W. H. WINSLOW.

BOILER.

APPLICATION FILED OCT. 23, 1911.

1,237,233.

Patented Aug. 14, 1917.

4 SHEETS—SHEET 1.

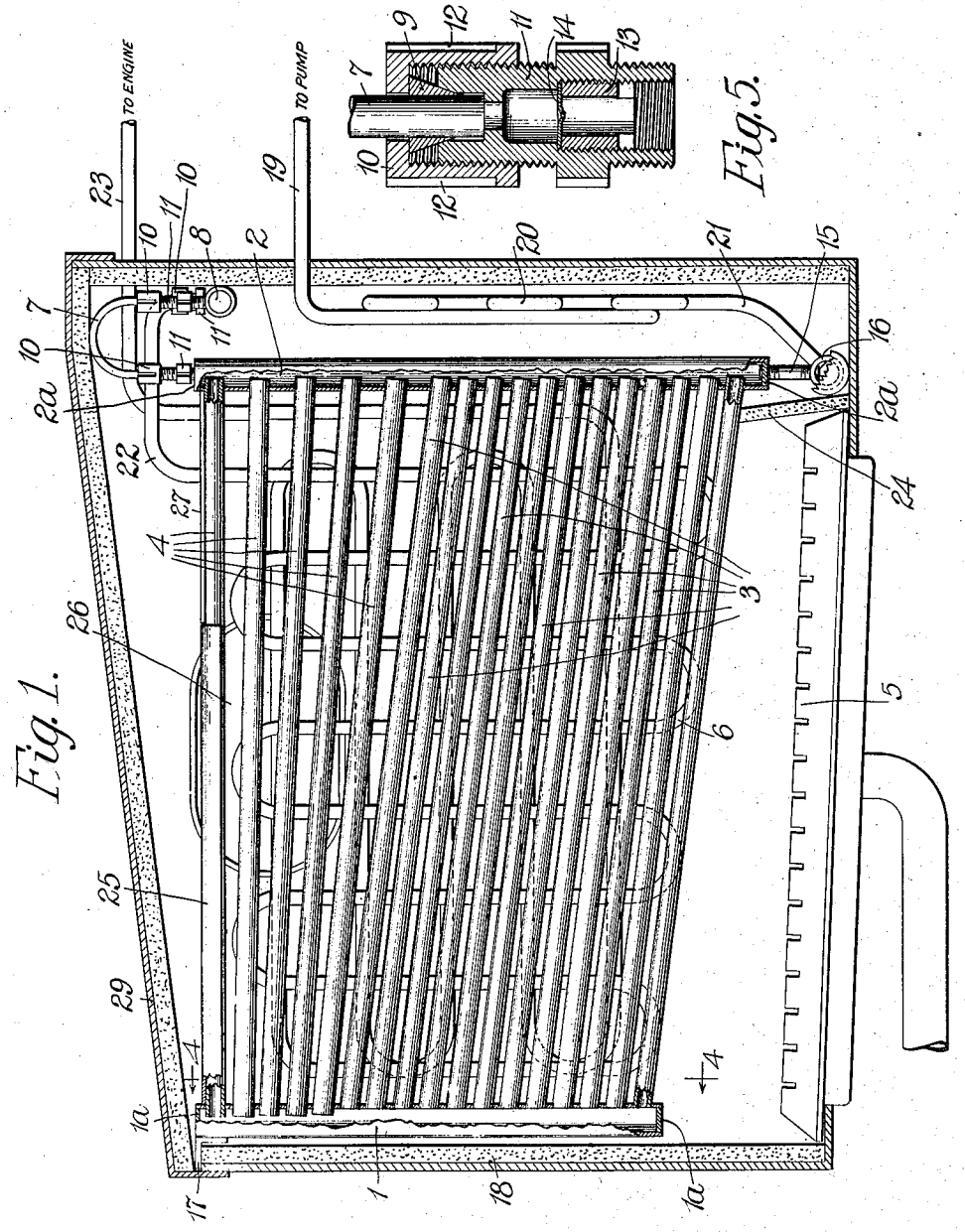

Fig. 1.

Fig. 5.

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4 SHEETS—SHEET 2.

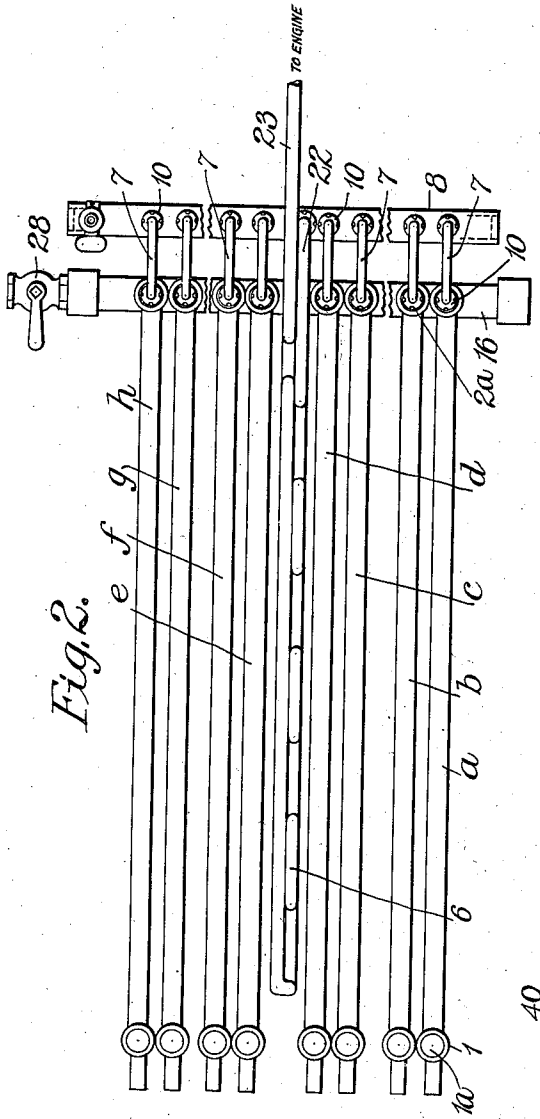

Fig. 2.

