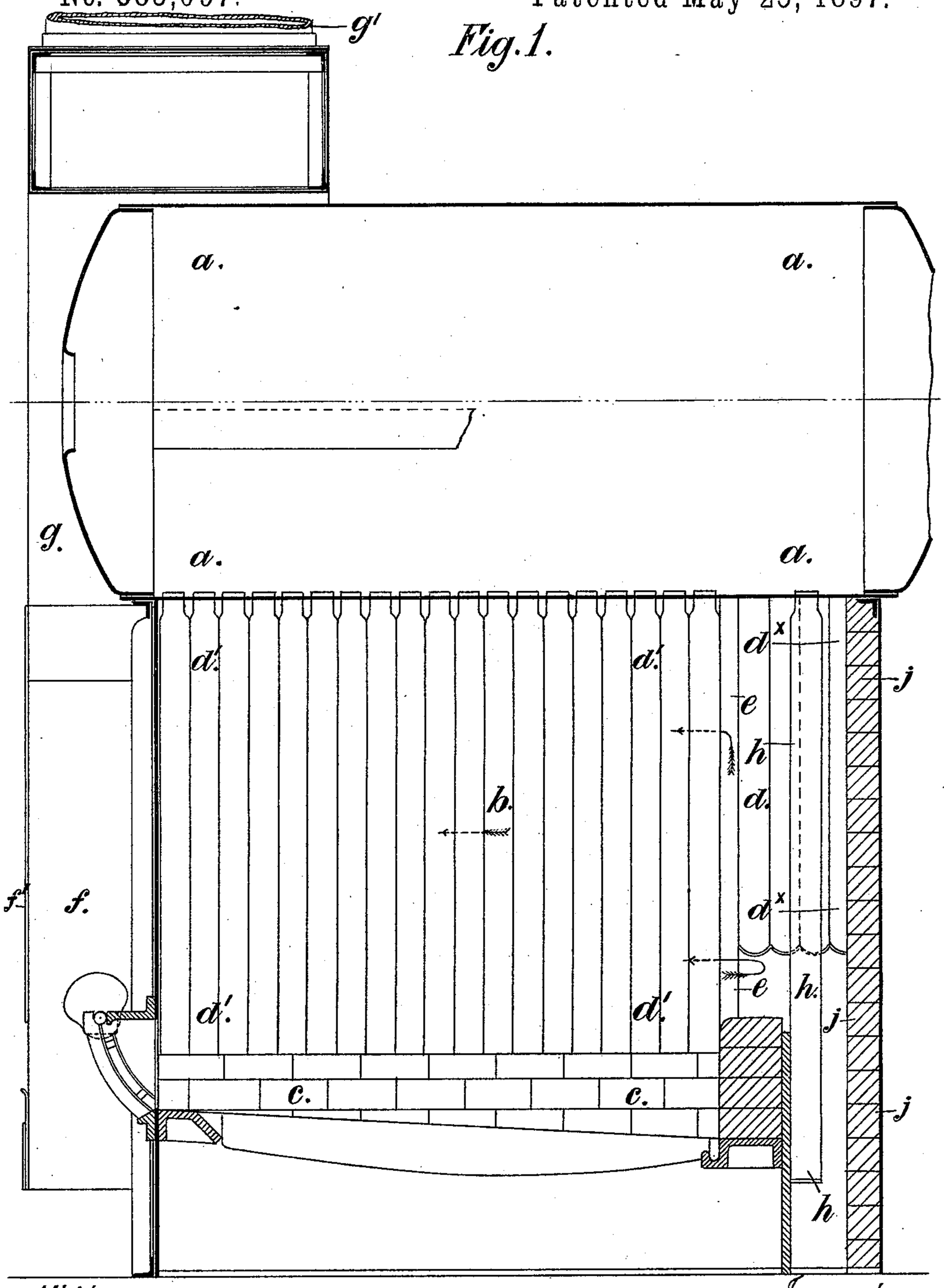
(No Model.) 13 Sheets—Sheet 1.

J. THOM.

STEAM GENERATOR.

No. 583,097. Patented May 25, 1897.

Fig. 1.



Witnesses.
Otto Ulmer
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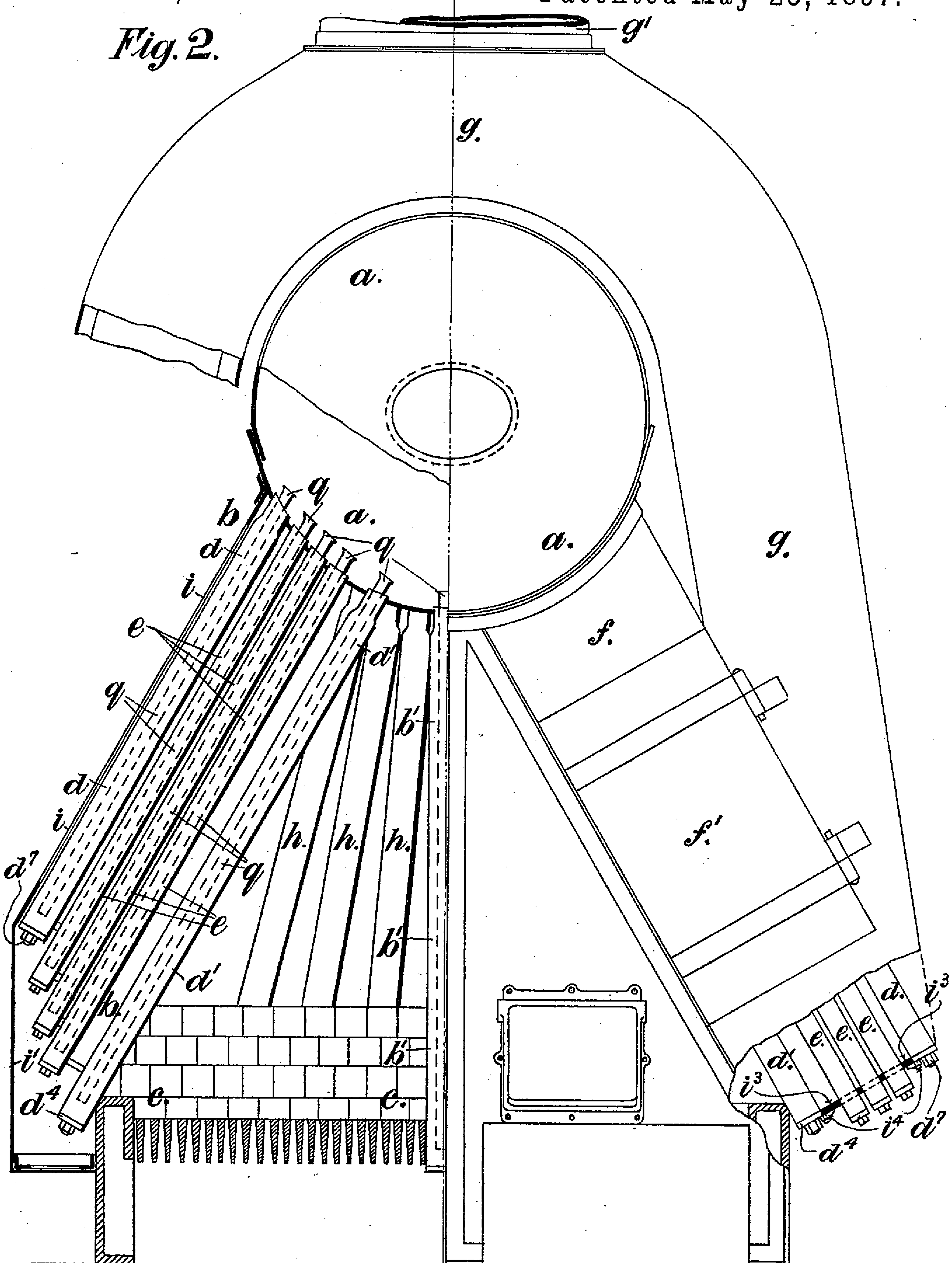
(No Model.) 13 Sheets—Sheet 2.

J. THOM.

STEAM GENERATOR.

No. 583,097. Patented May 25, 1897.

Fig. 2.



Witnesses.
Otto Munk
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(No Model.)

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J. THOM.

STEAM GENERATOR.

