April 11, 1967 J. JONAKIN ETAL 3,313,252

DRYING AND BURNING OF PIPELINE COAL

Original Filed Dec. 15, 1961 2 Sheets-Sheet 1

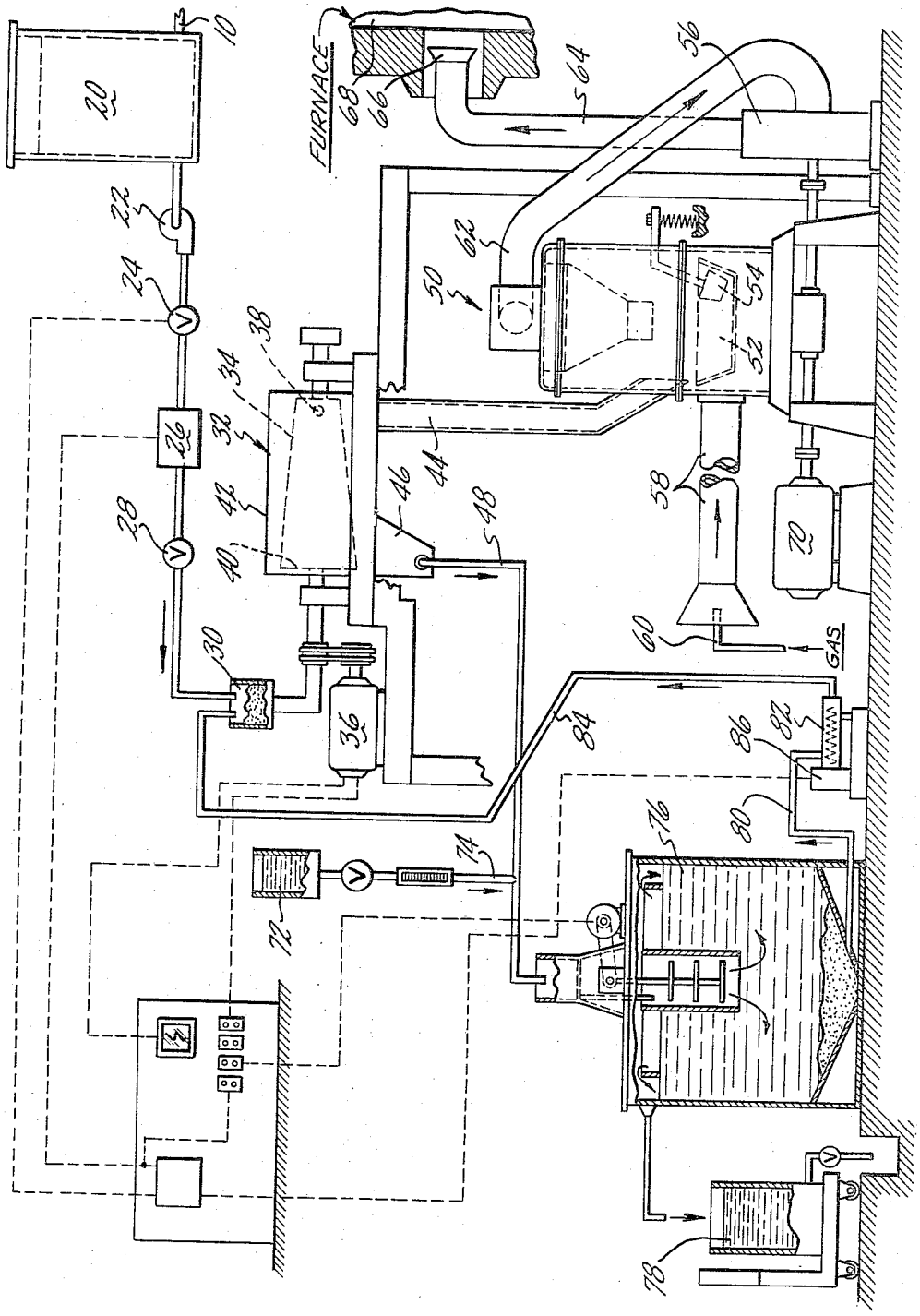


FIG. 1

INVENTORS
JAMES JONAKIN
ROBERT C. TULIS
BY Harris J. Luther