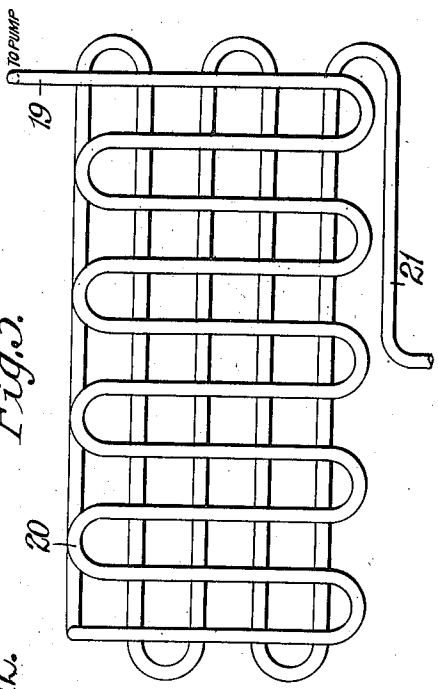

Fig. 3.

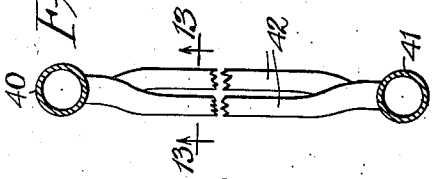

Fig. 12.

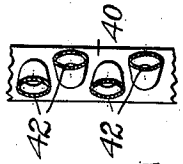

Fig. 13.

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4 SHEETS—SHEET 3.

Fig. 4.

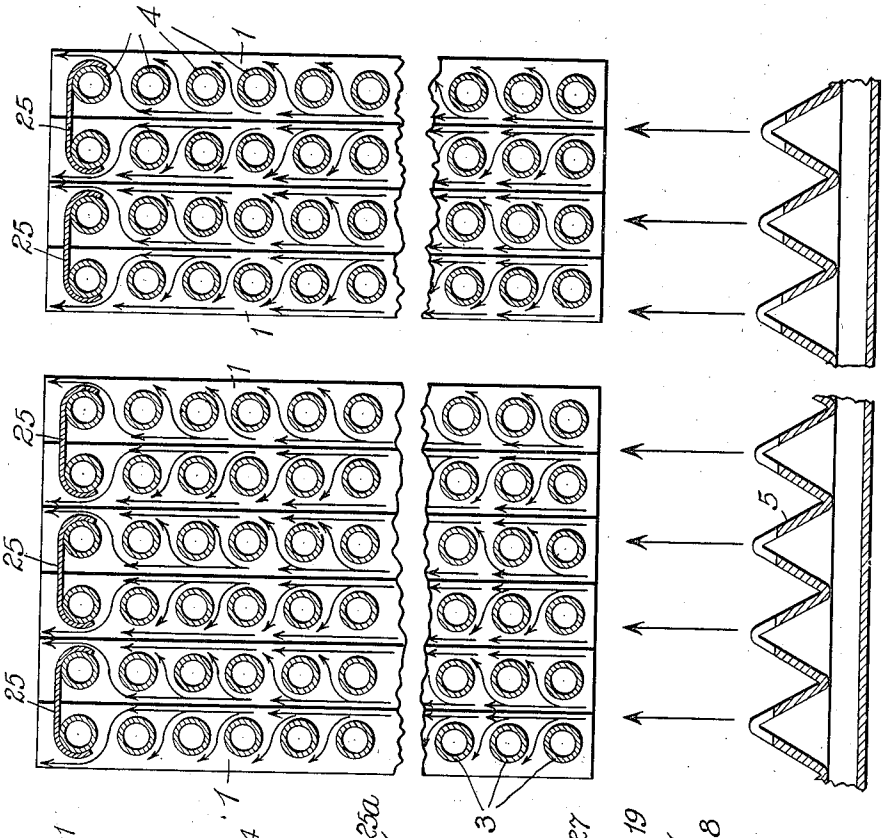
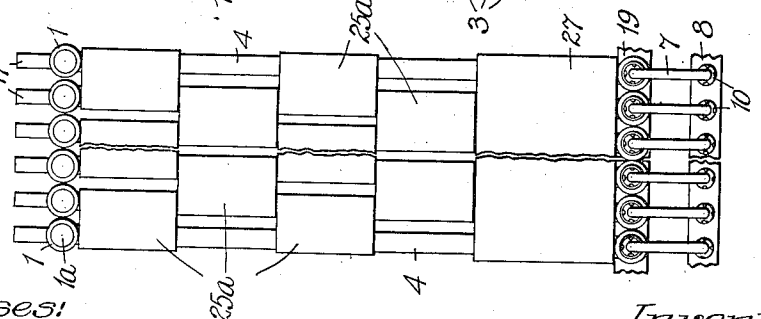


Fig. 6.



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4 SHEETS—SHEET 4.

