Sept. 12, 1967 D. J. FREY ET AL 3,340,830

DRYING AND BURNING PIPELINE COAL IN A HEAT EXCHANGE SYSTEM

Filed May 4, 1966 2 Sheets-Sheet 1

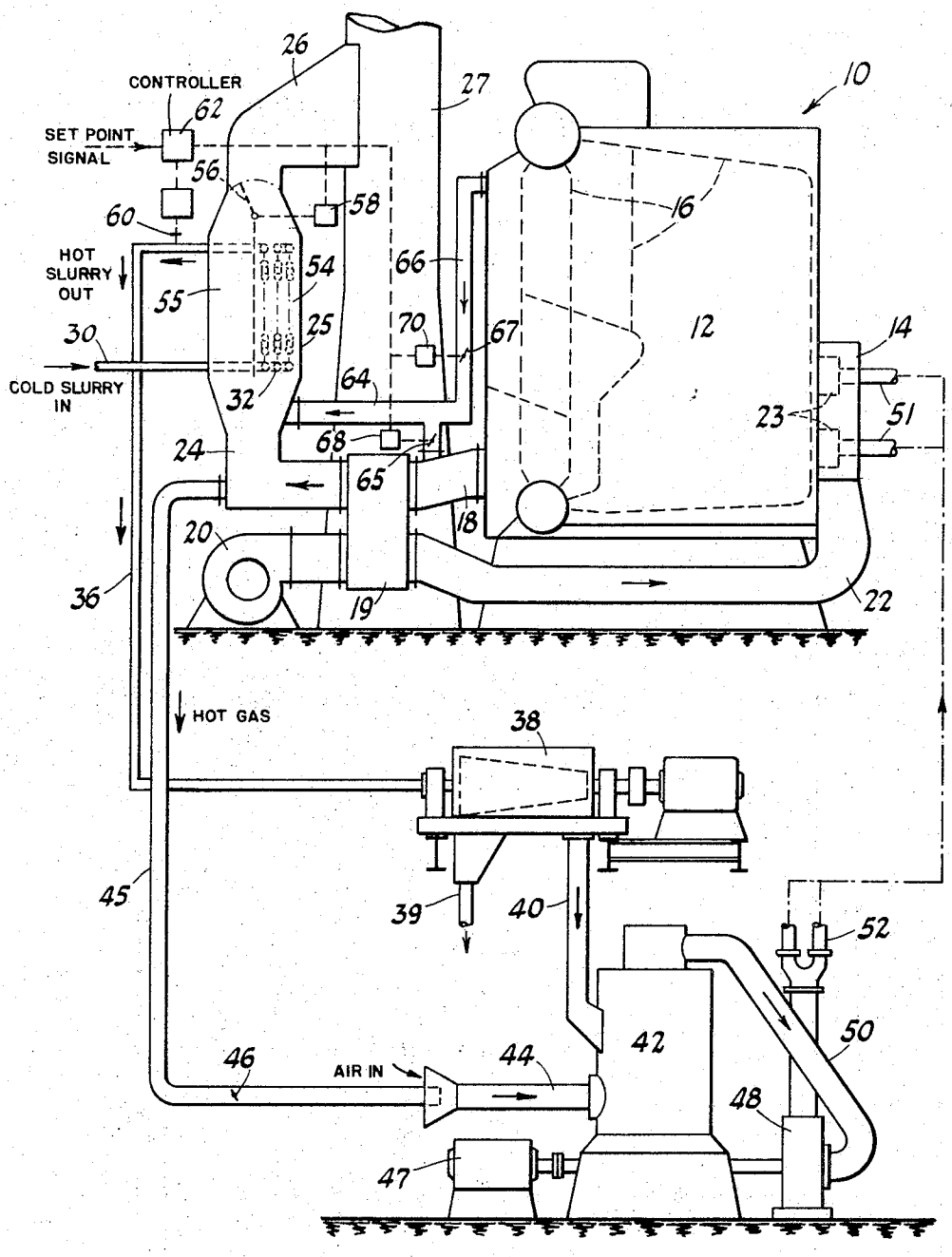



FIG. 1

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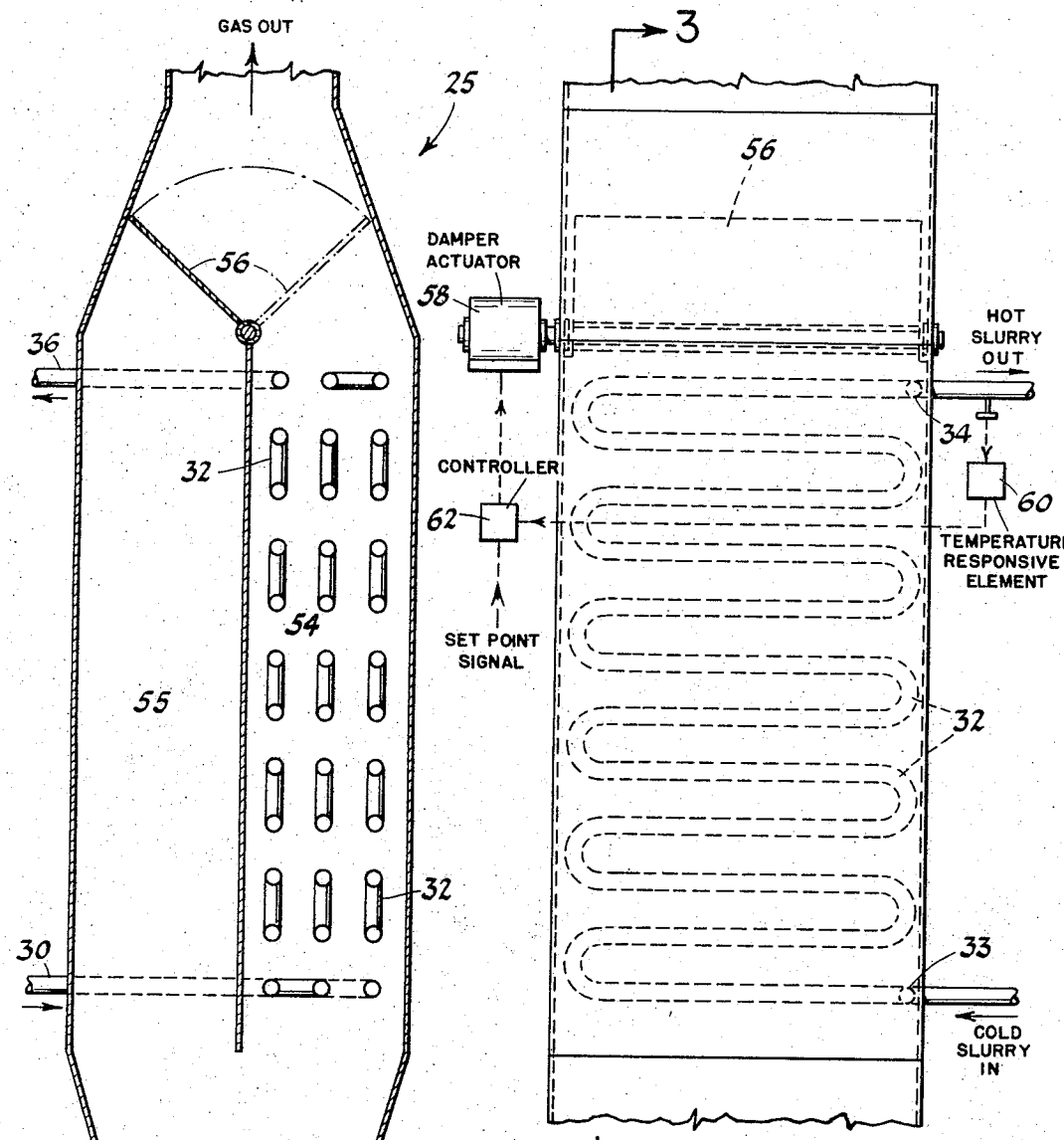