ATTORNEY

April 11, 1967 J. JONAKIN ETAL 3,313,252

DRYING AND BURNING OF PIPELINE COAL

Original Filed Dec. 15, 1961 2 Sheets-Sheet 2

FIG_2

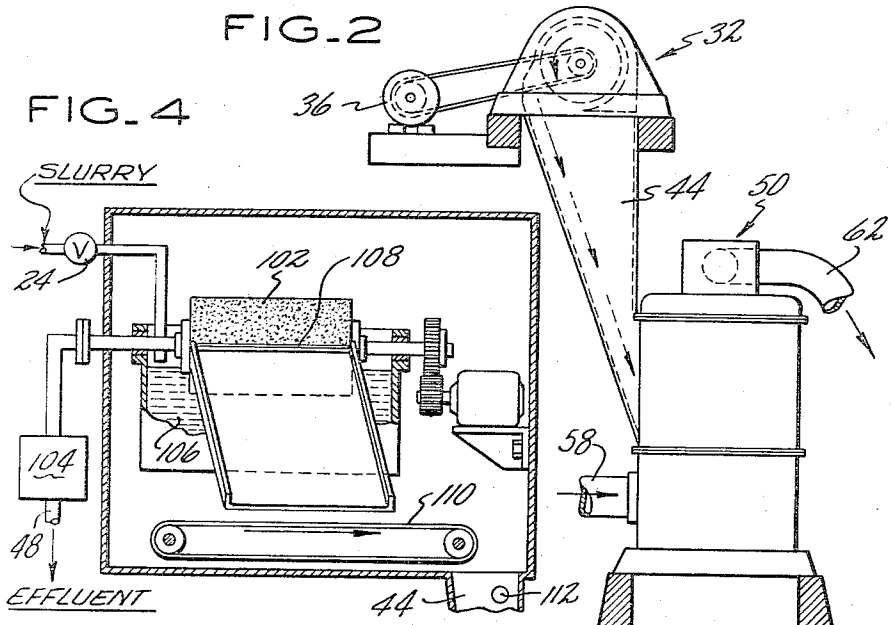
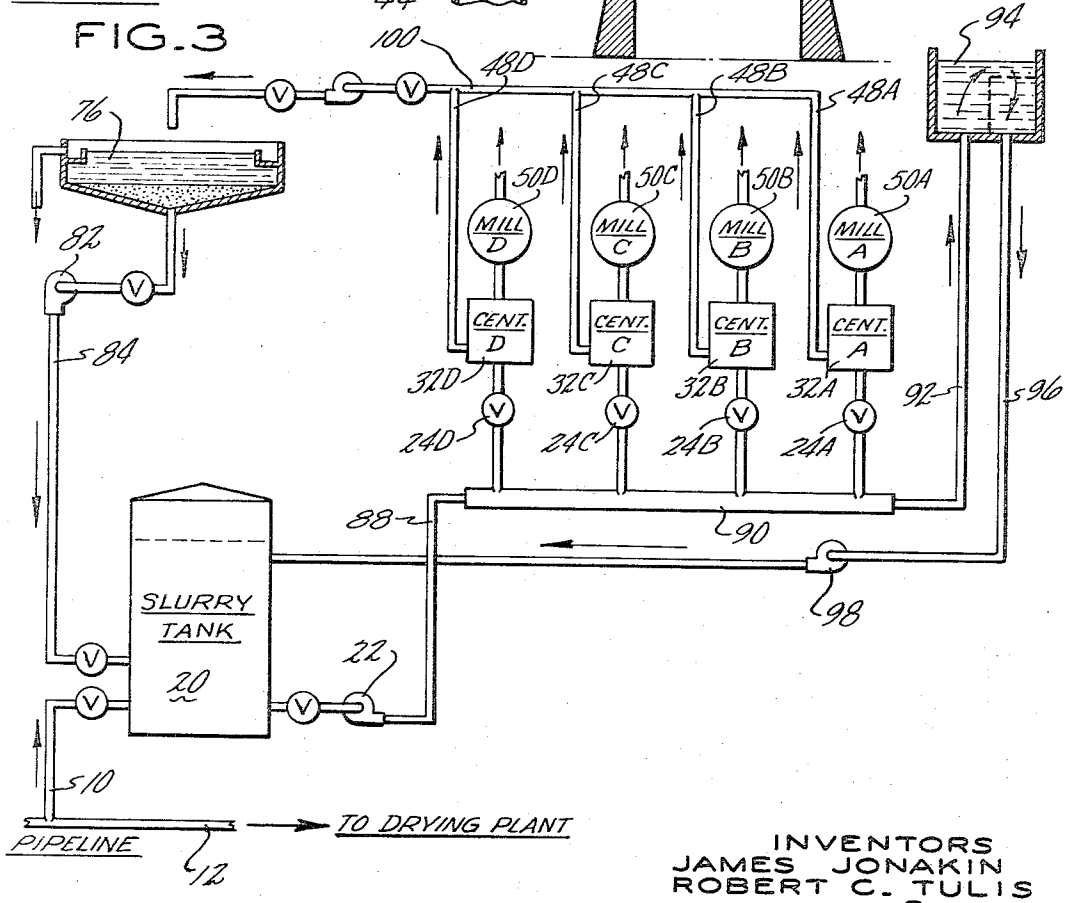


