J. J. DUFFY.

BOILER.

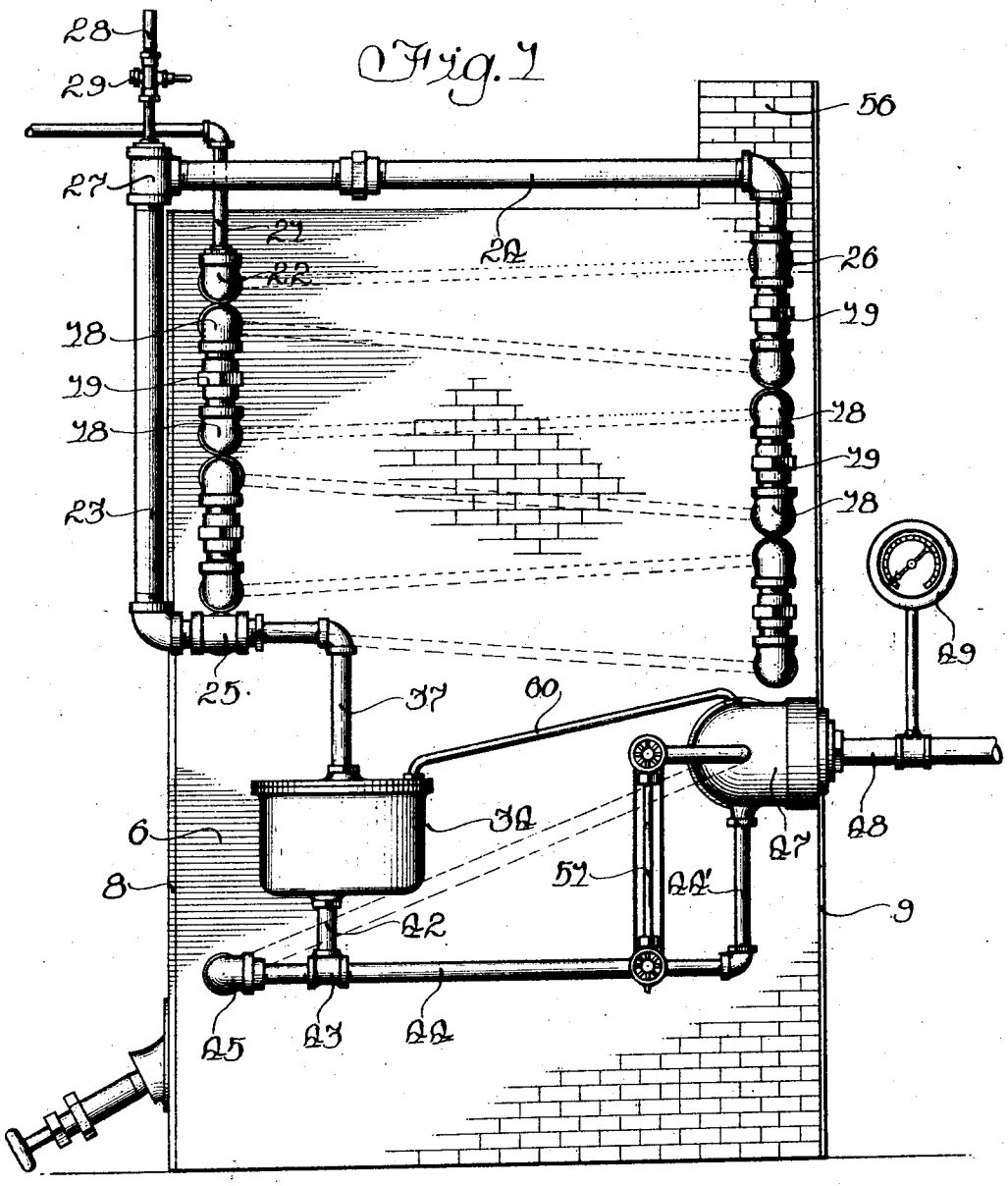
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1,411,327.

