June 13, 1950 G. P. JACKSON 2,511,587

METHOD OF BURNING PULVERIZED FUEL

Filed Oct. 26, 1945 2 Sheets-Sheet 1

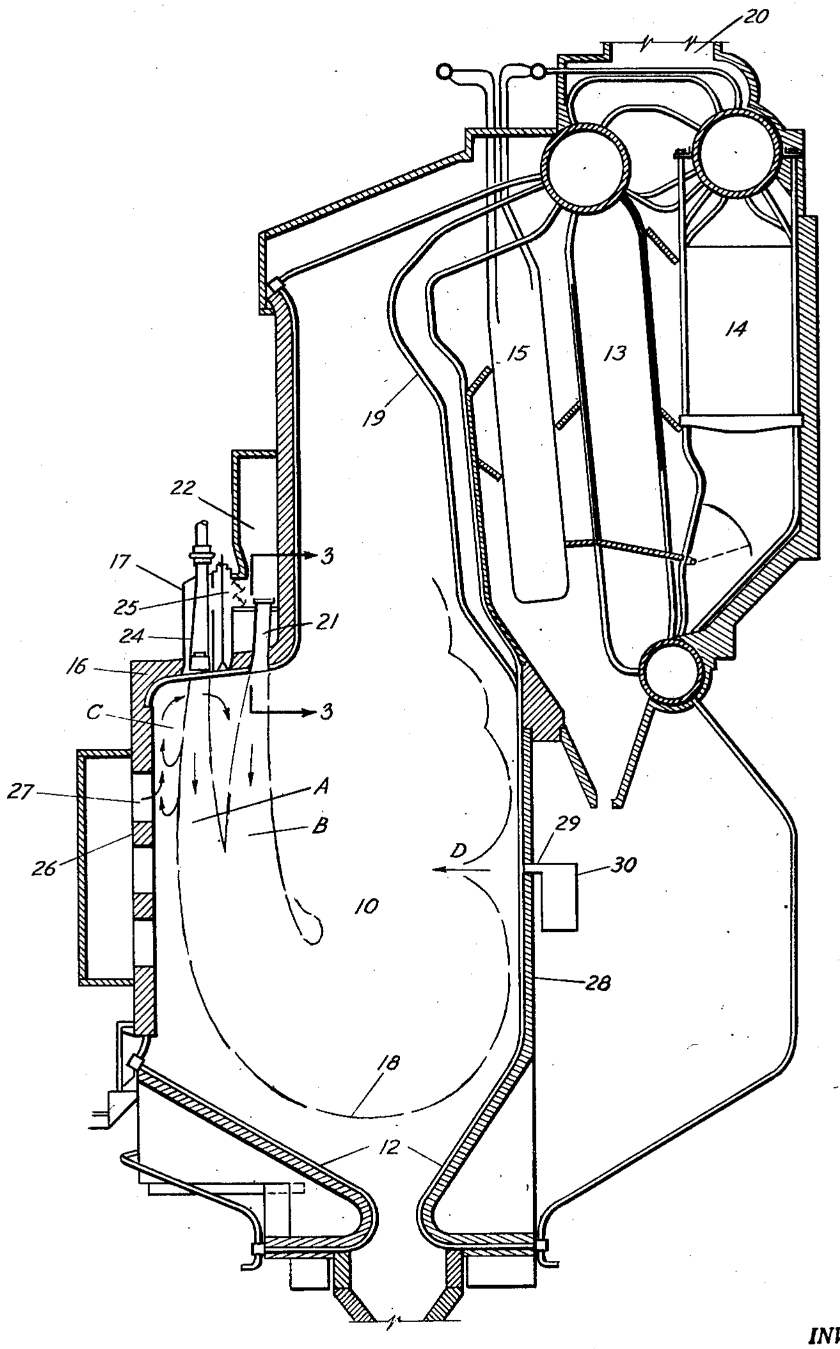

Fig. 1

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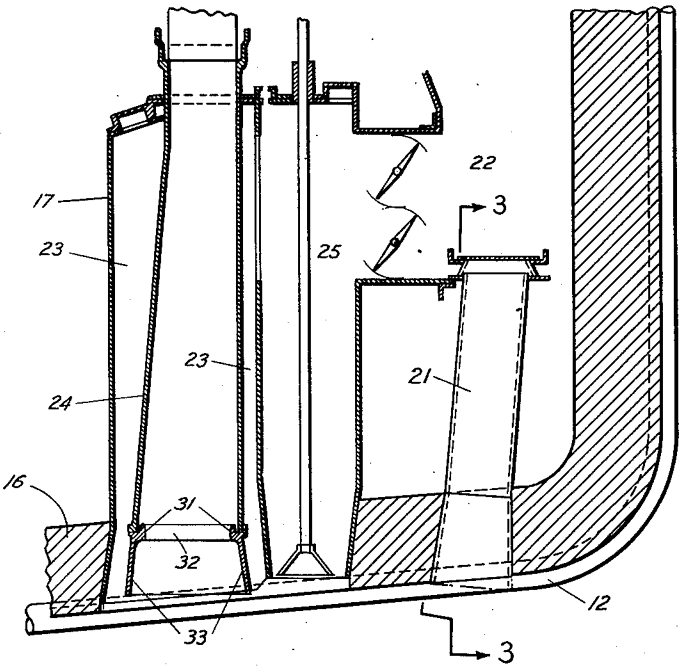

Fig. 2

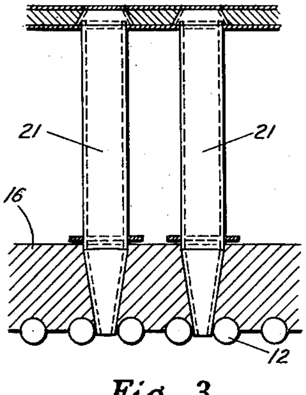

Fig. 3

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METHOD OF BURNING PULVERIZED FUEL

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5 Claims. (Cl. 110—28)

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This invention relates to the combustion of fuels and particularly to burning fuels that are difficult to ignite, such as low volatile coals.

When burning low volatile fuels carried into a furnace suspended in a stream of air it is customary to increase the ratio of fuel to air so as to obtain a relatively rich mixture. This has been done because it has been found that the speed of flame propagation is slower for low volatile than for high volatile fuels and that a material reduction in the air carrying the low volatile fuels speeds up the burning rate of the fuel. The reduced amount of carrying air slows the speed of fuel into the furnace thereby compensating for the slower burning rate. Also the carrying air must be heated by the burning fuel to the temperature of ignition of the fuel and the reduced volume of air takes less time to heat, further compensating for the slower burning rate of the fuel. It has been also found that an improvement in the speed of burning may be further aided by preheating the carrying air.

Even the above expedients are not satisfactory when burning certain low volatile anthracites because the primary air needs to be reduced to an amount which approaches or may even be less than that required for satisfactory operation of the mill for grinding the fuel with the result that the air swept through the mill is insufficient to satisfactorily carry off the ground fuel.

On the other hand the amount of primary air required for directly delivering low volatile fuels from mills may be too much for satisfactory ignition of the fuel. One method employed when using an amount of air above the limits for satisfactory ignition is to separate the air-coal mixture, between the mill and the burner, into two portions, one portion being relatively rich in fuel and the other relatively poor. The rich portion is delivered to the burner and into the furnace and the poor portion to a separate nozzle which directs it into the furnace to mix with the rich fuel stream at a location where the fuel portion has attained satisfactory ignition. To accomplish this separation requires special separating apparatus between the mill and burner or separating means within the burner.

It is an object of this invention to overcome the above difficulties by providing improved means and a novel method for burning low volatile fuels.

