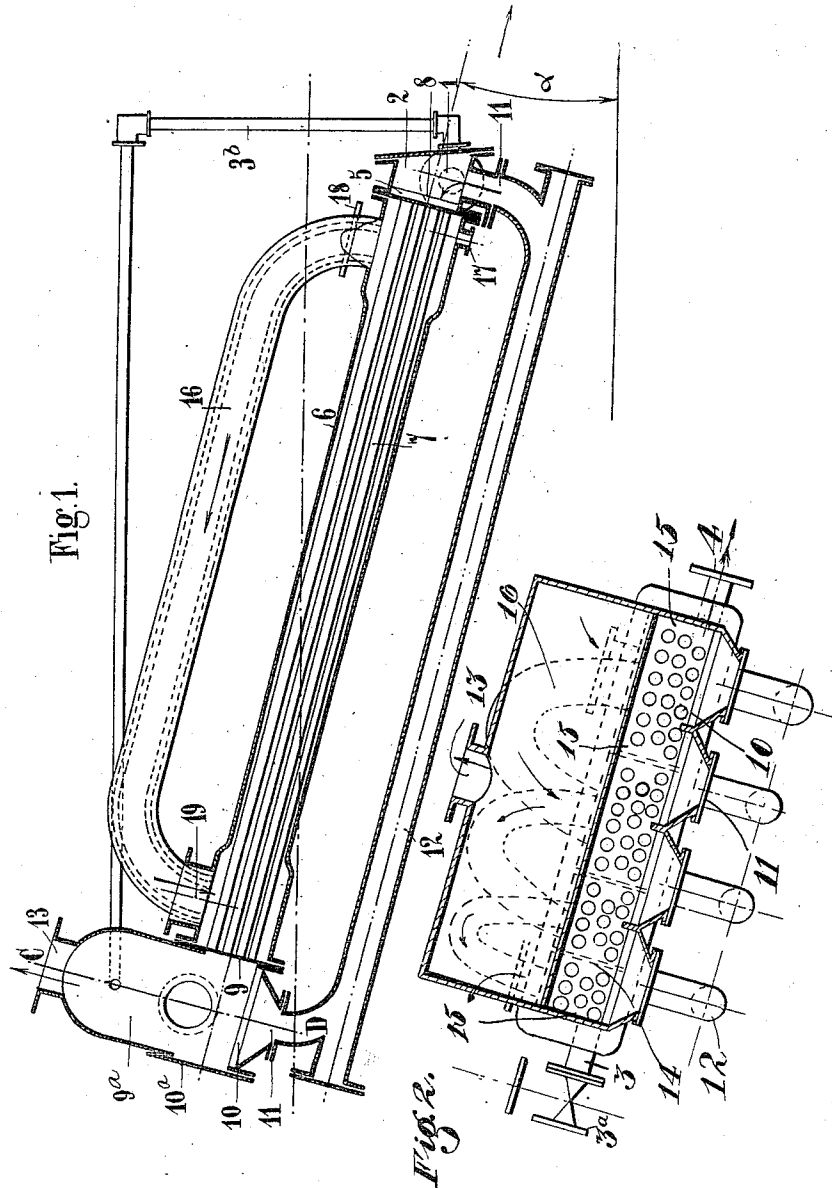


C. PRACHE.
 EVAPORATION BOILER WITH INCLINED TUBES.
 APPLICATION FILED MAY 13, 1909.

972,572.

Patented Oct. 11, 1910.

6 SHEETS—SHEET 1.



WITNESSES:

