

July 1, 1958

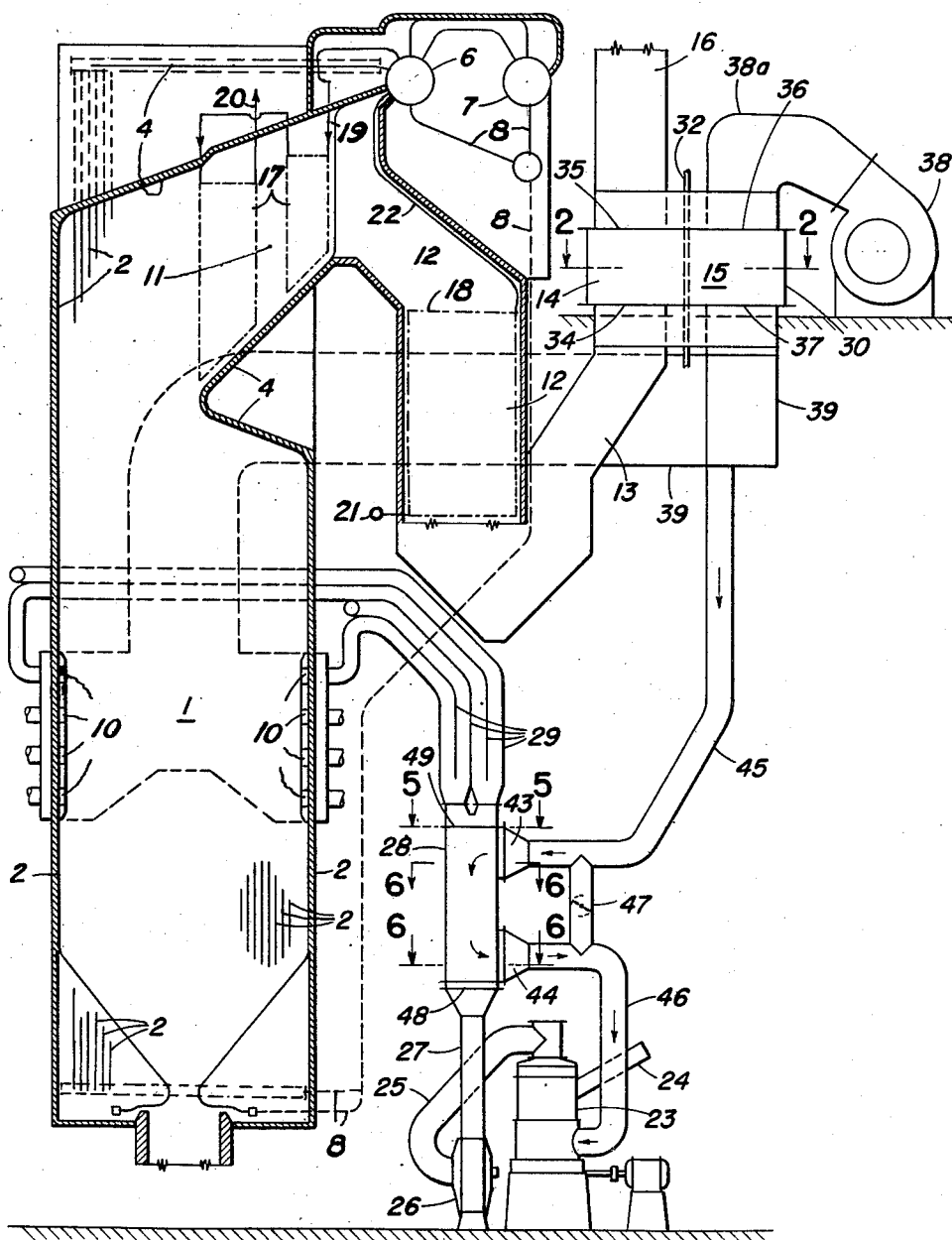
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2,841,102

HEAT EXCHANGER

Filed July 24, 1953

3 Sheets-Sheet 1



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Fig. I.

