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SLURRY BURNER FOR STEAM GENERATING UNIT

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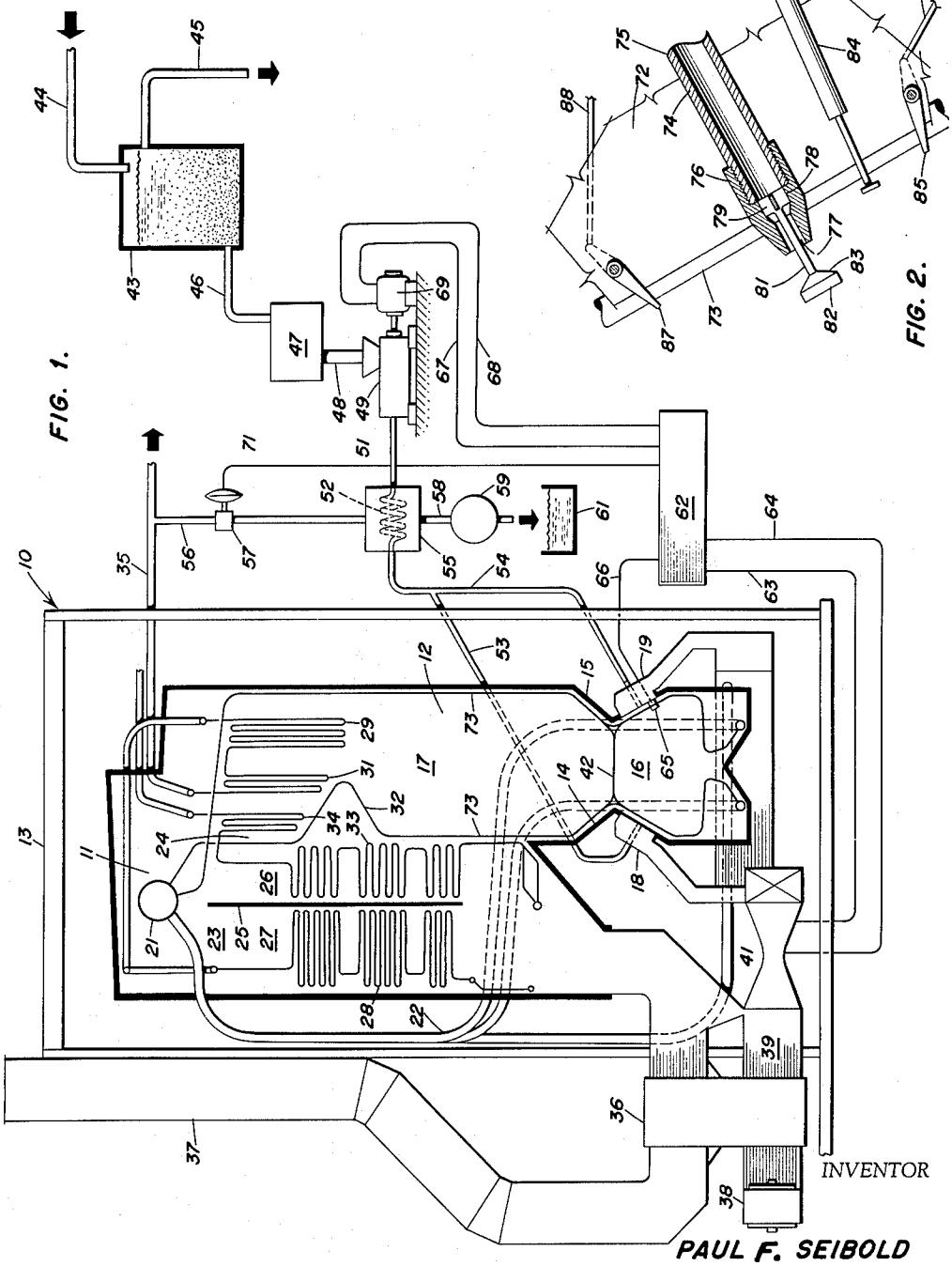


FIG. 1.

FIG. 2.

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SLURRY BURNER FOR STEAM GENERATING UNIT

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This invention relates to a steam generating unit and more particularly to apparatus arranged to produce steam by burning wet solid fuel in suspension.

