No. 666,713. Patented Jan. 29, 1901.

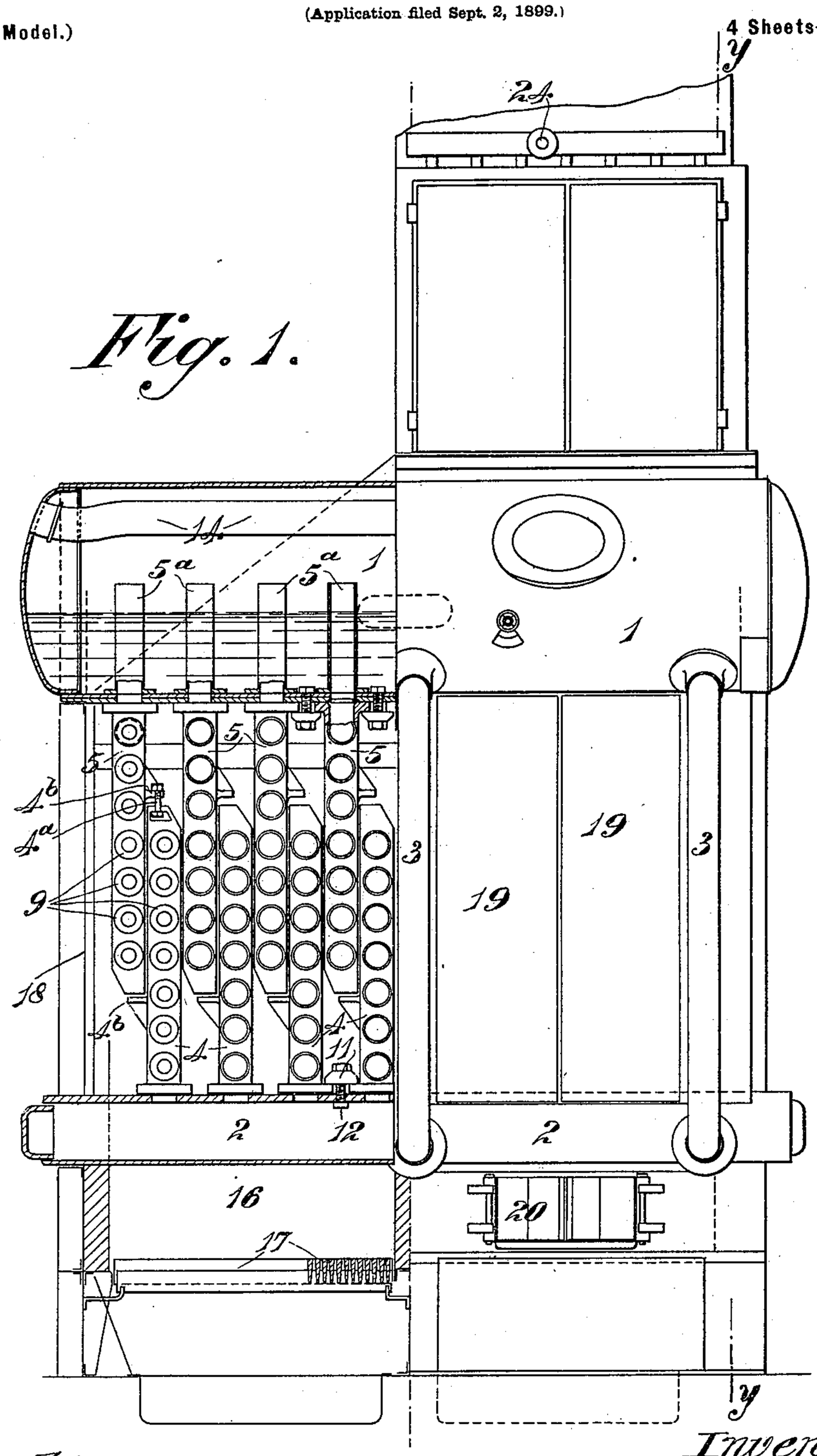
J. E. THORNYCROFT.

STEAM BOILER.

(Application filed Sept. 2, 1899.)

