. H. Jones. Drainage and Utilization of Firedamp. Colliery Eng., v. 32, No. 6, June 1955, pp. 222-232.

[9] Centibas, Abdurrahman, R. P. Vinson, J. Cervik, and M. G. Zabetakis. Methane and Dust Controls for Longwalls: Pocahontas No. 3 Coalbed, Grundy, Va. BuMines RI 7849, 1974, 16 pp.

[10] Fields, H. H., S. Krickovic, A. Sainato, and M. G. Zabetakis. Degasification of Virgin Pittsburgh Coalbed Through a Large Borehole. BuMines RI 7800, 1973, 27 pp.

[11] Work cited in footnote 4.

within the coalbed are redistributed. Because gas pressures at the back part of the hole are higher than those near the collar, gas will begin to flow from the hole into the coalbed near the collar and eventually into the mine opening.

Referring to figure 2, during the first test, hole 3 was shut-in and gas pressure buildup was monitored while holes 1, 2, 4, and 5 remained open to flow. Over a period of 42 hours, gas pressure in hole 3 increased from near atmospheric to 29.5 lb/in^{2}g. However, gas flow rate from the adjacent hole 5 increased from 114,000 to 170,000 ft^3/d. Flow at hole 1 increased also from 85,000 to 107,000 ft^3/d. No increase in flows was observed at holes 2 and 4. These results are shown plotted in figures 18 and 19. Holes 3 and 5 are connected through the more permeable face cleat. Therefore, one would expect gas to cross over to hole 5 easily. However, the increase in gas flow from hole 1 is more difficult because gas from the vicinity of hole 3 or 5 must flow through the less permeable butt cleat to reach hole 1.

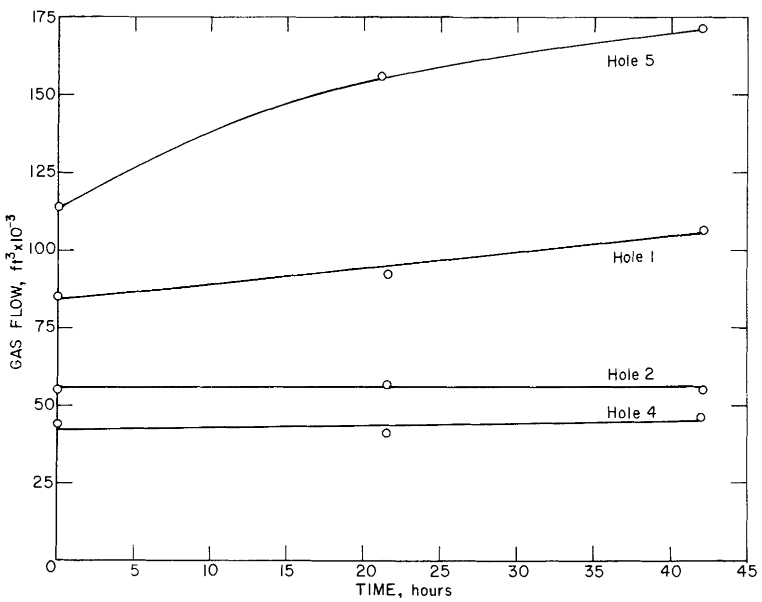

FIGURE 18. - Shut-in gas pressure buildup; holes 1, 2, 4, and 5.