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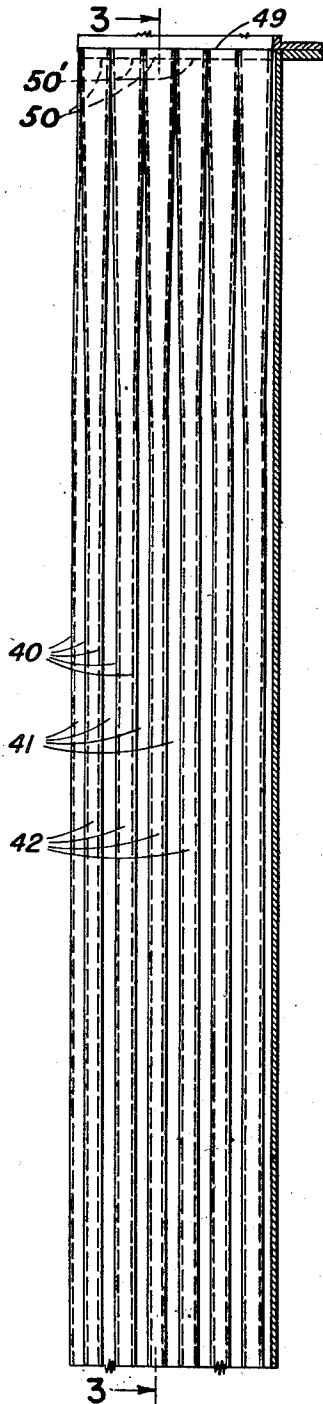


Fig. 4.

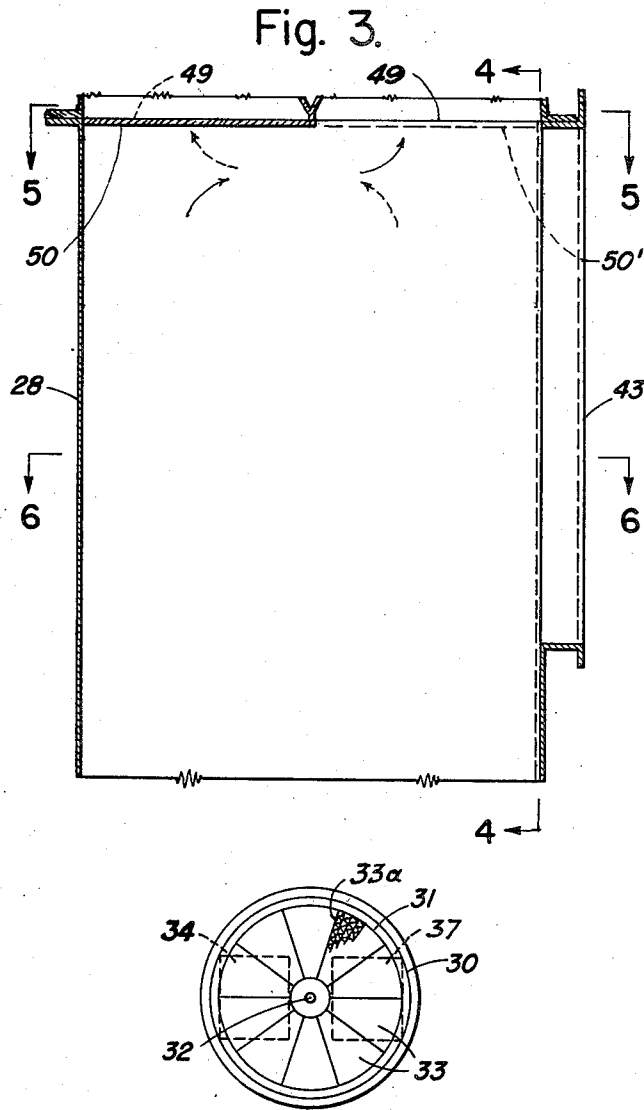


Fig. 2.