(No Model.) 4 Sheets—Sheet 1.

Fig. 1.



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THE NORRIS PETERS CO., PHOTO-LITHO., WASHINGTON, D. C.

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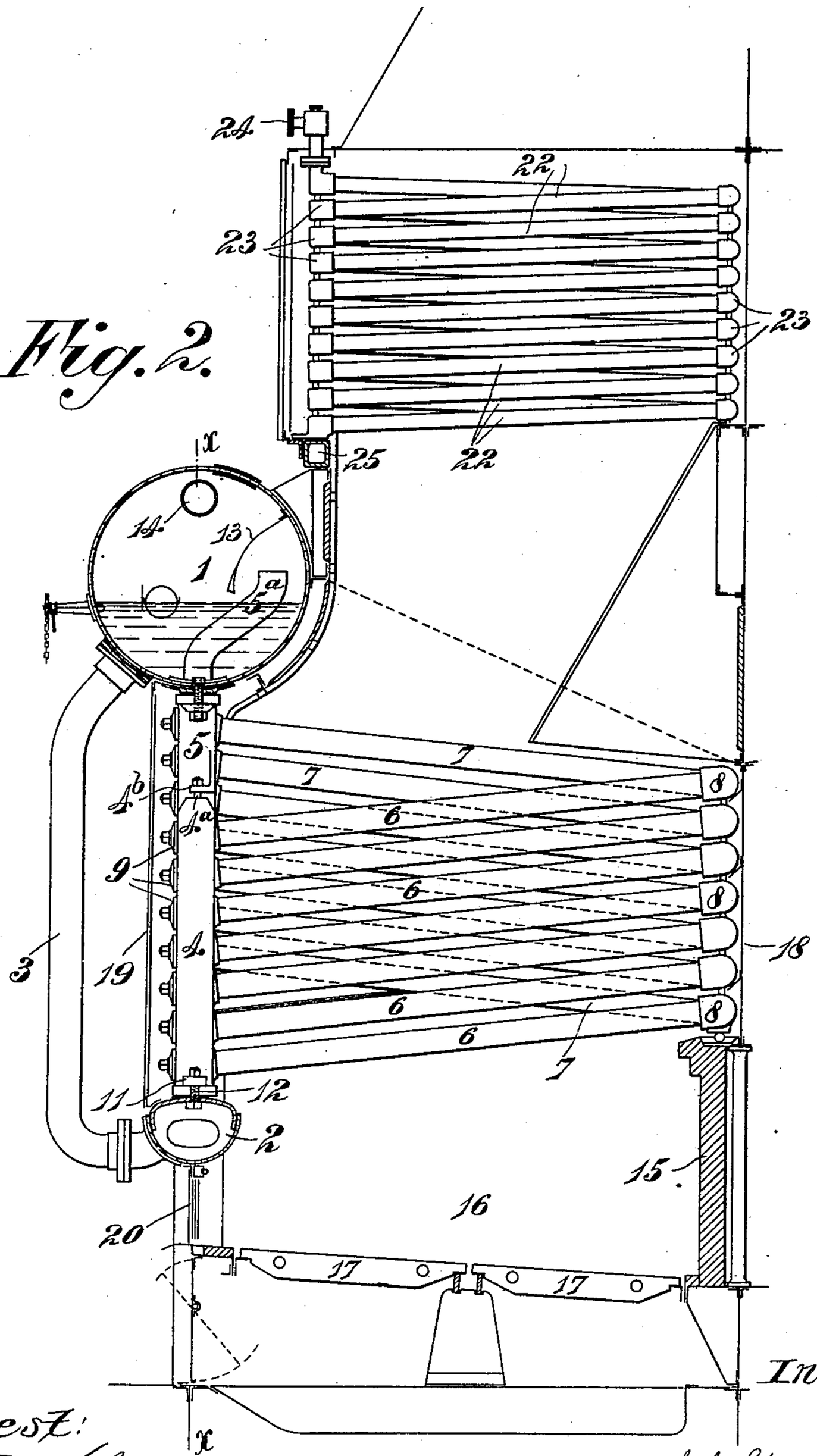
(No Model.) 4 Sheets—Sheet 2.