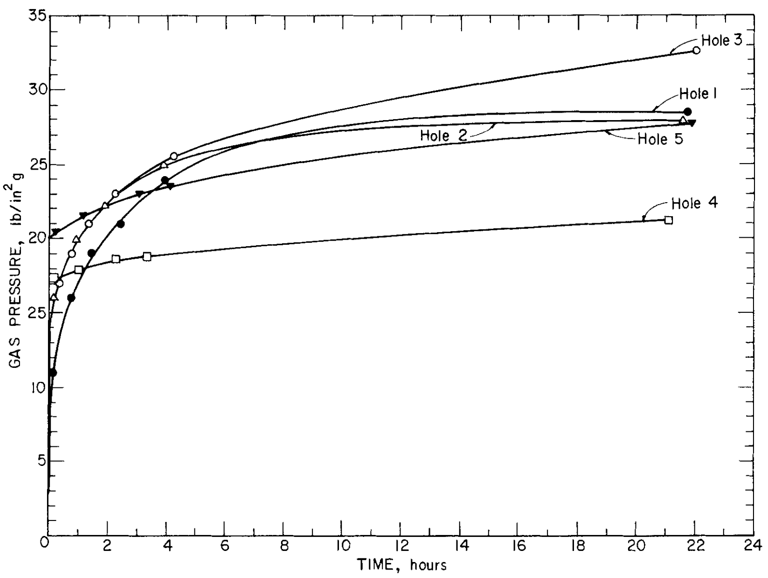

FIGURE 19. - Shut-in gas pressure buildup; holes 1, 2, 3, 4, and 5.

In a second test, all holes were shut-in and gas pressure was monitored at each hole. Figure 19 shows the buildup pressure at each hole for a period of about 21 hours. During this shut-in period, gas flow through the faces and ribs of the shaft increased and when the methane concentration reached 2 pct, the test was terminated. The shut-in pressures ranged from a low of 21.3 lb/in^{2}g at hole 4 to a high of 32.6 lb/in^{2}g at hole 3 (fig. 20).

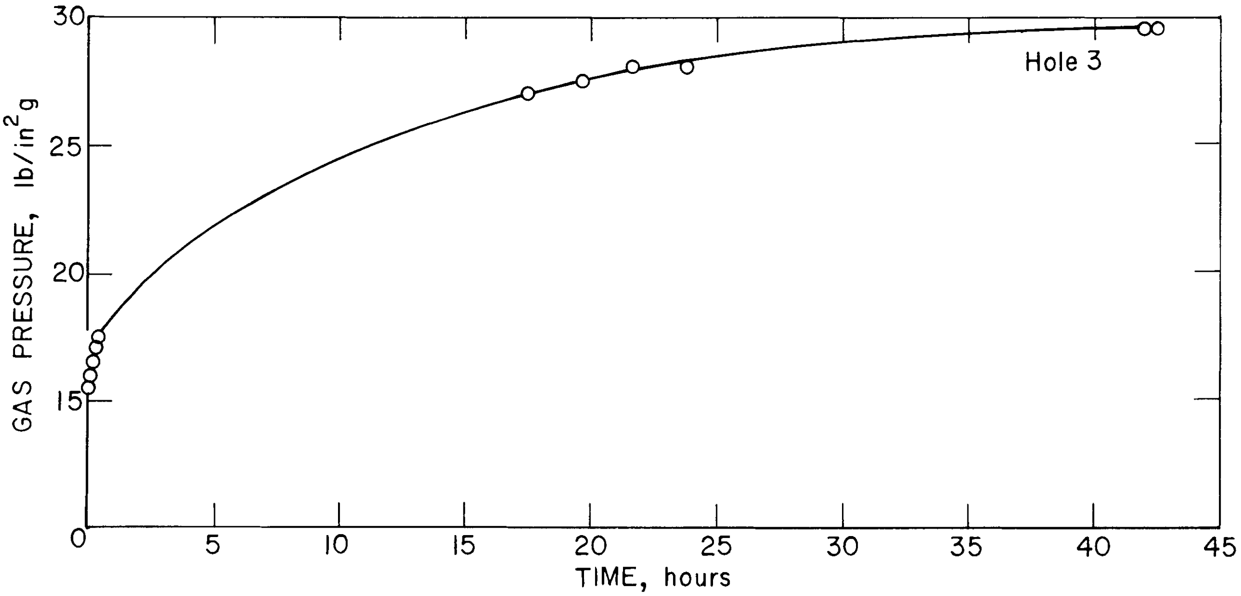

FIGURE 20. - Shut-in gas pressure buildup; hole 3.

