Sept. 23, 1958 O. CRAIG 2,853,059

FURNACE CONSTRUCTION

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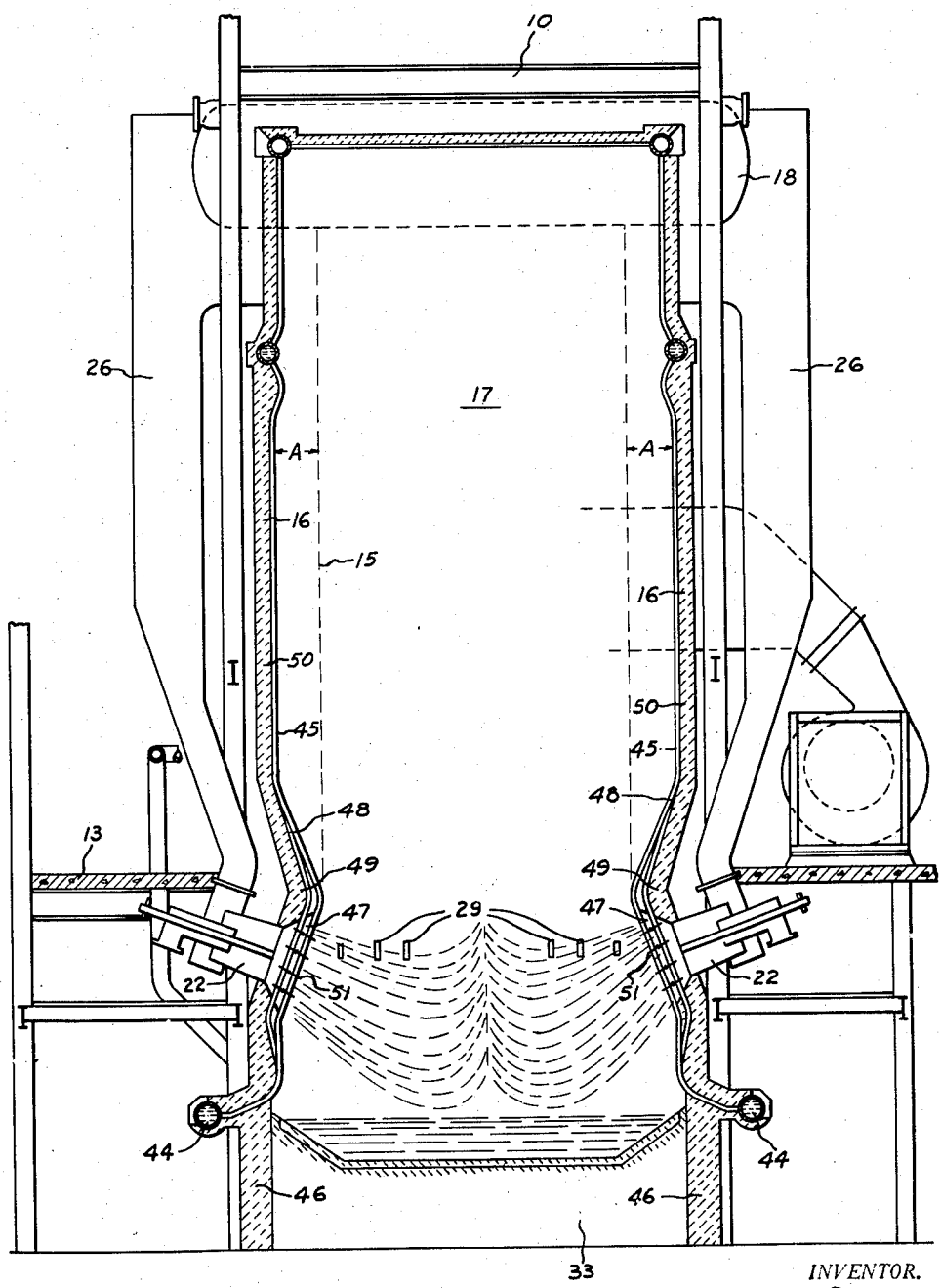