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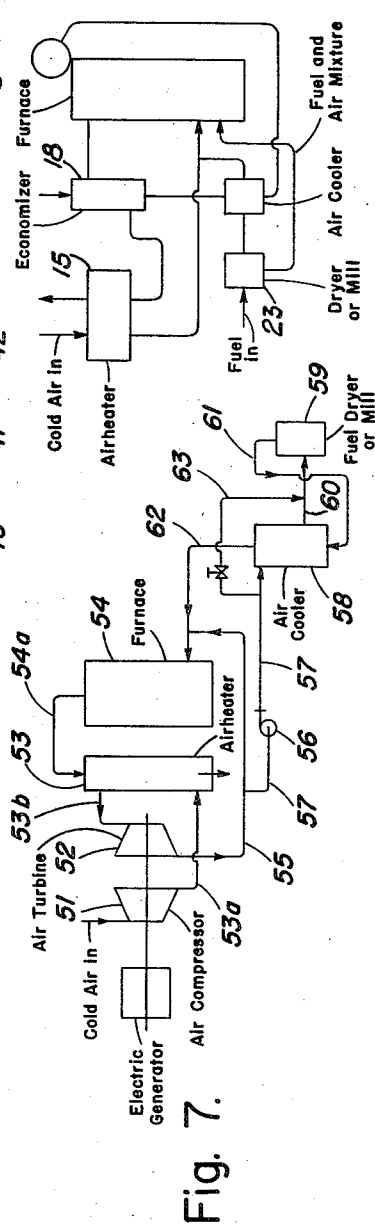
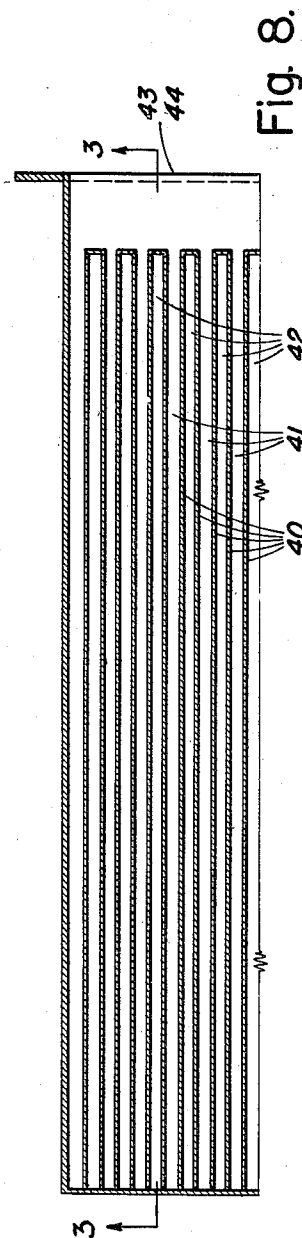
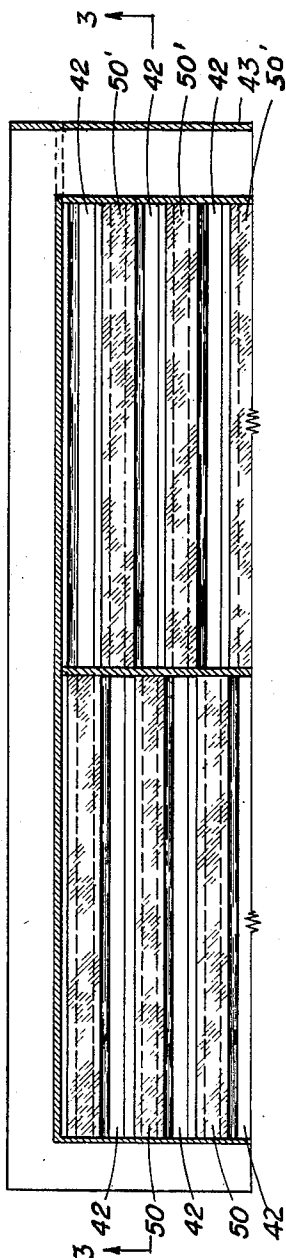
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HEAT EXCHANGER

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3 Sheets-Sheet 3



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HEAT EXCHANGER

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Application July 24, 1953, Serial No. 370,139

3 Claims. (Cl. 110—106)

This invention relates to air heating systems and is particularly concerned with improvements in the arrangement and performance of such systems wherein a portion of the cold air, which would normally have passed through the air heater, has heretofore been employed to temper hot air from the heater used as a heating or drying medium.