Fig. 7

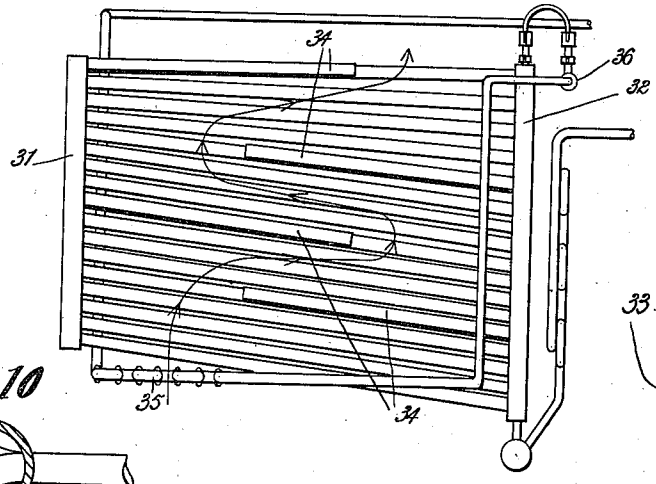


Fig. 10

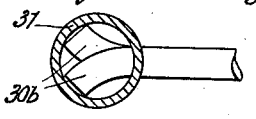


Fig. 9

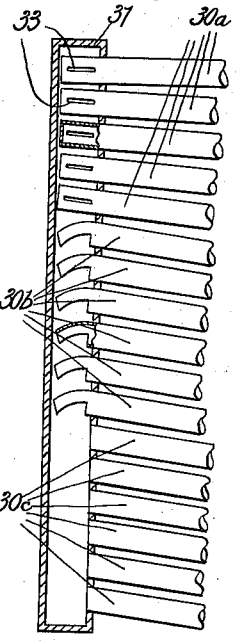


Fig. 8

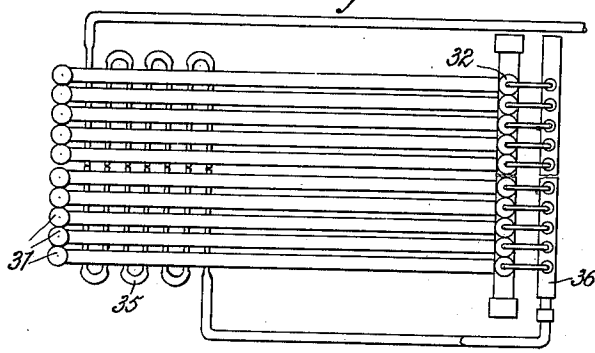
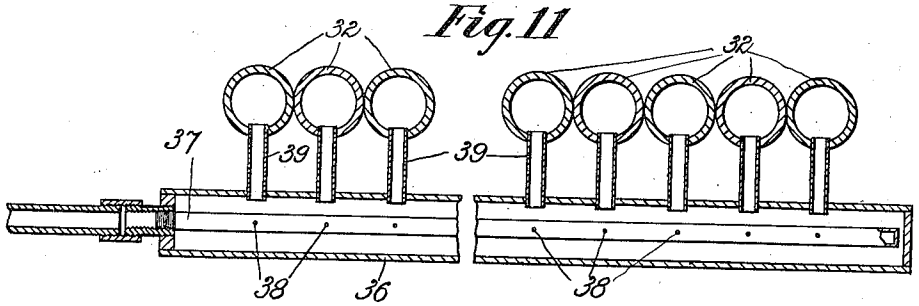


Fig. 11



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UNITED STATES PATENT OFFICE.

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BOILER.

1,237,233. Specification of Letters Patent. Patented Aug. 14, 1917.

Application filed October 23, 1911. Serial No. 656,179.

To all whom it may concern:

Be it known that I, WILLIAM H. WINSLOW, 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 an improved form of boiler for high pressure, characterized by extreme simplicity of construction and rapid steaming capacity. Furthermore, the boiler, while of the water circulating type is so constructed as to deliver dry and superheated steam without danger of priming.

The several drawings illustrating my invention are as follows:

Figure 1 is a side view of the boiler complete, the casing of the boiler being sectioned to disclose the inner construction.

Fig. 2 is a top view of the heating units shown in Fig. 1, the casing being removed in this figure.

Fig. 3 is an elevation view of the coil employed to heat the feed water as it is supplied to the boiler.

Fig. 4 is a vertical sectional view of the boiler units and burner shown in Fig. 1, the casing being removed in this figure.

Fig. 5 is a detail view of a union connector employed.

Fig. 6 shows a modified arrangement of baffle plates for distributing the fire through the boiler tubes.

Fig. 7 is a side view of a modified construction of boiler.

Fig. 8 is a top view of the mechanism shown in Fig. 7.

Fig. 9 is an enlarged sectional view of one of the left-hand vertical headers shown in Figs. 7 and 8.

Fig. 10 is a horizontal sectional view of the header shown in Fig. 9.

Fig. 11 is an enlarged detail sectional view of the steam header shown in Figs. 7 and 8.

Fig. 12 shows in top view a portion of one of the heating units in which a modified form of water tube is employed.

Fig. 13 is a sectional view of the parts shown in Fig. 12, taken along the line 13—13.