Fig. 1

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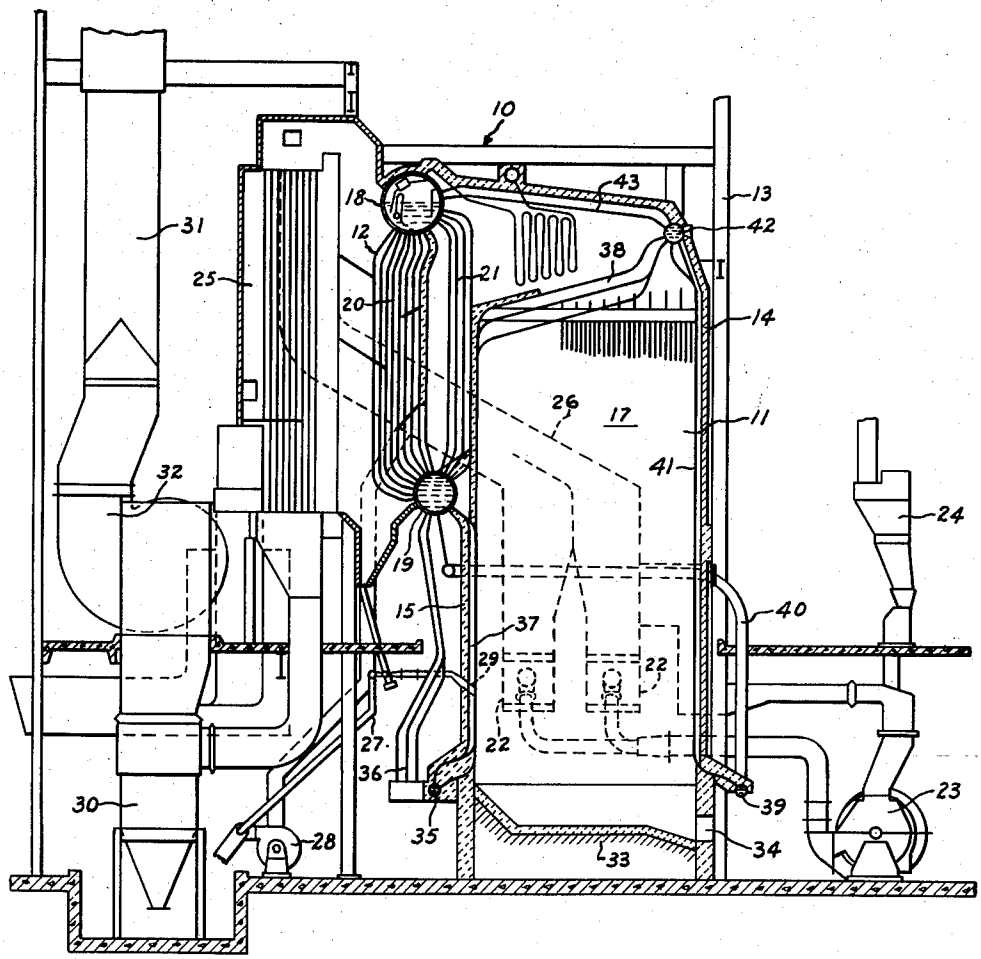

Fig. 2

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2,853,059

FURNACE CONSTRUCTION

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Application February 15, 1955, Serial No. 488,188

2 Claims. (Cl. 122—235)

This invention relates to a furnace construction and, more particularly, to apparatus arranged to produce steam by the burning of pulverized coal or the like in suspension.

