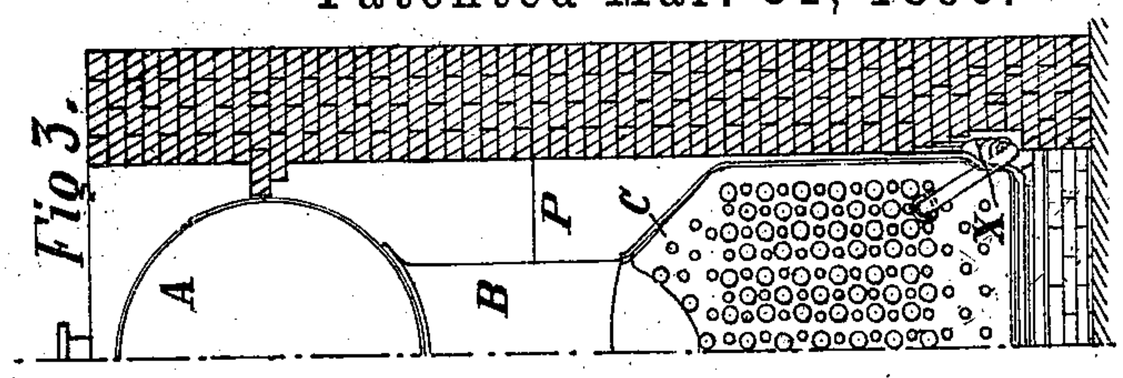
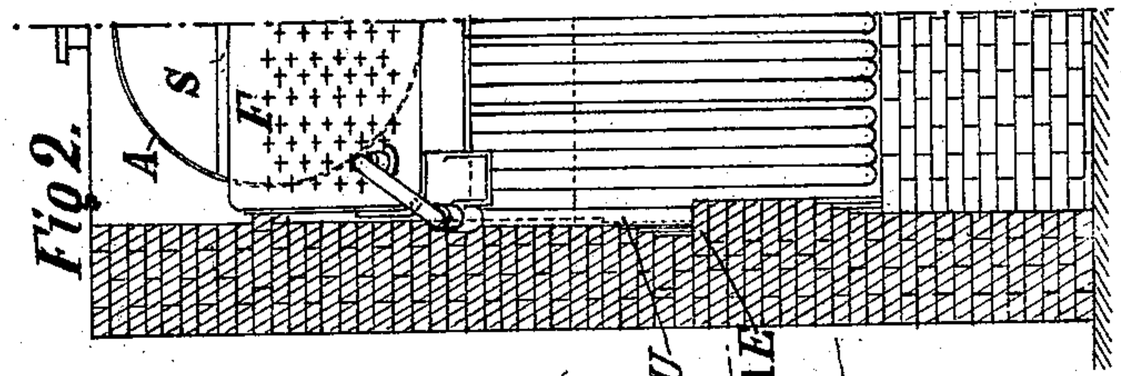
(No Model.)

