

May 20, 1958

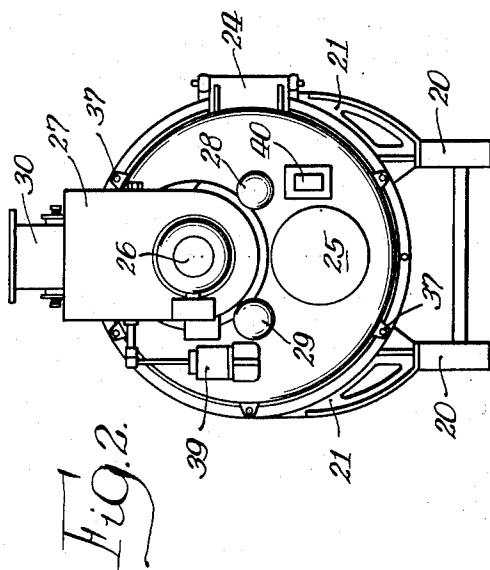
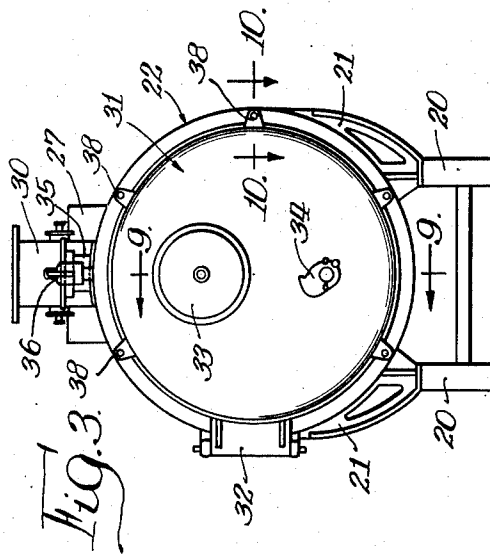
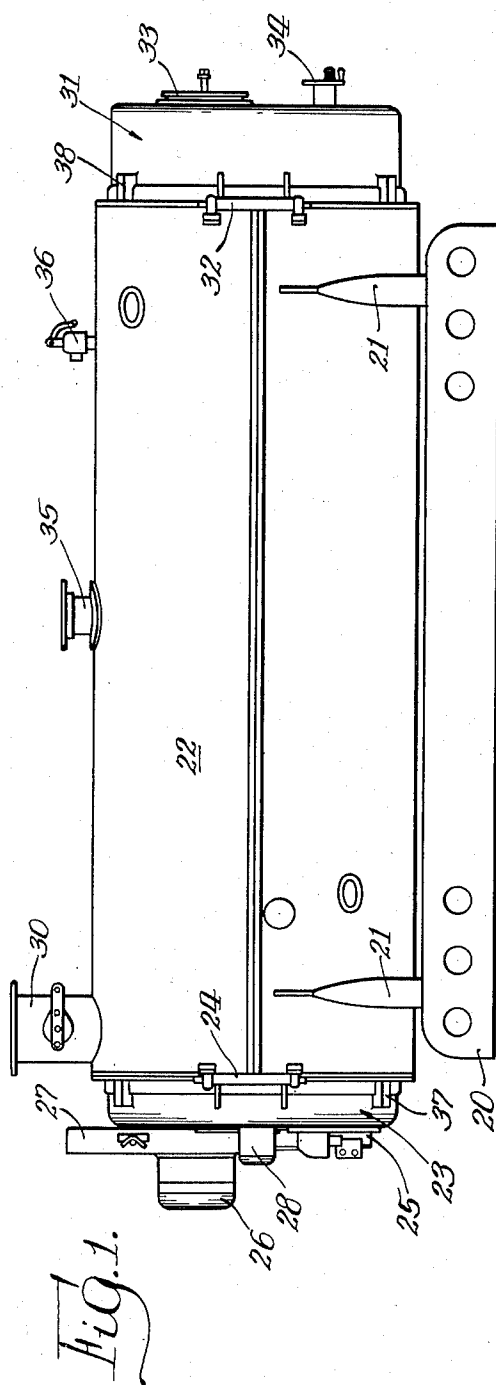
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BOILER

