

No. 672,250.

Patented Apr. 16, 1901.

A. WORTHINGTON.
STEAM BOILER.

(Application filed Nov. 20, 1900.)

(No Model.)

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Fig: 1.

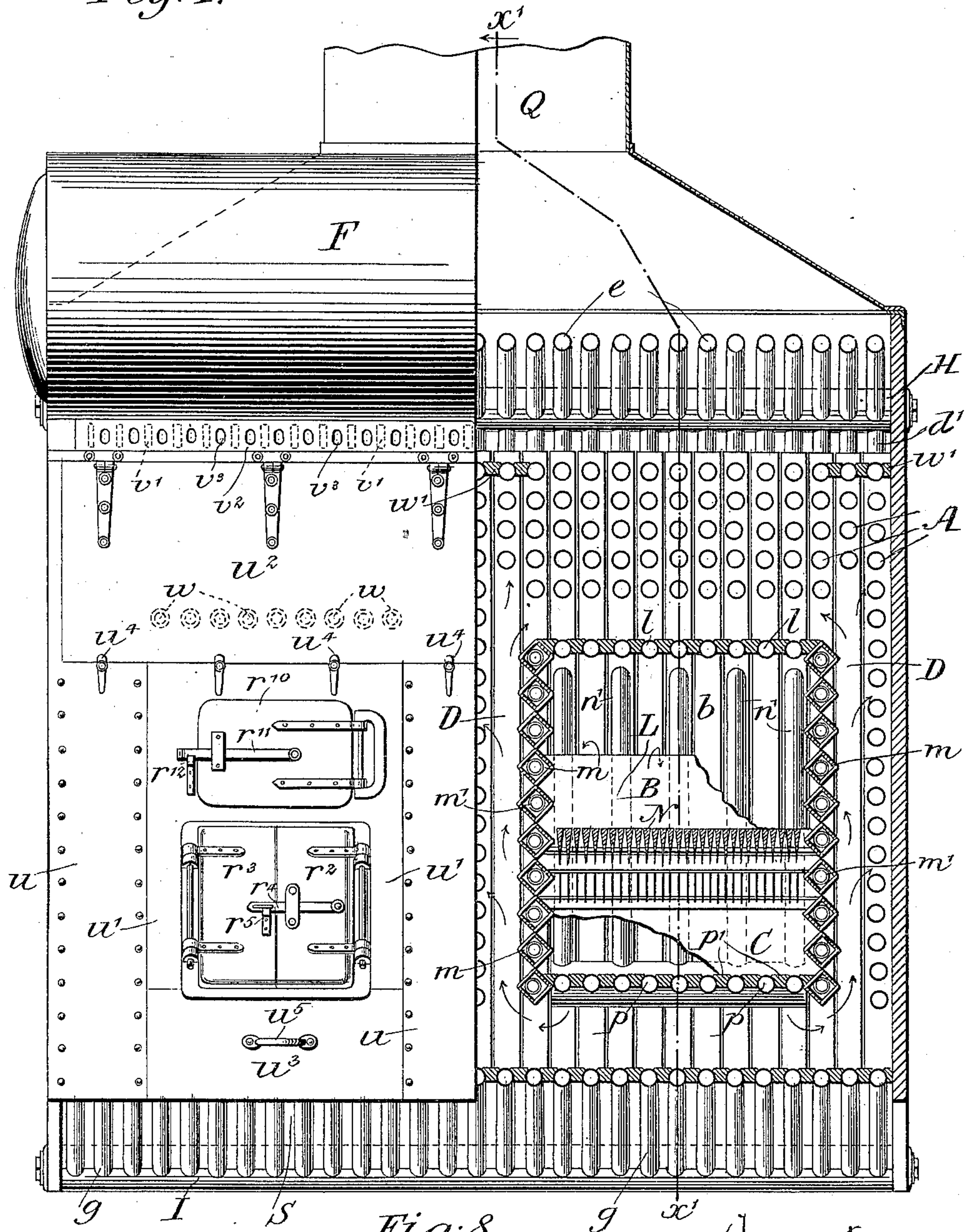
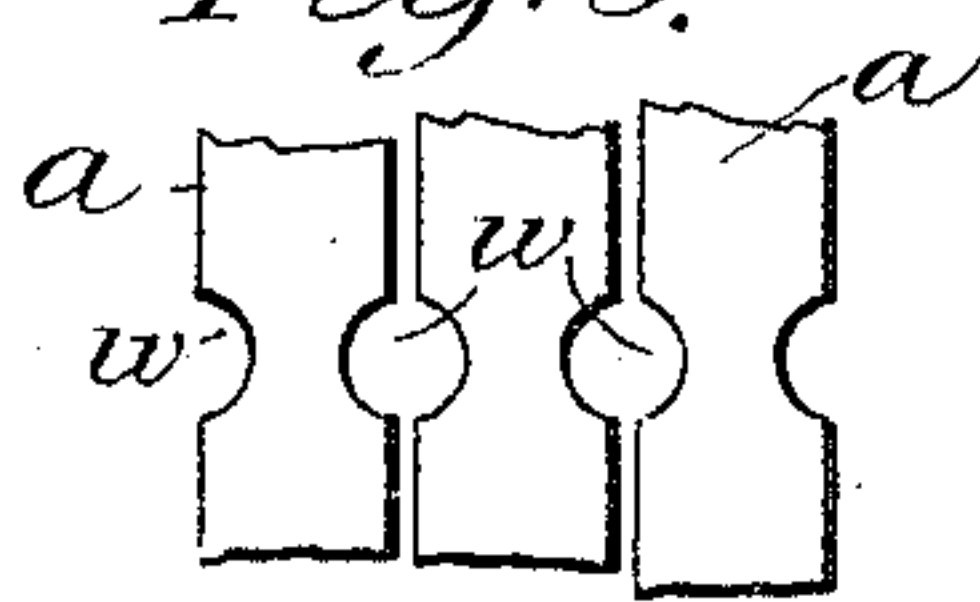


Fig: 8.



Witnesses:
J. A. Kennie.
R. F. Sweeney.

Inventor;
Amasa Worthington
By *Wm. S. Abbe*,
his Attorney.