Patented Apr. 4, 1922.

3 SHEETS—SHEET 1.

Fig. 1




Inventor

Joseph J. Duffy

By Brown, Boettcher & Penner

Attorneys

J. J. DUFFY.

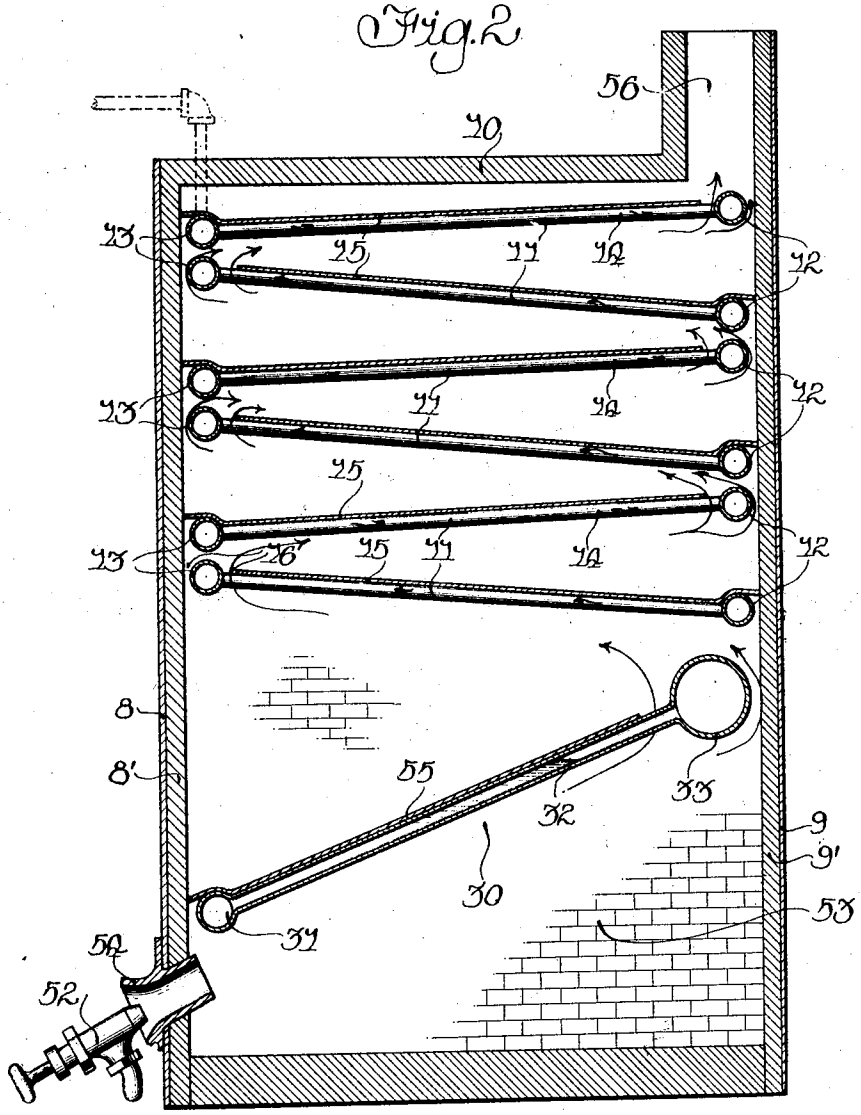
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3 SHEETS—SHEET 2.

Fig. 2




Inventor
Joseph J. Duffy
By Brown, Boettcher & Kenner
Attorneys

J. J. DUFFY.

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3 SHEETS—SHEET 3.

