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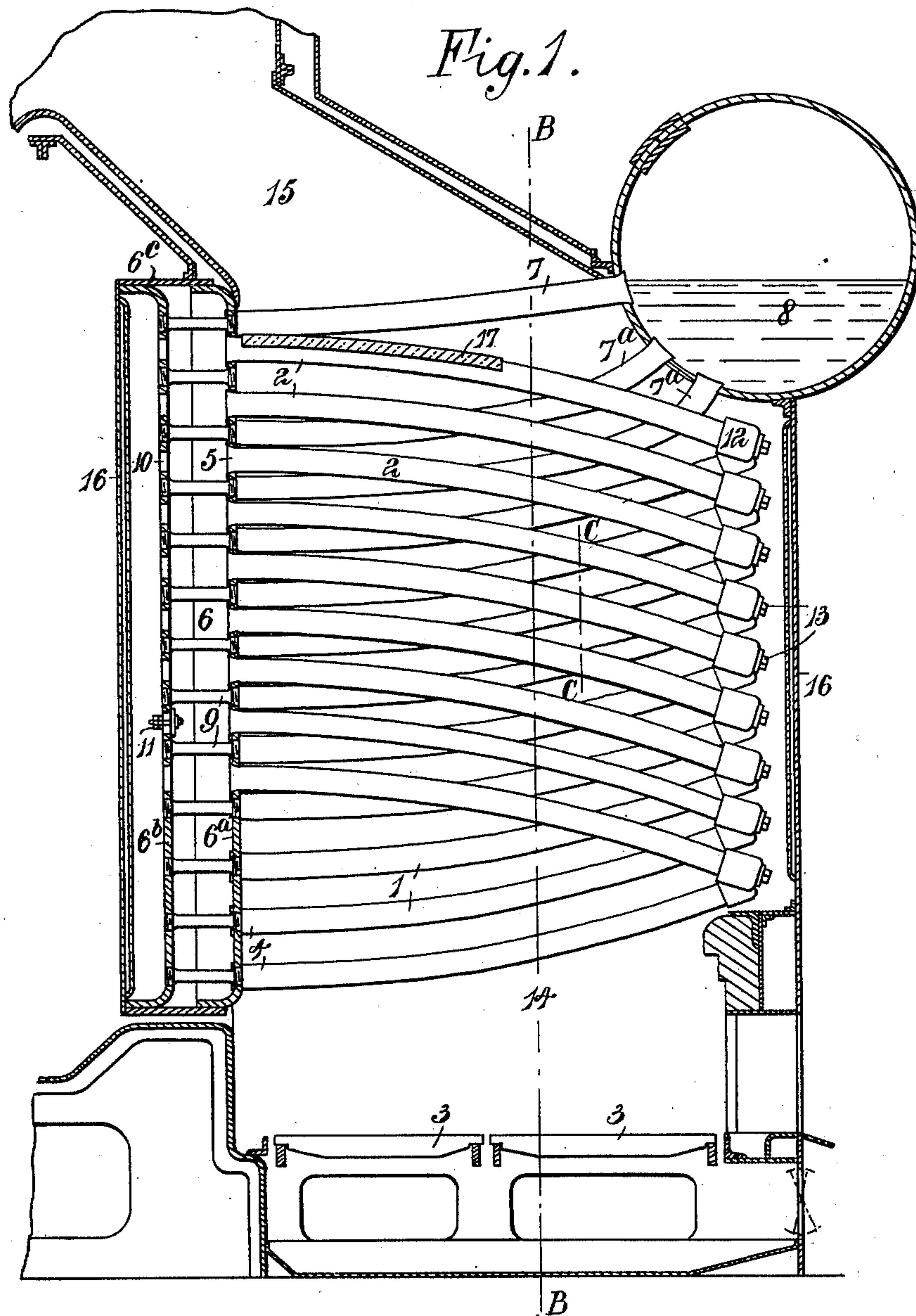
Patented Apr. 2, 1901.

J. E. THORNYCROFT.  
WATER TUBE BOILER.

(Application filed May 23, 1900.)

(No Model.)

4 Sheets—Sheet 1.



Attest:  
Geo H. Bott  
T. O. Schae

Inventor:  
John Edward Thornycroft  
by Phillips, Sawyer, Rice & Kennedy  
Attys.

