No. 816,811. PATENTED APR. 3, 1906.

D. B. MORISON.

APPARATUS FOR CONDENSING STEAM.

APPLICATION FILED JAN. 23, 1905.

4 SHEETS—SHEET 1.

Fig. 1.

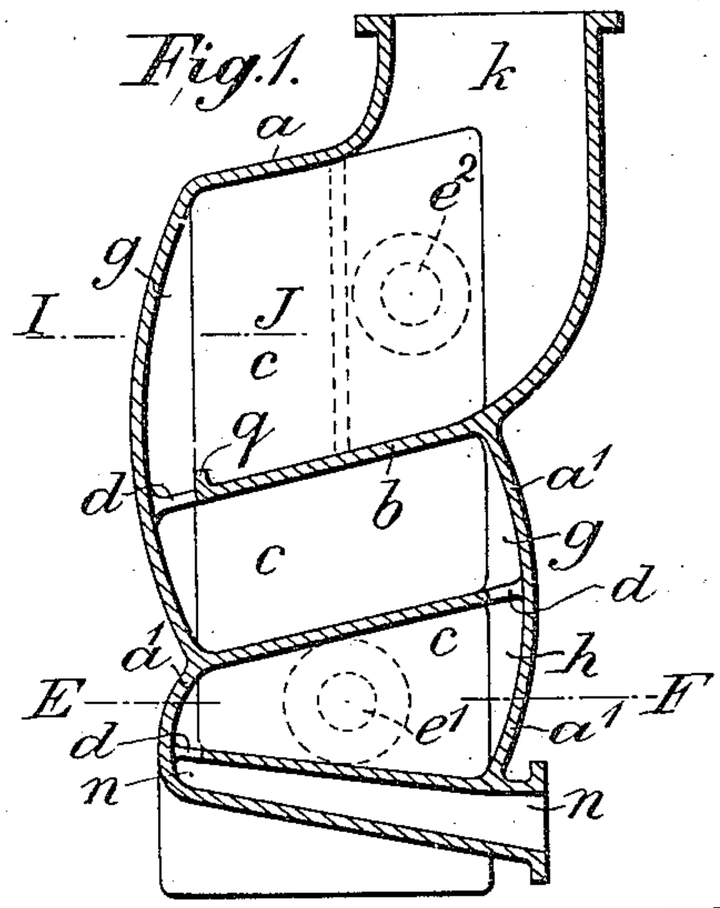


Fig. 2.

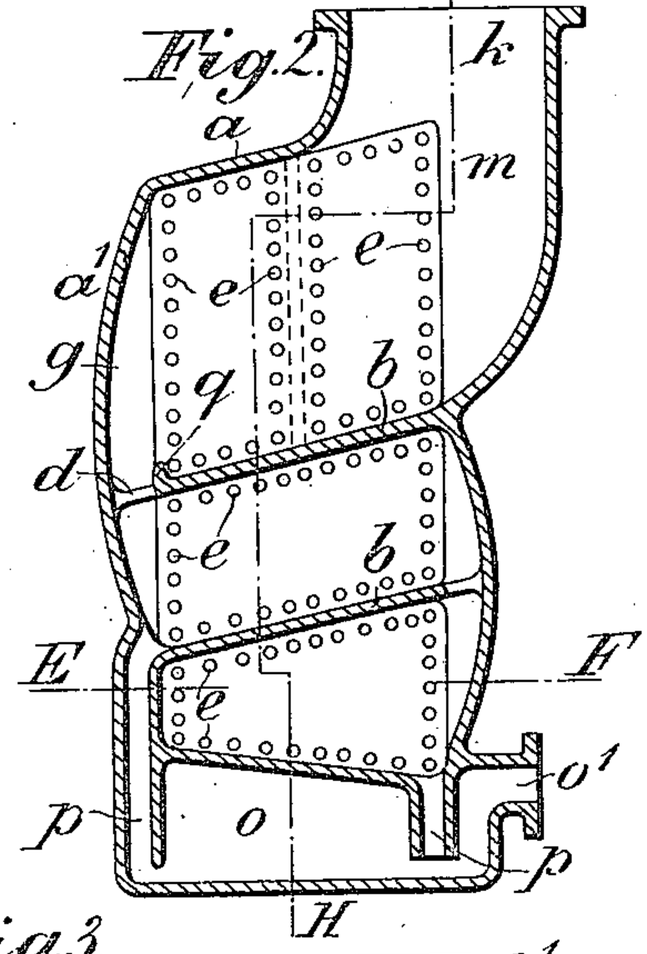


Fig. 3.