FIG_4



INVENTORS
JAMES JONAKIN
ROBERT C. TULIS

BY Harris O. Luther
ATTORNEY

United States Patent Office 3,313,252 Patented Apr. 11, 1967

3,313,252

DRYING AND BURNING OF PIPELINE COAL

James Jonakin, Simsbury, Conn., and Robert C. Tulis, Chattanooga, Tenn., assignors to Combustion Engineering, Inc., Windsor, Conn., a corporation of Delaware

Continuation of application Ser. No. 159,603, Dec. 15, 1961. This application Dec. 20, 1965, Ser. No. 521,238
23 Claims. (Cl. 110—7)

This appication is a continuation of U.S. Ser. No. 159,600, filed in the names of James Jonakin and Robert C. Tulis on Dec. 15, 1961, for "Drying and Burning of Pipeline Coal."

Copending application Serial No. 159,603 of Jonakin filed Dec. 15, 1961 shows and claims feeding and dewatering method and apparatus limited to cyclone furnaces.

This invention relates to a method of, and mechanism for, utilizing pipeline coal slurry as a source of heat particularly for firing vapor generators.

An object of this invention is to efficiently prepare coal slurry for burning.

A further object of the invention is to efficiently mechanically extract water from the slurry and feed the dewatered slurry to a furnace.

A further object is to feed a continuous stream of pumpable coal slurry directly from a pipeline, at a controlled rate, through a mechanical dewatering station or zone where the water content is reduced from the 30 to 50 percent content of the slurry to approximately 15 to 20 percent and the stream rendered substantially non-pumpable, and then to a combustion chamber of a vapor generator for burning therein.

A still further object is to feed mechanically dewatered slury directly to a pulverizing mill feeding directly to a furnace.

Other objects and advantages will be apparent from the following specification and the accompanying drawings in which:

FIG. 1 is a schematic side elevation of the slurry preparation system;

FIG. 2 is an end elevation of the centrifuge and the pulverizer mill;

FIG. 3 is a schematic view of the slurry preparation system showing four units; and

FIG. 4 is a side elevation of a vacuum filter.

Coal is crushed at the mine to ¼ inch or less and mixed with water to form a coal slurry, of say 60 percent coal and 40 percent water, having the characteristics of a liquid which may be pumped long distances through a pipeline to the place of utilization of the coal such as a steam generating plant. There the coal may be prepared for burning by drying the coal in such equipment as flash dryers reducing the moisture content to eight or nine percent and conveying the coal as a granular material to storage facilities for later conveying to the furnaces in the usual and well-known manner.

The consistency of the slurry depends upon a number of factors. It is, however, desired that there be as small a percentage of water in the slurry as is practicable from the pumping and handling standpoint. A slurry of 50 percent coal and 50 percent water with the coal being crushed so that the coarse fractions are approximately one-quarter inch can be satisfactorily pumped through a pipeline over long distances. By crushing the coal to a somewhat smaller size, a 60 percent coal and 40 percent water slurry may be satisfactorily pumped, this is currently about the limit of coal concentration in water slurry that can economically be pumped through a pipeline over long distances. A relatively recent development indicates that still more concentrated coal-water slurries may

be pumped through pipelines over relative short distances, such as a few miles, with a slurry wherein the coarse fractions are somewhat less than one-eighth of an inch being pumpable in a 70 percent coal and 30 percent water slurry and with indications being that this concentrated slurry is more stable with regard to settling, i.e., requires a longer time for the coal to settle out, than the previously identified slurries and with this being a very desirable property in that it makes the slurry much less difficult to handle.

While the concentration of the crushed coal and water slurry may vary as explained hereinbefore, it remains within the bounds, in accordance with the invention, within which there is produced a slurry that may be satisfactorily and economically pumped through a pipeline. The greater the percentage of water that is pumped the less economical the processes because the water is merely a carrier which must be eliminated in some manner at the location where the coal is utilized for burning. Thus a slurry wherein the water content is greater than the 50 percent is not economically feasible. On the other hand, the concentration of coal in the slurry must be sufficiently dilute so that the slurry can be pumped and handled satisfactorily as a liquid. As previously mentioned, a concentration of 60 percent crushed coal and water has been indicated to be a pumpable slurry which may be economically pumped over long distances while a slurry with a crushed coal concentration of 70 percent has been indicated as pumpable over short distances. These coal slurries to which reference is being made are comprised of crushed coal and water with crushed coal being a term that is well known and has long been used in the coal and fuel handling art. Crushed coal is distinguished from pulverized coal in that in the crushed coal relatively large or coarse coal fractions are present, with the crushed coal, as a result of the action of the crusher, containing particle sizes which range from the coarse fractions of about one-quarter or preferably one-eighth inch size on down to very fine particles known as "fines" which will pass through a 325 mesh screen. Pulverized coal in contrast is a powder with all the coal being reduced to very fine particles through the action of a pulverizer so that all the particles will pass through say a 100 or 200 mesh screen.

