

No. 639,952.

Patented Dec. 26, 1899.

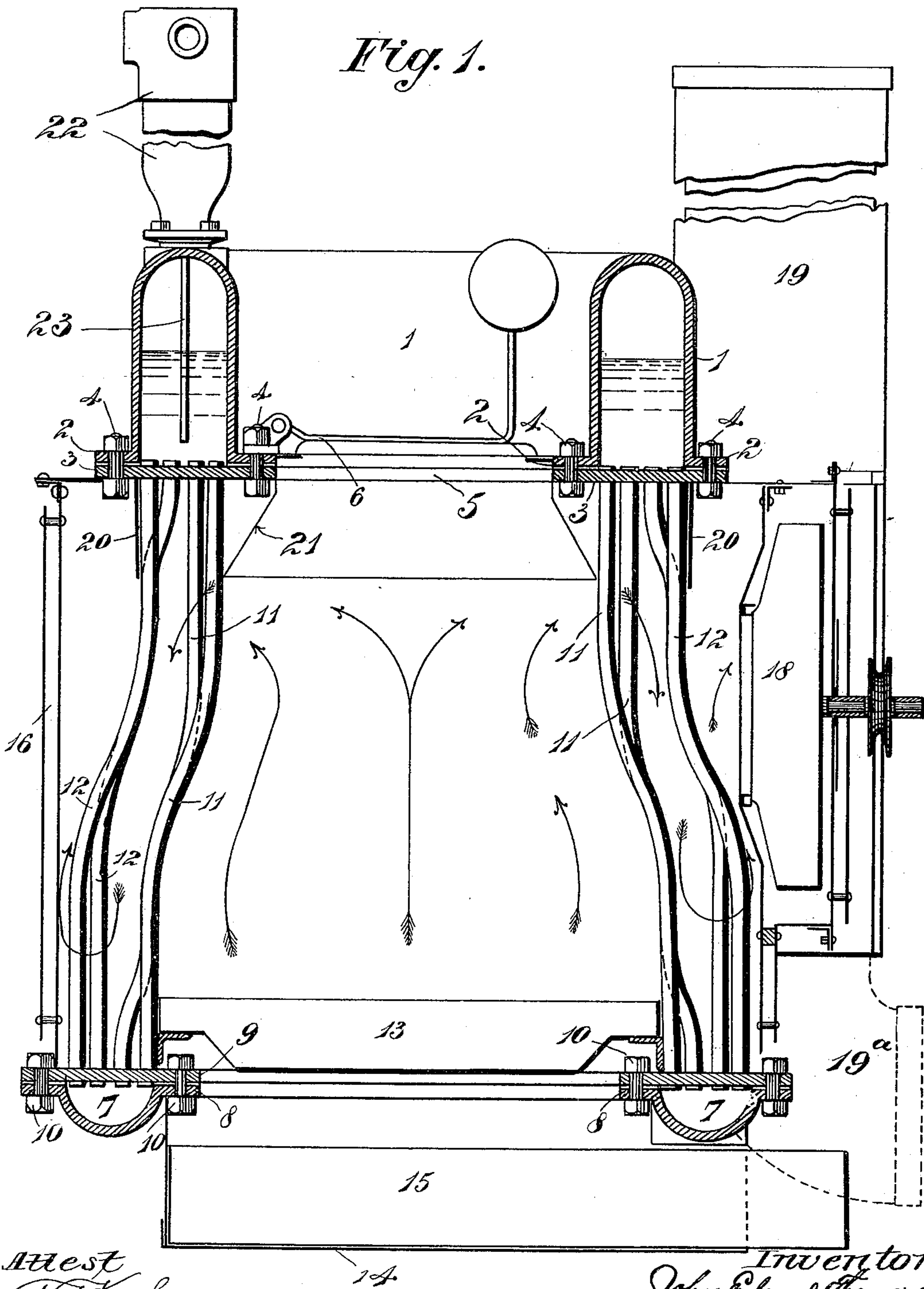
J. E. THORNYCROFT.
STEAM GENERATOR.

(Application filed Dec. 22, 1897.)

(No Model.)

4 Sheets—Sheet 1.

Fig. 1.