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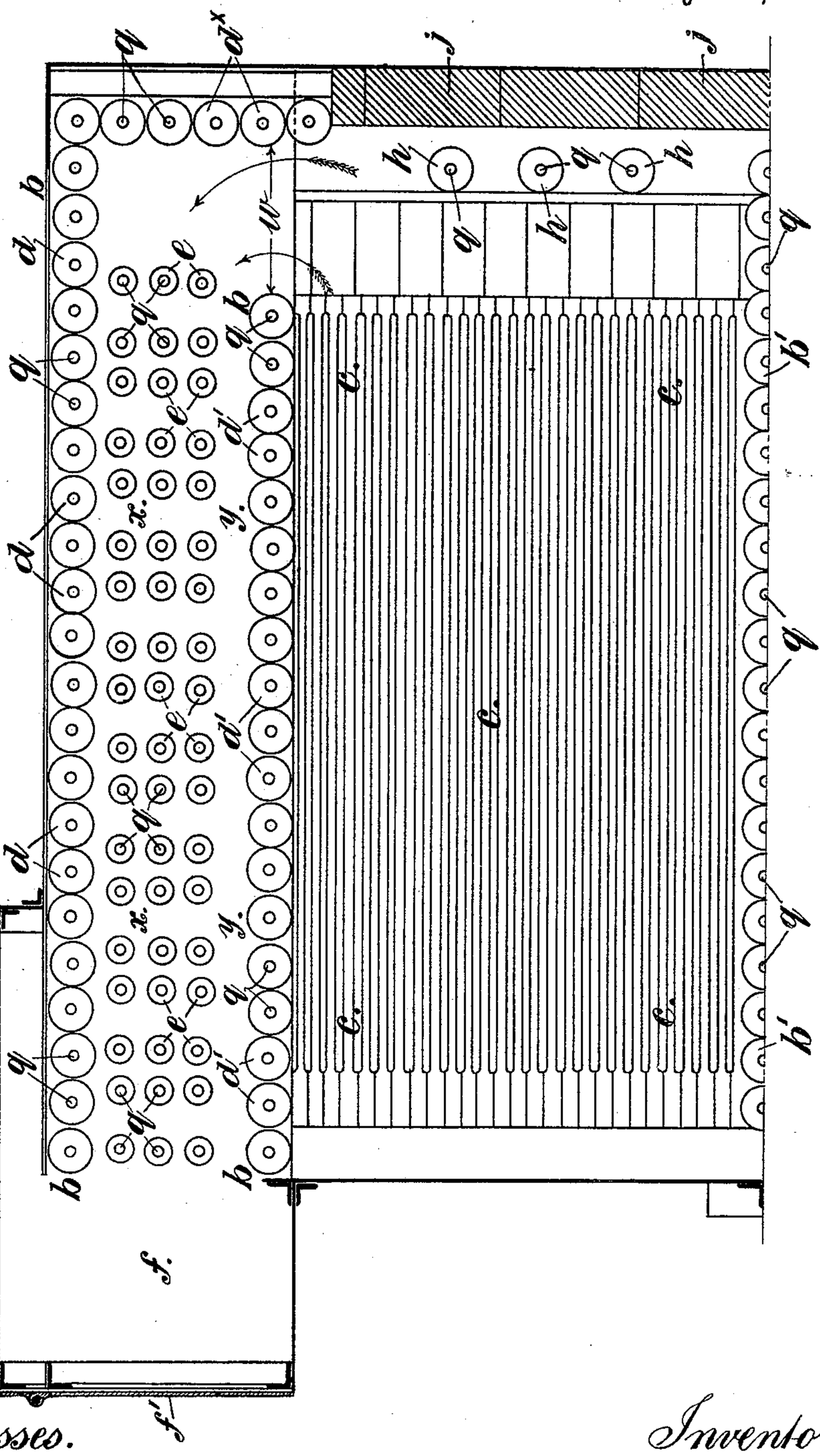

Fig. 3.

Witnesses.
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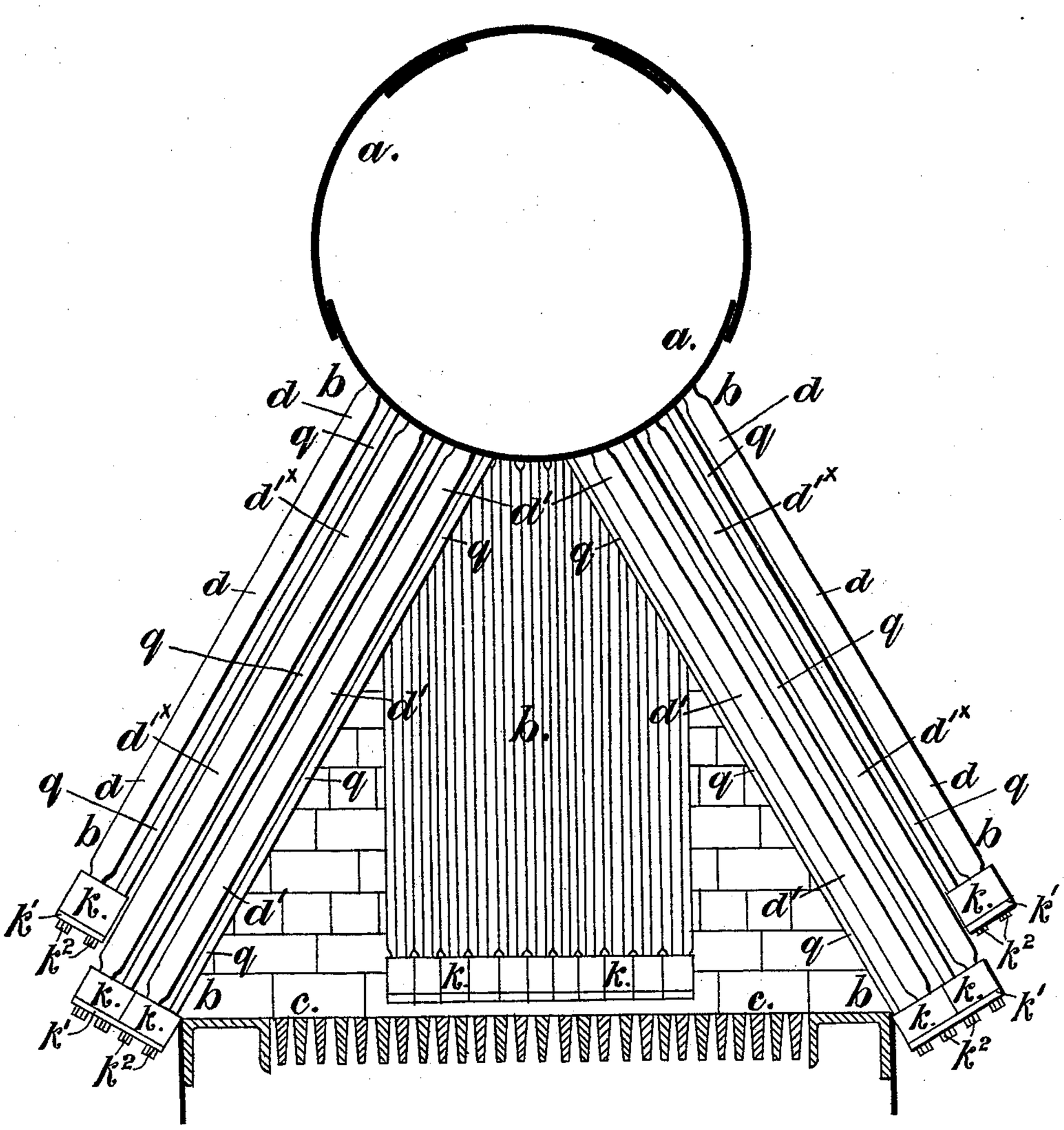
(No Model.) 13 Sheets—Sheet 4.

J. THOM.

STEAM GENERATOR.

No. 583,097. Patented May 25, 1897.

Fig. 4.