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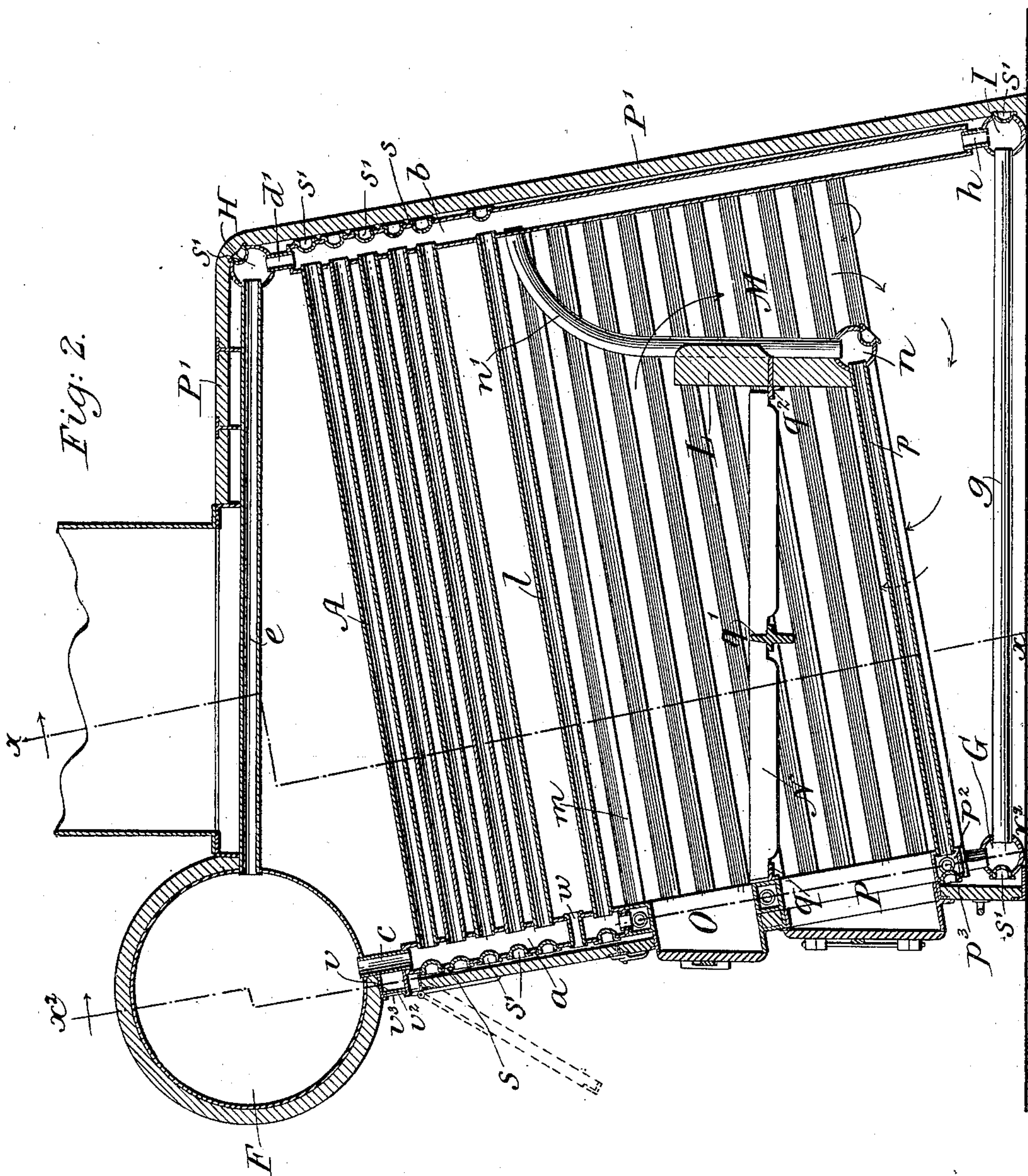
A. WORTHINGTON.

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5 Sheets—Sheet 2.



Witnesses:
J. A. Rennie
A. F. Sweeney.

Inventor;
Amasa Worthington
By Wm. S. Appleton
his Attorney.

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A. WORTHINGTON.

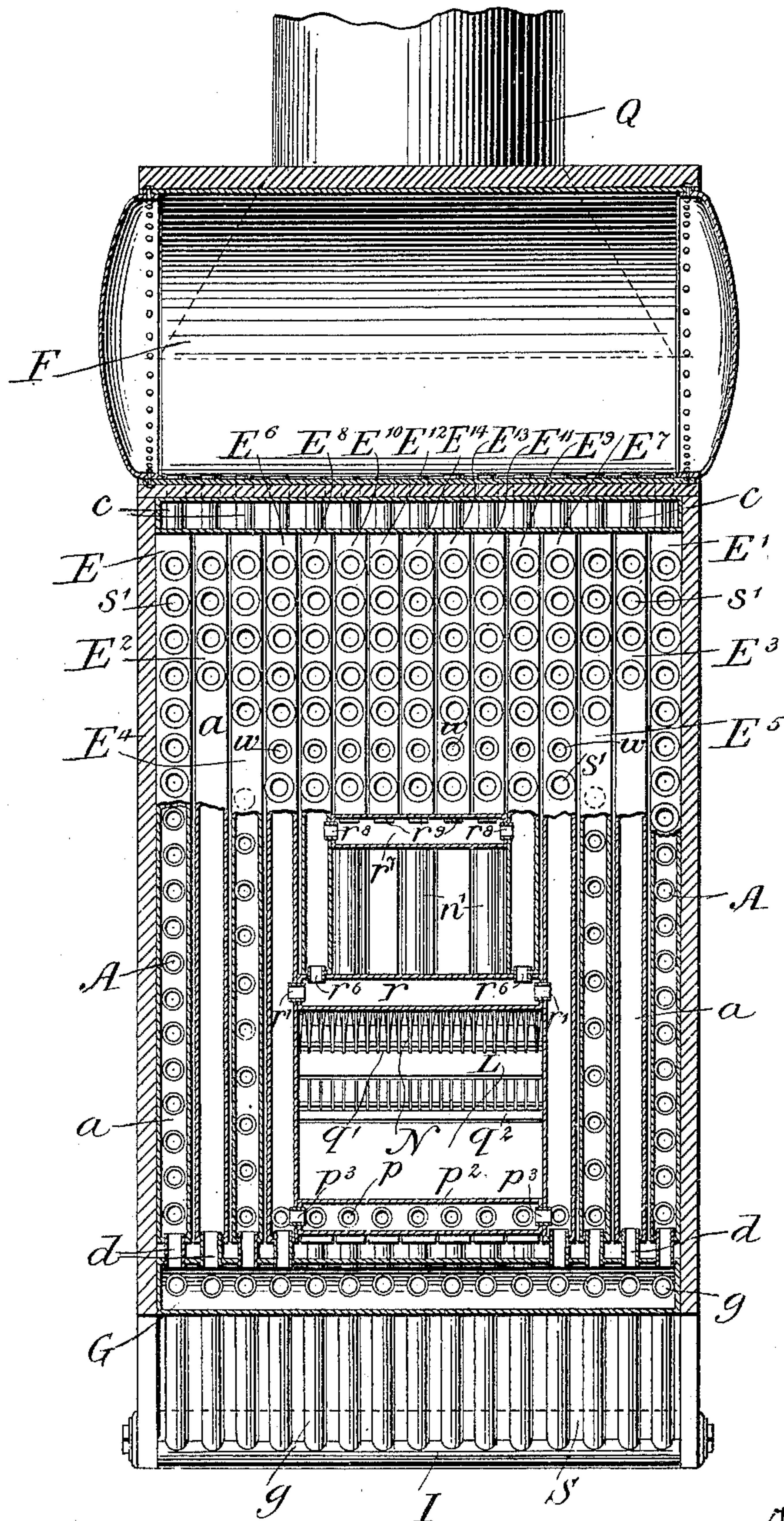
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Fig. 3.