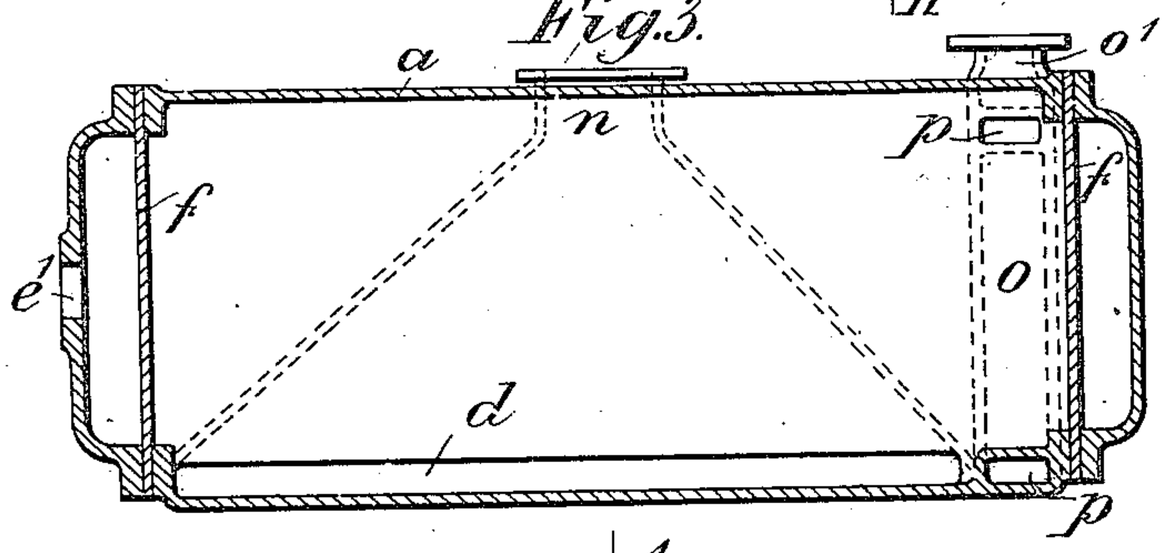
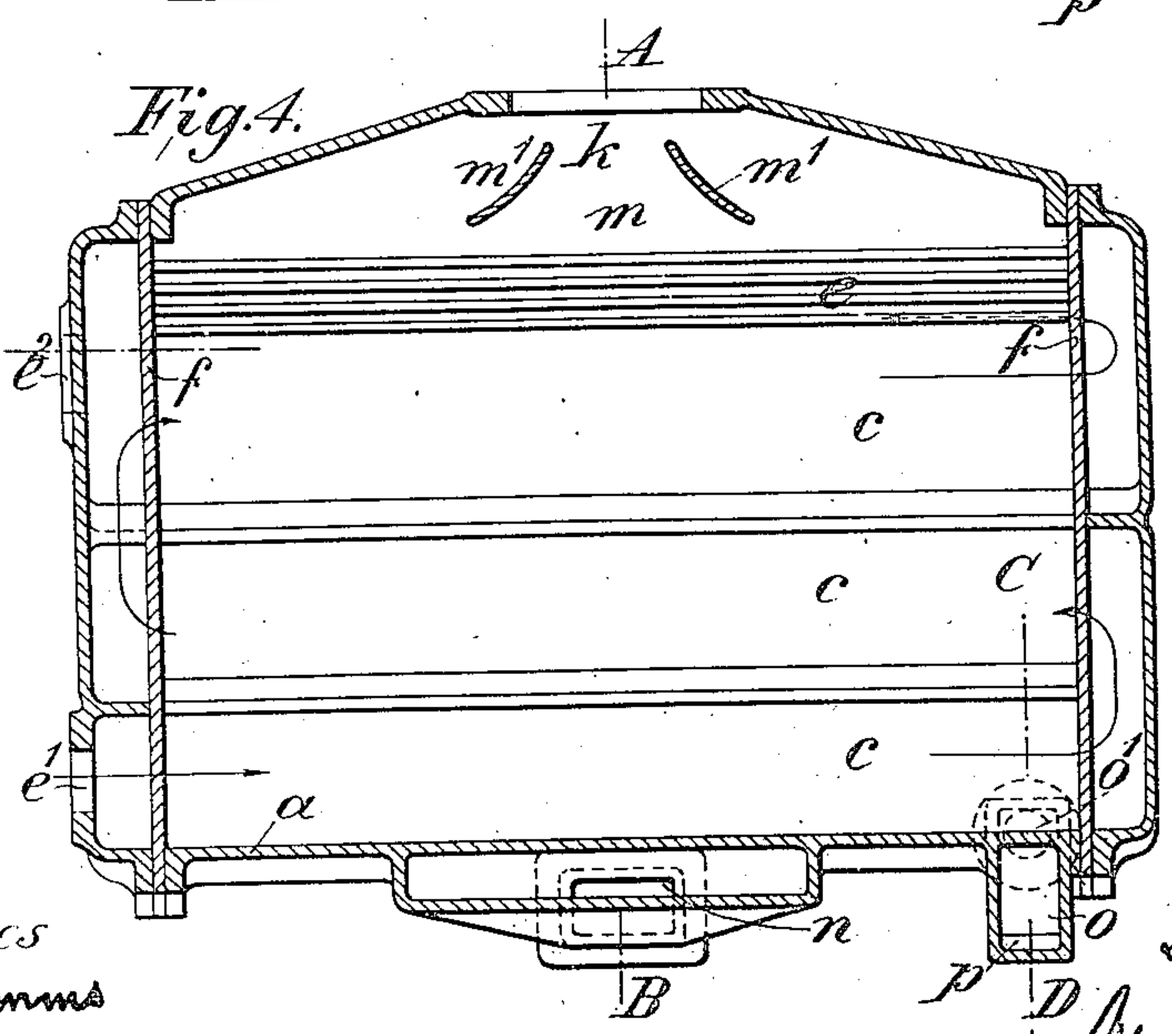


Fig. 4.



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4 SHEETS—SHEET 2.

Fig. 5.

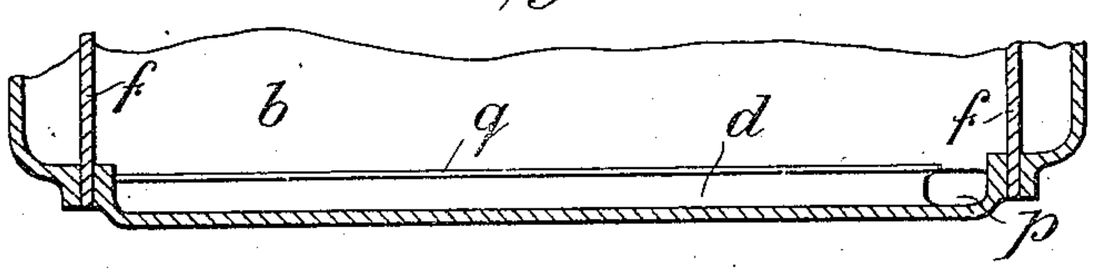
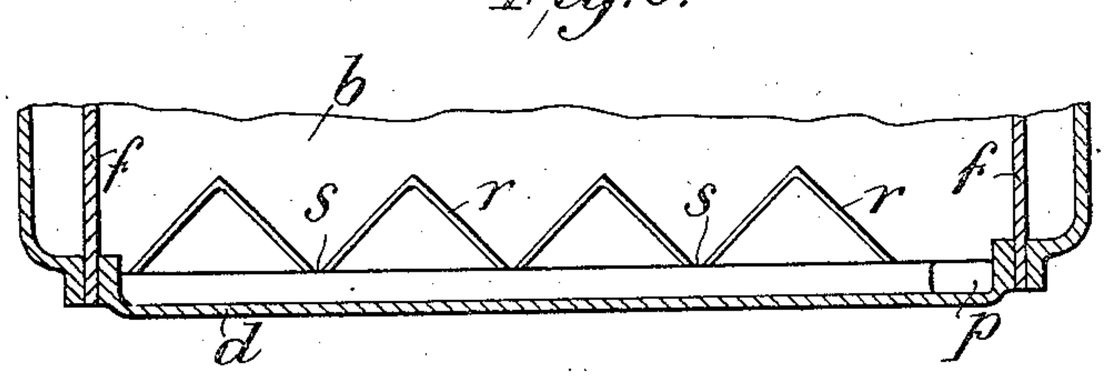


Fig. 6.



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4 SHEETS—SHEET 3.

Fig. 7.