The tests show that gas pressure in a blocked pipeline will not build up to the reservoir pressure of the coalbed. Leakage of gas into the mine opening through coal surrounding the hole and the redistribution of gas within the coalbed from higher gas pressure to lower pressure zones prevents the buildup. The shut-in gas pressure will be highest immediately after the hole is drilled. As degasification proceeds over a number of years, the shut-in pressure declines. If methane gas is piped underground in coal mines, a 90 lb/in^{2}g test pressure for underground pipelines appears reasonable in the Pittsburgh coalbed (Fairview, W. Va., area) based upon a safety factor of two.

Pittsburgh Coalbed: Flows From Individual Holes

Attempts were made to drill each hole to a depth of about 1,000 feet, and holes are numbered in order of drilling. Hole 1 was terminated at a depth of 670 feet because the rotating drill pipe wore the casing thin. A liner casing has been installed for safety.

Gas and water flows from hole 1 are shown in figure 11. Upon completion of hole 1, drilling of hole 2 was started. The effect of drilling hole 2 on gas flows from hole 1 is clearly shown by comparison in figures 11 and 12. Approximately 35 days after hole 1 was completed and hole 2 was being drilled at a depth of 500 feet, gas flow from hole 1 was dropping rapidly. At their collars, holes 1 and 2 are about 15 feet apart. At a depth of 500 feet along hole 2, these holes are about 600 feet apart and they are interconnected through the more permeable face cleat of the coalbed. Further evidence of an interference effect between these holes at a time of 270 days is shown in figure 16. Gas flow from hole 1 drops rapidly. Waterflow from hole 1 at this time is declining steadily but at hole 2, a small but steady increase in waterflow is observed. Gas and water flows from hole 1 subsequently declined to zero, which was caused by a blockage near the collar of the hole. When cleaned, initial gas flow was 190,000 ft^3/d which declined to 76,000 ft^3/d in 10 days. Water flowed at a steady rate of 0.5 gal/min.

Gas flow from hole 2 shows a sharp dropoff at a time of about 400 days (fig. 12). There is no apparent reason for this dropoff, except possible blockage of water from hole 1. This blockage causes an accumulation of water in the coalbed which affects gas flow from hole 2.

The in situ gas pressure monitoring hole is located between holes 1 and 2 (fig. 2), and the gas pressure history is shown in figure 10. The rise in gas pressure between 400 and 550 days is due to blockage of gas flow from hole 1. When hole 1 was cleaned of debris, gas pressure in the coalbed dropped from 27 to 15 lb/in^2g in 2 hours and to 10 lb/in^2g 10 days later.

Hole 3 was drilled at an angle of 90° to the face cleat and flows are plotted in figure 13. Initial gas flow was highest for this hole and substantiates previous observations[12] that higher flows in the Pittsburgh coalbed are obtained from holes which intercept the face cleats at a right angle. Flow decreases as the angle increases with respect to the butt cleat (fig. 21). The sharp decline in flow from hole 3 at about 250 days coincides with drilling of hole 4 and subsequent gas flow does not appear to affect gas flow from hole 2. These holes are interconnected through butt cleats. Undoubtedly,