In the drawings:

Figure 1 is a vertical cross section through the furnace of a steam generator embodying the invention.

Figure 2 is an enlarged view of a burner in

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Figure 1 and an associated auxiliary air nozzle.

Figure 3 is an end view of a fragment of the furnace taken on line 3—3 of Figures 1 and 2, showing auxiliary air nozzles.

In Figure 1 the furnace 10 is a part of a steam generator comprising furnace wall tubes 12 which line the four walls of the furnace, a bank of steam generating tubes 13, an economizer 14 and a superheater 15. Pulverized fuel is delivered to the furnace through an offset arch 16 by means of burners 17. There are usually a multiplicity of such burners in alignment. The fuel A flows downwardly while burning within the furnace and as the fuel-gas mixture approaches the bottom it makes a U turn at bend 18 and rises up through the furnace to pass thereafter through the screen tubes 19, the superheater 15, convection bank 13 and economizer 14 to offtake 20.

Adjacent the burners 17 and offset therefrom are nozzles 21 directing jets B of air downwardly, through arch 16 and substantially parallel to the direction of flow of the fuel stream from the burners. The nozzles 21 are connected to an air duct 22 from which they receive air under pressure. The burners 17 may have the usual secondary air channels 23 surrounding the primary air and fuel nozzles 24 which secondary air channels may receive their air from duct 22 through a damper-controlled connection 25. In the front wall 26 of furnace 10 there may be additional ducts 27 for the purpose of supplying additional air for combustion as the fuel stream A passes downwardly past them. Projecting through the rear wall 28 of furnace 10 are nozzles 29 for directing further air into the furnace which receive their air direct from duct 30.

I have found that by spacing the air nozzles 21 a substantial distance from the burner nozzles 24 so that the adjacent jets of air B and fuel A are spaced apart, say about 2 feet, and that if the air stream B from the nozzles 21 issues at a substantially higher velocity than the fuel stream A from the nozzles 24, there is an entraining action which causes the gases C immediately below the arch 16 through which the fuel jets A are injected to flow toward said air jets B and between the adjacent fuel jets A. This entraining action is sufficient to cause an upward flow of the gases between the fuel streams A and the front wall 26. As shown by the arrows in the Figure 1, this upward flow C comprises burning fuel removed from the outer layers of the fuel streams A and may include some of the air issuing from the upper air ducts 27 adjacent the front wall. Not only is this burning fuel and gas

C taken from the fuel stream extremely hot but the air joining it also becomes extremely hot from heating in the furnace and by participating in combustion. Thus, as the mixture of the two passes between the adjacent fuel jets A below the arch 16 it adds a substantial amount of heat to the entering fuel jets A thereby accelerating the rate of ignition of the fuel.

I have found that in burning low volatile fuels such as anthracite coal it is difficult to maintain ignition at some distance from the burner, even with a low quantity of primary air, without the use of the air through air nozzles 21. When injecting air through the nozzles 21 at a relatively high velocity and creating said crosscurrents of burning fuel between the jets A issuing from the fuel burner nozzles 24, ignition occurs closely adjacent the fuel nozzles 24 and it is possible to substantially increase the amount of primary air. With the use of the high velocity jets B through air nozzles 21 it is possible to increase the amount of primary air entering the furnace with the fuel to the quantity necessary for successful removal of the pulverized fuel from the mill. In this manner, the fuel may be delivered directly from mill to burner and it becomes unnecessary to employ separating means in the conduit between the mill and the burners or in the burners in order to reduce the quantity of primary air to enrich the fuel mixture issuing from the burners and then injecting the separated coal-air mixture at other points into the furnace. By way of example, I employ a velocity for the air stream issuing from nozzles 21 of about 150 to 200 feet per second, while the velocity of the fuel and primary air stream issuing from fuel nozzles 24 is about 35 feet per second.