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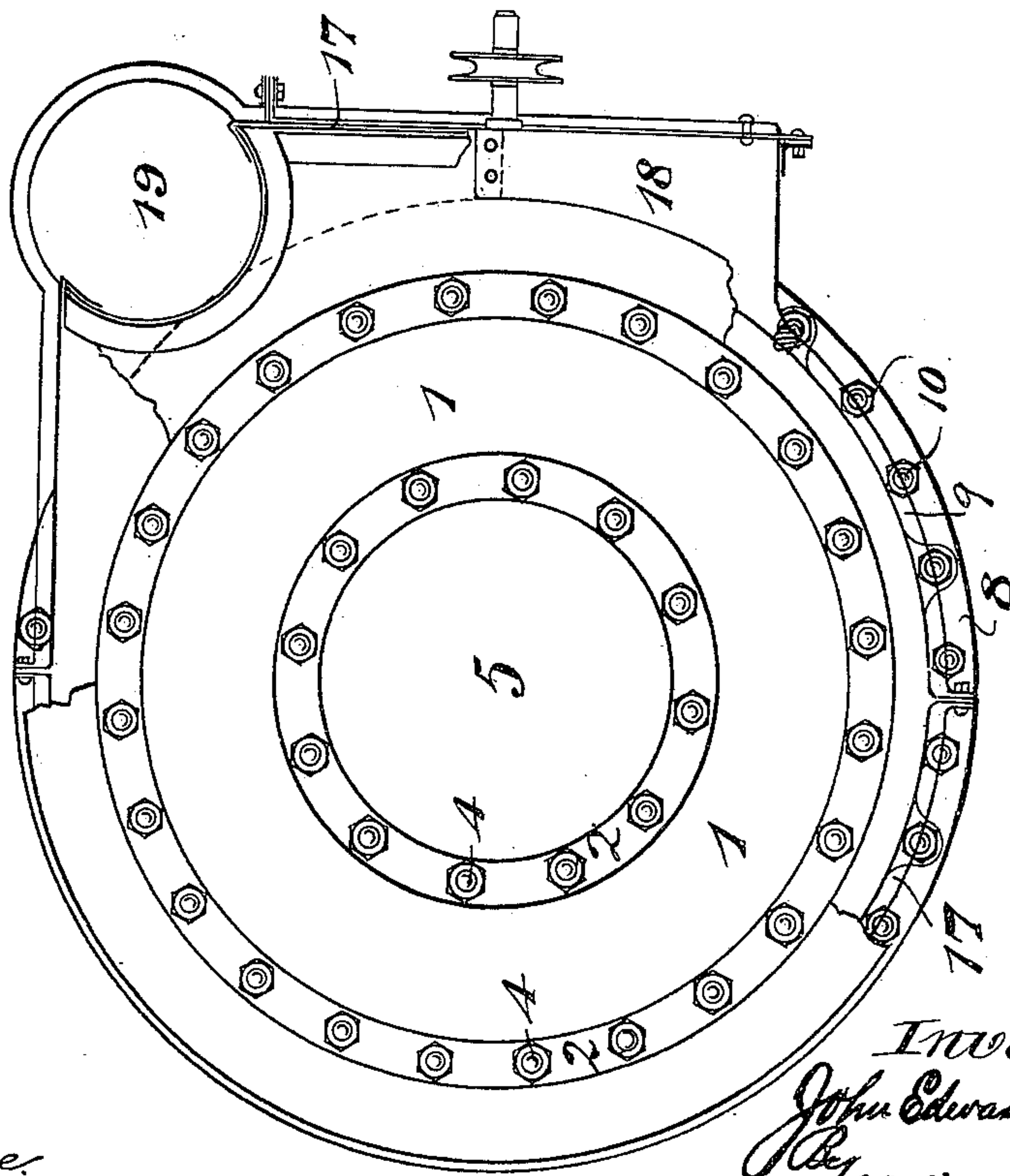
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