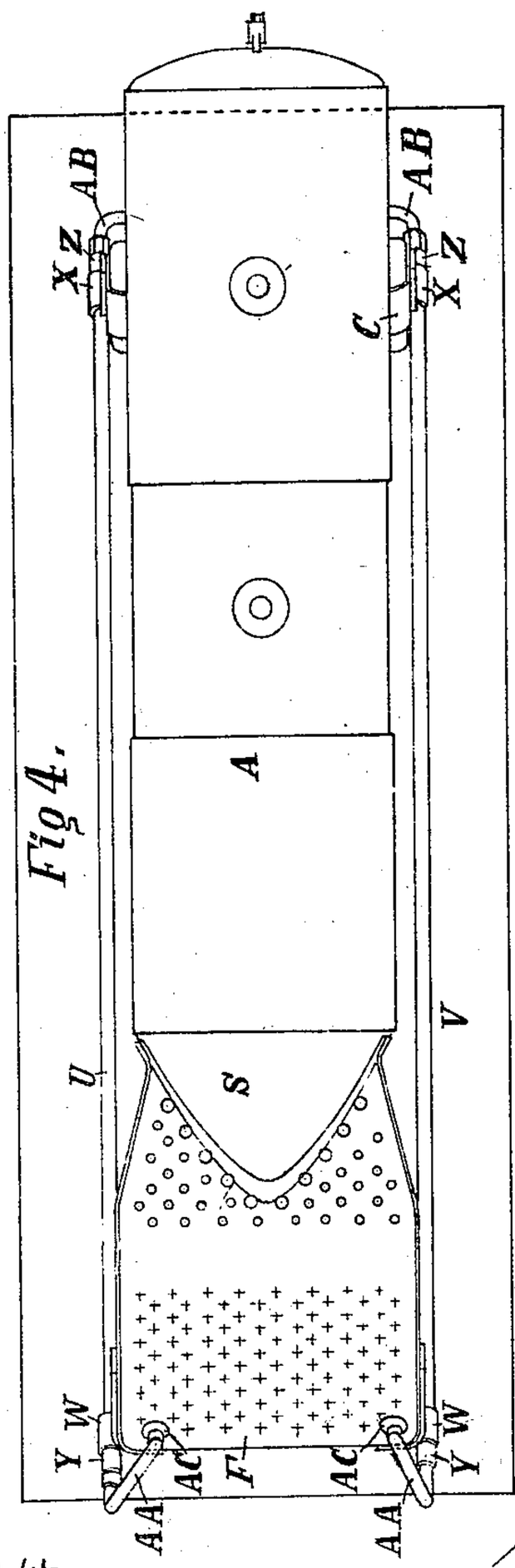
J. J. BUTCHER.

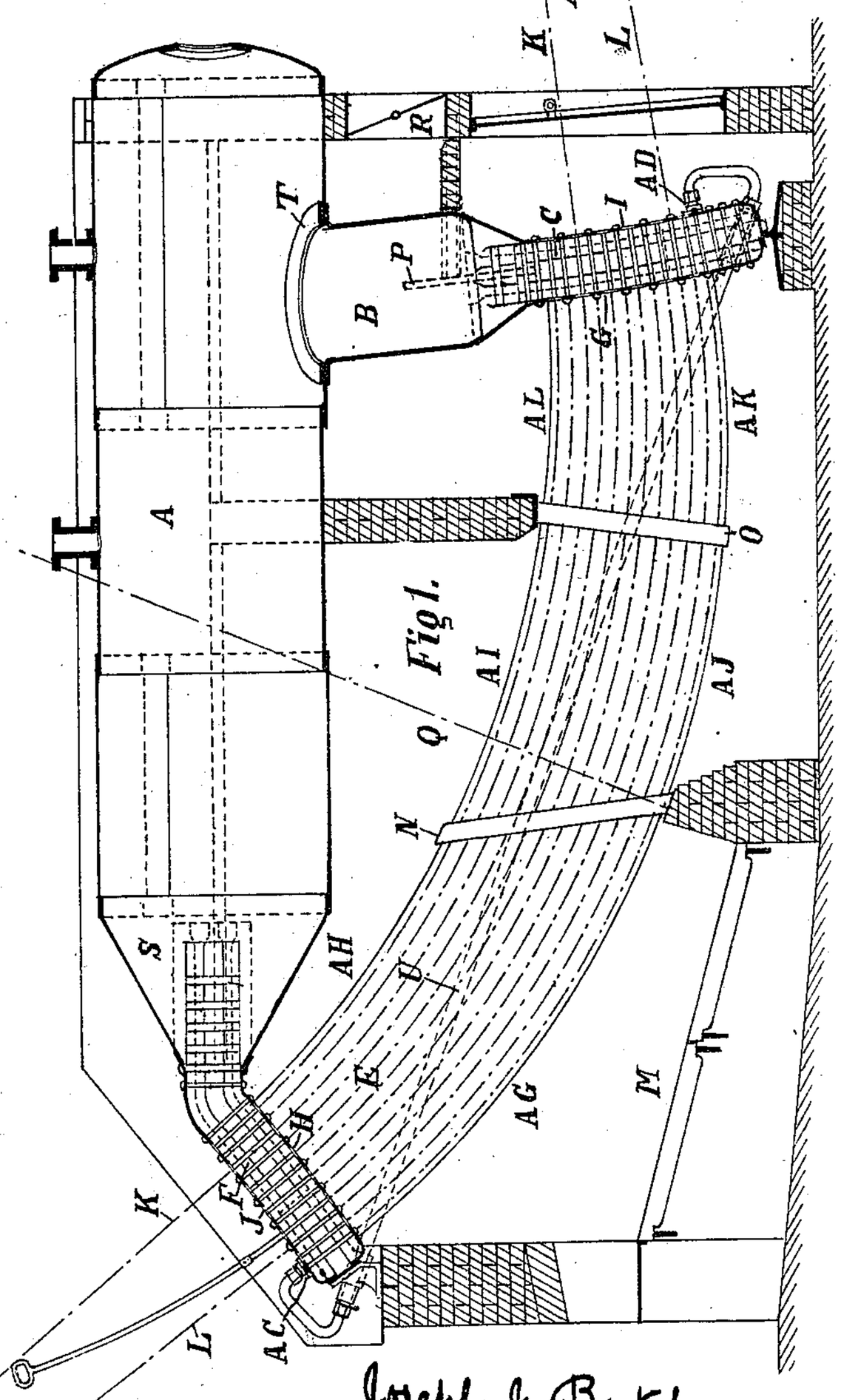
STEAM BOILER.