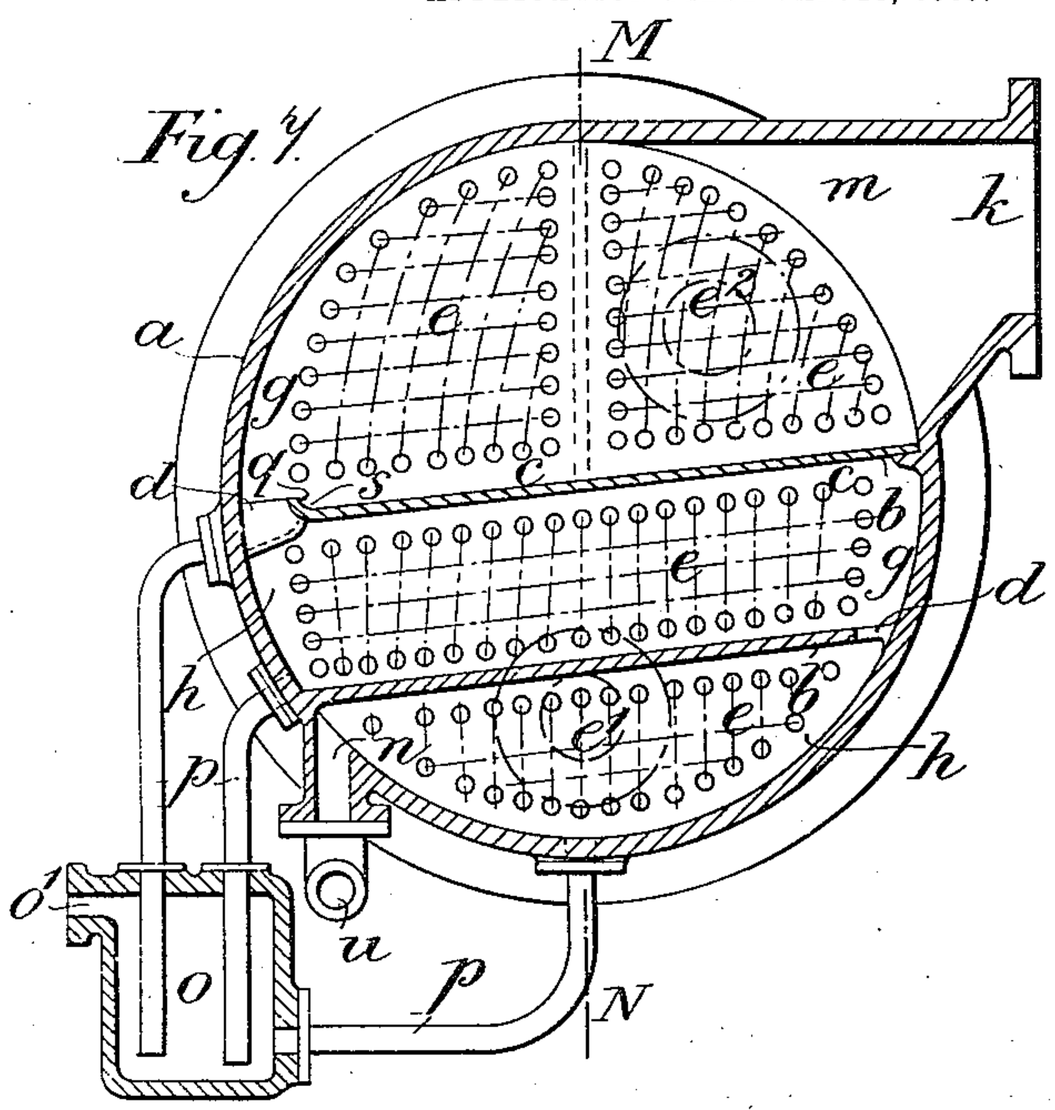


Fig. 8.

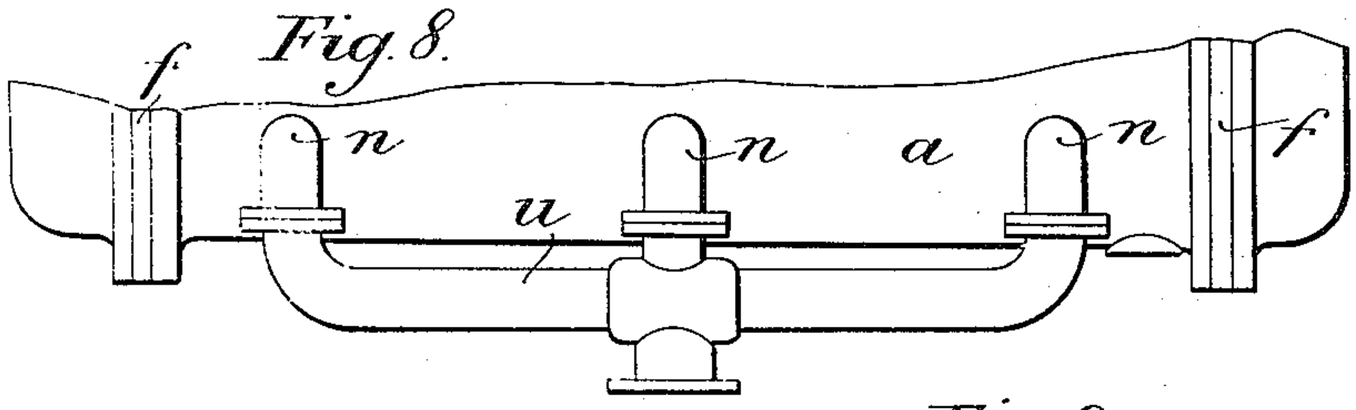
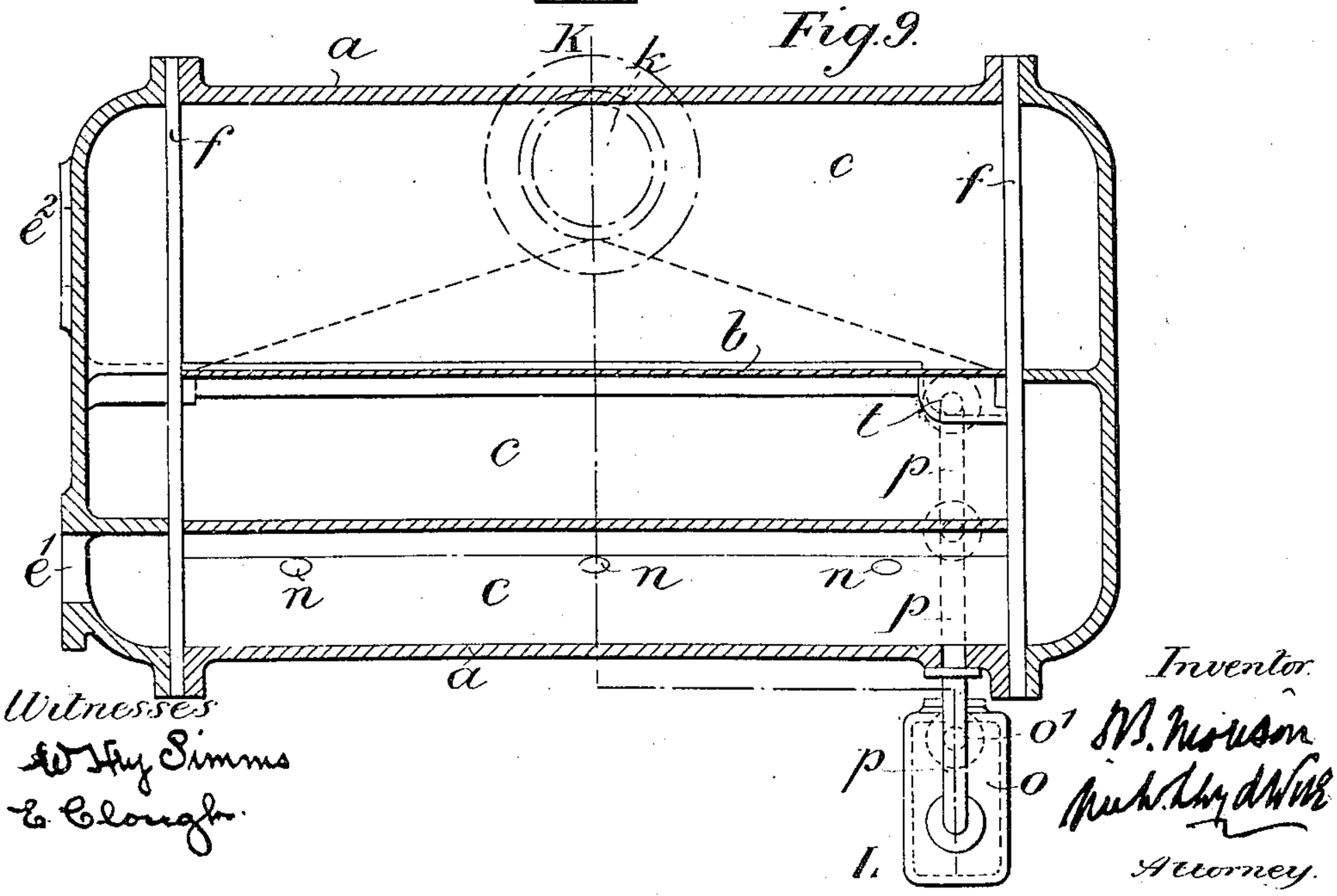