Witnesses.
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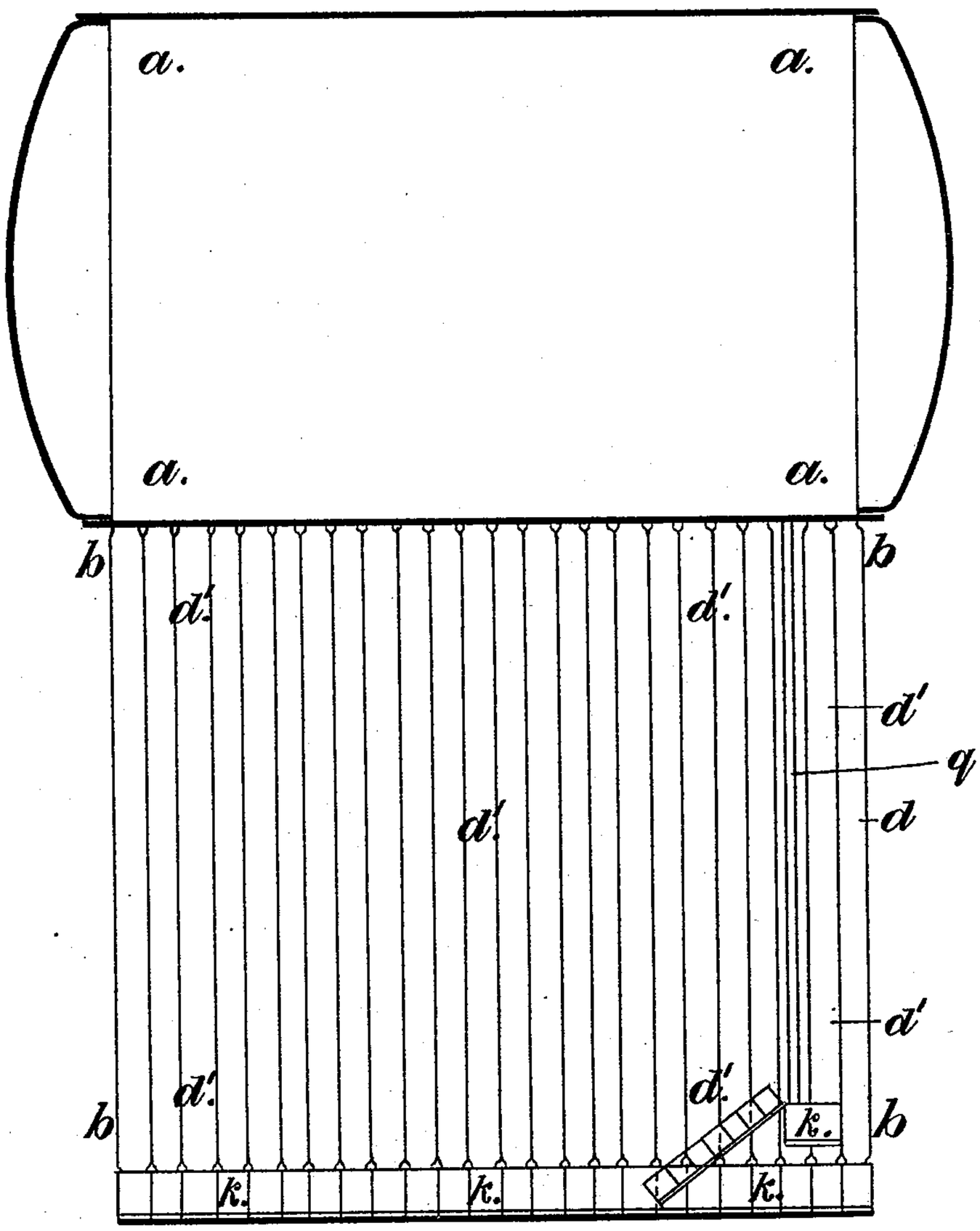
(No Model.) 13 Sheets—Sheet 5.

J. THOM.

STEAM GENERATOR.

No. 583,097. Patented May 25, 1897.

Fig. 5.



Witnesses.
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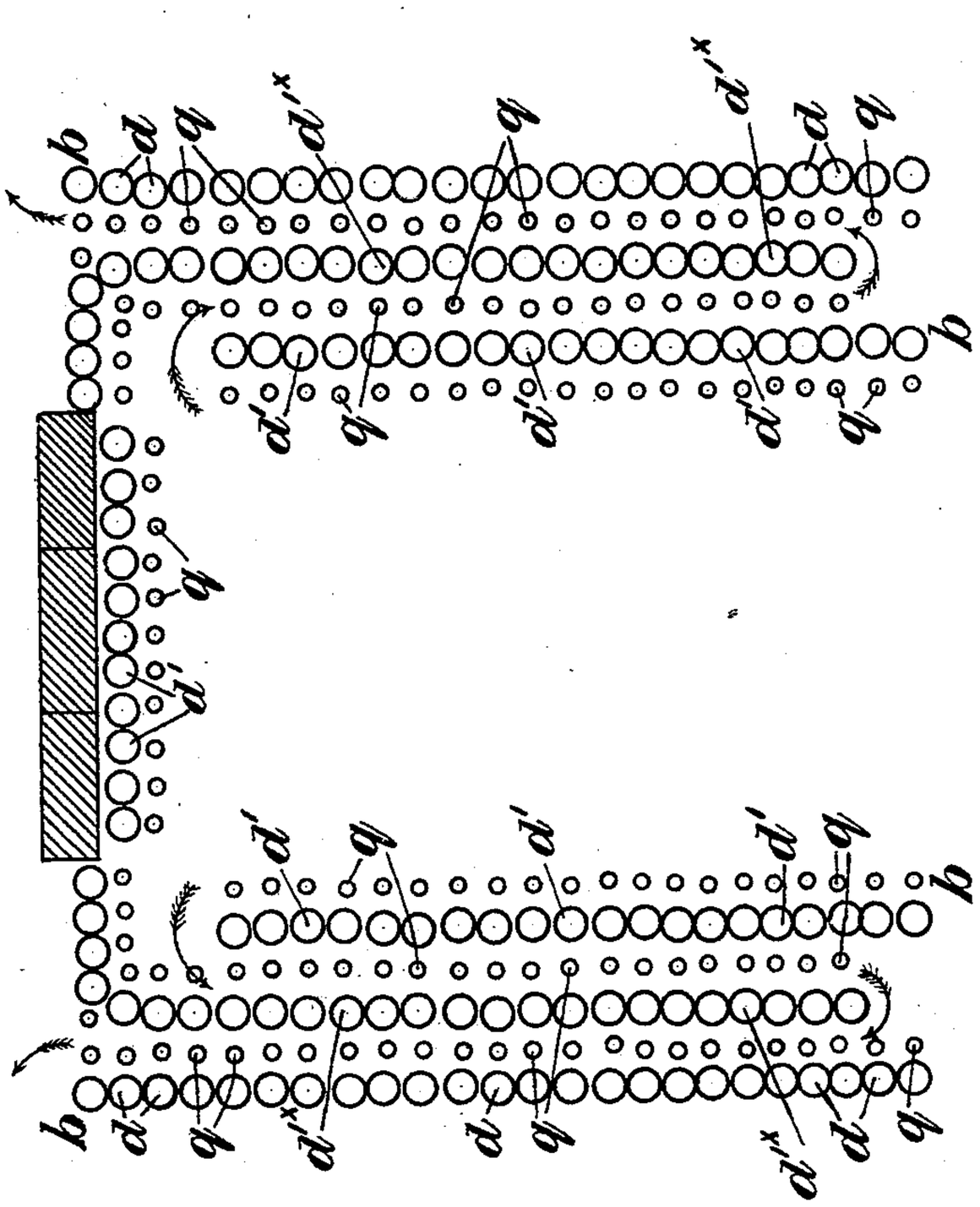
(No Model.) 13 Sheets—Sheet 6.

J. THOM.

STEAM GENERATOR.

No. 583,097. Patented May 25, 1897.

Fig. 6.



Witnesses.

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(No Model.) 13 Sheets—Sheet 7.

J. THOM.

STEAM GENERATOR.

No. 583,097. Patented May 25, 1897.

