J. PARKER.

EVAPORATING APPARATUS.

APPLICATION FILED DEC. 22, 1908.

940,473.

Patented Nov. 16, 1909.

2 SHEETS—SHEET 1.

Fig. 1.

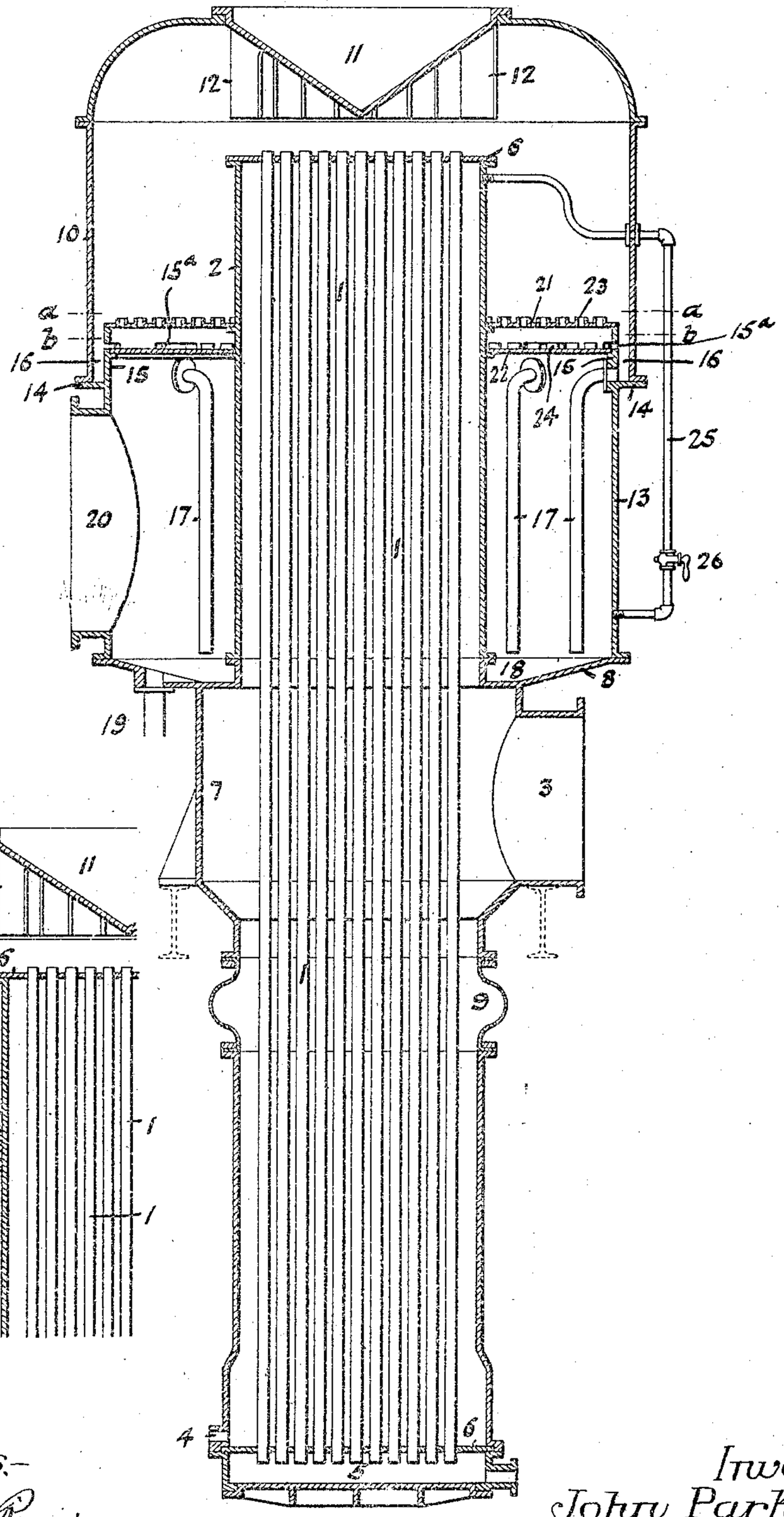
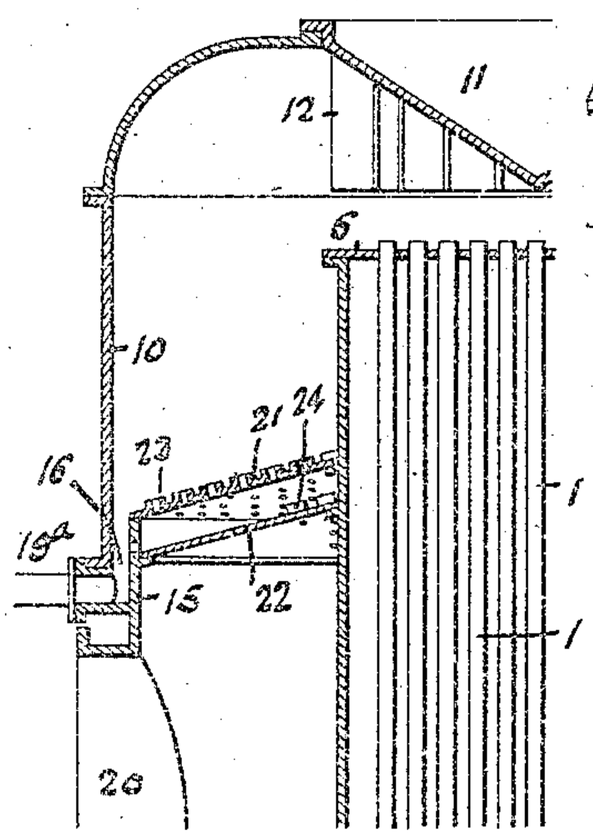