FIG.3

FIG.2

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3,340,830

# DRYING AND BURNING PIPELINE COAL IN A HEAT EXCHANGE SYSTEM

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This invention relates to a heat exchange system utilizing pipeline coal as a fuel. It is specifically concerned with an improved organization and method in which the pipeline coal is dewatered by mechanical means such as by the use of a centrifuge, and is burned in the furnace of a heat exchange apparatus, for example, a steam boiler.

Coal crushed in the mine to ¼-inch or less and mixed with water to form a coal slurry of, for instance, 60 percent coal and 40 percent water, may be pumped long distances through pipelines to the place of utilization of the coal, such as a steam generating plant. There the coal may be prepared for burning by partially dewatering the coal in such equipment as a centrifuge. Then the dewatered coal may be conveyed directly to a pulverizer for further grinding and drying. This may be followed by delivery of the finely ground coal to a coal bunker for temporary storage or immediately to the furnace for burning.

From the standpoint of improving the over-all efficiency of the steam generating plant, it is highly desirable to introduce the coal into the furnace in as dry a condition as possible. While the water content of the coal leaving the centrifuge has been reduced by centrifugal force to a large extent, additional drying of the coal takes place in the pulverizer by introducing therein heated air and/or hot gases. In a system where the effluent from the mill is directly fed to the furnace for burning the moisture evaporated from the coal in the mill and absorbed by the hot gases also enters the furnace. Accordingly, increasing the drying capacity of the mill does not necessarily increase the efficiency of the steam boiler. In an effort to improve the thermal efficiency of the steam boiler it is therefore important to reduce the moisture content of the coal *before* entry thereof into the pulverizer.

This is accomplished in accordance with the invention by improving the capability of the centrifuge in separating the water in a coal slurry from the coal. When subjecting the coal slurry to high centrifugal forces within the centrifuge, surface tensional forces existing between the coal particles and the water clinging thereto oppose the centrifugal forces striving to separate the water from the coal particles. We have found that by preheating the coal slurry before delivery thereof to the centrifuge the surface tension between the water and the coal can be significantly reduced. Thus, under certain operating conditions and without preheating the coal slurry as heretofore practiced, it is possible to reduce the water content of the coal slurry by 80 percent or with 20 percent water remaining in the coal that is discharged from the centrifuge. However, by heating the coal slurry as disclosed herein from a temperature of 60–80° F. to 150–180° F., for example, it was found that the 20 percent of residual moisture can be reduced by about 20 percent or to 16 percent with the power requirement of the centrifuge remaining substantially the same. This reduction of the moisture content of the coal entering the mill, however, will significantly reduce the dry load and the power requirement of the mill and may also reduce the moisture content of the air and coal entering the furnace, thereby increasing the operating efficiency of the steam generator.



By utilizing, in accordance with the invention, part of the residual heat in the stack gases for preheating the coal slurry, which stack gas heat ordinarily would be lost to the atmosphere, the over-all efficiency of the boiler is additionally improved.

It is accordingly an important object of the invention to significantly increase the over-all operating efficiency of a steam boiler burning pipeline coal.

It is another object of the invention to increase the water separating capacity of a centrifuge by reducing the surface tension between the water and the coal particles before the coal slurry is fed to the centrifuge.

It is an additional object of the invention to improve the grinding efficiency and lower the power requirement of a mill operationally connected to a pipeline coal centrifuge and to an associated furnace.

It is a further object of the invention to increase the thermal efficiency of a steam boiler firing pulverized pipeline coal which is received from a pulverizing mill and associated centrifuge, by reducing the moisture in coal loss and the dry gas loss.