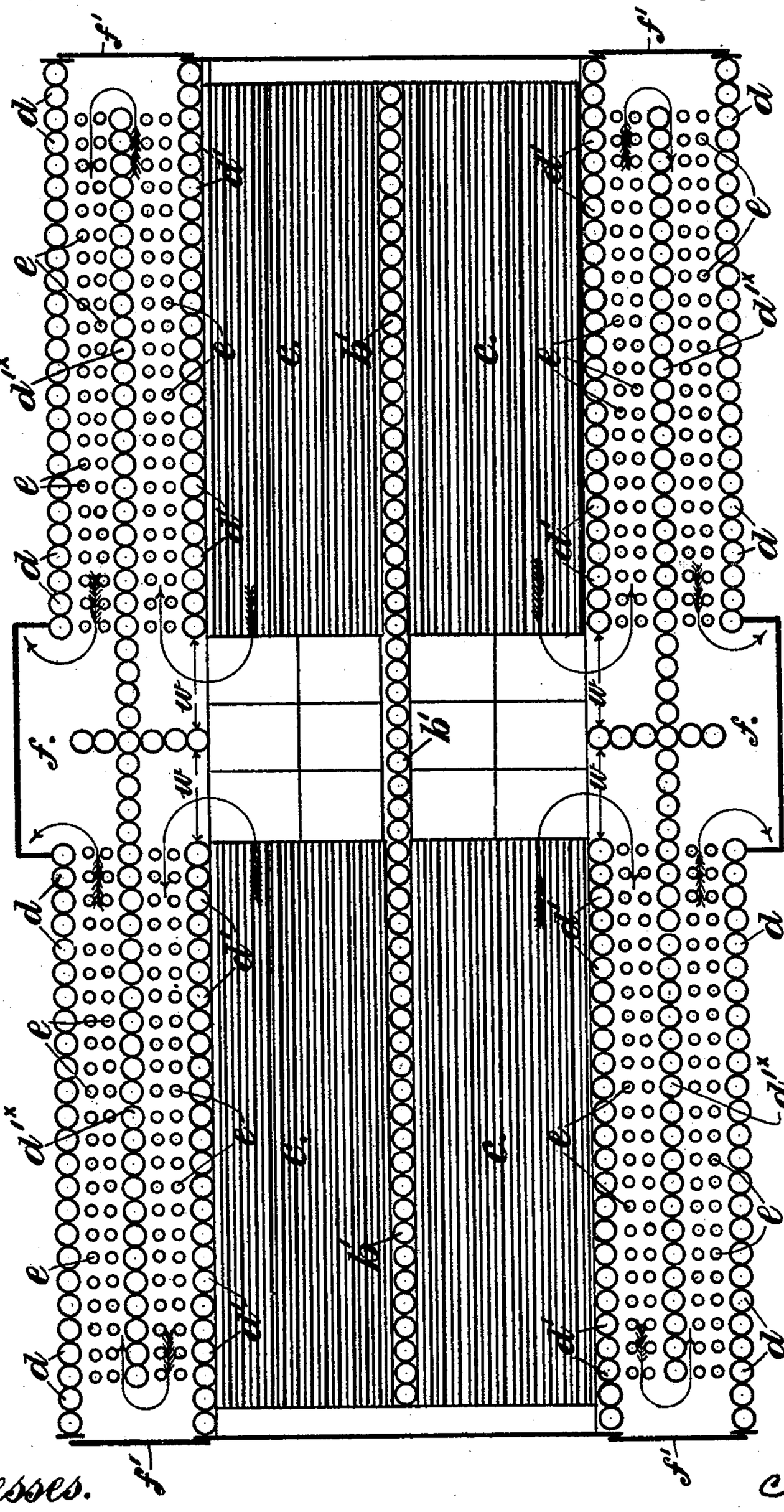

Fig. 7.

Witnesses.
Otto Munk
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(No Model.)

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J. THOM.

STEAM GENERATOR.

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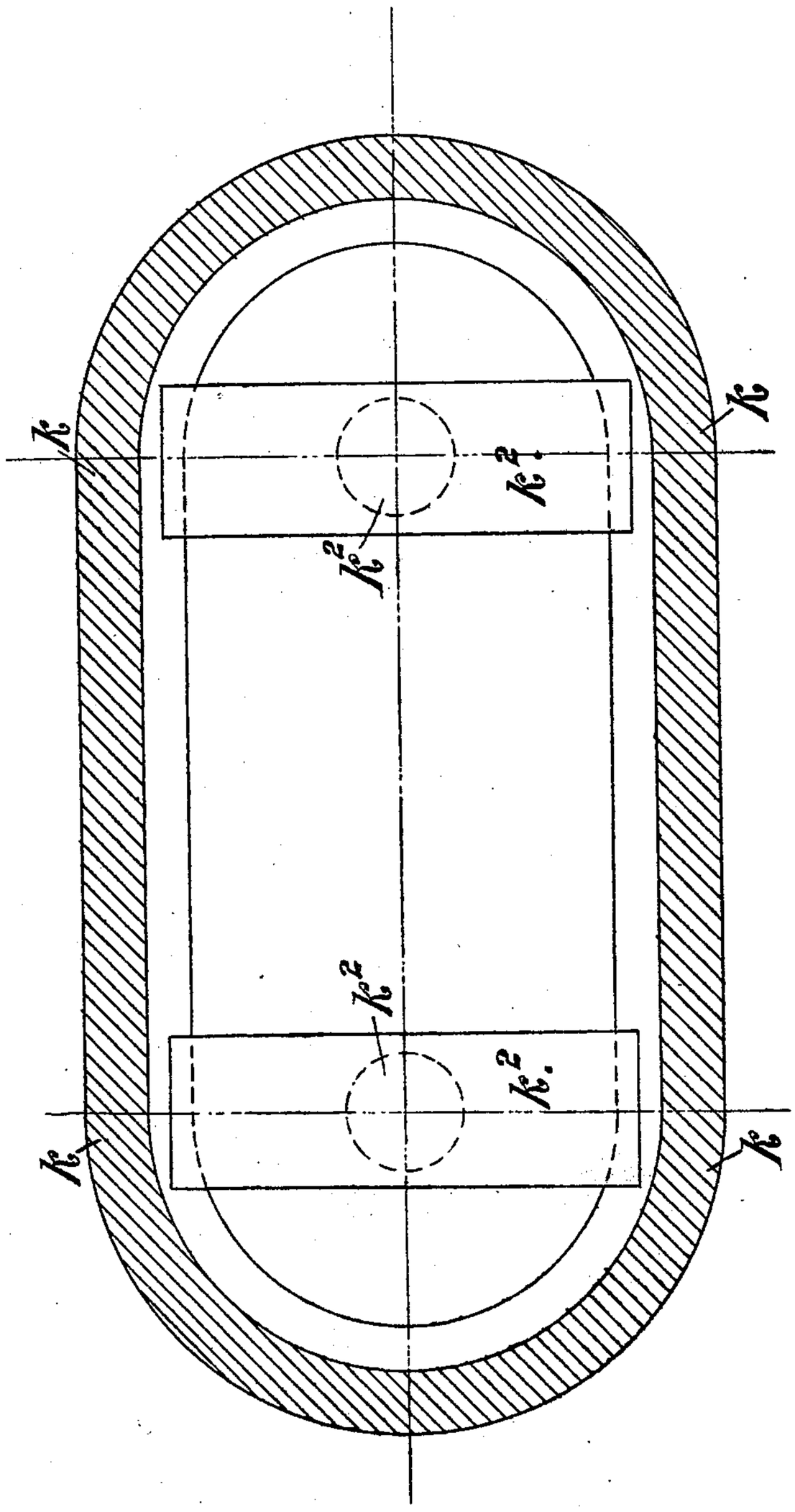

Fig. 8.

Witnesses.
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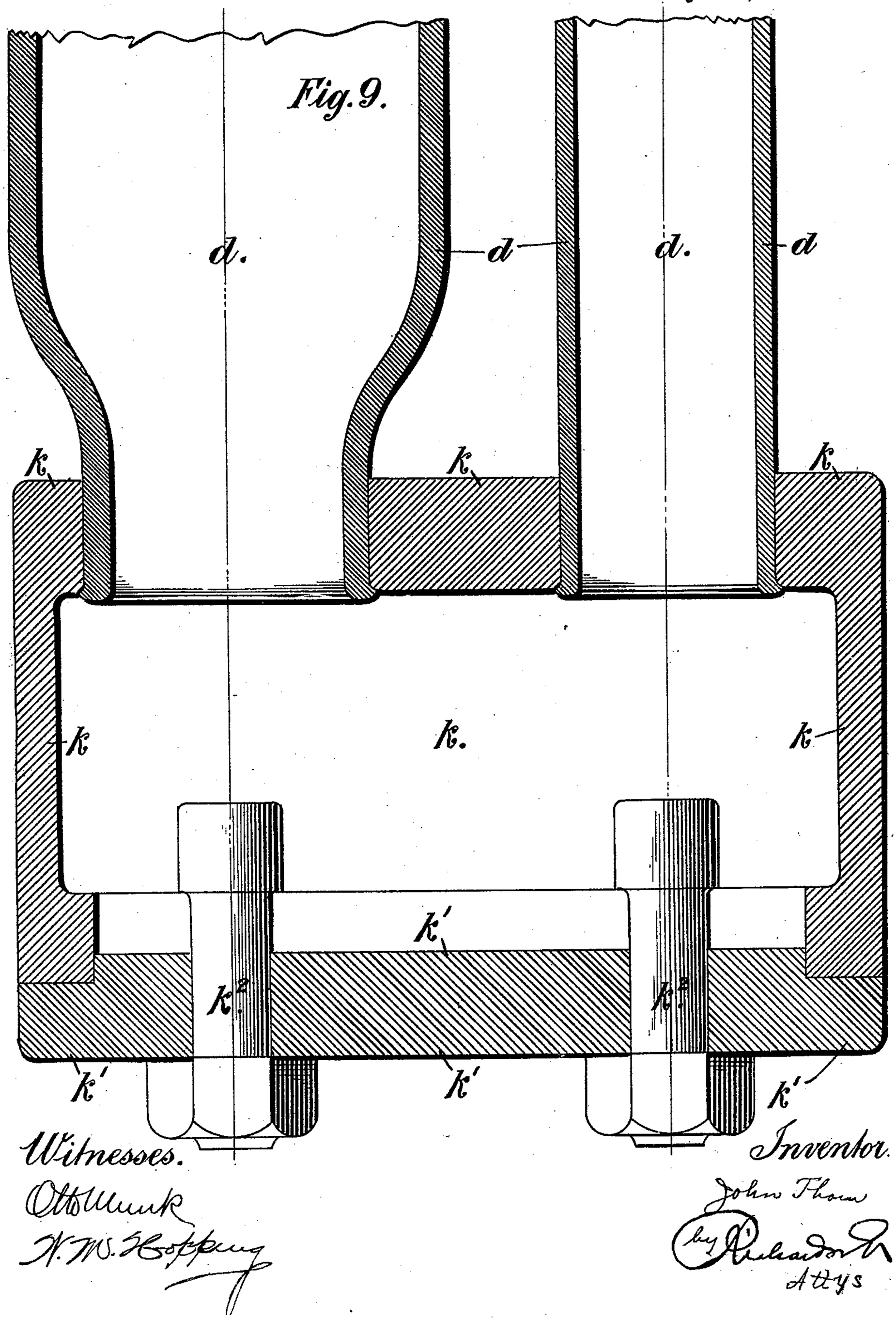
(No Model.) 13 Sheets—Sheet 9.