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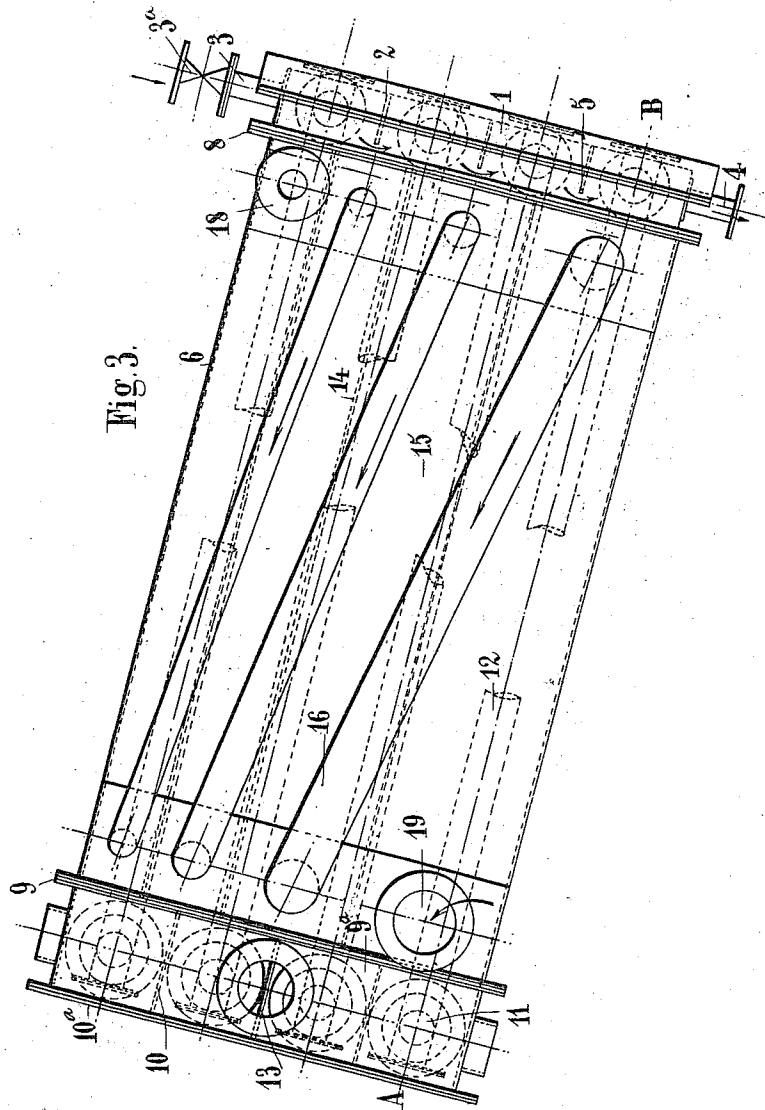
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 6 SHEETS—SHEET 2.



WITNESSES:
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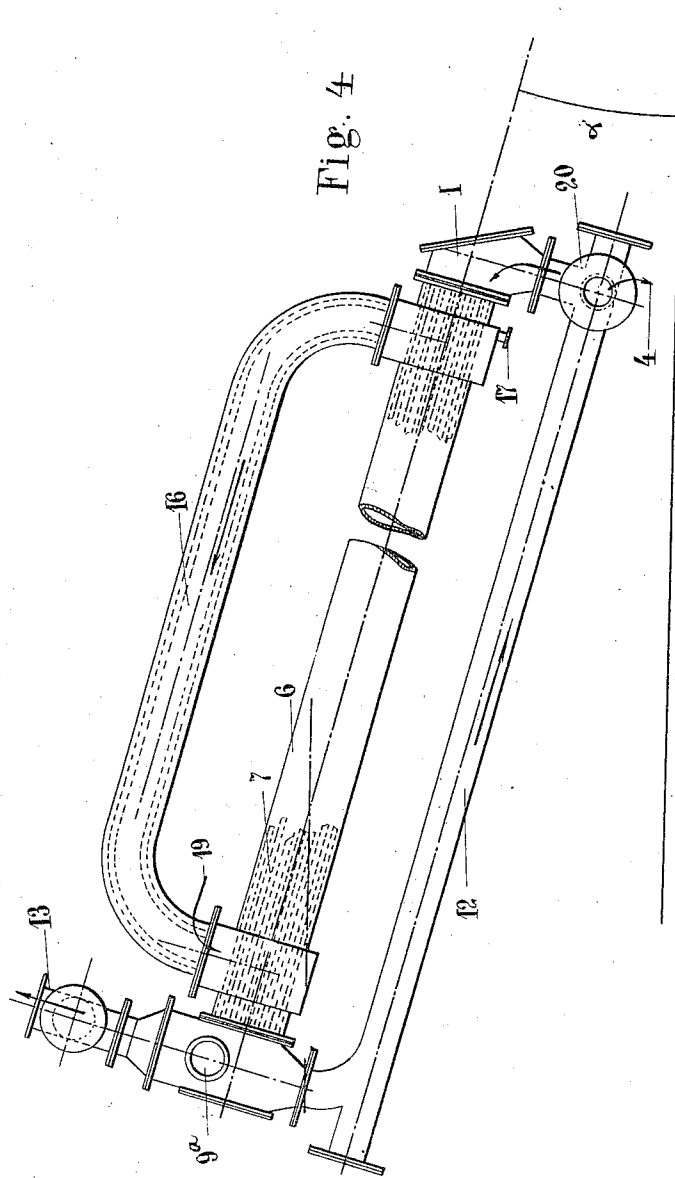
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6 SHEETS—SHEET 3.