Witnesses:
J. A. Rennie
A. F. Sweeney

Inventor;
Amasa Worthington
By M. H. Appleton,
his Attorney.

No. 672,250.

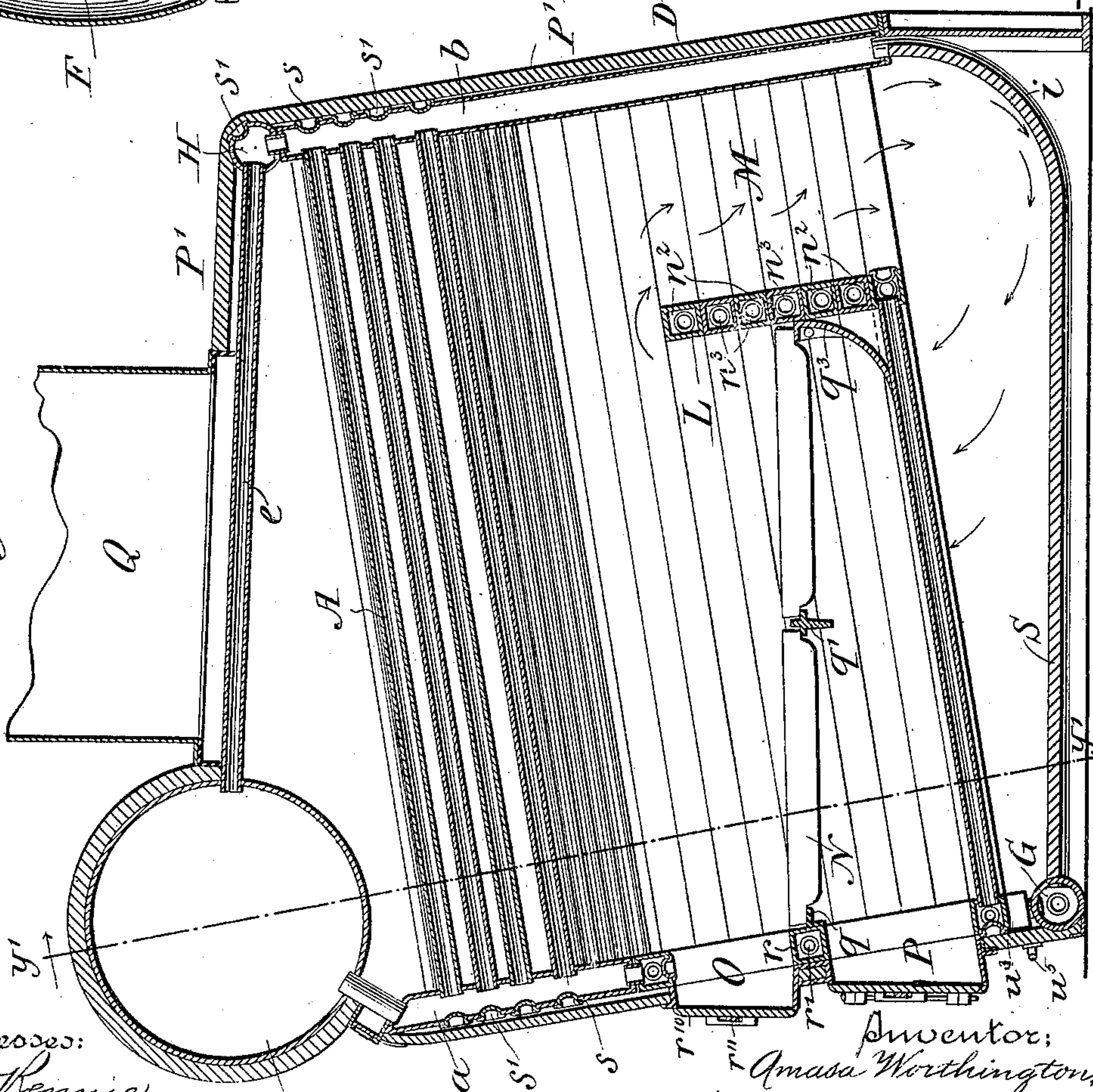
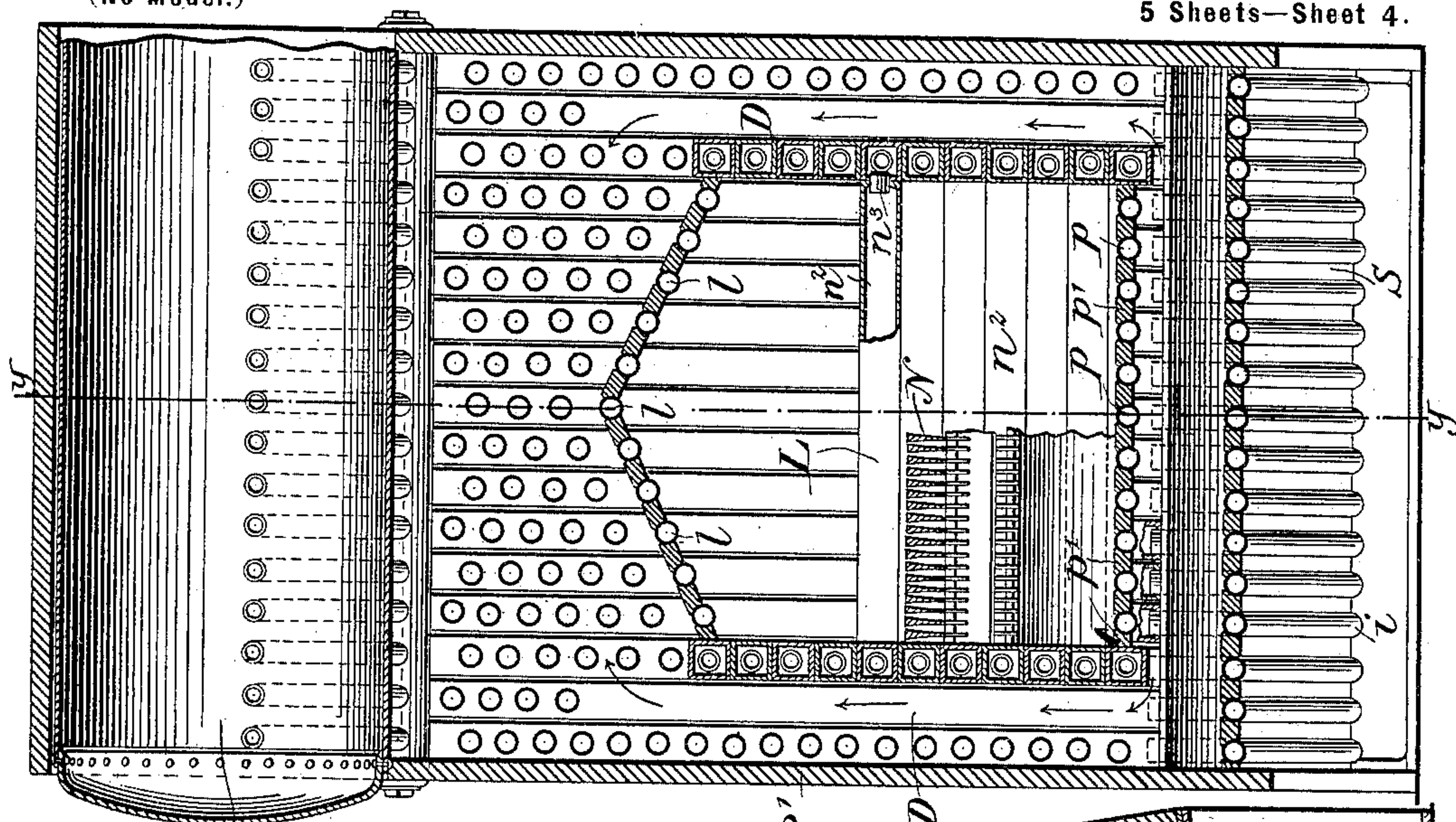
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5 Sheets—Sheet 4.