One of the outstanding difficulties experienced at present in the operation of furnaces which serve steam generating units is that steam generating tubes become coated with slag and similar substances. This problem becomes more acute because of the present tendency to burn the so-called inferior fuels; that is to say, fuels which for one reason or another are more economical to burn, but which, because of the aforementioned fouling difficulties sometimes do not increase the efficiency of the unit as a whole. Many devices have been evolved for cleaning boiler tubes when their heat transmission ability is cut down by a coating of slag. However, all of these apparatus are very expensive and complicated and require the attention of a certain amount of labor. These slagging difficulties are experienced for the most part in units burning pulverized coal in suspension. However, it is to be realized that in the burning of oil, for instance, there is a chemical residue, which, while not as great in quantity, has a strong corrosive effect on the boiler tubes. In the burning of petroleum coke, for instance, there are many corrosive residues which decrease the attractiveness of this fuel despite its low cost. Many of these difficulties encountered with apparatus of the prior art have been obviated in a novel manner by the present invention.

It is therefore an outstanding object of this invention to provide a furnace construction which will permit the use of inferior fuels and fuels having large amounts of unburnable residue without objectionable fouling of the boiler tubes.

Another object of this invention is the provision of a furnace construction in which the slagging of the boiler tubes is reduced to a minimum.

A still further object of this invention is the provision of a steam generating unit in which the conditions in the combustion chamber can be regulated to permit the crystallization of slag particles before they come in contact with boiler tube surfaces.

Another object of this invention is the provision of a furnace of the slag tap type in which the slag pool may be maintained in a suitably molten condition and yet the major portion of the combustion chamber may be maintained at an advantageously low temperature.

A still further object of the instant invention is the provision of a steam generating unit in which directional flame burners are used in conjunction with a slag pool to reduce flyash carryover and slagging of boiler tubes.

It is a still further object of this invention to provide a combustion chamber of the slag tap type in which combustion is substantially completed in the lower portion of the furnace adjacent the slag pool, so that objectionable combustion does not take place in the upper part of the furnace or in the boiler passes.

Another object of the invention is the provision of a

furnace which will operate with low excess air and yet will have a very low amount of carbon loss.

Although the novel features which I believe to be characteristic of this invention will be particularly pointed out in the claims appended hereto, the invention itself, as to its objects and advantages, the mode of its operation, and the manner of its organization, may be better understood by referring to the following description taken in connection with the accompanying drawings forming a part thereof, in which

Figure 1 is a transverse sectional view of a steam generating unit embodying the principles of the present invention, and

Figure 2 is a longitudinal sectional view of the steam generating apparatus.

Referring to the drawings a steam generating unit, designated generally by the reference numeral **10**, is shown as comprising a furnace **11** and a boiler **12** supported on a structural framework **13**. The furnace **11** is made up of a forward wall **14**, a rear wall **15**, and side walls **16** defining a combustion chamber **17**. The boiler **12** is made up of an upper steam and water drum **18**, a lower or mud drum **19**, downcomer tubes **20**, riser tubes **21** making up a boiler circulation system. Burners **22** are situated in the sidewalls **16** and are provided with pulverized coal from a pulverizer **23**, which is served by a feeder mechanism **24**. An air heater **25** is situated at the rear of the steam generating unit and is connected to the burners **22** by a duct **26**. The unit is provided with a cinder reinjection system **27** served by a fan **28** and gaining entrance into the combustion chamber **17** to the apertures **29** in the rear wall **15**. The gas exit end of the air heater **25** is connected to a dust collector **30** which is connected to a breeching **31** to an induced draft fan **32**. In the lower portion of the combustion chamber **17** is situated a slag basin **33** in which a pool of slag may be formed. A tapping entrance **34** is provided in the forward wall **14** of the furnace. It is to be noted that a portion of the boiler **12** is used to provide waterwalls for the combustion chamber **17**. For instance, a header **35** located transversely and rearwardly of the rear wall **15** is served by downcomers **36** and in turn serves waterwall tubes **37** extending upwardly along the rear wall **15**. Some of the tubes **37** extend forwardly at the upper portion of the combustion chamber to form a screen **38**. A header **39** is located transversely and forwardly of the forward wall **14** and is served by a downcomer **40**. Upwardly from the header **39** extend tubes **41** along the inner surface of the forward wall **14** and join with the screen tubes **38** at the header **42**. These tubes **43** extend from the header **42** to the steam and water drum **18**.