Fig. 5

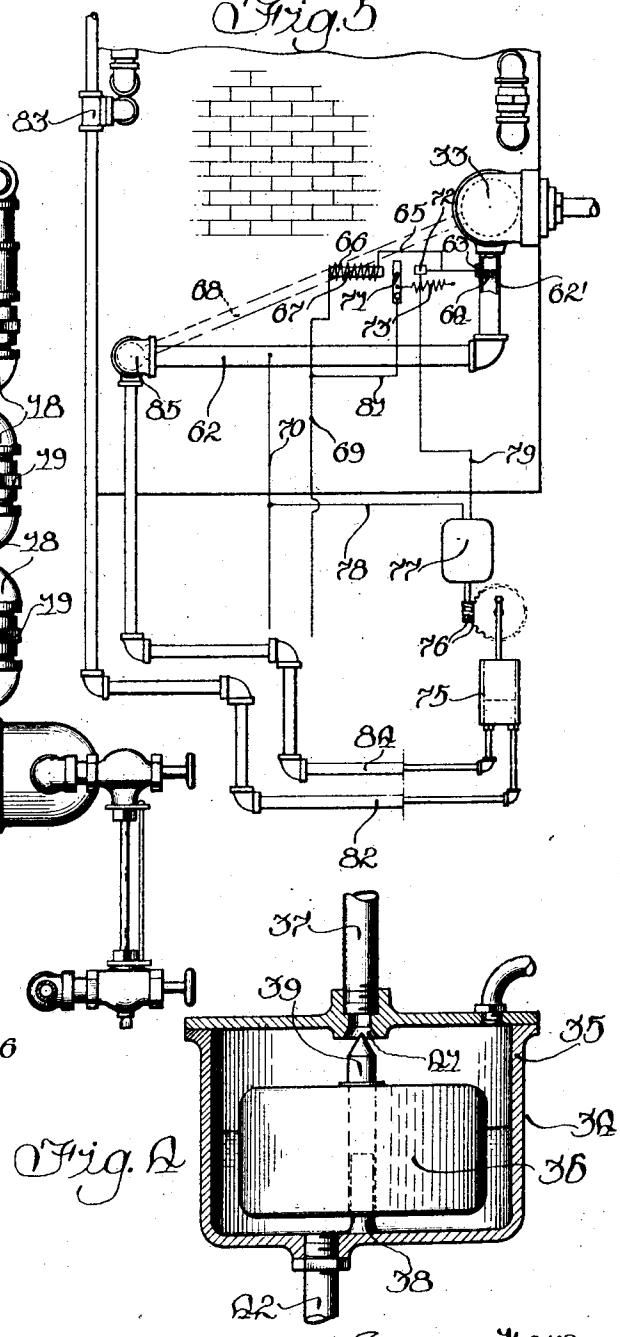



Fig. 3

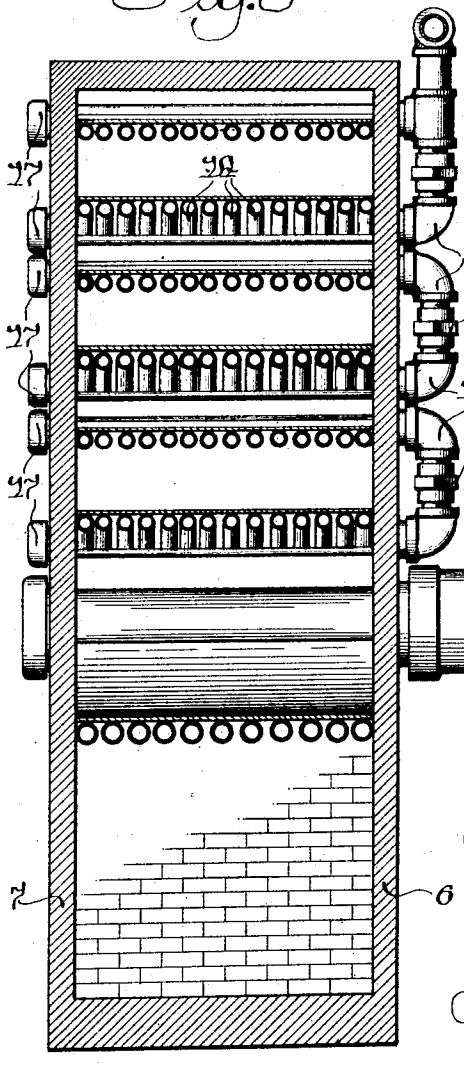



Fig. 4

Inventor

Joseph J. Duffy

By Brown, Boettcher & Kiesner

Attorneys

# UNITED STATES PATENT OFFICE.

JOSEPH J. DUFFY, OF CHICAGO, ILLINOIS.