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5 Sheets-Sheet 1



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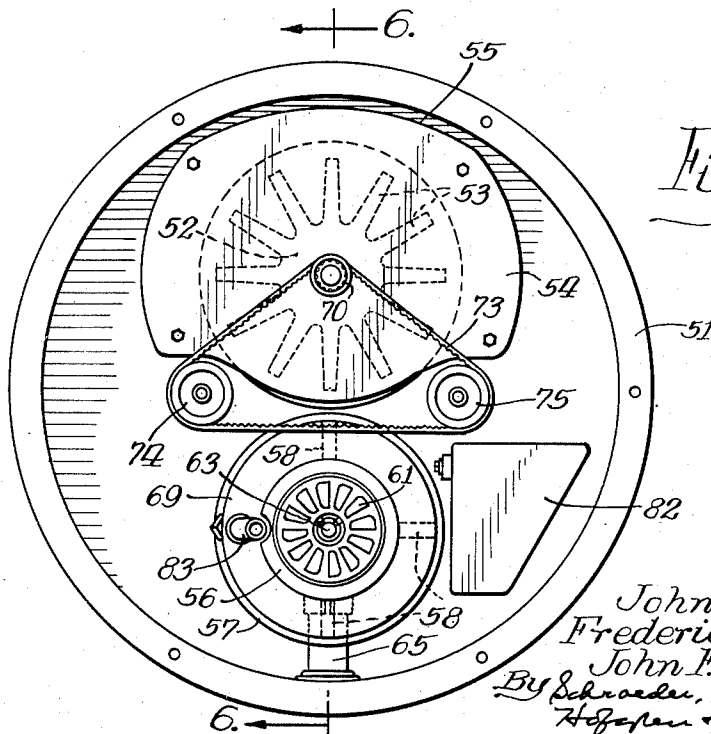
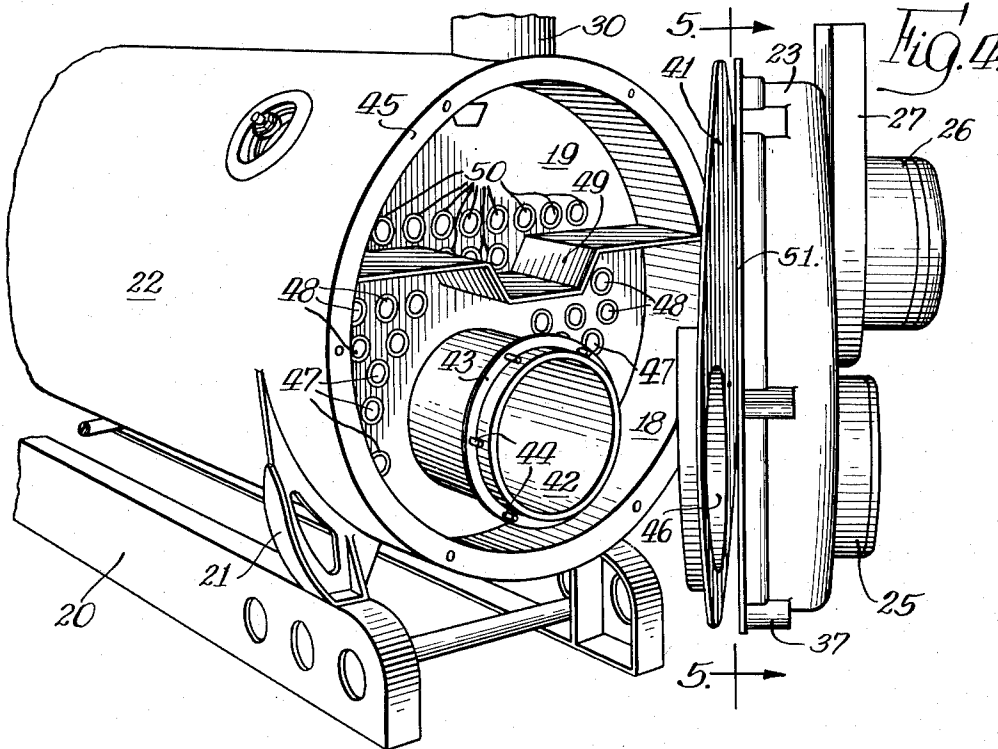
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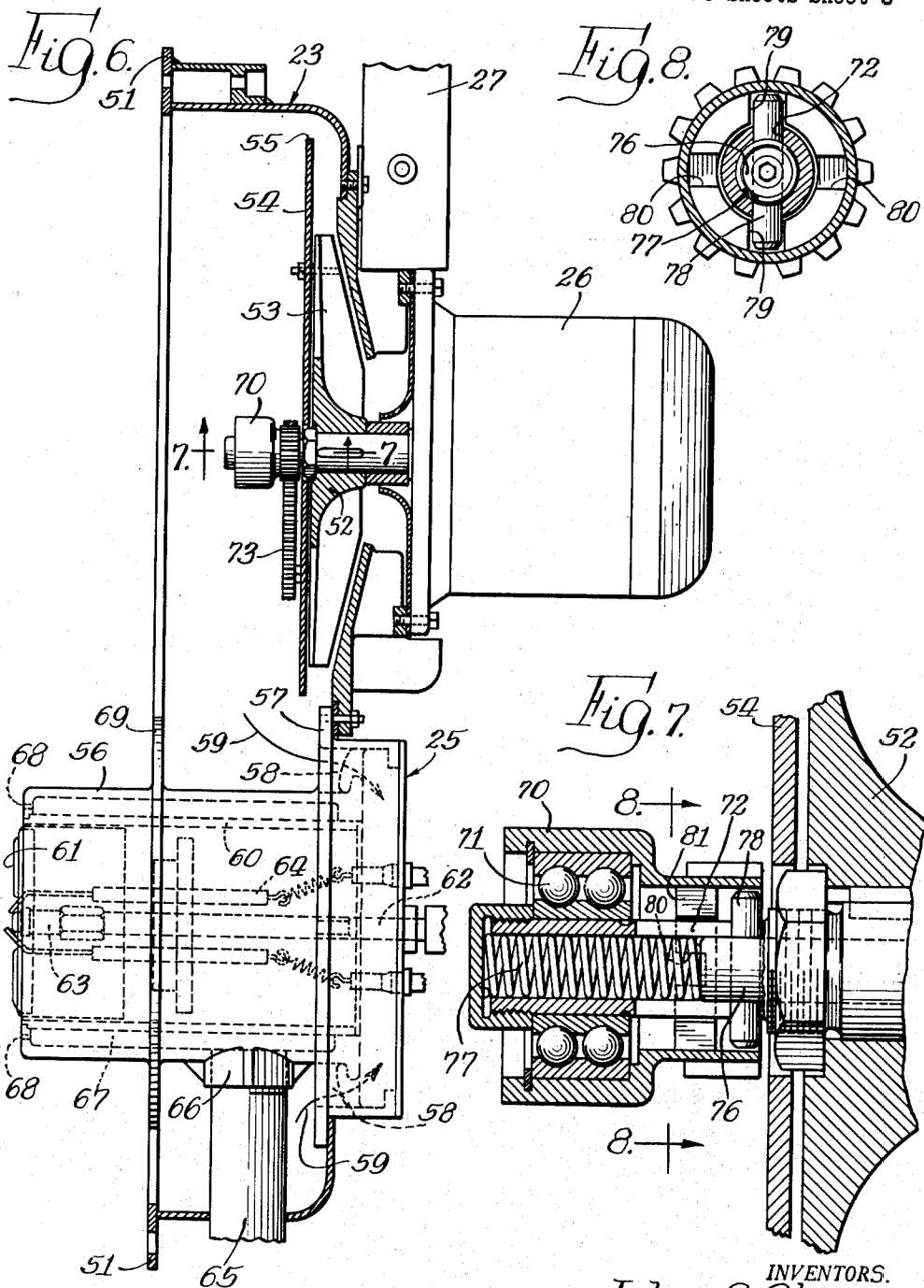
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5 Sheets-Sheet 3