J. THOM.

STEAM GENERATOR.

No. 583,097. Patented May 25, 1897.

Fig. 9.



Witnesses.
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(No Model.)

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STEAM GENERATOR.

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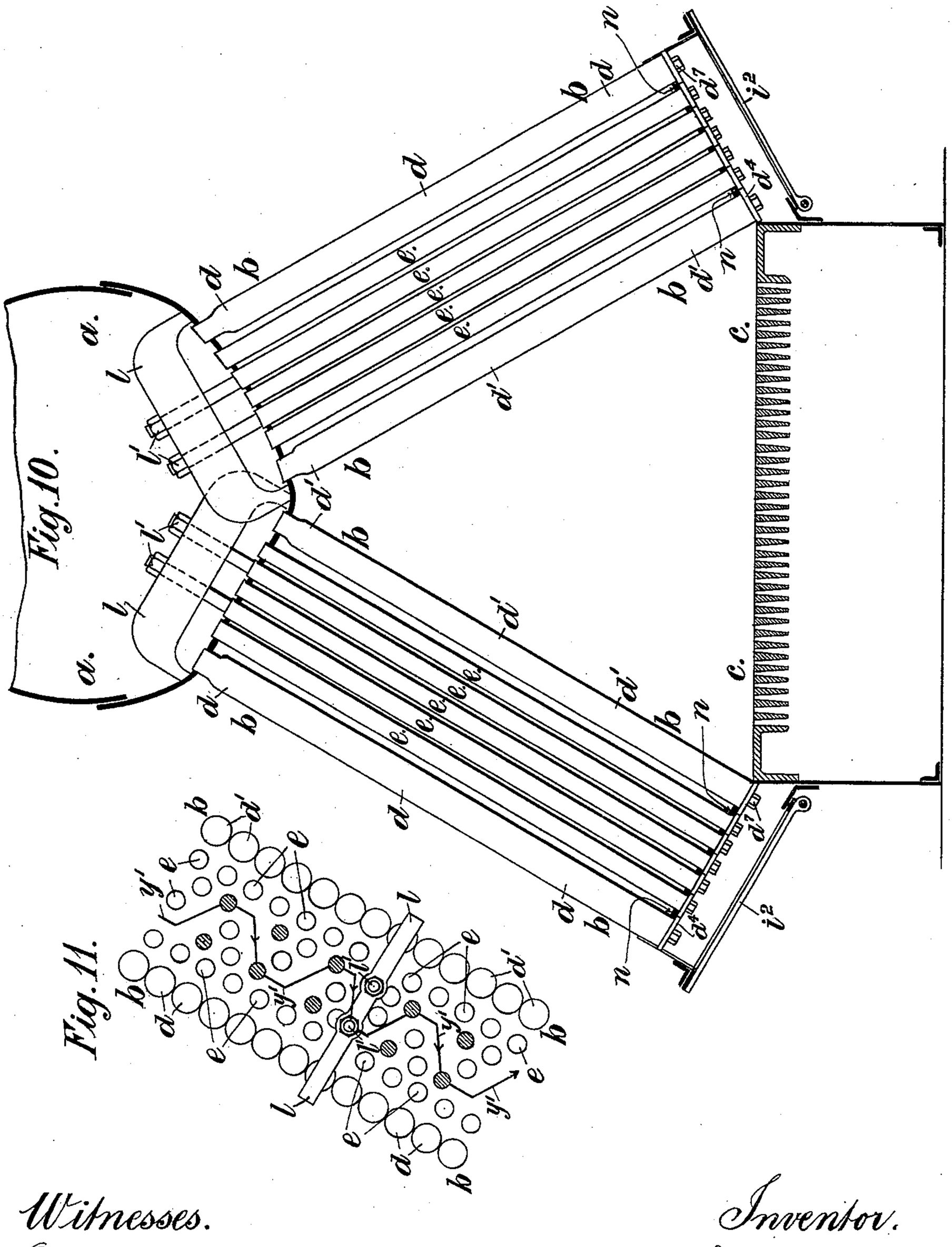

Fig. 10.

Fig. 11.

Witnesses.

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(No Model.)

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J. THOM.

STEAM GENERATOR.

No. 583,097. Patented May 25, 1897.

Fig. 12.

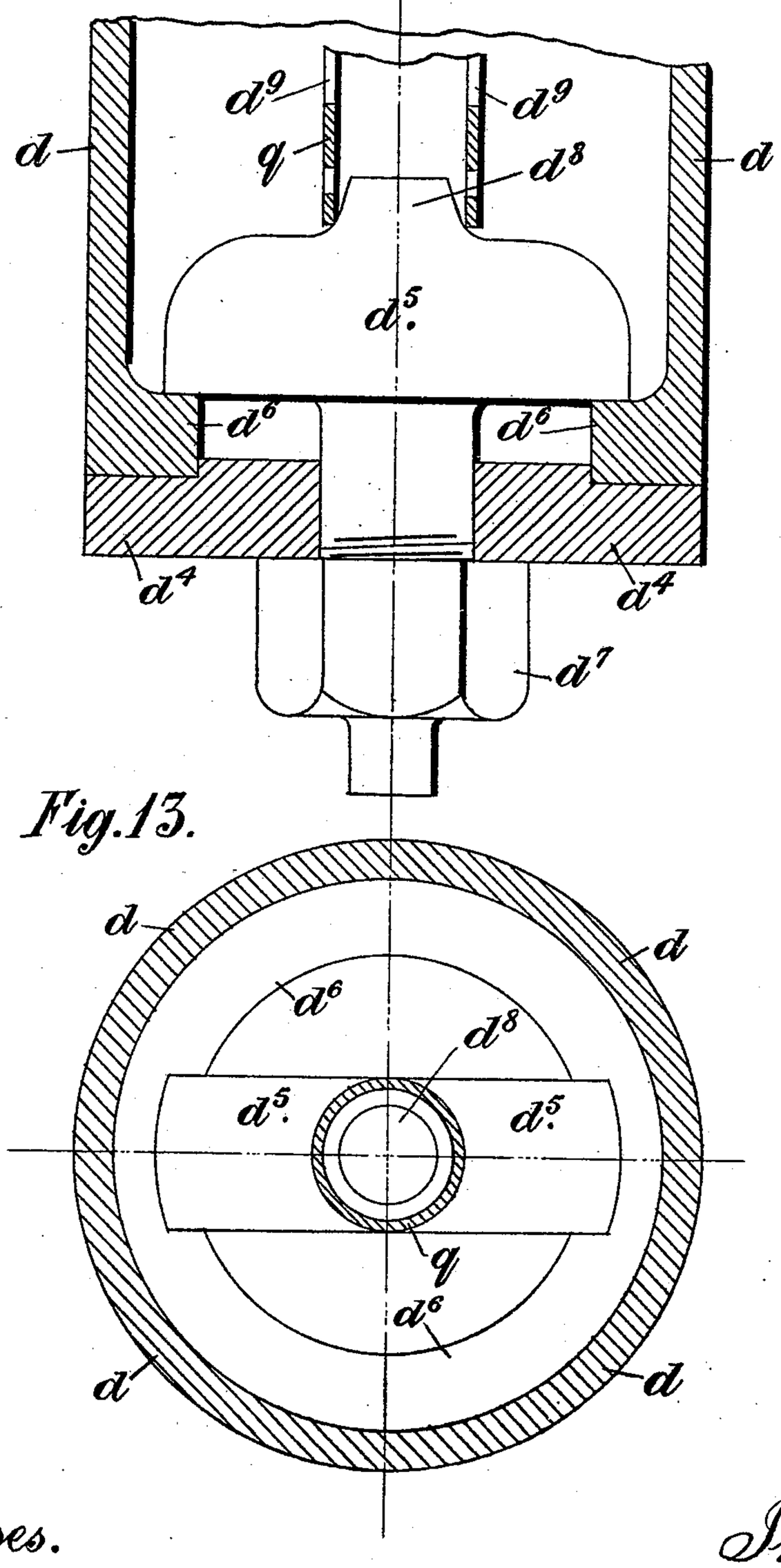

Fig. 13.