Referring particularly to Figure 1, a header **44** provided at the lower part of each of the sidewalls **16**, these headers being served by downcomer means not shown. Side waterwall tubes **45** leave the headers **44** and extend upwardly from along the inner surfaces of the sidewalls **16**. These tubes **45** extend upwardly in the usual manner and eventually discharge into the steam and water drum. The form of the sidewalls **16** is worthy of note. Each sidewall is provided with a vertical portion **46** extending upwardly to a short distance above the slag basin **33**. This lower vertical portion merges into an inclined portion **47** situated adjacent the cinder reinjection apertures **29**. The surface **49** is inclined inwardly and upwardly and merges with another inclined surface **48** which is inclined upwardly and outwardly. The junction of the surfaces **47** and **48** forms nose portions **49** as is evident in the drawings. The upper part of the inclined surface **48** merges into a vertical portion **50** which extends upwardly through the remainder of the combustion chamber. The burners **22** are introduced

through the sidewalls **16** in the center of the upwardly and inwardly inclined surface **47**. The construction of the burners **22** and the manner in which the waterwall tubes **45** are bent to admit fuel access is best described in the copending patent application of Ollison Craig, Serial Number 299,888, filed July 19, 1952. This burner is of the directional-flame, intertube type and is provided with vanes **51** which permit the inclination of the flame to be adjusted. It should be noted that the noses **49** formed in the sidewalls **16** extend inwardly of the vertical portion **50** of the sidewall a distance marked as "A" in the drawings.

The operation of the apparatus of the invention will now be clearly understood in view of the above description.

Raw coal is provided to the pulverizer **23** by means of the feeder **24** and this pulverized coal mixed with air originating in the air heater **25** is introduced to the burners **22**. Secondary air introduced through the ducts **26** is introduced at the burners and the flame passes into the combustion chamber **17**. Water is heated and steam is generated in the boiler tubes in the usual manner. The burners **22** are adjusted so that the flame is projected downwardly toward the slag basin **33**. Eventually a considerable body of the slag accumulates in the basin and forms a slag pool. The presence of the molten slag in the slag pool and the fact that the noses **49** formed in the sidewalls **16** define a small semi-enclosed chamber means that this lower portion of the combustion chamber is maintained at a very high degree of temperature. The incombustible slag formed during the combustion is thrown forcibly against the surface of the slag pool and to a great extent remains there. In this same way, incombustible particles or particles which are difficult to burn because of their large size float on top of the slag pool and burn there completely. Particles of molten slag and other foreign matter which are not removed from the gases in this manner flow upwardly through the furnace. They attach through the restricted passes between the noses **49** and a considerable amount of combustion is completed there because of the high gas flow and extreme turbulence brought about by the presence of the apertures **29**. The molten slag particles which continue upwardly in the gas flow flow through the upper portion of the combustion chamber, but are maintained away from the sidewalls **16** at least by a distance indicated in the drawings by the letter A. As has been explained, the upper portion of the combustion chamber will be maintained at a relatively low temperature and before slag particles or molten chemicals touch any of the boiler surfaces, they have been permitted to solidify or crystallize in the low temperature atmosphere. Once these materials are solidified of course, they no longer have a tendency to stick to boiler surfaces and are easily disposed of in the usual manner. They will either catch in cinder pockets located throughout the boiler system, or they will be removed from the gas flow in the centrifugal separator **30**. In any case they will be returned to the main combustion chamber **17** by the reinjection system **27** through the apertures **29**. It can be seen then that with this arrangement it will be possible to obtain combustion of even the poorest fuel with a minimum of tube fouling.