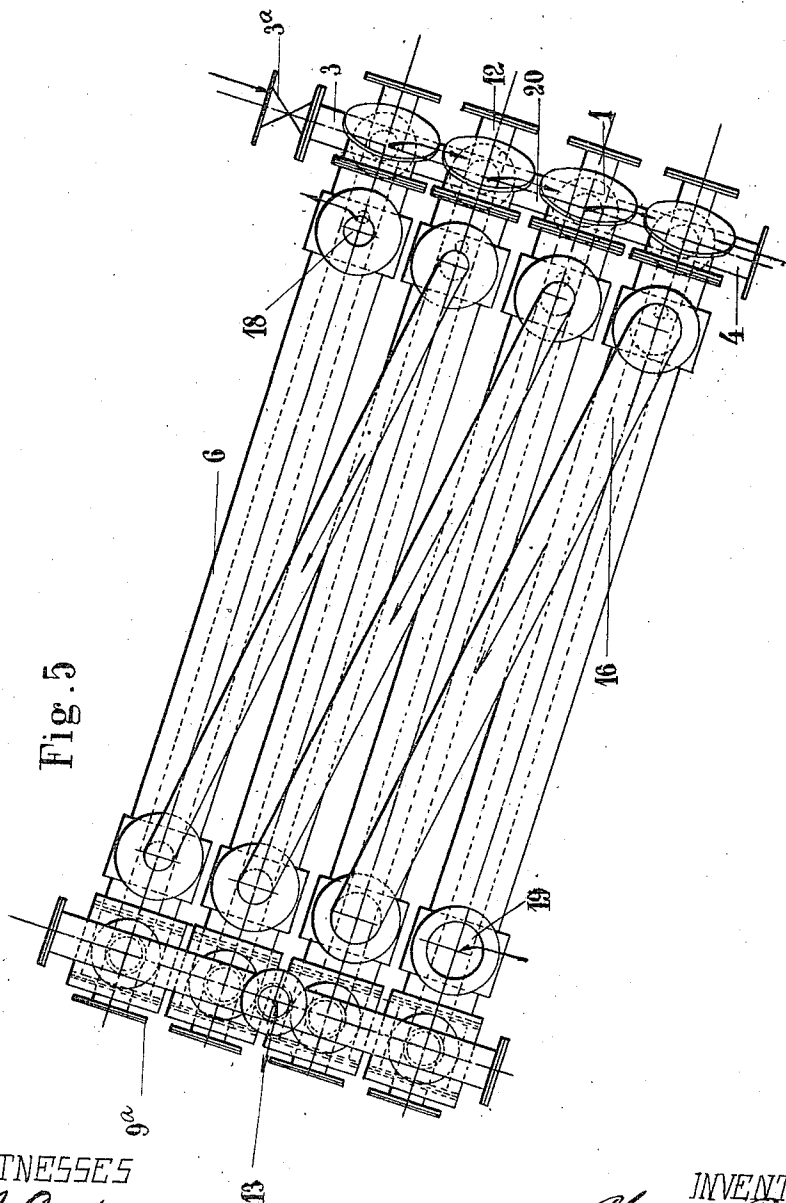


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6 SHEETS—SHEET 5.