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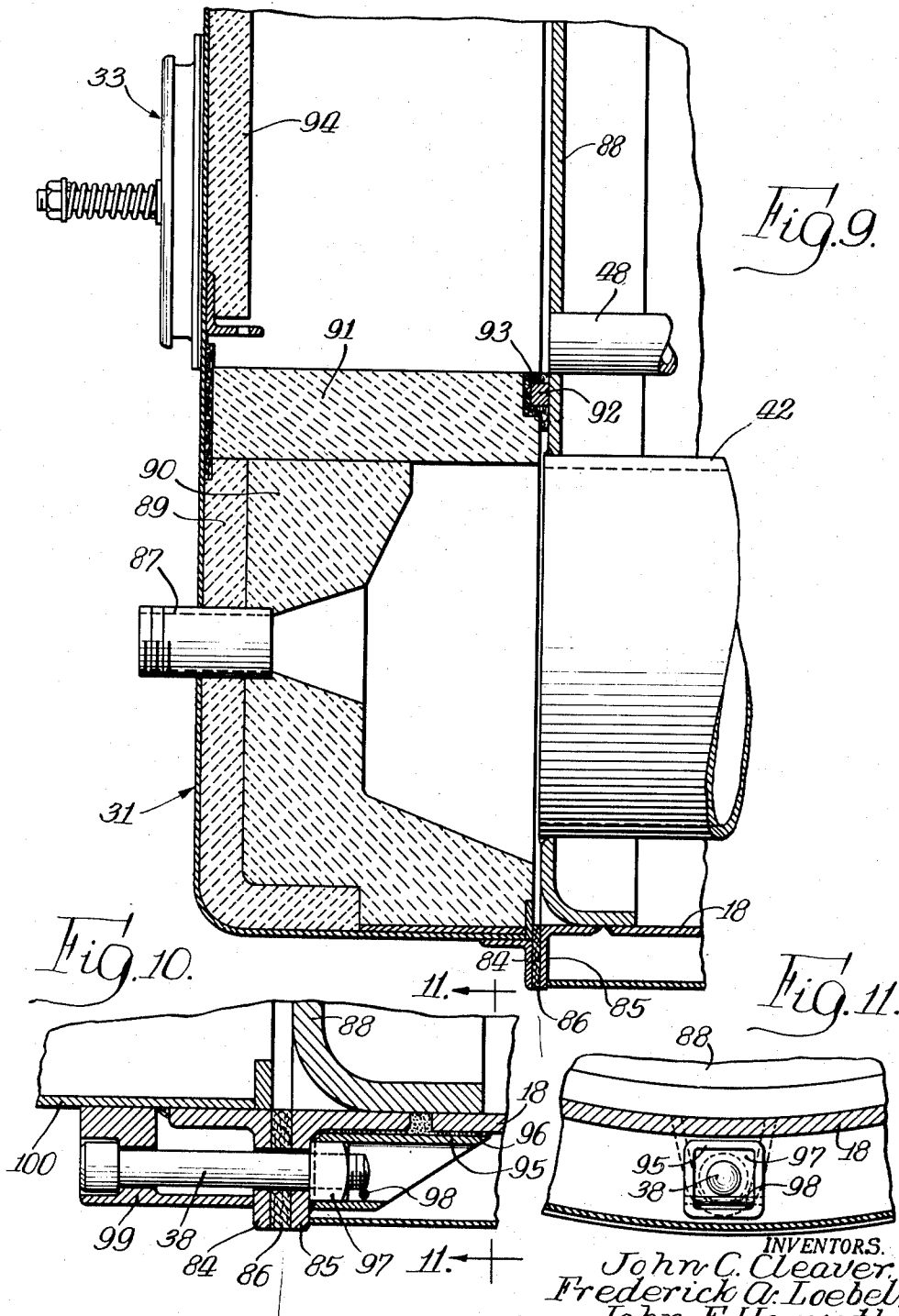
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BOILER