No. 557,524. Patented Mar. 31, 1896.









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JOSEPH J. BUTCHER, OF NEW YORK, N. Y.

STEAM-BOILER.

SPECIFICATION forming part of Letters Patent No. 557,524, dated March 31, 1896.

Application filed August 13, 1894. Serial No. 520,220. (No model.)

To all whom it may concern:

Be it known that I, JOSEPH JOHN BUTCHER, a subject of Her Majesty the Queen of Great Britain and Ireland, residing at 35 West Thirty-sixth street, New York, in the county of New York, in the State of New York, have invented certain new and useful Improvements in Steam-Boilers, of which the following is a specification.

My invention relates to a boiler consisting of a cylindrical drum, front and back headers, and of a number of curved water-tubes uniting the said headers together, and of other details, as is described below in reference to the accompanying drawings.

Figure 1 is a longitudinal section of my boiler. Fig. 2 is a half-transverse section through the brickwork setting, showing a front view of the boiler within it. Fig. 3 is a half view of the boiler from the back with the brickwork in section. Fig. 4 is a plan of the boiler with an outline of the setting.

A is a horizontal drum communicating, by means of the downtake-tube B, with the back header C and the numerous curved water-tubes E. These tubes E communicate at their front ends with the front header F, which opens into the front end of the drum A.

I usually bend all the tubes E to the same radius, and in the drawings they are thus shown and are not concentric. The object of this arrangement is so that they may be all cleaned with an ordinary tube-scraper, the rod of which is bent to the same curve as the tubes are bent to. Where there is not headroom to get this scraper and rod entered from the front, it may be formed of short pieces and bolted or otherwise suitably fastened together as each piece is successively forced into the tube. The center lines of the tubes alone are shown in Fig. 1, together with the top line of the top tube and the bottom line of the bottom tube, and these tubes are expanded into the tube-plates G and H in the usual way. On the outside plates of the headers I and J are hand-holes, closed by tube-caps (not shown) in the usual manner, through which the tubes may be entered before expanding or withdrawn for renewal, and which also enable them to be cleaned internally by scraper, as described.