It is of interest to note that in some installations where disposal of flyash is an economic problem, a slag-tap unit of this type with complete reinjection of flyash is very useful. As a matter of fact, it is one facet of the invention that flyash from other steam generating units in the same area may be returned to this unit. The opposed firing of the invention provides extreme turbulence and excellent combustion in the lower part of the furnace. Combustion is completed in the bottom of the furnace with no evidence of flame extending beyond the burner level. In a practical installation of the type shown in the drawings there was complete absence of slagging in any part of the furnace. The only soot blowers installed were two long retractable units, one on each side to clean the slag screen. However, it was found that it was not necessary to use these soot blowers, since there was no necessity for doing so. There was some evidence of a powdery fluffy ash between the tubes, front to back, in the boiler section. However, no difference in exit temperatures occurred when this ash was completely removed. While the ash fusion temperature was quite high, 210 degrees F., slagging did occur on other conventional units in the same area using the same coal. This unit not only relieved the operator of the high expense of disposal of flyash, but a test showed that an extremely low carbon loss figure and high efficiency was obtained. The loss, due to sensible heat in the slag, was approximately .50 of the loss shown of .62. A carbon loss figure of .12 was based on a carbon content of 10% in ash omitted from the stack and 1 lb. of flue dust per 1,000 lbs. of wet gas. The carbon content of ash in the boiler hoppers was only .54% and in the precipitator hoppers only .97%, so the 10% assumption seems high, and it is questionable whether carbon loss exclusive of sensible heat and the molten slag is more than .05%. Tests have indicated that a far greater portion of ash is retained in the furnace, possibly three times as much as with a conventional unit, though not enough to permit elimination of a dust collector. In view of the completeness of combustion in the lower part of the furnace due to the opposed firing and the high temperatures in the bottom, it is possible that furnace volumes in units of this type can be materially reduced with considerable savings in the initial cost of the unit.

It is suggested that the ability of this unit to operate with low excess air, and yet with low carbon loss, will inhibit the formation of higher oxide, such as SO_3, which reacts with other chemicals in the combustion gas to form harmful acids and sulphates.

While certain novel features of the invention have been shown and described and are pointed out in the annexed claims, it will be understood that various omissions, substitutions, and changes in the forms and details of the device illustrated and in its operation may be made by those skilled in the art without departing from the spirit of the invention.

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

1. A steam generating unit for use with pulverized solid fuel comprising a furnace, a boiler, water walls defining a combustion chamber, a horizontal slag basin formed entirely of high-temperature insulating refractory material at the lower portion of the combustion chamber, two of the water walls being in opposed relation and being vertical throughout most of their height, an abutment extending from each of the said two walls a short distance above the slag basin, the abutments extending toward each other a substantial distance on the same horizontal level close to the said slag basin to define a restricted passage therebetween, burners adapted for use with pulverized fuel mounted on the undersides of the abutments and directed downwardly toward the slag basin, the burners being adapted to form a thorough mixture of fuel and air for passage therethrough, the burners having vanes which are adjustable about a horizontal axis to adjust the direction of flow of the said mixture, the burners being of the intertube type, whereby combustion takes place without slagging of the boiler surfaces.

2. A steam generating unit for use with pulverized solid fuel comprising a furnace, a boiler, means associated with the boiler for collecting cinders and flyash, walls defining a combustion chamber, a slag basin formed of high-temperature insulating refractory material at the lower portion of the combustion chamber, two of the walls being in opposed relation and being vertical throughout most of their height, an abutment extending from

each of the said two walls a short distance above the slag basin, the abutments extending toward each other substantial distances on the same horizontal level close to the said slag basin to define a restricted passage therebetween, means for reinjecting the cinders and flyash collected from the boiler into the combustion chamber within the restricted passage, each abutment consisting of an upper surface which is inclined upwardly and outwardly and a lower surface which is inclined upwardly and inwardly, burners mounted on the said lower surface of each of the abutments and directed downwardly toward the slag basin, the burners being adapted to form a thorough mixture of fuel and air for passage therethrough, water wall tubes covering said two walls of the abutments and bent in the area of the burners to define passages

through which the burners may fire, the burners having vanes which are adjustable to adjust the direction of flow of the said mixture about a horizontal axis, whereby combustion takes place without slagging of the boiler surface.

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