May 7, 1957 J. T. CLANCEY ET AL 2,791,471

TRANSPORTATION OF COAL BY PIPELINE

Filed Oct. 26, 1953 5 Sheets-Sheet 1

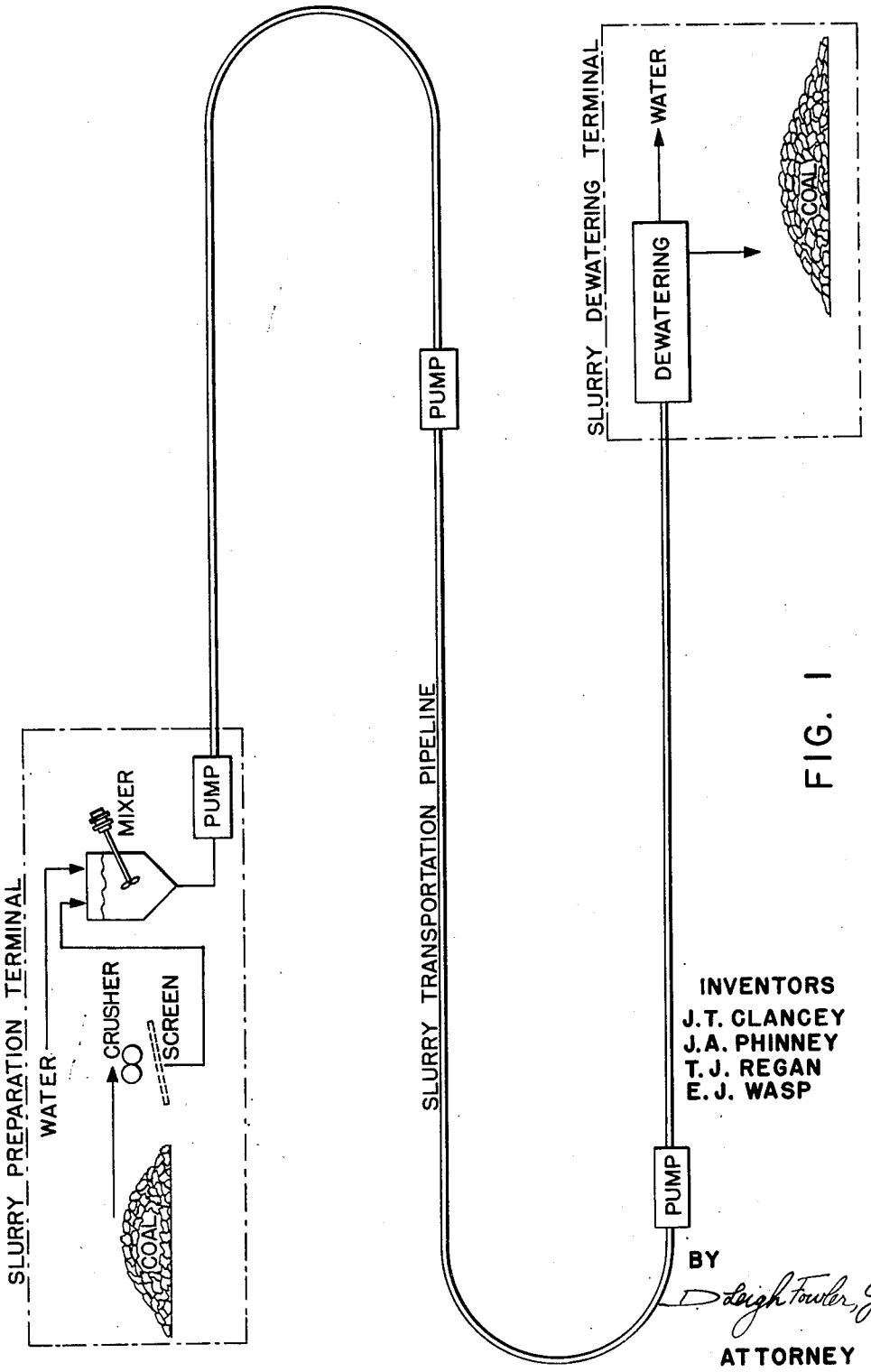


FIG. 1

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TRANSPORTATION OF COAL BY PIPELINE