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5 Sheets-Sheet 4



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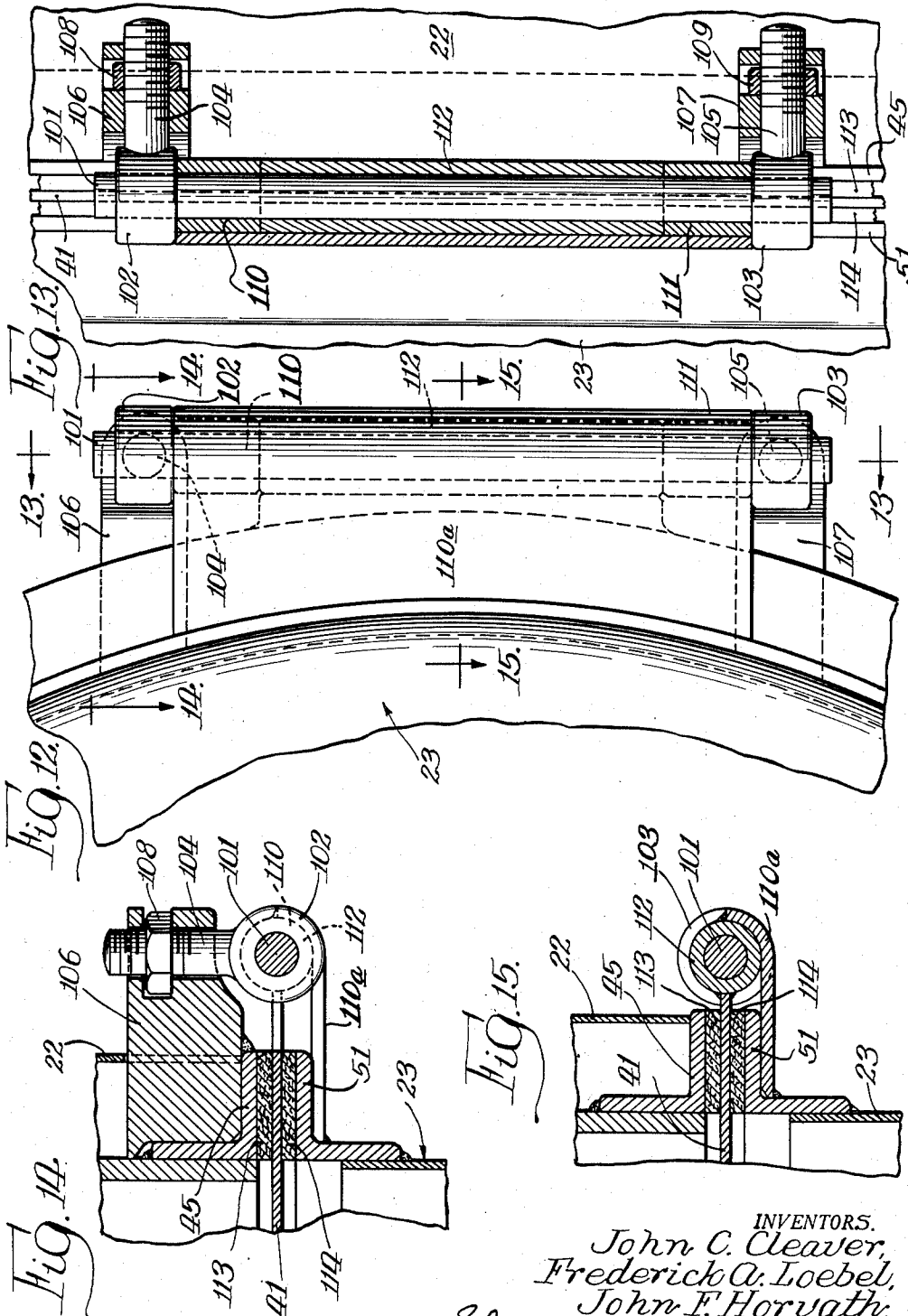
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5 Sheets-Sheet 5



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2,835,230

BOILER

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16 Claims. (Cl. 122—75)

This invention relates to a boiler and more particularly to a steam generating unit complete except for necessary fuel, water and electrical connections to sources of the same.

In the past, it has been a practice to provide steam generating units substantially complete and on skids serving for ease of transport from factory to place of use and for installation in a boiler room. In general, these units included a boiler with the usual fire tube and a number of boiler tubes plus a burner and the necessary controls mounted in the front end of the fire tube. The necessary blower motors and fuel pumps along with the controls for these items were complete in the skids upon which the boiler was mounted. It was thus necessary only to connect lines providing fuel and water, a smokestack connection and an electrical connection to the control panel of the unit in order that the installation of the generating unit be complete.

The boiler of these units has, in the past, been constructed along conventional lines in that it included tube sheets each spaced inwardly from the adjacent end of the boiler shell and the provision of refractory brick and mortar placed in the end of the boiler shell itself to form passages directing the combustion products out of some of the boiler tubes into the other boiler tubes. In this manner, the combustion gases were made to pass alternately through different sets of the boiler tubes before entering the stack. The tubes require cleaning after use for some time and generally at least once a year. In order to accomplish the cleaning, the ends of the tubes must be exposed so that cleaning tools may be run through the tubes. To do this job has required considerable work in removing the end plates of the boiler which have been fastened with a great number of bolts and then in chipping away of the fire brick and refractories to eventually expose the ends of the tubes. The removal of the fuel feeding apparatus has required extensive work and the disconnection of many lines around the front end of the boiler. Thus, cleaning a steam generating unit has been a major task requiring the shutdown of the unit for several days.

The present invention presents a new approach to boiler design and to the mounting of fuel burners and the other necessary appurtenances in a steam generating unit. The structure is so made that the boiler may be opened in a matter of a few minutes, often less than five minutes, to completely expose the fire tube and boiler tubes for cleaning, inspection, or any other purposes. The unit may be placed back in service in a similar length of time. The unit is compact and, in effect, has the fuel introducing agencies built into a part of the boiler proper. Thus, the skids support only the boiler shell and need not have other apparatus mounted on the skids in addition to the shell.

The principal object of the present invention is to provide a new and improved boiler and a steam generating unit utilizing the boiler.

Another object is to provide a steam generating unit

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which may be shut down, opened for cleaning of the tubes and then quickly be put back in service with less work than has heretofore been possible.

Another object is the provision of a steam generating unit having a boiler with hinged doors at each end secured to the boiler in gas-tight fashion by very few bolts to make opening and closing of the doors easily accomplished.