Each of the headers C and F is built on a curve, so that the tube-plate is approximately at right angles to each tube as it enters the plate. If the center lines of the top and bottom tubes be bisected between the two tube-plates, and these points of bisection be joined by a straight line Q and this line extended upward, then the center from which the curve of each tube is described will be upon this line, and the radius for any tube will be of the same length as those for all the other tubes. Thus the tubes converge as they enter the tube-plates. To find the centers of curvature of the headers I continue these curves to the center lines of the headers and then produce the lines as tangents beyond the headers until they meet. These tangents do not all meet at the same point; but for practical purposes I find that if the tangents from the center lines of the third tubes from the top and bottom K and L be produced, and the points where they meet be used as centers from which the curves of the header-plates are struck, all purposes required are served. Then the center lines passing through the hand-holes and tube-holes will be made radial to these centers, and the stays between the holes will also be set radial to these centers, and they will then be at right angles to both the inside and outside plates of the headers.

As the front and back plates of the headers have to be flanged on a former, this former may be shaped to the required curve, as shown in Fig. 1, so that the plates may be both flanged and curved in a single operation without additional expense being incurred.

M is the furnace, and the hot products of combustion pass upward among the tubes and over the top of the baffle N and then downward among the tubes and under the baffle O, and then again upward among the tubes and around each side of the downtake B, over the baffles P, to the damper-opening R. As most of the steam is developed over the furnace in the first run of gas, it is much more essential to have the tubes steeply inclined upward in this region than it is in the vicinity of the back header. Very little steam is formed behind the baffle O, and, therefore, as the difference between the specific gravity of the steam and water within the tubes in this part of the boiler and that of the water in the back header is but slight, there is but little value

in any rise of tube in this region. I therefore prefer to so arrange that the centers of curvature of my tubes are somewhat forward of the back header, so that the bottom tubes may incline downward as they leave the back header and rise to about the original level again when they reach the baffle O. Thus, in effect, the bottom tubes are level from the back header to the baffle O, while the top tubes have only a slight upcast in this region.

Between the baffles O and N the upward incline of the tubes increases considerably. As steam is throughout this region accumulating within the tubes and the specific gravity of the combined steam and water decreasing, an upward inclination is becoming of more and more value for circulating purposes. Between the baffle N and the front header the greater proportion of the steam is made, and this is especially the case with the two bottom rows of tubes, which are exposed to the radiant energy of the furnace as well as to the very hottest of the flame. Here, therefore, I make the tubes very steeply inclined, because the difference between the specific gravity of the water and the entrained steam within the tubes and of the solid water in the back header has reached its maximum.

It will be observed from Fig. 1 that the actual hydrostatic head within the lowermost tubes, measured from the level at which they leave the baffle N to that at which they discharge themselves into the front header F, is greater than in the upper tubes between corresponding points. This feature is very desirable, because as more steam is formed in the lower tubes they should have the quicker circulation.

Within the tubes the steam-bubbles are entrained with the water—that is, they have little tendency to circulate through it, but are entangled with it, and both move very much as one mass. When this mixed product of steam and water emerges into the front header, however, the steam-bubbles rise through the water immediately to the surface. This happens because the front head being large compared with the size of each bubble of steam the latter is surrounded by water, and the water flowing underneath it displaces it upward at a much greater velocity than that of the general flow of the water. Thus the amount of steam contained in the water of the front header at any instant is proportionally much less than that contained in the tubes over the furnace. For this reason the front header is of but little value for circulating purposes, as the water and steam within it are together not very much lighter than is the solid water in the back header. Thus I so arrange that the lower tubes rise almost to the level of the drum before they enter the front header, while the upper tubes enter the header at a level not far from that of the water-line, the normal position of which is the center of the drum. With this object, as is shown in Fig. 1, my front header is built outward from the center of the drum and inclined downward at a suitable angle, while the back header is built considerably below the drum and is inclined backward at a slight angle behind the vertical.