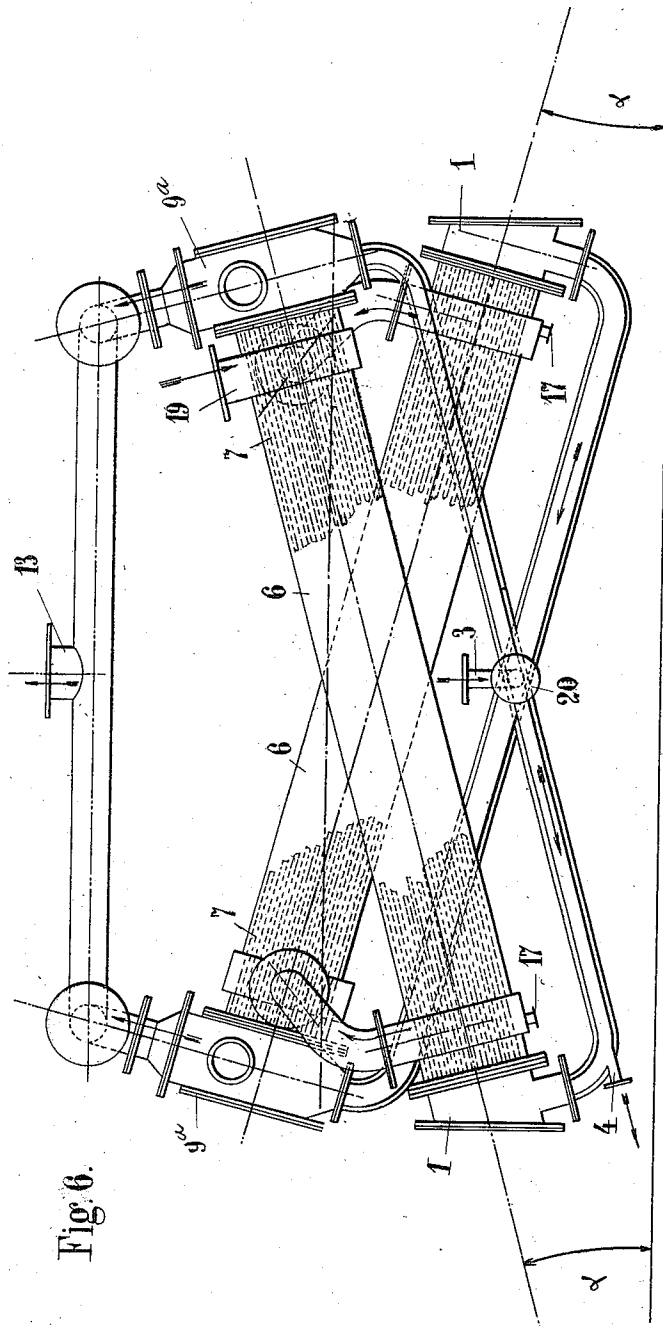


Fig. 6.