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(No Model.) 13 Sheets—Sheet 12.

J. THOM.

STEAM GENERATOR.

No. 583,097. Patented May 25, 1897.

Fig. 14.

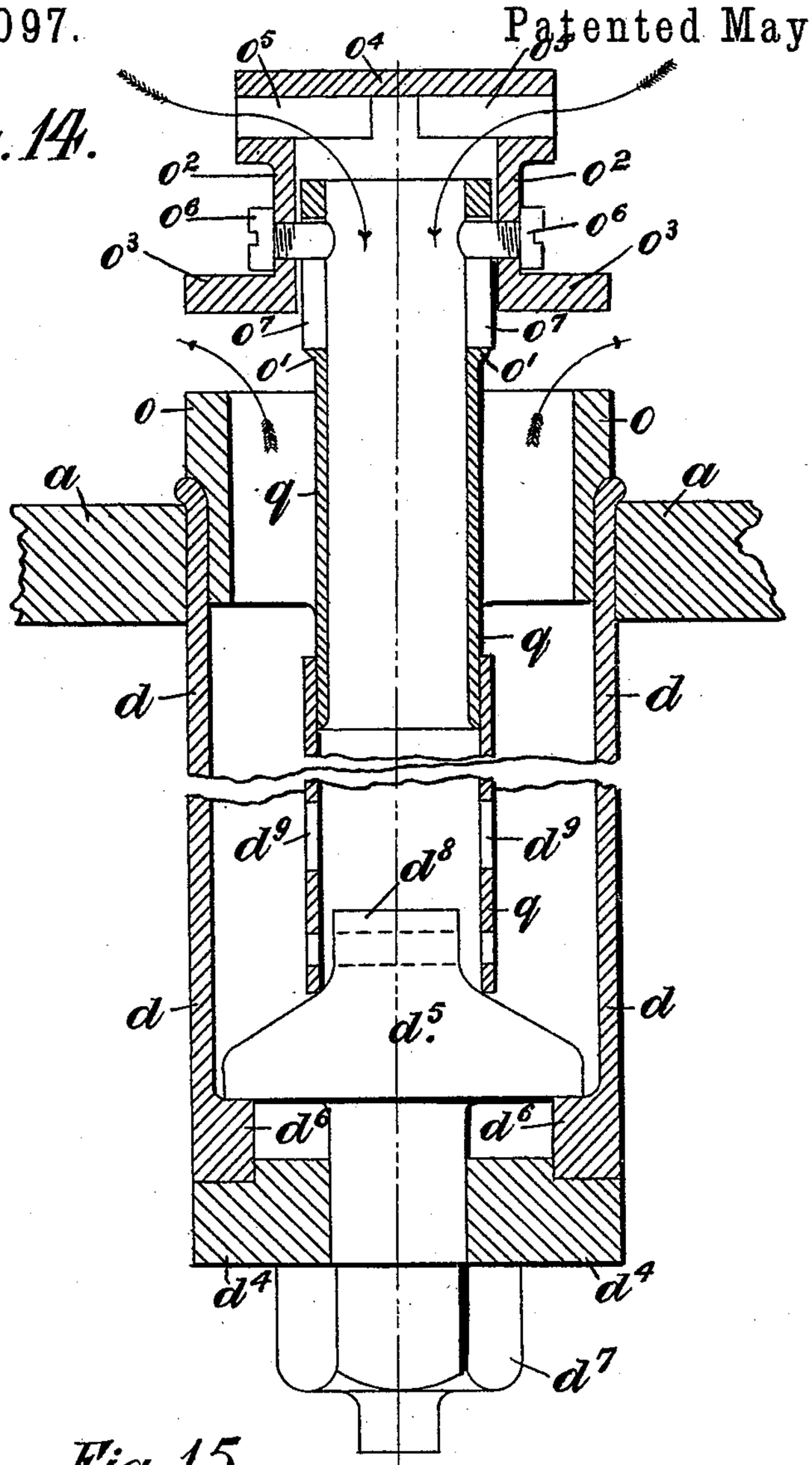
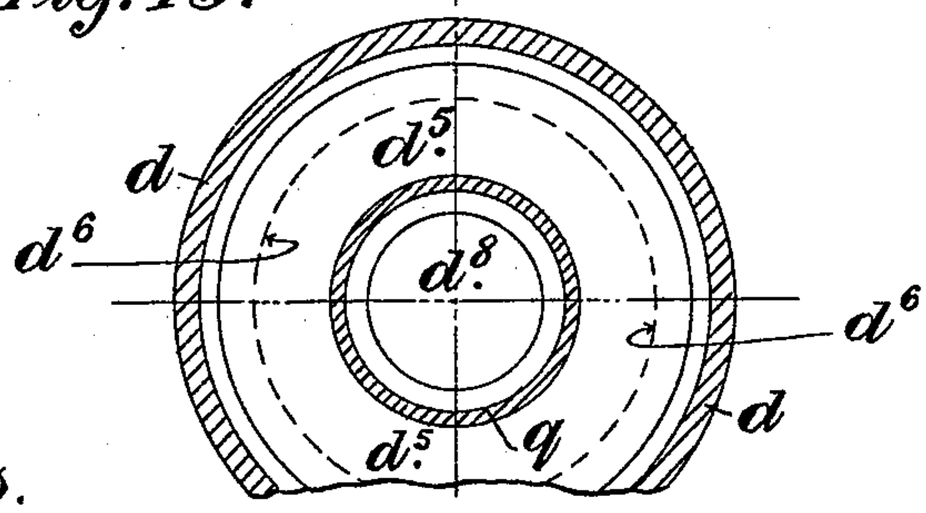


Fig. 15.



Witnesses.

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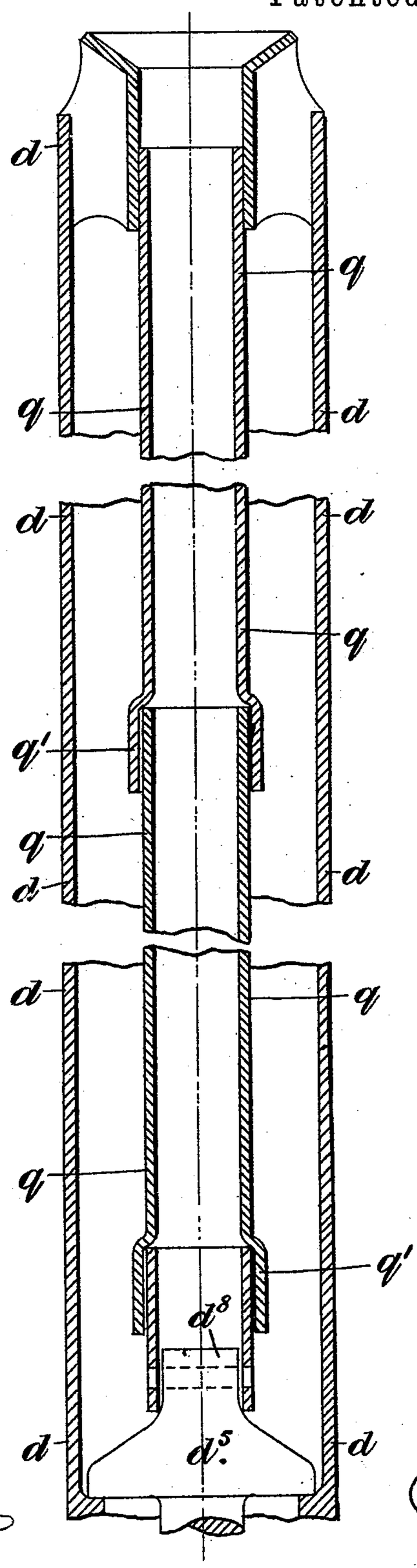
(No Model.) 13 Sheets—Sheet 13.

J. THOM.

STEAM GENERATOR.

No. 583,097. Patented May 25, 1897.

Fig. 16.



Witnesses.
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UNITED STATES PATENT OFFICE.

JOHN THOM, OF GLASGOW, SCOTLAND.

STEAM-GENERATOR.

SPECIFICATION forming part of Letters Patent No. 583,097, dated May 25, 1897.

Application filed November 24, 1896. Serial No. 613,305. (No model.)

To all whom it may concern:

Be it known that I, JOHN THOM, a subject of the Queen of Great Britain, residing at Glasgow, Scotland, have invented certain new and useful Improvements in Steam-Generators, of which the following is a specification.

This invention has special reference to steam-generators of the type generally called "water-tube" steam-generators—that is, generators in which the bulk of the heating-surface is provided by a number of tubes through which the water circulates, the tubes being secured to a drum or drums or vessels and subjected externally to the action and heat of the fire-gases.

My invention will now be described with reference to the accompanying drawings, which illustrate by examples the application of the improvements hereunder, the novel features constituting the improvements under the invention being pointed out or specified particularly in the claiming clauses concluding the specification.