Fig. 5.



Witnesses:-
William A. Rivoir.
Willa A. Burrows

Inventor:-
John Parker.
by his Attorneys:-
Howson & Howson

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2 SHEETS—SHEET 2.

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Fig. 2.

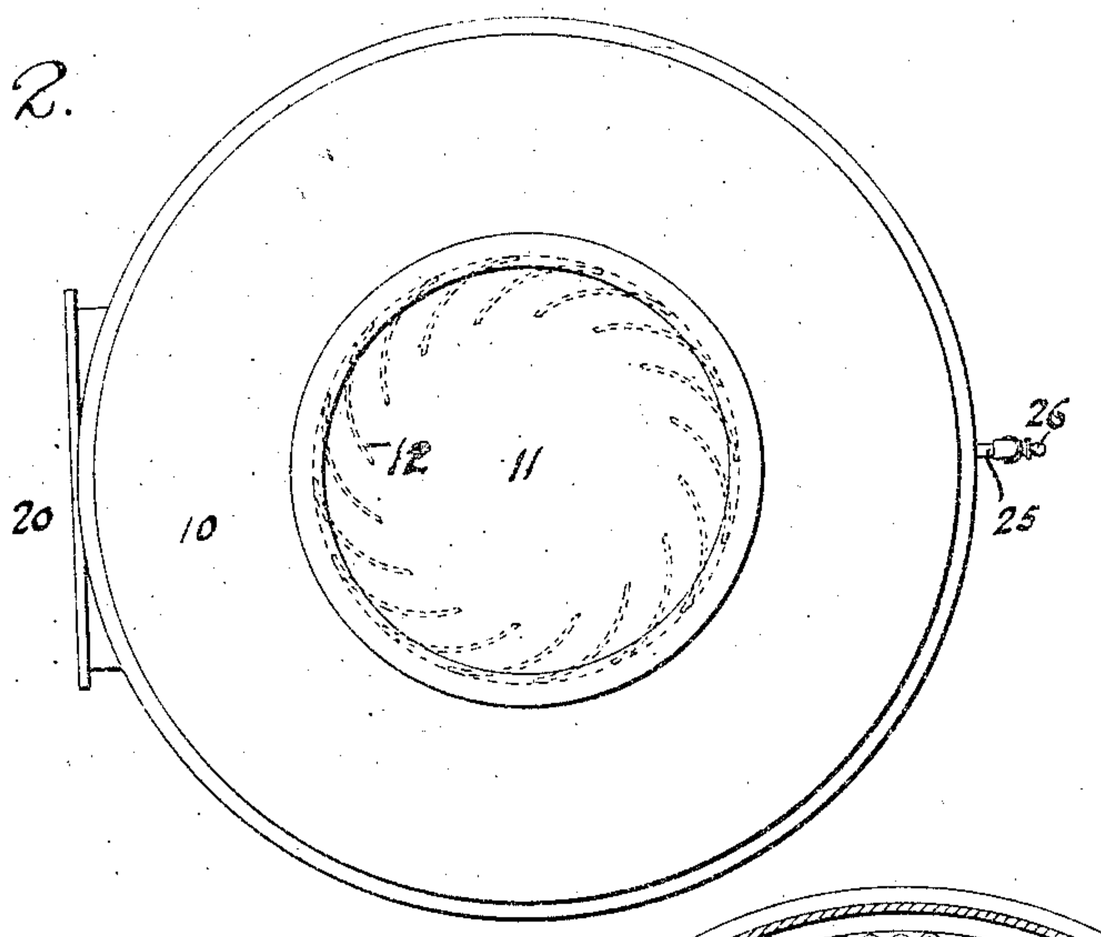


Fig. 6.