One advantageous application of the invention is in connection with large steam generating units where air for combustion is heated to a high temperature and the fuel is dried by a portion of the heated air. Such drying is commonly done in the pulverizing mill within which the moist fuel and the hot air for drying are intimately mixed while the fuel is being pulverized. The air leaving the air heater may be hotter than desirable for drying the fuel in the mill and consequently cold air is admixed to the hot air diverted from the heater to the mill for drying. This cold air which is used for tempering the drying air represents a portion of the total air required for combustion and therefore reduces the amount of air passing through the air heater. The amount of such cold or tempering air may by way of example amount to about 12% of the total air required for combustion of the coal used in a large steam generating plant when the fuel contains about 5% moisture. The consequent reduction in the air flow through the air heater materially reduces the heat recovery by the air from the products of combustion passing through the heater resulting in a reduction in efficiency of the steam generating unit. With increasing fuel cost there is a demand for still higher efficiencies in steam generating units and the present use of the tempering air for drying fuel is detrimental to their realization.

An object of the invention is to improve the efficiency of a steam generator, wherein an air heater is included for cooling all of the products of combustion and wherein a portion of the heated air is utilized for drying the fuel by (1) flowing all of the air required for combustion of the fuel through the air heater, (2) cooling the aforesaid portion of heated air by a cooling medium in a heat exchanger to a temperature suitable for drying the fuel and (3) returning the heat thus absorbed by the cooling medium to the steam generator.

A more specific object of the invention is to improve the efficiency of a steam generator where an air heater is included for cooling all of the products of combustion and wherein a portion of the heated air is utilized for drying the fuel, by (1) flowing all of the air from combustion of the fuel through the air heater, (2) cooling said portion of the heated air in an air cooler to a suitable temperature for use in drying the fuel in a pulverizing mill, using as the cooling medium the air-fuel mixture from the mill, and (3) returning the heat thus absorbed to the furnace.

A still further object is to construct the above mentioned air cooler in such a manner that the discharge end thereof delivers the fuel-air mixture in separate portions of substantially equal quantity and densities.

Additional objects and advantages will become apparent from the following description of an illustrative em-

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bodiment of the invention when read in conjunction with the accompanying drawings wherein:

Figure 1 is a diagrammatic representation of an embodiment of the invention applied to a large steam generating unit.

Figure 2 is a cross section through a main air heater taken on line 2—2 of Figure 1;

Figure 3 is a sectional elevation taken on line 3—3 of Figures 4, 5, and 6 (to a reduced scale) of the upper portion of the air heater adjacent the mill in Figure 1;

Figures 4, 5 and 6 are enlarged partial cross sections taken respectively on lines 4—4, 5—5 and 6—6 of Figures 3 and 1;

Figure 7 is a diagrammatic representation of another application of the invention;

Figure 8 is a diagrammatic representation of a third application of the invention.

In Figure 1 is shown a typical steam generating unit having a furnace 1 the sides of which are lined with steam generating tubes 2 discharging through tubes 4 a steam and water mixture into steam and water drums 6 and 7. To these drums are connected downcomer tubes 8 which feed water to the lower ends of steam generating tubes 2. Fuel and air for combustion are delivered into furnace 1 through burners 10 here shown as adjacent the corners of the furnace 1. The products of combustion leave the furnace 1 through offtake 11 and thence pass downwardly through conduit 12 into a duct 13 which delivers them into the gas side 14 of an air heater 15. From the air heater 15 the cooled gases pass through flue 16 to the chimney (not shown).