One of the methods that has been proposed for transporting solid fuels from the mines to a central electrical generating station involves crushing the fuel (which, in most cases, would be a form of coal) and mixing it with water to form a suspension of the crushed fuel in the water. This slurry may be pumped through pipelines in a manner similar to any other fluid and its distribution may be controlled by valves and other well-known elements of fluid systems. However, one of the drawbacks to this method of fuel distribution is that the amount of water which must be mixed with the fuel to form a controllable slurry is quite high, being in the order of 30% by weight. While this is not an excessive amount of water, so far as burning in a conventional furnace is concerned, the solid fuel in the slurry contains a large consist; for instance, it is not uncommon to encounter 10% of coal particles of over 8 mesh in size. These large particles cannot be burned in suspension. One possibility is to remove the water and pulverize the fuel, since the slurry cannot be pulverized readily in its wet form. However, the cost of removing the water, either centrifugally or by some heating means, renders such a procedure prohibitive. These and other difficulties experienced with the prior art systems have been obviated in a novel manner by the present invention.

It is, therefore, an outstanding object of the invention to provide a steam generating unit capable of burning effectively a slurry of water and of solid fuel containing a high proportion of large particles of solid fuel which are incapable of burning in suspension.

Another object of this invention is the provision of a steam generating unit for burning a slurry in which a novel means is provided for reducing large particles of fuel to a size which will render them capable of being burned in suspension.

A further object of the present invention is the provision of a steam generating unit for burning a slurry of solid fuel without requiring that the water be removed from the slurry before introduction into the furnace.

It is another object of the instant invention to provide a steam generating unit for burning a slurry in which the slurry is projected with substantial velocity from the mouth of the burner against an impingement member which reduces large particles of solid fuel to a burnable size.

It is a further object of the invention to provide a steam generating unit for burning a slurry in which the water in the slurry is raised to its flash point temperature prior to its arrival at the burner.

A still further object of this invention is the provision of a steam generating unit for burning a slurry in which large particles of solid fuel are reduced to a burnable size by heating the water in the slurry to its flash point and by impingement of the stream of slurry against a pulverization member.

With these and other objects in view, as will be apparent to those skilled in the art, the invention resides in the combination of parts set forth in the specification and covered by the claims appended hereto.

The character of the invention, however, may be best understood by reference to one of its structural forms as illustrated by the accompanying drawings, in which:

FIG. 1 is a somewhat schematic vertical sectional view of a steam generating unit embodying the principles of the present invention; and

FIG. 2 is a vertical sectional view of a burned used in the unit.

Referring first to FIG. 1, wherein are best shown the general features of the invention, the steam generating unit, indicated generally by the reference numeral **10**, is shown as consisting of a boiler **11** and a furnace **12** mounted on a supporting structure **13**. The furnace **12** is of the general type shown and described in the patent of Miller No. 2,947,289 and is provided with two abutments **14** and **15** extending along the rearward wall and the forward wall, respectively. These abutments divide the furnace into a high-temperature lower cell **16** and an upper combustion chamber **17**. The lower surfaces of the abutments **14** and **15** are provided with inter-tube directional-flame burners **18** and **19** of the type shown and described in the above-mentioned patent to Miller No. 2,947,289.

The boiler **11** is provided with a steam-and-water drum **21** from which downcomers **22** carry water to the lower part of the furnace **12**. Water tubes **73** cover the walls of the furnace and discharge into the steam-and-water drum in the usual manner. Underlying the steam-and-water drum **21** is a back pass **23** connected to the upper part of the furnace **12** by a gas off-take opening **24**. The back pass **23** is divided by a vertical baffle **25** into a forward portion **26** and a rearward portion **27**. Lying in the rearward portion **27** is a low-temperature superheater **28** of the convection type whose upper discharge end is connected to a radiant superheater **29** which, in turn, discharges into a convection superheater **31** overlying a nose **32** which extends from the rear wall of the furnace immediately under the gas offtake opening **24**.