A convenient method of uniting the front header to the drum is shown in Figs. 1, 2, and 4. The outer and inner plates of the header are built to a curve, as shown, and are flanged to meet the side plates, which latter are formed to the same curve, all being riveted together. Thus a bend is formed sufficient to bring the upper portion of the header into a horizontal position, and this upper portion is so formed and flanged as to fit like an open mouth upon the conical drumhead S. This drumhead may be bent in two separate portions on a former, one forming the upper and the other the lower section of the cone, and these two separate pieces welded together where they meet at the sides of the header, so as to form the complete conical head, with the required mouth-opening of suitable shape to receive the header. This method avoids the necessity for cutting away so much plate in forming the required mouth as would have to be removed if a complete cone were in the first instance made. I prefer to make all these plates of steel or good wrought-iron and flange and rivet them together. The staying between the tube-plates and hand-hole plates is of a similar character to that usual for flat surfaces, and the same may be said of the horizontal portions of these plates. The mouth where the header is flanged onto the conical drumhead is held together by somewhat stronger stays, in proportion to the pressure which has to be resisted.

The cylindrical downtake B is flanged onto the bottom of the drum, the opening in which is strengthened by the reinforcement-ring T. This cylinder is flanged in at the bottom to meet the conical portion of the back header, as shown. This conical portion may be conveniently formed upon the back and front plates of the header and strongly stayed together where it arises from the header-tube and hand-hole plates, which latter are stayed together in a similar manner to that previously described in regard to the front header.

As there is a tendency in curved tubes to straighten when subjected to internal pressure, and as the structure of drum and headers in my boiler is very rigid and will not yield to this tendency without injury, I prefer to bind the two headers together at their bottom ends by means of a pair of thick straight stay-tubes U and V. These tubes are made sufficiently strong to resist any tendency that may occur to force the headers apart at their lower ends. The tubes are screwed at each end and passed through the cast-steel (or other suitable) eyes W and X, which latter have suitable flanges, as shown, formed upon them and so shaped as to fit upon the lower parts of the back and front headers, to which they are riveted or otherwise rigidly

attached. The nuts Y and Z resist the thrust of the eyes. Beyond these nuts the pipes A A and A B are coupled onto the ends of the stay-tubes. The hand-hole caps A C and A D have suitably-formed nozzles projecting from them through the hand-holes, and these nozzles are screwed so as both to receive the nuts which draw the hand-hole covers firmly down upon their seats, so as to be steam-tight, and also to receive the couplings at the inner ends of the circulating-pipes A A and A B. These pipes make the circulating waterways complete from the back header through the stay-tubes to the front header. As the object of the water in these tubes is simply to keep them from getting overheated, I protect them from the greater part of the heat by building offsets A E of brickwork underneath them from header to header, leaving space enough between each offset and the boiler-tubes for inserting the steam-jet for blowing the dust off them.

The baffles N and O are so sloped with regard to one another and to the tube-plates H and G as to form passages for the hot products of combustion of such character that the sectional openings among the tubes for the gases at each of the six positions at which they enter and leave the tubes A G, A H, A I, A J, A K, and A L are roughly proportional to the absolute temperatures of the gases in these positions. The object of this arrangement is to insure that the entire length of each tube is, as far as is practicable, immersed in the actual stream of hot gases, and that there are no portions about which eddies of comparatively stagnant gas may form. With this object in view the baffle N slopes rapidly toward the tube-plate F, so that the passage for the gases is very rapidly contracted throughout its first upward run where the fall of gas-temperature is greatest. In boilers where this baffle is parallel with the tube-plate a large portion of the tubes, especially at the upper portion in the vicinity of the header, is left untouched by the main stream of the products of combustion, which clings to the baffle preparatory to turning over its top edge. This portion of the tubes is only covered by almost stagnant gas, which has very little heating effect, and thus the tube-heating surface as a whole is reduced in efficiency. In the second and downward run of the gases in my boiler the baffles N and O also slope toward each other in the direction of the flow of the gases, but the contraction of passage resulting is not so great as that described for the first upward run of the gases, as in the second and downward run the loss of heat is not so great as in the former case. As there is a slight loss of heat to the drum between A H and A I, I make the entry at A I slightly smaller than the exit at A H, about in proportion to the average difference of absolute temperature found to occur between these two positions. As between A J and A K scarcely any loss of heat occurs after the brickwork and floor have once been heated to the normal, I usually make the entry at A K about the same size as the exit at A J. The baffle O and the tube-plate G also converge in the direction of the flow, and about in proportion to the loss of heat consequent upon the natural contraction of the gases in this region, and the aggregate apertures between the tubes at A L is but little more than the full-way damper-opening at R, plus an addition required for increased friction due to the subdivision of the gases among the tubes. Thus there is a continual convergence of passage from A G to A L, which is most rapid at first where the fall of gas-temperature is greatest, but is continued with decreased rapidity until all the tubes have been passed.