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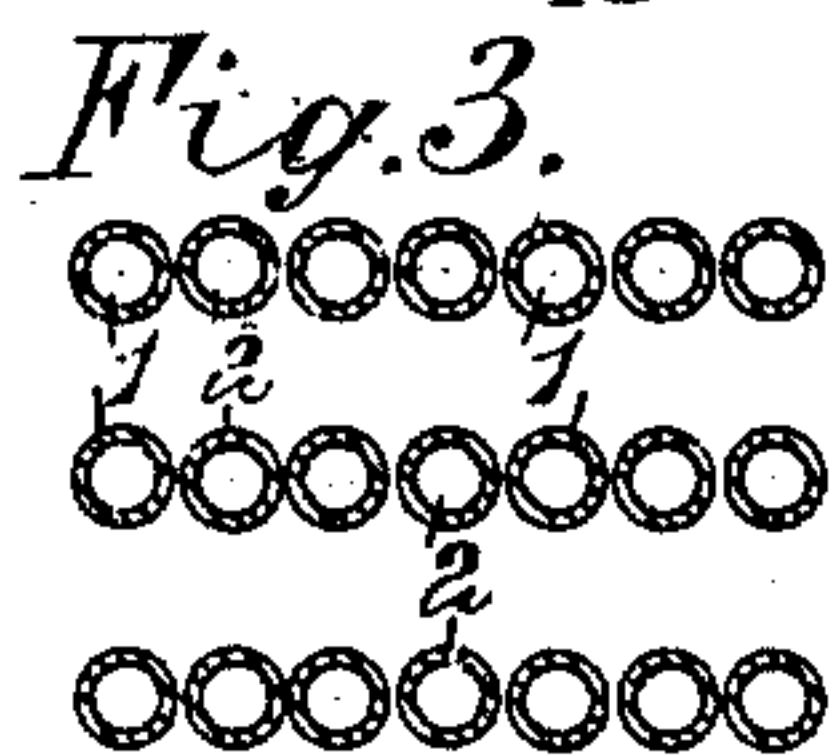
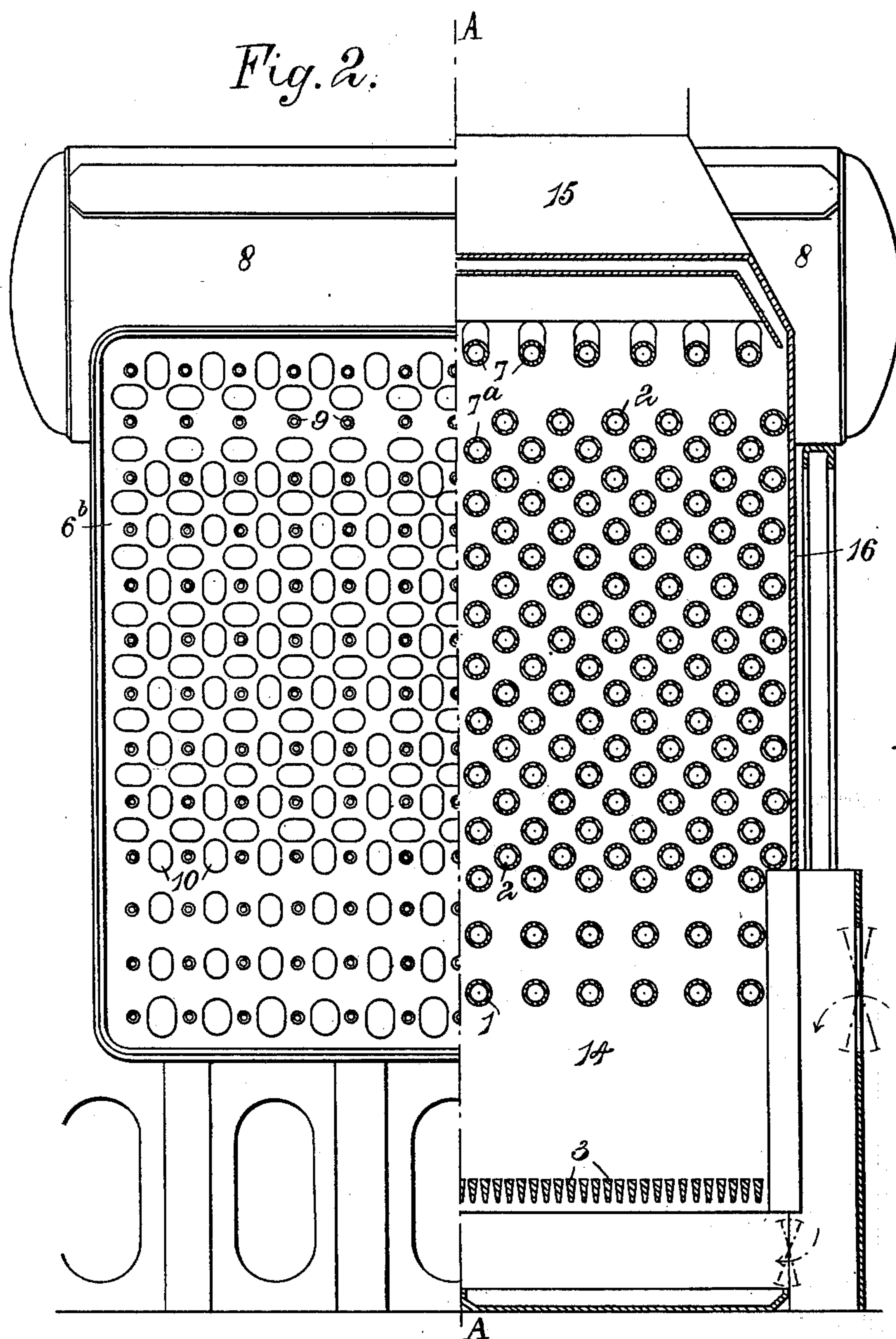
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4 Sheets— Sheet 2.