Other objects and advantages of the invention will become apparent from the following description of an illustrative embodiment thereof when taken in conjunction with the accompanying drawings wherein:

FIG. 1 is a schematic representation of the improved pipeline coal preparation and burning system as employed in connection with a steam boiler;

FIG. 2 is a diagrammatic sectional view of a preferred design of a coal slurry preheater; and

FIG. 3 is a cross section of the preheater when taken on line 3—3 of FIG. 2.

Referring now to the drawings wherein like reference characters are used throughout to designate like elements, the illustrative and preferred embodiment of the invention depicted therein includes a vapor generator designated generally as **10** and comprising a furnace chamber **12** including a burner assembly **14** for feeding pulverized coal and air for combustion to the furnace chamber. Heat exchange equipment such as steam evaporating and steam heating surfaces generally designated as **16** are suitably disposed in the furnace chamber **12** with the combustion gases passing thereover and leaving by way of outlet duct **18** at greatly reduced temperature. An air preheated **19** through which the gases pass after leaving the steam boiler serves to further reduce the temperature of the gases and to preheat the air for combustion. Thus, air enters the air heater **19** by way of forced draft fan **20**, is heated by passing through the heater and flows through duct **22** to burner assembly **14**. There the heated air joins streams of pulverized coal which are being discharged into the furnace by way of nozzles **23** for burning. The gases leaving air heater **19** pass through duct **24** to a slurry preheater **25** which will be described in greater detail hereinbelow. They are then discharged into the atmosphere by way of duct **26** and stack **27**.

In the steam generating plant to which the invention is applied pipeline coal is delivered by way of a pipe **30** from a source, not shown, and in the form of a slurry which may contain, for example, 60 percent water and 40 percent crushed coal.

In accordance with the invention, the coal slurry before being treated in the centrifuge is preheated in slurry preheater **25**. For this purpose the slurry passes through tubular heat exchange surface which as shown in the preferred embodiment of FIG. 2 takes the form of serpentine tubes **32** having an inlet **33** and an outlet **34**. After having been heated in the heater **25** the slurry passes through conduit **36** to a centrifuge **38** wherein separation of water from coal takes place by centrifugal force in a well known manner. Reference is made to co-pending application

Serial No. 159,600, now abandoned, filed December 15, 1961, by James Jonakin et al., which application contains a detailed description of the preparation of pipeline coal. The water separated from the slurry is discharged from the centrifuge at **39**. The dewatered coal also called filter cake leaving the centrifuge **38** enters a duct **40** and is fed to a mill **42** for grinding and further removal of moisture therefrom. This is accomplished by introducing into the mill **42** cold air or hot gases or a mixture thereof by way of an inlet duct **44**, with the hot gases taken from the combustion gas duct **24** and conducted to inlet duct **44** by way of pipe **45**. A damper **46** may be employed to control the hot gas supply to the mill **42**.

Any suitable type of pulverizer or mill may be used for grinding the coal discharged from centrifuge **38**. While a bowl mill is shown herein of the type described in U.S. Patent 2,848,170, issued to J. Crites on Aug. 19, 1958, a beater type of mill may also be used such as that shown in U.S. Patent 2,985,390, issued to P. Raetz on May 23, 1961. The type of mill illustrated in FIG. 1 is of the suction type equipped with a motor **47** for driving the mill and also for driving an exhauster **48** which maintains the interior of the mill under suction and which draws in a blast of air and hot gases through duct **44** which gases, while sweeping through the mill, evaporate moisture from the pulverized coal and serve as carrier gas for transporting the coal dust to burners **23** by way of pipe **50**, exhauster **48** and fuel pipes **52**.