As shown in Fig. 1, each of the boiler units consists of two vertical tubes or headers 1 and 2, the ends of which are closed by plugs 1^a and 2^a, fused in place by the use of the oxy-acetylene flame. The upper ends of the tubes or headers 1 and 2 are substantially in line and the tube 1 is considerably shorter than the tube 2. A plurality of pipes 3 extend between the headers 1 and 2 in substantially parallel arrangement, the inclination of these pipes being such as to cause circulation through them when the water in them is heated. This circulation takes place in a manner well-known in connection with water tube boilers. In my boiler the normal water level is at about the middle of the header 2. Above the pipes 3, additional pipes 4 are disposed, which have successively less inclination as the top of the section of the boiler is approached until the upper one of such pipes is reached, which is disposed in substantially horizontal position. The pipes 3 and 4 are secured at their ends to the headers 1 and 2 by fusion by means of the oxy-acetylene flame, as a result of which the headers and pipes constitute an integral homogeneous structure incapable of being damaged by any degree of heat less than that required to soften or melt the pipes or headers themselves. As a result of the construction described, the fire produced by the burner 5 beneath the pipes 3 and 4 causes an extremely rapid circulation of the water through the pipes 3 in a manner well-known in water tube boilers, the water in the lower ones of such pipes being impelled forcibly to the left, as shown in Fig. 1, and upward in the header 1 and returning through the upper ones of such pipes 3 to the header 2 and thus again to the lower ones of such pipes 3. After the pipes 3 have been secured in place in the header 1, as described, the inner ends of such pipes are trimmed off flush with the inner surface of the header 1 to facilitate the circulation described. The ebullition produced is so violent that the water is thrown forcibly upward in the header 1, frequently striking the top of such header, and, therefore, a small amount of the water finds its way with the steam produced into the pipes 4, the lower ones of such pipes, as they have the greater inclination serving to return more of such surplus water to the header 2 than do the upper ones of the pipes 4. The upper ones of the pipes 4 serve to completely convert the last traces of water carried by the steam, into steam

and to make the steam delivered into the upper end of the header 2 perfectly dry. The reason for this is that, as the upper pipes 4 are substantially horizontal, the water which may be caught or trapped in such pipes has practically no tendency to flow toward the header 2, but is, on the other hand, entirely converted into steam before it passes from such pipes to the right into such header 2. A plurality of horizontally disposed pipes 4 may be employed, if desired, in addition to the pipes shown.

Thus it will appear, that in each of the heating sections of the boiler, two circulatory systems are provided, the lower one in the pipes 3 serving to convert the water into steam in the manner well-known in water tube boilers, while the upper pipes 4 serve to afford a means for circulation of the wet steam produced by the pipes 3, so that such steam is dried and to a certain degree superheated. Each section or unit is in reality an individual boiler which functions independently of the other sections heating the water, circulating it and separating the steam. In this manner I secure all of the advantages of a water tube boiler without any of the disadvantages of a construction common in water tube boilers, involving a common steam and water drum located over the heating pipes or tubes. This is a signal advantage, as the boiler constituting the present invention is designed particularly for use for portable purposes, as for automobiles, self-propelling trucks, etc.

From the above description it will appear that the units of the boiler may be very simply constructed, and to make up a complete boiler a plurality of such units is employed, as shown in Fig. 2, from which figure it will appear that these units represented by *a*, *b*, *c*, *d*, *e*, *f*, *g*, *h* are placed as closely together as consistent with the dimensions of the vertical headers, with the exception that between central ones of such sections a sufficient space is left for a superheating coil 6, which is conformed as indicated in Fig. 1, the lower ends of the coils being farther removed from the burner at the left-hand side than at the right-hand side, so that none of the loops may be overheated. The units *a* to *h* inclusive are each provided with a steam connection 7 from the upper end of the vertical header 2 to the common steam header 8, which steam header is constructed in a similar manner to the headers 1 and 2. The connections 7 are made of small tubing secured at either end to the corresponding headers by means of connectors, as shown in detail in Fig. 5. As shown in this figure, the end of the tube 7 extends through a taper collar 9, which snugly fits the end of the tube, and around the tube back of the collar an internally threaded sleeve 10 is disposed, the end of which engages the large end of the collar 9. The internal threads formed in the sleeve 10 are adapted to engage the external threads formed on the upper end of the screw plug 11, which is threaded at its lower end to be screwed into the header with which it is used. When the sleeve 10 is screwed on to the plug 11, so as to press the collar 9 into the tapered upper end of the plug 10, the end of the tube 7 is firmly held in place and a perfectly tight joint results. The sleeve 10 is provided with slots 12 in its outer cylindrical surface, as indicated, to facilitate screwing the sleeve into proper engagement with the plug 11. The lower end of the plug 11 is internally threaded, as indicated, and an inner sleeve 13 is screwed into the lower end to securely hold the washer 14 against the shoulder formed at the upper end of the threaded counterbore formed in the lower end of the plug to receive the tube 13. The washer 14 has a small central aperture for preventing an excessive rush of steam from any of the headers 2 into the header 8, if for any reason an excessive demand is made upon the header 8. As a result of the construction described any of the headers 2 may be readily separated from the header 8, if it is necessary to remove one of the units of the boiler from the casing for effecting repairs.

Each of the headers 2 is provided at its lower end with a pipe connection 15, the lower end of which connection is threaded into a water header or drum 16, and to facilitate the insertion of the pipe connections 15 they are provided with right and left hand threads, as indicated. Each of the headers 1 is provided with an angle bracket 17 at its upper end, which rests upon the top of the side wall of the boiler casing 18 to support the corresponding end of the boiler unit, and thus the units are held in proper operating position. To remove any unit, therefore, it is only necessary to undo its pipe connection 15 and remove the sleeve 12 connecting it with the corresponding connecting tube 7, after which the unit may be lifted from the boiler and another similar unit inserted in its stead. Water is supplied to the water header 16 from a suitable pump through the pipe 19 which conveys the water to a pre-heating coil 20 located within the boiler casing but out of contact with the direct action of the fire from the burner. The lower end of the coil 20 connects by means of a pipe 21 with the water header 16, at or near its central portion, so that water may be supplied to the header and thus to the several boiler units, as required.

The steam delivered to the steam header 8 is taken from such header to a superheating coil 6 by means of a connection 22 at or near the central portion of the header 8 and from the superheating coil 6 the steam is

communicated by a pipe 23 to the engine or motor to be driven. A baffle plate 24 is provided between the water header 16 and the several vertical headers 2 and the burner 5 to prevent the fire from the burner directly attacking the water in the water header and in the headers 2, as contact with the fire would to a considerable degree interfere with the proper circulation of the water through the pipes 3. A baffle plate 27 is placed upon the top of the upper pipes 4, so as to cause the fire to strongly heat the left-hand ends of the pipes 4, as shown in Fig. 1, to thus entirely convert the entrained water into steam and to superheat the steam to a slight degree before it enters the steam header 8. After passing from between the upper pipes 4 the gases of combustion are conveyed from the boiler casing 18 by a suitable flue 26.