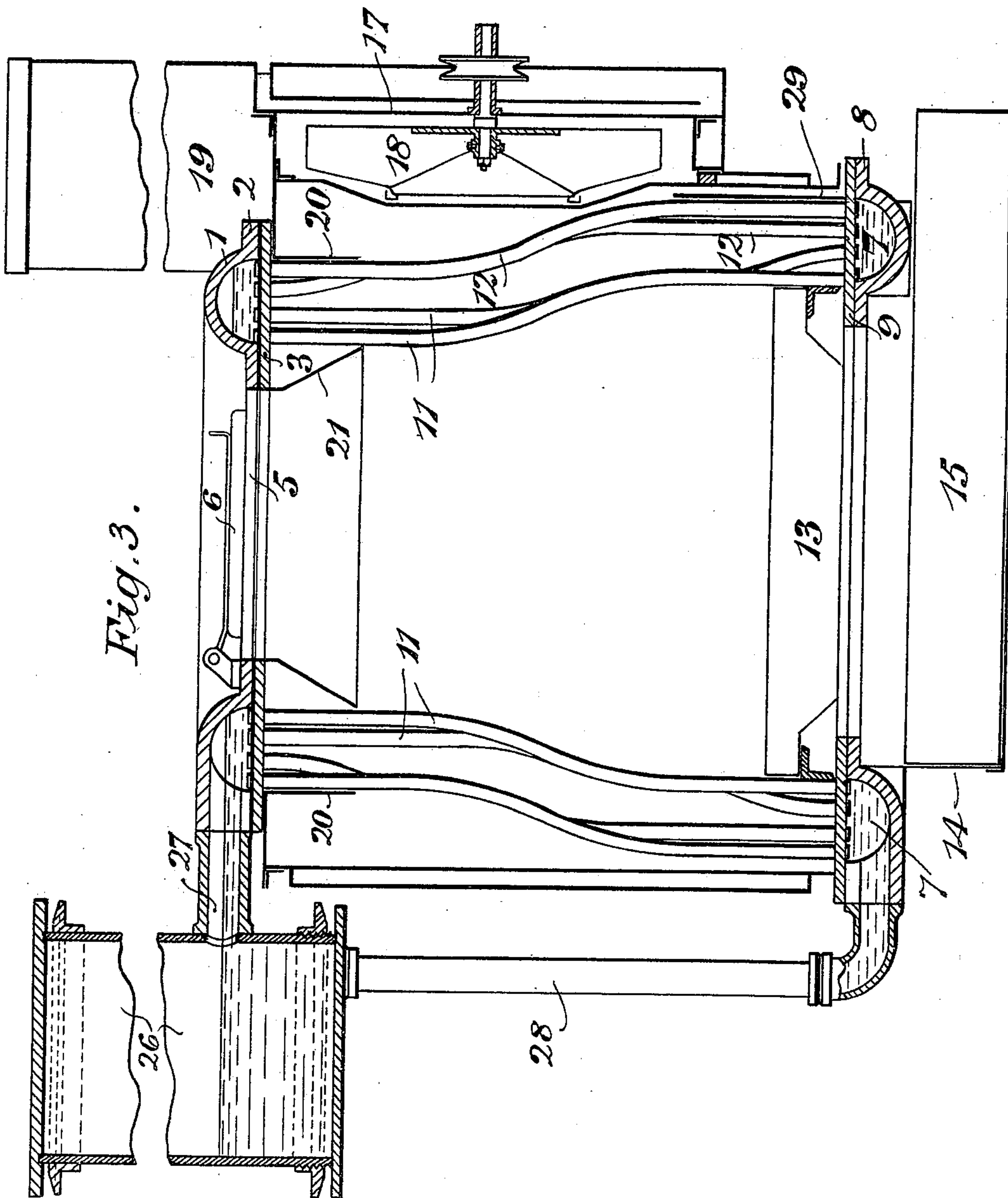
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