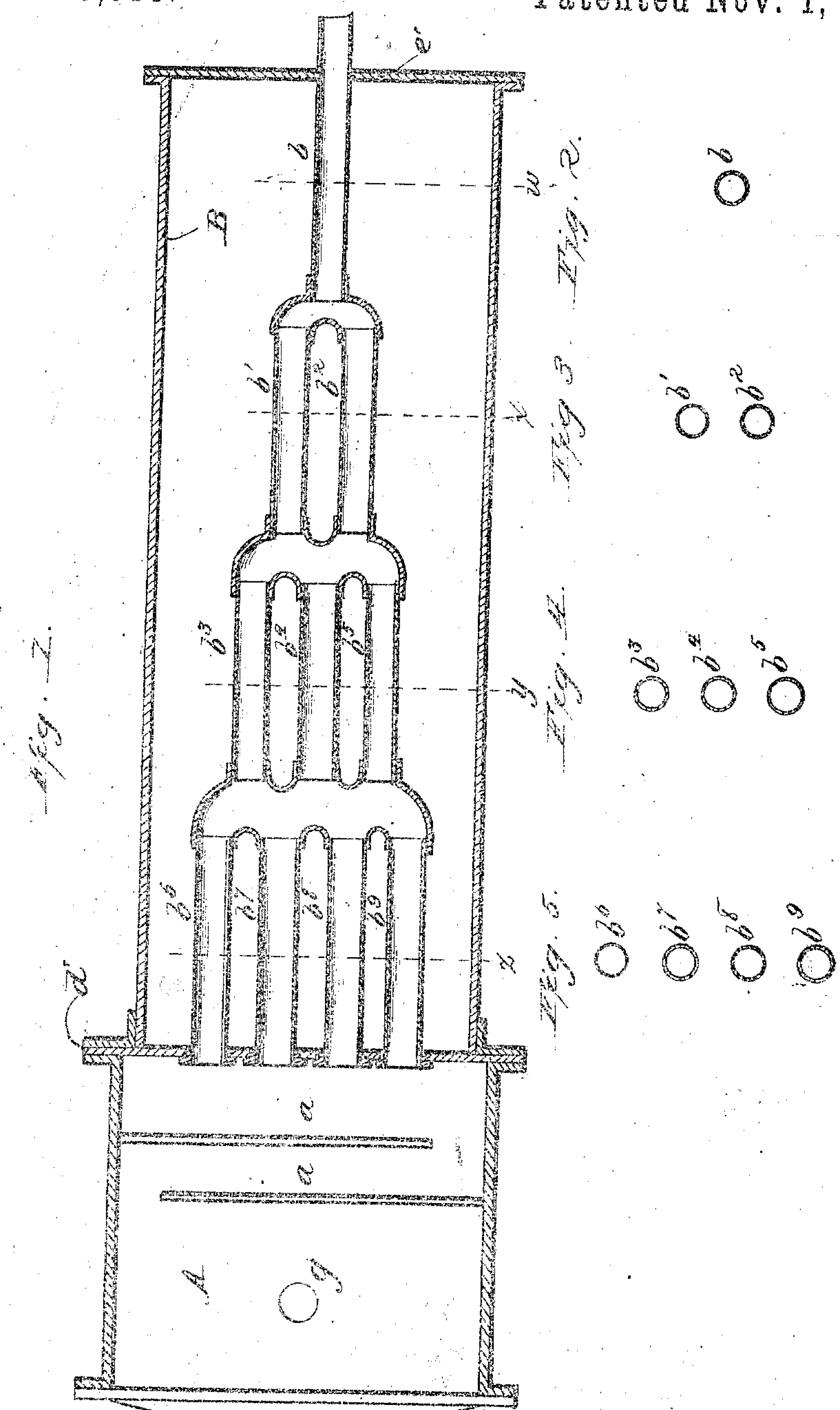
(No Model.) 2 Sheets—Sheet 1.

H. T. YARYAN.

VACUUM EVAPORATING APPARATUS.

No. 485,315. Patented Nov. 1, 1892.



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(No Model.) 2 Sheets—Sheet 2.