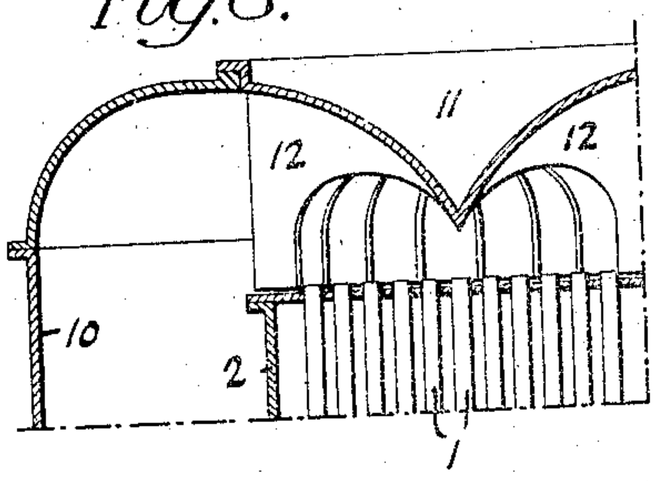


Fig. 3.

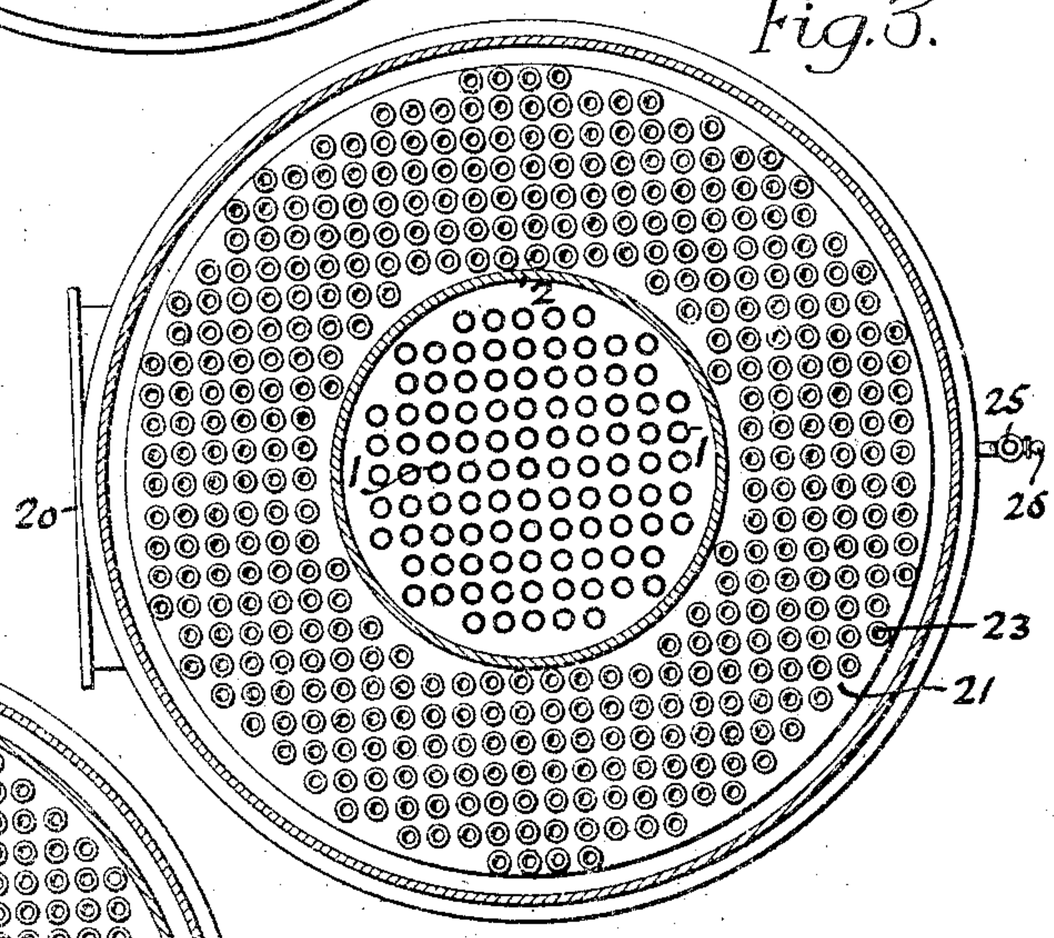
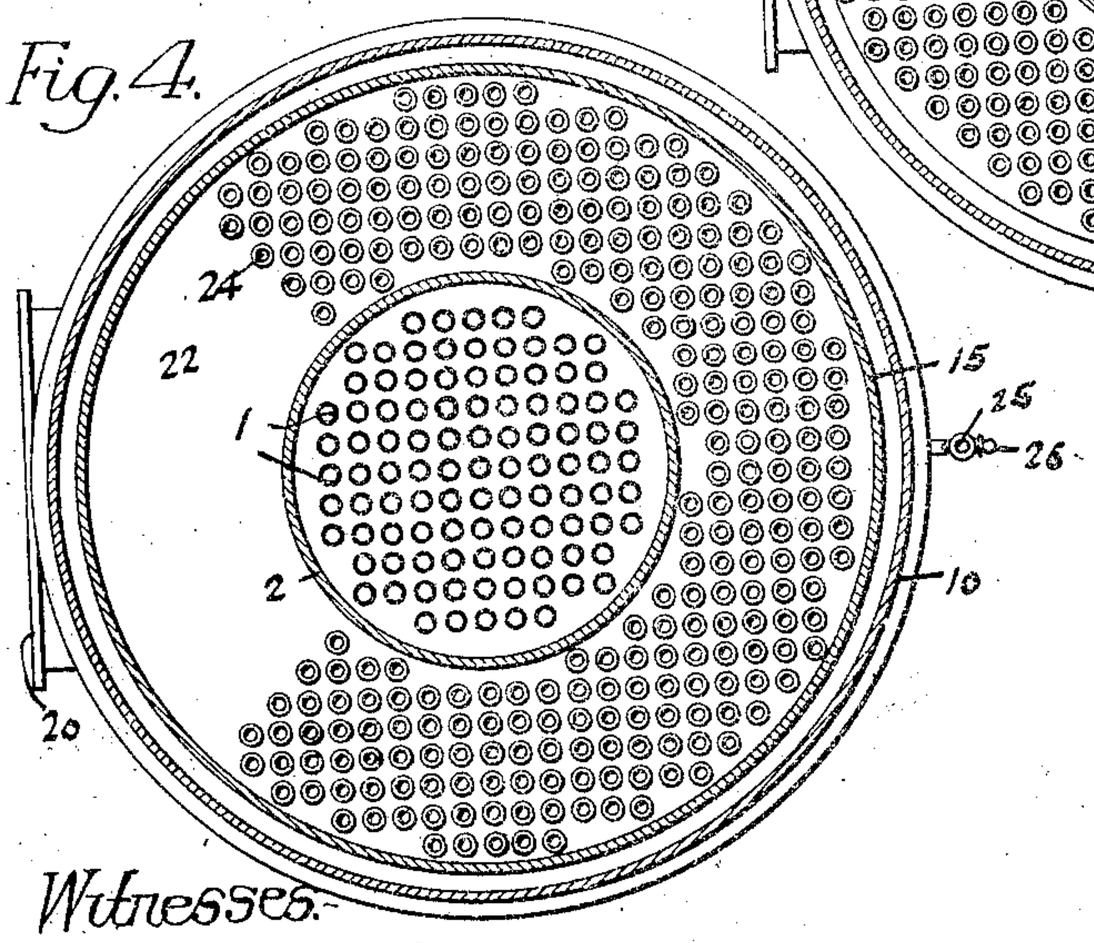


Fig. 4.



Witnesses:-

William A. Kwoir.

Wills A. Burrows

Inventor:-

John Parker:

by his Attorneys

Howson & Howson

UNITED STATES PATENT OFFICE.

JOHN PARKER, OF PHILADELPHIA, PENNSYLVANIA, ASSIGNOR TO KESTNER EVAPORATOR COMPANY, OF PHILADELPHIA, PENNSYLVANIA, A CORPORATION OF PENNSYLVANIA.

EVAPORATING APPARATUS.

940,473. Specification of Letters Patent. Patented Nov. 16, 1909.