Fig. 9.



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No. 816,811. PATENTED APR. 3, 1906.

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APPLICATION FILED JAN. 23, 1905.

4 SHEETS—SHEET 4.

Fig. 10.

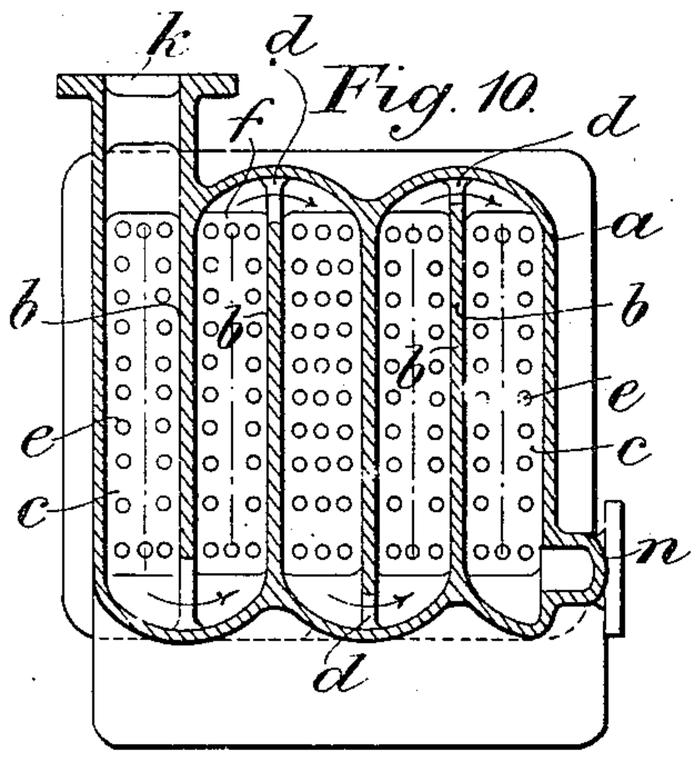


Fig. 11.

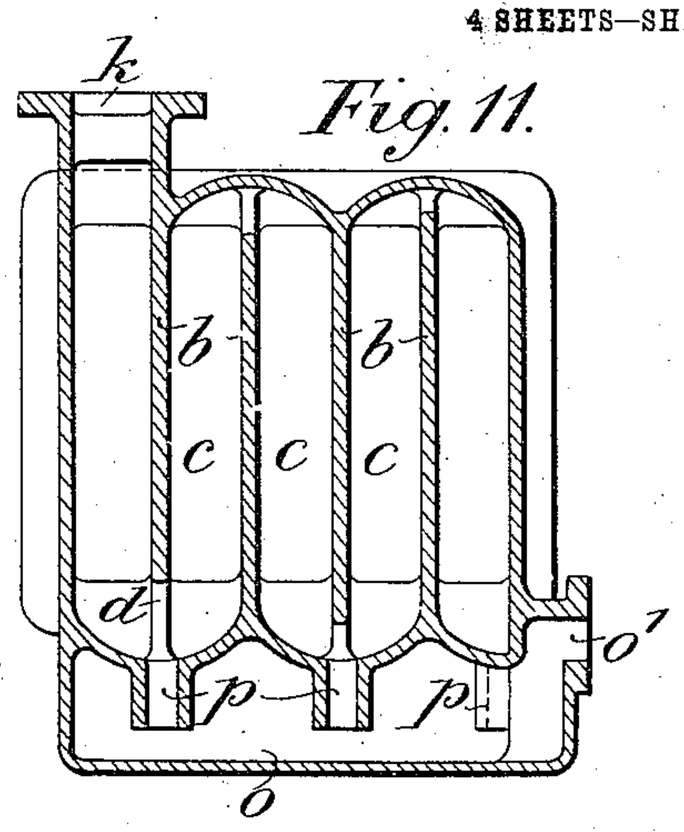


Fig. 12.

