

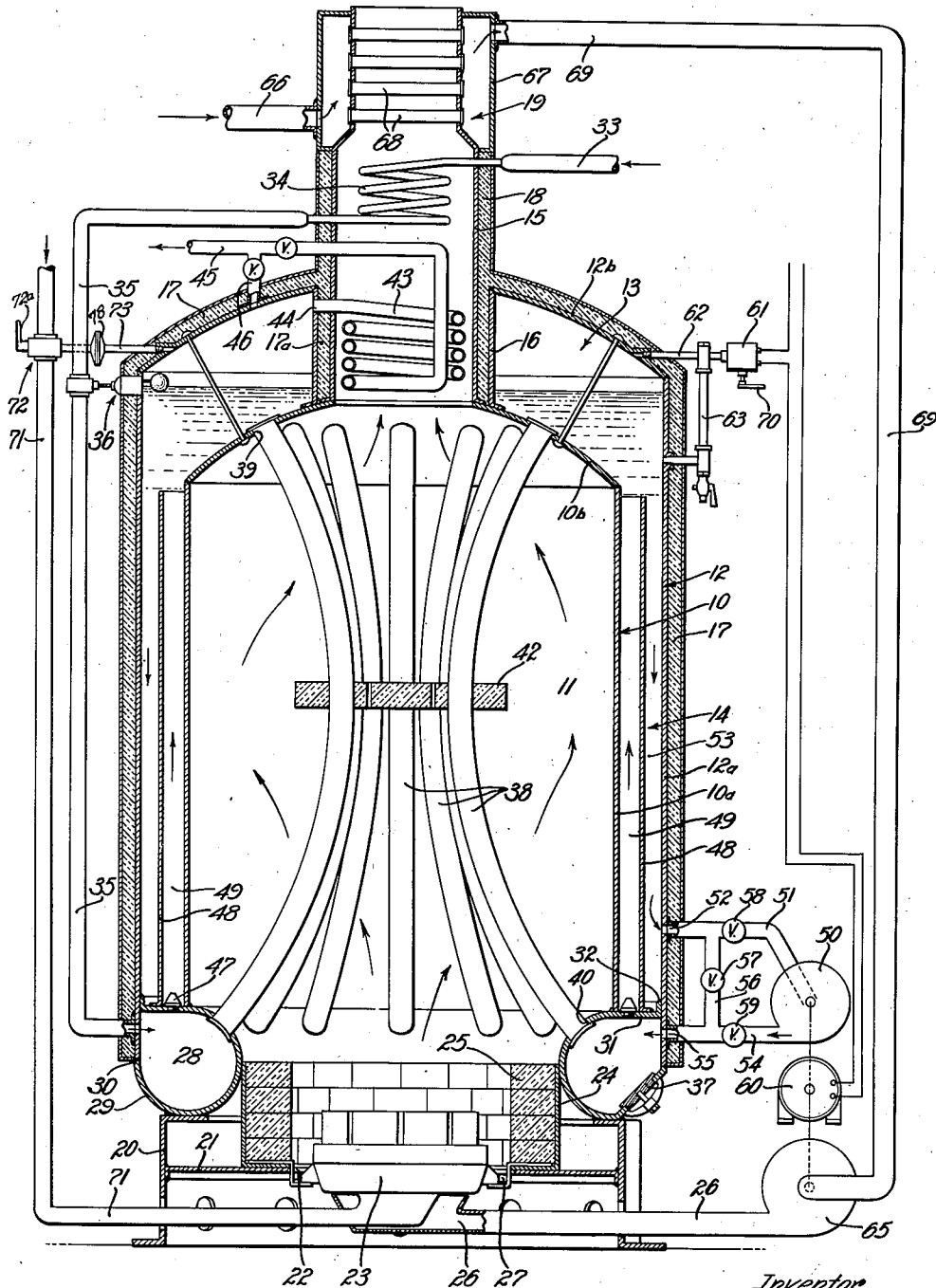
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STEAM BOILER AND PRESSURE CONTROL

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STEAM BOILER AND PRESSURE CONTROL

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This invention has to do with improvements in steam boilers, and has for its primary object to provide for such increased heating efficiency, economy and responsiveness to varying load requirements as to adapt the boiler to uses and methods of operation for which the usual boilers are unsuited by reason of their lower heating efficiencies and inability to promptly develop steam pressures in accordance with varying loads. The present application is a continuation-in-part of my copending application Ser. No. 210,896, on Steam boiler, allowed July 14, 1939, now Patent No. 2,189,443.