Attest  
Geo H. Botto.  
J. A. Lohoe

Inventor:  
John Edward Thornycroft  
by Philipps. Mueggen. Rea & Munnely  
Attys

No. 670,976.

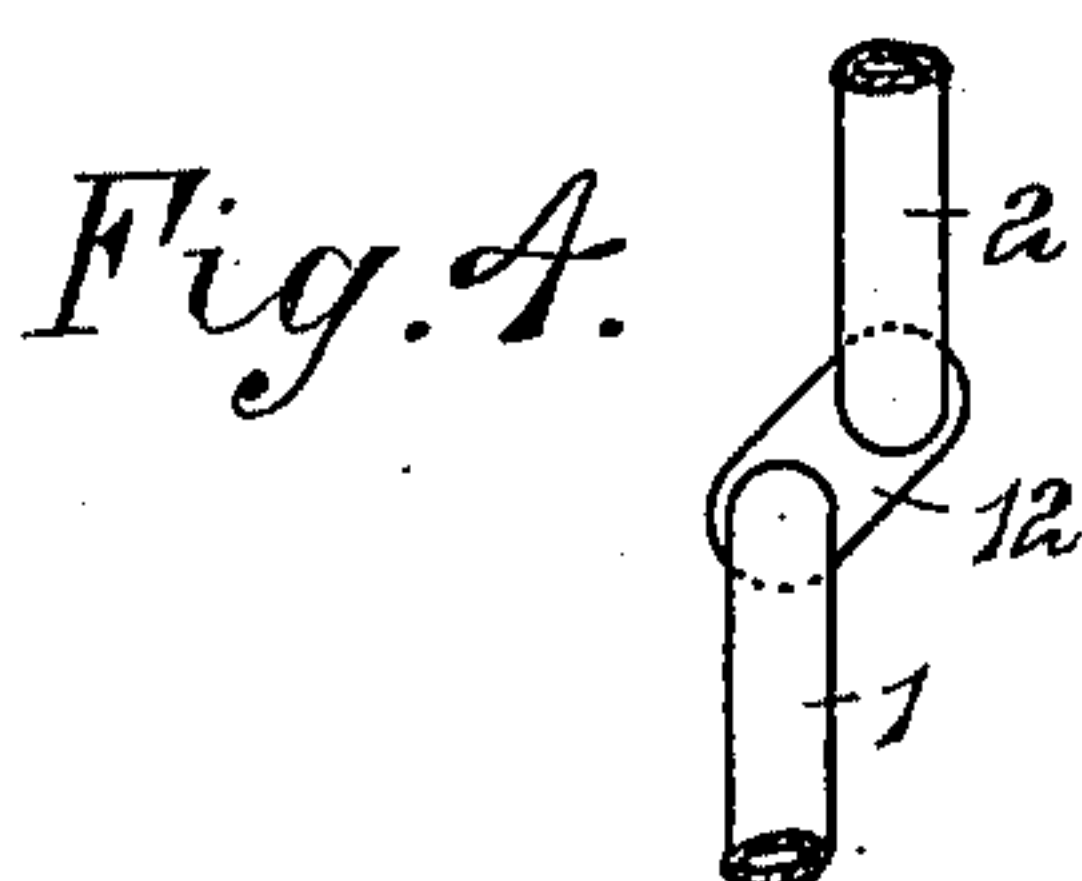
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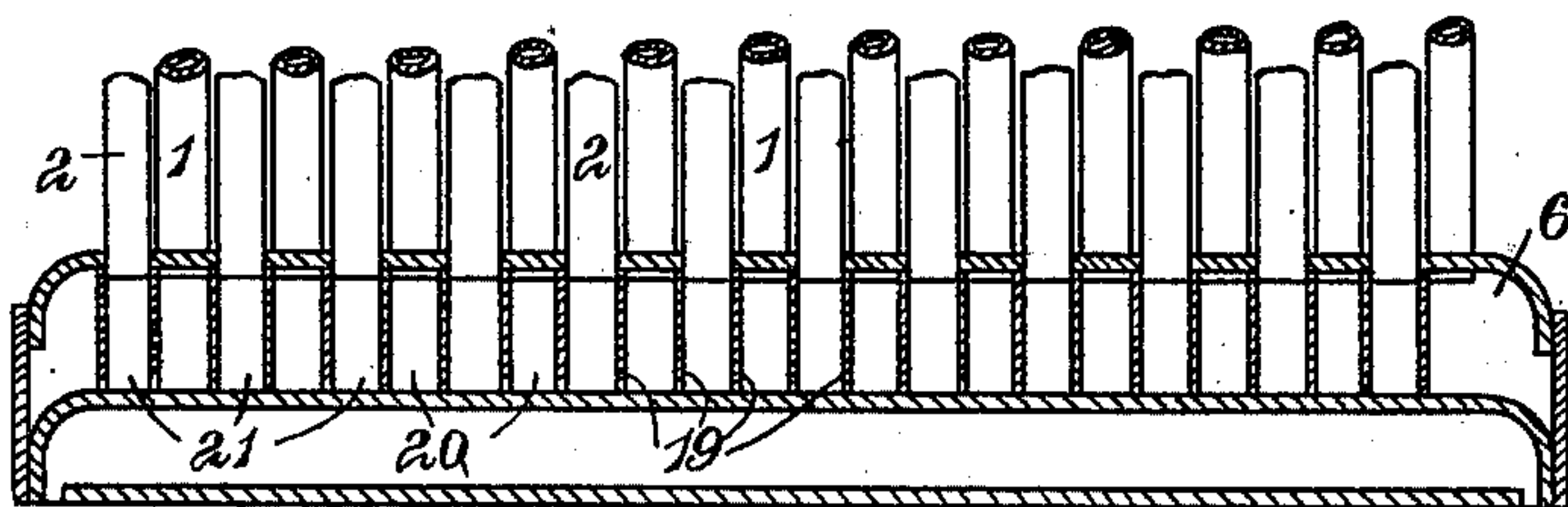
(Application filed May 23, 1900.)