Fig. 2.



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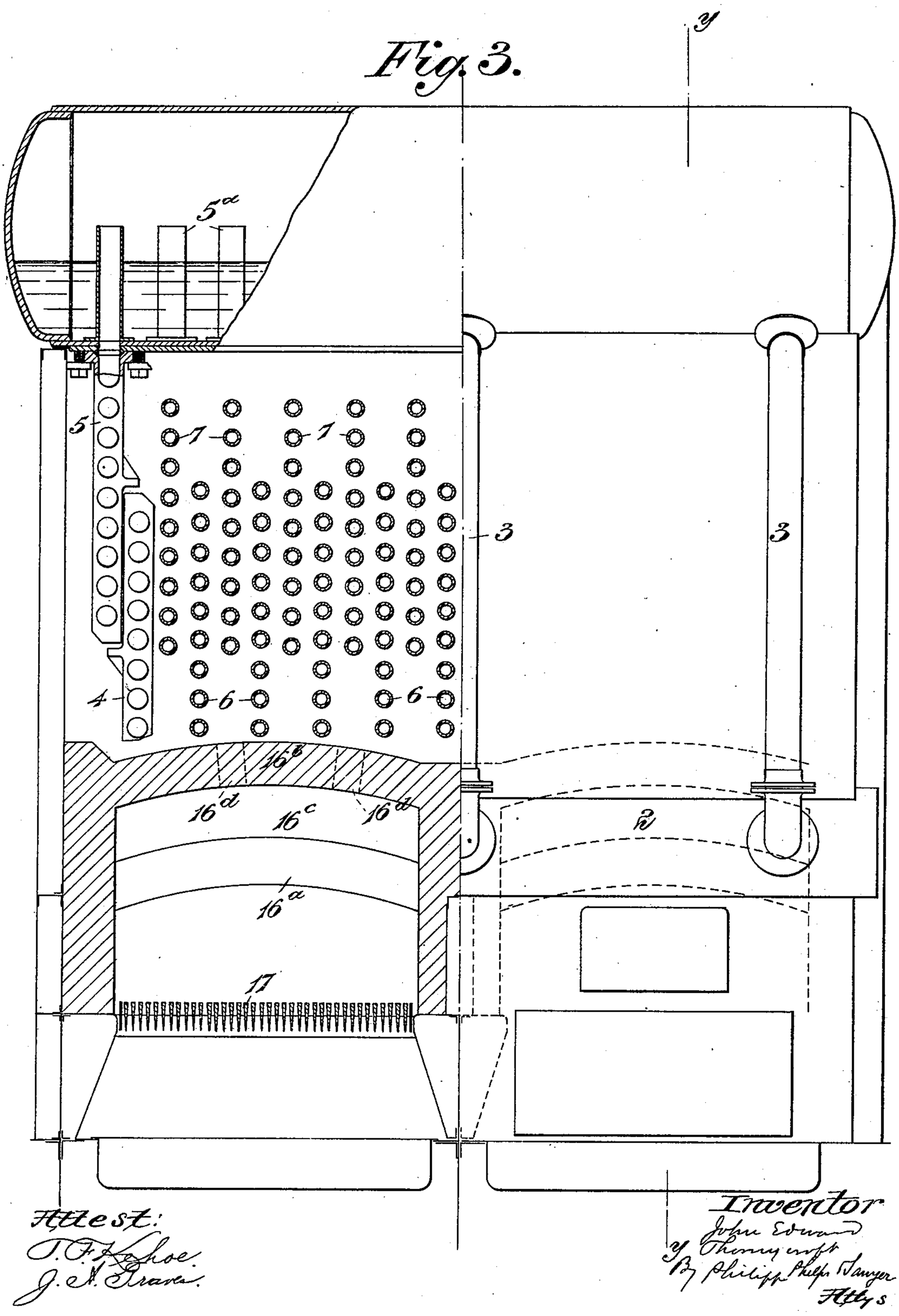
(No Model.) 4 Sheets—Sheet 3.

