Nov. 24, 1942. H. M. GRAHAM 2,302,993

EVAPORATOR

Filed Dec. 7, 1940 3 Sheets-Sheet 1

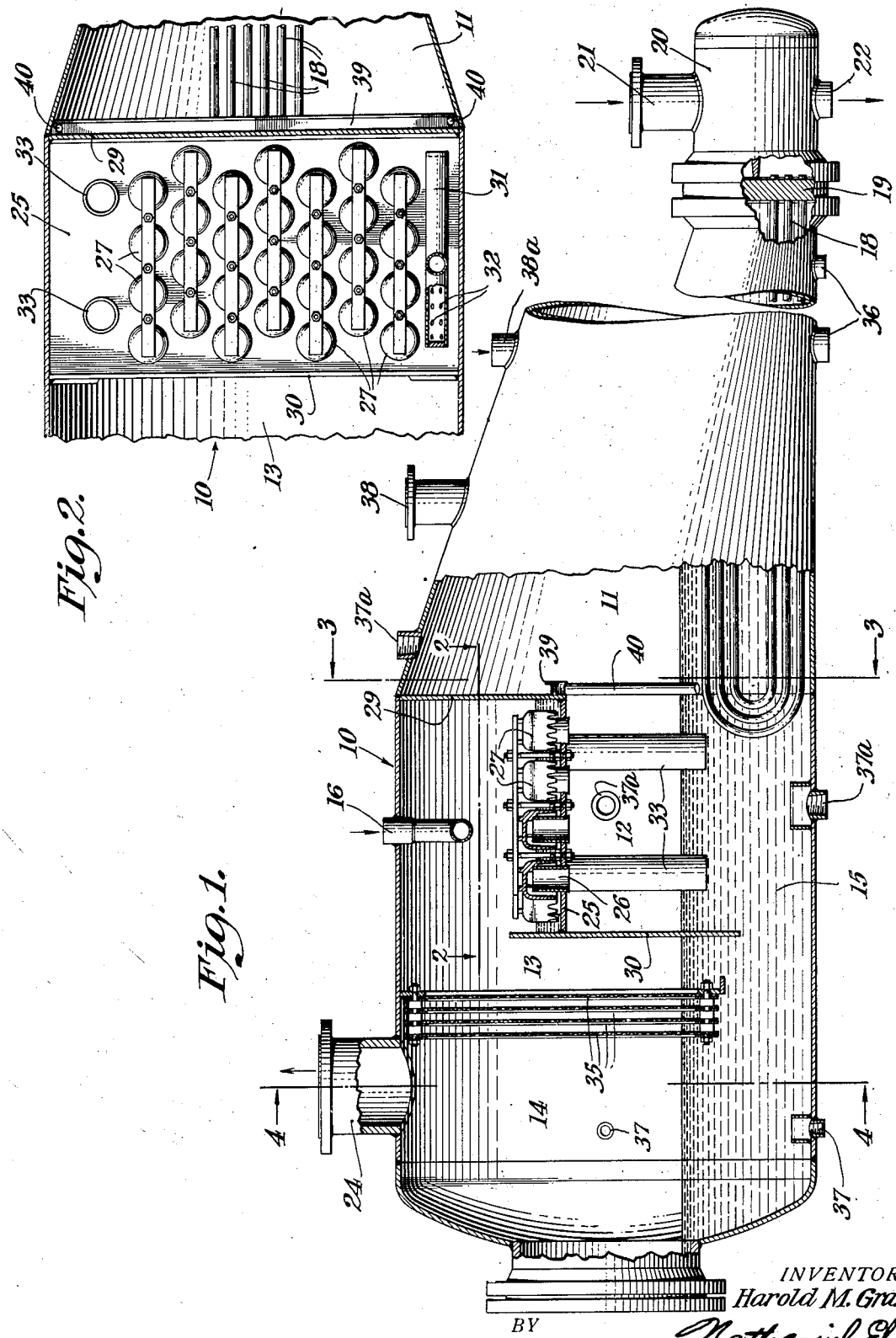


Fig. 2.

Fig. 1.

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Fig. 3.