WITNESSES

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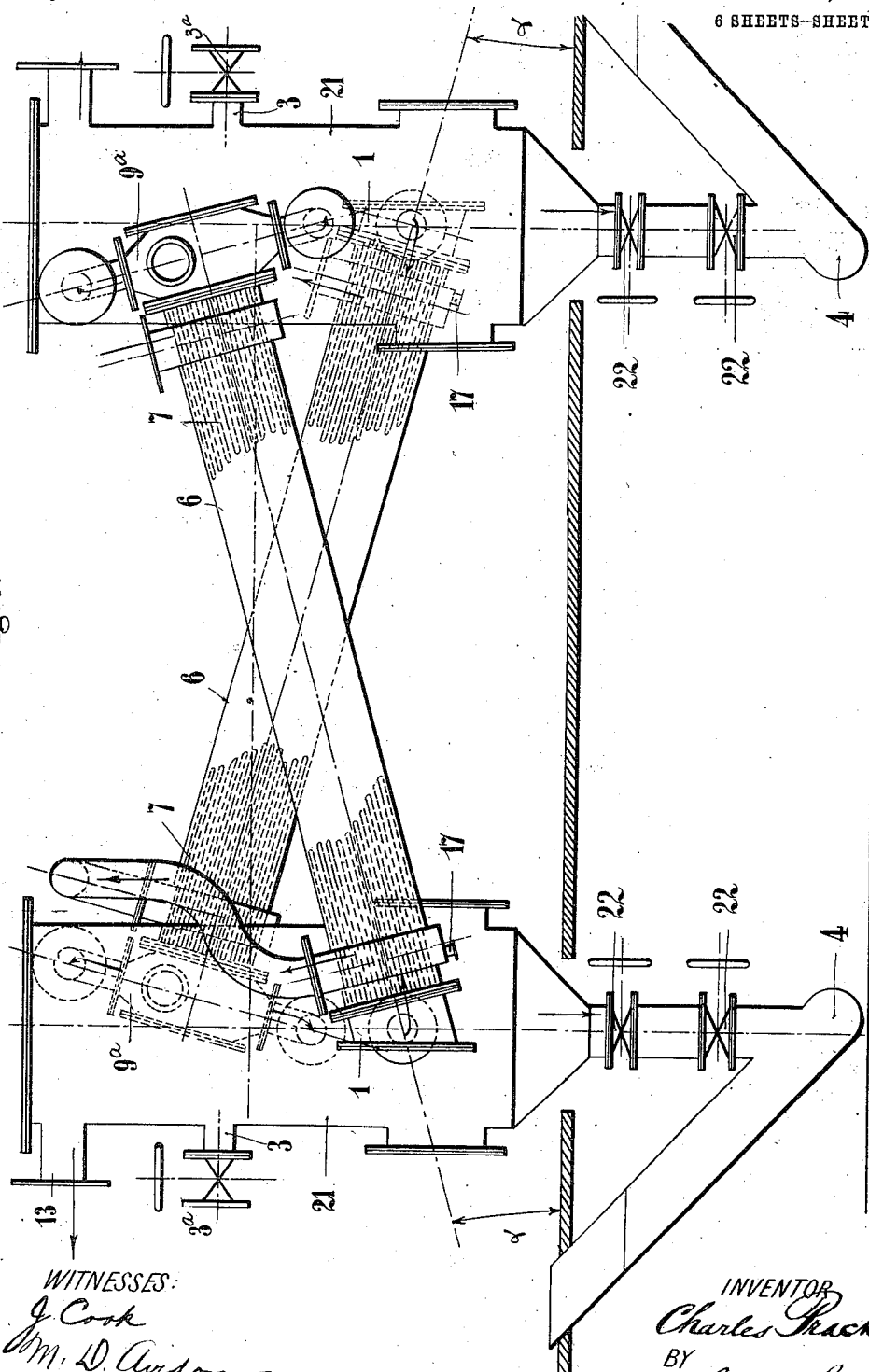
C. PRACHE.
 EVAPORATION BOILER, WITH INCLINED TUBES.
 APPLICATION FILED MAY 13, 1909.

972,572.

Patented Oct. 11, 1910.

6 SHEETS—SHEET 6.

Fig. 7.



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UNITED STATES PATENT OFFICE.

CHARLES PRACHE, OF PARIS, FRANCE, ASSIGNOR TO LA SOCIÉTÉ D'EXPLOITATION DE PROCÉDÉS ÉVAPORATOIRES, SYSTÈME PRACHE ET BOUILLON, OF PARIS, FRANCE.

EVAPORATION-BOILER WITH INCLINED TUBES.

972,572.

Specification of Letters Patent.

Patented Oct. 11, 1910.

Application filed May 13, 1909. Serial No. 495,719.

To all whom it may concern:

Be it known that I, CHARLES PRACHE, a citizen of the Republic of France, and resident of Paris, France, have invented a new and useful Improvement in Evaporation-Boilers with Inclined Tubes, which improvement is fully set forth in the following specification.

This invention relates to liquid concentrating evaporators of the type having inclined heating tubes heated from the exterior by steam, and through which the liquid to be concentrated is caused to circulate.

The object of this invention is to provide evaporators of this kind which may be operated with extreme economy of fuel and labor and which will obviate troubles due to frothing. To this end I have provided various forms of apparatus, examples of which, together with the advantages resulting therefrom, are described hereinafter and the new features thereof claimed.

