CONDENSIBLE FLUID SWEPT PULVERIZER

Filed Feb. 4, 1954 2 Sheets-Sheet 1

Fig. 1.

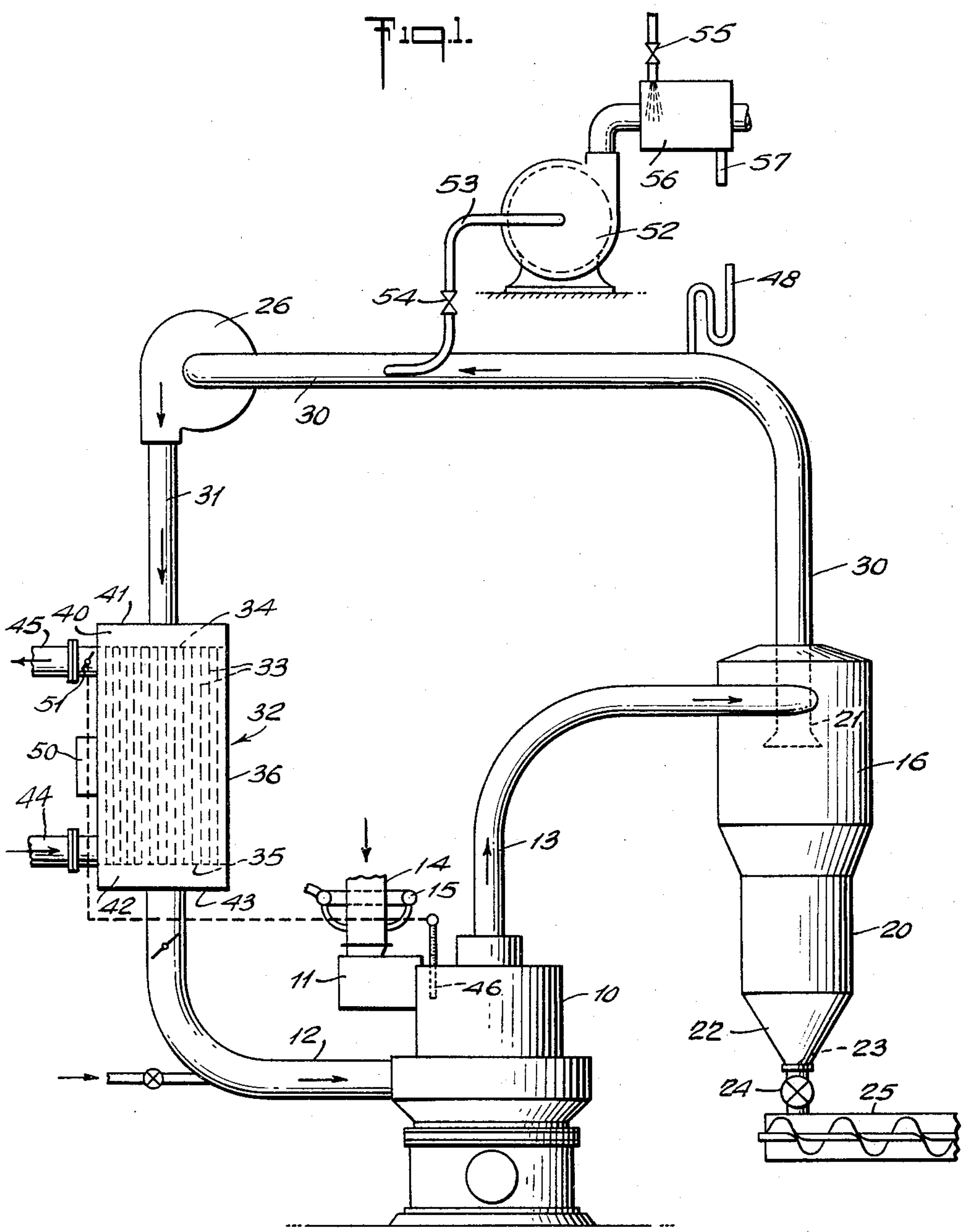
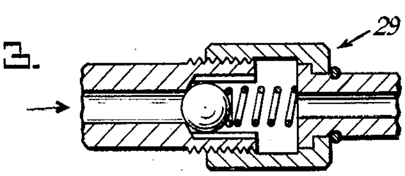


Fig. 3.