In certain types of furnaces such as a cyclone furnace it is possible to feed the slurry directly from the pipeline into the furnace where the water is evaporated and the coal burned. In such a system the evaporated water is fed through the furnace, over the steam generating surfaces and out the stack and represents a material heat loss which will reduce the boiler efficiency, from a possible 88.1 percent obtainable in normal operation with a normal 9 percent moisture bituminous coal, to an efficiency of 83.0 percent. At present day prices this represents about 43 cents a ton above the base price of the coal. The flash drying and storage represents approximately the same additional cost, in addition to the extensive equipment which is both bulky and expensive.

Applicant has found that by mechanically dewatering the crushed coal slurry in equipment such as a vacuum filter or a centrifuge the moisture content can be reduced from the 30 to 50 percent generally required to provide a pumpable slurry which has the consistency of a thick mud to less than 25 percent such as 20 percent or less. This dewatered coal slurry can then be fed, preferably by gravity, directly to a pulverizing mill, such as bowl mill, and pulverized to a size that will permit burning in any furnace adapted to burn pulverized coal. The dewatering equipment is operated at a rate which will reduce the water content of the slurry to as low a percentage as is practical, usually approximately 15 and 20 percent.

Heated air is passed through the bowl mill and serves to further dry the pulverized coal and to transport it to the burners in the furnace. In such a system as only 20 percent or less such as approximately 15 to 20 percent of the mixture is water, which is evaporated and passed through the furnace and out the stack, the boiler efficiency attainable is 86.2 percent or greater and the increase in fuel cost over that of normal operation with 9 percent moisture bituminous coal is 16 cents or less a ton above the base cost of the fuel at present day prices.

Such a mechanical dewatering system is shown in FIG. 1 in which the crushed coal slurry is received through pipe **10** feeding a surge tank **20** which may be of any required size depending upon the requirements of the particular coal burning plant. The slurry is pumped by a pump **22** from the tank **20**, in a continuous stream through a control valve **24**, past a flow meter **26**, such as a magnetic flow meter, through a shut-off valve **28** and into a hopper **30**. As will be described later this hopper **30** also receives flocculated fines. The contents of hopper **30** are fed by gravity or may be pumped by a pump, not shown, to a centrifuge indicated generally at **32**. This centrifuge which may be a standard commercial article such as the centrifuge manufactured by the Bird Machine Company comprises a hollow drum in the form of a cone frustum **34** adapted to be rapidly rotated as by a motor **36** and having a substantially imperforate outer surface except for discharge openings **38** at the small end of the frustum and having closed ends except for a discharge opening in the large end **40** spaced inwardly from the outer surface of the frustum and an opening in a large end **40** at the axis of the frustum for receiving slurry from the tank **30**. A casing **42** surrounds the rotating frustum and contains one or more partitions dividing the casing into two discharge chambers one of which discharges into duct **44** and the other into receiver **46** and pipe **48**.

The slurry discharged into the interior of the frustum collects at the large end as it is thrown out by centrifugal force. A screw conveyor, not shown, cooperates with the interior of the frustum as the frustum rotates relative to the screw conveyor to force coal in a continuous stream from the large end towards the small end of the frustum where it is discharged through the orifice **38**. Water, being lighter than the coal, will tend to stay nearer the axis of the centrifuge as the coal is pressed, squeezed or forced against the drum and will be discharged through the orifices in the end **40** of the frustum. The coal, which contained from 30 to 50 percent moisture when introduced into the centrifuge and which still may contain 20 percent or a little less of moisture, say 15 to 20 percent, is discharged as a pasty material having the consistency of a thick mud with considerable force from the orifice **38** and is forced down the duct **44** by this discharging force and by gravity to a pulverizing mill indicated generally at **50**. The pulverizing mill which may be a standard commercial bowl mill receives the slurry discharged from duct **44** in a rotating bowl **52**. As the bowl rotates it passes by, and carries the coal under, a spring pressed roll **54** which crushes and pulverizes any coal lumps remaining in the slurry. Heated air is drawn into the exhaust fan **56** through pipe or duct **58**. This air which is used as combustion supporting air by the burner **66** in the furnace combustion chamber **63** is normally heated mill air and is further heated as by a gas heater fed through line **60** to provide additional heat for evaporating the moisture in the pulverized slurry. This heated air in passing through the bowl mill further dries the coal by evaporating substantially all of the 15 to 20 percent moisture of the slurry and provides a stream of combustion air and a stream of substantially dry pulverized coal and also acts to convey the coal through the mill and out through duct **62**, exhaust fan **56** and discharge duct **64** to the burner **66** for burning in the furnace **68**. Secondary air may be supplied to the burner in the

usual manner, not shown. The motor **70** supplies power for the bowl mill **50** and the exhaust fan **56**.