In order to cause effective distribution of the fire between the various pipes 3 and 4 use is made of the construction shown in Fig. 4, in which baffle plates 25 are disposed over adjacent pairs of the upper pipes 4, the space between such pairs, however, being left uninterrupted so that the gases may pass through such spaces and out from the casing, as described. Each of the baffle plates 25 is formed of metal having some elasticity, so that the bent edges of the baffle plates which extend slightly below the centers of the pipes 4 may be sprung into place and thus be securely held in proper position without the danger of being jarred loose by motion of the boiler, if used in connection with a self-propelling vehicle. The baffle plate 27 is similarly constructed at its edges to engage the upper pipes 4. As a result of this construction, the baffle plates 25, which extend from the headers 1 to the left-hand end of the baffle plate 27, cause the gases to take the paths indicated in Fig. 4 by the arrows, and thus the pipes 3 and 4 are heated on practically all of their exposed surface and the heating efficiency of the boiler as a whole is rendered a maximum.

Besides serving as a water supply drum for the boiler, the water header 16 also serves as a mud drum, since all of the impurities in the water gradually collect in the lower ends of the headers 2 and pass down in the pipe connections 15 into the header 16, from which they may be blown periodically, as desired, by opening the blow-off cock 28 connected with one end of the header 16.

A cover 29 is provided for the boiler casing to inclose all of the heating parts and cause the fire to take a proper course to the flue 26.

In the construction shown in Fig. 6, the baffle plates 25^a are arranged similarly to the baffle plates 25, shown in Figs. 1 and 4, with the exception that they are shorter than the baffle plates 25, and the short sections are disposed in staggered arrangement so as to cause a more perfect distribution of the fire through the boiler tubes or pipes.

It will be noticed that the burner 5 is higher at its left-hand end than it is at its right-hand end, as a result of which the gas delivered to the burner by the mixing tube indicated will pass to the left-hand end in greater quantity than it will to the right-hand end, and thus the fire will be hotter under the portions of the pipes 3 and 4 adjacent to the headers 1. This is a desirable condition in order to stimulate the circulation of the water through the pipes 3.

In the modified construction shown in Figs. 7 to 11 inclusive, the tubes 30 extending between the left-hand headers 31 and the right-hand headers 32 are similar to the tubes 3, shown in Fig. 1, with the exception that the upper ones 30^a of such tubes are conformed at their left-hand ends, as indicated in Fig. 9, so that a slot 33 extends horizontally through each tube within the header 31, the left-hand end of each of these slotted tubes being closed as indicated. This construction is employed in connection with the tubes which are to receive and superheat to some degree the steam developed in the remaining portion of the boiler. The slots provide for the ready entry into the tubes of the steam produced, but serve to trap to a considerable degree the water which from time to time is thrown violently upward against the upper portion of the header 31.

The tubes 30^b immediately below the slotted tubes 30^a have their left-hand ends bent downward, as indicated, and the lower portion of the projecting ends of the tubes removed, so that the remaining upper portions operate as deflectors for engaging the water flowing upward in the header 31 so as to cause it to pass into the upper ones 30^b of the water tubes. To facilitate the engagement by the bent ends of the tubes 30^b with the water rising in the header 31, the projecting ends of these tubes are bent in horizontal planes in opposite directions, as indicated in Fig. 10, alternating ones of such tubes being bent toward one side of the header 31, while the intermediate ones of such tubes are bent toward the other side. The lower ones 30^c of the tubes are cut off flush with the inside surface of the header 31, as indicated.

In connection with this modification, baffle plates 34 are provided to cause the hot gases of combustion to take the path indicated through the tubes 30, as a result of which the efficiency of operation of the boiler is much increased.

In this modification, I provide an improved form of superheating coil 35 formed of a tube which is flattened over the burner so as to present a maximum of heating surface and a minimum obstruction to the gases of combustion as they pass from the burner

upward to the tubes of the boiler. The superheating coil 35 is disposed in substantially horizontal position between the left-hand ends of the lower tubes 30 and the burner, and is in a position to be effectively operated upon by the gases of combustion as they pass to the left to go around the left-hand end of the lower baffle plate 34. One end of the superheating coil 35 is connected with the steam header 36, while the other end constitutes the delivery pipe from the boiler.

As shown in Fig. 11, the steam header 36 has supported within it from one of its end walls an inner pipe 37 of relatively small diameter, through which a plurality of small holes 38 are drilled opposite the connections 39 between the steam header and the right-hand vertical headers 32, shown in Fig. 7. The wall of the tube 38 is comparatively thin and is open to the inside of the steam header 36 only through the holes 38, which are of such a size that their added area is equal to the cross-sectional area of the inner bore of the tube 37. As a result of this construction, the steam demand made upon any one of the vertical headers 32 is prevented from being excessive, and each of these vertical headers is caused to supply its proportionate amount of the steam taken from the boiler and thus the demand upon the several boiler units is equalized.