Filed Oct. 26, 1953 5 Sheets-Sheet 2

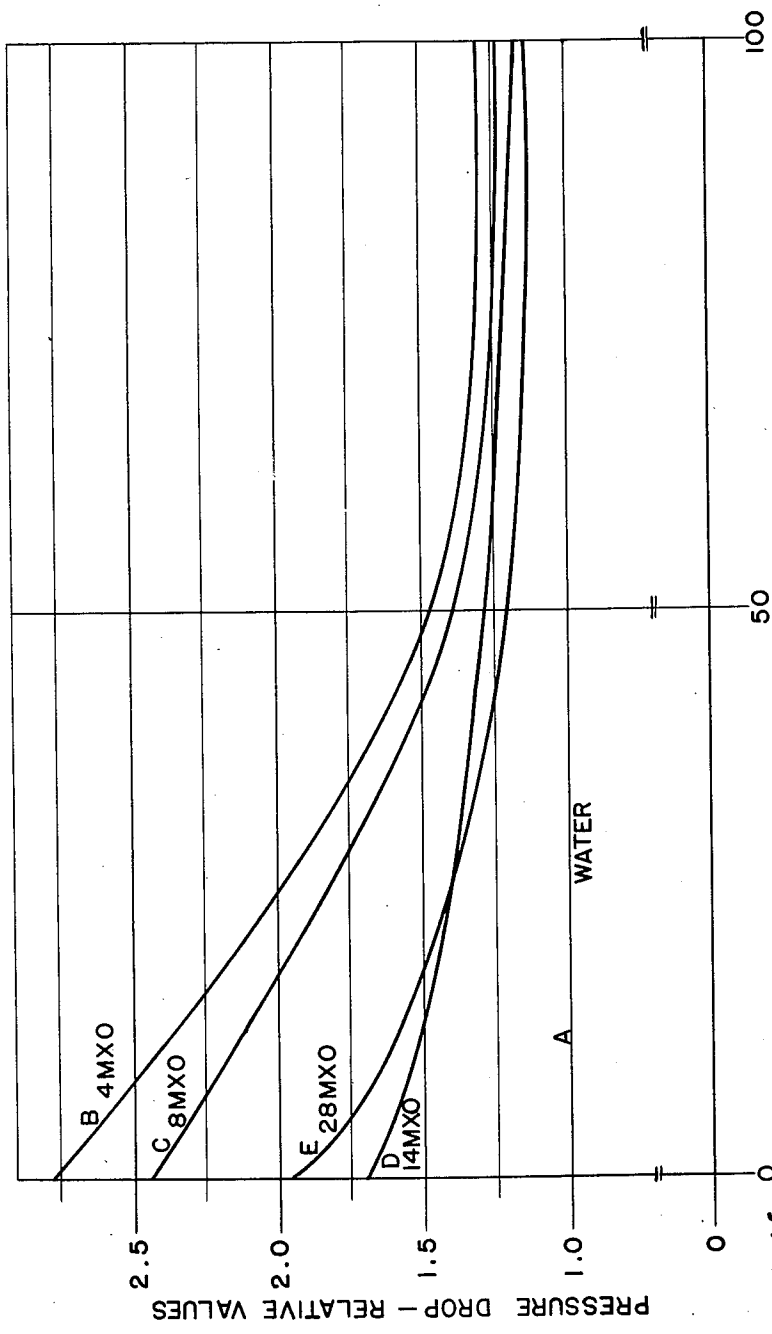


FIG. 2

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TRANSPORTATION OF COAL BY PIPELINE

Filed Oct. 26, 1953 5 Sheets-Sheet 3

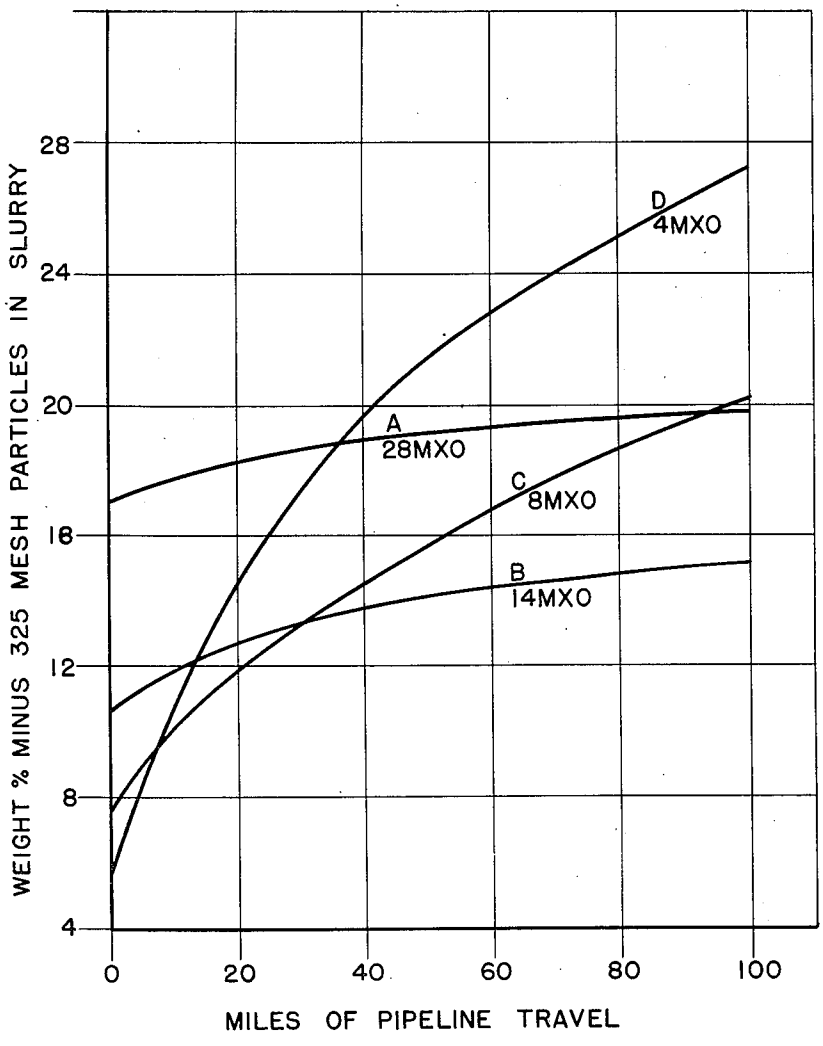


FIG. 3

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TRANSPORTATION OF COAL BY PIPELINE