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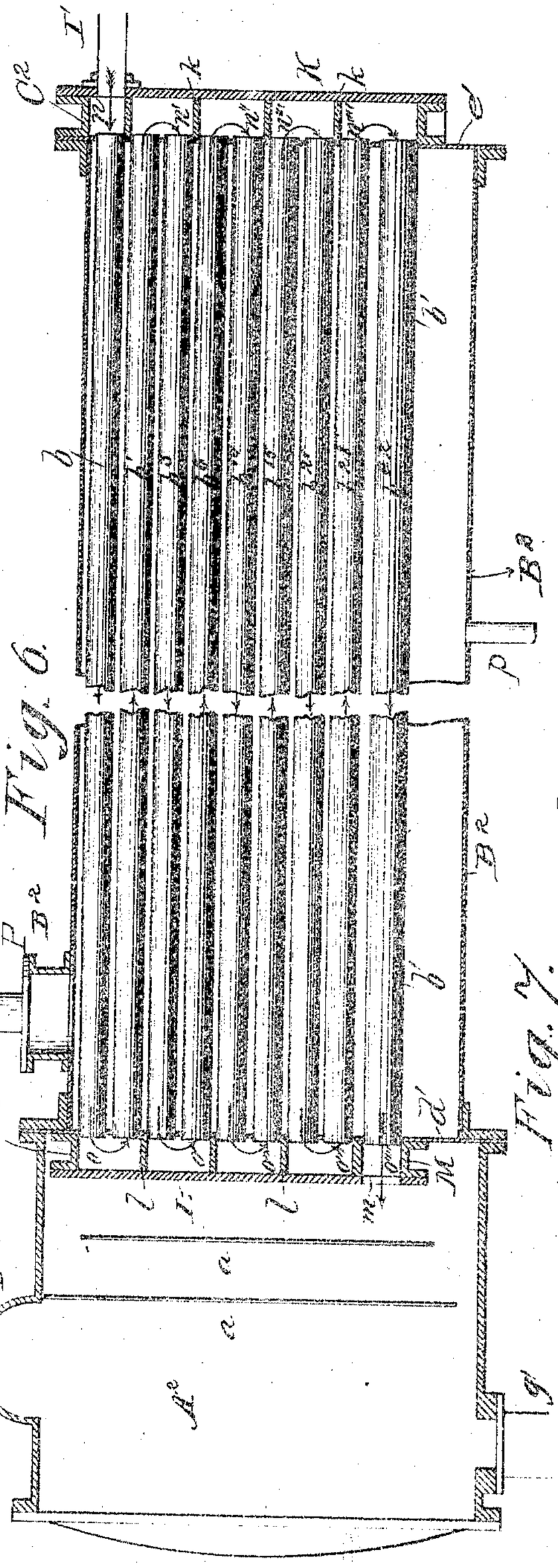

Fig. 6.