## BOILER.

1,411,327. Specification of Letters Patent. Patented Apr. 4, 1922.

Application filed April 30, 1920. Serial No. 377,914.

*To all whom it may concern:*

Be it known that I, JOSEPH J. DUFFY, a citizen of the United States, residing at Chicago, in the county of Cook and State of Illinois, have invented a certain new and useful Improvement in Boilers, of which the following is a full, clear, concise, and exact description, reference being had to the accompanying drawings, forming a part of this specification.

My invention relates to boilers, and is directed to improve principles of boiler construction which I contemplate embodying in low pressure boilers for heating purposes; in high pressure boilers for power or other purposes; or in boilers generally. The fundamental purpose of these improved principles of boiler construction is to increase the economy and efficiency of boilers.

One of the particular objects of the invention, by which I aim to attain the above general object, is to create a circulation of the water which, in its general direction of flow is progressively counter to the flow of the gases, although concurrent with the flow of the gases in each of the several heating sections. More specifically stated, this general direction of flow of the water is progressively downward, counter to the ascending flow of the gases, and is at the same time concurrent with the upward flow of the gases in each of the heating sections. These relative directions of flow of the water and the heating gases are attained in the present construction by utilizing the buoyancy of the heated water in each of the heating sections to impel the water downwardly through the boiler. The particular benefit of this arrangement is well recognized by those skilled in the art, and resides in having the inlet water first pre-heated by the colder gases adjacent the exhaust flue, and then having the water progressively heated by circulating the same progressively counter to the flow of the gases and toward the point of highest temperature until a maximum temperature is reached in the fire gases adjacent the fire box. It will be apparent that the present construction and arrangement of the circulating tubes by which this improved circulation is obtained also has application to hot water heaters as well as boilers.

Another object of the invention is to provide a construction of boiler, the interior of which is divided into two separate and distinct areas, namely, (1) a circulating zone where the water is first pre-heated and brought up to a temperature approaching that of the boiling point; and (2) a steam separating zone wherein the water is brought to a steaming temperature and steam generation is effected. The heated water in the circulating zone is transferred into the steam separating zone intermittently or continuously at a predetermined rate, this transfer being preferably from the hottest point in the circulating zone so that full benefit will be had from the pre-heated condition of the water therein. This transfer of the heated water between the two zones is preferably controlled by the water level in the separating zone, so that a substantially level and uniform steam freeing surface is always maintained in the separating zone. I contemplate, under conditions which might render the same necessary as in certain heating systems or power systems, to establish a steam vent connection between the circulating zone and the separating zone to vent any small amount of steam which may be generated in the circulating zone, and tending to trap therein, over into the separating zone.

Another object of the invention is to provide a sectional construction of boiler which can be manufactered at small expense, and which may be erected with facility and will permit of convenient removal and substitution of sections.

In the accompanying drawings illustrating a preferred embodiment of my invention:

Figure 1 is a front elevational view of my improved boiler;

Figure 2 is a vertical sectional view through the same;

Figure 3 is a transverse sectional view through the boiler;

Figure 4 is a detail sectional view of the float mechanism; and

Figure 5 is a diagrammatic illustration of the transfer pump and control mechanism therefor for high pressure boilers.