In the modification shown in Figs. 12 and 13, each unit consists of two substantially vertical headers 40 and 41, between which the bent tubes 42 are disposed. These tubes, as indicated, are joined to the headers in vertical alinement and alternate ones of the tubes are bent slightly to one side, while the remaining ones are bent to the other side, so that the total thickness of the section over the tubes will be not to exceed the diameter of the headers. The portions of the tubes between the headers, which are offset as described, are flattened so that they are given an elongated cross-section vertically, the flattening being done preferably in such a manner that the section is elliptical. In this way the amount of heating surface presented to the hot gases of combustion is increased relatively to the volume of the water in the tubes and the construction is comparatively simple to make. Another advantage of this modification is that the tubes may be of larger diameter and fewer in number than is the case when the tubes are not flattened. A still further advantage of this modification consists in the fact that the tubes bend laterally more readily than if they were round in cross-section, as a result of which the expansion and contraction of the tubes does not exert as serious strain upon the headers and supporting devices as though the tubes were not free to deflect laterally. The same advantage is obtained in connection with the type of superheating coil 35 shown in Figs. 7 and 8.

While I have shown throughout the drawings different modifications in which the headers are substantially vertical, it is to be understood that any disposition or arrangement of the headers and tubes between them may be made that will result in securing in the same system a first structure in which the water may move by convection rapidly from one point to another along closed and continuous paths so that the heating of the water may be effected as rapidly as possible, and also a second structure in which the steam developed in the first structure is moved rapidly through suitable paths to remove and return the entrained moisture by gravity and produce dry steam. By my invention, the combination of structures as described provides broadly a construction in which the two actions may be of varying extent in the same structures, depending upon the particular operating conditions from time to time and the relation of the structures to each other, that is to say, certain tubes may for one level of the water in the boiler serve to heat the water and at other times, for a lower water level, the same tubes may serve to separate the water from the steam. Whatever the relation between the structures, the separating structure is of such a nature that the delivery of wet steam from the boiler is prevented.

In connection with the boiler construction described above, I find that a very satisfactory indication of when the water level is raised above a proper working point is afforded by a tendency of the boiler to prime for such condition. In practice, it will be understood, the pump used with the boiler must be of such a capacity as to supply water to the boiler slightly in excess of the maximum demand that may be made upon the boiler. By means of any suitable device, as, for example, a thermometer, the temperature of the steam may be indicated either absolutely or relatively and, as long as the water level in the boiler is below the high level position, the boiler will deliver dry steam, the temperature of which will be indicated by the device employed. For this condition the pump should be in operation and when the pump has raised the level of the water in the boiler slightly above the high level position, the boiler will begin to prime slightly as a result of the separating portion of the boiler being unable to handle the large amount of water projected into the steam generated owing to the high level of the water in the boiler. The water carried over in the priming operation is vaporized by the heat of the steam and the slight decrease in pressure when it reaches the delivery pipe, and this action absorbs a considerable amount of heat from the steam

with a consequent drop in the temperature of the steam delivered, which at once is noticeable on the device employed to indicate the temperature. As a result, for all normal working conditions, the indication afforded by the temperature device will remain practically constant, but, as soon as the water has passed its high level position, the temperature indicator shows a decided drop in the temperature of the steam delivered and thus gives a positive indication that the pump must be stopped in order to prevent priming. After the boiler has been used for a short time and the temperature of the steam, as indicated by the temperature device, has regained its normal condition, the pump is again started. In this way the necessity of employing a water gage or test cocks for determining the level of the water in the boiler is avoided. The temperature device may be so constructed, if desired, as to automatically control the operation of the pump, so as to pump water into the boiler when a predetermined temperature is being maintained, while the pump is shut off when the temperature is reduced. If, for any reason, the boiler is used too long after shutting off the pump and all of the water is turned into steam, no harm is done with the construction above described, since, as all of the joints are made by fusing the parts together by means of the oxy-acetylene flame, the boiler is of non-burning construction and may be heated to redness as many times as desired and immediately cooled without injury to the boiler. Without the use of a non-burning construction, however, the boiler would, of course, be seriously damaged by permitting the pump to remain inoperative for too long an interval.

While I have shown my invention in the particular embodiment herein described, I do not, however, limit myself to its exact construction, but may use any equivalent thereof that may suggest itself to those skilled in the art.

What I claim is:

1. In a boiler, the combination of two substantially vertical headers, and a plurality of pipes extending between such headers, the lower one or ones of such pipes being inclined, the upper one or ones of such pipes being substantially horizontal, and the intermediate pipes having inclinations gradually changing from the inclination of the lower pipe or pipes to a horizontal position, each header affording direct communication between the corresponding ends of all of said pipes.

2. In a boiler, the combination of two substantially vertical headers having their upper ends practically in horizontal line with each other, one of such headers being shorter than the other, pipes extending from one header to the other, the spacing of the pipes in the shorter header being substantially uniform and smaller than the spacing of the pipes in the longer header, each header affording direct communication between the corresponding ends of all of said pipes.

3. In a boiler, the combination of two substantially vertical headers having their upper ends practically in horizontal line with each other, one of such headers being shorter than the other, pipes extending from one header to the other, the spacing of the pipes in the shorter header being substantially uniform and smaller than the spacing of the pipes in the longer header, such pipes secured in the headers by fusion.

4. In a boiler, the combination of two substantially vertical headers having their upper ends practically in horizontal line with each other, one of such headers being shorter than the other, pipes extending from one header to the other, the spacing of the pipes in the shorter header being substantially uniform and smaller than the spacing of the pipes in the longer header, such pipes secured in the headers by fusion, and metal plugs fused into the ends of the headers.

5. In a boiler, the combination of a plurality of independently functioning separable units each comprising two substantially vertical headers, a plurality of pipes extending between such headers, the lower ones of such pipes being inclined while the upper one or ones of such pipes are substantially horizontal, each unit comprising a flat nest of tubes, said units being supported vertically side by side, a common transverse steam header for such units, and a flat superheating coil disposed vertically between two such units.