Filed Oct. 26, 1953 5 Sheets-Sheet 4

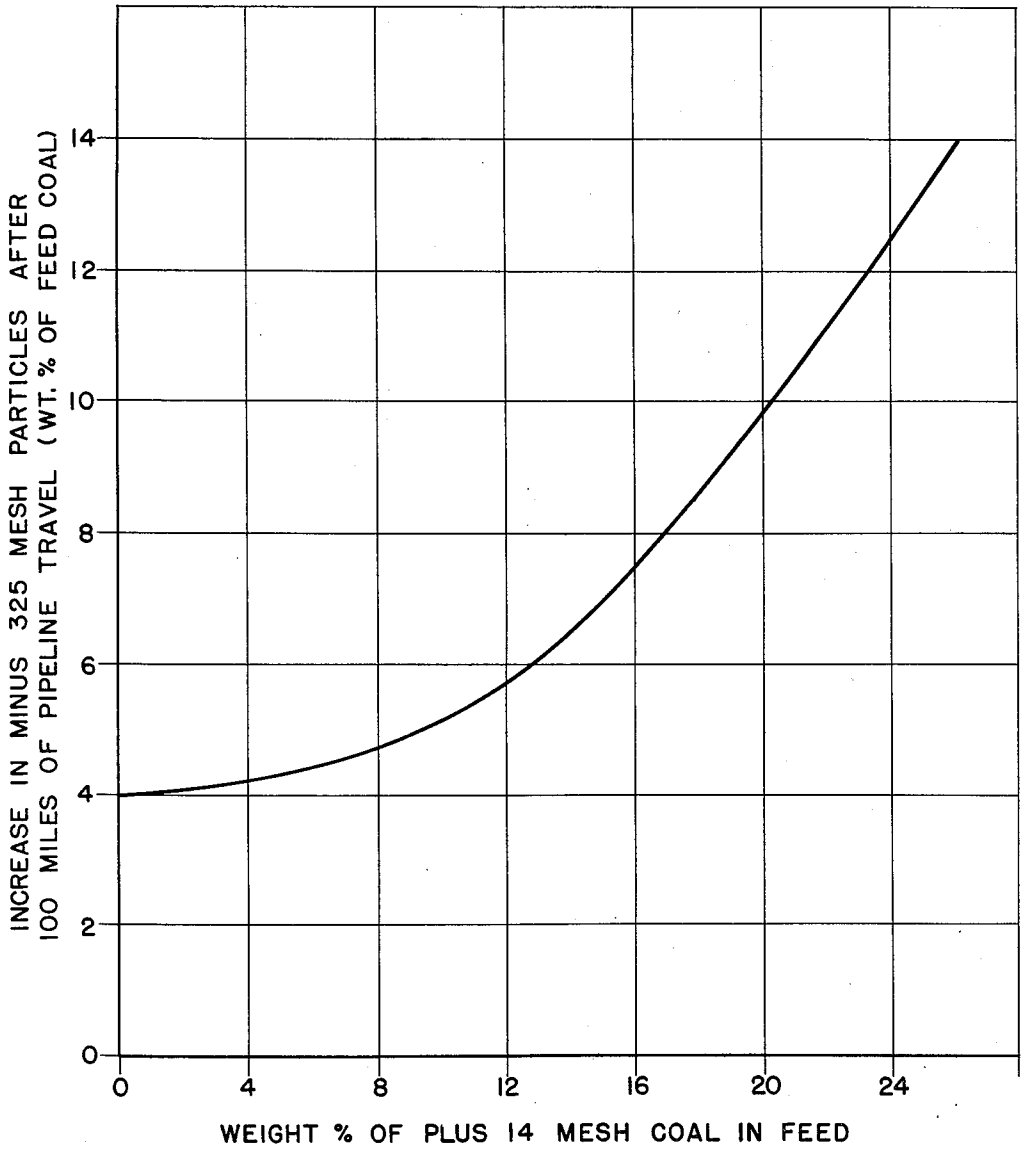


FIG. 4

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TRANSPORTATION OF COAL BY PIPELINE