In the drawings, Figure 1 is a sectional elevation, Fig. 2 a cross-section, and Fig. 3 a part plan in section, of a generator according to this invention. Fig. 4 is a cross-section, Fig. 5 a sectional elevation, and Fig. 6 a plan, of generator, showing further improvements and modifications under this invention; and Fig. 7 is a sectional plan showing a steam-generator fired at both ends. Figs. 8 and 9 are sectional plan and elevation of details. Fig. 10 is a cross-section showing a steam-generator according to this invention having a modified construction as regards the upper steam and water vessel, and Fig. 11 shows a modified arrangement of the tubes. Fig. 12 is a sectional view of the lower end of a water-tube with the means for closing the same. Fig. 13 is a sectional plan view of the same. Fig. 14 is a sectional view showing a valve for cutting off a tube from the water vessel when said tube bursts. Fig. 15 is a sectional plan view of the same. Fig. 16 shows a sectional view of the water-tube in which is used a sectional inner tube.

Referring to the drawings, and more particularly to Figs. 1, 2, and 3, the generator, it will be seen, comprises a horizontal upper water vessel *a*, nests of "Field" tubes *b*, held at their upper ends in the shell of the vessel *a* and extending down in inclined directions, while between them at the lower part the grate *c* is disposed. The tubes forming the nests *b* are of different forms, namely, the outer row *d* and the inner row *d'* are arranged so that their sides touch each other and form water-tube walls, while the tubes *e* between these walls do not touch each other and are smaller in diameter, but have spaces between them, and, further, at the back end of the grate *c* the wall of tubes *d'* does not extend to the back of the generator, but is stopped, a gap or passage being thereby formed for the distance *w*. This gap forms an entrance or communication between the back of the grate *c* and the space or chamber between the rows *d d'*. Thus, it will be seen, the flames and gases of combustion are first caused to pass from the front to the back end of the grate and then through the space *w* into the chamber between the tube-walls *d d'* and along same to the front end of the generator, where it is provided on each side with a smoke-box *f*, having a door *f'* in front, from which gases pass up the uptake *g* to the funnel *g'*. Within the chamber formed by the walls of tubes *d d'* the tubes *e* are disposed, and over and around these the gases pass, but both the tubes *e* and the wall-tubes *d d'* constitute heating-surface.

According to a further feature hereunder in some cases there is provided, as shown in Figs. 2 and 3, (and other figures hereinafter described,) a duplex-furnace steam-generator, the two furnaces being formed by another row or nest of tubes *b'*. In Figs. 1, 2, and 3 these central tubes consist of a single row of tubes touching each other, or the central nest of tubes may consist of two or more rows of tubes, as in the outer nests. In the case of duplex furnaces so formed being used, one furnace at one side can be stoked, cleaned, or otherwise attended to while the other is in full combustion and without interfering with it. The effect and action of this construction is that the flames and gases of combustion rising from the burning fuel on the grate or grates *c* first are caused to pass from the front to the back end of the furnace, heating the inner sides of the wall-tubes *d'*, and then pass by way of the spaces *w* into the chambers within the walls *d d'* and back to the front end of the generator, heating in the

backward flow the tubes *e* and the sides of the wall-tubes *d d'* within these chambers. Thus the gases have a forward and then a backward flow, and their heat is gradually given up to the heating-surface of the tubes, entering the smoke-boxes *f* in a comparatively cool state, and so effecting the highest efficiency and economy.

According to a further constructive feature shown in Figs. 1, 2, and 3 the generator is provided at the back end of the furnace with radiating Field tubes *h*, arranged as shown, the necks of which lie closely together at the plate of the water vessel *a*, they being fastened within this vessel *a* or lying between the end tube of the wall of tubes *d'* and the end row of wall-tubes $d^{\times}$. This arrangement provides heating-surface at the end of the furnace and at the same time prevents the brickwork *j* at the end of the generator from falling down in case it becomes loose.

The lower ends of the outer larger tubes of the Field tubes are provided with suitable caps d^4, which are removable for gaining access to them, while their upper ends are fastened at the necks in the plate of the water vessel *a*. These necks, in the case of the larger or wall tubes *d d'*, are narrowed where they are fastened to the drum *a*, so that they can be fastened in the drum without bending and so that their bodies touch each other for the whole length, and the upper ends of the internal tubes project into the vessel *a*, as shown. The inner tube for conveying the water from the vessel *a* to the tubes *b*, which latter tubes act as return-tubes, is marked *q* in the drawings.

In some cases the internal tubes *q* are made in two or more lengths, as shown in Fig. 16, so that they can be placed in position or removed from within the vessel *a*, this vessel being of less diameter than the whole length of the tubes. In the construction shown in this figure one part of the tube *q* is provided with an enlarged part *q'* or socket, into which the end of the lower part slides. The end of the lower part should fit into the socket with sufficient tightness to make the two parts hold together to the extent of lifting their own weight, but not so tight as to prevent them being pulled apart by hand, or they may be held together by a pin passed through the two parts. Thus when the upper half-tube is drawn into the vessel *a* it can be taken off the lower part, and then the lower part can be taken out of the outer tube. Another form of inner tube *q* consists in making one half smaller than the other and arranging one part to telescope into the other.

The nests of tubes are inclosed externally at the top and bottom by a simple metal plate *i*, and this plating in some cases, as shown on the left-hand side of Fig. 2, is carried down below the ends of the tubes at *i'*, and provided at the front end with sliding doors. Thus this lower portion forms a box or receptacle for ashes or dirt which may fall and which can be withdrawn therefrom through suitable doorways. In another case, as shown on the right-hand side of Fig. 2, the nests of tubes are inclosed below by a plate i^3, through which the ends of the intermediate tubes *e* pass, this plate being held in place by catches i^4, hinged to the caps of the outer tubes *d*. The plate is made to fit about the tubes and completely closing the bottom of the nests. This construction of generator requires at its sides no brickwork, and the only brickwork wall *j* is that at the back end of the furnace, and this is held in position or prevented from falling by the end tubes *h*.

The tubes shown in Figs. 4 to 6 are return-tubes, consisting of a small one and a large one, the one being outside the other and connected at their lower ends and carried up in return form. In this case the smaller tubes *q* serve as the up-current tubes and the larger ones as down-current tubes. These tubes are fastened at the upper ends to the shell *a*, as shown, while their lower ends are fitted in boxes *k*, with covers *k'*, fastened by bolts k^2 at their lower ends for gaining access to them and to the tubes. The larger tubes, forming the tube-walls, have their necks of smaller diameter than their bodies, so that they can be fastened in the shell *a* without bending and their bodies touch along their whole length. Instead of providing these return-tubes in pairs, as described, each pair having a box *k*, they may be arranged in sets of two or more of the small and larger tubes with common boxes *k*. In these views, Figs. 4 to 6 and 8 and 9, in which this construction of return-tube is shown, there is also shown a modified arrangement of steam-generator provided with this form of tube, namely: The nest of tubes *b* consist of three sets of return-tubes, consisting of the larger and small tubes. The larger tubes touch each other and are shrunk where they fit in the vessel *a* and the boxes *k*, and these tubes are so arranged in rows, as shown, that the gases from the furnace pass from the back end of same into the space between the inner and intermediate row of tubes *d'* and $d'^{\times}$ to the front of the generator and then return back through the space *e* between the intermediate row $d'^{\times}$ and the outer row *d* to the back end of the generator, where it would be provided with smoke-boxes which lead the gases to the chimney, the gases of combustion passing over both the larger and smaller tubes. Thus a lengthened run of the gases and time contact with the heating-surfaces in passing from the furnace to the chimney is obtained, with the result that as much heat as is practically possible is utilized and transferred to the water.

The sectional plan in Fig. 7 shows a generator fired at both ends, in which the side nests of tubes are arranged as in Figs. 4 to 6. The gases of combustion in this case first pass to the back of the furnaces—viz, at the center of the generator—and enter the nests *b* through the spaces *w* in the inner-tube walls.

From here they pass to the two front ends and then back to the central part at the outside of the nests, whence they pass into the smoke-boxes *f*, as shown by the arrows. Doors *f'* are provided at the front ends of the generators to permit of the tubes being brushed from these ends and access obtained to them. Intermediate tubes *e*, between the tube-walls *d d' d'*×, are provided in the construction shown in this figure. This arrangement of the tube-walls by which the return flow of the gases through nests of tubes in water-tube steam-generators is effected may be employed in some cases without the intermediate smaller tubes *e* and in different kinds of the modern type of water-tube steam-generators.