Ordinarily in the operation of boilers supplying steam for varying loads and at correspondingly varying pressures, the boiler steam pressure is held at some constant value sufficient to handle the maximum load. Much of the time however the boiler may be operating under considerably less load with resultant wasted energy by reason of the nonworking reduction of steam pressure from the maximum or constant pressure maintained in the boiler, down to the lower pressure required to operate the work. A familiar example where the load may vary from comparatively little, requiring low steam pressure, up to heavy loads requiring high steam pressure (the constant pressure maintained in the boiler) is in well drilling operations where the mud pumps and other equipment are steam operated and the load varies widely in accordance with the depth of drilling and the particular operations at any one time. In view of the loss of heat and pressure energy because of having to maintain, much of the time, a considerably higher boiler pressure than is required to operate the work, it is apparent that the efficiency of any plant operating in this manner might be greatly improved were it possible to maintain the boiler pressure in correspondence with the necessary working pressure, and to vary the boiler pressure as such necessary working pressure changes.

Insofar as I am aware it has not been possible heretofore, at least in the use of heavy duty boilers, to operate by the method and under the conditions last stated, due to the inability of the ordinary boilers to generate steam at sufficient rate to meet varying load requirements. Accordingly the present invention has been made with that object in view. The invention is particularly applicable to forced draft boilers, and specifically where primary air is supplied to the burner under variable pressure, by reason of the desirability for intense firing and heat genera-

tion and rapid changes in the rate of heat generation in accordance with load requirements. In the broad aspects of the invention the boiler may be of any suitable type or design provided with means for maintaining positive internal flow or circulation of water along walls or surfaces through which heat is transmitted from the burner combustion gases.

Broadly the boiler may be described structurally as comprising a burner fired heating chamber or space, walls through which heat is transferred from the heating chamber to water in the boiler, and means for mechanically producing a flow of water along said walls. Preferably I employ a power driven pump operating to maintain a rapid flow of water along heating surfaces in the boiler, and control the speed of the pump, and therefore the rate of water flow along the heating surfaces (and consequently the rate of steam generation), in accordance with the boiler steam pressure. The rates of fuel and air supply to the burner are similarly controlled so that both the rates of water circulation and air and fuel supply vary as the boiler steam pressure changes, and conversely, both may be varied to control the boiler steam pressure. By virtue of forced draft firing and the maintenance of rapid water circulation along the heating surfaces in the boiler, provision is made for highly efficient and rapid steam generation, and by rendering these factors controllable and variable by the operator it becomes possible to regulate and vary the boiler steam pressure in accordance with the load, rather than having to maintain a fixed boiler pressure that may greatly exceed the necessary working pressure, as is customarily the case.

Water circulation may be maintained within the boiler by a pressure controlled pump of the type disclosed in my Patent No. 2,189,443 and while, as previously stated, any suitable type and form of boiler construction may be used, I prefer in order to obtain maximum heat economies and heat transfer rates, to employ a boiler of a type in which the fire box is jacketed by a water and steam containing space, as for example shown in the application referred to, and also in my recent application Ser. No. 315,031, filed January 22, 1940, on Steam boiler.

A more complete explanation and understanding of the invention will be had from the detailed description to follow and throughout reference is had to the accompanying drawing illustrative of the invention in one of its typical and preferred forms.

The drawing shows a vertical type boiler comprising an inner fire box 10 containing a combustion chamber or heating space 11, surrounded by and enclosed within an outer shell 12 which is annularly spaced from the fire box to form an upper steam chamber 13 and a water leg 14 within which water is circulated, as will later appear, along the outer surface of the fire box wall. The fire box 10 comprises a cylindric shell 10a having a segmental hemispherical head 10b through which the combustion gases flow to the stack 15. The outer shell 12 similarly comprises a cylindric section 12a and a segmental hemispherical head 12b welded to a tube section 16 exposed to the steam chamber 13 and spaced from the stack 15. The boiler may be thermally insulated by a jacket 17 of suitable heat insulating material, the insulation being placed also in a space 17a between wall 16 and the stack 15 and also at 18 about the stack below the air pre-heater 19.