(No Model.)

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*Fig. 5.*



*Attest:*  
*Geo H. Bott*  
*O. G. Asher*

*Inventor:*  
*John Edward Thornycroft*  
*By Philip P. Sawyer, Rice & Kennedy*  
*Attys*



No. 670,976.

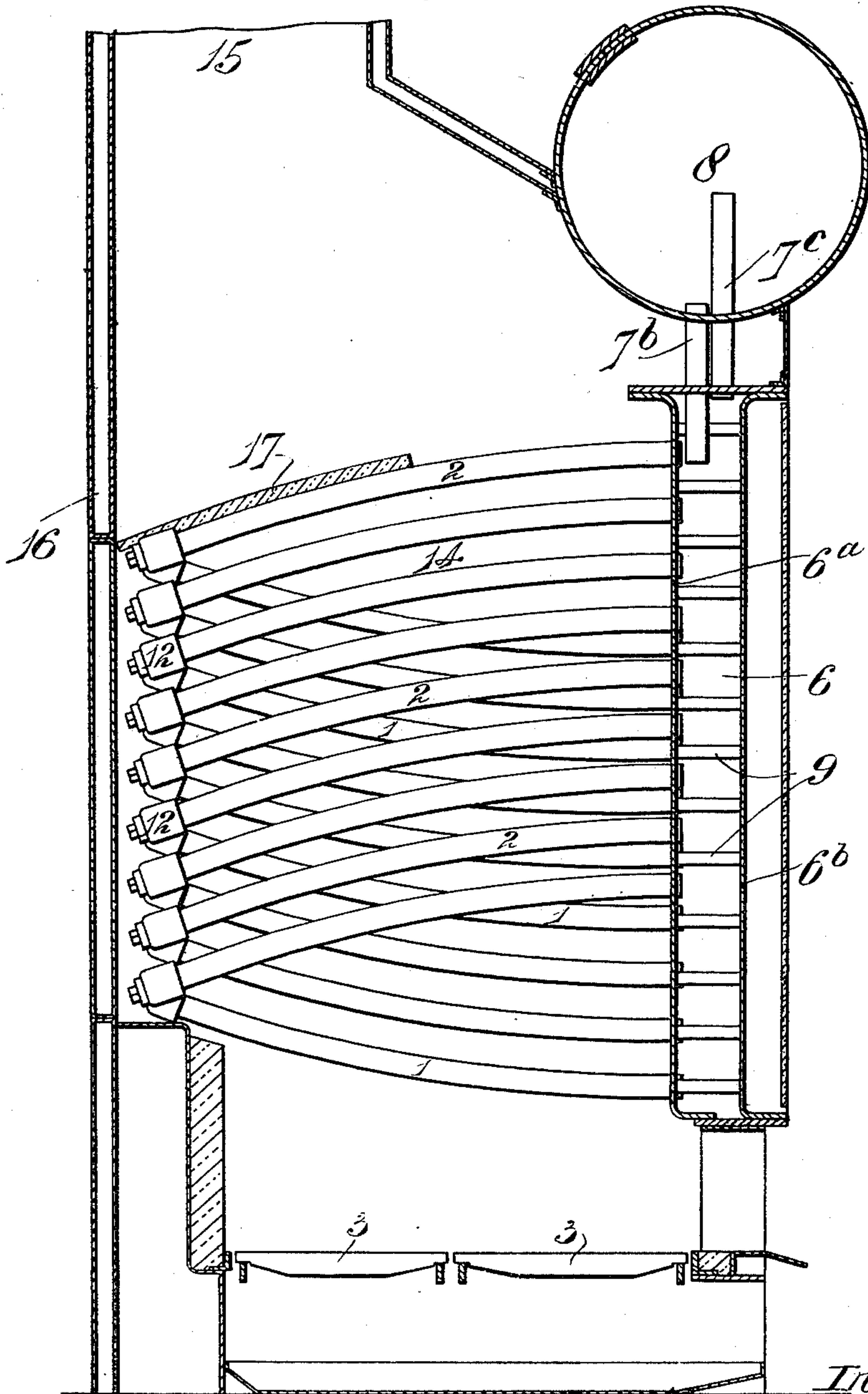
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*Fig. 6.*



Attest:  
Geo H. Bott  
T. F. T. Shae

Inventor:  
John Edward Thornycroft  
by Phillips, Sawyer, Rice & Kennedy  
Attorneys



# UNITED STATES PATENT OFFICE.

JOHN EDWARD THORNYCROFT, OF CHISWICK, ENGLAND.

## WATER-TUBE BOILER.

SPECIFICATION forming part of Letters Patent No. 670,976, dated April 2, 1901.

Application filed May 23, 1900. Serial No. 17,640. (No model.)

*To all whom it may concern:*

Be it known that I, JOHN EDWARD THORNYCROFT, a subject of the Queen of Great Britain and Ireland, residing at Homefield, Chiswick, in the county of Middlesex, England, have invented Improvements in Water-Tube Boilers, of which the following is a specification.

This invention has reference to water-tube boilers of the kind wherein water is caused to pass through a number of pairs of water-tubes that are arranged to extend from front to back of the boiler over a fire grate or grates, and the two tubes of each pair are inclined toward one another, as seen from either side of the boiler, and have their converging ends connected together through a junction-box and their diverging ends connected at different levels to one or more water-supply boxes or headers, so that water can flow upward simultaneously through all the pairs of tubes.

One object of the present invention is to enable water after flowing through the pairs of tubes and becoming thereby heated to immediately reënter the tubes without loss of time and heat, so that it can be quickly converted into steam and so enable a boiler of the kind referred to having a high evaporative efficiency to be obtained.

A further object is to enable the upper steam and water vessel to be connected to the upper part of the water-supply box or chamber in such a manner as to enable steam to readily flow from the latter to the former and water from the former to the latter through connections so arranged as not to unduly weaken the said steam and water vessel.

With these and other objects in view the invention consists in certain improved constructions and arrangements of parts of boilers of the kind referred to, as will be hereinafter fully described, and pointed out in the claims hereunto appended.