A further object is to provide a steam generating unit in which the burner unit and air introducing device are mounted on a hinged door easily removable from operative position to permit service or replacement of units.

A further object is the provision of a new burner housing for use in a steam generating unit of new design permitting the use of the housing alternatively for different fuels and the inclusion of the housing in a hinged door on the boiler.

Further objects, advantages and features of the present invention will be apparent in the following description taken in conjunction with the accompanying drawings in which:

Figure 1 is a side elevational view of the new boiler illustrating the fuel and air introducing agencies and showing the unit without its connections to outside sources of fuel, water and smoke ducts;

Figure 2 is a front end elevational view of the unit shown in Figure 1;

Figure 3 is a rear end elevational view of the unit shown in Figure 1;

Figure 4 is a fragmentary perspective view of the front end of the unit shown in Figure 1 showing the front inner and outer doors swung partially open;

Figure 5 is an inside front view of the outer front door taken substantially along line 5—5 in Figure 4 and showing the fuel burner fan, oil pump and atomizing air pump as mounted on the inside of the front door;

Figure 6 is a vertical sectional view taken substantially through the center of the front outer door and substantially along line 6—6 in Figure 5;

Figure 7 is a sectional view through the inner end of the fan motor shaft and taken substantially along line 7—7 in Figure 6;

Figure 8 is a sectional view taken substantially along line 8—8 in Figure 7 and showing the clutch connection between the motor shaft and drive pulley for the oil and air atomizing pumps;

Figure 9 is a fragmentary sectional view taken substantially vertically through the rear door as indicated along line 9—9 in Figure 3;

Figure 10 is a horizontal sectional view through one of the fastening bolts on the rear door and taken substantially along line 10—10 in Figure 3;

Figure 11 is a fragmentary end sectional view looking toward the bolt shown in Figure 10 and taken substantially along line 11—11 in Figure 10;

Figure 12 is a fragmentary enlarged view of the hinge for the front doors;

Figure 13 is a fragmentary sectional view taken through the hinge pin of the hinge shown in Figure 12 and substantially along line 13—13 of Figure 12;

Figure 14 is a fragmentary horizontal sectional view taken through the upper hinge pintle bearing and substantially along line 14—14 in Figure 12; and

Figure 15 is a fragmentary horizontal sectional view through the hinge illustrated in Figure 12 and taken substantially along line 15—15 in Figure 12.

The steam generating unit illustrated is one of about forty horse power capacity adapted to use a light oil as fuel. The unit is a forced draft type with the combustion products making four passes through the fire tube and boiler tubes before entering the stack.

In Figures 1, 2 and 3, the general outward appearance of the new generating unit shows that the unit is supported on skids 20 connected to the boiler shell by a pair of upwardly extending brackets 21 on either side of the boiler shell. The shell itself is not visible as it is covered by insulating bats pre-formed to the cylindrical shape of the boiler shell and in turn having an outer covering of thin sheet material 22. This outer covering may be given an enameled baked-on surface covering and the skids may be painted a similar or contrasting color so that the outward appearance of the unit is very pleasing to the eye.

A front outer door 23 is hinged by hinge 24 to the boiler shell. It carries a fuel burner housing 25 in its lower portion and an electrical motor 26 which is directly connected to a fan inside the door 23. Air is conducted through an intake duct 27 to the fan which distributes the air inside the inner door and into the burner housing 25. An oil pump 28 is also mounted on the front door as is an atomizing air pump 29.

The combustion products pass four times through the boiler shell and exit through the smokestack 30 which will be given an appropriate connection with the chimney or stack of the institution where the unit is installed for use. The rear door 31 is also swingably secured by the means of a hinge 32. This door is quite deep in order that it may contain and support refractory material as will be described in detail below. A pressure relief plate 33 is carried on the outer side of the rear door as is an inspection sight glass 34 opposite the fire tube running through the boiler.

Connections are provided for the fuel burner and water connections to the boiler. Steam is taken from the unit through a nipple 35 generally centrally located in the boiler shell while a pressure relief valve 36 is provided in an appropriate location.

The details of the connections of both front and rear doors will be given below, however, it should be noted that five bolts 37 are required on the front door and five similar bolts 38 are required to secure the rear door to the shell. The hinges 24 and 32 form the dual capacity of securing the doors to the shell at their particular location. The particular structure of these bolt connections is of importance in securing a gas-tight fit between the doors and the shell. These also will be described in detail.

The control unit 39 for the damper in the air inlet 27 and the solenoid control 40 for the oil pump 28 are also mounted on the front door and swing with it when the door is opened. Unit 39 is a modutrol motor responsive to pressure control (or temperature control in water boilers) actuating damper and gas valve or damper and control 40 for high fire operation.

The various parts of the steam generating unit which will be discussed in the following paragraphs are each of importance in the forming of an entirely new concept in such units. As far as it is known, there has been no structure made and used which is complete and as easily serviced as the present unit. In the past, it has been necessary to throw away the refractories and replace them every time the boiler had to be opened. And further, there has been no quick and easy method of opening such a boiler and returning it to service in a short length of time. In the present invention, the unit may be opened and closed completely within a matter of a few minutes and several of the structures to be described contribute toward making such a result possible.

The front outer door 23 is shown in Figure 4 in partially open position to expose the inner front door 41. The inside of the front end of the boiler shell 18 is exposed to show the front tube sheet 19. The fire tube 42 is shown as extending through the front tube sheet and provided with a flange 43 having a plurality of bolts 44 therein. The inner front door 41 is substantially flat and extends outwardly so that its peripheral edge may en-

gage the flange 45 on the boiler shell 18 when closed upon it. An opening 46 in the inner door permits the outer end of the fire tube 42 to extend through the inner door so as to be engaged by a flange on the burner housing. The inner door is held in place about the fire tube by the bolts 44 and nuts applied to the bolts on the outer side of the inner door when closed.