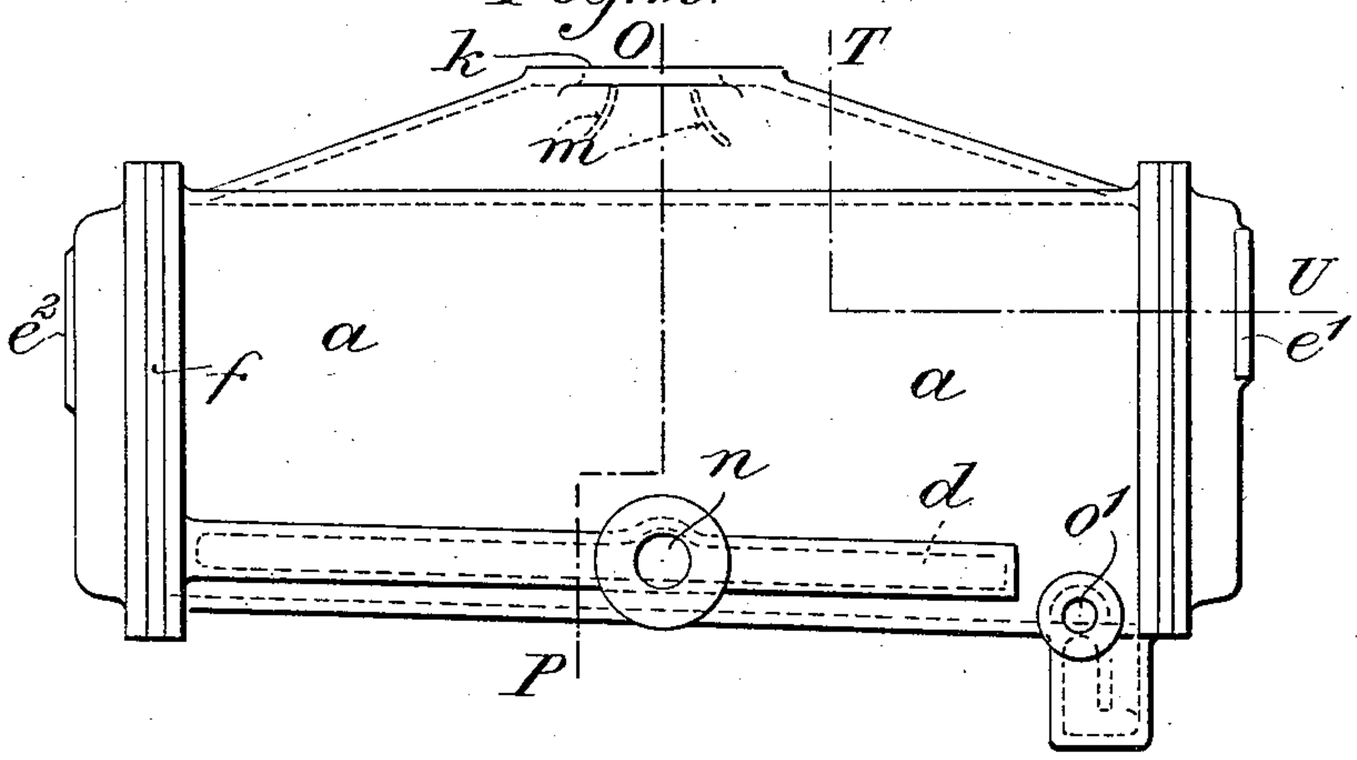
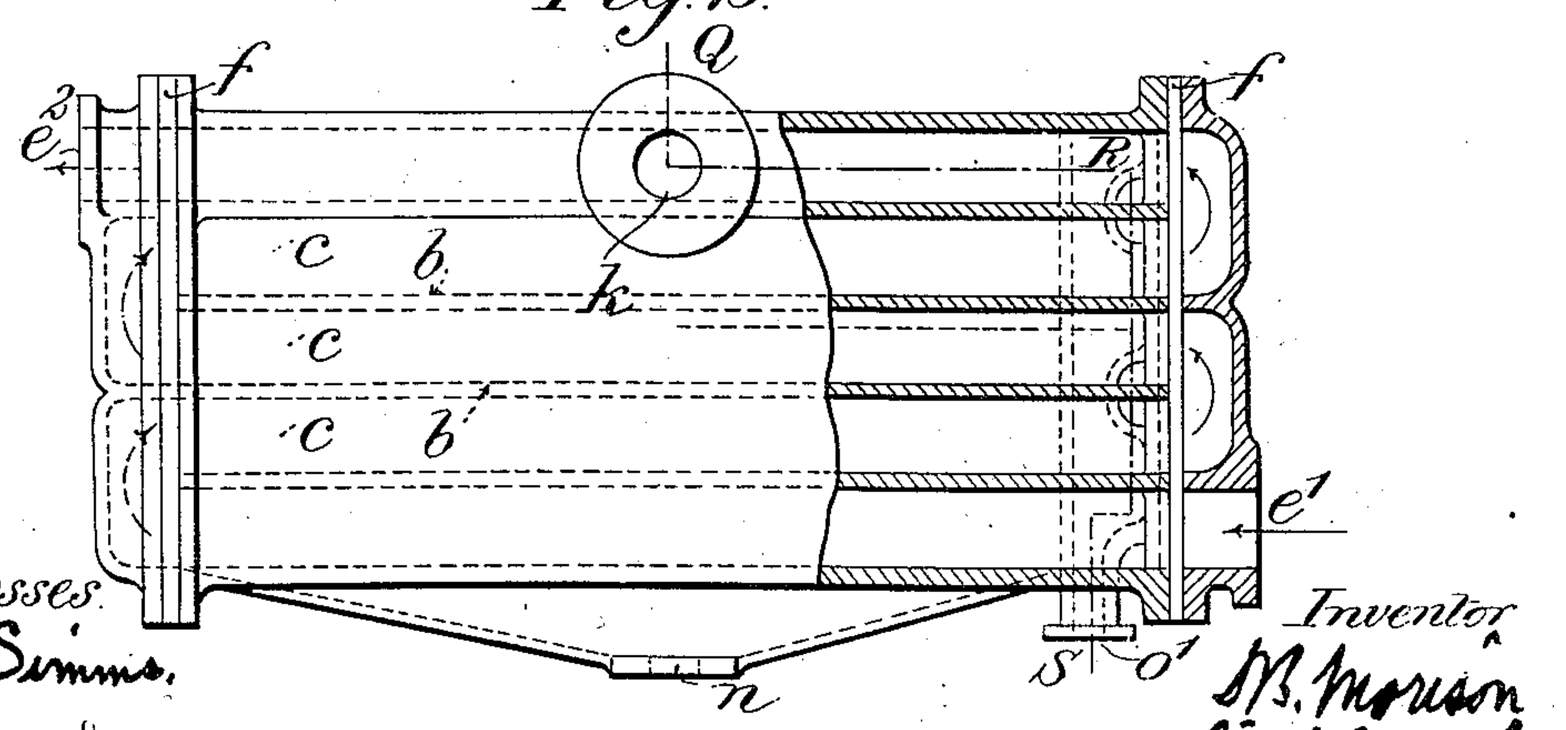


Fig. 13.



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UNITED STATES PATENT OFFICE.

DONALD BARNS MORISON, OF HARTLEPOOL, ENGLAND.

APPARATUS FOR CONDENSING STEAM.

No. 816,811. Specification of Letters Patent. Patented April 3, 1906.

Application filed January 23, 1905. Serial No. 242,422.

To all whom it may concern:

Be it known that I, DONALD BARNS MORISON, a subject of the King of Great Britain and Ireland, residing at Hartleppol, in the county of Durham, England, have invented Improvements in Apparatus for Condensing Steam and for Utilizing Steam to Heat Liquid, of which the following is a specification.

This invention relates to improvements in that type of apparatus for condensing steam and heating water that is of the tubular-surface type and is divided internally into communicating compartments; and it has for objects to obtain a high efficiency of the heat-transmitting surface in such apparatus by insuring a uniform flow of vapor into and through the apparatus and also into and from each compartment thereof, to minimize the back pressure resulting from the change of direction of flow from one compartment into the next compartment, to minimize local accumulations of partially-stagnant vapor and air which when using the apparatus with an air-pump impair the vacuum within the apparatus, and to increase the thermal efficiency of the condenser by obtaining a temperature of condensed-steam water closely approaching the temperature corresponding to the pressure within the condensing-compartments. These objects are attained by subdividing the interior of the apparatus into successive compartments by means of diaphragms that are arranged parallel to the axes of the condenser-tubes and connecting the successive compartments with each other by connecting ports or passages (hereinafter called, for distinction, "connecting-ports") that extend practically the whole length of the condenser-tubes and are parallel to such tubes, by diminishing the area of the successive connecting-ports in proportion to the diminishing quantity of steam flowing through such ports, by providing between the sides of the groups of water-tubes in the condensing-compartments and the adjacent side walls of such compartments tubeless spaces or passages adapted to promote the even outflow of steam from each compartment and the even inflow of steam into the next compartment, and to minimize the resistance or back pressure consequent on the change of direction of flow, and by collecting the condensed-steam water from each compartment as quickly as possible after its formation and discharging it through water-sealed connections of small surface area into a hot-well.