In the accompanying illustrative drawings, which form part of this specification, Figure 1 is a longitudinal section on the line A A of Fig. 2; and Fig. 2 is a part rear elevation and a part cross-section on the line B B of Fig. 1, showing a boiler of the kind referred to constructed according to this invention and suitable for marine use. Fig. 3 is a part section on the line C C of Fig. 1. Fig. 4 is a front

view of one of the pairs of water-tubes. Fig. 5 is a sectional plan view showing a modification. Fig. 6 is a similar view to Fig. 1, showing a modified construction of boiler suitable for land use.

1 and 2 are the two inclined water-tubes composing each pair of water-tubes extending from front to rear of the boiler above the fire-grate 3. The diverging ends 4 and 5 of each pair of water-tubes 1 and 2, respectively, are fixed in a common tube-plate 6<sup>a</sup>, that forms one wall of a vertically-arranged water-box 6, the interior of which is common to and is in free and direct communication with the interiors of all the water-tubes, so that the diverging ends 4 and 5 of the several tubes are in direct and free communication with each other through the said water-box. This water-box in the arrangement shown in Figs. 1 to 4, inclusive, which show the preferred construction of boiler, is arranged at the rear of the combustion-chamber, is closed at the bottom, and is directly connected by a number of forwardly-extending tubes 7<sup>a</sup> to the lower part of a comparatively large transversely-arranged cylindrical steam and water vessel 8, (hereinafter called the "steam-drum,") arranged at the front of the boiler above the converging ends of the pairs of water-tubes 1 and 2. Other tubes 7 connect the steam and water vessel 8 with the upper part of the water-box 6 and convey steam from the latter to the former. The other or rear flat wall 6<sup>b</sup> of the water-box is connected to the front wall 6<sup>a</sup> thereof by stays 9, (preferably made tubular,) and is formed with holes 10, that are arranged opposite the diverging ends 4 and 5 of the water-tubes 1 and 2 and are normally closed by suitable removable stoppers 11. The converging ends of each pair of water-tubes 1 and 2 are connected by a common junction-box 12, that is also formed with holes provided with stoppers 13, arranged opposite the adjacent ends of the tubes. By removing the stoppers 11 and 13 the tubes can be readily examined and cleaned. The connected water-tubes 1 and 2 and junction-boxes 12 are arranged in a combustion-chamber 14 above the fire-grate 3 (or grates) and below a chimney or uptake 15, and are inclosed in a suitable casing 16, the front and back of which are provided, as usual, with doors for gaining access to the tube ends.



By the construction described water can flow from the water-box 6 to the lower ends 4 of all the pairs of water-tubes 1 and 2 simultaneously, and water and steam can flow from the upper ends 5 of the pairs of tubes into the water-box 6, wherein the steam will rise to the top of the box and pass by the upper connecting-tubes 7 to the steam-drum 8, while the water can at once reënter the lower ends 4 of the water-tubes without the loss of time and heat that usually takes place when such water has first to pass up to the steam-drum 8 and thence back through an external or other downtake pipe or pipes to a lower water vessel, from which it flows through a number of vertical headers to the lower ends of the pairs of water-tubes, as in some earlier constructions of water-tube boilers of the type referred to. Water that enters the steam-drum 8 with the steam through the tubes 7 can return to the water-box 6 through the lower connecting-tubes 7<sup>a</sup>. Also by arranging the steam-drum 8 at the front of the boiler and the water-box 6 at the back thereof, as described, a comparatively large number of tubes 7 7<sup>a</sup> can be used for connecting the two. Consequently the holes in the lower part of the steam-drum can be made comparatively small and arranged in a zigzag manner, so that the steam-drum will not be weakened to such an extent as when the water-box is located directly below it and communicates with its interior through a single row of comparatively large holes, as in some former constructions of boilers of the type referred to.

The junction-box 12, connecting the converging ends of each pair of water-tubes 1 and 2, is inclined upward from the part where the lower tube 1 is connected to it to the part where the upper tube 2 is connected to it, Fig. 4, in order that the said tubes may be arranged closer together, as seen in plan, than would be possible if the junction-box were arranged horizontally. By this arrangement the inner walls of the tubes of each pair can be brought into approximately the same vertical plane. Also the holes in the tube-plate 6<sup>a</sup>, in which the ends 4 and 5 of the tubes 1 and 2 are fixed, are for a like purpose and as shown in Fig. 2 correspondingly arranged, so that, as seen in plan, the tubes 1 and 2 of each pair are parallel and apparently touching one another, or nearly so. By this means when all the water-tubes are in place within the combustion-chamber 14 the hot gases will have to take a zigzag course between the tubes while passing to the chimney, no vertical spaces of appreciable width being left between the tubes through which hot gases can ascend without being brought into intimate and effective contact with the tubes. One or more baffle-plates or devices 17 may be arranged on or above or between the uppermost water-tubes to assist the effective distribution of the hot gases among the tubes.