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Nov. 15, 1960 S. K. CULP 2,960,324

CONDENSIBLE FLUID SWEPT PULVERIZER

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Fig. 2.

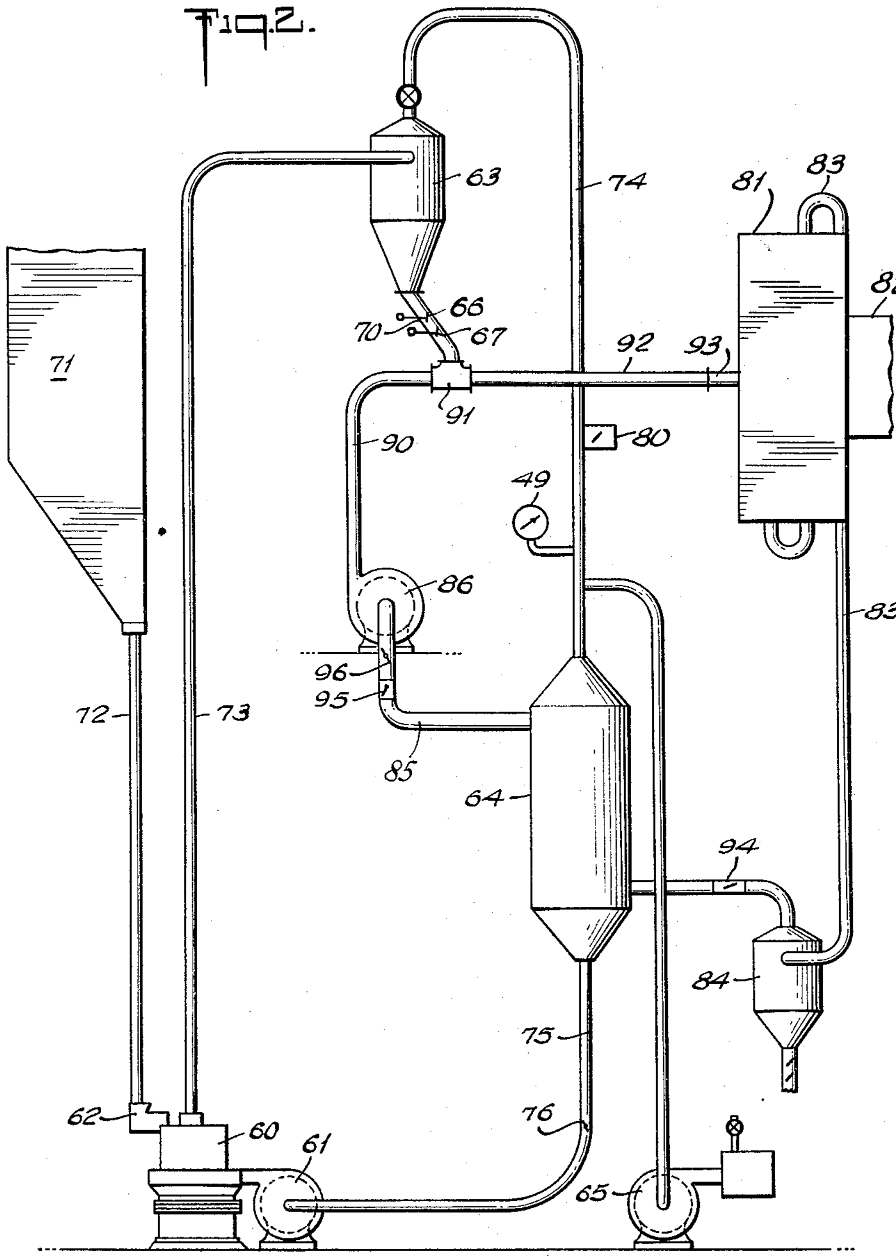


Fig. 4.

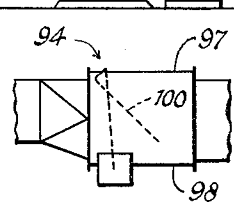
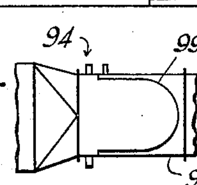


Fig. 5.