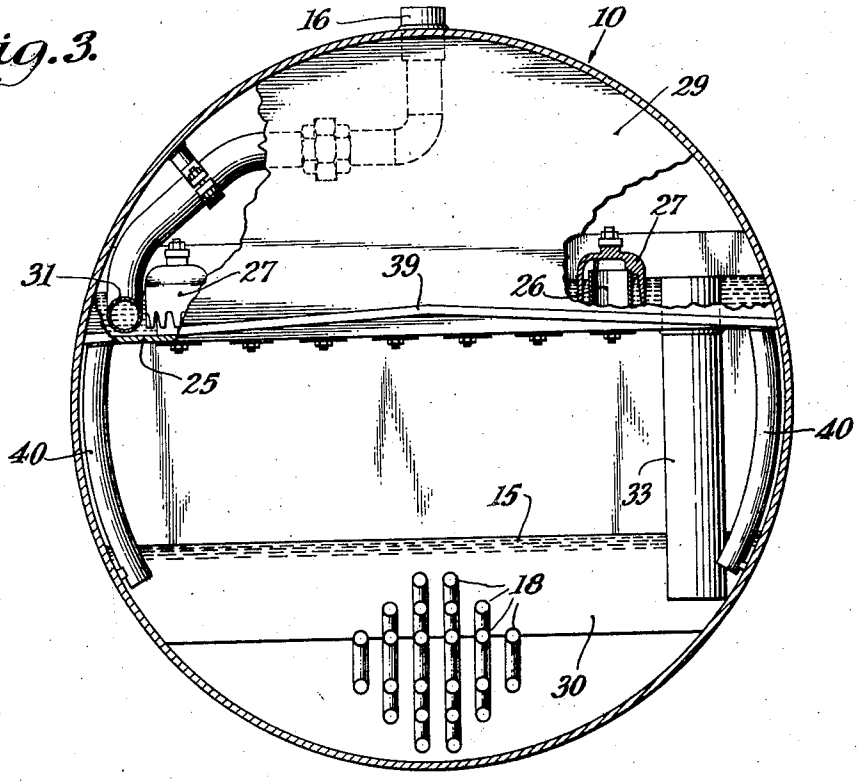
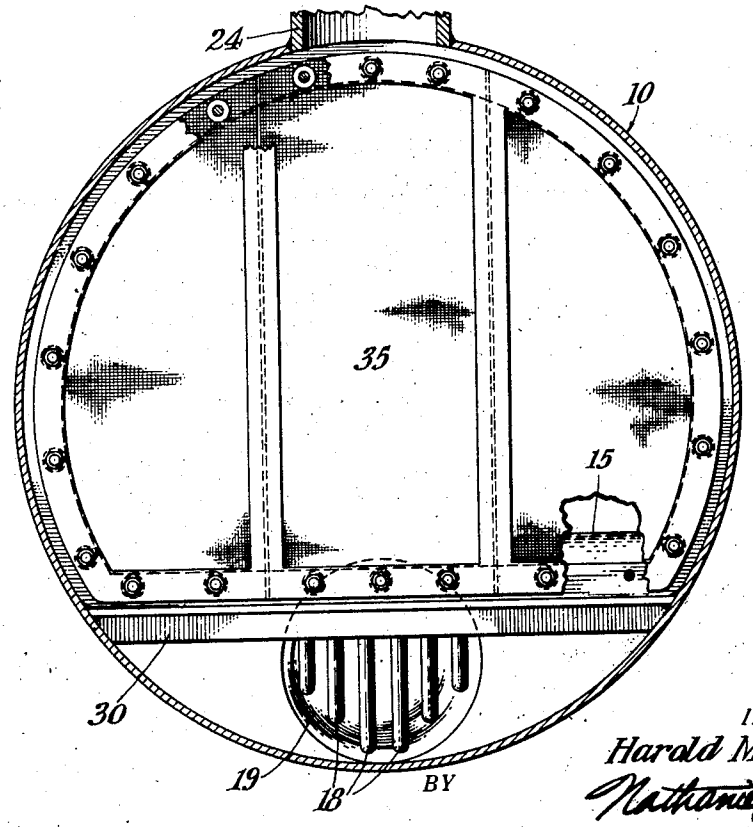


Fig. 4.