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To all whom it may concern:

Be it known that I, JOHN PARKER, a subject of the King of Great Britain and Ireland and the Isle of Man, residing in Philadelphia, Pennsylvania, have invented certain Improvements in Evaporating Apparatus, of which the following is a specification.

My invention relates to apparatus designed for evaporating or concentrating liquids of various characters; and the object of my invention is to provide a device wherein I am enabled to facilitate the separation of the steam or vapor produced from the liquid during the process of concentration; recover the entire liquid content, and insure that no entrained liquid is passed off with the steam or vapor discharged.

My invention comprises certain improvements in what are known as "climbing film" evaporators; evaporators in which a body of liquid in the base of an externally heated tube or series of tubes is carried upward therein under the influence of the vapor formed by the heat. These evaporators are customarily of comparatively great height and discharge liquid and vapor at their top. In the use of these devices, the heated walls of the tube or tubes form vapor in the liquid, lowering its specific gravity and causing it to rise while the progressive evolution of more and more vapor after a time converts the liquid mass into a climbing film of liquid, wetting the walls of the tube and carried upward and forward by the current of vapor. If a current of vapor traverses such a tube at a suitable and relatively high velocity, liquid in the tube is carried forward as a thin uniform layer along the wall, and where the tube is vertical this layer will form a substantially uniform annular wetting film thereon. In the described apparatus, therefore, the tubes may be described as being almost entirely vapor filled and film lined, the liquid climbing upward and thus filming the tube or "creeping" upward as it is sometimes expressed.

In the described types of apparatus, the concentration of the liquid discharged at the top of the tube or tubes may be carried so far as may be desired and the apparatus may work under atmospheric pressure, vacuum or plus pressure. Ordinarily, vacuum is employed. A series of such evaporators under different pressures, may be arranged to operate in what is termed "multiple effect"; the vapors evolved in a prior evaporation under higher pressure being used to heat the liquid in a succeeding evaporation under lower pressure. In such a series any fraction of the total concentration to be produced may be performed in any individual effect.

In the described apparatus, because of the high duty of the heating surfaces and the relatively great quantity of vapor formed from the liquid in a given time unit, efficient means are required for effecting a separation of the vapor and liquid discharged from the effect. In the ordinary types of apparatus working on this principle, this separation is effected in a relatively high dome or separator surmounting the effect.

In the present invention I have devised an improvement on this type whereby the evaporator may be of less total height, the vapor and liquid emerging from the top of the effect being carried downward in a suitable separating chamber and this separating chamber being used to jacket the effect, thereby precluding losses by radiation from the effect itself. The upper ends of the tubes and their contents may be at a higher temperature than the lower, or, in other words, there may be less temperature differential between the tube contents and the heating steam at the top than at the bottom, and since the most efficient operation of the apparatus depends upon substantially uniform heating of the tubes, by prolonging the vapor chamber downward around the steam chamber, irregular condensation in the steam chamber is prevented, radiation losses being precluded, and the heating in the evaporation tubes is made more uniform, with the result of greater efficiency in operation. The vapor in the vapor chamber is of about the same temperature as the liquid in the evaporation tube, but it does not absorb heat to the same extent, and the main conduction of heat from the steam jacket is, therefore, inward. Radiation losses from the vapor chamber outward are not so important and do not disturb the effective working of the apparatus. In effect, the vapor chamber forms a thermal sheath around more or less of the evaporating por-

tion of the apparatus. While the vapor chamber may extend downward around the entire effect, yet in the ordinary and preferred use of the apparatus it is carried downward only a part of the distance.

As apparatus of the climbing film type operate very rapidly, producing a relatively high concentration in a time unit and as the evaporating tubes discharge vapor currents traveling at a relatively high rate of speed, efficient means for separating vapor and liquid are ordinarily necessary. The vapor chamber should, therefore, be of comparatively large cross-sectional area to reduce the speed of travel correspondingly prior to emergence of the vapor therefrom, but prior to losing this high velocity of travel the vapor currents should be passed through a suitable separating device. In this, the suspended or entrained droplets of liquid are thrown out. In the subsequent slow travel of the vapor, separation is perfected and completed.

In the accompanying drawings: Figure 1, is a sectional elevation of an apparatus embodying my invention; Fig. 2, is a plan view of the same; Figs. 3 and 4, are sectional views on the lines *a*—*a* and *b*—*b*, respectively, Fig. 1, and Figs. 5 and 6, are sectional views illustrating modified details of the structure embodying my invention.