Filed Oct. 26, 1953 5 Sheets-Sheet 5

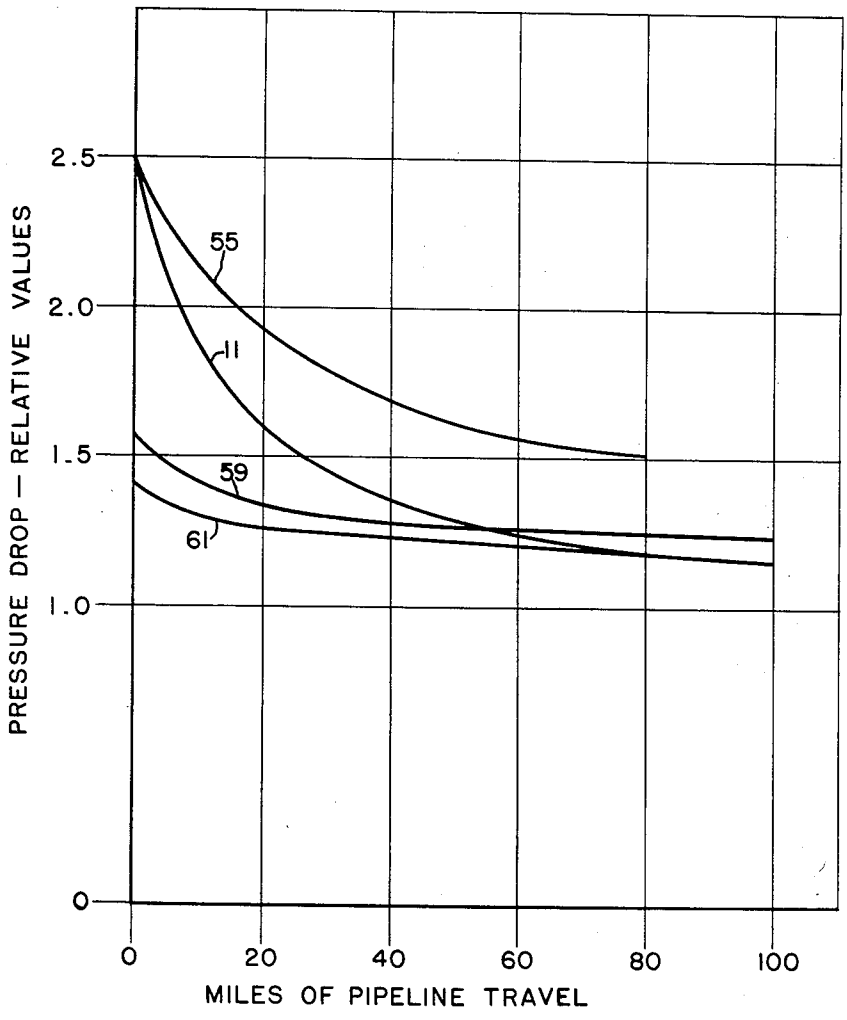


FIG. 5

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TRANSPORTATION OF COAL BY PIPELINE

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Application October 26, 1953, Serial No. 388,399

5 Claims. (Cl. 302—66)

This application relates to the art of transporting coal with water through pipelines. More particularly it relates to a method for operating coal pipelines designed to deliver commercial quantities of coal to distant markets.

From the coal customer's point of view, the competitive delivered cost of coal per B. t. u. considered in relation to such incidental factors as dust nuisance, handling properties, moisture content, et cetera, determines what he will pay for tonnage coal. With a bulk tonnage product such as coal, freight is a very considerable part of the delivered fuel cost. Hence any appreciable reduction in the transportation cost will decrease substantially the delivered B. t. u. cost to the coal consumer.

Coal traditionally is shipped from mine to market by railroad, although for years less expensive means have been envisioned. As early as 1891, W. C. Andrews obtained U. S. Patent 449,102 broadly outlining the technique of pumping coal in mixture with water through pipelines. Since Andrews, many schemes have been proposed for implementing the Andrews patent, although no coal pipeline has been operated commercially for long distances, e. g., 50 miles or more. See, for example, U. S. Bureau of Mines Report of Investigation 4799, "A Survey of the Hydraulic Transportation of Coal," by R. W. Dougherty, July 1951.

Any coal pipeline installation comprises three basic and separable stages: (1) a preparation stage comprising treatment of the coal and mixing it with water to form a slurry; (2) a transportation stage comprising the pipeline proper together with pumping apparatus for moving the slurry through the long distance pipeline; and (3) a recovery stage at the pipeline terminal in which water is removed from the delivered slurry to permit recovery of marketable or usable coal.

We have discovered that by properly selecting, within narrowly defined limitations, the coal to be transported through pipelines, the significant operating costs in each of the three stages can be minimized. In addition, the coal delivered from a pipeline operated in accordance with this invention is more acceptable to the customer because of its minimum content of fines.

The primary object of this invention is to reduce the overall energy required for transporting coal from mine to market through pipelines by minimizing the energy requirements for coal preparation, slurry pumping and slurry dewatering.

Another object of this invention is to transport coal with water through pipelines to deliver at distant points a coal slurry which has a minimum weight fraction of undesirable fine-sized coal particles, thereby minimizing storage and handling problems of pipeline coals.

The invention is best described with reference to the accompanying drawings in which:

Figure 1 is a schematic illustration of a coal pipeline transportation system;

Figure 2 is a graphical illustration showing the effect of pumping distance on the pressure drop of coal slurries throughout a commercial scale pipeline;

Figure 3 is a graphical illustration showing the particle attrition which results from transporting coal slurries through commercial scale pipelines;

Figure 4 is a graphical illustration showing the effect of one factor in the initial particle size distribution of a coal slurry on the particle attrition resulting from transporting coal through a commercial scale pipeline; and

Figure 5 is a graphical illustration showing the pressure drop of selected coal slurries throughout a commercial scale pipeline.

Referring to Figure 1, coal at the slurry preparation terminal which is preferably located adjacent to a coal mining area or a coal cleaning plant, is mixed with water to form a slurry. If necessary, the coal may be crushed and screened prior to being mixed with water. The resulting slurry should contain about 35 to 55 percent coal by weight. Slurry from the preparation stage is introduced into the transportation pipeline and pumped at pressures up to about 1200 pounds per square inch through the pipeline for long distances, e. g., 50 or 100 miles or more to a slurry dewatering terminal where dry, marketable coal is recovered from the slurry for delivery to customers. The preferred linear velocity of the slurry through the pipeline is in the range of about 4 to 7 feet per second. With linear velocities in this range, 5500 to 8000 tons of coal can be delivered daily by a commercial pipeline having an internal diameter of about 12 inches.