In the forward portion **26** of the back pass is located a convection reheater **33** which discharges into a high-temperature convection reheater **34** located above the nose **32** close to the gas off-take opening **24**. The high-temperature superheater **31** discharges into a superheated steam pipe **35** connected to a turbine (not shown). The lower end of the back pass **23** is connected through an air preheater **36** which, in turn, is connected to a stack **37**. Incoming air passes from a forced-draft fan **38** through the air preheater **36** and through a duct **39** which has a venturi section **41**. The duct **39** is connected to the burners **18** and **19** to supply them with air. Some of the water-wall tubes **73** on the front and rear walls of the furnace **12** cross to the opposite wall in the vicinity of the abutments **14** and **15** to form a screen **42**.

Mounted well above the burners **18** and **19** is a tank **43** receiving a slurry of water and coal from a pipe **44**. A decanting pipe **45** is located at the upper part of the tank and at the lower part of the tank a pipe **46** leads to a storage tank **47**. The storage tank **47** is connected by a pipe **48** to the inlet of a slurry pump **49**. This pump is of the general type shown and described in the patent of Zalis No. 2,994,562. The outlet of the pump **49** is connected by a pipe **51** to a heat exchanger **52** consisting of a coil which may have an extended surface. The outlet of the heat exchanger **52** is connected by pipes **53** and **54** to the burners **18** and **19**, respectively. Surrounding the heat exchanger **52** is a chamber **55** which is connected to the superheated steam pipe **35** by a pipe **56** in which is located a diaphragm-operated flow-regulative valve **57**. The chamber is connected by a pipe **58** to a condenser **59** which, in turn, discharges into a water storage sump **61**.

The apparatus is provided with a main control **62** which receives an input signal from the venturi section **41**

through conduits 63 and 64, which signal is indicative of load on the unit. A thermostat 65 is mounted in the furnace beside a burner 19 and is connected by a conduit 66 to the input of the main control 62, the conduit 66 carrying a signal indicative of the temperature in the furnace adjacent the burner. The output side of the main control is connected by two conduits 67 and 68 to an electric motor 69 driving the pump 49, the conduits 67 and 68 carrying a current which will regulate the speed of the motor 69 and, therefore, will regulate the rate of feed of slurry through the pump 49. The output side of the main control is also connected by a conduit 71 to the diaphragm of the valve 57, the signal in the conduit 71 being, in the preferred embodiment, pneumatic and serving to set the valve 57 in accordance with load on the unit and temperature in the furnace.

FIG. 2 shows the details of the burner 19; it consists of a housing 72 mounted on the water-wall tubes 73 and having a slurry gun 74. The gun comprises a pipe 75 which is connected to the pipe 54 carrying slurry to the unit. The inner end of the pipe 74 is threadedly connected to a nozzle 76 having a reduced outlet passage 77. The nozzle 76 is provided with a counter-bore 78 in which is mounted a cross-shaped spider 79, the spider having firmly attached thereto a shaft 81 which extends axially of the outlet passage 77 and carries a head 82 at its outer end. The head is formed of an abrasive-resistant hard material, such as tungsten carbide, and is provided with a conical face 83 which is directed toward the nozzle 76 and is spaced a substantial distance therefrom. As is evident in the drawings, the threading of the nozzle 76 onto the pipe 75 serves to lock the spider 79 in the counterbore 78. Mounted on the housing and extending closely adjacent to the gun 74 is an ignition gun 84 of the electrically-ignited gas type. Below the ignition gun 84 is an air-flow regulating vane 85 pivotally mounted for angular movement about a horizontal axis under the regulation of a control rod 86. Above the gun 74 is a similar vane 87 whose angular position is determined by a control rod 88.