The evaporating tubes are indicated at 1, being inclosed within a shell 2 to which steam is admitted at the point 3, such shell having an outlet 4 for the discharge of condensation from such steam. The liquid is fed to a chamber 5 at the base of said tubes and under the influence of the heat surrounding the latter, rises within said tubes in the form of a film on the inner surface of the same, being partially evaporated in transit, and from the upper ends of said tubes it is discharged with more or less velocity together with the accompanying vapor. In the present instance, the shell 2 is made in several sections, the upper and lower ends of the same carrying the plates 6 into which the ends of the tubes are fitted in any usual and well-known manner. Intermediate the ends, an enlarged section 7 is provided, having the steam inlet connection 3, and a flange 8 for a purpose to be described, which flange may be dished, and below the section 7, or at any other convenient point in the shell 2, an expansion section 9 is placed.

Surrounding the upper portion of the shell 2 and in communication with the upper ends of the tubes 1, is an annular casing or shell 10 forming a vapor chamber and having a centrally disposed cover 11, substantially in the shape of an inverted cone, lying directly over said tubes, which cone has depending from it, at or adjacent its marginal edge, a series of vanes 12, for a purpose to be described. These vanes may be of various contours and variously disposed, but they are preferably curved and disposed in the manner shown.

Below the casing 10, being interposed between said casing and the flange 8 of the section 7, of the shell 2, is a casing 13 having a flange 14 upon which said casing 10 rests, and a wall 15 which extends upwardly into the vapor chamber inclosed by the casing 10, such wall forming, with said casing wall, an annular gutter 16 to receive the liquid flowing down the inner surface of the walls of the casing 10. The top of the casing forming the vapor chamber is curved in the manner shown, and the liquid and vapor ejected from the tubes at a high velocity are diverted by the cone and the blades, the liquid reaching the walls of the casing down which it flows to the annular gutter 16, and from the latter it may pass to the bottom of the casing 13, or may be drawn from said gutter 16. When delivered from the gutter 16 to the casing 13, it is preferably by means of a series of pipes or tubes 17 which extend nearly to the bottom of said latter casing and empty into another pocket or gutter 18 in the lower part of the same formed by the flange 8 of the section 7, from which latter pocket the liquid may be discharged through a pipe 19 to another effect or to any other desired point. If desired, the liquid may be drawn from the gutter 16 by means of a pipe 19ª, as indicated in the modified view, Fig. 5.

The steam or vapor outlet from the upper casing structure is indicated at 20 and communicates directly with the casing 13 so that all vapor passing from the tubes after separation from the liquid is discharged through the same. The blades surrounding the cone tend to give the liquid and vapor discharged from the tubes a certain amount of centrifugal action, which has the effect of hurling the liquid against the walls of the casing down which it flows to the pocket before referred to. The vapor passes through the apertures of transverse baffle plates 21 and 22 disposed between the top of the evaporating tubes and the vapor outlet 20; each of said baffle plates removing practically all of the liquid remaining entrained with the steam which liquid drains into the annular gutter. These baffle plates are provided with well known devices such as the cupped apertures 23 and 24 in staggered relation for the passage of the steam or vapor whereby the latter may find its exit through the outlet 20. Any suitable form of baffle plates which will serve the purpose of separating the liquid and vapor and collecting the former may be used. In consequence of this arrangement, all of the liquid is separated

from the vapor; the latter is conducted from the separating chamber without entrained liquid, and all of the liquid is conveyed to the annular gutter 16 from which it may be taken direct, or to the lower part 18 of the casing from which it may be discharged as desired.

In lieu of the form of separator shown in Fig. 1, I may employ one of the type shown in Fig. 6, in which the vanes are somewhat different in shape, and extend downward nearly to the upper tube sheet. The cone too, is curved instead of having the angular wall illustrated in Fig. 1. In each instance the inner edge of the vanes lies outside the discharge area of the tubes, and the possible employment of the modified form of vane which extends nearly to the tube sheet is for the purpose of preventing the passage of vapor radially from the top of said tubes. The covers illustrated are placed directly over the tubes, and they are of such diameter that all of the tubes may be readily examined from the top when such cover is removed. By removing the bottom casing containing the feed chamber as well, it is possible to examine all of the tubes from end to end, to clean them, and to replace any defective ones.

Where the described apparatus is to be used as an element of a multiple effect apparatus, the vapors passing outward through 20 may be conducted to the heating jacket of a next succeeding effect in the usual way. Similarly, the heating vapor in the heating jacket, in lieu of being live or exhaust steam, may be vapor from another preceding effect. Any desired degree of plus or minus pressure may, of course, be maintained in the effect; and generally the pressure in the evaporating chamber and the temperature of the steam or vapor in the heating jacket will be so correlated as to produce a high rate of evaporation in the tubes.