In the accompanying illustrative drawings, Figures 1 to 5, inclusive, show apparatus embodying the present invention suitable for use as a surface condenser working under a vacuum and in connection with an air-pump, Figs. 1 and 2 being sections taken on the lines A B and A C D, respectively, of Fig. 4; Fig. 3, a sectional plan taken on the line E F of Figs. 1 and 2; Fig. 4, a sectional elevation on the line G H of Fig. 2, and Fig. 5 a sectional detail view on the line I J of Fig. 1. Fig. 6 is a similar view to Fig. 5, showing a modification. Fig. 7 is a section on the line K L of Fig. 9; Fig. 8, a part side elevation; and Fig. 9, a sectional elevation on the line M N of Fig. 7, showing a lighter construction of apparatus embodying the present invention and suitable for use on war-ships. Figs. 10 to 13, inclusive, show a further modified construction of apparatus according to this invention suitable for working at atmospheric pressure, Figs. 10 and 11 being cross-sections corresponding, respectively, to the line O P of Fig. 12 and the line Q R S of Fig. 13; Fig. 12, a side elevation, and Fig. 13 a plan, partly in section, on the line T U of Fig. 12.

In the example shown in Figs. 1 to 5, inclusive, the interior of the casing *a* is subdivided by partitions *b*, that extend in a horizontal direction and are inclined to one side of the casing into condensing-compartments *c* of different capacities, which communicate with each other through connecting-ports *d*, extending practically throughout the length of the compartments and parallel to the water-tubes therein, the compartment into which the steam first flows being at the top and of the largest capacity and the compartment from which the air is finally drawn being of the smallest capacity and at the base. *e* represents groups of tubes carried by tube-plates *f* and through which the cooling-water flows, the tubes extending in the same direction as the partitions *b* and practically at right angles to the direction of flow of steam through the condensing-compartments *c*. The entering cooling-water flows from an inlet *e'* through the group of tubes *e* in the lowest compartment *c*, through which the vapor and air flows lastly, and thence flows through the successive groups of tubes, gradually rising in temperature until it attains its maximum when flowing through the tubes contained in the upper

compartment *c*, into which the steam first enters, the water passing off through an outlet e^2. The tubes in the upper and larger compartment *c* are divided into two groups that are in series with each other and the remaining groups with the object of increasing the velocity of flow of water through such tubes. *g* represents collecting and deflecting outlet spaces or passages, and *h* represents corresponding collecting and deflecting inlet spaces or passages located at opposite sides of the connecting-ports *d* and between the groups of tubes *e* and the adjacent walls *a'* of the casing *a*, these spaces or passages being free from tubes and extending the full length of the condensing-compartments *c*. The steam mixed with air on entering the apparatus through an inlet *k* flows into a distributing-chamber *m*, Fig. 4, which extends the full length of the first condensing-compartment *c*, of which it, in effect, forms the inlet end, so that the steam will be distributed throughout the length of the said condensing-compartment, from which it will flow toward the first collecting and deflecting space or passage *g*, which, as before stated, also extends throughout the length of the condensing-compartment, thus establishing planes of flow of the steam that are parallel to the axes of the tubes *e* and are maintained parallel during the passage of the steam over the entire tube-surface. The uniform flow of the steam and air over the entire tube-surface has the important practical effect of increasing the heat-transmitting efficiency of such surface, and also, by assisting and maintaining an even flow of air toward the final outlet *n*, of increasing the efficiency of the air-pump, and thereby improving the vacuum. To assist in distributing the steam over the tubes, the chamber *m* may be provided with curved deflecting-plates *m'*, Fig. 4. It has been found from careful experiment that a sudden or abrupt change in the direction of the planes of flow of the vapor in a condenser working under vacuum, as when passing from one condensing-compartment to the next, results in the creation of a greater pressure in the compartment from which the steam flows than in the compartment into which the steam flows, and the same effect is produced by any sudden change in the velocity of flow. This creation of back pressure prevails in all condensing apparatus subdivided into communicating compartments by partitions, and it is of great practical importance that it should be reduced to a minimum in such condensing apparatus, and especially in those used in connection with steam-turbines, in which a high vacuum is so essential to maximum economy. It is also of practical importance in condensers divided into communicating compartments that the steam should flow uniformly from the several spaces between the rows of water-tubes in one compartment and should flow uniformly into the several spaces between the rows of tubes in the next compartment. To enable these valuable technical effects to be attained, the longitudinal collecting and deflecting spaces or passages *g* and *h* are, according to this invention and as shown in Figs. 1 and 2, made of varying cross-sectional area in a direction transverse, or approximately so, to that in which the steam flows, the cross-sectional area of each outlet space or passage *g* from one group of tubes *e* gradually increasing in the direction toward the adjacent connecting-port *d* and the next group of tubes *e* and the cross-sectional area of each inlet space or passage *h* gradually decreasing in a direction away from such connecting-port. For this purpose the outer walls *a'* of the condensing-compartments are preferably made of curved form, as seen in section, Figs. 1 and 2. By this arrangement the resistance due to change of direction is minimized and a practically uniform velocity of flow maintained. It is also an important feature that the collecting and deflecting spaces or passages *g* and *h* should, as shown, be of successively-decreasing cross-sectional area from the steam-inlet *k* to the air-outlet *n* of the apparatus and that the areas of the successive connecting-ports *d* should be suitably reduced with the object of proportioning them to the amount of uncondensed vapor flowing through them, and so preventing any partial stagnation of flow locally which would result if all the passages *g* and *h* and ports *d* were of the same area. With the object of maintaining in condensing apparatus of the kind referred to a temperature of the condensed-steam water which shall closely approach the temperature corresponding to the pressure within the several condensing-compartments *e* the condensed-steam water from each compartment or from adjacent compartments, depending on the particular design of apparatus adopted, is according to this invention rapidly led away by a drain pipe or passage *p* of comparatively small section and surface area and which is water-sealed, water thus flowing away directly and simultaneously from different parts of the apparatus. In the example of apparatus now being described there is a drain pipe or passage *p*, into which the condensed water from the two upper adjacent condensing-compartments *c* is delivered and a separate drain pipe or passage *p* for the lowest condensing-compartment, the lower ends of these drain pipes or passages terminating below the outlet *o'* of a hot-well *o*, so that they will be sealed by the water in the hot-well. This rapid withdrawal of the water of condensation in stages from the condensing-compartments of a condenser of the type referred to reduces the quantity of heat stored at any given time in the condenser and correspond-

ingly increases the useful heat imparted to the hot-well *o*, while the vaporization of the water in the hot-well is minimized by the restriction of the surface area in direct communication with the condensing-compartments, the very important technical effect being to considerably increase the thermal efficiency of the condenser.

