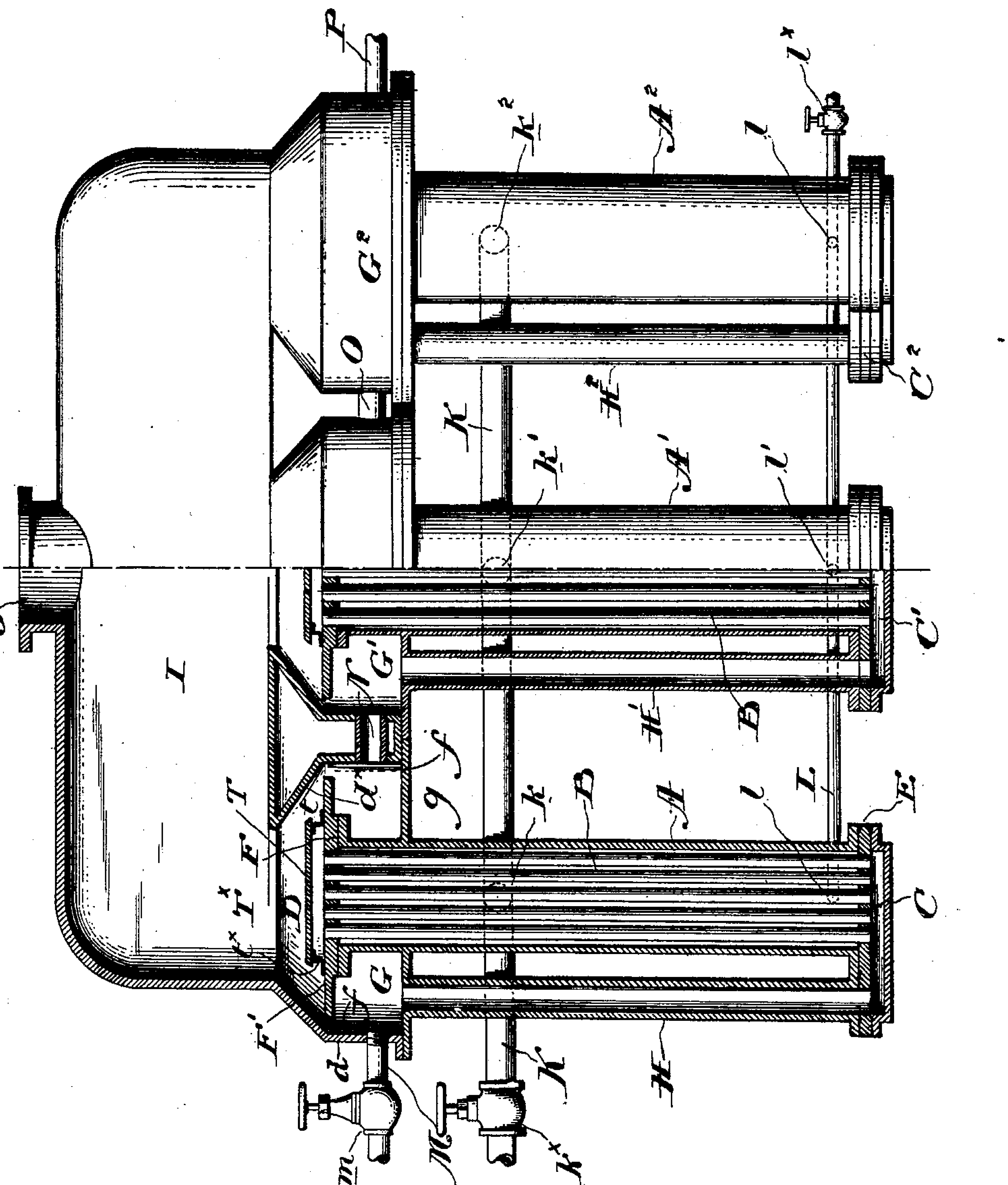
(No Model.) 2 Sheets—Sheet 1.

C. W. COOPER.

APPARATUS FOR EVAPORATING LIQUIDS.

No. 482,340. Patented Sept. 13, 1892.

Fig. 1.