Economic advantages of coal pipelines cannot be obtained in pipelines less than about 8 inches in internal diameter because of the limited throughput in smaller pipes. In general, pipelines of about 8 to 15 inches in diameter are preferred, although larger pipes are feasible provided the coal demand is sufficient to consume their delivery.

The present invention, moreover, is applicable only to these larger diameter pipelines which are of commercial interest. We have found that the size consist of the pipeline coal is a critical factor in the economics of coal pipeline operation only in those large diameter pipes which are commercially feasible. Small diameter experimental coal slurry pipelines indicated the pressure drop exhibited by coal slurries to be independent of coal size consist in a 3-inch diameter pipe, and also to have a constant value regardless of the pumping distance. Upon constructing a commercial size pipeline having a diameter of 12 inches, however, we discovered that surprisingly the operation of commercial pipelines is sensitive to the coal size consist and also the pumping ditance. We found that the size consist of the coal affects costs of operation and costs of equipment at all three stages of a commercial pipeline.

In the preparation stage, the crushing energy required as well as the equipment costs can be minimized by using as pipeline feed a coal size consist which can be prepared readily with relatively simple equipment.

Even more important, however, is the effect of coal size on the energy required for pumping slurry through the transportation pipeline itself. We have found that pumping energy, a direct cost factor, can be minimized by selecting certain narrowly defined coal size fractions for pipeline transportation.

Moreover the size distribution of the coal in the slurry also affects the relative difficulty of recovering dry, marketable coal in the dewatering stage at the pipeline delivery terminal.

Finally the size consist of the recovered coal is a significant factor in its marketability because of its effect upon the handling and storage characteristics of the de-

livered coal. Extremely fine coal tends to clog and cause bridging in coal hoppers and handling equipment, resulting in erratic feeding of such coals to continuously fed boilers. Furthermore extremely fine coals, when stored in open stockpiles are readily blown away by winds and air currents resulting in dust nuisances as well as an economic loss of potential fuel. Coal having excessive fines is quite susceptible in storage piles to spontaneous combustion. To resolve these problems, the purchaser of extremely fine coal must resort to elaborate and costly stockpiling techniques.

We have discovered that surprisingly all of these problems, as well as the magnitude of the energy required to deliver dry coal can be minimized if the coal selected for pipeline transportation has a nominal top size of from 6 mesh to 28 mesh Tyler Standard Screen Series, and in addition not more than 25 percent of the coal by weight is retained on a 14-mesh Tyler Standard Screen.

It is evident that only limited crushing is required to prepare a coal feed for commercial pipelines in the critical size consist range. Since crushing energy requirements increase rapidly with desired product fineness, a substantial savings results from the limited size comminution required to produce the critical feed material of this invention. Conventional hammer mills in general can be used for size reduction to about a 28 mesh nominal top size; more elaborate crushing apparatus would have to be provided to comminute feed coal to any smaller size. Furthermore screens having openings of less than 28 mesh are generally impractical for commercial use because of the tendency of fine coal particles to become caught in the openings resulting in a "blinding" of the screen. To effect size grading of coals to a top size of less than about 28 mesh requires apparatus other than relatively inexpensive screens. Hence conventional hammer milling and screening is adequate to provide the critical coal size consist required for pipeline transportation.

Thus, through its effect on the costs of the preparation stages, the size consist of the feed coal is a substantial factor in the overall costs of coal pipeline transportation.

To illustrate the effect of coal size on pumping power requirements, Figure 2 shows the pressure drop exhibited by several typical coal slurries of differing size consists. All the data for the relationships of Figure 2 were obtained from slurry pumping operations at about 6 feet per second through a pipeline having an internal diameter of 12 inches. Each of the slurries shown had a solids concentration of about 50 percent by weight.

The pressure drop of water alone is shown in line A and is assigned a value of 1.0 for comparison; the value is seen to be unvarying with pumping distance. Each of the curves B, C, D and E shows the phenomenon of high initial pressure drop which is characteristic of raw coal slurries being pumped through commercial pipelines. Curve B shows 4 mesh x 0 coal; curve C shows 8 mesh x 0 coal; curve D shows 14 mesh x 0 coal; and curve E shows 28 mesh x 0 coal. All mesh sizes are Tyler Standard Screen Series. The term "raw coal" as used herein applies to any coal which has not previously passed through a long distance coal slurry transportation pipeline.

Figure 2 shows that after about 50 miles of travel in a commercial scale pipeline, coal slurries regardless of their particle size distribution, require about the same pumping energy. The disparity of the pumping energy requirement for various slurries exists to a pronounced degree only in the initial portion of the pipeline, e. g., the first 50 miles. The initial pressure drop for 4 mesh x 0 coal slurries has been shown to be 1.5 and more times greater than that of 14 mesh x 0 slurries. It is further evident that coals having a size composition of about 14 mesh x 0 exhibit a minimum initial pressure drop. Coals having a nominal top size larger than about 6 mesh exhibit an excessive initial pressure drop in a commercial scale pipeline. Similarly coals having a nominal top size less than about 28 mesh result in excessive initial pressure drop.

The phenomenon of high initial pressure drop exhibited by coal slurries occurs only in pipelines having relatively large diameters, i. e., those which are economically feasible for long distance commercial transportation of coal.