In a condenser of the type herein referred to, wherein the diaphragms are so disposed as to collect water of condensation, the free edge of each diaphragm may be provided with a lip or lips adapted to prevent the water passing over such edge or the whole length of such edge and to direct its flow into or toward the corresponding drain passage or passages. This arrangement by preventing undue subdivision of the water into drops or spray also serves to minimize reëvaporation of the water. In Figs. 1 and 5 the lower edge of the upper diaphragm *b* is provided with a single longitudinal lip *q*, by which the water is collected and drained toward the corresponding drain pipe or passage *p*, or, as shown in Fig. 6, the diaphragm may be provided with a number of guide-ribs *r*, arranged to form converging drain-passages *s*, in which the condensed water is concentrated into small streams that fall into the gutter at the lower end of the next lower diaphragm, and thence flow to the drain-passage *p* at one end thereof instead of falling over the edge of the diaphragm in the form of drops or spray, in which form it is highly susceptible to reevaporization.

In the example shown in Figs. 7 to 9, inclusive, the casing *a* is of circular section and the tubes *e* are arranged to form, with the casing, collecting and deflecting spaces or passages *g* and *h* of the kind hereinbefore described, and each condensing-compartment *c* is provided with a separate water-sealed drain-pipe *p*, leading to a hot-well *o*, separate from the casing, the condensed water deposited on the uppermost diaphragm *b* being led by a gutter *s*, formed by the lip *q*, to a pocket *t* at one end, and thence to the corresponding drain-pipe *p*. The air is withdrawn from the last compartment *c* through a number of outlet-passages *n*, connected to a common pipe *u*, with the object of promoting a practically uniform flow of air from the apparatus and avoiding stagnation at any part thereof. In other respects this arrangement is similar to that shown in Figs. 1 to 6, inclusive. Sometimes, as in the case of condensers for war-ships and with the object of reducing the weight of the condenser, one or more of the diaphragms *b* may be formed of one or more thin metal sheets made independent of the casing *a* and arranged to rest upon suitable seats therein, as shown in connection with the uppermost diaphragm *b* in Fig. 7.

In the example shown in Figs. 10 to 13, inclusive, the diaphragms *b* are shown vertical, so that the condensing-compartments *c* are side by side and the connecting-ports *d* are at the bottom and top alternately of the casing, each pair of condensing-compartments *c* being provided at one end of the curved bottom common to them with a drain-pipe *p*, dipping into a hot-well *o*, and the last compartment *c* being provided with an outlet *n* in communication with the external atmosphere. This example of apparatus is suitable for use as a condenser in connection with steam-winches on shipboard and also for use as an exhaust-steam feed-water heater, the exhaust-steam flowing through the successive compartments *c* and thence to the atmosphere through the outlet *n*, while the water to be heated flows through the tubes *e*. As the volume of a given weight of steam is smaller at atmospheric pressure than at a less pressure, the compartments *c* should be made as small as conditions will permit in order to maintain an active flow of the steam over the tube-surface. In other respects the apparatus shown in Figs. 10 to 13, inclusive, is similar to that shown in Figs. 1 to 6, inclusive. Instead of arranging the apparatus as shown in Figs. 10 to 13, so that the steam flows alternately downward and upward in passing through the successive compartments *c*, it may be turned over onto one end, so that the steam flows alternately from side to side of the casing *a*, the successive connecting-ports *d* being then at opposite sides of the casing. This arrangement will be readily understood if Figs. 10 and 11 be regarded as horizontal sections of the apparatus instead of vertical sections, Fig. 12 as a plan, and Fig. 13 as a sectional side view, or the apparatus may be turned over onto one side, so that the compartments *c* and partitions are one over the other, as in Figs. 1 to 9, inclusive. In these alternative arrangements the positions of the small drain pipes or passages *p* and hot-well *o* would of course need to be suitably altered in a manner that will be readily understood without further description, so as to admit of the rapid withdrawal of the condensed-steam water in stages and simultaneously from the several compartments of the condenser, as and for the purpose hereinbefore set forth.

What I claim is—

1. Apparatus for condensing steam and heating water, comprising a heat-transferring compartment traversed by water-tubes and having at one side a steam-distributing chamber of gradually-increasing length in the direction of the length of the apparatus from its inlet to its outlet end and having its latter end corresponding in area and shape to the inlet end of said compartment and in open and free communication therewith, and at the other side a steam-outlet parallel to and of practically the same length as said tubes.

2. Apparatus for condensing steam and heating water, comprising a heat-transfer-

ring compartment having at one side thereof a downwardly-extending steam-distributing inlet-chamber of gradually-increasing length in the direction of the length of the apparatus and having its lower outlet end corresponding in length and height to the length and height of said compartment and curved toward said compartment for part of its length, and at the opposite side of said compartment a steam-outlet chamber also of the full height and length of the compartment, and water-tubes traversing said compartment and parallel to the steam inlet and outlet.

3. Apparatus for condensing steam and heating water, comprising a heat-transferring compartment having at one side a steam-inlet space and at the other side a steam-outlet space, said steam-spaces each extending the full length and depth of the said compartment and in free and open communication therewith, the steam-inlet space gradually decreasing in cross-sectional area from its inlet and the steam-outlet space gradually increasing in cross-sectional area toward its outlet end, and water-tubes traversing said compartment in a direction parallel to said steam-spaces.

4. Apparatus for condensing steam and heating water comprising a casing provided internally with diaphragms arranged to form successive heat-transferring compartments and water-tubes extending longitudinally through said compartments, the successive compartments communicating with each other through alternately-arranged connecting-ports each of which extends longitudinally and practically throughout the full length of the compartments and parallel to the water-tubes therein.

5. Apparatus for condensing steam and heating water comprising a casing provided internally with diaphragms arranged to form successive heat-transferring compartments and water-tubes extending longitudinally through said compartments, the successive compartments communicating with each other through alternately-arranged steam inlet and outlet spaces or openings and connecting-ports that extend longitudinally and practically throughout the full length of the compartments and are parallel to the water-tubes therein for the purpose set forth.

6. Apparatus for condensing steam and heating water comprising a casing provided internally with diaphragms arranged to form successive heat-transferring compartments and water-tubes extending longitudinally through said compartments, the successive compartments communicating with each other through alternately-arranged connecting-ports of successively-decreasing cross-sectional area in the direction in which the steam flows through the apparatus, for the purpose set forth.

7. Apparatus for condensing steam and heating water comprising a casing divided internally by diaphragms into successive heat-transferring compartments that communicate with each other through alternately-arranged connecting-ports, and groups of water-tubes arranged to traverse the said compartments in a direction parallel to said connecting-ports and to leave between them and the adjacent sides of the compartments and at opposite sides of each connecting-port clear uninterrupted or tubeless outlet and inlet spaces or passages, the cross-sectional area of each connecting-port being such that the velocity of flow through the port and the adjacent inlet space or passage will approximate to the velocity of flow from the group of tubes in the adjacent compartment.