Although the capacity of a bowl mill is generally reduced when the coal to be pulverized is wet it has been found that raising the temperature of the air fed through the mill, as by the gas burner **60**, provides sufficient additional drying so that the capacity of the mill is not materially reduced by the 15 to 20 percent water content of the slurry.

The effluent discharged from the large end of the frustum of the centrifuge contains a considerable quantity of fines or coal dust which are carried along with the water from the centrifuge, and which may constitute 4 to 8 percent of the total contents of the coal in the slurry. It is necessary to recover these fines both because the dirty water cannot be discharged into a lake or stream and because these fines represent a material heat value. The effluent containing these fines is fed through pipe **48** and is mixed with a flocculating agent fed from tank **72** through pipe **74** into pipe **48**. This flocculating agent may be any of the well known commercial flocculating agents such as "Separan" sold by the Dow Chemical Company, Midland, Michigan. The treated effluent is fed to a clarifier or settling tank **76** where the flocculating agent serves to flocculate or coagulate the fines or coal dust into larger particles which settle out in the bottom of the storage tank. The clear water then overflows into a receptacle **78** from which it may be discharged into a lake, river or reservoir. The flocculated fines which have collected in the bottom of the tank **76** are led through pipe **80** through a constant volume pump such as a gear or screw pump **82** and fed back through line **84** to a hopper **30** at the entrance to the centrifuge **32**.

The effluent fed back to the hopper **30** contains approximately 30 percent flocculated fines and 70 percent water and is mixed with the slurry being fed from the tank **20** and fed to the centrifuge **32**. In the centrifuge the flocculated fines do not break down and are not again carried out with the effluent but remain as particles large enough to be fed by the screw conveyor in the centrifuge **38** and are discharged into the chute **44** along with the rest of the filter cake discharged from the centrifuge.

It will be noted that the slurry is fed in a continuous stream from the pipeline directly and sequentially to and through converting stations including the centrifuge and pulverizer and that all of the filter cake discharged by the centrifuge **32** is fed in a continuous stream through the bowl mill directly to the furnace so that the control of the rate of flow of the stream of slurry fed to the centrifuge controls the rate of flow and the quantity of coal supplied to the furnace. The magnetic flow meter **26** measures the flow of slurry to the centrifuge and a condition of the steam generator such as pressure, temperature, or load demand, determines or regulates the fuel or slurry quantity or fuel flow rate desired in a manner well known in the art, such as that shown in United States Patents Nos. 2,530,117 or 2,538,428. For example, the fuel quantity or flow rate, as measured by the flow meter **26** may be compared with the fuel quantity or flow rate necessary to maintain a selected vapor generator condition as indicated by the control mechanism and any variation between the two utilized to operate the valve **24** to change the flow rate to correspond to that called for by the vapor generator condition or a variation between the actual condition of the vapor generator such as pressure or temperature and a selected condition may be used to vary the slurry flow to eliminate the variation. As the quantity of effluent discharged by the centrifuge **32** will vary directly with the quantity or flow rate of slurry supplied to the centrifuge, the speed of the motor **86** driving the pump **82** is varied in accordance with the opening of the valve **24** so as to maintain the same proportion of effluent returned for each position of the valve **24**.

While a bowl mill has been shown in the drawing and described in the specification it should be understood that

any suitable type of pulverizer may be used for pulverizing the slurry discharged by the centrifuge. Whatever type of pulverizer is used provision should be made for the further drying of the centrifuge discharge preferably by a blast of hot air passing through the mill which will act to dry and transport the pulverized coal or coal dust and act as combustion supporting air in the combustion chamber of the furnace. This air blast can be supplied by the exhaust fan such as exhaust fan 56 or it can be supplied by a pressure fan supplying air under pressure to the duct 58 supplying air to the pulverizer or if desired both a pressure fan and an exhaust fan may be used. A suitable type of bowl mill is shown in United States Patent No. 2,848,170 issued to J. Crites on Aug. 19, 1958, and a suitable type of beater mill is shown in United States Patent No. 2,985,390 issued to P. Raetz on May 23, 1961.