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CONDENSIBLE FLUID SWEPT PULVERIZER

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4 Claims. (Cl. 263—33)

The present invention relates to pulverizing systems, and more particularly to the method of and apparatus for sweeping a pulverizer with a condensible fluid.

The pulverization of moisture-laden raw materials has usually been accomplished in air-swept pulverizers where air or hot gases have been used as the drying, classifying and pulverized material carrier medium. In such systems of pulverization, the air is heated to an entering temperature of, for example from 300 to 500° F., which is sufficient in view of the weight of air used for classification and carrier purposes, to maintain the temperature of the air-borne stream above dew point upon leaving the pulverizer. Under such conditions the moisture evaporated from the solid material during pulverization is present in vapor form with the air and pulverized material mixture leaving the pulverizer. When the pulverizer is utilized for the pulverization of solid fuels such as coal or the like, the pulverized coal and air stream discharged from the pulverizer is usually delivered directly to a burner or burners in a furnace for combustion of the fuel, as the fuel is prepared. Under these circumstances, the moisture originally present in the fuel is likewise delivered in the form of a vapor to the furnace with the fuel and air. With high moisture containing fuels the presence of the vapor with the pulverized fuel upon introduction to the furnace will limit the combustion temperature. Such temperature limitation is not particularly important in heat exchange applications, such as in the generation of steam, but can be detrimental in certain processes, as for example in the production of cement clinker, where definite temperatures are required for process reactions.

While the direct firing system for pulverized solid fuels is utilized in the great majority of heating applications, some installations are arranged for the preparation of the pulverized solid fuel in an air-swept pulverizer with the pulverized solids separated from its moisture laden carrier air, and the pulverized solids stored for subsequent mixing with combustion air and delivery to furnace burners. In these circumstances the separated air, with included vapor and fine fuel particles, is at least partially vented to atmosphere, or in some installations delivered to the furnace. The storage system of pulverized fuel preparation avoids the delivery of at least some of the original raw material moisture to the furnace zone where the pulverized fuel is burned. Other systems of drying solid fuels before fuel combustion are known, as for example where at least some portion of the moisture in the raw material is removed in separate dryers before the material is pulverized and delivered to the combustion zone.

Steam has been previously suggested as a drying and carrier medium in the preparation of pulverized fuels, such as coal, since steam is limited in its drying capacity only by its superheat temperature. However, steam has not proven satisfactory in direct firing systems where the coal is pulverized as it is needed for combustion requirements and passes directly from the pulverizer to the furnace burners. The difficulty with steam under such conditions lies in the smothering effect of steam on the flame produced in burning the pulverized fuel.

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According to the present invention, I utilize a carrier medium predominantly composed of steam as a drying and carrier medium, and separate the carrier medium from the pulverized fuel externally of the pulverizer before the introduction of the fuel into the combustion zone. The separated carrier medium is reheated to a desired temperature and recirculated to the pulverizer for reuse in drying the raw material and serving as a carrier. Since the heat from the superheat steam vaporizes the moisture in the fuel during pulverization the moisture adds to the total amount of steam present in the system and must be vented. Preferably, the amount of carrier medium vented should be equal, or substantially equal, to the amount of vapor added during the operation of the system. The vent can be conveniently operated by a pressure relief valve whereby excess steam increases the system pressure to actuate the valve and to vent sufficient medium to maintain the system at normal operating pressures. Alternately, a controlled amount of carrier medium can be withdrawn by a vent fan. Preferably the vented medium is cooled to condense the steam and to thereby remove the dust particles in the vented medium with the condensate, as a slurry.

The various features of novelty which characterize my invention are pointed out with particularity in the claims annexed to and forming a part of this specification. For a better understanding of the invention, its operating advantages and specific objects attained by its use, reference should be had to the accompanying drawings and descriptive matter in which I have illustrated and described a preferred embodiment of the invention.

Of the drawings:

Fig. 1 is a schematic arrangement of a pulverizing system incorporating the present invention;

Fig. 2 is a schematic arrangement of the novel pulverized fuel system as applied to a rotary kiln;

Fig. 3 is a vertical section of a pressure relief valve; and

Figs. 4 and 5 are plan and elevation views, respectively of the proportioning valve shown in Fig. 2.