The construction of boiler illustrated in Figure 1 is designed for low pressure heating purposes. such as for vapor steam systems and other steam heating systems. The boiler may be enclosed in any suitable manner, the arrangement illustrated consisting

of a brick setting having front and rear brick walls 6 and 7 and removable side plates 8 and 9 for affording access to the interior of the boiler. The boiler enclosure is covered off by a top 10 of brick or heat insulating material. The removable side plates 8 and 9 are provided with a slab or facing of insulating material 8′ and 9′.

Referring to Figure 2, the circulating zone of the boiler comprises a plurality of heating sections 11—11; the uppermost section being inclined upwardly from left to right and the succeeding lower sections being alternately inclined in reverse directions in zig-zag relation. Each of these heating sections 11 comprises right and left hand headers 12 and 13, which extend transversely through the flue area of the boiler, and which are provided with a multiplicity of small circulating tubes 14 extending across the flue area. These tubes are arranged in spaced relation from front to rear of the boiler, being welded to the headers 12 and 13. Above each series of tubes 14 and preferably resting thereon, is a baffle 15, constructed of heat insulating material, which is preferably arranged to induce an upward circulation of the gases along the tubes of each section. To this end the lower edge of each baffle is extended up and over the top of the lowermost header of its respective section so as to intersect the end wall of the boiler casing and prevent upward passage of the flue gases around the lowermost header, and the upper edge of each baffle adjacent the upper header of its section is cut off short of the header so as to provide flue areas around the outside of the header and between the circulating tubes 14 on the inside of the header, as indicated at 16—16. The headers are spaced sufficiently from the side walls to permit free circulation of the flue gases around and about the headers.

The several sections 11 are supported in the boiler by extending the ends of the headers out through the front and rear walls 6 and 7, which comprise the brick walls of the setting. At their rear ends (Figure 3) the headers are closed off by threaded caps 17, which thread over the outer ends of the headers. At their front ends the headers have circulating connection through elbows 18 and coupling unions 19, which may be readily coupled and uncoupled to permit of the disconnection or substitution of a section. It should be particularly noted that these end circulating connections 19 are arranged to connect the uppermost and lowermost headers of each adjacent pair of sections, e. g.—the first and second sections 11, beginning from the top, have their upper and lower headers 12—12 connected together, the second and third sections have their upper and lower headers 13—13 connected together, the third and fourth sections have their upper and lower headers 12 connected together, and so on—from which it will be observed that the several sections are all serially connected together for a progressively downward circulation of the water. The inlet to the boiler is through pipe 21 which has connection through elbow 22 with the lower header 13 of the top section 11. The six independent heating sections 11 constitute the circulating zone through which the water is first circulated before being admitted to the steam generating and separating portion of the boiler (to be hereinafter described). The closed circuit through this circulating zone is completed by a return connection consisting of pipes 23 and 24, which connect the upper header 13 of the bottom section with the upper header 12 of the top section. These return pipes are preferably situated outside of the boiler enclosure, and have connection with the headers 13 and 12 of the bottom and top sections respectively through the connections 25 and 26. The pipes 23 and 24 are connected by a T connection 27, this T connection being the highest point in the circuit and being provided with a vent 28 and vent valve 29 for venting air out of the system. The T connection 26, it will be noted, has communication through the end circulating connection 19 with the header 12 of the second section 11, so that the return circulation in reality is into the bottom header 12 of the second section.

Directly below the sections 11—constituting the circulating zone—is a relatively large section 30 which constitutes a steam generating and separating zone adapted to receive the heated water from the circulating zone for effecting the vaporization thereof. The section just mentioned continues in the reversely inclined relation of the superposed sections 11, only at a steeper pitch; and in structure comprises a lower header 31, a plurality of tubes 32, and an upper header 33 of relatively large dimension which functions as a steam space for receiving the steam from the tubes 32. The headers 31 and 33 are extended through the front and rear walls of the boiler and similarly to the headers 12 and 13. A steam freeing level is maintained in the series of pipes 32 at substantially the point indicated, the upper ends of the tubes above this level and the header 33 constituting the steam collecting chamber. This steaming level is maintained by intermittently admitting heated water from the circulating zone into the steaming section 30 when the level recedes therein, this being accomplished through the instrumentality of a float mechanism 34 which connects the T 25 of the circulating system with the lower header 31 of the steaming section. This float mechanism is illustrated in detail in Figure 4, and comprises a float chamber 35 in which is disposed a relatively