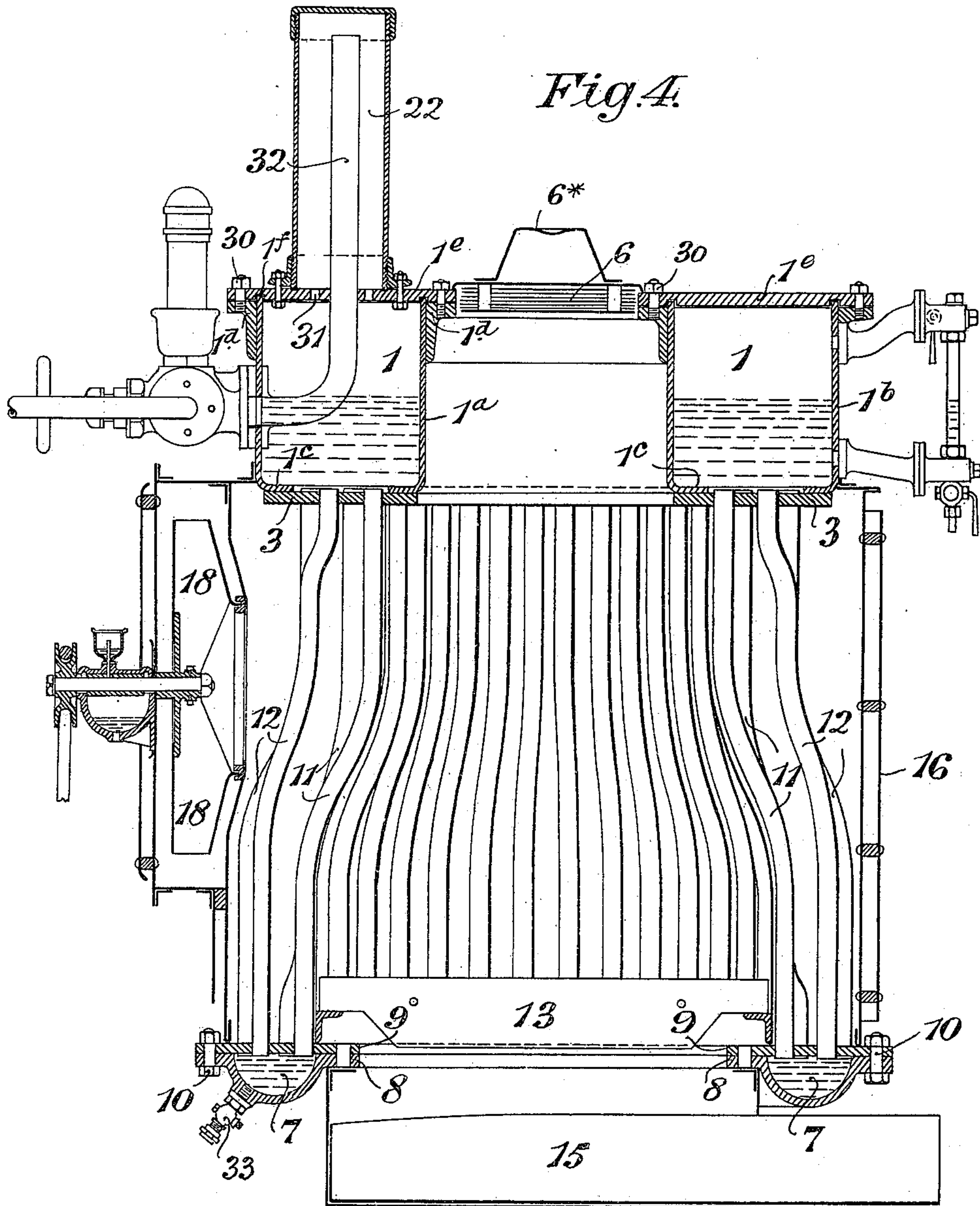
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UNITED STATES PATENT OFFICE.