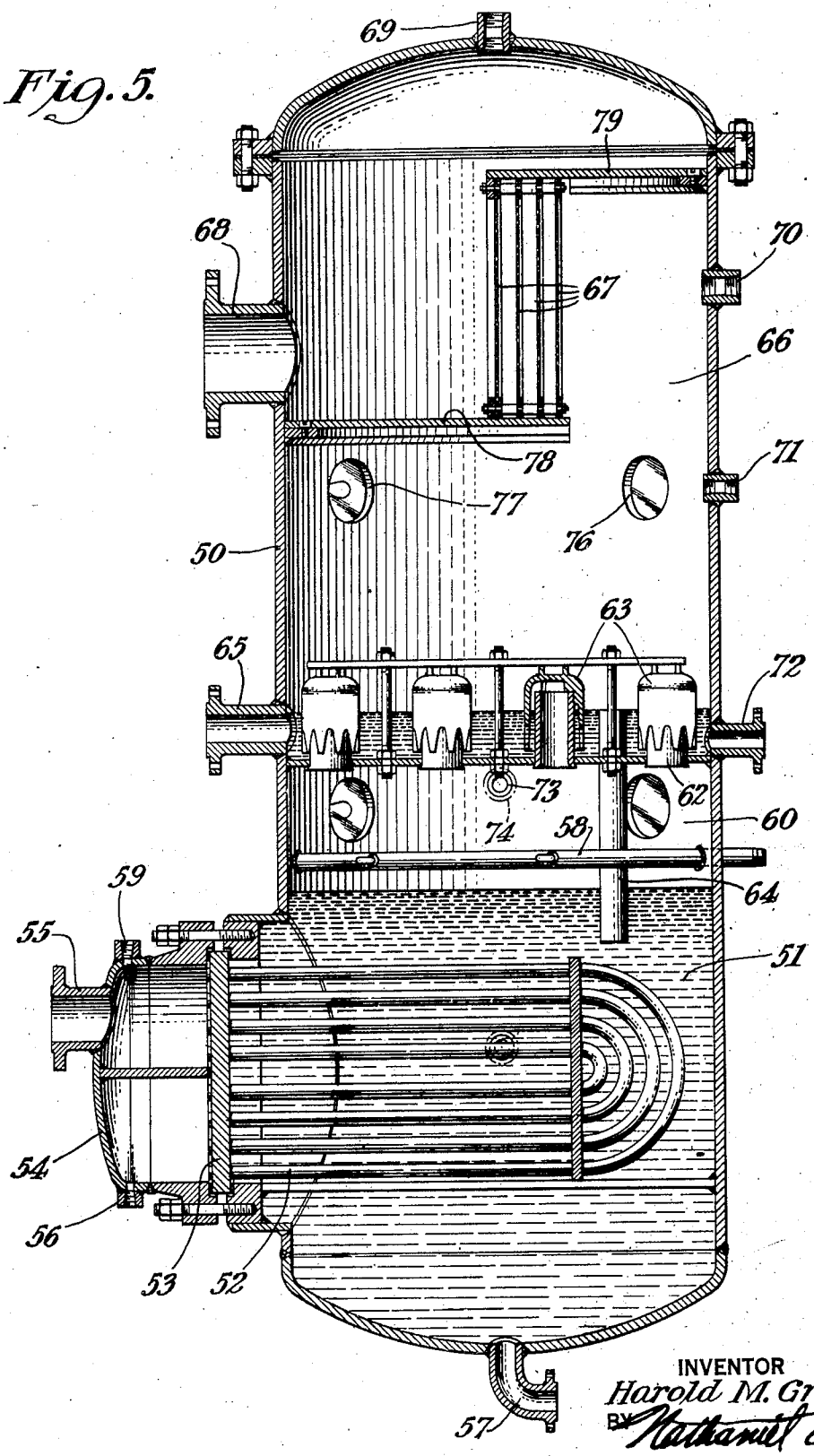
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Fig. 5.



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2,302,993

EVAPORATOR

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Application December 7, 1940, Serial No. 368,981

5 Claims. (Cl. 122—34)

This invention relates to improvements in evaporators.

In the evaporation of water for the purpose of generating steam, it is common to treat the water to reduce its hardness and the water used may also contain some sediment in the form of solid matter, which, together with the treating material, must be eliminated in order to produce the desired pure steam required in present day high pressure steam power practice.