In Table I pressure drop characteristics of various coal slurries are compared at the initial point of a pipeline and also after 100 miles of travel through a pipeline for both a 3-inch diameter pipe and a 12-inch diameter pipe.

TABLE I

Pressure drop of coal slurry relative to water in various pipes at 6 ft./sec. linear velocity

	Initial Pressure Drop		Pressure Drop at 100 Miles	
	3" pipe	12" pipe	3" pipe	12" pipe
Water	1.0	1.0	1.0	1.0
4m x 0 coal [1]	1.3	2.8	1.3	------
8m x 0 coal [1]	1.3	1.85	1.3	------
14m x 0 coal [1]	1.3	1.52	1.3	1.38
28m x 0 coal [1]	1.3	1.67	1.3	------

[1] 50 wt. percent coal in water.

The pressure drop for water is taken as a reference point and assigned a value of 1.0. The pressure drop of 50 wt. percent coal slurries in a pipe having a diameter of 3 inches is 1.3 times that of water in the same pipe at the same velocity. This pressure drop does not vary with size consist of the coal (in the range of 4 mesh x 0 to 28 mesh x 0) and furthermore does not vary with the length of travel through the small pipe. Pressure drop of all the coal slurries for a 3-inches diameter pipe in Table I is 1.3 times that of water throughout the pipe. Nevertheless in the pipe having a diameter of 12 inches, the size consist of the coal is seen to exert a substantial effect on the pressure drop of the coal slurry. The 4 mesh x 0 slurry exhibits initially a pressure drop 2.8 times that of water whereas the 14 mesh x 0 slurry has a pressure drop of only 1.52 times that of water. Moreover the pressure drop of coal slurries in the large pipeline is not uniform throughout its length. The pressure drop of 14 mesh x 0 slurry, for example, is seen to diminish from 1.52 times that of water initially to only 1.38 times that of water after traveling through 100 miles of the 12 inches diameter pipeline. Even after 100 miles of travel, however, the 14 mesh x 0 slurry in the 12 inches diameter pipe exceeds that of water by a factor of 1.38 whereas at any point in the 3 inches diameter pipe the 14 mesh x 0 coal slurry pressure drop is only 1.3 times that of water.

Thus, it is seen that pressure drop phenomenon (which controls the pumping energy requirements for coal slurries and hence the cost of transporting coals through pipelines) occurs only in those large diameter pipes which are of interest commercially, i. e., larger than about 8 inches in diameter.

Accordingly we have discovered that the pumping energy requirements for transporting coal slurries through commercial pipelines can be minimized where the coal has a nominal top size in the range of about 28 mesh to about 6 mesh.

One of the most troublesome problems associated with transporting coal by pipeline is that of separating the coal from the slurry in the slurry dewatering stage at the pipeline delivery terminal. Dewatering difficulties in general arise from the presence of very fine size attrited particles in the delivered slurry.

In passing through a slurry pipeline, the coal particles experienced attrition which causes a rounding off of their sharp edges to produce what are termed "minus 325

mesh attrited particles." These minus 325 mesh attrited particles are the most difficult to recover and also render difficult the dewatering of the balance of the coal particles. The minus 325 mesh particles initially in the coal slurry are not nearly so troublesome as the minus 325 mesh attrited particles.

The minus 325 mesh attrited coal fills the interstices between larger particles and obstructs drying by natural drainage of the coal. The minus 325 attrited coal also tends to clog the interstices of a filter septem in conventional filtration equipment and frequently passes through the equipment into the liquid filtrate. Both the rate and efficiency of filtration are reduced by the presence of minus 325 mesh attrited coal. Centrifugal and cyclone-type separators are generally ineffective for separating these minus 325 mesh attrited solids from their liquid medium. The only really satisfactory technique for separating the water medium from the delivered slurry containing appreciable minus 325 mesh attrited coal is thermal drying which is costly, cumbersome and inefficient with respect to solids recovery.

Hence it is desirable to deliver through commercial pipelines to a slurry dewatering stage a minimum quantity of attrited particles which will pass through a 325 mesh screen.

Coals which have been ground to nominal top sizes of less than 28 mesh normally will contain a substantial quantity of initial minus 325 mesh particles after the grinding operation. In passing through a slurry pipeline, these finely ground coals undergo only slight attrition to yield additional minus 325 mesh particles in the form of attrited coal.

On the other hand, coals which have been ground to a nominal top size larger than about 6 mesh will undergo excessive attrition in passing through a slurry pipeline to yield large fractions of minus 325 mesh attrited particles in the delivered slurry. Whereas these coarser fractions initially contain only small quantities of minus 325 mesh coal, they have excessive fractions of minus 325 mesh attrited coal at the delivery terminal and are particularly difficult to dewater.

We have thus discovered that coal can be delivered by means of slurries through pipelines with a minimum of minus 325 mesh attrited particles where the initial coal has a nominal top size of from about 6 mesh to about 28 mesh. When the pipeline is operated with such coal, the dewatering difficulties are minimized, and, in addition, the recovered dried coal is more readily stored and handled.