At D the rod of a tube-cleaner is shown projecting from a tube. It is bent to the same curve as are all the tubes, and may consequently be used with equal facility for any of them.

A M is a joint in the rod to enable it to be taken to pieces and inserted piece by piece in a case in which the head-room is insufficient to allow of a solid rod being introduced into the tube. To the inner end of this rod any kind of suitable tube-scraper may be attached and worked through the tube in a similar manner to that in which a straight-rod tube-scraper is worked through a straight tube.

What I claim, and desire to secure by Letters Patent, is—

1. In a water-tube boiler, the combination of headers with a number of tubes, placed both in horizontal and vertical rows, and all bent to a circular curve of the same radius and secured into headers at each end of the tubes, the said headers having hand-holes one opposite each tube, substantially as described.

2. In a water-tube boiler, the combination of a number of tubes all bent to the same radius and placed one above the other in the plane of their curvature with curved headers, the tube-plates of which are approximately at right angles to each tube at the point where it enters the header, substantially as described.

3. In a water-tube boiler, the combination of a number of tubes of the same radius of curvature and placed one above the other in the plane of their curvature, with headers forming the terminals of the said tubes and formed of stayed surfaces, the stays occupying intermediate positions in the tube-plates and hand-hole plates between the tubes, and also converging at angles intermediate to the angles of convergence of center lines passing through the corresponding tube-holes and hand-holes next above and below them, substantially as described.

4. In a water-tube boiler, the combination of a number of tubes all bent to the same radius and placed one above the other in the plane of their curvature, with front and back headers and baffles, the tubes being approxi-

mately horizontal in the vicinity of the back header, while they increase in upward inclination as they come forward to the front header, substantially as described.

5. In a water-tube boiler, the combination of a drum with a front header set to slope downward and forward at an oblique angle with regard to the axis of the drum, and built of stayed boiler-plate with a knee-bend formed in the said header uniting it to a horizontal portion, also of stayed boiler-plate, and formed to fit upon the drum-head, and attached thereto, substantially as hereinbefore described.

6. In a water-tube boiler, the combination of a horizontal drum having a conical head with front and back headers, the front header projecting outward and downward from the center of the conical head, and with water-tubes curved to a common radius and sloping downward and backward from the front header, substantially as and for the purpose described.

7. In a water-tube boiler, the combination of a horizontal drum having a cylindrical downtake with a back header of stayed boiler-plate, having its upper tube and hand-hole plates in a conical form, and the side plates meeting them, and united with the downtake, substantially as described.

8. In a water-tube boiler, the combination of a set of water-tubes, all curved to the same radius, with a back header either approximately vertical or sloping downward and backward at a slight angle behind the vertical with a front header sloping downward and forward at an angle of fifty degrees or thereabout in front of the vertical, the said headers forming the terminals of the said water-tubes, substantially as described.

9. In a water-tube boiler, the combination of a set of curved water-tubes with front and back headers united by a drum at their upper ends, and forming the terminals of the said water-tubes, with a pair of straight stay-tubes holding the said headers firmly together, and through which the water of the boiler is allowed to circulate, substantially as described.

10. In a water-tube boiler, the combination of a front header with a baffle above the bridge-wall, the said header and baffle converging toward each other in the direction of the flow of the gases, as and for the purpose described.

11. In a water-tube boiler, the combination of a baffle with a back header, the said baffle and header converging toward each other in the direction of the flow of the gases, as and for the purpose described.

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