Heat absorbing elements, such as a superheater 17 and an economizer 18, may be provided respectively within the offtake 11 and the conduit 12 to extract heat from the products of combustion passing thereover prior to their entry into the air heater 15. The superheater 17 is connected to the steam drum 6 via pipe 19 and discharges superheated steam through pipe 20 to the point of use. The economizer 18 receives boiler feed water from a pump (not shown) via pipe 21 and discharges heated water through pipes 22 to the steam and water drum 6. A motor driven mill 23 pulverizes coal fed to it in measured quantities through pipe 24. The sufficiently finely pulverized coal is withdrawn from the mill 23 entrained by a current of air passing through the duct 25 into a fan 26. The fan 26 delivers the coal-air mixture via duct 27 through one side of an air cooler 28 and thence through duct or ducts 29 to the burners 10 which deliver it into the furnace 1 to be burned therein.

The air heater 15 here shown as the Ljungstrom type (but may be of any type), comprises a cylindrical housing 30 within which a rotor 31 (Fig. 2) is rotated by a motor (not shown) about a shaft 32 mounted concentrically with the cylindrical housing 30. The rotor is divided by partitions into a multiplicity of segmental passages 33 arranged circumferentially about the shaft 32 and parallel thereto. Each segmental passage 33 is filled with metal plates 33a (shown as partly filling one such segment) shaped to divide the passage into a multiplicity of smaller passages whereby the gas passing therethrough is subdivided into small streams each contacting a mass of adjoining metal. As the rotor 31 rotates each segmental passage 33 in turn passes between a gas inlet 34 and an opposite gas outlet 35 (Fig. 1), thereby permitting hot gases from duct 13 to flow over the plates 33a within said segment 33 to heat them. As each said segmental passage 33 rotates to a location about diametrically opposite to the gas inlet 34 and outlet 35, it passes between an air inlet 36 and an opposite air outlet 37, thereby permitting cold air from fan 26 to flow via duct 38a over the plates 33a within said segment 33 to extract the heat from said plates. The air outlet 37 is connected by duct 39 to the

burners 10 in furnace 1 to supply air for combustion. In this manner the plates 33a within segments 33 serve to cool the gases from the steam generating unit and to transfer the heat absorbed therefrom to the air for combustion to the unit.

According to the invention, an air cooler 38 is provided through which the air-coal mixture from the mill 23 passes to absorb heat from a portion of the heated air from the air heater 15 to cool said air to a suitable temperature for drying the coal in the mill 23. This air cooler 28 as here shown is of the plate type comprising a multiplicity of parallel plates 40 (see Figs. 4, 6) forming alternate passages 41 and 42. Heated air to the mill 23 flows through passages 41 and a comparatively cool coal and air mixture from the mill 23 flows through passages 42. Figure 6 which is a partial cross section at either the air inlet 43 or the air outlet 44 (Figs. 1, 3) shows the air-coal passages 42 closed at said inlet 43 and outlet 44 and the air passages 41 open. As shown in Fig. 1 the hot air from the air heater 15 flows via ducts 39, 45 into inlet 43 then through the passages 41 to the outlet 44 whence it flows through duct 46 into the mill 23. A dampered by-pass duct 47 connects ducts 45 and 46 to by-pass air cooler 28. The air-coal passages 42 are open at the bottom inlet 48 and at the top outlet 49 (Figs. 1, 4) and the mixture flows from mill fan 26 via duct 27 into inlet 48, thence through the passages 42 to the outlet 49 whence it flows via duct or ducts 29 to the burners 10.

The air cooler 28 may be constructed at its air-coal outlet end 49 in a manner as disclosed in Figs. 3, 4 and 5. As shown in Fig. 4, the top portion of the air-coal passages 42 may be flared outwardly so that the adjoining plates 40 meet over the adjacent air passages 41 thereby sealing off the air passages. As shown in Figs. 3 and 5, a deflector plate 50 within one of the air-coal passages 42 will deflect the air-coal mixture rising in said passage to flow out of the right half of the outlet 49. Similarly a deflector plate 50' in the next adjacent air-coal passage 42 will deflect the air-coal mixture rising in said passage to flow out of the left half of the outlet 49. By so deflecting the air-coal mixture through alternate passages 42, respectively to the right and left half portions of the outlet 49, each said half will receive half of the air-coal mixture flowing through the air heater 28 and the distribution of coal to each said half will be substantially equal. Each such half of the air-coal mixture may then be conducted to burners of equal capacity. The air cooler 28 will thereby serve as a distributor for the air-coal mixture to the burners.