The invention is illustrated in the drawings in the form of a mechanical pulverizer of the type in which solid materials are subjected to the grinding action of relatively moving grinding elements. A pulverizer of this type is described in the S. T. Schwartz Patent 2,275,595. Other types of mechanical pulverizers employing a fluid carrier medium for entraining the pulverized material may be used.

In the embodiment of the invention shown in the drawings, the apparatus is arranged for the preparation of pulverized coal for use as a fuel. It will be understood the apparatus is equally applicable for the pulverization of other solid materials containing moisture, and for purposes other than the preparation of fuel.

As shown in Fig. 1, the pulverizer **10** is provided with a feeder **11** for the delivery of screened coal at a controllable rate to the pulverizer. In addition, the fluid carrier medium is introduced into the lower portion of the pulverizer **10** through an inlet duct **12**. The carrier medium passes upwardly through the pulverizer, entraining the pulverized coal resulting from the grinding action of the pulverizer elements, and discharges through an outlet pipe **13** with the entrained pulverized coal.

In accordance with the invention, the fluid carrier medium includes a predominant percentage of superheated steam which is maintained above saturated temperature throughout the flow circuit of the pulverizing system, as hereinafter described. The pulverizer, the feeder and the connecting piping are preferably provided with a layer of insulating material to reduce heat losses and to maintain the carrier medium above a selected temperature.

The pulverizer is provided with necessary sealing means to prevent the escape of carrier medium from the system and to avoid flow of the carrier medium into the driving elements of the unit. Sealing means utilizing compressed air are used to prevent movement of the carrier medium through the feeder and upwardly through the raw material spout 14 into the coal bin (not shown). Such a sealing means is illustrated in Fig. 1 by a manifold 15 encircling the spout 14, with the manifold provided with compressed air from an external source (not shown) and discharging compressed air into the interior of the spout at a higher pressure than the carrier medium pressure prevalent in the upper portion of the pulverizer.

The mixture of pulverized coal and carrier medium passing through the pipe 13 is tangentially introduced into a cyclonic type separator 16. Within the separator, the carrier medium is separated from the pulverized coal by centrifugal force so that the pulverized coal deposits in the lower portion 20 of the separator, and the carrier medium discharges upwardly through a pipe 21 from the central portion of the separator. The lower portion of the cyclone is provided with an inverted frusto-conical hopper bottom 22 having a central opening 23 therein which is connected with a rotary seal type valve 24. Beneath the valve 24 is a screw conveyor 25 arranged for the transportation of pulverized coal from the separator 16 to a point or points of use. The combination of the valve and screw conveyor provides a seal to prevent flow of gaseous fluid to or from the separator 16 and the atmosphere.

The fluid carrier medium passes from the upper end of the separator 16 and the pipe 21 to the inlet side of a blower 26 through a connecting pipe 30. The discharge side of the blower 26 is connected with a tubular heater 32 by a connecting pipe 31. Leaving the heater, the reheated fluid carrier medium reenters the inlet duct 12 to pass to the pulverizer 10.

The heater shown in Fig. 1 is formed with a plurality of tubular elements 33 having their opposite ends expanded into tube sheets 34 and 35 positioned in the end portions of the casing 36 enclosing the heater 32. The fluid carrier medium enters an inlet chamber 40 formed between the tube sheet 34 and the upper end wall 41 of the heater, passes through the tubular elements 33 and discharges into an outlet chamber 42 which is defined by the lower tube sheet 35 and the lower end wall 43 of the heater casing 36. Inlet and outlet ducts 44 and 45, respectively, are provided at opposite ends of the heater 32 between the tube sheets 34 and 35 for the passage of a heating fluid through the heater. The heating fluid will be at a sufficient temperature and in sufficient volume to heat the carrier medium to the desired temperature, and may take the form of hot flue gases obtained from a convenient source, or any other hot fluid from any source.