Fig. 3.



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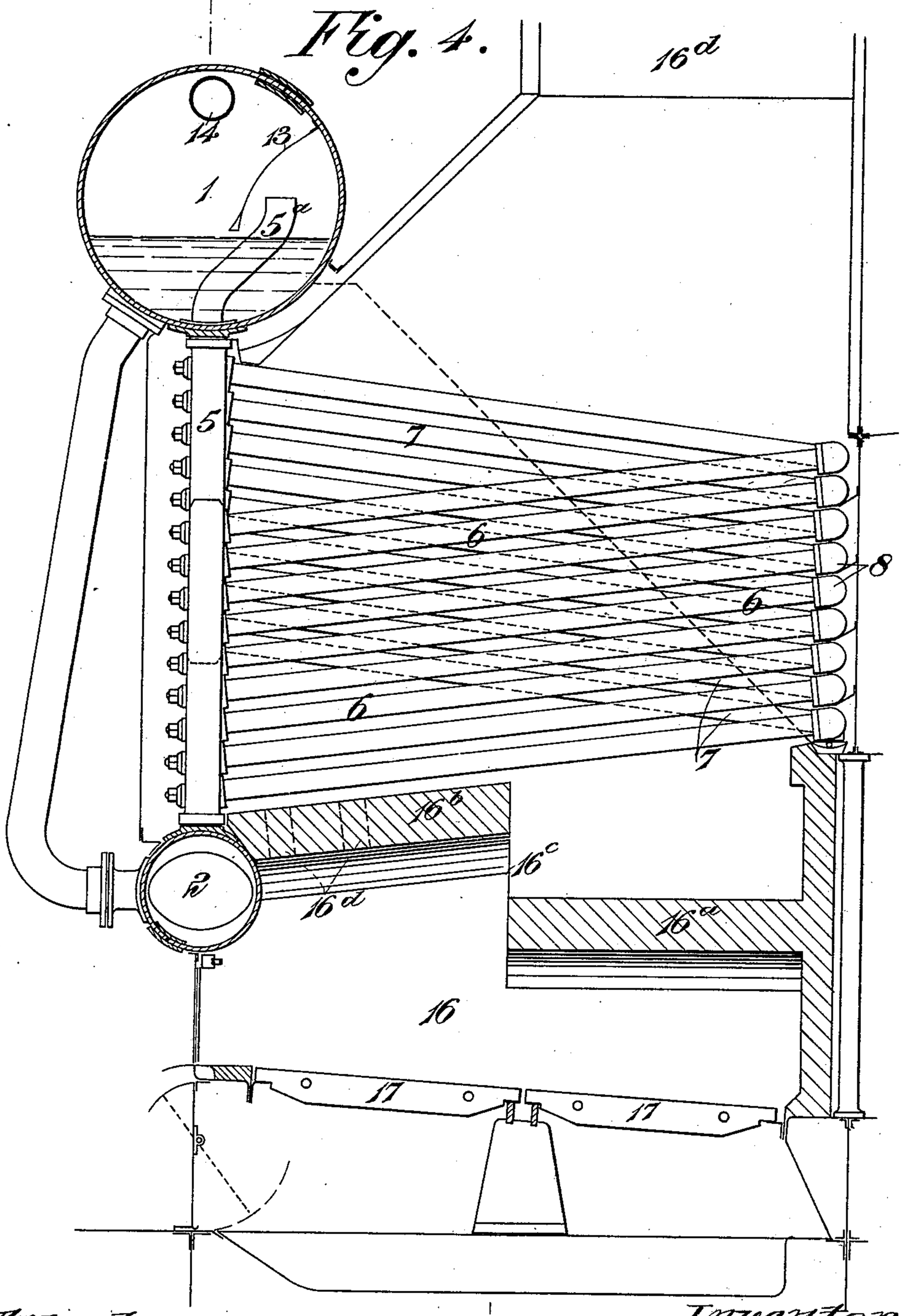
(No Model.) 4 Sheets—Sheet 4.

Fig. 4.



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UNITED STATES PATENT OFFICE.