A general object of my invention is to provide an improved evaporating apparatus for the production of relatively pure steam for boiler feed water in which sludge, sediment, and other solid matter are continuously knocked out of the steam by incoming feed water with the solids accumulating in the evaporating region, from which they may be blown down as necessary.

A further object of the invention is to provide an improved unit evaporator for the production of high purity steam, in the lower part of which is an evaporating coil submerged by a water bath and in the upper part of which are spaced steam generating, steam scrubbing, and steam drying sections with a flow of steam from section to section, by which impurities and moisture are removed.

Still further objects of my invention will appear from the following description of a preferred form of embodiment thereof taken in connection with the attached drawings, in which:

Fig. 1 is a partial elevation with parts in central vertical section through an improved form of evaporator;

Fig. 2 is a partial horizontal cross section taken substantially along the line 2—2 of Fig. 1;

Figs. 3 and 4 are vertical cross sections taken respectively along the lines 3—3 and 4—4 of Fig. 1; and

Fig. 5 is a vertical section of a modified form of construction.

In accordance with the preferred form of embodiment of my invention, I provide an evaporator for the generation of steam in the production of boiler feed water, in which the maximum efficiency of heat transfer is obtained with a minimum loss of sensible heat. The heat source may be of any type as it is only in indirect heat exchange with the water and the water is of any available type and is usually alkali treated but is evaporated to provide pure distillate.

In detail, the evaporator is generally indicated at 10. It consists substantially of a horizontal elongated vessel which includes a steam generating chamber 11, a steam scrubbing chamber 12, a steam drying section 13, and the steam reservoir 14. Except for the baffles, these respective chambers are all continuous and form the interior of the evaporator 10.

For convenience, the evaporator may also be considered to include a water chamber 15 below the vapor chambers 11, 12, 13, and 14 above mentioned, the water chamber being adapted to receive the water which is to be evaporated into steam from the water inlet 16 by means to be hereinafter described.

Preferably, the water in the water chamber 15 is evaporated by heat exchange with a heating fluid which passes through tubular heat exchange bundle generally indicated at 18, which may have a suitable fixed tube sheet 19 and the channel 20, into which the heating fluid is introduced through the nozzle 21 and discharged through the nozzle 22. As will be noted, the relative diameter of the heat exchange tube sheet 19, with respect to the required diameter of the evaporator 10, makes it desirable to provide a conical shell for the chamber 11, which is the principal steam evaporating chamber. This is in the interest of economy and permits the appropriate location of the tube bundle 18 at the bottom of the evaporator 10 where it is submerged by the water in the water chamber 15. Furthermore, it aids the natural movement of steam toward the reservoir chamber 14 and the steam discharge nozzle 24.

In the usual operation of the apparatus, sufficient heat is transferred to the water in the chamber 15 to cause a continuous evaporation of a part thereof. I find, however, that the steam formed usually contains an objectionable amount of entrained solid matter which may amount to approximately 1% of its total weight. This material must be removed, and I, therefore, provide a suitable scrubbing section through which the steam must pass. This scrubbing section includes a relatively horizontal plate or deck 25 suitably perforated and provided with upstanding risers 26, through which the steam passes. These risers 26 may carry imperforate caps 27 in the nature of well-known bubble caps, the edges of which are preferably serrated, such caps being spaced sufficiently from the upper ends of the risers 26 so that the steam will pass upwardly through the deck 25, downwardly under the cap 27, and thence upwardly into the chamber 13. The passage of steam in this direction is definitely established by the provision of baffles 29 and 30.

To establish a scrubbing action, the feed water, which is introduced through the pipe 16,

is carried down by means of the pipe 31 onto the deck 25. As will be seen in Figs. 2 and 3, the pipe 31 is provided with a series of openings 32 on the bottom so that the water which is introduced will be discharged substantially across the width of the deck 25. A suitable height of liquid is established on the deck 25 by means of the downflow pipes 33, which extend sufficiently above the deck 25 so that the water level as shown in Fig. 3 will partially cover the walls of the caps 27, and the steam, which thus passes under the caps 27, must therefore pass through some of the water before it can reach the chamber 13.