The boiler structure is supported on a suitable base 20 comprising an intermediate floor 21 having a central opening 22 to receive the conventionally illustrated burner 23. As will be understood, the burner may be of any suitable type, including one or an assembly of individual burner units such as are customarily used, capable of high capacity and intense heat generation. It is desirable to employ a type of burner capable of producing combustion of the gas or other fuel in a short intense heat flame to avoid flame impingement against the water tubes. The floor 21 supports an annular shell 24 within which is placed a fire brick wall 25 about the burner opening 22. Suitable provision may be made for supplying primary air to the burner, as through a conduit 26, the particular form and arrangement of which may vary in accordance with the particular type and design of the burner. Ordinarily it will be preferred to supply all the burner air through conduit 26, and normally under pressure so that the boiler operates under forced draft. If for any reason desired, secondary air may be supplied by leaving a space at 27 between the burner and the surrounding wall.

Supported on the top of the base 20 is an annular water chamber 28 formed by an annular tube 29 of curved, and for the most part circular cross section, welded at 30 to the bottom of shell 12a and having a horizontally extending top portion 31 welded to the shell at 32. The boiler feed water introduced through line 33 may be pre-heated by circulation through coil 34 in the stack 15 and then discharged through line 35 under control of the conventionally illustrated liquid level regulator 36 to chamber 28. Normally closed hand holes 37 are provided at suitable intervals in the bottom of the water chamber shell 29 to facilitate cleaning the chamber and to permit access to the lower ends of the water tubes.

The heating chamber 11 contains a series of circularly arranged water tubes 38 of segmental circular curvature, the upper and lower ends of which extend at 39 and 40 through the fire box crown sheet 10b and shell 29 to permit circulation of water from the water chamber upwardly through the tubes into the steam chamber 13 and water leg 14. A baffle 42 positioned at the longitudinal centers of tubes 38 serves to direct the upwardly flowing combustion gases in the paths indicated by the arrows, outwardly along the fire box shell 10a, thus increasing the rate of heat transfer through the fire box shell to the water flowing along its outer surface in the water leg

14. Leaving chamber 11, the gases flow upwardly into the stack in contact with a superheater coil 43 having an inlet at 44 through which the steam flows from chamber 13 to be super heated in the coil and then discharged through the outlet line 45. Where superheating is not desired, the steam may be taken directly from chamber 13 through pipe 46 to line 45.

A portion of the feed and recirculated water is discharged directly from chamber 28 upwardly through nozzles 47 into the lower portion of the water leg 14 at the inside of an annular cylindric baffle 48. The water discharged from the nozzles 47 flows upwardly along the outer surface of the fire box shell 10a in high velocity streams, by reason of the nozzle discharge velocity and the stream confinement between the fire box and baffle. The maintenance of water circulation in space 49 thus serves to effectively remove steam baffles and immobile films from the heating surface of the fire box and thereby to maintain maximum heat transfer rates from the heating chamber 11 to the surrounding water.

Positive circulation of water from chamber 28 upwardly through tubes 38, and return water circulation from the water leg 14 to chamber 28, is maintained by a suitable pump, conventionally illustrated at 50, having an inlet line 51 leading at 52 from space 53 at the outside of baffle 48, and an outlet line 54 discharging at 55 into the water chamber. A by-pass line 56 and suitable valves 57, 58 and 59 may be provided so that if desirable at any time, convection or thermo-syphonic circulation may be maintained without using the pump. As will be apparent, the pump operates to maintain positive and high velocity circulation of water from chamber 28 through the water tubes 38 and through nozzles 47 within the inner space 49 of the water leg. The pump draws water from the downflowing circulation in space 53 at the outside of the baffle, the latter thus preventing interference by the water flowing to the pump with the upwardly flowing stream at the outside of the fire box.

Pump 50 may be driven by any suitable means, as by the conventionally illustrated motor or turbine 60 which may be either electrical or steam operated and so controlled that its speed, and therefore the speed of the pump 50, varies or is variable in accordance with the changes in the boiler steam pressure or desired variations in that pressure. Typically, the motor or turbine speed may be controlled by a suitable pressure operated regulator 61, particular types of which are known and in common use, to which the boiler steam pressure is communicated through line 62 above the boiler water gauge 63. The regulator or governor 61 may control the supply of electric current through lines 64 where the mover 60 consists of an electric motor, or it may control the supply of steam through lines which may be taken as illustrated by 64, where the mover 60 consists of a steam turbine or engine.