For the purpose of removing any air that may exist in the upper portion of the casing surrounding the tubes, I provide the pipe 25 which leads from said steam space to the bottom part of the casing 10 having a valve 26 controlling the passage of such air to the casing 10, or to some suitable point at lower pressure.

If desired, the chamber formed by the casings 10 and 13 which inclose the upper portion of the steam shell 2 within which the evaporating tubes 1 are mounted, may be extended to the bottom of the same, and the steam inlet supplying the shell inclosing said tubes may pass through said casing. In practice, however, I prefer to employ a structure substantially of the character and design shown.

The deflector or baffle plates 21 and 22 are slightly convex to insure the flow of the liquid caught by the same to the gutter 16, and the wall 15 of said gutter is apertured at 15^a for the passage of liquid from the lower plate. If desired, the baffle plates may be disposed at a decided angle as indicated in Fig. 5.

A single vertical tube will, of course, operate in the same manner as the plurality shown, but it is preferable for structural reasons to employ a plurality of comparatively narrow tubes in a single heating casing.

While I have described and shown the vapor chamber inclosing the evaporating tubes as composed of two casings 10 and 13; the one surrounding the other, it will be understood that this whole sheathing structure could be made in one piece without departing from my invention; provision being made for catching and discharging the liquid in substantially the manner shown. The shell 2 as described and as shown consists of upper and lower sections of substantially the same diameter, with an intermediate section of larger diameter having the steam inlet, with an expansion joint section disposed within the length of said shell 2. I may, however, alter the shape of the enlarged section, and in some instances it may be no greater in diameter than the other portions of said shell, and when employing metals of the same coefficient of expansion for the wall of the steam shell as well as the tubes, it may be unnecessary to employ the expansion section. In other instances it may be desirable to combine the expansion joint with the section having the steam inlet.

It is possible, in the use of the separating chamber I have devised to omit the vanes from the cover or plate 11, the conical or other contour of the same serving as a deflector to throw the liquid with its attendant vapor against the walls of the casing whereby the desired separation is effected.

Other modifications of the structure shown as embodying my invention I deem to be within the scope of the same and in illustrating such structure I do not wish to be limited in any sense to the precise form shown in the drawings, nor are my claims to be construed as limited to such structure.

I speak in certain of the claims of a "tubular column", and this language is intended a single evaporating tube as well as a plurality of evaporating tubes.

I claim:

1. In an evaporating apparatus, the combination of a heating chamber, a vertical evaporating tubular column, and a chamber communicating with the upper end of said tubular column and surrounding said heating chamber and having separate outlets for concentrated liquid and for vapor at points below the upper end of said tubular column.

2. In an evaporating apparatus, the combination of a heating chamber, a vertical evaporating tubular column therein, and a chamber containing liquid separating devices communicating with the upper end of said tubular column and surrounding said heating chamber and having separate outlets for concentrated liquid and for vapor at points below the upper end of said tubular column.

3. In an evaporating apparatus, the combination of a heating chamber, a vertical evaporating tubular column therein, and a chamber containing centrifugal liquid separating devices communicating with the upper end of said tubular column and surrounding said heating chamber and having separate outlets for concentrated liquid and for vapor at points below the upper end of said tubular column.

4. In an evaporating apparatus, a steam chamber, a plurality of vertical tubes therein, means for feeding liquid to the base of such tubes, a chamber inclosing the upper end of the steam chamber and in open communication with the ends of the tubes to receive liquid and vapor therefrom, means for separating entrained liquid from the vapors in such chamber, and means for separately removing concentrated liquid and vapor at points below the upper end of said tubes.

5. In an evaporating apparatus, a steam chamber, a plurality of vertical tubes therein, means for feeding liquid to the base of such tubes, a chamber inclosing the upper end of the steam chamber and in open communication with the ends of the tubes to receive liquid and vapor therefrom, means for separating entrained liquid from the vapor in such chamber, means for conducting the liquid to a point of discharge below the level of the top of the tubes and means for removing vapors at a point below the liquid discharge.

6. An evapoyating apparatus comprising a plurality of vertical tubes, means for feeding liquid into the base of such tubes, a steam jacket surrounding the tube nest, a chamber surmounting the tube nest and receiving concentrated liquid and vapor therefrom, a depending portion of said chamber surrounding the steam jacket and means for separately removing concentrated liquid and vapors from said chamber at points below the upper end of said tubes.