The water-tubes 1 and 2 are or may advantageously be slightly curved in the direction

of their length, the curvature being such that the lower tube 1 of each pair is convex toward the fire and the upper tube 2 of each pair is concave on the side toward the fire, as described in the specification of another application for Letters Patent filed by me, dated November 27, 1899, Serial No. 738,316. By this arrangement I obviate the injurious effects of the unequal expansion of the tubes brought about by reason of the lower tube of each pair being exposed to greater heat than the upper tube—viz., the tendency as the temperature rises of the upper tube of the pair to be withdrawn from the tube-plate 6<sup>a</sup> and junction-box 12, to which it is connected, the tendency of the lower tube of the pair to be forced into the said tube-plate and junction-box, whereby leaky joints are produced, and the tendency of the tubes to lift the junction-boxes by reason of unequal expansion of the tubes 1 and 2. The curving of the tubes also facilitates the escape of steam therefrom and so minimizes liability of overheating of the tubes. Furthermore, the curving of the tubes also enables their rear ends to be arranged at right angles to the tube-plate 6<sup>a</sup>, in which they can consequently be readily expanded and secured and facilitates the withdrawal of the tubes.

The water-box 6 may, as shown in Fig. 1, conveniently be formed of two approximately rectangular dished plates 6<sup>a</sup> 6<sup>b</sup>, fixed at a suitable distance apart by the stays 9 and secured by their flanged edges to and within an outer or peripheral plate 6<sup>c</sup> of approximately rectangular shape in end view. The water-box is or may be provided with a blow-off cock, so that all the pairs of water-tubes 1 and 2 can be simultaneously and quickly emptied of water when desired.

Instead of a single wide water-box constructed and arranged as described and common to all the pairs of connected water-tubes two or more narrower water-boxes may in some cases be used, arranged side by side. This modified construction will be understood from Fig. 2 if it be assumed that the dotted line A A shows the division between adjacent water-boxes.

A water-box 6, such as hereinbefore described and having no internal division-plates, may in some cases, as shown in Fig. 6, be arranged at the front of the boiler below the steam-drum 8, to which it is suitably connected, as by two rows of tubes 7<sup>b</sup> 7<sup>c</sup>, the converging ends of the pairs of water-tubes 1 and 2 being then at the rear of the boiler. This construction of boiler, which in other respects is like that hereinbefore described with reference to Figs. 1 to 4, inclusive, is more particularly suitable for land and other use where it is not desired to use it back to back with another boiler and where the pairs of water-tubes can therefore be readily withdrawn from the back of the boiler.

As will be obvious, various changes in the construction and arrangement of the boiler



may be made without departing from the essential features of the invention. The invention is not, therefore, to be considered as limited to the precise constructions described and shown, but as embracing all changes and variations which fall within its spirit and scope.

What I claim is—

1. In a steam-boiler, the combination of a plurality of independent pairs of water-tubes, the two tubes of each pair being arranged in different vertical planes and connected together at one end by a junction-box and having their other ends located at different levels, an upwardly-extending water-box having one of its sides connected to the ends of the tubes that are at different levels, and an upper steam and water vessel connected to said water-box, substantially as described.

2. In a steam-boiler, the combination of a plurality of independent pairs of inclined water-tubes, the two tubes of each pair being inclined toward one another and arranged with their inner walls in approximately the same vertical plane, and having their converging ends connected together by a junction-box, a water-box closed at the bottom and to one side of which the diverging ends of the pairs of water-tubes are connected at different levels, and an upper steam and water vessel connected to said water-box, substantially as described.

3. In a steam-boiler, the combination of a plurality of independent pairs of water-tubes, the two tubes of each pair being arranged in different vertical planes, connected together at one end by a junction-box and having their other ends located at different levels, an upwardly-extending water-box having one of its sides connected to the ends of the tubes that are at different levels and its interior undivided and in direct free and open communication with the interior of said water-tubes so that water can flow direct from the outlet ends of said pairs of tubes to the inlet ends thereof through said water-box, and an upper steam and water vessel connected to said water-box, substantially as described.

4. In a steam-boiler, the combination of an upwardly-extending water-box, pairs of oppositely-inclined water-tubes connected at one end to and extending from one side of said water-box and connected at their other ends by junction-boxes, and an upper steam and water vessel connected to said water-box and located above said junction-boxes, substantially as described.