The combustion products from the burner housing enter the large fire tube 42 and travel down its length, emerging from the opposite end where they are deflected laterally into the lower boiler or fire tubes 47 on each side of the fire tube. Upon returning through these tubes 47 to the space in the boiler shell between the front tube sheet 19 and the inner door 41, the gases enter the upper boiler or fire tubes 48 and return to the rear end of the boiler shell above refractory divider 91 and into the fire tubes 50. A metal divider 49 is welded in position between the front tube sheet and the sides of the boiler shell to partition the tubes 48 from the upper set of tubes 50. The inner front door seals against a tadpole gasket mounted on the outer edge of the divider 49, when the door is closed on the shell. The combustion products emerging from the tubes 50 are conducted to the smokestack 30.

It will be noted that the outer front door 23 is cup-shaped and provided with a flange 51 which mates with the flange 45 on the boiler shell. Figures 5 and 6 particularly show the apparatus mounted in the outer front door 23. At the upper end of the door, an electrical motor 26 is connected to a fan 52 having a plurality of radial blades 53. A diffuser plate 54 is mounted directly over the fan and is given an outer periphery 55 to cover as much of the fan area as possible. The particular shape of the diffuser plate 54 is chosen to direct the air from the fan outwardly against the cup-shaped sides of the door and thus distribute the air at low velocity from the fan as widely as possible within the space between the inner door 41 and outer door 23. This space acts as a plenum chamber for the air conducted through the intake 27 to the central portion of the fan and then radially outwardly behind the diffuser plate 54.

The burner housing 25 comprises a casting having a barrel 56 of cylindrical form and an outwardly extending front flanged portion 57 secured to the door metal. The barrel is smaller than the cylindrical rearward portion of the burner housing and is supported therein by a number of spider elements 58 so as to leave a passage for air from the plenum chamber into the rear portion of the burner housing in the direction of arrows 59. The air thus enters the space within the inner barrel 60 of the burner housing and is conducted into the fire tube through a diffuser 61 on the inner end of the housing. Since the illustrated burner is one for light oil, an oil tube 62 with a conventional nozzle 63 is illustrated centrally within the burner housing. Ignition apparatus 64 is illustrated in position about the oil supply tube 62.

The burner housing is so formed that it may be converted to gas simply by connecting a gas source to a pipe 65 extending through the outer door and connected to a nipple 66 which conducts gas to the space 67 between the outer barrel 56 and inner barrel 60 of the burner housing. This gas flows into the fire tube through a number of small openings 68 at the inner end of the burner housing and communicating with the space 67.

The burner housing is equipped intermediate its ends with a flange 69 which is seated against the inner door 41 when both doors are closed. A suitable sealing gasket is provided about the opening 46 in the inner door so that this flange 69 provides an airtight connection between the burner housing and the inner door. Thus, all air in the plenum chamber must enter the burner housing in the direction of the arrows 59 as indicated. It should also be understood that gaskets are provided between the inner door 41 and flange 45 on the boiler shell and be-

tween the mating flanges and peripheral part of the outer and inner doors respectively.

The selection of oil or gas as the fuel requires some change in the firing apparatus. With gas as the fuel, the oil pump 28 and atomizing air pump 29 are not used. With light oil, these units are in use. As illustrated in the drawings, the shaft of the motor 26 extends through the fan 52 and through the baffle plate 54. A pulley 70 is mounted on bearings 71 so as to freely rotate on the motor shaft 72. A belt drive 73 passes over the pulley 70 and similar pulleys 74 on the oil pump and 75 on the atomizing air pump. The belt is a flexible rubber belt provided with teeth on its inner surface so that a positive drive is provided.

Means are provided for selectively engaging and disengaging the pulley 70 from the motor shaft. The shaft is hollow and has a plunger 76 therein, spring pressed by spring 77 outwardly in the shaft. A pin 78 may be positioned inwardly through bayonet slots 79 in the pulley member and turned 90° to rest in retaining grooves 80, thus locking the pulley 70 to the hollow shaft 72 of the motor. In the position shown in Figure 7, the pin 78 rests behind the collar 81 containing the bayonet slots 79 and retaining grooves 80 so that the pulley 70 is free of connection with the shaft of the motor. The plunger 76 is provided with a screwdriver slot near the outer end of the motor 26 so that the connection of the pulley to the motor shaft may be easily made from outside without opening the doors.

Referring to Figure 5, the oil sump pit 82 is provided for cleaning the atomized air from the pump 28. Ignition of fuel may be provided by an igniting device 83 and formed in connection with the burner housing.

The back door 31 is hingedly secured to the boiler shell as is the front door. The door is cup-shaped and has a peripheral flange 84 which mates with a flange 85 on the boiler and is provided with an asbestos rope gasket 86 interposed between the flanges. The back door carries the spring pressed blow-out plate 33 and a nipple 87 on which a sight glass is placed so as to view the flame travelling down the large fire tube 42. The rear tube sheet 88 is shown with one of the tubes 48 extending through the tube sheet. The fire tube 42 discharges the gases and combustion products into the lower half of the door. This door carries a pre-formed insulation 89 over which is a poured-type of refractory 90 below a dividing refractory tile 91 extending across the rear door. The dividing tile is provided with an asbestos gasket 92 in conjunction with a formed asbestos refractory 93 which fits against the face of the tube sheet dividing the lower boiler tubes 47 from the upper tubes 48. The upper part of the door is also provided with a pre-formed refractory 94.