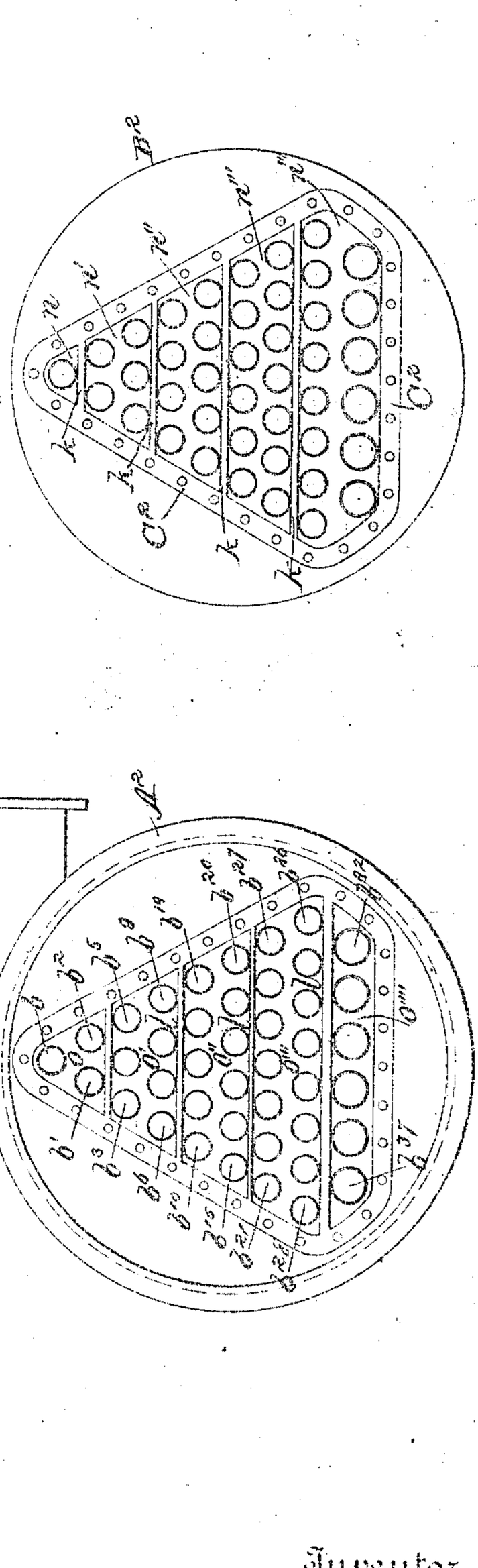

Fig. 8.

Fig. 7.

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VACUUM EVAPORATING APPARATUS.

SPECIFICATION forming part of Letters Patent No. 485,315, dated November 1, 1892.

Application filed February 7, 1891. Serial No. 380,638. (No model.)

To all whom it may concern:

Be it known that I, HOMER T. YARYAN, a citizen of the United States, residing at Toledo, in the county of Lucas and State of Ohio, have invented certain new and useful Improvements in Evaporating Apparatus; and I do hereby declare the following to be a full, clear, and exact description of the invention, such as will enable others skilled in the art to which it appertains to make and use the same.

My invention relates to apparatus of that class described in Letters Patent granted to me, No. 300,185, dated June 10, 1884.

I described in that patent an evaporating apparatus in which a coil of pipe is inclosed in a steam-drum, which supplies the heat required to evaporate liquid flowing through the coil. The liquid to be evaporated enters at the upper end of the coil and, with the vapor generated and constantly increasing in volume, flows through the coil and is discharged into a separating trap or chamber, from which the vapor is caused or allowed to pass off by one conduit and the more or less concentrated liquid by another.

In Letters Patent granted to me, No. 355,290, dated December 28, 1886, I described an evaporating apparatus in which several straight pipes are placed horizontally and arranged in series in a vertical plane and so connected end to end as to form one long pipe, which by its doubling back and forth upon itself is substantially an equivalent to the coil described in Patent No. 300,185. I stated in this patent, No. 355,290, that the capacity of such coils cannot be greatly increased by increasing to any considerable extent either the diameter or the length of the pipe constituting the coils, for reasons therein set forth, and I pointed out the importance of increasing the diameter of the pipes gradually from the inlet-pipe to the outlet-pipe of the coil to provide for the constantly-increasing volume of the contents of the coil as the evaporation proceeds. In this patent I suggested that a standard vaporizing-coil should be about seventy-five feet in length, starting at the inlet with a diameter of about two and one-half inches, increasing gradually to a diameter of about four inches at its outlet. In a coil of these dimensions the area at the inlet will be to the area at the outlet as are the squares of the diameters of the tubes at the inlet and outlet—that is, as six and one-fourth to sixteen—and the contents of given lengths of tube at the inlet and outlet ends will be to each other in the same ratio; but inasmuch as the circumference of tubes are proportional to their diameters and not to the squares of their diameters it is easy to see that the heating-surfaces of equal lengths of tube at the opposite ends of this standard coil will be to each other as two and one-half to four only and not like the contents, as six and one-fourth to sixteen. Since the numerical ratio between the surface of a tube of a given length and its capacity in cubic inches diminishes as its diameter is increased, it follows that the heating efficiency of a tube with reference to its cubic capacity diminishes as the diameter is increased. A cubic inch of water when converted into vapor at atmospheric pressure occupies a space of about a cubic foot, and therefore to provide for the increase of volume of the contents of a coil by vaporization as it moves toward the discharging end I suggested in my former patent a gradual increase in the diameter of the tubes constituting the coil toward the discharging end; but the increased capability for the flow and discharge of the contents of the coil thus attained is attended with a diminished heating-surface relatively to the increased contents of the coil.