JOHN EDWARD THORNYCROFT, OF LONDON, ENGLAND.

STEAM-BOILER.

SPECIFICATION forming part of Letters Patent No. 666,713, dated January 29, 1901.

Application filed September 2, 1899. Serial No. 729,299. (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, Cheswick, London, in the county of Middlesex, England, have invented Improvements in Steam-Boilers, of which the following is a specification.

This invention has reference to a construction of steam-boiler wherein an upper cylindrical steam and water vessel (hereinafter called the "steam-drum") is connected to a lower water pipe or vessel (hereinafter called the "lower water vessel") by a series of tubular steam-generating elements, each of which comprises two vertical or approximately vertical and adjacent pipes or headers (hereinafter called "headers) that are connected together by a number of pairs of straight water-tubes, which are located above the fire-grate and are arranged at an angle to one another—*i. e.*, the tubes in each pair—one of the two headers of each element being connected to the lower water vessel and to the lower end of each of the several pairs of water-tubes belonging to the element, and the other header being connected to the steam-drum and to the upper end of each of the several pairs of water-tubes, the other ends of each pair of water-tubes being connected together in any suitable way. The arrangement is such that when the boiler is in use water will flow from the lower water vessel into the lower header of each element and will then flow simultaneously through all the pairs of inclined water-tubes, which may be said to be in parallel to one another, of each element into the upper header of the element, and thence into the steam-drum, where the steam generated by the passage of the water through the tubes will become separated from the water. The upper headers may deliver water and steam into the steam-drum above the water-level therein, the water-space of the steam-drum being connected to the lower water vessel by one or more downtake-tubes. By constructing steam-generating elements in the manner hereinbefore described a large heating-surface is provided, while at the same time the length of tube through which water flows on its way from the lower water vessel to the steam-drum is comparatively short, whereby I insure that all the tubes shall be filled with water, and thus obviate the liability that obtains in practice when a large number of tubes are connected in series to form a long water-tube of portions of such tube being unduly heated and fractured owing to its containing steam only or to the occurrence of a reversed flow of steam or water through the lower end of the tube, whereby efficient circulation is prevented.

The several parts of a steam-boiler of the kind hereinbefore described can be variously arranged.

In the accompanying illustrative drawings, Figure 1 shows, partly in cross-section on the line *x x* of Fig. 2 and partly in end elevation, and Fig. 2 partly in longitudinal section on the line *y y* of Fig. 1 and partly in front elevation, one construction of steam-boiler according to this invention. Figs. 3 and 4 are similar views to Figs. 1 and 2, showing a modified construction.

According to this construction the steam-drum 1, which is made of comparatively large capacity, is arranged longitudinally at the front of the boiler and above a longitudinally-arranged lower water vessel 2, which is or may be made of comparatively small diameter and is connected to the water-space of the steam-drum by external downtake-tubes 3, of which there are three in the example shown.

4 and 5 are respectively the lower and upper headers of each steam-generating element, these headers being arranged vertically side by side at the front of the boiler and connected together by bolts 4^a and lugs 4^b.

6 and 7 are inclined water-tubes arranged in pairs, the tubes 6 and 7 in each pair being respectively connected in any suitable way at their front ends to the corresponding pair of headers 4 and 5. Each pair of tubes 6 and 7, which are made straight and of comparatively large diameter, are connected together at their rear ends by a junction-box 8, in which they are suitably fixed, but which is not fixed in position, so that each V-shaped pair of water-tubes thus obtained is free to expand and contract, the outer—*i. e.*, front—sides of the headers 4 and 5 provided with removable covers or closures 9, so that access can be readily gained to each tube for inspecting, cleaning, or removing it. The outer—*i. e.*,

rear—side of each junction-box 8 may also be provided with a removable cover or closure for a like purpose. The lower header 4 of each element is connected to the top of the lower water vessel 2 in a readily-detachable manner, and the upper header 5 of each element is similarly connected to the lower side of the steam-drum 1, so that the complete element comprising the connected headers 4 5, tubes 6 and 7, and junction-box 8 can be readily removed or replaced when desired. In the example shown the adjacent lower ends of the lower headers 4 are clamped to the water vessel 2 by clamping-plates 11 and bolts and nuts 12, the adjacent upper ends of the upper headers 5 being similarly connected to the lower side of the steam-drum 1.