The supply of primary air to the burner 23 is similarly controlled in accordance with variations in the boiler steam pressure, or desired variations in that pressure, by operating blower 65 in the air supply conduit 26 in essentially the same manner as the water circulation pump 50. For maximum heat efficiency in the operation of the boiler the burner air is passed from supply pipe 66 through preheater 19 wherein residual heat from the combustion gases is transferred

to the burner supply air and the gases are reduced to a low temperature. Typically the preheater 19 is shown to comprise an outer annular jacket 67 about the stack and horizontal tubes 68 extending through opposite sides of the stack. After becoming preheated in flowing through the jacket and tubes, the air flows through conduit 69 to the blower 65. The latter may be driven by motor 60 and the air supply to the burner thus controlled in accordance with the motor speed and boiler steam pressure, or the blower may be driven by an independent mover controlled in its operation similar to motor 60.

Assuming the control 61 to be set to maintain a predetermined constant boiler steam pressure, as the rate of steam withdrawal from the boiler drops the pressure, the control 61 operates to increase the speed of motor 60, and therefore of the pump 50 and the blower 65, with the result that the rate of water circulation in the boiler and the rate of heat supply from the burner are correspondingly increased. By reason of the immediate responsiveness of the control and the prompt steam generating capacity of the boiler under such increased water circulation rate and intensified firing, the normal boiler steam pressure is quickly restored. As that pressure is exceeded, the control 61 operates to slow down or even stop the motor 60, thus reducing or discontinuing water circulation in the boiler and operation of the burner, except the usual pilot light, until the steam pressure drops to normal.

The supply of fuel to the burner 23 similarly may be controlled in accordance with the boiler steam pressures so that as the steam pressure exceeds a predetermined maximum, the burner fuel feed will be reduced or discontinued, and conversely as the steam pressure falls below that predetermined maximum. As illustrative, supply of gas to the burner through line 71 is shown to be controlled by a conventionally illustrated valve 72 operated by a pressure responsive control 78, which may be of a diaphragm or other suitable type, connected to the boiler steam chamber by line 73.

As previously explained, it becomes possible by reason of the relatively quick responsiveness of the boiler to steam pressure requirements, to control the operation of the boiler so that its steam pressure may vary to correspond with the necessary pressures required for varying loads. For this purpose, the control 61 may be manually regulated, as by lever 70, so that as the pressure required to operate the work varies, the operator may regulate the control 61 to cause, as the case may be, increased or decreased rates of water circulation and heat supply by the burner. The control 61 may be of rheostat type which permits progressive changes in the motor speed, or it may be of a type adapted to cause predetermined variations in the motor speed corresponding, for example, to 10 to 25 pounds per sq. in. variations in the boiler steam pressure. The supply of fuel to the burner may be similarly controlled simultaneously and in accordance with variation by the operator of the rate of water circulation and the rate of primary air flow to the burner, by any suitable means such as, for example, a manual control 72a for operating the valve 72. Thus the flow of gas to the burner may be increased or decreased simultaneously with and in proportion to increased or decreased rate of primary air to the burner all in a manner so as to maintain the proper fuel to

air ratio for most efficient combustion and intensity of heating.

I claim:

1. In a boiler, the combination comprising a fire box, an outer wall spaced from the fire box to form a steam chamber and a water leg directly exposed to the side of the fire box wall, means forming a water chamber communicable with said water leg, water tubes connecting said water chamber with the space between said outer wall and the fire box, a pump for circulating water from the water chamber through said tubes, a burner supplying hot gases to said fire box, a blower for discharging air to the burner, and means for varying the pump and blower speeds in accordance with variations in the boiler steam pressure.

2. In a boiler, the combination comprising a fire box, an outer wall spaced from the fire box, to form a steam chamber and a water leg directly exposed to the side of the fire box wall, means forming a water chamber communicable with said water leg, water tubes connecting said water chamber with the space between said outer wall and the fire box, a pump for circulating water from the water chamber through said tubes and through an independent passage into said water leg, a burner supplying hot gases to said fire box, a blower for discharging air to the burner, and means for varying the pump and blower speeds in accordance with variations in the boiler steam pressure.

3. In a boiler, the combination comprising a wall forming a vertically extending fire box, an outer wall spaced from said fire box to form a steam chamber thereabove and an annular water leg surrounding and directly exposed to the sides of the fire box wall, a water chamber at the bottom of said water leg, water tubes extending from said water chamber upwardly within the fire box through its top wall, a pump operating to discharge water from the water chamber through said tubes, a burner for supplying hot combustion gases to the fire box, a blower for discharging air to the burner, and means for varying the pump and blower speeds in accordance with variations in the boiler steam pressure.