I have in the coil which is the subject of this application provided for any desired increase in the capacity of a coil at different distances from its receiving end. This I do not by increasing the diameter of the tubes constituting the coil, but by dividing them at intervals into any desired number of branch tubes each preferably of the same diameter as the inlet or initial pipe, thus increasing both the heating-surface of the coil and its capability to permit a free flow and discharge of its contents.

Figure 1 of the drawings shows a horizontal longitudinal section of an apparatus containing tubes arranged in sections which form an equivalent to a coil, whereby I secure the advantages which I have set forth. Figs. 2, 3, 4, and 5 show cross-sections of the tubes taken on lines *w*, *x*, *y*, and *z*. I show this con-

struction for the sake of clearness. In practice the construction shown in Figs. 6, 7, and 8 of the drawings will be preferable. Fig. 6 represents a vertical longitudinal section of an evaporating cylinder containing the connected series of evaporating-tubes. Fig. 7 represents an end view of the cylinder at the discharge end of the tubes with the cover-plate of the return-bend head removed. Fig. 8 represents an end view at the front end of the cylinder with the cover-plate removed.

The apparatus shown in Fig. 1 consists of a heating chamber or cylinder B, having a head or tube-sheet e' at one end and a tube-sheet d' at the other end. The inlet or initial evaporating-tube b is suitably set in the tube-sheet e', so as to form a tight joint and prevent leakage of steam from the heating-cylinder around it, and the discharge-tubes b^6, b^7, b^8, and b^9 being similarly set in the tube-sheet d'. A pipe P is provided for the admission of steam or other heating medium to the cylinder B^2 and a pipe p for the withdrawal of water of condensation. A separating-chamber A may be connected to the discharge end and provided with dash-plates a a, with a vapor-outlet D^2, and with a liquid-outlet g', as shown in Fig. 6.

The liquid to be evaporated enters the apparatus through the tube b. This tube delivers its contents into a section consisting of two branch tubes b' and b^2, which discharge into a section composed of three branch tubes b^3, b^4, and b^5, which in turn connects with and discharges its contents into a section composed of four branch tubes b^6, b^7, b^8, and b^9, which discharges its contents into the separating-chamber A. It will be apparent on an inspection of the cross-sections of the tubes in Figs. 2, 3, 4, and 5 that if the tubes b b' b^2 are of equal length the cubic contents of the section composed of tubes b' and b^2 is twice that of the initial tube b' and that its heating-surface is twice that of the initial tube; the cubic contents of the section composed of tubes b^3, b^4, and b^5 is three times that of the initial tube and its heating-surface three times that of the initial tube, and the cubic contents of the section composed of tubes b^6, b^7, b^8, and b^9 is four times that of the initial tube and its heating-surface also four times that of the initial tube. By this arrangement of tubes, therefore, the heating-surface of the apparatus increases directly as the capability of the tubes to accommodate the flow and discharge of their contents is increased.

The initial tube, instead of discharging into a section composed of two branch tubes, as shown, may discharge into a section composed of any desired number of tubes, and yet the same ratio in any given section between the cubic contents of the tubes and their combined heating-surface will be preserved. Thus I may have sections which, instead of increasing in cubic contents in the progression 1 2 3 4, as shown in Fig. 1, may increase in the progression 1 2 4 8, &c., and the heating-surface will increase in the same progression.

In Figs. 6, 7, and 8 I have shown a construction which will be found preferable in practice to that shown in Fig. 1.

This apparatus consists of a heating-cylinder B^2, containing the evaporating-tubes b b' b^2, &c., which are suitably set in the tube-sheets e' and d' at each end, so as to make tight joints. The initial tube b discharges into a section composed of two tubes, which are arranged parallel to it, connection between the initial pipe and the section being made by the employment of the construction described in Letters Patent granted to me May 22, 1888, No. 383,384—that is to say, by return-bend heads C^2 and M, provided with partitions k l, which when the cover-plates K and L are in place form cells n n' n'', &c., and o o' o'', &c.