While a centrifuge 32 is shown as being the now preferred form of mechanical water extracting mechanism is should be understood that other mechanical dewatering mechanisms such as well-known vacuum filter mechanisms might be used. In the vacuum filter mechanism rotating hollow discs or rotating hollow drums 102, having fine perforations or made of fine mesh material and having a vacuum maintained on the inside thereof, as by a pump 104, dip into a reservoir 106 of slurry as they rotate and the vacuum inside acts to hold the slurry against the outside surface of the discs or drum 102 and the disc or drum then draws the slurry out of the bath. As the disc or drum rotates in the air above the slurry bath, air passing through or pressing on the slurry, retained on or squeezed or forced against the disc or drum, by the pressure differential between the pressure outside and the vacuum inside of the disc or drum will cause some of the water in or squeezed out of the retained slurry to pass to the inside of the disc or drum and thus act to dry the slurry. As the retained slurry approaches the bath again knives or scrapers 108 will scrape the partially dry slurry from the filter screen 102 and direct the resulting filter cake onto a conveyor belt 110 which will collect the material discharged from the several scraper blades and convey it to one end of the vacuum filter where it may be discharged into a vertical chute such as the chute 44 shown in FIG. 1 and FIG. 2 and discharged into the pulverizing mill by gravity. If desired the chute 44 could be omitted and the belt could discharge directly into the pulverizing mill. If desired an air bleed 112 could be provided adjacent the discharge end of the belt to equalize any pressure difference between the vacuum filter and the pulverizer.

The mechanism which has been described so far is a unitized system in which a single centrifuge supplies a single mill which may supply one or more burners for the furnace. A single flocculator is provided for flocculating the effluent from the centrifuge. It may be found desirable to have a single furnace fed by several of these unitized systems. Such a structure is shown in FIG. 3. The slurry of crushed coal and water is fed into the tank 20 from the pipeline 10. A branch line 12 may be provided for directing excess slurry to a storage reservoir for storing as slurry or to a drying plant where the slurry may be dried as by a flash drying process and then stored as crushed coal. The slurry is pumped by the pump 22 through line 88 to a manifold 90. The several unitized systems each receive their proportion of the slurry through individual pipelines controlled by individual control valves 24*a*, 24*b*, 24*c* and 24*d*. Each valve controls the flow to its respective centrifuge in accordance with the vapor generator condition as previously described. These valves may be constructed to operate in unison from a single set of signals or may be constructed to operate individually from the error signal provided by the steam generator condition. If the valves are individually controlled each flow meter signal would be individually corrected by its respective control valve which is controlled by the error signal indicating a variation of the generator condition from the desired condition while if they are all controlled in unison the sum of the individual flow signals would be compared with the error signal. The flow meter is not shown in FIG. 3 but would be located as shown in FIG. 1 between each control valve at its respective centrifuge. The controls for the several control valves and motors may be assembled at a control panel 91. Each centrifuge 32*a*, 32*b*, 32*c*, and 32*d* feeds its respective pulverizing mill 50*a*, 50*b*, 50*c*, and 50*d* in the manner previously described and as shown in FIG. 1. In order to maintain a constant head across the several valves 24*a*, 24*b*, 24*c*, and 24*d*, excess slurry from the manifold 90 is fed through a pipe 92 to a tank 94 arranged at a suitable level, say 20 feet, above the valves to thus maintain a static head on them. Excess slurry is returned through the pipe 96 back to the slurry tank 20 by means of a pump 98 which may be controlled in any suitable manner to maintain the level in the tank 94. Effluent from the several centrifuges are led through the pipes 48*a*, 48*b*, 48*c*, 48*d* to a manifold 100 and thence back to the flocculating and clarifying tank 76. The flocculating agent, not shown in FIG. 3, may be added in any suitable manner such as introduced into the pipeline between the manifold 100 and the tank 76. The flocculated fines are returned through the line 84 back to the slurry tank 20.

It should be noted that in FIG. 3 that instead of returning the flocculated fines to the individual centrifuge they are returned to the slurry tank where they are mixed with the incoming slurry so that the pump 82 of the FIG. 3 construction does not have a direct effect on the centrifuge intake and may be controlled by any desired condition such as the condition of the tank 76 and not be dependent on the several valves 24.

From the above description it will be apparent that we have devised a system by which pumpable pipeline coal slurry may be mechanically dewatered and fed directly by gravity to a pulverizing mill where it may be further dried and then fed in the usual manner to a furnace suitable for burning pulverized coal. The system also includes means for recirculating the effluent from the mechanical dewatering mechanism and recovering the fines from the effluent only in a chamber separate from the main stream of slurry flow and returning them to the slurry flow line for eventual feeding to the furnace and burning. In this unitized system each mechanical dewatering mechanism and the pulverizing mill forms a convenient individual unit which is more efficient than burning the slurry directly in the furnace and provides more compact, less costly and more efficient mechanism than any flash drying system.