In operation all of the products of combustion leaving the steam generator flow via duct 13 through the hot side 14 of the air heater 15 and the cooled gases flow into the flue 16. All of the air for combustion leaving the fan 38 flows via duct 38a through the cold side of the air heater 15 and the heated air flows into the duct 39. Most of the heated air then flows via duct 39 directly to the burners 10. The remaining controlled portion of the heated air flows via duct 45 through air passages 41 of the air cooler 28 and thence into the mill 23 wherein the air serves as a heating medium for drying the coal as well as carrier for the pulverized coal leaving the mill 23. In drying the coal the air gives up heat to evaporate most of the moisture in the coal and is thereby cooled to such an extent that the air-coal mixture leaving the mill 23 may be used as a cooling medium for the hot air flowing into the air cooler 28 via duct 45. Accordingly, upon leaving the mill, the air-coal mixture flows via duct 25, fan 26 and duct 27 into the air-coal passages 42 of the air heater 28. Should the air heater 28 cool the hot gases passing therethrough too much, some of the hot air may be by-passed around the heater through the damper controlled duct 47.

These is but one mill 23 and one air cooler 28 disclosed in Fig. 1 and these may supply fuel and air to but

one set of burner nozzles such as the four top corner nozzles of burners 10 in furnace 1. Other similar mills—and air coolers—in combination (not shown) may supply additional nozzles in burners 10 such as groups of nozzles at different levels.

This invention is particularly applicable to large steam generating units employing air heaters for the final extraction of heat from the flue gases, from which heaters a portion of the heated air is diverted for drying fuel. This portion was heretofore tempered by the admixture of cold air thereby reducing the efficiency of such a unit. In the design of large steam generators it is found that the temperature difference between the entering gas and the leaving air of the air heater determines the overall efficiency of the unit. Improved air heater performance may be obtained with a lower hot end temperature difference, but to achieve this would require an excessive and uneconomical increase in the amount of heating surface in the air heater. In accordance with the present invention a considerable improvement in the hot end temperature difference may be obtained when the air, now used for tempering the heated fuel drying air, is passed through the air heater. For example, when drying coal with about 5% moisture in a pulverizer, the tempering air amounts to about 12% of the total air required for combustion. When this additional amount of air is passed through the air heater, the outlet gas temperature from the same heater will be substantially reduced. Or on the other hand, when the air flow through the air heater is increased by the amount of the tempering air, the same efficiency as before may be obtained with a substantially reduced air heating surface. Also, for the same draft loss and efficiency as before, the size of the air heater may be substantially reduced.

The above disclosure applies to steam generating units of the public utility type in which the only cooling medium available for the air cooler 28 is the air-coal mixture leaving the mill 23. Under some conditions, such as may prevail in industrial plants, it may also be desirable to improve the air heater performance by avoiding the use of tempering air. Such units (see Fig. 8) may or may not be equipped with economizers (such as 18) and the feed water temperatures may be relatively low so that the feed water to the boiler may provide a suitable cooling medium for the heated air diverted from the main air heater 15 for fuel drying purposes in the mill 23.