The upper headers 5 may be each provided with an upward extension 5^a, through which water and steam can be delivered above the water-level in the steam-drum 1.

13 is a baffle-plate, below which the upward extensions 5^d terminate, and 14 is the steam-main.

The connected elements are supported at the front by the lower water vessel 2 and at the back by a rear wall 15, above a fire-box 16 and grate 17 and within a casing 18, that may be of any known or suitable construction and is provided with suitable doors 19 and 20 for gaining access, respectively, to the water-tubes 6 7 and fire-box 16. In the example shown there are two fire-grates 17 extending from front to rear of the boiler below the water-tubes 6 7.

In order to obtain in a boiler constructed as described efficient combustion and good evaporative results with inferior fuel and also to obtain as nearly uniform distribution of the flame and hot gases among the water-tubes as possible, each fire-grate 17 may advantageously be covered, as shown in Figs. 3 and 4, with a fire-box of refractory brickwork having its roof made in two parts 16^a 16^b, arranged at different levels, with a narrow exit-opening 16^c between their adjacent ends. The two parts may be variously arranged. In the example shown the rear part 16^a is the lowest and the front part 16^b is inclined upward and backward; but this arrangement may be varied. With this arrangement when the boiler is in action the fire-brick walls and roof of each fire-box are raised to a high temperature and assist in mixing the gases and vapors resulting from the more or less complete combustion of the fuel with the air admitted to the fire-box and heating the mixture, with the result that practically complete combustion of the gaseous products is obtained and formation of soot avoided. Also the flame and hot gases on escaping from each fire-box through the exit-opening 16^c are directed backward in consequence of their inertia and are to a large extent caused to flow upward among and between the rear portions of the water-tubes, which are nearer together and offer greater resistance to the flow of the hot gases than the front portions of the tubes, which, as will be seen from Fig. 4, will offer much less resistance to the flow of the hot gases among them, owing to many of the lower tubes 6 and upper tubes 7 not being crossed by adjacent tubes. To insure that the front portions of the lower water-tubes 6 shall be effectually heated and perform their share of the work to be done, the front portion 16^b of the roof is formed with a few exit-holes 16^d, through which flame and hot gases can escape and come in contact with such portions of tube. To assist in the effective distribution of the flame and hot gases among the water-tubes, the chimney or uptake 16^e may, as shown in Fig. 4, be arranged above the rear portions of the water-tubes 6 7.

Steam-generating elements constructed according to this invention can with advantage be applied to many existing steam-boilers in place of the steam-generating elements previously employed therein. Also the combined steam-drum 1, water vessel 2, and steam-generating elements 4, 5, 6, and 7 constructed according to this invention may replace the corresponding parts of some kinds of existing steam-generators, so as to admit of the furnaces and casings of such steam-generators being utilized.

Two or more steam-generators of the kind hereinbefore described may be arranged back to back in a common casing, as in known constructions of boilers. A feed-water heater for use with the boiler hereinbefore described may, as shown at 22, be arranged above the steam-generating elements, as in existing types of boilers. This feed-water heater may be of any suitable construction, and in the example shown consists of a number of sets of inclined tubes 22, that are connected at their ends to junction-boxes 23 and are provided with an inlet 24 at the top and an outlet 25 at the bottom. The feed-water-regulating apparatus may be arranged external to or within the steam-drum, but preferably the latter.

What I claim is—

1. In a steam-boiler, the combination with an upper steam-drum and a lower water vessel, of a number of steam-generating elements each comprising upper and lower headers connected respectively to said steam-drum and water vessel, and a plurality of inclined pairs of straight water-tubes arranged one above the other and connecting the said headers at different heights.

2. In a steam-boiler, the combination with an upper steam-drum and a lower water vessel, of a number of steam-generating elements each comprising upper and lower headers connected respectively to said steam-drum and water vessel, and a plurality of pairs of straight water-tubes extending from and connecting said headers at different heights, the pipes of each pair being inclined

to one another, arranged with their axes in an inclined plane, and connected together at their rear ends by a junction-box.