Apparatus constructed in accordance with this invention are represented by way of example in the accompanying drawing in which:

Figure 1 is a sectional elevation on the line A—B of Fig. 3. Fig. 2 is a section on the line C—D of Fig. 1. Fig. 3 is a plan view of the apparatus. Fig. 4 is an elevation of an apparatus formed by four separate and juxtaposed elements. Fig. 5 is a plan view corresponding to Fig. 4. Fig. 6 is an elevation of an apparatus formed by four separate elements which are juxtaposed and crossed. Fig. 7 is an elevation of an apparatus formed by two crossed elements with a trapping device.

As shown in Fig. 1 the apparatus consists of a lower horizontal liquid reservoir 1 divided into several compartments by partitions 2 in which the liquid to be evaporated is introduced through the inlet-pipe 3 and from which it is extracted after concentration, through the out-let pipe 4 each of these compartments being placed in communication with the next by means of a rectangular port 5 which insures the same level in all the tubes of the nest notwithstanding the fact that the reservoir is divided into compartments.

A rectangular box or steam reservoir 6 is fitted to the reservoir 1 and contains the nest of inclined tubes 7. One of the end

walls of the reservoir is composed of a tube-sheet 8 in which the tubes of the nest, in each of which the liquid will be subjected to ebullition, are fixed.

The nest of tubes as a whole is contained in the steam reservoir 6 and each tube is fixed at its lower end to the lower tube-sheet 8. The reservoir 6 is provided at its upper part with an upper tube-sheet 9 to which the upper ends of all the tubes of the nest are fixed.

An upper reservoir 9^a is fixed to this upper tube-sheet 9 and forms a separator or separation box for separating steam and liquid of the mixture of liquid and steam projected from the tubes 7 by the ebullition. At its lower part this reservoir is divided into a number of compartments by partitions 10 which extend for a part of its height only.

At its lower part each of the compartments is provided with a branch-pipe 11 placing each compartment in communication with the corresponding compartment of the lower reservoir by means of a return pipe 12.

At its upper part the upper reservoir is provided with a steam discharge outlet 13 for discharging the steam produced.

The chamber 6 for the heating steam consists of the inter-tubular space around the tubes of the nest and is limited above and below by the two tube-sheets 8 and 9 and by the walls of the box 6.

The steam chamber is divided by the partitions 14 into a certain number of compartments 15 through which the steam passes in succession, proceeding from the lower end of one compartment to the upper end of the next, through the communication pipes 16. At the lower part of each compartment the condensed water is extracted through the drain-outlet 17 arranged at the lower part of each steam circulation while the incondensable gases are withdrawn through the exhaust outlet 18 located at the lower extremity of the last circulation.

The operation of the apparatus is as follows:

(1). *Circulation of the liquid.*—When the apparatus is operating normally, liquid at the ebullition temperature is introduced through the inlet-pipe 3 and its level is regulated by the cock 3^a as shown by the level

tube 3^b to a height corresponding approximately to the middle of the tubes 7. The liquid boils in the lower part of each tube and is carried upward by the steam produced in its mass which tends to become liberated toward the upper parts of the tubes. Owing to the high ratio of the length of the tube to the section of the internal passage the steam thus produced assumes a high velocity and carries with it the liquid which is there atomized and leaves the upper part of the tube intimately mixed with the steam. On leaving the tube the mixture is projected in the same direction as the tubes and into the separation box 9^a, the liquid jets coming from each tube striking against the plate 10^a forming the rear side of the box and falling to the bottom of the box, while the steam separated from the liquid rises in the dome and is discharged to the exterior through the discharge outlet 13. This arrangement produces an automatic froth skimming device for the liquids, which owing to the ebullition, furnish more or less abundant froth, the whole, being absorbed by the various liquid jets issuing from the tubes, forming an approximately horizontal liquid sheet, in rapid movement, which occupies the entire section of the separation box upon which the froth is unable to get a hold. The liquid collected at the lower part of each compartment of the upper reservoir 9^a returns to the corresponding lower reservoir 1 through the return pipe 12 which connects them. If no liquid were introduced or withdrawn through the pipes 3 and 4, the circulation described above would be produced independently in each of the four compartments formed by the partitions without any appreciable part of the liquid circulating in one of them having a tendency to pass to the adjacent compartment through the communication ports 5. If, however, (and this is what takes place in reality) liquid at a low density is introduced through the inlet pipe 3 while at the same time concentrated liquid is withdrawn through the outlet-pipe 4, a very slight difference of level will be established between the different compartments in such a manner that a certain quantity of liquid constantly tends to pass from one compartment into the next through the ports 5 in the direction indicated by the arrows. However, on account of the position of the ports 5 relative to the tube-sheet, and the intensity of the circulation current of each compartment, the liquid thus conducted through the ports 5 of the preceding compartment will become intimately mixed with the liquid in movement in the compartment into which it is introduced, the result being perfect homogeneity in the density of the liquid contained in each compartment and a perfectly uniform increase in the density from one compartment to the next.