The operation of the invention will now be readily understood in view of the above description. The mixture of slurry which enters the tank 43 from the pipe 44 is a mixture of water and of solid fuel of large consist. By large consist is meant that the particles of coal are such that around 10% of the particles are in the order of 8 mesh. This size is difficult to burn in the prior art furnaces. As much water as possible is decanted through the pipe 45 and the remainder of the slightly thicker slurry passes through the pipe 46, is stored in the tank 47, and eventually enters the pump 49 through the pipe 48. The speed of operation of the pump is determined by the motor 69 which, in turn, is regulated by the main control 62. The slurry leaves the pump 49 under considerable pressure and passes through the heat exchanger 52, receiving heat in a manner to be described hereinafter. The heated slurry passes through the pipes 53 and 54 into the burners 18 and 19. It then passes through the pipe 75, around in the gun 74, around the spider 79, and leaves the gun through the outlet passage 77. Because the slurry is under pressure, it leaves the nozzle at a high rate of speed and the large particles strike the conical surface face 83 and are pulverized by the impact. Air arriving from the duct 39 flows into the housing 72 of the burner and around the gun 74. Ignition takes place because of the operation of the ignition gun 84 and air direction is regulated by means of the control rods 86 and 87 which adjust the angularity of the vanes 85 and 87, respectively. The exposure of the heated water as it leaves the outlet passage 77 of the nozzle 76 to the low pressure in the furnace causes it to flash immediately to steam. This is because the temperature of the water and slurry is raised in the heat exchanger 52 close to what would be the boiling point at ambient pressure. Being at high pressure in the piping, due to the action of the pump 49, the water does not flash into steam until it emerges from the gun into the relatively low pressure of the high-temperature cell 16 of the furnace.

The temperature to which the water in the slurry is raised in the heat exchanger 52 is determined by the amount of steam flowing through the chamber 55. The valve 57 releases steam and causes it to pass through the pipe 56 into the chamber 55 through a valve setting dictated by the signal in the line 71 originating in the main control 62. Steam, after passing over the heat exchanger 52, passes through the pipe 58 and the condensers 59 and falls as a liquid into the sump 61.

The screen 42 has the effect, first of all, of maintaining the cell 16 at a higher temperature to assist the ignition of this wet material. It also has the effect of causing slag to remain in the cell and drop into the lower part of the furnace where it is removed in the usual way, so that it is not carried by the gases into the upper part of the furnace where it would stick to the heat exchanger surfaces.

As is evident, the system proposed by the invention would remove the necessity for drying and would also avoid the need for pulverization. The concept is to pass the slurry with considerable force into a burner having a nozzle and to cause the stream to impinge against the carbide plate which is preferably in the form of a mushroom-shaped member projecting axially of the nozzle. The light fuel particles pass around the head for hydrodynamic and aerodynamic flow reasons, but the heavy particles penetrate the boundary layer and smash against the head. Although there is a degree of power loss introduced into the system by the pump for forcing the fuel through the nozzle at high velocity, this power loss is returned in the energy required to pulverize the heavy particles. Furthermore, the energy taken from the steam product of the steam generating unit to flow around the heat exchanger 52 comes back when the liquid flashes into steam in the furnace; otherwise, this heat energy would have to be introduced to the water to cause it to evaporate in the furnace. It should also be noted that by introducing the heat into the slurry at the heat exchanger 52, it is possible to keep the cell 16 at a much higher temperature because heat is not being absorbed by the incoming water to cause it to flash into steam. As is well known, the amount of thermal energy required to change the water at boiling temperature to steam at the steam temperature (known as the "heat of vaporization") is quite high compared to the heat energy required to raise the temperature of the steam to a higher temperature. The furnace temperature, therefore, will be much higher and ignition will be more stable. Furthermore, the water which exists in the large particles will cause it to explode when the steam evaporates, in a manner similar to the well-known action of steam expansion in popping popcorn.

It is obvious that minor changes may be made in the form and construction of the invention without departing from the material spirit thereof. It is not, however, desired to confine the invention to the exact form herein shown and described, but it is desired to include all such as properly come within the scope claimed.

The invention having been thus described, what is claimed as new and desired to secure by Letters Patent, is:

1. A steam generating unit for burning a slurry of water and of solid fuel having a substantial proportion of large particles incapable of burning in suspension, comprising

(a) a furnace having a combustion chamber,

(b) at least one burner mounted to deliver slurry and combustion air into the combustion chamber, the burner being formed with a nozzle at its inner end,

(c) an impingement member mounted in line with the burner, the impingement member consisting of a stem mounted coaxially of the nozzle and an enlarged head at the end of the stem spaced away from

the exit of the nozzle and formed to spread the particles in the combustion chamber laterally of the axis of the nozzle,

(d) and means including a pump for introducing the slurry to the burner at high pressure so that the large particles of solid fuel strike the impingement member with substantial force and are pulverized.