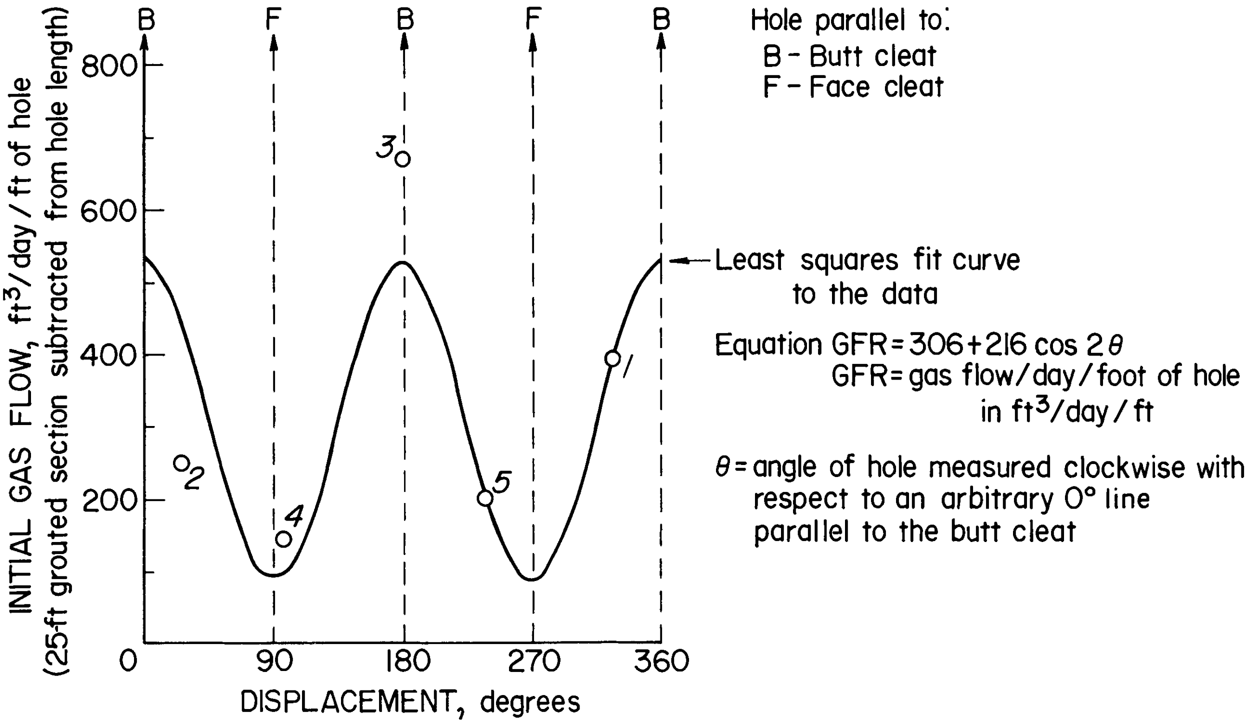

FIGURE 21. - Calculated trend curve of initial gas emission rates from degasification holes.

[12]Work cited in footnote 10.

interference effects will occur but are more gradual and, therefore, difficult to discern.

Drilling of hole 5 caused a slight but rapid dropoff in gas flow from hole 3 (fig. 13; 480 days). Hole 1 also shows a sharp drop at this time which is coincidental. This dropoff in gas flow was caused by complete blockage by debris. Partial blockage started on the 260th day (fig. 11). Flow from this hole was restored when cleaned of debris (fig. 11; 575 days).

Figure 18 shows the calculated trend curve of initial gas emission rates from the degasification holes against an angle measured clockwise from the butt cleat direction.

Assume the following equation:

$$GFR = 306 + 216 (\cos 2\theta),$$

where GFR = gas flow per day per foot of hole in cubic feet per day per foot,

and θ = angle of hole measured clockwise with respect to an arbitrary 0° line parallel to butt cleat.

Note that maximum flows are obtained from holes drilled parallel to the butt cleat (B), and the flows are greater by about a factor of 4 compared to holes drilled parallel to the face cleats (F). One might conclude that to obtain the greatest flow rates and quantity of gas from a shaft drilling site, all holes should be drilled in directions that are parallel or nearly parallel to butt cleats (0° and 180°; fig. 21). However, the previous discussion on interference effect shows that the flow from two adjacent holes in this direction will not be doubled. Holes 1 and 2 provide a good example of the interference effect. Both make an angle of about 30° with the butt cleat. Drilling another hole between holes 1 and 2 would increase flows only slightly. Note that flow into these holes would be primarily along the face cleat (fig. 21). Hole 1 intercepts gas flow from the left; hole 2 intercepts gas flow from the right. The hole between these two is shielded and the flow rate would decline rapidly.