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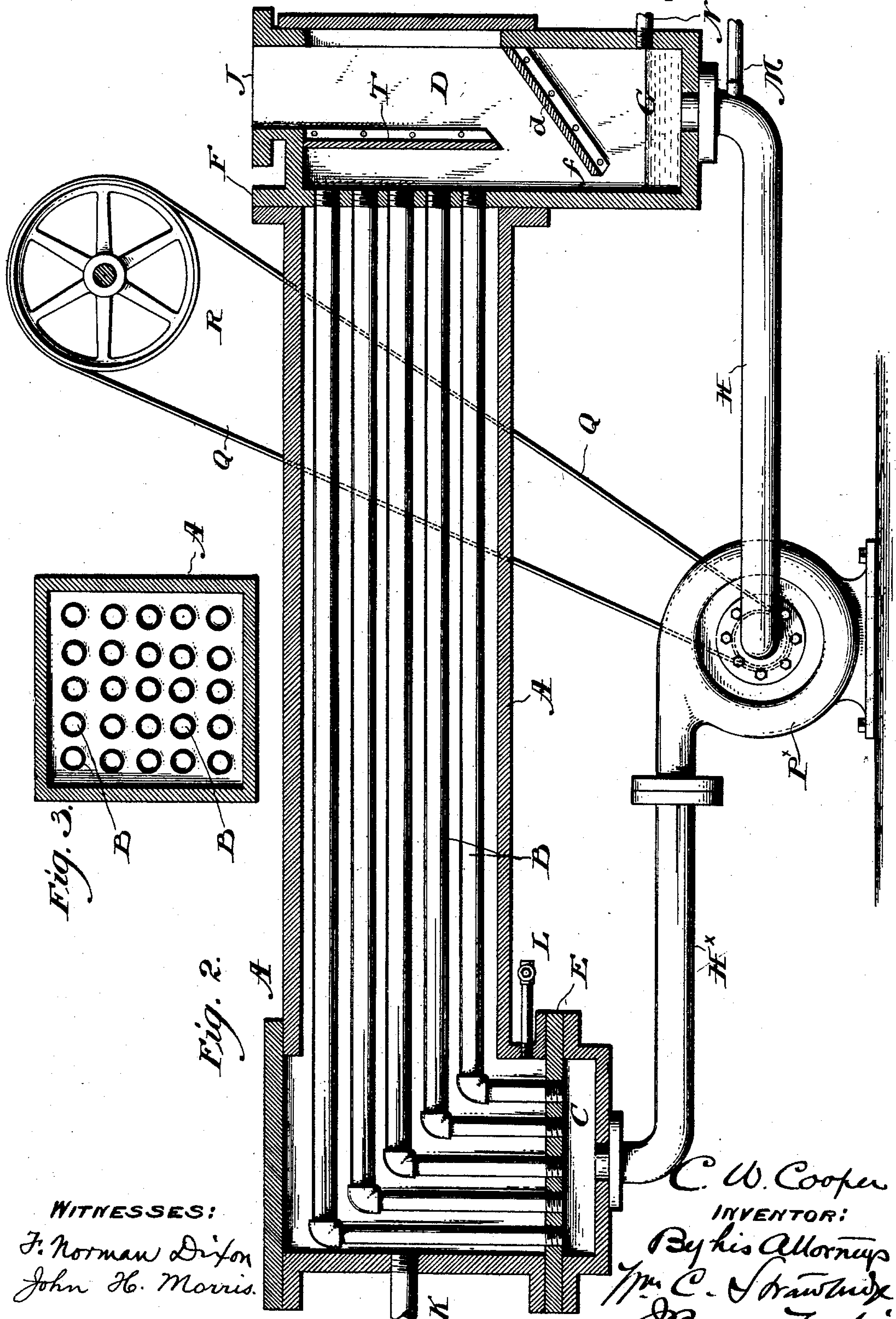

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UNITED STATES PATENT OFFICE.

CHARLES W. COOPER, OF NEW YORK, N. Y.

APPARATUS FOR EVAPORATING LIQUIDS.

SPECIFICATION forming part of Letters Patent No. 482,340, dated September 13, 1892.

Application filed June 30, 1891. Serial No. 397,968. (No model.)

To all whom it may concern:

Be it known that I, CHARLES W. COOPER, a citizen of the United States, residing in the city, county, and State of New York, have invented certain new and useful Improvements in Apparatus for Evaporating Liquids, of which the following is a specification.

My invention relates to that class of evaporating apparatus which are organized to embody systems of evaporating tubes, and its object is the improved construction of an apparatus into which the liquid may continuously be fed, from which it may be continuously discharged, and within which it may be caused continuously to circulate, while at the same time the supply may be controlled to an extent sufficient to secure a high rate of concentration.

To the foregoing ends my invention comprehends an evaporating apparatus of the character hereinafter set forth, and into which the supply is continuous, out of which the discharge is continuous, and within which the circulation of the liquid is continuous.