7. In an evaporating apparatus, a plurality of vertical evaporating tubes, a heating jacket surrounding said tubes, a vapor jacket surrounding said heating jacket and receiving vapor from said tubes, and means for discharging vapor located at a low point of said vapor jacket.

8. In an upward evaporator, a combined vapor and liquid receiver, a nest of tubes discharging liquid and vapor upwardly into said receiver, a heating jacket for said tubes, means for separating the liquid and vapor, and means for conducting the vapor downwardly around said jacket.

9. In an upward evaporator, a plurality of evaporating tubes discharging vapor and liquid upwardly, a heating jacket surrounding said tubes, a liquid and vapor receiver above the tube series having a downward extension surrounding the heating jacket and a vapor outlet in said extension, a vaned entrainment separator in said receiver above the tubes adapted to centrifugally separate liquid and vapor and throw the former against the wall of the receiver, and an annular gutter receiving liquid flowing down the wall of said receiver.

10. In an upward evaporator, a series of evaporating tubes discharging vapor and liquid upwardly, a heating jacket surrounding said tubes, a liquid and vapor receiver above the tubes having a downward extension surrounding the heating jacket and a vapor outlet in said extension, a vaned entrainment separator in said receiver above the tubes adapted to centrifugally separate liquid and vapor and throw the former against the wall of the receiver, an annular gutter receiving liquid flowing down the wall of said receiver, and a series of apertured plates spanning said downward extension and serving to pass liquid to said gutter.

11. In a vertical evaporating pan, the combination of a heating chamber, evaporating tubes located therein, a separating chamber surrounding the said heating chamber and extending partly above the top of the evaporating tubes, and having outlets near and on the bottom for the vapors of evaporation and the separated liquors, and means for separating the liquor from the vapor.

12. In a vertical evaporating pan, the combination of a heating chamber, evaporating tubes located therein, a separating chamber surrounding the said heating chamber and extending partly above the top of the evaporating tubes, and provided with a vapor outlet at a point below the top of said tubes, an annular channel on the inside of the said separating chamber above the vapor outlet, a deflecting plate or cover directly over the evaporating tubes for the purpose of directing the entrained liquor to said channel, and means for conducting said liquor from the channel.

13. In a vertical evaporating pan, the combination of a heating chamber, evaporating tubes located therein, a separating chamber surrounding said heating chamber and extending partly above the top of the evaporating tubes and partly below, said chamber being provided with a vapor outlet at a point

below the top of said tubes; and having an annular receiving channel, a deflecting plate or cover directly over the evaporating tubes, blades on said deflecting plate, and auxiliary baffle plates between it and the vapor outlet arranged to convey any entrained liquor to the receiving channel.

14. In an upward evaporator, a plurality of evaporating tubes discharging vapor and liquid upwardly, a heating jacket surrounding said tubes, a liquid and vapor receiver above the tube series having a downward extension surrounding the heating jacket, and having a vapor outlet in said downward extension a deflector of substantially inverted conical shape in said receiver above the tubes adapted to divert the liquid and vapor discharged from said tubes and throw the former against the wall of the receiver, and provision for discharging the liquid flowing down the wall of said receiver.

15. In an evaporating apparatus, the combination of a heating chamber, vertical evaporating tubes therein, and a chamber communicating with the upper end of said tubes and surrounding the upper end of said heating chamber and having separate outlets for concentrated liquid and for vapor at points below the upper end of said tubes.

16. In an evaporating apparatus, the combination of a heating chamber, vertical evaporating tubes therein, and a chamber containing centrifugal liquid separating devices communicating with the upper end of said tubes and surrounding the upper end of said heating chamber and having separate outlets for concentrated liquid and for vapor at points below the upper end of said tubes.

17. In a vertical evaporating pan, the combination of a heating chamber, a plurality of evaporating tubes located therein, a separating chamber surrounding said heating chamber and extending partly above the top of the evaporating tubes and partly below said top, said separating chamber being provided with a vapor outlet at a point below the top of said tubes and having an annular receiving channel, a deflecting plate or cover disposed directly over said evaporating tubes, spiral blades carried by said deflecting plate, and auxiliary baffle plates between said deflecting plate and the vapor outlet arranged to convey entrained liquid to the receiving channel.

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

JOHN PARKER.

Witnesses:
MURRAY C. BOYER,
JOS. H. KLEIN.