I have found in practice that the passage of steam containing a certain amount of entrained solids through the water in this manner will accomplish a substitution of moisture for solids with the result that the solids contained in the steam are removed therefrom and tend to flow down the pipes 33 into the water chamber 15.

The steam which reaches the chamber 13 is, therefore, free of solid matter but contains some entrained moisture which is also objectionable, and I, therefore, provide a multiple screen filter 35 which is preferably of a suitable mesh wire which removes the entrained moisture from the steam. The moisture follows the screen into the water chamber 15. The steam, therefore, that reaches the chamber 14 is substantially free of moisture and solids and is adapted for use.

The evaporator may be provided with suitable blowdown openings 36. Provision may be made as at 37 for the insertion of a gauge glass for inspection of the liquid level in the evaporator; provision may also be made at 37a for the installation of a liquid level control device. Connection 38 may be adapted for the insertion of a pressure relief valve or the like. Raw water may be introduced at 38a to be sprayed over the heat exchange bundle 18 when it is necessary or desirable to remove the scale therefrom. I also find it desirable to provide the baffle 29 with a channel 39 which is connected with a downpipe 40 extending below the water level in the chamber 15 as shown in Fig. 3 to draw off any moisture which may have been knocked out of the steam in its contact with the baffle 29. This reduces the moisture content of the steam and is beneficial in producing the maximum quality of steam in the chamber 14.

An evaporator of this type is of particular advantage where a heating fluid is available which it is undesirable to bring into direct contact with the water in the chamber 15. In many industrial chemical fields heating media are available which are of such poor quality as to be objectionable if passed directly into the water.

The evaporator is also of particular advantage in that there are no moving parts with nothing to become damaged or to get out of order; it is necessary only to maintain the desired level of water which simultaneously covers the heating coil 18 and forms a continuation of the baffles which separate the respective chambers one from the other. The flow of steam is thus automatically controlled by the water.

It is also possible to provide a vertical type of evaporator, one form of which is shown in Fig. 5. In this case the shell 50 is substantially cylindrical and has the water portion 51, the level of which is maintained such that the heating coil 52 is normally submerged. The heating coil is preferably provided with a detachable tube sheet 53, as in the first case, and a channel 54 having a safety valve nozzle 59 interconnects certain of the tubes with the heating media inlet nozzle 55. In the particular construction shown, this is adapted to receive a condensable material such as steam with the condensate removed through the drain 56. It is, of course, to be understood that, if a liquid such as hot oil or other material is used, a second nozzle would be provided for the removal thereof.

The water portion 51 of the evaporator is relatively deep in this form of the invention with a resultant adequate sludge collecting section at the lower portion, and a blowdown 57 is provided for the removal of the sludge as desired. Furthermore, a descaling spray means shown at 58 may be provided so that the scale may be washed from the heating coil 52 as desired.

Above the water chamber 51 I provide a steam evaporating chamber 60, above which is provided a relatively horizontal bubble plate having risers 62, bubble caps 63, and a downpipe 64. This latter will maintain a liquid level on the deck, and the steam must pass through this liquid on its way to the outlet. As in the prior case, the feed water is introduced onto the bubble plate as through the nozzle 65 and a substitution of moisture for the solids in the steam is thereby accomplished.

The steam then rises through the steam drying section 66 and passes through suitable screens 67, which remove the moisture, and the dry and clean steam then discharges through the outlet nozzle 68. A vent may be provided at 69 for the removal of air, and nozzles may be provided at 70 and 71 for suitable gauges and relief valves. If desired, a nozzle 72 may be provided for sampling purposes, and the evaporator wall may also be provided with nozzles, indicated at 73 and 74, for the gauge glass and the liquid level control. The device may also be provided with illuminated ports 76 and 77 for purposes of inspection.

While I have shown a preferred form of embodiment of my invention, I am aware that modifications may be made thereto, and I, therefore, desire a broad interpretation of my invention within the scope and spirit of the description herein and of the claims appended hereinafter.