2. A steam generating unit for burning a slurry of water and of solid fuel having a substantial proportion of large particles incapable of burning in suspension, comprising

(a) a furnace having front, side, rear, roof, and bottom walls defining a vertically-elongated combustion chamber, abutments extending from opposed walls adjacent the bottom wall to define a high-temperature cell at the bottom of the combustion chamber, the abutments having downwardly-directed lower surfaces,

(b) a plurality of burners mounted on the lower surfaces of the abutments to deliver slurry and combustion air into the combustion chamber, each burner being formed with a nozzle at its inner end,

(c) an impingement member mounted in line with the burner, the impingement member consisting of a stem mounted coaxially of the nozzle and an enlarged head at the end of the stem spaced away from the exit of the nozzle and formed to spread the particles in the combustion chamber laterally of the axis of the nozzle,

(d) and means including a pump for introducing the slurry to the burner at high pressure so that the large particles of solid fuel strike the impingement member with substantial force and are pulverized.

3. A steam generating unit for burning a slurry of water and of solid fuel having a substantial proportion of large particles which are incapable of burning in suspension, comprising

(a) a furnace having a combustion chamber,

(b) at least one burner directed toward the interior of the furnace to deliver slurry and combustion air into the combustion chamber, the burner being formed with a nozzle at its inner end,

(c) an impingement member mounted in line with the burner,

(d) means for heating the water in the slurry to the flash point prior to its arrival at the burner, the impingement member consisting of a stem mounted coaxially of the nozzle and an enlarged head at the end of the stem spaced away from the exit of the nozzle and formed to spread the particles in the combustion chamber laterally of the axis of the nozzle,

(e) and means including a pump for introducing the slurry to the burner at high pressure, the large particles of fuel striking the impingement member with substantial force with resultant pulverization, the water in the slurry flashing to steam upon leaving the burner to also cause pulverization of the fuel.

4. A steam generating unit for burning a slurry of water and a solid fuel having a substantial proportion of large particles which are incapable of burning in suspension, comprising

(a) a furnace having a combustion chamber,

(b) at least one burner directed toward the interior of the furnace to deliver slurry and combustion air into the combustion chamber, the burner being formed with a nozzle at its inner end,

(c) an impingement member mounted in line with the burner,

(d) a heat exchanger through which the slurry passes on its way to the burner,

(e) means for supplying steam to the heat exchanger for heating the water in the slurry to the flash point prior to its arrival at the burner, the impingement member consisting of a stem mounted coaxially of the nozzle and an enlarged head at the end of the stem spaced away from the exit of the nozzle and formed to spread the particles in the combustion chamber laterally of the axis of the nozzle,

(f) and means including a pump for introducing the slurry to the burner at high pressure, the large particles of fuel striking the impingement member with substantial force with resultant pulverization, the water in the slurry flashing to steam upon leaving the burner to also cause pulverization of the fuel.

5. A steam generating unit for burning a slurry of water and a solid fuel having a substantial proportion of large particles which are incapable for burning in suspension, comprising

(a) a furnace having side, front, rear, roof, and bottom walls defining a vertically-elongated combustion chamber, abutments extending from opposed walls to define a high-temperature cell at the lower end of the combustion chamber, the abutments having downwardly-directed lower surfaces,

(b) a plurality of burners mounted on the lower surfaces of the abutments and directed toward the interior of the furnace to deliver slurry and combustion air into the combustion chamber, each burner being formed with a nozzle at its inner end,

(c) a boiler associated with the furnace to receive hot products of combustion generated in the combustion chamber,

(d) an impingement member mounted in line with the burner,

(e) an indirect heat exchanger through which the slurry passes on its way to the burner,

(f) a valve-controlled conduit for supplying steam from the boiler to the heat exchanger for heating the water in the slurry to the flash point prior to its arrival at the burner, the impingement member consisting of a steam mounted coaxially of the nozzle and an enlarged head at the end of the stem spaced away from the exit of the nozzle and formed to spread the particles in the combustion chamber laterally of the axis of the nozzle,

(g) and means including a pump for introducing the slurry to the burner at high pressure, the large particles of fuel striking the impingement member with substantial force with resultant pulverization, the water in the slurry flashing to steam upon leaving the burner to also cause pulverization of the fuel.

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