In the accompanying drawings I have illustrated, and herein I describe, two forms of evaporating apparatus alike embodying my invention.

In the views Figure 1 is a central vertical central elevation partly in side elevation of an apparatus embodying my improvements in a simple and inexpensive form. Fig. 2 is a similar view of a modified form of the same apparatus, and Fig. 3 a transverse section through the evaporating chamber of the apparatus of Fig. 2.

Similar letters of reference indicate corresponding parts.

Referring first to Fig. 1,—A A′ A^2 represent three vertical and conveniently cylindrical evaporating chambers, all of the same construction and all applied in connection with a common vapor chamber. It will, therefore, for the purpose of this explanation, suffice, to describe the construction of the chamber A, and of such parts of the apparatus as are associated and operative in connection with it:— it being understood that counterparts of all such parts are employed in connection with the other chambers.

Within the chamber A are a group of vertically disposed parallel open-ended evaporating tubes B, respectively supported by being at their extremities tightly connected with and caused to pass through a lower tube head E and an upper tube head F. These tubes place a tube-supply chamber C formed at the base of the evaporating chamber A in communication with a separating chamber D preferably but not necessarily of conical form and located above the upper tube head.

The tube heads, within which, as stated, the ends of the tubes are closely fitted so as to be fluid tight, serve to separate the steam space of the evaporating chamber from both the tube-supply chamber and the separating chamber, and in connection with its cylindrical walls constitute it a closed chamber. The upper tube head is conveniently peripherally extended to form an annular flange F′, the outer edges of which extend so nearly to the walls *d* of the separating chamber as to leave only an annular passage *f* between said flange and walls.

G is an annular pocket surrounding the upper portion of the evaporating chamber below the flange F′, conveniently formed by the cylindrical downward extension $d^{\times}$ of the walls *d* and by the base plate *g*.

H is a vertical channel or conduit opening at its upper extremity through the base plate *g* of the pocket G, and at its lower extremity opening into the tube-supply chamber C, and thereby serving to place the pocket in communication with the tube-supply chamber. Supported above the upper tube head is a horizontal disk shield or deflector T, between the outer edges of which and the walls *d* of the separating chamber, is an annular opening *t*. This deflector is conveniently supported from the flange F′ by a series of brackets or angle irons $t^{\times}$, and it serves the purpose of a radiating device to occasion radial deflection of the vapor and liquid.

Above and in communication with each separating chamber, and common thereto, is a vapor chamber I, having a vapor outlet J for the final discharge of the vapor resulting from evaporation.

K is a steam-supply pipe, having three branches or pipes k k' k^2 leading respectively into the respective evaporating chambers A A′ A^2. This pipe is conveniently arranged at the height shown.

L is a discharge pipe, having three branch pipes l l' l^2 respectively leading out from the respective evaporating chambers near their lower portions.

The steam-supply pipe is provided with a suitable cock $k^\times$ for controlling the supply, and the discharge pipe is similarly provided with a cock $l^\times$ for controlling the discharge.

M is a feed pipe for supplying the liquid to be evaporated into the pocket of the first evaporating chamber, and this pipe is also provided with a cock m to regulate the feed.

N is an overflow passage from the pocket G into the pocket G′ of the evaporating chamber A′, and O is a similar passage from the pocket G′ into the pocket G^2 of the evaporating chamber A^2.

P is a final discharge pipe from the pocket G^2 for the concentrated liquid. In practice these pipes are to be placed as close to the base plates g as possible.

It being, as already stated, borne in mind that the evaporating chambers A′ A^2 and their associated parts are similar to the chamber A and the parts as described as in association therewith, the operation of the apparatus as an entirety will be readily understood:—steam being supplied to all of the evaporating chambers through the steam-supply pipe K and its branches, the liquid to be evaporated is continuously supplied into the pocket G of the first chamber, from which it descends through the conduit H into the first tube-supply chamber C. From out this last named chamber the liquid rises within the evaporating tubes B, and as it ascends is subjected to the heat of the steam which surrounds said tubes within the evaporating chamber A, with the result that much of the liquid is rapidly converted into vapor which, partly by reason of the difference in specific gravity of the column within the conduit H and the columns within the tubes B, ascends through the tubes with great velocity, and, in escaping through their upper aperatures, carries with it a portion of the unvaporized liquid which strikes against the under side of the deflector T and is, together with the ascending vapor, deflected horizontally against the walls d of the separating chamber with the result that the liquid, being heavier than the vapor and possessing such correspondingly greater momentum as to be driven against the walls d with greater force, is deflected by the inclination of the walls downward into the pocket G, while the vapor passes upward through the passage t into the vapor chamber I whence it escapes through the discharge-outlet J. The liquid falling into the pocket G again descends through the conduit H into the tube-supply-chamber C, and again ascends through the evaporating tubes B in a continuous circulation,—the surplus liquid supplied through the feed pipe in excess of the evaporation escaping, however, through the overflow passage N into the pocket G′ of the second evaporating chamber A′. There is thus continuously supplied to the second evaporating chamber the excess of the unevaporated liquid from the first supply chamber, and into the third evaporating chamber the excess of liquid from the second chamber, and the operation already described with reference to the first chamber being repeated in each of these chambers, the concentrated liquid is finally continuously discharged from the third evaporating chamber through the final discharge pipe P. In each of these last two chambers the evaporation proceeds under the same conditions as in the first, except in so far as the conditions are modified by the increased consistency of the liquid in each succeeding chamber.