8. In apparatus for condensing steam and heating water, a number of successive heat-transferring compartments that are traversed by nests of water-tubes arranged at right angles to the direction in which steam will flow through them and are connected together in pairs by ports parallel to said tubes, the longitudinal space located between each nest of tubes and the adjacent side wall of the compartment containing said nest of tubes being made of varying cross-sectional area in the direction in which the steam flows, the cross-sectional area of each outlet-space from one nest of tubes gradually increasing in the direction toward the port leading to the inlet-space of the next adjacent nest of tubes and the cross-sectional area of each inlet-space gradually decreasing in a direction away from the said port.

9. Apparatus for condensing steam and heating water comprising a casing divided internally by diaphragms into successive heat-transferring compartments that communicate with each other through alternately-arranged connecting-ports, and groups of water-tubes arranged to traverse the said compartments in a direction parallel to said connecting-ports and to leave between them and the adjacent sides of the compartments and at opposite sides of each connecting-port clear uninterrupted or tubeless outlet and inlet spaces or passages that extend approximately the full length of the compartments and embrace the adjacent sides of adjacent pairs of compartments and each of which increases in cross-sectional area from its remote end toward the corresponding connecting-port between two compartments.

10. In apparatus for condensing steam and heating water a pair of adjacent heat-transferring compartments in communication with each other at one side through a connecting-port extending practically the full length of the compartments and having a concave side wall common to the adjacent sides of the two compartments, and groups

of water-tubes extending lengthwise through said compartments parallel to said connecting-port and arranged to leave between them and the side wall outlet and inlet spaces of approximately plano-concave section at opposite sides of said connecting-port, each of said spaces having its widest part adjacent to the connecting-port between each pair of them and diminishing in width in a direction extending away from said port.

11. Apparatus for condensing steam and heating water, comprising a number of successive heat-transferring compartments traversed by water-tubes and connected together alternately at opposite sides by sets of tubeless outlet and inlet spaces with interposed connecting-ports that extend practically the full length of the compartments, the successive sets of outlet and inlet spaces with intervening connecting-port being of successively-decreasing size in the direction of the flow of steam through the apparatus.

12. Apparatus for condensing steam and heating water, comprising heat-transferring compartments provided with water-tubes, and separate liquid-sealed outlets arranged to simultaneously lead away water of condensation from different parts of said apparatus.

13. Apparatus for condensing steam and heating water, comprising successive heat-transferring compartments provided with water-tubes, a water-receptacle, and separate liquid-sealed outlet-passages of small surface area arranged to lead water of condensation simultaneously and independently from different parts of said apparatus to said water-receptacle.

14. Apparatus for condensing steam and heating water, comprising successive heat-transferring compartments provided with separate water-tubes, a hot-well, and water-sealed drain-passages of small surface area extending from different parts of said apparatus and in communication with said hot-well.

15. Apparatus for condensing steam and heating water, comprising a casing divided internally, by diaphragms into successive heat-transferring compartments arranged in communication with each other and having inclined lower sides, water-tubes traversing said compartments, water-sealed drain-passages of small surface area each leading from an inclined lower side, and a hot-well into which said drain-passages discharge.

16. Apparatus for condensing steam and heating water, comprising a casing divided internally by diaphragms into successive heat-transferring compartments that are in communication with each other through connecting-ports arranged alternately at opposite parts of the apparatus, a water-receptacle, and separate water-sealed drain-passages of small surface area arranged at one end of the apparatus and adapted to allow of water of condensation flowing off simultaneously from different compartments into said receptacle.

17. Apparatus for condensing steam and heating water, comprising a casing divided internally by diaphragms into successive heat-transferring compartments connected together in pairs by alternately-arranged ports and having inclined lower parts, a hot-well, and water-sealed drain pipes or passages arranged to receive water of condensation from said inclined lower parts and discharge it into said hot-well.

18. Apparatus for condensing steam and heating water comprising a casing divided into successive heat-transferring compartments arranged one above the other, connected together by a longitudinal port, and separated by a partition one side of which terminates adjacent to said port, and water collecting and guiding means arranged at the free side of said partition for the purpose set forth.

19. In apparatus for condensing steam and heating water, heat-transferring compartments arranged one above the other, connected together by a longitudinal port, and separated by a partition one side of which terminates adjacent to said port, and an upwardly-projecting lip extending along the free side of said partition and adapted to prevent water of condensation flowing over the edge of said partition in drops or spray.

20. Apparatus for condensing steam and heating water, comprising heat-transferring compartments arranged one above the other and connected together at one side of the apparatus through a connecting-port and separated by a partition one side of which terminates at one side of said port, a water-sealed drain-passage, and means arranged near the free edge of said partition and adapted to collect water of condensation flowing over said partition and guide it to said drain-passage.

21. Apparatus for condensing steam and heating water, comprising heat-transferring compartments arranged one above the other and connected together at one side of the apparatus through a connecting-port and separated by a partition one side of which terminates at one side of said port, a water-sealed drain-passage located at one end of said apparatus, and an upwardly-projecting lip extending along the free edge of said partition and adapted to collect water of condensation from said partition and direct it toward said drain-passage.

22. Apparatus for condensing steam and heating water, comprising a number of connected heat-transferring compartments arranged one above the other and separated by inclined diaphragms, the lowest compart-

ment having an inclined bottom, a steam-distributing chamber in connection with the first compartment, and an air-outlet in communication with the last compartment, nests of water-tubes extending horizontally through said compartments, means connecting the nests of tubes together to form a passage-way through which water can be caused to flow, a hot-well at the lower part of said apparatus, and separate drain-pipes extending from the lower parts of some of the compartments to said hot-well.

23. Apparatus for condensing steam and heating water, comprising a number of connected superimposed heat-transferring compartments made of different capacities and separated from each other by inclined diaphragms, the largest compartment being at the top and the smallest at the bottom, a steam-distributing chamber arranged at one side of the apparatus and made of increasing cross-sectional area from its inlet to its outlet end the latter end being in free and open communication practically over the whole length and height of the inlet end of said largest compartment and draining into that compartment, an air-outlet from the lowest compartment, nests of tubes extending through said compartments, communicating passages between the adjacent ends of said compartments, said passages extending practically the full length of said compartments, a drain-pipe for the upper pair of compartments and the steam-distributing chamber, a separate drain-pipe for the lowest compartment, and a hot-well into which said drain-pipes discharge.

24. Apparatus for condensing steam and heating water, comprising a casing, inclined diaphragms arranged one above the other and extending alternately from opposite sides of said casing so as to form a number of connected superimposed compartments of different capacities, a steam-distributing chamber of gradually-increasing length, in the direction of the length of the apparatus, from its inlet to its outlet end which is in direct communication with the inlet end of the largest compartment, an air-outlet from the smallest compartment, and connecting spaces of plano-concave section between the adjacent sides of pairs of compartments and the adjacent side wall of the casing, a drain-pipe leading from the inclined bottom of the lowest compartment, a drain-pipe leading from the lower end of the second diaphragm from the bottom of the casing, and a hot-well located at the bottom of said apparatus and into which the said drain-pipes discharge below the level of water therein.

Signed at West Hartlepool, in the county of Durham, England, this 12th day of January, 1905.

DONALD BARNS MORISON.

Witnesses:
HARRY RILEY,
THOS. E. LYMAN.