Witnesses:
J A Rennie
R F Sweeney

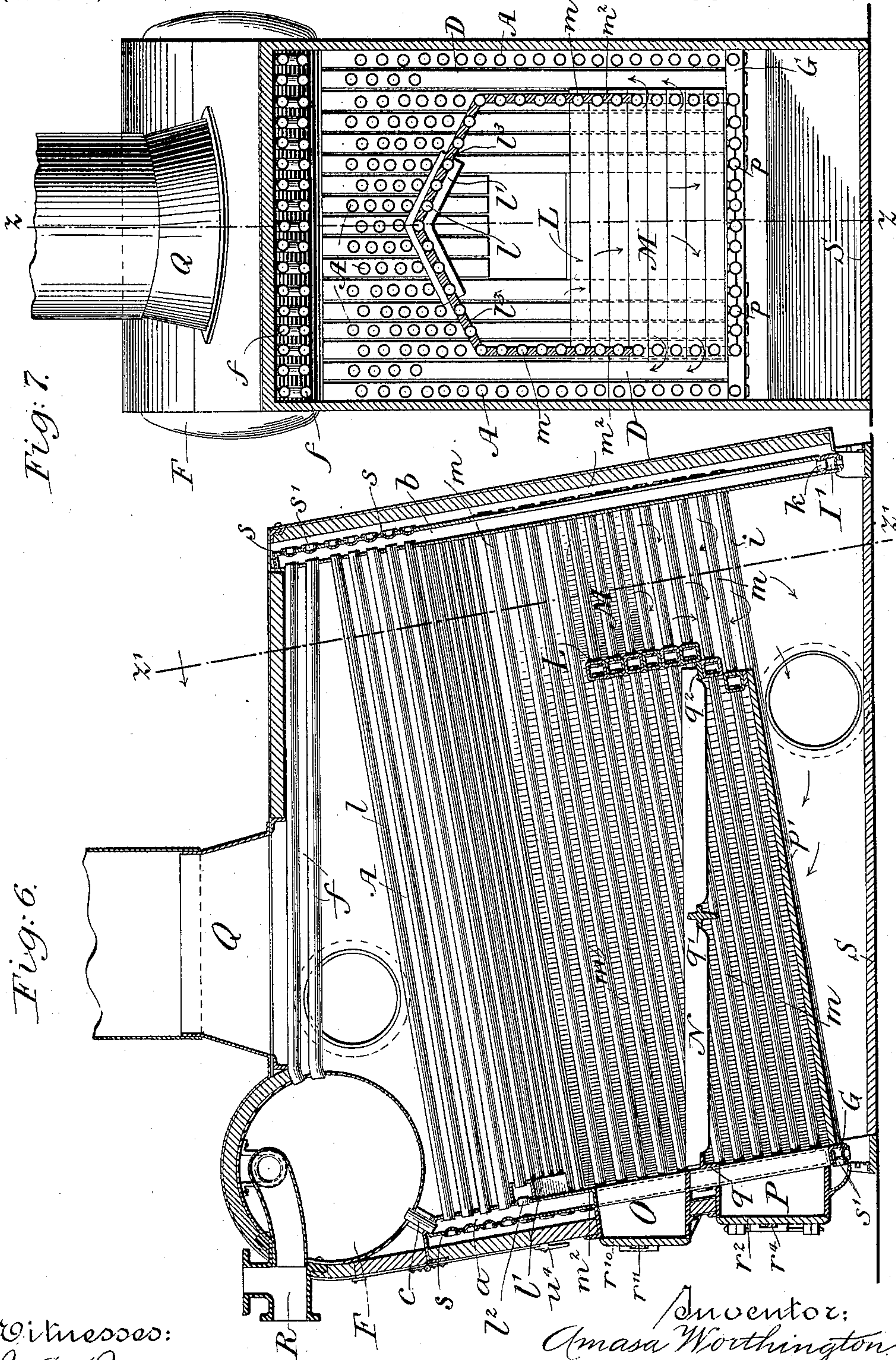
Inventor;
Amasa Worthington.
By Myself Ableton,
his Attorney.

A. WORTHINGTON.
STEAM BOILER.

(Application filed Nov. 20, 1900.)

(No Model.)

5 Sheets—Sheet 5.



Witnesses:
J. A. Bennie
R. F. Sweeney

Inventor:
Amasa Worthington
By *Wm. H. Appleton*,
his Attorney.

UNITED STATES PATENT OFFICE.

AMASA WORTHINGTON, OF BROOKLYN, NEW YORK.

STEAM-BOILER.

SPECIFICATION forming part of Letters Patent No. 672,250, dated April 16, 1901.

Application filed November 20, 1900. Serial No. 37,149. (No model.)

To all whom it may concern:

Be it known that I, AMASA WORTHINGTON, a citizen of the United States, and a resident of the borough of Brooklyn, in the city of New York, county of Kings, and 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 steam-boilers of the water-tube type in which a plurality of series of sections are combined with appropriate steam and water drums with which they cooperate, and while the same is primarily intended for marine use it may also be advantageously employed for generating steam for other and general purposes. With boilers of this class as heretofore constructed it has been the custom to locate the fire-box wholly below the water-tubes in the boiler-setting, whereby the heat and other products resulting from the combustion of the fuel have passed upwardly directly therefrom to and between the water-tubes. In some instances the heat and other products thus passed upwardly between the tubes have been conducted in a more or less direct line from the fire-box to the uptake, while in other instances they have been conducted upwardly first between the tubes, thence downwardly between them, over a suitably-arranged bridge-wall, and thence to the uptake. In both of these instances, however, no means have been provided for confining the products of combustion with the heat for any length of time or for the commingling of their gases before their admission between the water-tubes, and as a result thereof they have cooled rapidly when brought into contact with those tubes, with the consequent effect that the particles of carbon and the gases thrown off by the combustion of the fuel have not been properly consumed, but have been carried away in the form of smoke and unconsumed gases, with a corresponding lack of combustion and loss of heat.