(2). *Circulation of the heating steam.*—The steam introduced through steam-pipe 19 becomes distributed around the tubes 7 of the first compartment through which it passes downwardly in the direction of the tubes. It is then brought toward the top of the second compartment through an outer tube 16 and passes downwardly through the second compartment and so on in succession through the other compartments all of which it traverses in the downward direction being conducted in each case from the lower end of one compartment to the upper end of the next compartment by one of the tubes 16.

From the foregoing it will be seen that the apparatus forming the object of the present invention produces the following results:

A. An increase of the coefficient of transmission of the heating surface owing to a high circulation velocity of the liquid in the tubes on the one hand, and of the heating steam on the other hand, these results being obtained—

As regards the liquid: (1) By the employment of tubes in which the ratio of the length to the diameter is at least 75 the discharge velocity of the steam produced in each tube is high; as this steam carries a part of the liquid with it by emulsion it follows that the velocity of the steam will be partly communicated to the liquid which will itself assume a high circulation velocity in the tube. (2) By the employment of tubes slightly inclined to the horizontal preferably at an angle less than 25° which will cause the steam to become liberated always at the same end, that is, the top of the tubes. This arrangement supplemented by the upper and lower reservoirs connected by the return tubes enables the liquid to assume an exceedingly rapid circulatory movement, the level of the liquid always being maintained at about the middle of the tubes, but in any event below the level of the upper extremity of the tubes. As the upper reservoir is arranged at a rather higher level than the lower reservoir the liquid will return of itself from the upper reservoir into the lower reservoir owing to the difference of level, and a rapid circulation of the liquid will thus be produced without the employment of a pump and with the maximum of intensity, the lifting work required of the expansive force of the steam being reduced to a minimum owing to the slight difference of level between the two reservoirs.

For the heating steam: (1) By the employment of a circulation parallel with the direction of the tubes whereby the losses of pressure due to friction and to eddies are reduced to a minimum. (2) By arranging this circulation in such a manner that it takes place toward the lower end of the inclined tubes, the water condensed in each tube being thus carried toward the lower

part of the tubes by the rapidly moving current of steam and by gravity. (3) By partitioning the heating chamber into a number of compartments through which the steam passes in succession the number of these compartments being so large that the free cross section presented to the steam in each of them will be small enough to cause the steam to assume a high velocity in them.

10 B. The increase of the coefficient of transmission of the heating surface employed by the continuous circulation of the liquid from the time it enters the apparatus until it leaves the same, this circulation being caused by the partitioning of the upper and lower reservoirs, the result of which is that the concentrated liquid will not mix with the weak liquid entering the apparatus, and that consequently the retarding influence of the density of the liquid upon the transmission of the heat by the heating surface is reduced to the minimum.

C. The natural separation of the liquid and of the steam which takes place as they leave the heating tube without the possibility of the formation of froth owing to the fact that the separation reservoir which is narrow is arranged in such a manner that it is traversed at every part by an approximately horizontal sheet of liquid which naturally absorbs the froth.