JOHN EDWARD THORNYCROFT, OF LONDON, ENGLAND.

STEAM-GENERATOR.

SPECIFICATION forming part of Letters Patent No. 639,952, dated December 26, 1899.

Application filed December 22, 1897. Serial No. 662,968. (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 Chiswick, London, in the county of Middlesex, England, have invented certain Improvements in Steam-Generators, (for which Letters Patent of Great Britain and Ireland, No. 8,326, dated March 31, 1897, have been granted to me,) of which the following is a specification.

The object of the invention is to produce a light and compactly-built generator which shall be adapted for use in a limited space—such, for instance, as is afforded in motor-vehicles or in other similar relations wherein it is very important to economize space—and which shall have in proportion to its size a large area exposed to the action of the heating agencies, and consequently a high capacity for steam generation.

With this and other objects in view the invention consists in certain constructions, parts, improvements, and combinations, as will be hereinafter fully described and then pointed out in the claims hereunto appended.

In the accompanying drawings, which constitute a part of this specification and in which like reference characters indicate the same parts, Figure 1 shows a vertical central section of a steam-generator embodying the invention. Fig. 2 is a sectional plan thereof. Figs. 3 and 4 are sectional views showing modified forms of the generator.

Referring to the construction shown in Fig. 1, 3 indicates the tube-sheet of an upper annular steam and water chamber. The upper part 1 of this water-chamber, which is preferably of U shape in cross-section, though it may be of any form, and which may be made either of cast metal or pressed steel, is provided with outwardly-turned flanges 2. These flanges are connected to the tube-sheet 3 by bolts 4, passing through the flanges and the tube-sheet. The tube-sheet 3 is preferably formed to provide an opening 5, through which fuel may be fed to the combustion-chamber, said opening being closed by a suitable door, which is or may be counterweighted, so that it will remain open without being held. The generator is provided with a lower water-chamber, which is situated at the lower part of the generator and preferably in close prox-

imity to the fire-grate, and which is similar in configuration to the upper chamber, but is of lesser capacity. It is shown as comprising an annular part 7, also preferably of U or channel section, provided with flanges 8, to which a tube-sheet 9 is secured by bolts 10. The upper and lower annular chambers are connected by rows of water-tubes 11 and 12. As herein shown, these rows of tubes are two in number; but it will be understood that more tubes may be used, if desired. The tubes and annular chambers form a fire-box or combustion-chamber, as will be fully explained. In the construction shown the tubes of the inner row are marked 11, and the tubes of the outer row are marked 12. The tubes of each row are so arranged at their ends or the points where they connect with the tube-sheets 3 and 9 that every alternate tube of each row is at a greater radial distance from the vertical axis of the fire-box than the corresponding ends of the tube contiguous to it. Between its ends each tube is bent so that the contiguous tubes of each row touch each other at about the middle of their length and for a considerable distance each side of the middle. In other words, the tubes of the inner row 11 are bent inward, so that at their centers and for a considerable distance each side they are all at substantially the same radial distance from the vertical center of the fire-box, and the tubes of the outer row 12 are also bent inward, so that each tube of this row at its center and for a considerable distance each side is substantially at the same radial distance from the vertical axis of the fire-box. By thus bending the tubes I am enabled to form the entire inner wall of the combustion-chamber wholly of tubes and also to form the outer wall of the smoke-chamber entirely of tubes, thereby gaining largely in heating area, and at the same time I make the necessary provision for expansion and contraction of the tubes, and thereby am enabled to run the tubes into the tube-sheets or into the top and bottom of the water and steam and water chambers in a substantially vertical line, whereby I gain very materially in space, as it is obvious that if the tubes were bent and connected to the sides instead of the bottom and top of the annular chambers the diameter of the generator would be materially increased. It is also obvious

that if flat tube-sheets arranged as shown were connected by inner and outer walls consisting of straight tubes the expansion of the tubes would tend to strain or weaken the joints between the tubes and the tube-sheets. With tubes bent as shown, however, I construct a generator which will be practically but little greater in diameter than if straight tubes were used, and at the same time any tendency to weaken the joints between the tubes and the tube-sheets resulting from expansion and contraction will be obviated by reason of the bent tubes, as the expansion and contraction will be taken up in the tubes. By arranging the tubes of each row at different radial distances from the diameter of the fire-box a further advantage is gained, as I thus provide openings through which the products of combustion may be led into the space between the rows of tubes, and at the same time, although a large number of tubes are employed, the tube-sheets are not weakened by undue contiguity of the apertures in the tube-sheets.

In the construction shown in Fig. 1 the products of combustion are shown as being led between the tubes of the inner wall at their upper ends and then take a downward course between the two rows of tubes. In order to insure that the products take the downward course referred to, I provide a shield or guard 20 around the upper ends of the tubes which form the outer wall, thereby closing the openings between the tubes at this point.

In the lower part of the combustion-chamber is located the fire-box 13, below which is shown the usual chamber 14, containing the removable ash-pan 15. The outer casing of the generator is shown at 16. When the funnel or chimney cannot be made high enough to create sufficient draft, a suitable draft device may be used. Such a draft device may be a fan 18, provided with a casing 17, as herein shown. The blades of the fan may be, as represented, straight and radial, so as to have an exhausting action whether the fan be driven backward or forward. The fan-casing may be connected to a suitable funnel or chimney 19, as shown in Fig. 1 in full lines, or the fan may discharge the products of combustion downward into a flue 19^a, as indicated in dotted lines in the same figure.