3. A steam-boiler comprising an upper steam-drum, a lower water vessel, a series of steam-generating elements each comprising an upper header arranged to deliver into said steam-drum, a lower header connected to said water vessel, straight water-tubes extending in oppositely-inclined directions from said pair of headers, and junction-boxes each connecting the free ends of a pair of tubes that are inclined in opposite directions and are connected at their other ends the one to the lower header and the other to the upper header, and one or more downtake-tubes connecting said steam-drum and lower water vessel.

4. A steam-boiler comprising an upper steam-drum and a lower water vessel arranged at the front end of the boiler, a series of steam-generating elements each comprising two upwardly-extending tubular headers arranged side by side at the front of the boiler and connected the one to the steam-drum and the other to the water vessel, a number of pairs of straight water-tubes connecting said pair of headers and extending rearwardly and in oppositely-inclined directions therefrom, and junction-boxes connecting the rear ends of each pair of oppositely-inclined tubes, and a fire-box below said water-tubes, substantially as described.

5. A steam-boiler comprising an upper steam-drum, a lower water vessel, a series of steam-generating elements each comprising two upwardly-extending tubular headers arranged side by side, water-tubes arranged in pairs one above the other and connected in parallel and at various heights to said headers, the tubes of each pair having their axes inclined to one another and located in an inclined plane, and junction-boxes each connecting the rear ends of a pair of oppositely-inclined tubes, one of the headers of each pair being connected to the steam-drum and arranged to deliver into the steam-space thereof and the other header of the pair being connected to the lower water vessel, a casing surrounding said steam-generating elements, a fire-box below said water-tubes, and one or more downtake-tubes external to said casing, substantially as described.

6. A steam-boiler comprising the upper longitudinal steam-drum 1 and lower longitudinal water vessel 2 arranged at the front of the boiler, the tubular headers 4 and 5 detachably clamped to said water vessel and steam-drum respectively and provided with removable covers or closures at their front sides, the headers 5 each having an upward extension 5^a delivering into the steam-space of said steam-drum, the straight water-tubes 6 and 7 arranged in pairs one above the other and the rear junction-boxes 8 resting one upon another, the water-tubes of each pair being inclined to one another and to the horizontal and connected at their front ends to the corresponding pair of headers at different heights and at their rear ends to one of said junction-boxes, a fire-box below said water-tubes, a casing surrounding said headers and tubes and provided at the front with doors for gaining access to the headers and fire-box, and downtake-tubes located at the front of said casing and connecting the water-space of said steam-drum to said lower water vessel, all substantially as described and shown.

7. A steam-boiler comprising an upper steam-drum, a lower water vessel, a number of steam-generating elements each comprising upper and lower headers connected respectively to said steam-drum and water vessel and a plurality of inclined pairs of straight water-tubes arranged one above the other and connecting the said headers at different heights, and a fire-box located below said water-tubes and having a roof of refractory material made in two parts arranged at different levels with a narrow exit-opening between their adjacent ends, substantially as described for the purpose specified.

8. A steam-boiler comprising an upper steam-drum and a lower water vessel arranged at the front end of the boiler, a series of steam-generating elements each comprising two upwardly-extending tubular headers arranged side by side at the front of the boiler and connected the one to the steam-drum and the other to the water vessel, a number of pairs of straight water-tubes connecting said pair of headers and extending rearwardly and in oppositely-inclined directions therefrom, and junction-boxes connecting the rear ends of each pair of oppositely-inclined tubes, and a fire-box located below said water-tubes and formed of refractory material, the roof of said fire-box being made in two parts arranged at different levels with a narrow exit-opening between their adjacent ends, the back part of the roof being the lowest and the front part having holes therethrough, substantially as described for the purposes specified.

Signed at 77 Cornhill, in the city of London, England, this 15th day of June, 1899.

JOHN EDWARD THORNYCROFT.

Witnesses:
EDMUND S. SNEWIN,
WM. O. BROWN.