Figure 3 indicates the manner in which the content of minus 325 mesh particles increases with the length of travel of the coal slurry through a pipeline. The weight percentage of minus 325 mesh coal is plotted against the length of pipeline travel for a slurry containing about 50 weight percent coal being moved at a linear velocity of about 6 feet per second. Curve A shows the minus 325 mesh coal content of a typical slurry containing 28 mesh x 0 coal; curve B is for 14 mesh x 0 coal; curve C is for 8 mesh x 0 coal; and curve D is for 4 mesh x 0 coal. It is seen from Figure 3 that the initial content of minus 325 mesh particles is high for the generally less coarse coals, but is low for the generally coarse coals. At pipeline distances of commercial interest, i. e., 50 miles and more, the problem of attrition becomes acute. The curves indicate that coal delivered by pipelines over long distances of about 50 miles or more have a minimum total content of minus 325 mesh particles when the starting coal has a size composition ranging from about 6 mesh x 0 to about 28 mesh x 0.

In addition we have discovered that the weight of particles larger than 14 mesh size (hereinafter referred to as plus 14 mesh particles) should not exceed 25 percent of the feed coal in order to avoid the production of excessive minus 325 mesh coal by attrition.

The curve of Figure 4 shows the increase of minus 325 mesh coal in slurries which have been pumped for 100 miles through a commercial scale pipeline. It is seen that the quantity of minus 325 mesh coal resulting from attrition increases sharply as the quantity of plus 14 mesh particles in the feed coal increases.

To summarize our invention, we have found that by properly selecting the size of coals to be transported in slurry form through long distance pipelines, it is possible to minimize the capital investment, operating costs and energy requirements at all stages in a commercial long distance coal transportation pipeline system. Where the feed coal is in the size range of about 28 mesh x 0 to about 6 mesh x 0 and contains less than about 25 weight percent of plus 14 mesh particles, the energy requirements and cost of preparation are not excessive; the pumping energy required for these selected coal sizes over long distances is a minimum (see Figure 2); the coal delivered to the dewatering terminal has a minimum quantity of minus 325 mesh attrited particles, thereby assuring that dewatering will not be unduly troublesome (see Figures 3 and 4); and finally the coal delivered to the consumer is more acceptable for storage and handling because of its minimum quantity of total minus 325 mesh particles (see Figures 3 and 4).

In the following Table II, some experimental results obtained by transporting various coal slurries through long distances in commercial scale pipelines are tabulated to indicate quantitatively some of the advantages which attend the operation of coal slurry pipelines in accordance with the present invention.

TABLE II

Run No.	55	61	59	11
Nominal Feed Size	28m x 0	14m x 0	8m x 0	4m x 0
Feed Composition (weight percent of feed solids):				
on 4 mesh	0.0	0.0	0.0	0.8
on 8 mesh	0.0	0.0	0.8	12.6
on 14 mesh	0.3	0.3	24.7	18.6
on 28 mesh	0.4	28.1	26.1	22.2
on 48 mesh	37.8	30.9	20.2	18.4
on 100 mesh	31.6	19.0	13.1	11.8
on 200 mesh	13.5	8.1	6.2	5.9
on 325 mesh	6.8	3.9	3.3	3.6
Through 325 mesh	9.6	9.6	5.6	6.1
Slurry Concentration	60.0	50.0	60.0	48.1
Linear Velocity, ft./sec.	6.0	6.0	6.2	6.0
Delivered Slurry Composition at 100 miles (weight percent of feed solids):				
on 4 mesh	[1] 0.0	0.0	0.0	0.3
on 8 mesh	[1] 0.0	0.0	0.2	6.4
on 14 mesh	[1] 0.1	0.3	18.9	14.7
on 28 mesh	[1] 0.2	21.6	24.1	17.3
on 48 mesh	[1] 36.6	29.7	17.1	13.1
on 100 mesh	[1] 29.3	18.1	8.7	9.4
on 200 mesh	[1] 12.3	6.4	3.8	5.6
on 325 mesh	[1] 6.8	3.5	2.8	3.5
Through 325 mesh	[1] 14.7	20.4	24.4	29.2
Increase in minus 325 mesh coal weight percent	5.1	10.8	17.8	23.1
Filtration rate of Slurry (dry lbs. per hr. per sq. ft.)	37	72	50	[2]

[1] 80 miles.
[2] 4 mesh x 0 slurry was unfilterable.

The experimental runs are arranged in Table II from left to right in order of increasing coarseness of the feed material. The increase in the content of minus 325 mesh coal (i. e. attrition coal) after 100 miles (80 miles in the case of run 55) is shown to be greater as the coal feed becomes generally coarser. The effect of slurry transportation on the filtration characteristics of the delivered slurry is demonstrated by the filtration rates which are low for the 28 mesh x 0 slurry, reach a maximum with 14 mesh x 0 slurry, and again diminish with 8 mesh x 0 slurries. The 4 mesh x 0 slurry proved to be unfilterable in the drum-type filter employed in these tests, because of its excess of large coal particles. Although unfilterable in the particular equipment available, nevertheless the 4 mesh x 0 slurry could be satisfactorily separated into a coarse and a fine fraction with centrifuging equip-

ment; the slurry effluent from the centrifuge thereupon was filterable, although its filtration rate was low.

The minus 325 mesh screen analysis of the delivered slurries indicates that the 4 mesh x 0 slurry has an excessive quantity of minus 325 mesh coal fines, most of which result from attrition during transit in the pipeline. Hence 4 mesh x 0 slurries are both difficult to dewater and troublesome for consumer handling and storage. The particular 8 mesh x 0 slurry shown in Table II also has an excessive quantity of fines; however its initial composition is slightly beyond the critical limitations of this invention, namely, the plus 14 mesh content exceeds 25 weight percent of the feed coal.