The course of the products of combustion is indicated by the arrows in Fig. 1. They ascend to the upper part of the fire-box, then pass between the upper ends of the inner wall 11 into the chamber between the tubes, and thence downwardly and out between the lower ends of the outer walls of the tubes.

In the upper part of the combustion-chamber I preferably locate a suitable baffle-plate 21, by which the products of combustion are prevented from coming directly into contact with the tube-sheets 3.

22 is a steam-pipe forming a steam-dome, in which is contained a pipe 23, which may be perforated and connected with any suitable form of steam-separating device.

The fire-bars forming the grate may with advantage be riveted together in separate groups, so that when it is necessary to clean the fire the central group can be removed by pulling it out with a fire-tool and the clinkered fire be pushed through the opening thus formed in the grate and allowed to fall into the ash-pan.

In the form of generator shown in Fig. 3 the capacity of the upper steam and water chamber is comparatively small and there is provided a steam and water cylinder or drum 26, which is connected by means of a pipe 27 with the upper steam and water chamber and by a downtake-pipe 28 with the lower water-chamber.

In order to insure as far as possible that the passage of the hot gases shall take place evenly around the fire-box and not by a short course to the fan or chimney, a plate, such as 29, (see Fig. 3,) may be arranged to extend partly along the outer row of tubes.

In the form of generator shown in Fig. 4 the upper steam and water chamber is formed by an annular tube-sheet 3 and concentric inner and outer rings or plates 1^a and 1^b, each formed or provided at the lower ends with an inwardly-turned flange 1^c and at the upper end with an outwardly-turned flange 1^d and a removable cover-plate 1^e. The rings 1^a and 1^b are connected to the tube-sheet 3 by rivets or the like passing through the flanges 1^c, and the cover-plate 1^e is held in place by bolts or studs and nuts 30, as shown. The rings or plates 1^a and 1^b may be formed in one with the tube-plate 3, if desired. The cover-plate 1^e is formed with grooves 1^f, into which the edges of the rings 1^a and 1^b take. The pipe 22, forming the steam-dome, is bolted to the cover-plate 1^e over a steam-inlet opening or openings 31 in the latter, and the main steam-pipe 32, which is attached to and passes through the ring or plate 1^b, extends through the opening 31 into the upper part of the pipe 22. 33 is a mud-cock, of which several may be fitted to the water-chamber 7. The firing door or cover 6 is provided with a handle 6^x, by which it can be removed when required. As will be evident, a construction of this kind facilitates cleaning of the boiler, as by removing the cover-plate 1^e all the tubes can be easily got at and water can be introduced into the upper annular chamber for washing out the tubes, dirty water being run off through the mud-cocks 33.

It is to be understood that while it is preferable in most cases to make the upper water and steam chamber and the lower water-chamber of annular shape, as this form is usually the most economical, so far as room is concerned, yet it may be desirable in some cases to make these chambers of other shapes, which while not "annular" in the exact sense of the term may be said to be approximately so. For instance, under some circumstances it might be desirable to make these chambers oval in shape or even polygonal. Such forms

of generator, when embodying the other features of the invention, are within the scope of the invention, and it will be understood, therefore, that the term "annular," which is
 5 used in the claims hereunto appended, is not to be construed strictly, but is intended to cover generally forms of chambers which are composed of tubes either round or polygonal in cross-section and which are bent so as to
 10 return upon themselves, thus forming continuous chambers.

What I claim is—

1. A steam-generator comprising an upper annular steam and water chamber having a
 15 removable side, a fuel-opening bounded by the chamber, means for closing said opening, a lower annular water-chamber having a removable side, tubes connecting the under side of the upper chamber with the upper side of
 20 the lower chamber, said tubes being arranged close together so as to form a combustion-chamber, and means for maintaining a fire in the combustion-chamber, substantially as described.

25 2. A steam-generator comprising an upper annular steam and water chamber, said chamber having a removable side, a fuel-opening bounded by the chamber, means for closing said opening, a steam-dome connected to said
 30 chamber, a lower annular water-chamber having a removable side, tubes connecting the under side of the upper chamber with the upper side of the lower chamber, said tubes being arranged close together so as to form a
 35 combustion-chamber, and means for maintaining a fire in the combustion-chamber, substantially as described.