For optimum operation of the centrifuge **38** it is desirable that the temperature of the coal slurry entering the centrifuge be uniform regardless of variations in gas temperature such as due to load changes, for example. Accordingly slurry heater **25** is provided with two parallel gas passages **54** and **55**, with heating coils **32** located in gas passage **54**, and gas passage **55** constituting a bypass therearound. A damper **56** including actuator **58** is provided in the gas outlet end of the heater **25** organized to restrict the gas flow to either one of the passages **54** and **55**. A temperature responsive element **60** senses temperature deviations occurring in the coal slurry leaving the slurry heater **25**, with these temperature deviation impulses being transmitted to controller **62**. A set point signal received by controller **62** serves as a temperature standard. Deviations of the incoming temperature signal from the set point signal causes a correction impulse to be transmitted from controller **62** to actuator **58** for adjusting damper **56**. Thus, an increase of the slurry temperature, as indicated at **60**, above the set point temperature will cause the actuator **58** to adjust damper **56** so as to restrict the gas flow through gas pass **54** thereby lowering the slurry temperature. On the other hand, a decrease of the temperature of the slurry below the set point temperature will cause the actuator **58** to adjust damper **56** so as to open gas pass **54** and, if necessary, restrict the flow through gas bypass **55**.

Depending upon the operating conditions of the steam generator it may be desirable to increase the temperature of the gases entering the slurry heater **25** by bypassing air heater **19** or even part or all of the heating surface **16**. This is accomplished by providing bypass duct **64** leading from the gas inlet of air heater **19** to the gas inlet of slurry heater **25**. To obtain even higher temperature it may be desirable to provide a bypass duct **66**, **64** leading from a portion of the furnace interior to the slurry heater gas inlet. Dampers **65** and **67** serve to control the flow through bypass ducts **64** and **66**, respectively, in response to temperature variation impulses by damper actuators **68** and **70** received from controller **62**.

While we have illustrated and described a preferred embodiment of our invention, it is to be understood that such is merely illustrative and not restrictive and that variations and modifications may be made therein without departing from the spirit and scope of the invention. We therefore do not wish to be limited to the precise details set forth but desire to avail ourselves of such changes as fall within the purview of the following claims.



We claim:

**1.** In combination a steam generator having a furnace, and an adjoining offtake passage forming combustion gas path; a centrifuge receiving a coal slurry for dewatering said slurry; means for delivering the dewatered coal to said furnace for burning therein and for the generation of hot combustion gases flowing through said passage along said gas path; first and second heat exchange means located in said gas path for absorbing heat from said gases and for cooling said gases; means located in one portion of said gas path for heating said coal slurry; means for conducting the relatively cold coal slurry through said slurry heating means for heating and for further cooling said gases; means for flowing said heated slurry from said heating means to said centrifuge for dewatering and for delivery of the dewatered coal to said furnace as aforesaid.

**2.** The combination as defined in claim **1** wherein said slurry heating means comprise indirect contact heating elements exteriorly exposed to said gases and interiorly forming a path for the coal slurry.

**3.** The combination as defined in claim **2**, wherein said indirect contact heating elements comprise serpentine tubes.

**4.** The combination as defined in claim **2** wherein means are provided for altering the heat exchange between said gases and said heating elements; and control means organized for regulating said heat exchange.

**5.** The combination as defined in claim **4**, wherein said means for altering said heat exchange comprise a gas bypass around said heating elements; and flow restricting means organized for controlling said bypassed flow.

**6.** The combination as defined in claim **4** wherein a temperature sensing element is provided which is responsive to variations in the temperature of said heated coal slurry, and means for making said heat exchange regulating means responsive to impulses received from said temperature sensing element to maintain the temperature of said heated slurry constant with varying gas flow and gas temperature.

**7.** The combination as defined in claim **1**, wherein said coal slurry heating means are located in a portion of said gas path which is downstream in the gas flow sense of said first and second heat exchange means.

**8.** The combination as defined in claim **7**, wherein a gas bypass is provided around said second heat exchange means, and control means for regulating the gas flow through said bypass.

**9.** The combination as defined in claim **8**, wherein a temperature sensing element is provided which is responsive to variations in the temperature of said heated coal slurry, and means for causing said gas bypass regulating means to respond to impulses received from said temperature sensing element to maintain the temperature of said heated slurry constant with varying gas flow and temperature.


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