5. In a steam-boiler, the combination of an upwardly-extending water-box arranged at the rear of the boiler, a plurality of pairs of oppositely-inclined water-tubes extending from front to back of the boiler and having their diverging ends connected at different levels to the front wall of said water-box and their converging ends connected together by junction-boxes, and an upper steam and wa-

ter vessel connected to the upper part of said water-box, substantially as described.

6. In a steam-boiler, the combination of a plurality of pairs of water-tubes, one of the tubes of each pair being inclined upward and the other downward, the tubes of each pair having their axes in parallel vertical planes and arranged to cross and be arranged in close proximity to the tubes of laterally-adjacent pairs of tubes, means for supplying water to the lower ends of said pairs of tubes, and an upper steam and water drum in communication with the upper ends of said water-tubes, substantially as described.

7. In a steam-boiler, the combination of one or more water-boxes, water-tubes fixed to and extending from one side of said water box or boxes, said tubes being arranged in vertical rows with the axes of the tubes in each row in the same vertical plane, the tubes in each alternate row being inclined upward and those in the intermediate rows downward, and the tubes in each row crossing and being arranged in close proximity to the tubes in adjacent rows, junction-boxes each connecting the adjacent converging ends of two tubes together so as to form a connected pair of tubes, and an upper steam and water vessel connected to said water-box, substantially as described.

8. In a steam-boiler, the combination of a plurality of pairs of water-tubes, the tubes of each pair being inclined to each other and connected together at their converging ends and each curved in the direction of its length, a water-box having a free and undivided interior so that the diverging ends of all the pairs of tubes connected to said box are in direct and free communication with each other through said water-box, and an upper steam and water vessel connected to said box.

9. A steam-boiler comprising a furnace-chamber, an upwardly-extending water-box arranged at the rear of the boiler, a plurality of pairs of oppositely-inclined water-tubes connected at their diverging ends to the front wall of said water-box and extending over the fire-box toward the front of said boiler, the two tubes of each pair being arranged in different vertical planes and connected together at their converging ends by junction-boxes, an upper steam and water vessel connected to said water-box, an uptake located above said water-tubes, and a casing inclosing said water-tubes, substantially as described.

10. A steam-boiler comprising a furnace-chamber, an upwardly-extending water-box arranged at the rear of the boiler, a plurality of pairs of oppositely-inclined water-tubes connected at their diverging ends to the front wall of said water-box, extending over the fire-box toward the front of said boiler and connected together at their converging ends by junction-boxes, an upper steam and water vessel arranged transversely at the front of the boiler, a plurality of tubes located above



said water-tubes and connecting the upper part of said water-box to said steam and water vessel, an uptake located above said water and connecting tubes, and a casing inclosing said water-tubes, substantially as described.

11. A steam-boiler comprising a plurality of pairs of water-tubes extending from front to back of the boiler and arranged one above the other in laterally-adjacent vertical rows, the tubes of each pair being inclined to each other and to the horizontal and having their axes in parallel vertical planes, a water-box closed at the bottom, located at the rear of the boiler and to the front side of which the diverging ends of said water-tubes are fixed, junction-boxes connecting the converging ends of said pairs of tubes and arranged one above the other in vertical rows at the front of the boiler and each inclined to the planes containing the axes of the tubes, an upper transversely-arranged steam and water vessel located at the front of the boiler and connected to the upper portion of said water-box, a furnace-chamber arranged below said water-tubes, a casing surrounding said water-tubes, and a chimney or uptake located above said water-tubes, substantially as described.

12. A steam-boiler comprising a flat-sided and stayed vertical water-box located at the rear of the boiler and having a free undivided interior, the rear wall of said water-box being formed with holes normally closed by removable stoppers, pairs of oppositely inclined and curved water-tubes 1 and 2 having their diverging ends fixed to the front side of said water-box and arranged in different vertical planes, inclined junction-boxes with removable stoppers connecting the converging ends of said water-tubes, an upper transverse steam and water vessel located at the front of said boiler, rows of tubes arranged above the pairs of water-tubes and connecting the lower portion of said steam and water vessel to the upper portion of said water-box, a furnace-chamber located below said water-tubes, a chimney located above the water and connecting tubes, and a casing inclosing said water-tubes, substantially as described.

Signed at 77 Cornhill, in the city of London, England, this 7th day of May, 1900.

JOHN EDWARD THORNYCROFT.

Witnesses:

EDMUND S. SNEWIN,  
WM. O. BROWN.