Figs. 4, 5, 6 and 7 represent modifications of the apparatus described above. Thus the apparatus may comprise a series of separate elements with inclined nests of tubes of the type previously described that is to say each of them comprising an inclined nest of tubes provided at its lower part with a liquid reservoir and at its upper part with a reservoir for the separation of the liquid from the steam both these reservoirs being connected by a return tube but without partitions either as regards the heating steam chamber or as regards each of the two lower and upper reservoirs; these different elements being grouped together in such a manner that the heating steam passes in succession through all the heating chambers in the downward direction and that owing to the communication tubes 20 (Figs. 4 and 5) uniting the various lower reservoirs, the liquid is subjected to a progressive concentration identical with that described of Figs. 1 to 3. In the case of these modifications, the various elements may be arranged in juxtaposition parallel with each other as in Figs. 4 and 5 with liquid communication pipe uniting the various lower reservoirs; or they may be arranged in juxtaposition and crossed as shown in Fig. 6 with liquid communication pipe for the different elements uniting the various return tubes as shown at 20. In each of these cases the box surrounding the nest of tubes may be of any cross section such as

rectangular square or circular. In the case of liquids which during their evaporation form deposits or crystals the apparatus may comprise two inclined tubular elements as shown in Fig. 7 of the same kind as in the form of the invention shown in Figs. 4 and 5; but crossed and arranged in such a manner that each of the nests of tubes serves as return tube for the other, that is to say, the liquid conducted into the upper reservoir of one of the elements is re-conducted into the lower reservoir of this same element in passing through the other element, the upper reservoir of each element being united with the lower reservoir of the other by a chamber 21 forming a basin for decantation and separation of crystals each of these separation chambers being provided with means which may consist of a lock with two doors for trapping or extracting solid products or any other means.

I claim as new:

1. In an evaporator for concentrating liquids, the combination of a nest of heating tubes slightly inclined to the horizontal, means for conducting steam to the exterior of the tubes to heat the same, reservoirs at the opposite ends of said nest of tubes and connecting with the tubes, a return tube passing below said nest of tubes and connecting said reservoirs, and means for maintaining the level of the liquid in the heating tubes approximately midway between the ends of the nests of tubes, the length of the heating tubes relative to their diameters being very long whereby a very large heating surface relative to the diameter of the tubes and to the difference in the levels of the ends thereof is provided.

2. In an evaporator for concentrating liquids, the combination of a nest of heating tubes slightly inclined to the horizontal, means for conducting steam to the exterior of the tubes to heat the same, reservoirs at the opposite ends of said nest of tubes and connecting with the tubes, a return tube passing below said nest of tubes and connecting said reservoirs, and means for maintaining the level of the liquid in the heating tubes approximately midway between the ends of the nests of tubes, the length of the tubes being substantially 75 times their diameter.

3. In an evaporator for concentrating liquids, the combination of a gang of nest heating tubes slightly inclined both longitudinally and transversely, inclined reservoirs at opposite ends of said gangs of tubes, partial partitions dividing the lower reservoir into communicating compartments, return tubes connecting the respective corresponding compartments of said reservoirs, and passing below said nests of tubes, means for introducing liquid at the upper end of the lower reservoir, means for extracting the liquid from the lower end of the lower reser-

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4. In an evaporator for concentrating liquids, the combination of a gang of nests of tubes slightly inclined both laterally and horizontally, inclined reservoirs at opposite ends of said tubes, partial partitions dividing said reservoirs into communicating compartments, return-tubes connecting the respective corresponding compartments of said reservoirs, and passing below said nests of tubes, means for introducing liquid into the upper end of the lower reservoir, means for extracting the liquid from the lower end of the same, means for heating the exterior of the tubes, and a separation box above the uppermost of said reservoirs.
5. In an evaporator for concentrating liquids, the combination of a gang of nests of tubes slightly inclined both laterally and

horizontally, inclined reservoirs at opposite ends of said tubes, partial partitions dividing said reservoirs into communicating compartments, return-tubes connecting the respective corresponding compartments of said reservoirs, and passing below said nests of tubes, means for introducing liquid into the upper end of the lower reservoir, means for extracting the liquid from the lower end of the same, means for heating the exterior of the tubes, and a separation box above the uppermost of said reservoirs, each pipe being smaller than the preceding adjacent pipe.

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

CHARLES PRACHE.

Witnesses:

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 DEAN B. MASON.