The first evaporating chamber A with its connected appliances manifestly constitute a complete evaporator without the other chambers, and when a series of two or three or more chambers are employed they constitute but sub-chambers of a single evaporating apparatus,—the object of the succeeding chambers being merely to occasion the evaporation of a portion of the thinner liquid before it becomes commingled with the thicker liquid of a succeeding chamber, to the end that the average consistency of the liquid under evaporation may be less than the consistency of the liquid as finally discharged.

A further object of employing a series of evaporating chambers arises from the fact that the thicker the consistency of the liquid in process of evaporation the more the process of evaporation will become impeded; and from the further fact that, in the case of the employment of but a single chamber the thinner liquid becoming, as soon as it enters commingled with the thicker liquid that is being discharged, the process of evaporation will be retarded and rendered less satisfactory. Under these circumstances it will be apparent that, in the case of many liquids, the greater the number of the subdivisions of the apparatus, the less will be the average consistency of the liquid under evaporation. Where, however, the liquid is not to be evaporated to a consistency materially impeding the operation, it is not essential to have more than a single chamber containing any preferred number of evaporating tubes.

In the practice of this invention, in which, as explained the continuous circulation of the liquid to be evaporated in each evaporating chamber forms the most prominent feature,—I have discovered that the circulation and evaporation in each individual evaporating tube do not go on with entire and continuous uniformity, but that pulsations take place at intervals of a few seconds. For example, the liquid entering one of the evaporating tubes ascends a certain distance before becoming vaporized, and then at a certain level becomes instantly converted into a vapor which expels itself from the tube with great velocity carrying with it some of the liquid. The upward passage of this liquid, moreover, sweeps from the interior walls of the tube the lining of the thicker liquid from the preceding pulsation, that, in the interval, has been evaporating upon said walls, and replaces it by a lining of thinner liquid which in turn evaporates until driven off by the next pulsation. If, therefore, any bubbles or other non-conducting coating be formed upon the heating surfaces they are being constantly swept off and replaced by the thinner liquid.

It is obvious that, if desired, two or more evaporators of the character represented in Fig. 1 of the accompanying drawings, may be coupled to produce an effect of multiple evaporation—the vapor discharge pipe J of the first of these evaporators being connected with the steam or vapor supply pipe of a second evaporator, with the result that a double effect evaporator is obtained. In such multiple arrangement, the supply pipe K of the second evaporator and its branches should be enlarged so that the vapor from the vapor chamber I of the first evaporator may pass into the evaporating chambers of the second evaporator without loss of pressure. The series of evaporators, with a corresponding coupling arrangement, may of course, be extended to three or more.

Referring now to the apparatus represented in Figs. 2 and 3, which represent a single evaporating apparatus of a modified construction—susceptible however, of such mechanical modification as to permit of its being used in multiple arrangement—the evaporating chamber A is disposed horizontally and the group of evaporating tubes B are led into it at the left hand end, through a lower tube head E in connection with a tube-supply chamber C. Springing from this tube head the tubes, rising vertically to a given distance, are bent at right angles and carried along horizontally to an upper tube head F at the right hand end of the apparatus, through which they pass and discharge against a deflector or diaphragm T, erected in a suitable separating chamber D formed at the right hand extremity of the apparatus. An inclined diaphragm *d* corresponding to the deflecting walls *d* of the separating chamber of the apparatus of Fig. 1, stops short of the inner wall of the separating chamber so as to leave a passage *f* correspondent to the annular passage *f* in the apparatus of Fig. 1.

G is a pocket formed in the separating chamber, and J a vapor outlet from the upper portion of said separating chamber, which upper portion in effect constitutes a vapor chamber.