3. A steam-generator comprising an upper annular steam and water chamber, a lower
 40 water-chamber of substantially similar configuration, a row of tubes connecting the under side of the upper chamber with the upper side of the lower chamber, said tubes being bent between their ends so as to touch each
 45 other at their centers and for some distance on each side of the center whereby a combustion-chamber is formed and the tendency of the tubes to expand or contract is taken up in the tubes, thereby avoiding the weakening
 50 of the joints between the tubes and the chambers, substantially as described.

4. A steam-generator comprising an upper annular steam and water chamber, a lower
 55 water-chamber of substantially similar configuration, a row of tubes connecting the under side of the upper chamber with the upper side of the lower chamber, said tubes being bent between their ends so as to touch each other at their centers and for some distance
 60 on each side of the center whereby a combustion-chamber is formed and the tendency of the tubes to expand or contract is taken up in the tubes, thereby avoiding the weakening of the joints between the tubes
 65 and the chambers, and means for maintaining a fire in said combustion-chamber, substantially as described.

5. A steam-generator comprising an upper annular steam and water chamber, a lower
 70 water-chamber of substantially similar configuration, a plurality of rows of tubes connecting the bottom of the upper chamber with the top of the lower chamber, the said tubes being bent between their ends so as to touch each other at about their centers and for some
 75 distance each side thereof, alternate tubes of each row being arranged with their ends at a greater radial distance from the center of the space inclosed by the tubes than the ends of the contiguous tubes whereby the inner
 80 row of tubes forms a combustion-chamber and the other row of tubes a smoke-chamber, substantially as described.

6. A steam-generator comprising an upper annular steam and water chamber, a lower
 85 water-chamber of substantially similar configuration, a plurality of rows of tubes connecting the bottom of the upper chamber with the top of the lower chamber, the said tubes being bent between their ends so as to touch
 90 each other at about their centers and for some distance each side thereof, alternate tubes of each row being arranged with their ends at a greater radial distance from the center of the space inclosed by the tubes than the ends
 95 of the contiguous tubes whereby the inner row of tubes forms a combustion-chamber and the other row of tubes a smoke-chamber, and means for maintaining a fire in the combustion-chamber, substantially as described. 100

7. A steam-generator comprising an upper annular steam and water chamber, a lower
 105 water-chamber of substantially similar configuration, flat tube-sheets forming the bottom of the upper and the top of the lower chamber, a row of tubes connecting the tube-sheets and arranged so that the ends of each alternate tube shall be farther from the axial center of the space inclosed by the tubes than
 110 the ends of the contiguous tubes, said tubes being bent so as to touch each other at their centers and for a considerable distance each side thereof whereby a combustion-chamber is formed, substantially as described.

8. A steam-generator comprising an upper
 115 annular steam and water chamber, a lower water-chamber of substantially similar configuration, flat tube-sheets forming the bottom of the upper chamber and the top of the lower chamber, a row of tubes connecting the
 120 tube-sheets and arranged so that each alternate tube has its ends at a greater radial distance from the axial center of the space inclosed by the tube-sheets than the ends of the contiguous tube, the tubes being bent so
 125 as to touch each other at their centers and for a considerable distance each side, whereby a combustion-chamber is formed, and a second row of tubes also connecting the tube-sheets and similarly arranged whereby a
 130 chamber for the products of combustion is formed between the two rows of tubes, substantially as described.

9. A steam-generator comprising an upper

annular steam and water chamber, a lower water-chamber of substantially similar configuration, a fuel-opening bounded by the upper steam and water chamber, means for closing said opening, tubes connecting the under side of the upper chamber with the upper side of the lower chamber, said tubes being bent between their ends whereby any tendency to contract or expand will be taken up in the tubes and the joints between the tubes and the chambers will not be weakened, and means for maintaining a fire in the space inclosed by the tubes, substantially as described.

10. A steam-generator comprising an upper annular steam and water chamber, a lower water-chamber of substantially similar configuration, a fuel-opening bounded by the upper chamber, flat tube-sheets forming the bottom of the upper chamber and the top of the lower chamber, tubes bent between their ends connecting said tube-sheets whereby any tendency to contract or expand will be taken up in the tubes and the joints between the tubes and the tube-sheets will not be weakened, and means for maintaining a fire in the space inclosed by the tubes, substantially as described.