I claim:

1. An evaporator having a shell, a heat exchange coil in a lower part of said shell and normally submerged in contained water therein, an evaporation chamber, a steam scrubbing chamber, a steam drying chamber, and a vapor reservoir chamber above the normal water level in said shell, said chambers being interconnected whereby steam formed in said evaporation chamber must flow through each of said chambers in the order named, partition members delimiting said chambers to provide a circuitous path of flow for the steam, one of the partition members delimiting the scrubbing chamber being a perforated horizontal plate and having bubble caps surmounting the perforations to form steam scrubbing devices, means to introduce feed water above said scrubbing devices whereby the steam must pass through said feed water on said plate and exchange solid matter entrained therein for moisture, and vertical moisture removing means forming the partition between the steam drying chamber and the reservoir chamber to remove substantially all of the moisture from the steam in its passage therethrough.

2. An evaporator having a shell, a heat exchange coil in a lower part of said shell and normally submerged in contained water therein, an

evaporation chamber, a steam scrubbing chamber, a steam drying chamber, and a steam reservoir chamber above the normal water level in said shell, partition members delimiting said chambers and extending into said water whereby said water forms one of the walls of said chambers, said scrubbing chamber and said evaporating chamber being interconnected so that the steam formed in said evaporating chamber must pass through the scrubbing chamber into the steam drying chamber, scrubbing devices in said scrubbing chamber, means to introduce feed water above said scrubbing devices whereby the steam must pass through said feed water and exchange solid matter entrained therein for moisture, and moisture removing means forming the partition between the steam drying chamber and the reservoir chamber whereby substantially all of the moisture is removed from the steam in its passage therethrough, said evaporator being a substantially cylindrical horizontal shell with a tapered, truncated, conical portion forming the evaporator chamber.

3. An evaporator having a shell, a heat exchange coil in a lower part of said shell and normally submerged in water contained therein, an evaporation chamber, a steam scrubbing chamber, a steam drying chamber, and a steam reservoir chamber above the normal water level in said shell, partition members delimiting said chambers and extending into said water whereby said water forms one of the walls of said chambers, said scrubbing chamber and said evaporating chamber being interconnected so that the steam formed in said evaporating chamber must pass through the scrubbing chamber into the steam drying chamber, scrubbing devices in said scrubbing chamber, means to introduce feed water above said scrubbing devices whereby the steam must pass through said feed water and exchange solid matter entrained therein for moisture, and moisture removing screens forming the partition between the steam drying chamber and the reservoir chamber whereby substantially all of the moisture is removed from the steam in its passage therethrough, said shell being a substantially tubular member having a horizontal axis, in which baffles comprise some of the partition members that delimit the respective chambers, said baffles being vertical and spaced horizontally with respect to each other whereby the steam is given a circuitous course from its point of formation to its point of discharge.

4. An evaporator consisting of a horizontal shell, a heat exchange coil therein and normally adapted to be surrounded by water contained in said shell, a steam separator in said shell, a steam outlet in said shell, said separator including imperforate steam directing baffles, one of which extends into said water, and a perforate baffle, bubble caps surmounting the perforations in said perforate baffle, means to feed water onto said perforate baffle above said bubble caps, means to maintain a feed water level above the lower margins of said bubble caps whereby steam formed in said evaporator must pass through the feed water on said perforate baffle, means to remove the moisture entrained in said steam, said means including a vertical, perforate baffle spaced between the bubble caps and the steam outlet, said vertical baffle extending to a point below the top of the coil whereby the body of water covering said coil will act as a partial baffle to direct the flow of steam through said vertical baffle, said water also serving as a reservoir for solids contained in said water, and means to remove the solids from the shell.

5. An evaporator consisting of a vertical shell having a water chamber in the lower portion thereof and a steam outlet in an upper part thereof, a heat exchange coil extending into said evaporator and normally submerged in water contained in said water chamber, a steam evaporating chamber above the water chamber, a steam scrubbing chamber having a horizontal perforate baffle extending across the shell, bubble caps surmounting the perforations in said perforate baffle, means to introduce feed water onto said perforate baffle above the lower margins of said bubble caps whereby steam formed in said evaporator must pass through the feed water on said perforate baffle whereby solids entrained in said steam are removed by said feed water, additional baffles separating the steam scrubbing chamber from the steam outlet, certain of said latter baffles being vertical screens to remove the moisture contained in said steam, said water chamber being relatively deep to receive the solids separated from said steam, and means to blow down the solids from said water chamber.

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