Pressure drop profiles for each of the coal slurries tabulated in Table II are presented in Figure 5 where the pressure drop of each slurry is plotted against the length of travel by the slurry through the pipeline. The two slurries exhibiting the high initial pressure drop are the 4 mesh x 0 slurry and the 28 mesh x 0 slurry. Minimum pressure drop is indicated for the 14 mesh x 0 slurry.

Thus, it is seen, that by using a coal feed selected as herein provided, crushing costs can be maintained at a low value since the required size reduction is not excessive; pumping costs as reflected by the pressure drop curves of Figure 5 are minimized; dewatering costs indicated by the filtration rate data of Table II are minimized; and handling and storage characteristics of the delivered product (a substantial factor in its marketability) are improved as shown by the delivered screen analysis of Table II.

An additional implication of our discovery is applicable to the transportation of coals to commercial steam generating plants, most of which have burners adapted to operate with pulverized coals, for example, coals of which 100 percent will pass through a 100 mesh screen and at least 50 percent will pass through a 200 mesh screen. Because of the excessive pumping energy which would be required for such pulverized coals, their transportation through commercial pipelines is prohibitive. In order to convert mined coal into thermal energy at distant boiler plants, therefore, we have found that it is uneconomical to grind the coal to a pulverized state before it is shipped by pipeline. Instead, the mined coal should be comminuted to a size from about 6 mesh x 0 to about 28 mesh x 0 as previously set forth herein and pumped as a slurry through a long distance pipeline to the distant boiler plant. Attrition resulting from the movement of the coal through the pipeline is itself an effective factor in increasing the fineness of the delivered coal, thereby reducing the duty of any further mechanical crushing apparatus.

As a further consequence of our discovery that the pressure drop of coal slurry decreases with distance of travel through a commercial pipeline, we have found that the pumping stations should be placed along the pipeline at successively increasing intervals.

If, for example, five equal capacity pumping units will supply the energy required to move coal slurry at the desired rate through a commercial pipeline, these five pumping stations should not be placed along the pipeline at uniform intervals. One fifth of the total energy required to move coal slurry through the entire pipeline under stated conditions will not move the slurry through the first fifth of the pipeline at the stated conditions. Hence, in order to obtain maximum advantage from equal capacity pumping stations for coal slurry pipelines, it is necessary that they be placed at successively increasing intervals, with proper allowance for differences in elevation of the terrain which exert an independent effect on the pumping requirements.

According to the provisions of the patent statutes, we have explained the principle, preferred construction, and mode of operation of our invention and have illustrated and described what we now consider to represent its best embodiment. However, we desire to have it understood that, within the scope of the appended claims, the invention may be practiced otherwise than as specifically illustrated and described.

We claim:

1. A method for moving coal from mines to distant markets which comprises obtaining coal having a nominal top size in the range of 28 mesh to 6 mesh Tyler Screen Series and having less than 25 percent by weight of plus 14 mesh particles, preparing a water slurry comprising 35 to 55 percent by weight of said coal in water, pumping said slurry through a long distance pipeline at linear velocities of 4 to 7 feet per second, recovering slurry from the delivery end of said pipeline and recovering marketable coal from said slurry.

2. A method for preparing coal to be transported in the form of a water slurry through long distance commercial pipelines which comprises comminuting coal to a nominal top size in the range of 28 mesh to 6 mesh Tyler Screen Series in such manner that less than 25 percent by weight of said coal comprises plus 14 mesh particles, and preparing a water slurry comprising 35 to 55 percent by weight of said coal.

3. A method for delivering coal through commercial pipelines exceeding 50 miles in length which comprises obtaining coal having a nominal top size in the range of 28 mesh to 6 mesh Tyler Screen Series and having less than 25 percent of its weight as plus 14 mesh particles, mixing said coal with water to form a slurry containing a 35 to 55 percent solids concentration by weight, pumping said mixture at high pressures through a pipeline having an internal diameter exceeding 8 inches, at a linear velocity of 4 to 7 feet per second, removing the bulk of the water from the delivered slurry, and recovering marketable coal.

4. A method for delivering coal over distances exceeding 50 miles which comprises obtaining coal having a nominal top size in the range of 28 mesh to 6 mesh Tyler Screen Series, and having less than 25 percent by weight as plus 14 mesh particles, mixing said coal with water to form a slurry having 35 to 55 weight percent solids concentration, introducing said slurry into a pipeline having an internal diameter of at least 8 inches, introducing substantially equal quantities of energy into the pipeline at increasing intervals of length by means of pumping apparatus, recovering coal slurry at the delivery terminal of said pipeline, and recovering marketable coal from the delivered slurry.

5. A method for moving coal between two distant locations which comprises obtaining coal having a nominal top size in the range of 28 mesh to 6 mesh Tyler Screen Series and having less than 25 percent by weight of plus 14 mesh particles, preparing a water slurry comprising 35 to 55 percent by weight of said coal in water, pumping said slurry through a pipeline connecting said two distant locations, recovering slurry from the delivery end of said pipeline and recovering marketable coal from said slurry.

References Cited in the file of this patent

UNITED STATES PATENTS

449,102 Andrews ---------- Mar. 31, 1891