The object of my invention is therefore to overcome these and other defects and to produce a water-tube boiler which while simple in construction and possessed of the highest degree of efficiency shall at the same time so confine the products of combustion with the

heat and so commingle the gases thereof that the particles of carbon and gases thrown off in the combustion of the fuel shall be thoroughly consumed before they are passed with the heat among the water-tubes.

To these ends the invention consists, first, in a water-tube boiler having formed within itself an inclosed fire-box and flues leading therefrom, whereby the gases arising from the combustion of the fuel are commingled with the oxygen at a sufficiently high temperature to effect their complete consumption before being discharged among the water-tubes; second, in the peculiarities of construction of the inclosed fire-box and flues and their location within the boiler; third, in the peculiarities of construction within the boiler of the inclosed fire-box and ash-pit, with the flues leading from the former to the water-tubes; fourth, in the construction of the bridge-wall and in its arrangement with respect to the inclosed fire-box and the flues; fifth, in the peculiarities of construction of the boiler itself, and, sixth, in various other constructions and combinations of parts, all as will hereinafter more fully appear.

Referring to the accompanying drawings, which form a part of this specification, Figure 1 is a view of a double-furnace water-tube boiler constructed in accordance with my invention, a part of which is shown in front elevation and the other in vertical transverse section in the line xx of Fig. 2 and looking in the direction of the arrow in that figure, with a portion of the bridge-wall broken away; Fig. 2, a longitudinal vertical section of the same, taken in the plane $x'x'$ of Fig. 1; Fig. 3, a transverse vertical section of one of such boilers, taken in the line x^2x^2 of Fig. 2 and looking in the direction of the arrow in that figure, when constructed with a single furnace; Fig. 4, a longitudinal vertical section of a slightly-modified form of the boiler shown in Fig. 1, taken in the plane yy of Fig. 5; Fig. 5, a transverse vertical section thereof, taken in the plane $y'y'$ of Fig. 4, looking in the direction of the arrow in that figure; Fig. 6, a longitudinal vertical section of a still further modified form of the boiler illustrated in Fig. 1, taken in the plane zz of Fig. 7; Fig. 7, a transverse vertical section

of the same, taken in the plane $z'z'$ of Fig. 6; and Fig. 8, a detail front elevation of a number of front headers of a slightly-modified construction.

5 In all the figures like letters of reference are employed to designate corresponding parts.

A indicates the water-tubes, B the fire-box, C the ash-pit, and D the heat-conducting flues, of a boiler constructed in accordance
10 with my invention. Of these the water-tubes A are located in the upper portion of the boiler above the fire-box B and extend down along the side walls of the former, in which locations they are disposed in a number of
15 vertical series, with each of the series provided with a front header a and a rear header b , which are preferably constructed in rectangular form and provided in their inner faces with suitable orifices, in which the re-
20 spective ends of their appropriate tubes are secured. As thus constructed and arranged these several series, with their coöperating front and rear headers, constitute separate and independent sections $E E' E^2$, &c., which
25 in the completed boiler are arranged side by side in parallel relationship, with the front headers of the sections E to E^7 and the rear headers of all the sections extended from near the top of the boiler to near the bottom there-
30 of, while the front headers of the remaining sections are constructed somewhat shorter, whereby to permit of the location of the mouth or doors of the fire-box and ash-pit below them. With the front and rear headers constructed
35 as thus described the series of water-tubes A of the sections E and E' extend from near the top to near the bottom of the boiler and aid in forming the side walls thereof. The series of water-tubes of the other sections, on the
40 other hand, extend downward from near the top of the boiler to near the lower end of their front headers, whereby to locate the principal mass of the tubes above the fire-box, as before explained. As thus disposed the front
45 headers a of all the sections are connected at their upper ends with a transversely-arranged steam-drum F by short tubes or nipples c , which extend between them, while the lower ends of the front headers of the sections E to E^7
50 are similarly connected with the transversely-arranged mud-drum G by short tubes or nipples d . With the front headers a of all the sections thus connected with the steam-drum F the upper ends of all the rear headers b are
55 likewise connected therewith. In some instances this connection is effected through the intervention of a transversely-arranged drum H, as shown in Fig. 2, in which case the headers are connected with the drum H through
60 the medium of short tubes or nipples d' and the drum H then in turn connected with the drum F through the tubes e . In other instances this connection is accomplished without the intervention of the drum H, as shown
65 in Fig. 6, and in this case the upper end of each of the headers b is connected directly with the drum F through the intermediary of

a plurality of tubes ff . While the front and rear headers are thus connected at their upper ends with the drum F, the lower ends of
70 the rear headers b are also connected with the mud-drum G. In effecting this connection I sometimes make use of a second drum I, which, arranged transversely of the boiler, as shown in Fig. 2, and serving also as a mud-
75 drum, is connected with the mud-drum G through the tubes g and also with the lower end of each of the headers b through a short tube or nipple h . At other times I find it convenient to make this connection without
80 the aid of the drum I, and in this case I effect it by a tube i for each of the headers, which, connected at its front end with the mud-drum G, extends backward therefrom either in a straight line to its respective
85 header, with which it is connected some distance from its lower end, as shown in Fig. 6, or else in a curved line and is connected with the lower extremity of its header, as shown in Fig.
90 4, and any of these various forms of connection between the headers and steam and mud drum may be employed, as preferred, and the boiler operate with equal efficiency. When the form of connection intermediate the rear
95 headers b and the mud-drum G (shown in Fig. 6) is made use of, I sometimes find it convenient to employ a drum I' , which, extending transversely across the rear of the boiler, is connected with the lower end of each of the
100 rear headers b through the medium of short tubes or nipples k and serves not only to aid in the circulation of the water through the different headers with which it is connected, but also as an auxiliary to the mud-drum G. By thus connecting both the front and rear
105 headers with the steam-drum F the flow of the water from the water-tubes A into the rear headers b , thence to the steam-drum F, thence to the front headers a , and thence to the water-tubes A is permitted, and in order to in-
110 sure of the water being thus circulated when the boiler is in operation the tubes A, with those employed to form the top, sides, and bottom of the fire-box and ash-pit, instead of
115 being disposed in horizontal relationship are inclined upwardly somewhat from their front to their rear ends, as shown in the drawings. On the other hand, by connecting the front and rear headers with the mud-drum or mud-
120 drums the settlement of any mud or other sediment in the water into it or them is permitted, which may be afterward blown off or otherwise removed from it or them through an appropriate cock or cocks, with which it or
125 they is or are or may be provided.