Obviously the high velocity air jets B may be produced by means of steam jets placed within the air nozzles to give the air the required velocity. Or, steam jets alone may be used to induce the flow of gases past the entering jets of fuel.

The nozzles 29 projecting through the rear wall 28 of the furnace deliver jets of air at relatively high velocities which act to cause a turbulence in the rising burning fuel-gas stream and thereby increase the rate at which the remaining fuel particles burn. These jets also act to further intermix the downwardly flowing air and fuel streams issuing from nozzles 21 and 24 while maintaining their flow path adjacent the front wall and thereby serve as an aid in controlling the depth to which the bottom of the U flame travels in the furnace.

By means of the high velocity air jets B issuing adjacent the fuel streams A I am able by inducing hot currents C of burning fuel and gas to flow past the fuel jets issuing from the burners to cause ignition to occur substantially at the burner nozzle, thereby more effectively utilizing the entire furnace volume. By means of the high velocity air jets D issuing through the rear toward the front wall, I am able to cause greater turbulence and thereby more rapid combustion and to control the flow path of the fuel-gas mixture through the furnace, both of which actions further aiding in more effectively utilizing the entire furnace volume.

A preferred form of burner nozzle is one that causes the primary air and fuel stream to issue therefrom with its outer surfaces in a turbulent state. The advantage of this condition is that the tubulent fuel of the outer surfaces of the fuel stream nearest the front wall 26 of the furnace will more easily commingle with the air entering

from ducts 27 through the front wall 26 and will more quickly burn to furnish heat for igniting the incoming fuel as described above. In the form illustrated this surface turbulence is accomplished by introducing into the burner nozzle a restriction 31 forming a sharp edged orifice 32 which preferably completely circumvents the inside wall of the nozzle 24. Preferably the bottom of the nozzle 24, beyond orifice 32, with respect to the fuel flow, will have its sides 33 flared as shown.

While I have shown and described a preferred embodiment of my invention with a vertical type of burner, it will be understood that the invention may be adapted to the horizontal and other types of burners without departing from the spirit and scope of the invention as claimed.

What I claim is:

1. In a method of burning pulverized low volatile fuel in a furnace and accelerating the ignition of that fuel, the steps which comprise delivering said fuel into the furnace in a stream of primary air introduced at a given velocity; burning the fuel so introduced in a flame; delivering into the furnace at one side of said fuel-laden primary air stream a supplemental stream of further air which is continuous during said primary air and fuel entry and which has a velocity substantially higher than the primary stream's said given velocity; and directing said supplemental air stream along said one side of the primary stream adjacent and generally parallel thereto so as to produce, due to the secondary stream's higher velocity and the relative direction of the two streams, an entraining action which induces from the surface of a burning portion of the primary fuel-air stream a continuous reverse current of that stream's burning fuel-air mixture and which causes said reverse current of the aforesaid hot mixture to flow transversely past a colder portion of the incoming primary stream of air and fuel adjacent its point of delivery into the furnace, the aforesaid transverse flow of said hot mixture current serving directly to heat the contacted colder portion of said incoming primary fuel-air stream with resultant acceleration in the ignition of said fuel and accompanying intensification of said flame.

2. In a method of burning pulverized low volatile fuel in a furnace and accelerating the ignition of that fuel, the steps which comprise delivering said fuel into the furnace in flotation in a stream of primary air introduced downwardly at a given velocity; burning the fuel so introduced in a flame; delivering continuously during said primary air and fuel entry a supplemental stream of further air downwardly into the furnace at one side of said fuel-laden primary air stream at a velocity substantially higher than the primary stream's said given velocity; and directing said supplemental air stream along said one side of the primary mixture stream adjacent and generally parallel thereto so as to produce, due to the secondary stream's higher velocity and the relative direction of the two streams, an entraining action which induces from a burning portion of the primary fuel-air stream's opposite side a continuous upward current of that stream's burning fuel-air mixture and which causes said hot mixture current to flow transversely past a colder portion of the incoming primary air-fuel stream adjacent its point of delivery into the furnace, the aforesaid transverse flow of said hot mixture current serving directly to heat the contacted colder portion of said incoming primary

fuel-air stream with resultant acceleration in the ignition of said fuel and accompanying intensification of said flame.