From the description of the refractories placed in the rear door, it will be noted that they are separate from the boiler shell and wholly supported in the door itself. Thus, when the door is swung open on its hinge, the refractories are carried with it and not disturbed. This exposes the large fire tube and smaller fire or boiler tubes without the necessity of disturbing the refractories. Both front doors and the rear door are secured by a particular type of bolt element. From Figures 1 through 3, it will be noticed that there are very few bolts whereas in the past it has been thought necessary to have bolts fairly closely spaced so that the flanges between the bolt fastenings would not bulge and allow the escape of gases. In the present instance, the boiler shell and the cup shape of the doors has been used in effect as a beam. The flanges only serve as mating faces pressed together under sufficient pressure to seal against the gasket and no more. In Figures 10 and 11, the form of the bolt fastenings is shown. A gusset member 95 is a hollow rectangular piece placed against the flange and shell of the boiler. Welding 96 extends around the gusset member along

all edges touching either the shell or flange of the shell. Being square in cross-section, a square nut 97 may be placed in the gusset and held against removal by a cotter pin 98. A lug 99 is similarly secured to the door and flange of the door. The stresses imposed upon the flanges by tightening the bolts 38 are thus transmitted to the shell 18 of the boiler and the cup-shaped part 100 of the door. The stress pattern extends over the boiler shell and door surface 109 in the form of a fan with the narrow point of the fan at the bolt. In this manner, the stress applied by the bolt is not directly concentrated on a narrow portion of the flanges but it is spread into the metal of the boiler and door, which metal is, of course, aligned with its greatest dimension in the direction of the stress applied.

It is thus possible to secure the doors to the shell in tight fashion with the use of very few fastening bolts. This contributes to the quick opening and closing of the doors on the boiler shell for service of the unit.

The hinges which secure the doors to the shell are of particular form since they serve not only to swingably support the doors on the shell but to take the place of a securing bolt at their particular location. The hinges for the front door are illustrated particularly in Figures 12 through 15, it being understood that the rear door hinge is similar but supports only a single door. Each hinge includes a pin 101 supported in an upper pintle bearing 102 and a similar lower pintle bearing 103. Each bearing has a threaded shank 104, 105 passing through an apertured lug 106, 107 having a slot therein to receive a nut 108, 109 threaded on the shank. The nut is accessible from the outside so that it can be tightened or loosened to move the pintle bearing longitudinally of the boiler shell. This adjusts the position of the adjacent door flange 51 relative to the boiler flange 45. The outer front door is equipped with a plate 110a welded to pintle bearings 110 and 111 while the inner front door is equipped with a single pintle bearing 112, all mounted on the pin 101. In Figures 14 and 15, it will be noted that an asbestos rope gasket 113 is provided between the inner door 41 and the shell flange 45 and a similar gasket 114 is provided between the inner door and flange 51 of the outer front door.

The foregoing description of the detailed parts of the new steam generating unit illustrates that each of these parts contributes considerably to the formation of a new unit which is capable of being operated with considerably more ease than has heretofore been possible. The servicing of the unit is made easy by the use of the hinged doors. This servicing is also facilitated by the fact that the doors carry the refractory material which is necessary to divert the combustion product gases from some of the tubes into other of the tubes to obtain the necessary passes through the boiler. The fuel agencies and associated air supplies are all mounted in the front door with that door serving as a plenum chamber. The air admitted to the chamber also has the effect of cooling the door so that the drive for the oil and air pumps may be taken directly off the motor shaft for the fan without causing difficulty.

The air plenum and burner housing permit the appropriate amount of air to meet each atomized oil particle uniformly and as quickly as possible. In former gun type burners, when a discharge of centrifugal fan discharged directly to an air diffuser at the oil nozzle, it has been very difficult to secure uniform air distribution. It was commonly necessary to provide additional baffles by trial and error to obtain satisfactory air distribution. The plenum chamber in the present invention, allows the air to enter the tube 60 in a radial and uniform manner. Thus, the present oil burner is one capable of high heat release and uniform air distribution is accomplished. The unit is quite versatile in its application since it may quickly and easily be changed from one type of fuel to another. While one particular unit has

been shown, it should be understood that the same principles of construction may be incorporated in units of various horse power sizes.

While this invention is susceptible of embodiments in many different forms, there is shown in the drawings and is herein described in detail one specific embodiment, with the understanding that the present disclosure is to be considered as an exemplification of the principles of the invention and is not intended to limit the invention to the embodiment illustrated. The scope of the invention will be pointed out in the appended claims.

We claim:

1. A steam generator, comprising: a boiler shell having a large fire tube, a plurality of small fire tubes and spaced front and rear tube sheets with the tubes extending between and through the sheets, the front tube sheet being spaced inwardly of the front end of the shell; an inner door hinged to the front end of the shell and adapted to seal against means for diverting combustion products from some of the tubes into other tubes when the door is closed on the shell, said door having an opening aligned with said large fire tube; an outer front door also hinged to the boiler shell and having a burner housing and fan mounted therein, said outer front door being cup-shaped forming a plenum chamber between the inner and outer front doors for air discharged from said fan, and means for conducting air to the fan and fuel to the burner.

2. A steam generator, comprising: a boiler shell having a large fire tube, a plurality of small fire tubes and spaced front and rear tube sheets with the tubes extending between and through the sheets, the front tube sheet being spaced inwardly of the front end of the shell; an inner door hinged to the front end adapted to be sealed to the shell providing a space between the inner door and adjacent tube sheet for passage of combustion products from some of the tubes into other tubes when the inner door is closed on the shell; an outer front door having a burner housing and fan mounted therein and providing an air plenum chamber between the inner and outer doors for supplying air to the burner housing, said inner and outer doors being mounted on a single hinge and being swingable about the hinge to expose the large fire tube and small fire tubes.