For forming the top of the fire-box B, I make use of the tubes l , one of which extends from the front header a of each of the sections intermediate the sections E and E^5 to the rear header thereof, in which latter its rear end
130 enters a suitable orifice and is secured therein. In those cases where the water-tubes A in addition to being disposed in vertical series are likewise arranged in horizontal rows, as shown

in Figs. 1 and 3, these tubes l are likewise disposed in a horizontal series. On the other hand, when these tubes A instead of being disposed in horizontal rows are so arranged that the tubes of one section are arranged opposite the spaces between the tubes of the adjoining section, then these tubes l will be arranged in a flattened inverted-V form, as shown in Figs. 5 and 7. When arranged in a horizontal row, the front ends of these tubes l will be similarly secured in suitable orifices formed in their respective front headers a , and the same in some instances is also true respecting these tubes when they are disposed in the flattened inverted-V form, and their front ends will in like manner be secured in suitable orifices formed in their front headers, as shown in Fig. 4. In other instances, however, where these tubes l are thus disposed in the flattened inverted-V form their front ends instead of being all secured in their respective front headers a will have some secured in them and those immediately above the door of the fire-box secured in suitable orifices formed in a corresponding flattened inverted-V-shaped tube l' , which, preferably constructed of a rectangular form in cross-section, is secured to the inner side of the appropriate front headers by suitable nipples l^2 or otherwise, as shown in Fig. 6, whereby the lower ends of the headers immediately above the fire-box door are firmly bound together and the free circulation of the water through these headers and the tubes l , corresponding to them, insured. As thus disposed under any one of the arrangements specified the tubes will extend entirely across the top of the fire-box below the water-tubes A in a continuous series, and in order to prevent the passage of the heat or other products of the fuel combustion upwardly through the spaces between them these spaces throughout their entire length are filled with fire-brick l^3 or other heat-resisting material, as indicated. In like manner the tubes m are employed for forming the side walls of the fire-box B and ash-pit C , for which purpose they are disposed in two vertical series, of which one series leads downward from each edge of the top of the fire-box to the proper distance and extends longitudinally across from the front headers a to the rear headers b of the appropriate sections, to which the front and rear ends of their respective tubes are secured. In some instances these tubes are made of a rectangular form in cross-section, in which case their sides will sometimes be disposed in diagonal relationship, with the upper and under corners of the adjacent tubes in line and in contact, as shown in Fig. 1, while in other cases they will be so disposed as to bring the upper and under sides of adjacent tubes in parallel relationship and in contact, as shown in Fig. 5, in both of which cases a closed wall will be formed on each side of the fire-box and ash-pit without other assistance, and the

connection of the respective front and rear ends of these tubes with their appropriate front and rear headers will be effected through the intervention of nipples m . In other instances, on the other hand, these tubes will be made cylindrical, as shown in Fig. 7, in which event the spaces between the adjoining tubes will be completely closed by fire-brick or other heat-resisting material m^2 and their respective front and rear ends will be secured in suitable orifices provided for them in their cooperating front and rear headers. As thus arranged the fire-box and ash-pit, along with a closed top to the former, are provided with closed side walls, with heat-conducting flues B on opposite sides thereof, and a free circulation of the water through the tubes entering into their construction to their respective headers likewise permitted. With the side walls of the fire-box and ash-pit thus constructed I make use of a bridge-wall L , whereby to provide a descending flue M , through which the connection of the fire-box B with the flues D is established. This bridge-wall may be constructed either of fire or other form of brick or from water-circulating tubes. When constructed of fire or other form of brick, I prefer to make use of the tube n , which, extending across from one side of the ash-pit to the other, is connected at its opposite ends to the tubes of the respective walls either by being nipped in or by being otherwise secured at its ends to them, and is likewise connected along its upper side with the appropriate back headers b through the intervention of the curved tubes n' , which are secured at their opposite ends in suitable orifices formed in the tubes n and their cooperating headers, respectively. As thus supported the fire or other bricks are arranged upon the tube n and extending upwardly therefrom to the proper distance at a slightly-backward inclination have portions which pass between the tubes n' , whereby to aid in holding them in the proper position. On the other hand, when constructed of water-circulating tubes, as n^2 , these tubes, which are preferably constructed in rectangular form in cross-section, are disposed the one above the other in a continuous series, with the upper and under sides of the adjacent tubes in parallel relationship and in contact, as shown in Fig. 4, or with their sides disposed in a similar relationship and the lower tubes offset slightly in a forward direction, as shown in Fig. 6. When disposed under the first of these arrangements, the several tubes n^2 are united at their opposite ends to the tubes m in their respective sides of the fire-box and ash-pit by suitable nipples n^3 . On the other hand, when disposed under the second of these arrangements the ends of the tubes will be closed, and the tubes m of the side walls of the fire-box and ash-pit opposite to them instead of extending wholly across from their front headers a to their rear headers b will be constructed in two sections, with

their inner ends secured in suitable orifices formed in the opposite walls of the tubes n^2 , respectively, as shown in Fig. 6. With these tubes n^2 arranged under either of these arrangements a close wall is formed, and through their connection with the tubes m in the side walls of the fire-box and ash-pit a free circulation of the water through them is insured.

For closing the bottom of the ash-pit C, I sometimes make use of a plate, which may be constructed of metal or other heat-resisting material and may be composed of a single piece or a plurality of pieces, as may be desired. When this plate is employed, it may extend from one of the side walls of the ash-pit to the other and from the mud-drum G to the under of the tubes n^2 , composing the bridge-wall, and be secured in that position by any appropriate means. I prefer, however, to effect this closure with the tubes p and to fill the spaces between them from the front of the boiler to the bridge-wall with fire-bricks or other appropriate material p' . To this end the tubes are disposed in a horizontal series across the bottom of the ash-pit and may extend either from the front of the boiler to the bridge-wall or from the front of the boiler to the rear thereof, as preferred. When extended only to the bridge-wall, the rear ends of these tubes will be secured in suitable orifices formed in either the tube n when the construction of bridge-wall shown in Fig. 2 is employed or in the under of the tubes n^2 when the form of the invention shown in Fig. 4 is adopted. On the other hand, when extended to the rear of the boiler their rear ends will be secured in suitable orifices formed in their respective rear headers b , in which case the fire-bricks or other filling material m^2 between the tubes m will be omitted from between a number of the lowest of those tubes in the sides of the descending flue M, whereby to increase its capacity and compensate for the reduction therein occasioned by the tubes p extending transversely across it. While the rear ends of these tubes p are thus secured either in the bridge-wall or rear headers, as the case may be, their front ends are likewise secured in similar orifices formed in the lower ends of the front headers of appropriate sections—as, for instance, E^6 and E^7 —and in a rectangular tube p^2 , that extends between them and is connected at its opposite ends to those headers by nipples p^3 . As thus disposed these tubes p form, with the fire-brick or other filling material p' between them, a smooth plain surface extending throughout the entire extent of the bottom of the ash-pit, from its front end to the bridge-wall L, and from one of its side walls to the other. With the top, bottom, and side walls thus constructed an inclosed fire-box and ash-pit is formed wholly within the boiler, and in order to separate the fire-box from the ash-pit I make use of the grate-bars N, which, extending across from one of the side walls to the other, are supported at their front ends upon a suitable