3. In a method of burning pulverized low volatile fuel in a furnace and accelerating the ignition of that fuel, the steps which comprise delivering said fuel into the furnace in flotation in a stream of air introduced at a given velocity; burning the fuel so introduced in a flame; delivering into the furnace at one side of said fuel-laden primary air stream a further stream of supplemental air which is continuous during said primary air and fuel entry and which has a velocity substantially higher than said primary stream's given velocity; directing said supplemental air stream along said one side of the primary mixture stream adjacent and generally parallel thereto so as to produce, due to the secondary stream's higher velocity and the relative direction of the two streams, an entraining action which induces from a burning portion of the primary fuel-air stream's opposite side a continuous reverse current of the stream's burning fuel-air mixture and which causes said hot mixture current to flow transversely past a colder portion of the incoming primary air-fuel stream adjacent its point of delivery into the furnace, the aforesaid transverse flow of said hot mixture current serving directly to heat the contacted colder portion of said incoming primary fuel-air stream with resultant acceleration in the ignition of said fuel and accompanying intensification of said flame; and introducing still further furnace air at relatively low velocity into said primary stream of burning fuel-air mixture along the said opposite side thereof whereby to augment said entraining action of said supplemental air in inducing said reverse current and cross flow of the burning mixture.

4. In a method of burning pulverized low volatile fuel in a furnace and accelerating the ignition of that fuel, the steps which comprise delivering the fuel into the furnace in flotation in spaced jets of primary air introduced at a given velocity; burning the fuel so introduced in flames; delivering continuously during said primary air and fuel entry spaced supplemental streams of further air into the furnace at velocities substantially higher than said given primary jet velocity; and directing said supplemental air streams substantially parallel to and adjacent the primary-jet streams of burning fuel-air mixture so as to produce, due to the secondary stream's higher velocity and their direction relative to the adjacent primary mixture flames, entraining actions which induce from the opposite flame sides continuous reverse currents of the burning fuel-air mixture and which cause said hot mixture currents to flow between colder portions of the incoming primary air-fuel jets adjacent their points of delivery into the furnace, the aforesaid transverse flow of said hot mixture currents serving directly to heat the contacted colder portions of said incoming primary air-fuel jets with resultant acceleration in the ignition of said fuel and accompanying intensification of said flames.

5. In a method of burning pulverized low volatile fuel in a furnace and accelerating the ignition of that fuel, the steps which comprise delivering the fuel into the furnace in flotation in a stream of primary air introduced downwardly at a given velocity; burning the fuel so introduced in a flame; delivering continuously during said primary air and fuel entry a supplemental stream of further air downwardly into the furnace at one side of said fuel-laden primary air stream at a velocity substantially higher than the primary stream's said given velocity; directing said supplemental air stream along said one side of the burning primary mixture stream adjacent and generally parallel thereto so as to produce, due to the secondary stream's higher velocity and the relative direction of the two streams, an entraining action which induces from a burning portion of the primary fuel-air stream's opposite side a continuous upward current of that stream's burning fuel-air mixture and which causes said hot mixture current to flow transversely past a colder portion of the incoming primary air-fuel stream adjacent its point of delivery into the furnace, the aforesaid transverse flow of said hot mixture current serving directly to heat the contacted colder portion of said incoming primary fuel-air stream with resultant acceleration in the ignition of said fuel and intensification of said flame; and increasing the turbulence and rate of combustion of the burning primary fuel stream by delivering jets of additional air horizontally into that stream along the said one side thereof which said supplemental air stream adjoins.

GEORGE P. JACKSON.

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