The fluid carrier medium consists predominantly of steam with a minor proportion of non-condensible gases, such as air, carbon dioxide, or the like. The non-condensible gases enter the system by reason of leakage through, for example, the drive shaft of the blower 26, or as entrained air entering with the raw feed delivered through the feeder 11. Since steam is condensible, it is necessary to maintain the temperature of the fluid carrier medium above the saturation temperature of the steam. This is accomplished by heating the fluid carrier medium in the heater 32 to a temperature of for example, 300 to 500° F., or higher. The temperature of the carrier medium entering the pulverizer 10 through pipe 12 is dependent upon the moisture content of the raw material entering the pulverizer. The temperature of the carrier medium is reduced as a result of the evaporation of moisture from the raw material during its pulverization.

As shown in the drawing, I utilize a temperature sensitive means 46, such as a thermocouple or thermometer, positioned in the upper portion of the pulverizer 10 to measure the temperature of the mixture leaving the housing. The temperature sensitive means is operatively connected to a control apparatus 50 to actuate a damper 51 in the outlet duct 45 from the heater 32. In operation, the temperature sensitive means is preset for a temperature of, for example, 250° F. Thus, if the moisture content of the raw material entering the pulverizer is lowered, the temperature sensitive element will sense an increase in the temperature of the carrier medium in the upper portion of the pulverizer as a result of a decrease in the moisture evaporated from the raw material and will position the valve 51 in the heating fluid outlet duct to reduce the amount of heating gases supplied to the heater 32.

With the carrier medium being recirculated through the pulverizer with substantially no loss of weight, the moisture evaporated from the coal in the pulverizer will add to the total weight of the medium, and will increase the pressure thereof. Changes in the weight of the carrier medium in the pulverizing zone results in a change in density of the medium and effects the finished product fineness and/or the capacity of the pulverizer.

With the temperature of the fluid carrier medium controlled by the temperature sensitive means 46 which in turn regulates the position of the damper 51, the excess fluid carrier medium in the system is withdrawn or vented to maintain the weight of carrier medium recirculated through the system substantially constant. In the embodiment of Figure 1, the carrier medium entering the pulverizer 10 will be at a low pressure, i.e. one or two pounds per square inch above atmospheric, and the pressure in pipe 30 will be below atmospheric so that venting is accomplished by means of a vent fan 52 having a valved pipe connection 53 with the pipe 30. The fan withdraws the excess carrier fluid from the system in accordance with regulation of the valve 54 in the pipe 53. The valve may be of the variable orifice type adjusted automatically or by hand. Alternately, the fan 52 may be of the variable speed type which is automatically or manually adjusted in accordance with the amount of carrier fluid to be vented from the system.

When the entire system, including the carrier medium in pipe 30 is maintained at a superatmospheric pressure, a pressure relief valve may be used to vent the system. Under such conditions, the relief valve may be adjusted by means of a counterweight or spring tension to open when the pressure of the fluid in the pipe 30 exceeds a predetermined value. The use of a pressure relief valve 29 in the pipe 30 is illustrated schematically in Fig. 3.

Venting the excess carrier medium will maintain pressure conditions in the system substantially uniform, or at a selected value. Such pressure conditions can be observed by pressure sensitive means, such as a U-tube gage 48 illustrated in Fig. 1, or by a Bourdon tube pressure gage 49 illustrated in Fig. 2.

Since the vented fluid carrier medium is largely composed of superheated steam, the medium may be cooled after venting from the recirculated pipe system so as to condense the steam. The condensation of the steam may be accomplished by radiation cooling, or by the use of cooling water jets 55 projected into a chamber 56, through which the vented carrier medium is passed. In either event, the condensed steam from the vented carrier medium will entrap dust particles suspended in the carrier medium so that the escape of noncondensible gases to the atmosphere will not be accompanied by an appreciable amount of dust. The condensed vapor and dust may be withdrawn from the chamber 56 through a drain pipe 57 in the form of a slurry, for ease of disposal.