What we claim is:

1. A method for feeding pipeline coal to a furnace comprising feeding a pumpable slurry of crushed coal and water, containing over 25 percent water, in a continuous stream directly from the pipeline to and through a mechanical dewatering station, mechanically removing water from said continuous stream at said station thereby mechanically reducing the water content of said stream to less than 25 percent and approximately fifteen to twenty percent to provide a continuing partially dewatered continuous stream of coal and water and directing said continuous stream of mechanically dewatered coal and water to a furnace at the rate at which the mechanically dewatered coal and water is discharged from said mechanical dewatering station for burning the coal therein.

2. A method as claimed in claim 1 in which the mechanically removed water contains fines, including the steps of flocculating the fines in said mechanically removed water only and admitting the coal flocs to said dewatering station.

3. In a method as claimed in claim 1 in which the heat generated by burning the coal in the furnace heats a vapor generator, the steps of sensing a selected gen-

erator condition, utilizing said sensed condition for controlling the rate of delivery of the pipeline slurry stream to the dewatering station to provide a rate of coal delivery to the furnace controlled to maintain said selected generator condition at a desired value.

4. A method as claimed in claim 3 in which the mechanically removed water contains fines including the steps of flocculating the fines in said mechanically removed water only and admitting the coal flocs to said dewatering station along with said pipeline slurry stream.

5. A method as claimed in claim 1 in which the partially dewatered stream is fed directly from the dewatering station to a pulverizing station, pulverizing the coal in the partially dewatered stream and introducing heated air as an air stream for mixing the air with the coal at the pulverizing station, and utilizing the air stream for conveying the pulverized coal directly into the furnace.

6. A method as claimed in claim 5 in which the heat generated by burning the pulverized coal in the furnace heats a vapor generator, the step of sensing a selected generator condition, utilizing the sensed condition for regulating the rate of delivery of the pipeline slurry stream to the dewatering station to regulate the rate of delivery of coal to said furnace to maintain said selected generator condition at a desired value.

7. A method as claimed in claim 5 in which the mechanically removed water contains fines, including the steps of flocculating the fines in said mechanically removed water only and admitting the coal flocs to said dewatering station.

8. A method as claimed in claim 7 in which heat is generated by burning the pulverized coal in the furnace which has a variable heat demand, the steps of regulating the rate of delivery of the pipeline slurry stream to the dewatering station to provide a rate of coal delivery to the furnace proportional to the demand for heat.

9. A method of supplying pulverized coal to a burner comprising pumping a stream of pipeline coal slurry comprising crushed coal and water directly to a mechanical water extractor, mechanically reducing the water content of the pumpable pipeline slurry to less than 25 percent and approximately fifteen to twenty percent then feeding the partially dewatered slurry directly to a pulverizer, pulverizing the partially dewatered slurry, further drying the pulverized slurry with a stream of heated air in the pulverizer and conveying the dried pulverized coal of the slurry directly from the pulverizer with the substantially entire stream of heated air to a burner in a furnace heating a vapor generator, controlling the rate of delivery of the pipeline slurry stream to the mechanical water extractor to regulate the rate of coal delivered to the burner so as to be proportional to the load demand for the generation of vapor.

10. A method of supplying a burner with pulverized coal comprising pumping a stream of coal slurry of crushed coal and water through a pipe and feeding said stream from said pipe, continuously, directly and sequentially to and through converting stations, to said burner including, subjecting the slurry streams as delivered by said pipe first to a squeezing action to remove some of the water at the first converting station and provide a partially dewatered slurry having the consistency of a thick mud, then pulverizing the coal in the partially dewatered slurry at the second converting station and further drying the coal by mixing the coal with a stream of heated, combustion supporting, air during the pulverizing step and conveying the mixture with the air stream directly to a burner.

11. A method as claimed in claim 10 including the steps of utilizing heat generated by said burner to generate steam and controlling the rate of flow of pulverized coal to the burner by controlling the rate of flow of slurry through the pipe so as to be proportional to the load demand for the generation of steam.

12. A method as claimed in claim 10 in which said squeezing action creates a stream of partially dewatered coal and a stream of separated liquid containing coal fines and including the steps of extracting coal particles from the water removed from the slurry, flocculating said particles only in a zone separate from said slurry stream and then returning the extracted flocculated particles to said stream and then subjecting the flocculated particles to a squeezing action along with said stream of coal slurry.

13. In combination, means for drying, and preparing for burning, coal in pumpable pipeline coal slurry comprising a pipeline for conveying a stream of said coal slurry, a mechanical dewatering mechanism receiving a stream of said coal slurry directly from said pipeline, and mechanically reducing the water content of the slurry and discharging a continuous stream of coal and water having approximately 15 to 20 percent water, means for feeding the continuous stream, comprising the mechanically dewatered coal output of said dewatering mechanism, at the rate said output is discharged from said dewatering mechanism in a continuous stream to a furnace for burning and means for regulating the rate of flow of coal to said furnace.