11. A steam-generator comprising an upper annular steam and water chamber, a lower water-chamber of substantially similar configuration, a fuel-opening bounded by the upper chamber, flat tube-sheets forming the bottom of the upper and the top of the lower chamber, a row of tubes connecting the tube-sheets and arranged so that the ends of each alternate tube shall be farther from the axial center of the space inclosed by the tubes than the ends of the contiguous tube, said tubes being bent so as to touch each other at their centers and for a considerable distance each side thereof whereby a combustion-chamber is formed, substantially as described.

12. A steam-generator comprising an upper annular steam and water chamber, a lower water-chamber of substantially similar configuration, a fuel-opening bounded by the upper chamber, flat tube-sheets forming the bottom of the upper and the top of the lower chamber, a row of tubes connecting the tube-sheets and arranged so that the ends of each alternate tube shall be farther from the axial center of the space inclosed by the tubes than the ends of the contiguous tube, said tubes being bent so as to touch each other at their centers and for a considerable distance each side thereof whereby a combustion-chamber is formed, and a second row of tubes also connecting the tube-sheets and similarly arranged whereby a chamber for the products of combustion is formed between the two rows of tubes, substantially as described.

13. A steam-generator comprising an annular steam and water chamber, an annular water-chamber below the said steam and water chamber, water-tubes forming side walls of a fire-box, spaced apart to allow products of com-

bustion to pass between them, and connecting the interiors of the two said chambers, a casing surrounding and forming a passage with the said tubes, an outlet for the products of combustion from the said passage, a movable cover for the said fire-box, means for supporting fuel within and admitting air to the said fire-box, and a fan adapted to draw products of combustion from the said passage, substantially as described.

14. A steam-generator comprising an annular steam and water chamber, an annular water-chamber below the said steam and water chamber, annular rows of water-tubes forming side walls of a fire-box, arranged one within another, and connecting the interiors of the said chambers, the tubes of each row being bent and arranged so that adjacent tubes touch one another in their middle parts but that alternate tubes have their respective ends at a greater distance radially from the vertical axis of the fire-box than the corresponding ends of the tubes contiguous to them, means for preventing products of combustion from passing through the rows of tubes except at alternate ends of adjacent rows, a firing-door closing the opening bounded by the said steam and water chamber, a baffle adapted to prevent flame from coming into direct contact with the said steam and water chamber, and means for supporting fuel within, and admitting air to, the said fire-box, substantially as described.

15. A steam-generator comprising an annular steam and water chamber constructed of an annular tube-plate, inner and outer rings or plates forming the walls of the chamber and a removable cover-plate, an annular water-chamber, water-tubes forming side walls of a fire-box or furnace and connecting the interiors of the two said chambers, a casing surrounding said water-tubes, a fuel-supply opening bounded by the steam and water chamber and a movable door for closing said opening, substantially as described.

16. A steam-generator comprising an annular steam and water chamber constructed of an annular tube-plate, inner and outer rings or plates forming the walls of the chamber and a removable cover-plate, a steam-dome fixed to said cover-plate and in communication with the interior of said steam and water chamber, a steam-outlet pipe extending from said steam-dome, an annular water-chamber, water-tubes forming side walls of a fire-box or furnace and connecting the interiors of the two said chambers, a casing surrounding said water-tubes, a fuel-supply opening bounded by the steam and water chamber and a movable door for closing said opening, substantially as described.

17. A steam-generator comprising an annular upper steam and water vessel comprising a lower tube-plate, concentric inner and outer side walls and a removable cover-plate formed with one or more steam-exit openings, a closed steam pipe or drum fixed over said openings,

and a steam-exit pipe extending through one
side and the cover-plate of said steam and
water chamber to the upper portion of said
steam pipe or drum, an annular water-cham-
5 ber arranged below said steam and water
chamber and provided with one or more mud-
cocks, water-tubes connecting said upper and
lower chambers and arranged to form the
wall of a fire-box, a casing surrounding said
10 water-tubes, and a fuel-supply opening lo-
cated at the top of said fire-box and bounded

by said steam and water vessel, and a mov-
able door for said opening, substantially as
described.

In testimony whereof I have signed my 15
name to this specification in the presence of
two subscribing witnesses.

JOHN EDWARD THORNYCROFT.

Witnesses:

PERCY E. MATTOCKS,
EDMUND S. SNEWIN.