In the embodiment of the invention shown in Fig. 2, the system is arranged to supply pulverized coal to a cement kiln and includes a pulverizer 60, fan 61, raw coal feeder 62; a cyclone separator 63; a tubular heater

64; and a vent fan 65 for the removal of excess fluid carrier medium, all suitably interconnected by a piping and ducting system. Insofar as the pulverized coal preparation portion of the system is concerned, the apparatus of Fig. 2 is substantially the same as the arrangement shown in Fig. 1. In the Figure 2 arrangement, the solid material discharge connection at the lower end of the cyclone separator is provided with a pair of counterweighted flap valves 66 and 67 which are spaced apart in the discharge spout 70 from the separator 63. In operation, the counterweighted flap valves 66 and 67 serve as an effective seal against flow of gaseous fluid in either direction through the spout 70. Such an arrangement is effective as a seal when the differential pressure between the body of the separator 63 and the discharge end of the spout 70 is low or substantially equal to zero.

As shown, raw coal is withdrawn from an overhead bin 71 and through a coal spout 72 by the feeder 62 for delivery at a controlled rate to the pulverizer 60. Pulverized coal is swept up from the pulverizer by carrier medium delivered to the pulverizer by the fan 61 for discharge through a pipe 73 to the separator 63. The carrier medium leaving the separator 63 passes through a pipe 74 to the heater 64, and after it is heated to a desired temperature, thereafter passes through a pipe 75 to the inlet of the fan 61.

When a pulverized coal preparation system of the type described is utilized to supply coal to a rotary kiln, the rate of fuel demand to the kiln will vary from time to time in accordance with the requirements of the product being processed in the kiln. Minor variations in fuel requirements may be accomplished by changes in the rate of fuel delivery to the pulverizer by feeder adjustments. However, major changes in fuel requirements can be attained by changing both the raw material rate and the flow rate of carrier medium to the pulverizer. Change of flow rate through the circuit to the fan 61 is obtained by adjustment of a damper 76 in the pipe 75 on the inlet side of the fan. When the desirable or necessary, as for example, during start-up of the system, non-condensible gases can be drawn into the system through the valved inlet connection 80 in the pipe 74.

In the drawing, the source of heating gases for the heater 64 is the firing hood 81 of a rotary kiln 82. In this type of fuel-fired furnace, hot air is withdrawn from the kiln hood 81 through a duct 83, passed through a cyclonic separator 84 for the removal of entrained dust, and is passed through the heater 64 and a pipe 85 to the inlet, or suction side, of a fan 86. Leaving the fan 86, the hot air passes through a pipe 90 to a T connection 91 where the air and pulverized coal are mixed and passed through a pipe 92 and a burner 93 into the kiln 82.

As pointed out in connection with the apparatus shown in Fig. 1, the temperature of the medium leaving the pulverizer is advantageously maintained substantially uniform and automatic means are disclosed for accomplishing this. In the arrangement shown in Fig. 2 the temperature of the carrier medium is regulated by controlling the temperature of the hot air entering the heater from the separator 84. This is accomplished by means of a proportioning valve 94 which is manually or automatically regulated to mix ambient temperature air with the hot air from the kiln hood 81. A second proportioning valve 95, and a flow control valve 96 are positioned in the pipe 85 to regulate the temperature and weight of hot air passed through the T fitting 91 and delivered with entrained pulverizer coal to the burner 93.

A suitable tempering valve is shown in Figs. 4 and 5, where the valve body 97 is of generally rectangular cross-section shape with a rounded bottom 98. The top plate of the body 97 is cut to form an opening 99 dimensioned and shaped to correspond with the cross-section shape of the body, and is fitted with a pivoted plate 100. The plate is pivoted or hinged about a straight side opposite the curved or rounded end thereof so that when the plate is pivoted into a horizontal position the opening 99 is closed while when the plate is in a vertical position the opening is open and the passageway through the body is closed. By positioning the plate in an intermediate position, the fluid flowing from the valve body may be regulater for any desired mixture of hot and cold fluid for temperature regulation.

In the operation of the apparatus described, it has been found that superheated steam provides an excellent carrier medium for effective coal drying and efficient pulverized material classification in the pulverizer. In a pulverizer of the type described, a weight ratio of steam to coal in the range of 0.6 to 1.0 pound per pound has proven to be effective through a range of pulverizer output capacities with pulverized coal fineness in excess of 80% passing the 200 mesh screen. When pulverizing Eastern coals with total moisture contents of from 3 to 15 percent, no noticeable reduction in pulverizer capacities have been found. With a high moisture content in the coal entering the pulverizer the superheated steam was delivered at a temperature of 600° to 750° F., and the coal-steam mixture leaving the pulverizer was maintained at a temperature in excess of 220° F. Operation with steam as a carrier medium is generally comparable with the use of air insofar as coal pulverization is concerned, with some advantage for the steam in reduced pulverizer power requirements.