Another application of the invention, for example, may be to an air turbine driven air compressor installation as shown diagrammatically in Fig. 7. The compressed air from the compressor 51 expands through the turbine 52 after being heated in an air heater 53 by the products of combustion flowing via conduit 54a from a furnace 54 burning a fuel which requires drying. The compressed air flows via conduit 53a to the air heater 53 and via conduit 53b to the turbine 52. The air after expanding through the turbine 52 leaves via conduit 55 and is all used as combustion air for the fuel. A portion of the air leaving the turbine 52 via conduit 55 is delivered by fan 56 through conduit 57 to an air cooler 58 where it is cooled to a temperature suitable for drying the fuel and is delivered into the dryer 59 via conduit 60. The same portion upon leaving the dryer 59 is then passed via conduit 61 as a cooling medium through the air cooler 58 and thence passes into the furnace as air for combustion via conduit 62. Conduit 63 is a valved by-pass around air cooler 58. Thus all of the air for combustion flows through air turbine 52 and through the air heater 53 according to the invention. The air turbine 52 provides power for the air compressor 51 and may supply additional power to an electric generator 63. The dryer 59 may be a pulverizing mill and the fuel may be carried by the air leaving the mill through conduits 61, 62 and air cooler 58 into the furnace 54. Preferably steam generat-

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ing surfaces similar to those shown in Fig. 1, may be associated with the furnace 54 ahead of the air heater 53 to suitably lower the temperature of the products of combustion entering the air heater 53. Obviously boiler feed water, if at suitable temperature, may be used as a cooling medium to cool the air flowing through the heat exchanger 58. In this case the air or air-coal mixture leaving the drier or mill 59 will be conveyed directly from conduit 61 into conduit 62 and thence into the furnace 54.

While I have illustrated and described a preferred embodiment of my 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.

What I claim is:

1. In an apparatus for burning fuel and for extracting heat from the products of combustion, the combination of an air heater, a furnace, a conduit connecting said furnace to said air heater to convey the products of combustion in heat exchange relation in said heater with the air for burning said fuel to heat said air, an outlet conduit for the heated air connecting said air heater to said furnace, a non-contacting air cooler in fluid communication with the heated air outlet conduit of said air heater to receive a controlled portion of heated drying air for cooling said portion, said cooler having an outlet for the cooled drying air, a mill-drier connected to the drying air outlet of said cooler for receiving said cooled drying air and for pulverizing said fuel and drying said fuel while suspended in air, thereby lowering still further the temperature of said drying air due to evaporation of moisture from said fuel, an air and fuel mixture outlet of said mill drier, a conduit connecting said drier mixture outlet to said cooler, means for establishing within said non-contacting cooler heat exchange between said relatively cool mixture and said heated drying air for cooling the latter, a mixture outlet of said cooler, a conduit connecting said cooler mixture outlet to said furnace for feeding said fuel and air mixture to said apparatus for

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burning, and by-pass means for by-passing a portion of at least one of said heat exchange fluids around said air cooler, whereby to controllably lower the temperature of the drying air leaving said cooler, while maintaining constant the quantity of said drying air passing through said mill-drier.

2. The apparatus as claimed in claim 1 wherein said by-pass means comprise a by-pass conduit for by-passing a controlled quantity of said heated drying air around said cooler, and damper means for controlling said by-passed quantity.

3. In a steam generating unit comprising a furnace in which fuel is burned and producing hot gaseous products of combustion, the combination of an air heater receiving said products of combustion for heating the air for burning said fuel; a conduit conveying a major portion of said heated air directly to said furnace; a non-contacting air cooler having inlet means and outlet means to receive and discharge, respectively, the remaining portion of said heated air, said air cooler having also means for passing a cooling fluid therethrough for absorbing heat by non-contacting relationship from said remaining air; a duct connected to said air inlet means and said air outlet means of said air cooler for bypassing air around said cooler; a mill dryer having means for receiving said cooled remaining air and also having means for receiving a solid fuel and means for pulverizing said fuel in an atmosphere of said remaining cooled air; and a conduit for conveying said fuel and remaining air from said mill drier into said furnace for burning.

References Cited in the file of this patent

UNITED STATES PATENTS

1,409,520	Bird	Mar. 14, 1922
1,636,958	Harter	July 26, 1927
1,753,363	Coghlan et al.	Apr. 8, 1930
1,875,934	Sancton	Sept. 6, 1932
1,955,255	Sengstaken	Apr. 17, 1934
2,053,037	Lintern	Sept. 1, 1936