6. In a boiler, the combination of a plurality of units each comprising two substantially vertical headers, a plurality of pipes extending between such headers, the lower ones of such pipes being inclined while the upper one or ones of such pipes are substantially horizontal, a common water header connected to such units, and a flat heating coil connected with the water header to pre-heat the water delivered to such header, said units being placed side by side with the corresponding headers in contact to form walls, said preheating coil being placed substantially parallel with and adjacent to one of said walls.

7. In a boiler, the combination of a plurality of functionally independent wrought metal steam generating units, each unit comprising two continuous substantially vertical headers, a plurality of pipes extending between such headers, the lower ones of said pipes being inclined in one direction while the upper one or ones of said pipes are

not so inclined, said vertical headers each comprising a continuous passageway providing direct communication between the corresponding ends of the connected tubes, a common steam header, readily separable unions joining said units and said steam header, a common water header connected to said units, said water header being disposed below and connected to the lower ends of the longer vertical headers and readily separable pipe connections for connecting the water headers with the adjacent vertical headers.

8. In a boiler, the combination of a plurality of integral units, each comprising two substantially vertical headers, a plurality of pipes extending between said headers, said units being separate from each other and in substantially vertical planes, the lower ones of such pipes being inclined in one direction, while the upper one or ones of such pipes are not so inclined, said vertical headers each comprising a continuous passageway providing direct communication between the corresponding ends of the pipes, a casing for the units, means for independently suspending the front end of each unit from the casing, said means being secured to the corresponding unit adjacent the top of the front header and a furnace below said units, said units being suspended with their front headers over said furnace.

9. In a boiler, the combination of a plurality of functionally independent steam generating units, each unit comprising two continuous substantially vertical headers, the end of the rear headers projecting down below the end of the front header, a plurality of pipes extending between said headers, the lower ones of said pipes being inclined downward toward the rear headers, the upper pipe or pipes of each section being substantially horizontal and pipes of intermediate inclinations between said upper and said lower pipes, a casing for the units, a furnace in the lower part of the casing extending substantially from the front to the rear of the boiler, said boiler units having their front headers supported above said furnace, a water drum connected to the bottom of the rear headers and extending transversely of said units and a transverse baffle plate for protecting said drum and the adjacent ends of the vertical headers from the heat of the furnace.

10. In a boiler, the combination of a plurality of functionally independent steam generating units, each unit comprising two continuous substantially vertical headers, the end of the rear header projecting downward below the end of the front header, a plurality of pipes extending between said headers, the lower ones of said pipes being inclined downwardly toward the rear header, the upper ones of said pipes being not so inclined, a casing for the units, a furnace in the lower part of the casing below said units and extending substantially their full length, the units being suspended with their front headers above said furnace, a transverse water header, ready releasable means for joining each of said vertical rear headers to said water drum, a baffle plate for protecting the lower end of the vertical headers and the drum from the heat of the furnace and other baffle means disposed among said pipes for directing the fire from the furnace through said pipes, said baffle permitting a first pass of the gases through said pipes to a point above the water level.

11. In a boiler, the combination of two substantially vertical round tubular headers having their upper ends practically in horizontal line with each other, one of such headers being shorter than the other, pipes extending from one header to the other, the spacing of the pipes in the shorter header being substantially uniform and smaller than the spacing of the pipes in the longer header, the ends of the lower ones of such pipes connected with the shorter vertical header being cut off flush with the inside surface of such header, each vertical header affording direct communication between the corresponding ends of all of the pipes of the unit of which said header is a part.

12. In a boiler, the combination of two substantially vertical headers having their upper ends practically in horizontal alinement with each other, one of said headers being shorter than the other, and pipes extending from one header to the other, the spacing of the pipes in the shorter header being substantially uniform and smaller than the spacing in the pipes in the longer header, the ends of the upper ones of said pipes extending into one of the said headers and being horizontally slotted.

13. In a boiler, the combination of two substantially vertical headers having their upper ends practically in horizontal alinement with each other, one of said headers being shorter than the other and pipes extending from one header to the other, the spacing of the pipes in the shorter header being substantially uniform and smaller than the spacing in the pipes in the longer header, the ends of the pipes serving as water return pipes projecting into one of the headers and conformed to serve as deflectors to direct the water into such pipes.

14. In a boiler, the combination of two substantially vertical headers having their upper ends practically in horizontal alinement with each other, one of said headers being shorter than the other and pipes extending from one header to the other, the spacing of the pipes in the shorter header being substantially uniform and smaller

than the spacing in the pipes in the longer header, the ends of the pipes serving as water return pipes projecting into one of the headers and conformed to serve as deflectors to direct the water into such pipes and the ends of the pipes above the water return pipes projecting into the last mentioned header and being slotted horizontally.

15. In combination two substantially vertical headers comprising a front and a rear header, said rear header comprising a length of tubing having a row of circular perforations in one side wall thereof, said front header comprising a length of tubing having a row of circular perforations in one side wall thereof the perforations in said rear header being spaced apart farther than in said front header, means closing off the top and bottoms of both headers, a plurality of pipes between said headers and having their ends joined to the edges of said aperture to form closed passages between said headers, the lowermost one of said pipes being inclined downward toward said rear header, said upper pipes being provided with means in the upper end of said front headers for restricting the flow of water into said pipes and a steam connection for drawing off steam from the upper end of the rear header.

16. In combination a plurality of independently functioning boiler units, a common steam header supported above the water level in said unit, and being free of water at all times, delivery pipes for each of said units, said pipes being connected to said header and being adapted to deliver steam only to said header, an equalizing pipe lying within said header, said pipe having apertures of small size through the side walls thereof, said pipe communicating with the interior of said headers through said apertures only, the total area of said apertures being substantially the same as the cross-sectional area of said equalizing pipe.