large float 36. The inlet to this float chamber is through a pipe 37 which connects into the end of the T connection 25. The pipe 37 preferably connects with the circulating system at the T 25, inasmuch as the circulating water is at its highest temperature when it emerges from the lowest circulating section 11 at this point, although the pipe 37 might instead be connected with any other point of the circulating system. The float 36 is guided on a stem 38, and carries a valve 39 which is adapted to control the inlet port 41, communicating with the inlet pipe 37. The outlet from the float chamber 35 is by way of pipe 42, which extends down from the bottom of the float chamber and has connection with a T connection 43. The T 43 is interposed in a pipe 44, which has connection at one end through an elbow 45 with the end of the lower head 31 of the steaming section, and at the other end has connection through a pipe 44′ with the bottom of the projecting steam header 33. The projecting end of this steam header 33 has connection through an elbow 47 or other suitable fitting, with a steam discharge pipe 48. A gauge 49 indicates the effective pressure in the steam discharge pipe 48. The water level in the steaming section 30 is indicated in a gauge glass 51, which has connection at one end with the elbow 47 and at the other end has connection in the return pipe 44. This pipe 44 functions primarily as a return pipe for returning the condensation and any slight amount of water discharged into the steam header 33 during rapid steaming, this condensate and discharge water settling down through the pipes 44′ and 44 and returning to the lower header 31.

The boiler may be heated in any preferred manner—an oil or gas burner 52 being illustrated as discharging into the lower combustion area 53 through an air induction tube 54. The steam generating section 30 is disposed in the combustion area 53 with a view to having it utilize a large proportion of the effective heat units. The section 30 is provided with an upper baffle 55 for deflecting the gases of combustion up along the tubes 32 and around the steam header 33. At its lower end the baffle 55 is extended over the top of the header 31 to intersect with the side wall 8 and close off this end against passage of the gases, and at its upper end the baffle is cut short of the header 33 so as to permit the gases to completely envelop the steam header, both on the outside between the header and the side wall and on the inside between the tubes 32. After circulating through the devious passes between the several sections 11 of the circulating zone the gases are exhausted through a stack 56 leading from the top of the boiler setting.

Lagging or other suitable heat insulating material may be applied to the circulating connections 19 which connect the ends of the headers of the circulating sections, and to the return pipes 23 and 24 of the circulating system as well as to the return pipes 44 and 44′ of the steam generating section; or, as an alternative construction, these pipes may be enclosed within the boiler enclosure or may be set into the wall thereof, where they will be immune to heat radiation. In this regard, I also contemplate a unit block construction built up of superposed, integral, block-shaped castings which constitute in unit form, the four walls of the boiler enclosure, the upper and lower headers, and the inclined tubes or heating passages; these block-shaped castings being so constructed that the boiler can be assembled by merely erecting the castings one upon the other, without necessitating end connections 19 and the like.

The operation of the boiler is as follows:

We shall assume that the boiler is employed in a vapor heating system, or in a one-pipe steam heating system. The feed water enters the inlet pipe 21 under the gravity head from the vapor tank (in the case of a vapor system), or under the city water pressure (in the case of a one-pipe steam system), and maintains a certain pressure in the circulating zone of the boiler at all times. The steam generating zone fills with water until a predetermined level, as indicated, is reached, whereupon the float 36 rises and shuts off further admission from the circulating zone. The float 36 is designed with sufficient capacity to function against a considerable water pressure in the circulating zone. From the circulation of the gases, which are as indicated by the large direction arrows, it will be observed that the lowermost section 11 will be the first section of the circulating zone to be subjected to the heat arising from the combustion chamber 53, this heat being most intense at the lower end of the section and rising along the section to the flue openings 16 which envelop the upper header 13. As a result, an upward circulation of the water will be induced in the tubes 14, concurrent in direction with the flow of the gases as indicated by the small direction arrows. As a result of this upward circulation created in the tubes of the lower section, there will be induced a downward circulation of the colder water in the end circulating connection 19, which leads to the lower header 12. The gases in rising through the flue openings 16 of the lower section pass along the under side of the next succeeding section and induce a corresponding upward circulation of the water in this section—in augmentation of the circulation created in the lower section and in the end connection 19 connecting the two sections. This action of inducing an upward circula-

tion in the inclined circulating sections is repeated throughout the entire series of sections, the buoyancy and the circulating pressure of the heated water decreasing with each succeeding section owing to the decreased heat absorption of each higher section. The heated water rising in each of the several sections compels a downward circulation through each of the end connections 19 to the next lower section, owing to the fact that the section per se is primarily the heat absorbing area as compared to the end connection, which receives little or no heat, and also owing to the fact that the preponderating circulation in the lower section is in a direction away from the end connection and thereby induces a downward circulation in this end connection to take the place of the more buoyant water circulating upward from the lower end of the lower section. Hence it will be seen that a progressively downward circulation will be created by this upward flow of the water in each of the circulating sections, the heated water discharging from the lower end of the circulating zone through the T connection 25 and rising through the return pipes 23 and 24 to the upper end of the circulating zone, where it enters the header 12 of the second section 11.

As steam is formed in the steam generating zone of the boiler the water level in the tubes 32 recedes until the lowering of the float 36 unseats the valve 39, whereupon the heated water from the circulating zone enters the tubes 32 and restores the level to its predetermined height. Thus, only a definite, predetermined quantity of water is exposed to the fire for steam generation at any one time. When a more rapid rate of steaming is required, the heated water is merely admitted to the steam generating zone at a faster rate, under the automatic control of the float valve. In ordinary heating boilers the effective pressure in the circulating zone will always be higher than in the steam generating zone so that the water will enter the section 30 immediately upon unseating of the valve 39. It will be noted that the water in the steam generating zone is quiescent and that there are no pressures acting in rear of the water column in the steaming section 30 which might tend to discharge water with the steam; consequently there is an entire absence of priming effect or water vapor in the steam discharged. To prevent any possibility of the steam pressures in the steam generating zone from retarding or influencing the rise and fall of the water level in the float chamber 35, I contemplate connecting the top of the steam header 33 with the top of the float chamber 35 through a pressure equalizing pipe 60, which will insure uniformity of pressures acting upon each end of the water column in the steam generating section so that the rise and fall of the water level in the float chamber will be immediately responsive to the rise and fall of the water level in the tubes 32. As water is withdrawn from the circulating zone to supply the steam generating zone, feed water is drawn into the boiler through the inlet pipe 21 and uppermost heating section 11. There is normally practically no circulation in the upper section 11 and consequently the feed water therein is pre-heated in this section between periods of influx of feed water into the boiler, so that each quantity of feed water will enter the circulating zone in a pre-heated condition.