14. The combination claimed in claim 13 including means effectively responsive to the heat evolved by burning the coal in the furnace for controlling the rate of flow of the pumpable pipeline slurry to said dewatering means to provide a rate of coal delivery to said furnace proportional to the demand for heat.

15. The combination of claim 13 in which the dewatering mechanism separates the slurry into a mechanically dewatered output and an effluent containing fines, a flocculating device operative to receive said effluent and add a flocculant to said effluent only and flocculate said fines and means returning the flocs to said mechanical mechanism.

16. The combination of claim 15 including means by which vapor is generated by heat evolved in burning said coal in said furnace, and means by which the rate of delivery of coal delivered to said furnace for burning is controlled by said regulating means so as to be proportional to the demand for vapor.

17. A unitized system for preparing pumpable pipeline crushed coal slurry for burning comprising a liquid extractor means mechanically separating some of the liquid from the pumpable pipeline slurry and changing the pumpable pipeline slurry to a pasty mixture having less than 25 percent moisture and substantially more than nine percent moisture, a pulverizing mill, means conveying the partially dried coal mixture directly from the extractor means to the pulverizing mill, and means creating a heated air stream through the pulverizer mill for further drying the coal in the pulverizer and conveying it directly to a combustion chamber for burning.

18. A combination as claimed in claim 17 in which vapor is generated by the heat evolved in burning said coal including means for controlling the rate of supply of slurry to said liquid extractor means to control the rate of delivery of pulverized coal delivered to said combustion chamber so as to be proportional to the demand for vapor including means maintaining a fixed head across said controlling means.

19. A combination as claimed in claim 17 including means recycling the extracted liquid through a flocculating device independent of said crushed coal slurry and then back to said coal slurry and said liquid separating means including means adding a flocculant to said extracted liquid only to extract the fines in the extracted liquid.

20. Means for feeding coal directly from a pumpable coal slurry supply of crushed coal and water to a combustion chamber for burning comprising means receiving pumpable coal slurry directly from said supply and mechanically removing some of the water from the slurry and producing a slurry of approximately 15 to 20 percent

moisture, means for pulverizing coal, means for feeding the partially dewatered slurry directly from the water removing means to the pulverizer, means for feeding the output of the pulverizer directly to a combustion chamber for burning, means utilizing heat generated by said burning for creating vapor and means for regulating the rate of feed of pulverized coal fed to the combustion chamber by regulating the rate of supply of pumpable slurry fed to the water removing means to be proportional to the demand for vapor.

21. In combination a pipeline for conveying a pumpable crushed coal slurry, means for mechanically extracting a portion of the liquid from said pumpable slurry and producing a non-pumpable water-coal mixture having substantially more than nine percent moisture but less than 25 percent moisture, pulverizer means for pulverizing the coal in the non-pumpable mixture, and a burner, means conveying the coal slurry from the pipeline directly to the liquid extracting means, means directing said mixture by gravity from the liquid extracting means directly to said pulverizer, and means for further drying the pulverized coal in said pulverizer and conducting the further dried pulverized coal from the pulverizer directly to said burner.

22. A combination as claimed in claim 21 in which the liquid extracting means is a centrifuge and the liquid effluent from said mechanical liquid extracting means carries some coal dust, a settling chamber, independent of the main stream of slurry, receiving said effluent means, means, including a flocculator, for separating and flocculating the coal dust from the effluent in said separate settling chamber and then returning the flocculated coal dust to said coal slurry conveying means and then to said liquid extracting device.

23. A slurry converting unit for converting a pumpable coal slurry supply of crushed coal and water into a combustible mixture of pulverized coal and air comprising a pipeline delivering a coal slurry, valve means controlling the flow in said line, a centrifuge receiving the entire output of said line and separating the slurry into an effluent of water and coal fines and partially dewatered slurry, a pulverizer, means receiving the entire partially dewatered slurry from the centrifuge and feeding said partially dewatered slurry directly to said pulverizer, fan means creating an air stream through said pulverizer for conveying the coal pulverized by said pulverizer, a heater for heating said air stream, the output of pulverized coal from said pulverizer being controlled by said valve means, a flocculator for flocculating the fines in said effluent only, and means for recycling the floc back into the slurry supply.

References Cited by the Examiner

UNITED STATES PATENTS

2,346,151	4/1944	Burk	44—1
2,357,301	9/1944	Bailey et al.	122—336
2,538,428	1/1951	Sawyer	236—14
2,685,369	8/1954	Crossley	233—14
2,716,002	8/1955	Craig	110—106 X
2,920,923	1/1960	Wasp et al.	302—66
3,073,652	1/1963	Reichl	302—6
3,124,086	3/1964	Sage et al.	110—7

FREDERICK L. MATTESON, JR., *Primary Examiner.*
E. G. FAVOR, *Assistant Examiner.*