3. A steam generator as specified in claim 2 wherein an oil pump and atomizing air pump are also mounted on the outer door, a motor is secured to the outer door for driving said fan and a selectively engageable drive is provided between said motor and said oil and air pump said burner housing having means for connecting gas and oil supply thereto.

4. A steam generator comprising: a boiler shell having spaced tube sheets, a plurality of small fire tubes secured in the sheets and a large fire tube extending through the tube sheets in usual manner; an inner door hinged to the front of the boiler shell and having an opening about the large fire tube; an outer door also hinged to the front of the boiler shell and providing with the inner door an air-tight plenum chamber between the doors; an air supply fan and driving motor mounted in the outer door; a burner housing mounted on the outer door for alignment with the large fire tube, said housing having connections for both oil and gas fuels; and an oil pump and an air pump each mounted in the outer door and having selectively engageable drive means from said fan motor for driving the air and oil pumps, said fan, pump, and burner housing being swingable with said outer door to remove them from operative position relative to the boiler shell.

5. A steam generator as specified in claim 4 wherein the drive to said pumps comprise a belt positioned inside the outer door and passing over pulleys respectively on shafts of said motor and said pumps, said motor having a hollow shaft with a clutch member mounted therein

for selectively engaging the pulley on said shaft in drive relation thereto.

6. A steam generator as specified in claim 4 wherein said burner housing has a central barrel and a supporting annulus connected thereto and to the outer door, said annulus forming air passages from the plenum chamber into the rear end of said barrel.

7. A steam generator as specified in claim 4 wherein said barrel of the burner housing is provided with a fitting intermediate its ends for introducing gaseous fuel to the housing when the steam generator is used with gas as the fuel.

8. A steam generator comprising: a boiler shell having spaced tube sheets and a plurality of fire tubes terminating in the sheets; a cup-shaped outer door hinged to one end of the shell and a generally flat inner door also hinged to said end of the shell, said doors and providing a plenum chamber; a burner housing and fan mounted in said outer door, said fan delivering air to the plenum chamber for conduction to the burner housing.

9. A steam generator comprising: a boiler shell having a large fire tube and a plurality of small fire tubes secured therein; a closure hinged to one end of the shell and adapted when open to expose all of the tubes, said closure being shaped and having spaced parts to provide a plenum chamber therein; a burner housing and a fan mounted in said closure, said fan delivering air to the plenum chamber for conduction to said burner housing.

10. A boiler for a steam generating unit, comprising: a generally cylindrical boiler shell having a base for supporting the shell horizontally; a rear tube sheet mounted in the rear of the shell generally in the plane of the rear end of the shell; a front tube sheet mounted in the shell and spaced inwardly from the front end thereof; a large fire tube and a plurality of small fire tubes extending between and through said tube sheets and being secured thereto in liquid-tight relation; a generally cup-shaped rear door hinged to the boiler shell and having refractory material carried on the door; a resilient seal carried by the refractory material on the door and positioned sealingly to engage the rear tube sheet, said refractory material on the door forming combustion product passages from the large fire tube into some of the other tubes when the door is closed upon the shell; a two part front door having an inner door portion and an outer door portion hinged to the shell; means dividing the space in the shell in front of the adjacent tube sheet into passages for directing combustion products between said last mentioned and the remaining tubes when said inner front door portion is closed on the shell, said large fire tube extending through the front inner door portion, said front outer door portion and rear door having flanges and said shell having mating flanges for securing the doors to the shell in gas-tight relation.

11. The boiler of claim 10 in which said resilient seal is surrounded on all sides except the side contacting the rear tube sheet with refractory material.

12. The boiler of claim 10 in which said seal is shielded from the heat in the combustion passages by refractory material and is cooled by contact with the rear tube sheet when the door is in closed position.

13. A closure for a boiler shell, comprising: a flange on one end of said shell; a door hinged to said end of the shell and having a flange adapted to seal against the shell flange; a plurality of widely spaced securing bolts arranged about the periphery of the door for securing the door in position with the door flange sealingly engaging the shell flange; and a plurality of gusset members secured respectively to the shell flange and shell for securing said bolts and spreading stress on the bolts when tightened while avoiding localized stress in the flanges.

14. A steam generator as specified in claim 13, wherein each gusset member secured to the shell has a box

portion for receiving a nut for the bolt and is rigidly secured to the boiler shell and flange whereby any stress applied through the bolt is transferred to the shell.

15. A steam generator as specified in claim 14 wherein the box portion has one side secured to the boiler shell and an end portion abutting and secured to the boiler shell flange.

16. A boiler for a steam generating unit, comprising: a generally cylindrical boiler shell having a base for supporting the shell horizontally; a rear tube sheet mounted in the rear of the shell; a front tube sheet mounted in the front of the shell; a large fire tube and a plurality of small fire tubes extending between and through said tube sheets and being secured thereto in liquid-tight relation; burner means at the front of said large fire tube, for directing combustion products into said large tube for travel therefrom into some of said small fire tubes; a generally cup-shaped rear door hingedly secured to the boiler shell and having refractory material carried on the door in position to form a combustion product passage from said large fire tube into said last mentioned small fire tubes; and a resilient seal carried by the refractory material on the door and having an exposed portion, substantially all of which is positioned sealingly to engage

the rear tube sheet to seal said passage from communication with the remaining small fire tubes, said refractory material providing a heat barrier between the seal and said passage and covering the remaining portion of said seal for shielding the same from contact with said combustion products.

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