For high pressure installations, such as in power plants and the like, it is necessary to employ a forced injection arrangement for forcibly injecting feed water into the circulating zone, or for forcibly injecting the heated water from the circulating zone into the steam generating zone. I preferably employ the latter method, and as illustrated in Figure 5, control the operation of the injector mechanism through electrical apparatus which is responsive to the fall of the water level in the steam generating section. In this embodiment, the lower header of the steam generating section has connection at its end with a water return pipe 62, which comprises an upright section 62′ threading into the bottom of the steam header 33. Extending through the side wall of the pipe section 62′ at substantially the predetermined water level is an insulating bushing 63 which supports an electrical contact 64 within the pipe 62′ and in position for contact with the water level therein. This electrical contact has connection through a wire 65 with the winding 66 of a relay 67. The other end of the winding 66 has connection with one wire 69 of a source of current, such as a standard lighting circuit, the other wire 70 of which has connection with the pipe 62 or other grounded part of the boiler structure. The relay 67 is normally energized by reason of the water level in the pipe 62′ being normally in contact with the electrode 64, and in this energized condition the relay maintains its armature 71 out of engagement with a back contact 72, against the tension of the spring 73. The armature 71 and contact 72 control a circuit, which in turn controls the operation of the injector mechanism. This injector mechanism may consist of an electrically actuated steam injector, or a power driven force pump, preferably the latter, however, as indicated at 75. The pump 75 is an ordinary force feed reciprocating pump which is driven through suitable reduction gearing 76 from an electric motor 77. One terminal of the motor 77 has connection through wire 78 with the wire 70 of the lighting circuit, the other terminal of the motor having connection

through wire 79 with the back contact 72 of the relay 67. The armature 71 has connection through wire 81 with the other wire 69 of the lighting circuit. Thus, current is only supplied to the motor 77 when the armature 71 is drawn back into engagement with the back contact 72 upon de-energization of the relay 67. The inlet port of the injector pump 75 has connection through a pipe 82 with the circulating system of the boiler, the pipe 82 tapping into the circulating system at its lowest point through a T connection 83. The discharge port of the pump 75 has connection through the pipe 84 with the connection 85 on the end of the lower header of the steam generating section. It will be obvious that when the water level in the steam generating zone falls below its predetermined height the relay 67 will be de-energized by interruption of the circuit through the contact 64 and the winding 66, and that the electric motor 77 will be energized by the completion of the circuit thereof through the armature 71 and back contact 72; whereupon the operation of the injector pump 75 will withdraw heated water from the circulating zone and inject it into the steam generating zone until the predetermined level is restored and the relay 67 re-energized. It will be understood that this electrical control of the transfer of water between the circulating zone and the steam generating zone also has application to the low pressure form of heating boiler previously described. As exemplifying such adaptation I contemplate interposing an ordinary valve in the transfer pipe 37 in lieu of the float mechanism 34, and actuating this valve electrically by a solenoid or electro-magnet under the control of a relay 67 or under the direct electrical control of the contact 64.

It will be apparent that various modifications and rearrangement of parts may be made by those skilled in the art, but I intend these modifications and re-arrangements shall come within the spirit and scope of the appended claims.

I claim:

1. In heating means, the combination of end headers and successive banks of superposed circulating tubes extending between said headers, said headers defining separate manifold conduits connecting with the ends of said banks of tubes, said banks of tubes being alternately inclined in reverse directions, the high manifold conduit of each bank of tubes being connected to the low manifold conduit of a lower bank of tubes, whereby the circulation is upward in each bank of tubes and progressively downward from top to bottom of the series of tubes, means connecting the several banks of tubes in a closed circuit whereby a continuously recurring circulation is created through the banks of tubes, and baffle means forming a zig-zag heating flue winding between the banks of tubes.

2. In water heating means, the combination of a series of superposed water conduits alternately inclined in zig-zag relation, baffles forming a zig-zag flue conduit between said water conduits, and circulating connections connecting the upper end of each water conduit with the lower end of the succeeding lower conduit for producing an upward circulation in each of said water conduits, and a progressively downward circulation throughout the entire series of water conduits.

3. In combination, a plurality of superposed heating sections, each of said sections comprising horizontal end headers and a row of circulating tubes extending between said headers, the tubes and headers of each section being formed as an integral unit, the successive rows of tubes being inclined in zig-zag relation, means connecting the header at the upper end of each bank of tubes with the header at the lower end of the next lower bank of tubes, and baffles defining a zig-zag heating flue between said banks of tubes.

In witness whereof I hereunto subscribe my name this 22nd day of April, A. D. 1920.

JOSEPH J. DUFFY.