Figs. 10 and 11 show modifications wherein the part of the shell *a* in which the tube ends are fastened is flattened completely or partially, as shown, respectively on the left and the right hand side, these flattened parts being stayed by internal girders *l*, with stay-bolts *l'* extending between the shell and such girders. The plan in Fig. 11 of this arrangement shows the position of girders and bolts. In this case the door i^2, by which ashes and dirt are removed from the casing of the generator, is hinged to the side plate of the ash-pit and opening from the front end about said hinge. The tubes in this case are shown supported at their lower ends and kept in position by the longitudinal guide-bars *n*, which are introduced between the rows of tubes, and are kept in position by the caps d^4 being made a little larger in diameter than the tubes.

According to a further feature under this invention the internal smaller tubes *e* of the nests are arranged in sets, and spaces are provided between these sets so that ways or passages are provided by which any tube can be passed along these ways when a tube is to be taken out or put in position from any point from the front end of the generator or smoke-box doors. For instance, in Figs. 1, 2, and 3 there are lateral spaces or ways *x* between the internal tubes *e*, while longitudinally there is another way or space *y* at one side between said internal tubes and the inner wall-tubes *d'*, and through these ways any of the small tubes *e* can be passed in or out when putting it in place or taking it out. In the arrangement shown in Figs. 10 and 11 the same effect is obtained, but this is secured by making this way zigzag, as indicated by the line *y'*, which is drawn through the center of this way.

With regard to the details of steam-generators—viz., those of the kind shown in Figs. 1, 2, and 3—details of construction of caps or means for closing the lower ends of same are shown in Figs. 12 to 15, and there is also illustrated in Fig. 13 an automatic means for closing the tubes when the circulation in them ceases from any cause, as, for instance, in case of a burst. In these, Figs. 12 and 14 are sectional elevations and Figs. 13 and 15 plans of same, respectively.

Referring now to the closing caps or covers d^4 for closing the lower ends of the large Field tubes or wall-tubes *d* or *d'*, they are held in position by a T-bolt d^5, the ends of the horizontal bar of which rest on an internal flange d^6 in the tube end, while the shank is threaded and has a nut d^7 thereon, and by screwing it up the caps d^4 are pressed tightly and make a water-tight joint with the flanges d^6. The upper part of the horizontal bars of the T-bolts are carried up to form a projection d^8, over which the lower end of the inner tube fits, as shown, said inner tube being provided with holes d^9 of sufficient area to allow of the outlet of water from the inner to the outer tube. The T-bolts d^5 in this case can be introduced into the tube from the lower end.

The construction of cap and mode of holding it in position shown in Figs. 14 and 15 is the same as that just described and shown in Figs. 12 and 13, with the exception that the holding part d^5, instead of being a bar, consists of a disk, and together with its shank the whole device takes a mushroom form. In this case (which is more particularly applicable to the smaller kind of tubes *e*) these bolts are introduced from the upper end of the tube and are used more especially in connection with the smaller tubes used in the generator.

The automatic means of closing a tube in the case of the circulation ceasing, as when a burst takes place, (shown in Fig. 14,) consists of an automatic lift valvular device so arranged that the upward flow of water from the outer tube of an annular tube acts upon, lifts, and normally keeps open a valve while the circulation lasts, but when the circulation stops through a burst or when the cap at the lower end of the tube is removed this valve falls and closes the mouths of the inner and the outer tubes. In the construction shown the valvular device consists of a seat portion *o*, fitting into the mouth of the outer tube of such annular pair of tubes, and an internal annular tubular portion *o'*, formed one with *o* by webs therefrom and supporting the internal tube from its lower end, as shown. The upper edges of *o* and *o'* form seats on which the valve o^2 rests when the valve is closed. This valve o^2 has a flange o^3 and a cap or roof o^4 and slides up and down on the shank of the tube *o'*. At the upper end of the valve, under the cover o^4, apertures o^5 are provided, which form inlets to the inner tube. The movement of the valve o^2 on the inner tubular part *o'* is controlled by pins o^6 working in slots o^7.

In action the upward flow of water in the outlet-tube lifts the valve o^2 into the position shown in the drawings, thereby providing an outlet between the flange o^3 and the seat *o*, and at the same time moving the cover o^4 off the lip of the part *o'*, and freely opens the inlet-passages o^5 to the interior of *o'*, circulation taking place in the direction indicated by the arrows. When the circulation ceases

from any cause, the valve o^2 falls down, the cover o^4 closing the mouth of o' and the flange o^3 closing the seat o, and therefore no water can pass out.

In the drawings hereto annexed the generators shown have only a single upper water and steam drum a, with return-tubes, there being no side water-drums connecting the lower ends of the tubes, as usual. It is, however, to be understood that such of the improvements herein described as are applicable to this latter kind of steam-generator may be used in connection with such generators without departing from this invention. Also, the generators may be arranged back to back or end to end and fired at the ends, (or sides, if desired,) and in some cases, where they are arranged in sets of two or more side by side, the space between them may be utilized as a space in which the air supplied to the furnaces may be heated by the waste gases of combustion in suitable air-heating pipes or apparatus.

What is claimed in respect of the herein-described invention is—

1. The tube steam-generator having an upper horizontal water vessel a, and nests of tubes b, descending down from same over a furnace c below, a wall above the sides of said nests of tubes next the furnace and extending imperforate from the vessel a to a point below the furnace by which the gases of combustion are prevented from passing direct from the furnace to the interior of the nests, and caused to pass to the back of the furnace, an opening w in the back end of said nests of tubes through which the gases pass into the interior of said nests; the gases being thus caused to pass longitudinally over the bed of coals to the rear and thence forwardly and longitudinally of the furnace-wall, substantially as set forth.

2. A water-tube steam-generator having an upper water vessel a, nests of tubes b descending down from same over a furnace c below, inner and outer walls d d' composed of tubes touching each other throughout their length and presenting an imperforate wall from the vessel a down to the furnace, and so disposed that the gases of the furnace pass to the back end of the generator, and a space at the back end of said tube by which the gases enter the spaces between said walls of tubes; substantially as and for the purposes set forth.

3. A steam-generator having an upper water vessel a, and nests of return-tubes b descending from same over a furnace below, and fastened in their upper necks to the said upper water and steam vessel, said nests of tubes consisting of tubes d d' at the sides of said nests and constituting imperforate tube-walls reaching from the vessel a to the furnace, and tubes e within the chamber formed by said wall-tubes, the fire-gases being caused by having a single opening at the back of the tube-nest to pass to the back of the generator, and then to the front into smoke-boxes; substantially as and for the purposes set forth.

4. A water-tube steam-generator having a water vessel a, outer nests of tubes b descending from the said vessel, an intermediate row or nest of tubes b' between said outer nests extending longitudinally along the generator and forming an imperforate wall, and separate grates or furnaces c arranged between said nests or rows of tubes; each of said tube-nests having its own return-flues, substantially as set forth.

5. A water-tube generator having a water vessel a and nests of tubes b extending down from same, said tubes being arranged in a series of groups and having a way or ways (such as x, or x and y) by which the tubes can be passed from or into any part of the nests; substantially as and for the purposes set forth.

6. A steam-generator having an upper water vessel a, nests of tubes b extending down from same on either side of a furnace c, the brickwork wall j, and the tubes h arranged in front of said brickwork j by which such brickwork is prevented from moving or falling out of place; said tubes h extending across the space between and at the rear of the tube-nests b, substantially as set forth.

7. In combination, the furnace, the boiler, the tubes of large diameter, and the independent tubes of smaller diameter, said larger tubes being in contact to form a flue-wall, the said smaller tube being connected directly with the boiler at the upper ends and with the lower end of the larger tube at its lower end, substantially as described.

8. A water-tube steam-generator having an upper water vessel a and Field tubes fastened by their upper ends in same and having in their lower ends caps or covers d^4, an internal flange d^6 to said tubes, a bolt d^5 by which said caps are held in position and an inner tube held by said bolt; substantially as set forth.

9. A water-tube steam-generator comprising an upper water vessel a and Field tubes consisting of inner and outer tubes connected together, the inner tubes whereof are in two or more detachable parts; substantially as and for the purposes set forth.

10. A water-tube steam-generator having an upper water vessel a, nests of tubes extending down from same and a furnace between said tubes, said nests of tubes consisting of a plurality of rows of such tubes touching each other and forming imperforate walls with spaces between them at the front and rear ends of the furnace, and adapted to cause the gases to flow in a plurality of courses backward and forward longitudinally of the furnace through such spaces between the rows; substantially as set forth.

11. In combination with the water vessel,

the water-tubes comprising the outflow and return portions and the automatic valve between the water vessel and the water-tube controlled by the return flow of the water, substantially as described.

12. In combination, the water vessel, the water-tube comprising the inner and outer sections forming outflow and return passages and the valve controlled by the return flow for controlling the opening to both of said sections, substantially as described.

In testimony whereof I have hereunto set my hand in presence of two subscribing witnesses.

JOHN THOM.

Witnesses:

FREDERICK JOHN CHEESBROUGH.

ERNEST R. ROYSTON.