17. In a boiler, a steam header adapted to contain steam only, a plurality of steam generating units having steam delivery pipes connected with the header, and a comparatively small diameter tube in said header, said tube having small bore openings through it constituting the only communication between the header and the inside of the tube and serving to deliver the steam from the headers, said openings corresponding in number to the generating units and being located adjacent the steam delivery pipes.

18. In combination, a pair of headers having unobstructed passage throughout their length, a plurality of tubes joining said headers, said headers and tubes constituting a single unitary piece of wrought metal, said tubes being flattened and alternately offset between said headers.

19. In a boiler, the combination of two headers, and a plurality of pipes extending between the headers, the lower ones of such pipes being inclined in substantially the same direction to constitute closed paths for the circulation by convection of the water being heated and the upper ones of said pipes being spread out in fan-shaped arrangement to dry the steam produced, each header affording direct communication between the corresponding ends of all of said pipes.

20. In combination, a plurality of unitary, integral wrought metal boiler sections, said sections comprising a short header and a longer header and tubes of graduated inclinations joining said headers, a transverse steam header joined to each section at the top of said longer header, and a transverse water header joined to each section adjacent the bottom of said longer header.

21. In combination a plurality of functionally independent steam generating units, common means for heating said units, a common steam header adapted during normal operation to contain steam only, individual steam connections joining said headers and said units, said connections containing each a steam flow restricting orifice tending to equalize the steam delivered by said units.

22. In a boiler, a plurality of similar functionally independent units, each unit comprising a front and a rear vertical header, each of said headers comprising a continuous length of wrought metal tubing, plugs closing off the ends of said headers, said headers having each a row of apertures cut through the walls thereof along one side, the spacing of the apertures being generally greater on the rear header, the lower end of the front header being above the lower end of the rear header, a plurality of tubes having their ends secured to the edges of the apertures in the header to form closed passages therebetween, said tubes comprising a tube inclined downwardly toward the rear header joining the lower ends of the headers, said tubes and headers all lying in substantially the same plane.

23. In a boiler a plurality of similar functionally independent units, each unit comprising a front and a rear vertical header, each of said headers comprising a continuous length of wrought metal tubing, plugs closing off the ends of said headers, said headers having each a row of apertures cut through the walls thereof along one side, the spacing of the apertures being generally greater on the rear header, the lower end of the front header being above the lower end of the rear header, a plurality of tubes having their ends secured to the edges of the apertures in the headers to form closed passages therebetween, said tubes comprising a tube inclined down-

wardly toward the rear header joining the lower ends of the headers, said tubes and headers all lying in substantially the same plane, said units being placed together with their corresponding headers in contact, a transverse steam drum at the top of said headers, a transverse water drum at the bottom of said headers and tubes of smaller diameter than said headers joining said headers to the steam and water drums, each of said smaller tubes having releasable screw-threaded connections for removing a unit.

24. A boiler unit comprising a pair of wrought metal headers of different lengths, a plurality of wrought metal tubes welded to said headers to form an integral unitary piece of metal, the space between said tubes being substantially uniformly greater at the longer header than at the shorter header.

25. In a boiler, a pair of unitary vertical headers, a plurality of tubes joined at their ends to said headers and having unobstructed communication therewith, said tubes and said headers constituting a unitary integral piece of metal, said tubes being of graduated inclinations from the top to the bottom of said headers.

26. In a boiler, a functionally complete steam generating unit constructed solely of different lengths and diameters of stock tubing, said unit comprising a front and a rear vertical header, each of said headers consisting of a continuous length of wrought metal tubing having plugs welded to the ends to close the same, said tubes having each a longitudinal row of apertures along one side, the spacing of the apertures being generally greater on the rear header than on the front header, the lower end of the front header being above the lower end of the rear header, a plurality of cross tubes having their ends welded to the edges of the apertures in the headers to form closed passages therebetween, said tubes and headers all lying in substantially the same plane, and tubes of smaller diameter connected to the rear header for supplying water and for delivering steam.

27. In a high pressure boiler the combination of a plurality of independently functioning steam generating units, each unit comprising a front and a rear header and a plurality of cross tubes interconnecting said headers, the lowermost tubes being inclined from the lower end of the front header to the lower end of the rear header, the upper tubes being not so inclined, intermediate tubes of graduated inclination, said headers being only partially filled with water during the normal operation of the boiler so that some of the tubes lie above the water level and the lowermost tubes lie below the water level, a casing surrounding said boiler, and a furnace below said units, said casing having means for passing the gases from the furnace directly through the tubes below the water level and through the tubes above the water level at one pass, the lower end of said front header being supported over said furnace and being adapted to be highly heated thereby.

28. In a steam boiler, a header, tubes opening into said header at different levels, a second header into which said tubes open, the ends of the tubes being spaced apart farther where they join the second header than where they join the first header, said boiler being organized for operation with the water level in said second header below the corresponding ends of some tubes and above that of others, a casing surrounding said boiler, said casing containing a furnace in the lower end thereof, said furnace being arranged to heat intensely the first header and the adjacent ends of the tubes, said casing being organized to pass the furnace gases up through the tubes to a point substantially above the water level during operation and a steam connection joining said second header for withdrawing the steam generated.

29. A water tube boiler comprising a pair of headers, a plurality of inclined connecting tubes, said tubes being arranged one above the other, other tubes similarly arranged above said first tubes and having a different degree of inclination, a furnace and means for heating all of said tubes at one pass of the furnace gases, said boiler being organized for operation with the water level below the upper ones of said second set of tubes.

In witness whereof, I hereunto subscribe my name this 18th day of October, A. D., 1911.

WILLIAM H. WINSLOW.

Witnesses:
ALBERT C. BELL,
LEONARD E. BOGUE.