4. In a boiler, the combination comprising a wall forming a vertically extending fire box, an outer wall spaced from said fire box to form a steam chamber thereabove and an annular water leg surrounding and directly exposed to the sides of the fire box wall, a water chamber at the bottom of said water leg, water tubes extending from said water chamber upwardly within the fire box through its top wall, a pump operating to discharge water from the water chamber through said tubes, a burner for supplying hot combustion gases to the fire box, means for preheating air by combustion gases discharged from said fire box, a blower for discharging the preheated air to the burner, and means for varying the pump and blower speeds in accordance with variations in the boiler steam pressure.

5. In a boiler, the combination comprising a fire box, an outer wall spaced from the fire box, an outer wall spaced from the fire box to form a steam chamber and a water leg directly exposed to the side of the fire box wall, means forming a water chamber communicable with said water leg, water tubes connecting said water chamber with the space between said outer wall and the fire box, a pump for circulating water from the water chamber through said tubes, a

burner supplying hot gases to said fire box, a blower for discharging air to the burner, and means for varying the pump and blower speeds in accordance with variations in the boiler steam pressure, and means for supplying fuel to the burner at a rate varying with changes in the boiler steam pressure.

6. In a boiler, the combination comprising a wall forming a vertically extending fire box, an outer wall spaced from said fire box to form a steam chamber thereabove and an annular water leg surrounding and directly exposed to the sides of the fire box wall, a water chamber at the bottom of said water leg, water tubes extending from said water chamber upwardly within the fire box through its top wall, a pump operating to discharge water from the water chamber through said tubes, a burner for supplying hot combustion gases to the fire box, a blower for discharging air to the burner, means for varying the pump and blower speeds in accordance with variations in the boiler steam pressure, and means controlled by the boiler steam pressure for supplying fuel to the burner.

7. In a boiler having an outer shell and a steam outlet, the combination comprising a burner for supplying hot gases to a heating chamber within the boiler, means for supplying fuel and air to the burner, walls through which heat is transferred from said heating chamber to a water chamber inside said boiler shell and substantially surrounding the heating chamber, water tubes within said heating chamber and communicating with said water chamber so that water can circulate through said tubes and water chamber, means for mechanically producing high velocity water circulation through said tubes and water chamber and along said walls, and means for varying the rate of said water circulation and the rate of fuel and air supply to the burner in accordance with variations in the boiler steam pressure.

8. In a steam boiler having an outer shell and a steam outlet, the combination comprising a burner for supplying hot gases to a heating chamber within the boiler, means for preheating air by combustion gases from said space and for supplying the preheated air to the burner, walls through which heat is transferred from said heating chamber to a water chamber inside said boiler shell and substantially surrounding the heating chamber, water tubes within said heating chamber and communicating with said water chamber so that water can circulate through said tubes and water chamber, means for mechanically producing high velocity water circulation through said tubes and water chamber and along said walls, and means for varying the rate of

said water circulation and the rate of air supply to the burner in accordance with variations in the boiler steam pressure.

9. In a boiler having an outer shell containing a steam space, the combination comprising a burner for supplying hot gases to a heating chamber within the boiler, a blower for discharging air to the burner, walls through which heat is transferred from said heating chamber to a water chamber inside said boiler shell directly below said steam space and substantially surrounding the heating chamber, water tubes within said heating chamber and communicating with said water chamber so that water can circulate through said tubes and water chamber, a pump for producing high velocity water circulation through said tubes and water chamber and along said walls, and means for varying the speeds of said blower and pump in accordance with variations in the boiler steam pressure.

10. In a boiler having an outer shell and a steam outlet, the combination comprising a burner for supplying hot gases to a heating chamber within the boiler, walls through which heat is transferred from said heating chamber to a water chamber inside said boiler shell and substantially surrounding the heating chamber, water tubes within said heating chamber and communicating with said water chamber so that water can circulate through said tubes and water chamber, means for mechanically producing high velocity water circulation through said tubes and water chamber and along said walls, means for varying the rate of said water circulation in accordance with variations in the boiler steam pressure, and means for manually controlling and varying the boiler steam pressure.

11. In a boiler having an outer shell containing a steam space, the combination comprising a burner for supplying hot gases to a heating chamber within the boiler, means for supplying fuel and air to the burner, walls through which heat is transferred from said heating chamber to a water chamber inside said boiler shell directly below said steam space and substantially surrounding the heating chamber, water tubes within said heating chamber and communicating with said water chamber so that water can circulate through said tubes and water chamber, means for mechanically producing high velocity water circulation through said tubes and water chamber and along said walls, means for varying the rate of said water circulation and the rates of fuel and air supply to the burner in accordance with variations in the boiler steam pressure, and means for manually controlling and varying the boiler steam pressure.

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