angle-bar q , that extends across from the front header of one section, as E^6 , to the front header of another section, as E^7 , and is secured to their inner sides by rivets or otherwise. The rear ends of these grate-bars, on the other hand, are supported by the bridge-wall L, with a suitable support q' extending across intermediate their ends and connected at its opposite ends to the side walls of the ash-pit in any convenient way. When the bridge-wall is constructed of fire or other form of brick, this support of the rear ends of the grate-bars will be effected by a bar q^2 , arranged within the same and projecting from its face, as shown in Fig. 2. On the other hand, when constructed of tubes, as shown in Fig. 4, a suitable curved deflecting-plate q^3 may be employed for the purpose, which, resting upon the bottom of the ash-pit and extending across from one of its side walls to the other, is secured at its ends to the walls by screws or other equivalent fastening devices. On the other hand, when the form of bridge-wall as shown in Fig. 6 is employed their support may be effected by one of the offset tubes n^2 , upon which the rear ends of the grate-bars may rest. While the fire-box is thus separated from the ash-pit, the opening for the door-frame O of the former is separated from the opening for the door-frame P of the latter by a transversely-arranged tube r , which, preferably constructed of rectangular form in cross-section, extends across from the front header of the section E^7 to the front header of the section E^8 and is secured at its respective ends to them by suitable nipples r' . As thus divided the door-frame P of the ash-pit is secured in the lower of these openings by suitable bolts or rivets and is provided with suitable doors r^2 and r^3 , which, hinged thereto, are respectively provided with an appropriate latch r^4 and a catch r^5 , as shown in Fig. 1. The door-frame O, on the other hand, is located in the upper of these openings, in which it is similarly secured by bolts or rivets, and in order to reduce the width of the opening to suit it to the width of the frame the lower ends of the respective front headers of the sections on opposite sides of it, as E^8 and E^9 , are extended downward to the cross-tube r , in which they are secured by suitable nipples r^6 . With the parts disposed as thus described the lower ends of the front headers immediately above the door of the fire-box are bound together and firmly held, either by the flattened inverted-V-shaped tube l' when the arrangement of the tubes for the top of the fire-box shown in Fig. 5 is employed, as before explained, or by a rectangular-shaped tube r^7 , which, extending across above the door-frame between the front headers of the sections on opposite sides of it, as E^8 and E^9 , and having its opposite ends respectively secured to them by short tubes or nipples r^8 , has the lower end of the former headers secured in its upper sides by short tubes or nipples r^9 when the arrangement of tubes shown

in Fig. 1 is adopted. As thus secured in place the door-frame N is provided with an appropriate door r^{10} , which is hinged thereto and is provided with a suitable latch r^{11} , that engages with a catch r^{12} , secured to the frame, as shown.

In effecting the securing of the ends of the various tubes and nipples in the respective orifices in which they enter any of the ordinary and well-known expedients usually adopted for that purpose may be employed. I prefer, however, to accomplish this result by expanding the portion of the tube or nipple which enters the orifice until it completely fills the same and has its own extremity made somewhat larger than the latter, as is now common to boilers of this class, and in order to provide for the expansion of these ends the various headers, tubes, and other members in which they are expanded are provided in the side opposite to them with suitable hand-holes s , through which access may be had to them for that purpose and which may be closed by any appropriate means, such as screw plugs or caps. In the form of the invention which I have selected for illustration, however, these closing devices consist of cup-shaped stoppers s' , which are constructed of ductile sheet metal and, provided with outwardly-extending flanges around their upper edges, are inserted in the hand-holes to be closed and expanded in them until beads are formed in them on the inner sides of the members in which they are respectively employed, all as shown and described in the application for Letters Patent filed by me in the United States Patent Office June 15, 1900, Serial No. 20,406, to which reference may be had.

The boiler being constructed as above described may be inclosed within an ordinary brick or other masonry setting. I prefer, however, to inclose it in a setting composed of plates P' , which may be formed from cement, magnesia, or fire-felt properly treated and firmly packed and solidified in pan-shaped sheet-metal backs that are provided with ribs and flanges on their inner sides, which are formed by securing angle-irons to them by rivets or otherwise, as illustrated and described in United States Letters Patent No. 524,878, which were granted to me August 21, 1894. As thus formed these plates may be constructed of a size sufficiently great to cover the entire side, back, or top of the boiler, or they may be constructed as constituent sections or panels and afterward secured together, as preferred. In the construction of the fronts of the settings, however, I find it convenient to form the plates into sections which comprise plates u , an intermediate plate u' , an upper plate u^2 , and an under plate u^3 . As thus constructed the intermediate plate is formed to receive the respective door-frames of the fire-box and ash-pit and extend both above and on opposite sides of them and, with the side plates u ,

is secured by rivets or other fastening devices to the headers or other convenient parts of the boiler. The plate u^2 , on the other hand, extends across the boiler above the plates u and u' and may be either fixedly secured in place by bolts or otherwise or hinged at its upper edge to a suitable support arranged for that purpose above it, in which latter case it may be swung upward to admit of access to the front headers a or be held in a closed position by suitable buttons u^4 , pivoted to the plates u and u' , as shown. While the plates u , u' , and u^2 are thus arranged, the removable plate u^3 is disposed beneath the door to the ash-pit and is removable therefrom to admit access to the lower portion of the boiler beneath the ash-pit for cleaning, &c., being provided with a suitable handle u^5 or other convenient means whereby it may be readily handled. With the boiler inclosed as thus described the floor S below the ash-pit and the descending flue may be formed either from cement disposed in the form of a sheet, as shown in Figs. 6 and 7, or by fireproof bricks or other similar material interposed between the tubes i , that extend backward from the mud-drum to the back of the boiler, as shown in Fig. 4.

In order to provide for removing the ashes and other accumulation from the water-tubes A , I sometimes find it convenient to employ a plate v , which, extending across the boiler beneath the steam-drum F , is provided with suitable orifices v' opposite the spaces between the short tubes or nipples c , through which a brush or jet of steam may be inserted or injected, as may be desired, and with a view to closing and opening them when desired I make use of a plate v^2 , which, fitted to slide back and forth over the same, is provided with similar orifices v^3 , that register with the orifices v' when brought opposite to them and close the same when carried into positions that are intermediate. To aid in thus removing the ashes or other accumulation from the water-tubes and top of the fire-box, I sometimes find it convenient to employ a row of tubes w , which, extending through the headers from their front to their back, permits of steam being introduced therethrough from a suitable nozzle and diffused along the tubes and over the top of the boiler, as will be readily understood. In some cases these tubes w will extend directly through the front headers, in which case they will be expanded in them, as is the case with the various nipples employed, and as shown in Figs. 2 and 3. In other instances they will be formed by swaging them in the walls of the header, as shown in Fig. 8, in which cases one-half of the orifices will be formed in one of the headers and the other in the cooperating wall of the adjacent header, as shown.