Initial waterflow from all holes after completion is lower (2.95 gal/min) at the 18-foot-diam shaft than at the multipurpose borehole (43.1 gal/min). The small waterflow from the holes in the 18-foot-diam shaft is being influenced by a second 18-foot-diam shaft located 425 feet away. This shaft has been kept dewatered to the bottom of the coalbed both during and after drilling operations, and acts as a natural drainage sump for the coalbed in this area. Consequently, lower water flow rates from the degasification holes are observed when compared to the multipurpose borehole. As water is removed from the coalbed or if there is no water, gas flow increases until the in situ pressure and gas migration flow rates stabilize. In both the multipurpose borehole and the 18-foot-diam shaft, the in situ pressure fluctuates within the same range (7 to 18 lb/in^2g).

Shaft Drilling Patterns

Over a period of 500 days, total gas flow from the shaft site averaged 884,000 ft^3/d (fig. 9). Total waterflow averaged 1.8 gal/min. Drilling of additional holes in north and south directions is not expected to increase substantially the gas flow from the shaft because of interference effects noted previously between holes in these directions. The slight increase in gas flow that might result from additional holes is not warranted. However, additional holes in the east and west directions may be warranted. No apparend interference effects were noted between holes 1 and 5 or 4 and 2. Interference occurs through the butt cleat, which is not as permeable as the face cleat; therefore, the effect is gradual and tends to be masked by normal decline in gas flow with time. Therefore, to degasify the coalbed in the east and west directions as rapidly as the north and south directions, additional holes are warranted in the east and west directions. A recommended pattern for the Pittsburgh coalbed is shown in figure 22.

The influence of gas wells upon gas emission from the horizontal degasification holes was noted only in hole 4 where a significant increase in gas flow was observed as the hole was drilled past the well. At a depth of 785 feet, gas flow from hole 4 was 122,000 ft^3/d; at a depth of 856 feet, only 71 feet further, the flow had increased 98,000 ft^3/d to 220,000 ft^3/d. The hole is approximately 70 feet from the well.

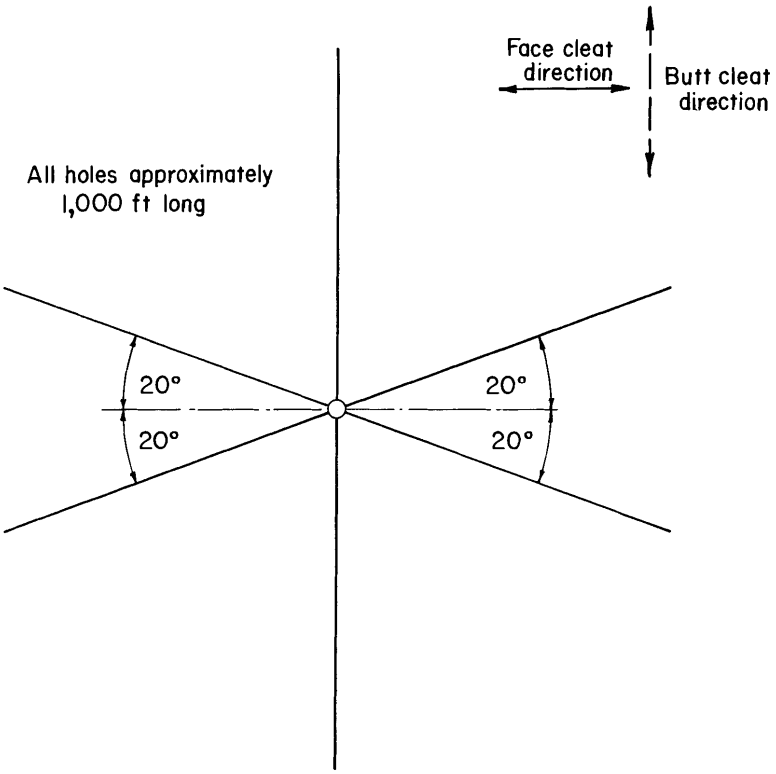

FIGURE 22. - Recommended direction of holes with respect to butt and face cleat systems.