The return-bend heads C^2 and M are of triangular form, and each is set with an apex at the top. The head C^2 is divided by horizontal plates k into cells n n' n'' n''' n'''', as shown in Fig. 8, and is closed by the outer plate K, which is riveted or bolted to its outer flange. The head is secured by its inner flange to the tube-sheet e', and the partition-plates k are fitted to make tight joints against such tube-sheet, so as to form tight cells connecting the adjacent ends of horizontal rows of tubes. The return-bend head M is secured to the tube-sheet d' and is provided with horizontal partition-plates l, dividing it into cells o o' o'' o''' o'''', and is closed by the plate L. The liquid-supply pipe I' connects with the cell n of head C^2, the plate K having an opening for such purpose. Plate L of the inner head M is provided near its bottom with a horizontal opening m, leading from the bottom cell o'''', to permit the discharge of vapor and liquid from the lower set of tubes b^{37} to b^{42}, inclusive. A separating-chamber A^2 may be connected to the apparatus when it is desired to separate the liquid and vapor, into which the last series of tubes in the coil shall discharge. It is shown in Figs. 6, 7, and 8 as provided with dash-plates a a, a liquid-discharge pipe g', and a vapor-outlet D^2.

According to this my preferred construction and arrangement of the evaporating-tubes, the inlet or initial evaporating-tube b connects the cell n with the cell o and two tubes b' and b^2 connect cell o with cell n', being equivalent to a division of tube b into two branch tubes. Three tubes b^3, b^4, and b^5 connect cell n' with cell o'. Three tubes b^6, b^7, and b^8 connect cell o' with cell n'', and so on, an increasing number of tubes connecting the successive cells. The liquid to be evaporated flows from the supply-tank through supply-pipe I' to the initial pipe b of the series, and thence through eight sections of branch tubes, whence the liquid and vapor are discharged. The sections of the evaporating-coil in this

apparatus increase as to the number of tubes in each in the progression 1, 2, 3, 4, 5, 6, 7, and 8, and the tubes are of uniform diameter until the last section, Nos. 37 to 42, in which the number of tubes for the sake of convenience in arranging them in the heating-cylinder is diminished to six, which are of increased diameter, so as to be substantially equivalent in capacity to nine tubes of the diameter of the initial tube. By this arrangement of the evaporating-tubes, if each tube is assumed to be twelve feet long I obtain the equivalent of a coil about one hundred and eight feet long, increasing gradually in capability to accommodate the volume of liquid or liquid and vapor contained in it from unity in the initial tube to about nine times that capability in the delivery-section, the extent of heating-surface also being increased in the same ratio. If in any section it is desired to diminish the heating-surface and preserve the capability to accommodate the flow and discharge of the contents, the number of tubes constituting the section may remain the same or be diminished and their diameter increased. In fact, any desired relation may be established between the heating-surface of each section and its capability to accommodate the flow and discharge of its contents.

Instead of a single initial tube, two or more tubes may be used, which shall connect with and discharge into a section composed of an increased number of tubes. This arrangement of tubes is included in my invention; but I prefer the arrangement shown herein, where but a single inlet-tube is employed.

I do not limit myself to the mechanical construction shown in the drawings, as it is obvious that the tubes and sections may be otherwise connected together without a heating-chamber—for instance, by return bends and heads such as are in ordinary use by steam-fitters. My improved apparatus is adapted to be used as a vacuum apparatus, when desirable, and may be combined with like apparatus to form double and multiple effects.

I claim—

1. In an evaporating apparatus, evaporating-tubes arranged in sections in a heating-cylinder, the initial tube connecting with and discharging its contents into a section composed of two or more branch tubes, which in turn connects with and discharges its contents into a section composed of an increased number of branch tubes, and so on in progression, whereby any desired relation may be established between the heating-surface of each section and its capability to accommodate the flow and discharge of its contents, substantially as set forth.

2. In an evaporating apparatus, an evaporating-coil composed of parallel tubes arranged in sections in a heating-cylinder, the initial tube connecting with and discharging its contents into a section composed of two or more tubes parallel to the initial tube, which in turn connects with and discharges its contents into a section composed of an increased number of tubes also parallel to the initial tube, substantially as and for the purpose set forth.

3. In combination with the return-bend heads having cells of progressively-increasing size, the series of evaporating-tubes connecting in successively-increasing number with such cells from the single liquid-supply pipe at the top toward the discharge-tubes at the bottom.

4. In combination with the return-bend heads divided into suitable cells, the series of evaporating-tubes connecting in successively-increasing number with the successive cells from the inlet to the outlet end of the series, a liquid-supply pipe connecting with a cell at the inlet end, a separating-chamber connecting with the discharge end of the series of tubes, and a heating-chamber surrounding the tubes, substantially as described.

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