The boiler being constructed as above described, the chimney or uptake Q will preferably extend from its top immediately in rear of its steam-drum F . When but a single furnace is employed, it will be located midway

the sides thereof, as shown in Fig. 3. On the other hand, when two furnaces are to be used together, as shown in Fig. 1, it will preferably be located directly between them and will be provided at its lower end with a conical cap, which will extend outward over both of the furnaces to their opposite sides. While the chimney or uptake Q is thus located, the steam will be preferably conducted from the boiler through a pipe R, which will extend outward from the interior of the steam-drum, as illustrated in Fig. 6.

With the boiler constructed as above described the heat and other products of combustion arising from the fuel on the grate-bars N instead of passing directly upward into and among the water-tubes A will impinge against the top of the fire-box and be thereby deflected toward the rear of the boiler, where, contacting with the rear headers b, they will be deflected downward through the descending flue M, where in turn they will contact with the bottom S and, passing outward in opposite directions beneath the walls of the ash-pit and fire-box, will be deflected upwardly through the flues D and discharged among the water-tubes A on their way to the uptake Q. As a result of the tortuous course thus given to these products in passing from the fire-box to the water-tubes and the many abrupt deflections with which they meet in traveling along the same in closed flues with the heat not only are the gases contained in them more thoroughly commingled, but the same, with the particles of carbon arising from the combustion, more thoroughly consumed before being discharged among those tubes than has been possible with boilers of this class as heretofore constructed. Moreover, with the top, side, bottom, and end walls of the fire-box and heat-conducting flues constructed in whole or in part of water-circulating tubes the loss of heat experienced when these parts are constructed of masonry is obviated and the maximum amount of the heat arising from the combustion utilized. From the upper ends of the flues D the heat passes to and among the water-tubes A, and in order to more thoroughly deflect it inward among them I sometimes find it desirable to employ deflectors w', which extend inward from the outer side walls of the boiler over a number of the water-tubes of the outer sections and are preferably formed from fire-brick interposed between those tubes, as shown more fully in Fig. 1.

It will thus be seen that I produce a water-tube boiler which, while simple and compact in construction and capable of use either on shipboard or elsewhere, insures not only the thorough commingling of the gases arising from the combustion of the fuel, but also of their complete consumption with the particles of carbon before being delivered between the water-tubes, and at the same time permits of the use of either anthracite or bituminous

coal without objectionably contaminating the atmosphere with smoke or soot.

While in the foregoing I have described the form of my invention which I prefer to adopt in practice, it is to be understood that I do not limit myself thereto, but reserve to myself the right to modify the same in various ways without departing from its spirit and scope.

Having now described my invention and specified certain of the ways in which it is or may be carried into effect, I claim and desire to secure by Letters Patent of the United States—

1. A water-tube boiler, comprising a plurality of independent sections of water-tubes and headers, an inclosed fire-box, and flues leading downward and then upward from the fire-box to the water-tubes, with both the fire-box and flues formed within the boiler and provided in their respective walls with water-circulating tubes, substantially as described.

2. The combination, with a plurality of series of water-tubes, and the front and rear headers thereof, of a fire-box and flues leading from the fire-box to the water-tubes, the walls of both of which fire-box and flues are provided with water-circulating tubes, substantially as described.

3. The combination, with a plurality of series of water-tubes and the front and rear headers thereof, which form with such series of water-tubes independent sections, of an inclosed fire-box and flues leading therefrom to the water-tubes, the walls of both of which fire-box and flues are provided with water-circulating tubes that connect at their respective front and rear ends with the front and rear headers, substantially as described.

4. The combination, with a plurality of series of water-tubes, and the front and rear headers thereof, which, with such series of water-tubes, form independent sections, of an inclosed fire-box, an inclosed ash-pit, and flues leading from the fire-box to the water-tubes, the walls of the fire-box, the ash-pit and the flues being provided with water-circulating tubes that connect at their respective front and rear ends with the front and rear headers, substantially as described.

5. The combination, with a plurality of series of water-tubes, front and rear headers therefor, and an inclosed fire-box, of a descending flue leading from such fire-box, and upwardly-extending flues arranged on opposite sides of the fire-box and connecting the descending flue with the spaces between the water-tubes, substantially as described.

6. The combination, with a plurality of water-tubes, and means whereby they are connected to permit of the water circulating through them, of a fire-box the top and side walls of which are formed of water-circulating tubes that are connected with the first-mentioned tubes, with the spaces between them filled with heat-resisting material, a de-

scending flue, and ascending flues located on opposite sides of the fire-box and connecting the descending flue with the spaces between the water-tubes, with the side walls of these ascending flues formed of water-circulating tubes which are likewise connected with the first-mentioned tubes, substantially as described.

7. The combination, with a plurality of series of water-tubes, means whereby they are connected to permit of the water circulating through them, and a fire-box the top and side walls of which are provided with water-circulating tubes that are connected with the first-mentioned tubes, of a bridge-wall arranged transversely of the fire-box and provided with means by which the water is circulated through it, of a descending flue arranged in rear of such bridge-wall and leading from the fire-box, and ascending flues for connecting the descending flue with the spaces between the first-mentioned tubes, substantially as described.

8. The combination, with a plurality of series of water-tubes, means whereby they are connected to permit of the water circulating through them, a fire-box and an ash-pit, the top and side walls of which fire-box and the bottom and side walls of which ash-pit are provided with water-circulating tubes that are connected with the first-mentioned tubes, of a bridge-wall arranged transversely of the rear of the fire-box and ash-pit and constructed of water-circulating tubes through which the water contained in both of the above-mentioned tubes may circulate, a descending flue arranged in rear of such bridge-wall, and ascending flues leading from the lower end of the descending flue to the spaces between the first-mentioned tubes, with the walls of both of the descending and ascending flues pro-

vided with water-circulating tubes, substantially as described.

9. The combination, with a plurality of series of water-tubes, front and rear headers therefor and which with such series of water-tubes constitute separate and independent sections, a steam-drum, a mud-drum, and means whereby the upper ends of both the front and rear headers are connected with such steam-drum, and the lower ends of such headers connected with the mud-drum, of a fire-box and ash-pit, the top and side walls of which fire-box and the bottom and side walls of which ash-pit are provided with water-circulating tubes that are connected with the first-mentioned tubes, substantially as described.

10. The combination, with a plurality of series of water-tubes, and the front and rear headers thereof, of the water-circulating tubes that extend through the top and side walls of the fire-box and the bottom and side walls of the ash-pit and are connected with the front and rear headers, substantially as described.

11. The combination, with a plurality of water-tubes, the chimney or uptake, and the side walls of the boiler, of the fire-box, the downwardly and upwardly extending flues leading from the fire-box to the water-tubes, and the deflectors arranged above and across the upper ends of the upwardly-extending flues to deflect the heat passing upwardly through them inwardly from the outer walls of the boiler, substantially as described.

In witness whereof I have hereunto set my hand this 16th day of November, 1900.

AMASA WORTHINGTON.

Witnesses:

FRANK S. OBER,
R. F. SWEENEY.