Because the holes were partially or complete closed in during drilling, the flow data recorded during drilling are not include in the flow charts. The readings, when plotted, are not meaningful when compared to the constant dynamic gas flow curves after all holes were connected to the collector system. When flow data from holes 1 and 2 are compared (fig. 16), it is evident that the holes are interconnected through the face cleats. It also was noted that if hole 1 was closed in, flow from hole 2 would increase correspondingly. The same is true if holes 3, 4, and 5, respectively, are compared (fig. 17).

Observations on Gas Flow From Horizontal Holes in Other Coalbeds

The Beckley coalbed near Beckley, W. Va., is similar to the Pittsburgh coalbed. Both are blocky-type coals with well-developed face and butt cleats. Drilling studies in the Beckley coalbed indicate that flow rates from holes drilled perpendicular to the face cleat are two to three times the flow rates from holes drilled parallel to the face cleat. Therefore, the shaft drilling pattern for the Pittsburgh coalbed (fig. 22) is applicable to the Beckley coalbed.

The friable-type coalbeds that do not have well-developed face and butt cleats tend to have a lower fracture permeability than the blocky type of coalbed. Gas flow from holes tend to be independent of hole direction with respect to face and butt cleats. Typical friable-type coalbeds include Upper Kittanning and Lower Kittanning, Upper Freeport and Lower Freeport, Pocahontas No. 3, and the B seam at the Dutch Creek Mine, Colorado. In general, for shaft drilling in friable coalbeds, six holes at 60° between holes appear adequate. If the holes are 1,000 feet long, the ends of two adjacent holes will be 1,000 feet apart. For holes 2,000 feet long, the ends of two adjacent holes will be 2,000 feet apart, and additional holes may be necessary to degasify the coalbed rapidly.

As of June 1, 1976, methane emissions at the active working faces of 1 West mains heading system at Eastern Associated Coal Corp., Federal No. 2 mine, has been reduced by 50 pct. This is significant, and fully demonstrates the feasibility of coalbed degasification by long horizontal holes drilled from shaft bottoms 2 years or more ahead of mining. Methane emission was reduced from 200 to 100 ft^3/min at the working faces when development had advanced to within 2,700 feet of the shaft bottom.

CONCLUSIONS AND RECOMMENDATIONS

Degasification of the Pittsburgh coalbed has been successfully demonstrated at two sites--the multipurpose borehole and the 18-foot-diam shaft. Figure 1 shows location of both shafts in the Federal No. 2 mine. The decline of gas flow from the shaft site (fig. 9) shows that flows of methane exceeding 600,000 ft^3/d can be expected for the next 2 or 3 years. Therefore, shafts should be located 5 years or more ahead of mining to adequately degasify the coalbed surrounding the shaft and to realize maximum benefits from the sale of gas. Shaft degasification projects should be planned so that mine entries are not closer than 3,000 feet from the shaft area during the planned degasification period. Driving entries toward the shaft will reduce substantially the flows from the shaft degasification site.

As of June 1, 1976, methane emission had decreased from the initial stabilized flow of 860,000 to 600,000 ft^3/d.

It also is significant that the gas from the shaft degasification project was piped for commercial use directly to the community of Wadestown, W. Va. No remedial treatment nor blending was required although the CO_2 content was high.

It is concluded that degasification by long horizontal holes drilled 2 to 5 years ahead of mining is a most effective way to (1) degasify large virgin areas of the very gassy Pittsburgh coalbed; (2) reduce methane emission at mine working faces, thereby reducing ignition and explosion hazard; (3) decrease ventilation cost; and (4) increase coal production.

The average depth of the seven horizontal holes is 618 feet. At the 18-foot-diam shaft, gas flows have averaged 884,000 ft^3/d for 1.6 years and the average depth of the five degasification holes is 1,166 feet. Therefore, a large area of the coalbed will be degasified at the shaft site.

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