While in accordance with the provisions of the statutes, I have illustrated and described herein a preferred embodiment of the invention, those skilled in the art will understand that changes may be made in the method of operation and form of the apparatus disclosed without departing from the spirit of the invention covered by our claims, and that certain features of the invention may sometimes be used to advantage without a corresponding use of other features.

What is claimed is:

1. In a pulverizing system including a pulverizer of the type in which coal is pulverized by abrasion, feeder means for delivering moisture-laden coal to said pulverizer, a blower arranged to discharge carrier fluid to said pulverizer, heater means positioned in the flow path of said carrier fluid, a source of heating medium for said heater means, a centrifugal separator arranged to receive a mixture of carrier fluid and pulverized coal from said pulverizer, gaseous flow sealing means in the lower portion of said separator, a conduit connecting the carrier fluid discharge from said separator with the inlet to said blower, a vent fan, a valved pipe connecting the inlet of said vent fan with said conduit for the controlled withdrawal of carrier fluid from said pulverizing system, and means operable in response to the temperature of said carrier fluid leaving said pulverizer to regulate the flow of heating medium through said heater.

2. In a pulverizing system including a mechanical pulverizer, feeder means for delivering moisture-laden coal to said pulverizer, a blower arranged to discharge carrier medium to said pulverizer, indirect heater means positioned between said blower and said pulverizer in the path of said carrier fluid, a source of heating medium for said indirect heater means, a centrifugal separator arranged to receive a mixture of carrier fluid and pulverized coal from said pulverizer, a bin positioned beneath said separator to receive the pulverized coal separated from said carrier fluid, sealing means in the lower portion of said bin, a conduit connecting the carrier fluid discharge from said separator with the inlet to said blower, a vent fan, a valved pipe connecting the inlet of said vent fan with said conduit for the withdrawal of carrier fluid from said pulverizing system in amount substantially equal to the vapor added to said carrier medium by evaporation of moisture from said coal in said pulverizing system, and means operable in response to the temperature of said carrier fluid leaving said pulverizer to regulate the flow of heating medium through said heater.

3. The combination with a rotary kiln having a hot air duct opening to the kiln hood thereof and connected with a cyclone separator and a fan for the removal of dust from the hot air withdrawal from the kiln hood, of a pulverizer having a feeder and a blower arranged to deliver moisture-laden coal and carrier fluid respectively to said pulverizer, a discharge pipe from said pulverizer for pulverized coal-laden carrier medium, a cyclonic separator arranged to receive the coal-laden carrier medium from said discharge pipe and to discharge separated carrier medium therefrom, an indirect heater positioned between said cyclonic separator and said blower and connected therewith by pipes for carrier medium flow, said indirect heater arranged for the passage therethrough of hot air from said kiln hood to heat said carrier fluid to a selected temperature, and means for mixing the pulverized coal from said cyclonic separator with the hot air from said kiln hood for delivery as a combustible mixture to said rotary kiln.

4. The combination with a rotary kiln having a hot air duct opening to the kiln hood thereof and connected with a cyclone separator and a fan for the removal of dust from the hot air withdrawal from the kiln hood, of a pulverizer having a feeder and a blower arranged to deliver moisture-laden coal and carrier fluid respectively to said pulverizer, a discharge pipe from said pulverizer for pulverized coal-laden carrier medium, a cyclonic separator arranged to receive the coal-laden carrier medium from said discharge pipe and to discharge sepa-

rated carrier medium therefrom, and indirect heater positioned between said cyclonic separator and said blower and connected therewith by pipes for carrier medium flow, said indirect heater arranged for the passage therethrough of hot air from said kiln hood to heat said carrier fluid to a selected temperature, means for venting excess carrier medium including condensible vapors from the pipes between said separator and pulverizer, and means for mixing the pulverized coal from said cyclonic separator with the hot air from said kiln hood for delivery as a combustible mixture to said rotary kiln.

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