K is a steam-supply pipe and L a discharge pipe for the condensed water, both arranged in connection with the evaporating chamber A.

H is a return channel or conduit leading from the pocket G, into which conduit leads the liquid pipe M for supplying liquor to the apparatus. The conduit H leads into a liquid pump $P^{\times}$ of any preferred character, a centrifugal device answering the purpose, and out of said pump the conduit leads and continues under the designation $H^{\times}$, to its discharge into the tube-supply chamber C. A belt Q and driving pulley R are shown as a driving device for the pump.

N is an overflow passage or discharge leading from the pocket G.

The operation of this apparatus is essentially identical with that of the evaporator A of the apparatus of Fig. 1, and all of its parts perform the same functions as the corresponding parts in said evaporator, the only distinction being that the circulation between the pocket of the separating chamber,—the discharge from which is below the level of the tube-supply chamber,—and the tube-supply chamber, is occasioned by the action of the pump which sucks the liquid from the pocket into its own casing and thence forces it into the liquid supply chamber. Of course in the operation of this apparatus the surplus of the liquid which is continuously fed into the evaporator over that which passes off as vapor is continuously discharged from the overflow passage N in the form of a concentrated liquid resulting from the evaporation. In this form of apparatus a rapid circulation can be produced of many times as much liquid in a given time as the quantity which in the same time is fed into the apparatus, and in the forced circulation taking place in it a greater scouring effect upon the interior of the tubes can be produced than in the natural gravitative circulation taking place in the apparatus in Fig. 1.

The modification represented in Fig. 2 is to be understood simply as a type of variation of the apparatus generically as such represented by the apparatus of Fig. 1. Formal re-arrangement or modification in which however the retention of the return channel or conduit which makes the continuous circulation possible, as a feature may obviously be resorted to without departure from the invention.

Having thus described my invention, I claim and desire to secure by Letters Patent:—

1. An evaporating apparatus in which provision is made for the continuous supply, continuous circulation, and continuous discharge, of liquid to be concentrated, and wherein are combined the following elements:—an evaporating chamber,—a tube supply chamber located at the base of said evaporating chamber,—a vapor and liquid separating chamber located at the upper portion of said evaporating chamber,—evaporating tubes leading from said tube-supply chamber upward to said separating chamber through said evaporating chamber, an independent return channel or conduit leading from said separating chamber downward to said tube supply chamber,—a feed pipe or liquid supply for the tube supply chamber,—an overflow or discharge passage leading from said separating chamber near its basal portion,—a vapor exit from

said separating chamber,—and means for supplying a heating medium to the evaporating chamber, substantially as set forth.

2. An evaporating apparatus in which provision is made for the continuous supply, continuous circulation, and continuous discharge of liquid to be concentrated, and wherein are combined the following elements:—a tube-supply chamber located at the base of the evaporating chamber;—a vapor and liquid separating chamber located at the upper portion of the evaporating chamber;—evaporating tubes leading from said tube-supply chamber upward to said separating chamber;—an evaporating chamber or casing which incloses the evaporating tubes and is provided with tube heads through which said tubes pass and also with means for supplying it with a heating medium;—an independent return channel or conduit leading from the basal portion of the separating chamber downward to the tube-supply chamber;—a deflector or diaphragm within the separating chamber;—a feed for supplying liquid to the tube-supply chamber;—an overflow or discharge passage leading from the separating chamber near its basal portion;—and a vapor outlet from said separating chamber;—substantially as set forth.

3. An evaporating apparatus in which provision is made for the continuous supply, continuous circulation, and continuous discharge of liquid to be concentrated, and wherein are combined the following elements:—a series of evaporating chambers substantially such as hereinbefore set forth, that is to say a series each of which is composed essentially of a basal tube-supply chamber from which evaporating tubes lead upward to a separating chamber, and of an independent return channel or conduit, and each of which is provided with means whereby it is supplied with a heating medium to heat its evaporating tubes;—a vapor chamber common to each evaporating chamber of the series;—a liquid supply to the tube-supply chamber of the first evaporating chamber of the series;—overflow passages or discharge outlets from a preceding to a succeeding separating chamber of each evaporating chamber throughout the series;—and an overflow passage or discharge outlet from the separating chamber of the last evaporating chamber of the series;—substantially as set forth.

In testimony that I claim the foregoing as my invention I have hereunto signed my name this 23d day of June, A. D. 1891.

CHAS. W. COOPER.

In presence of—
W. H. WOODHULL,
H. A. TONSING.