Jan. 2, 1923.

C. W. DYSON ET AL.

EVAPORATOR.

FILED MAR. 26, 1920.

1,440,723.

2 SHEETS—SHEET 1.

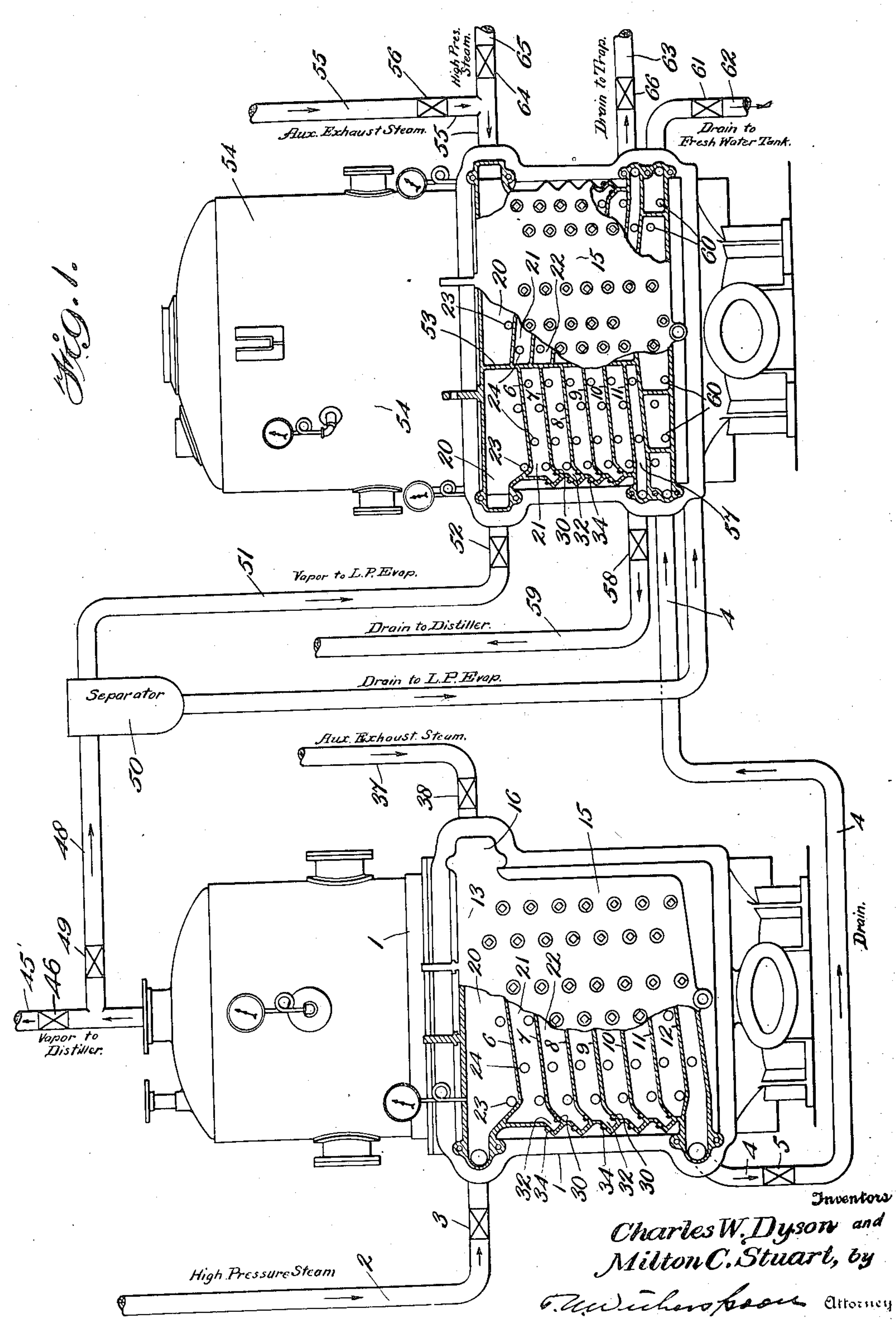

Fig. 1.

Inventors

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[signature] Attorney

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2 SHEETS—SHEET 2.

Fig. 2.

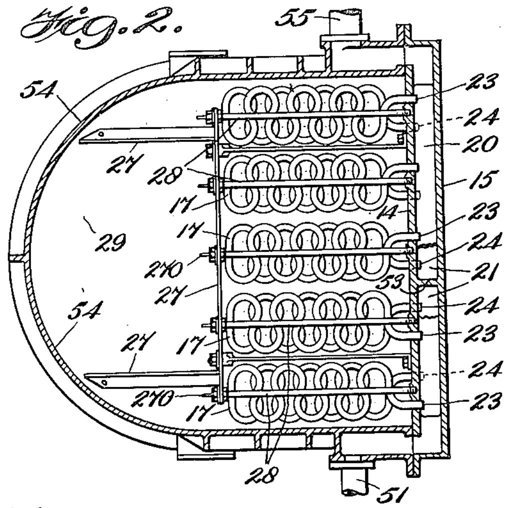


Fig. 4.

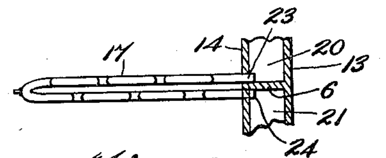


Fig. 5.

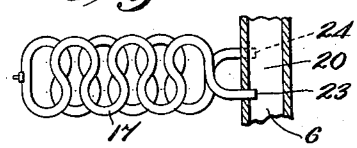


Fig. 3.

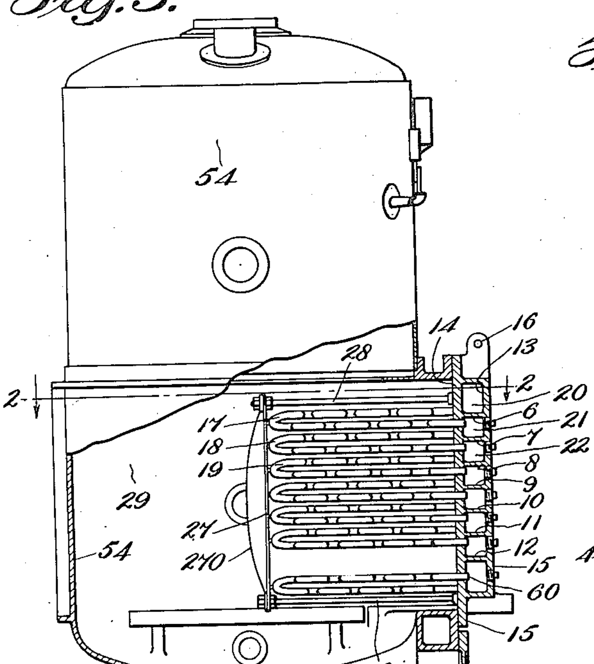


Fig. 6.

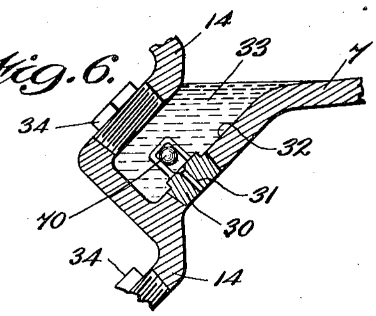


Fig. 7.

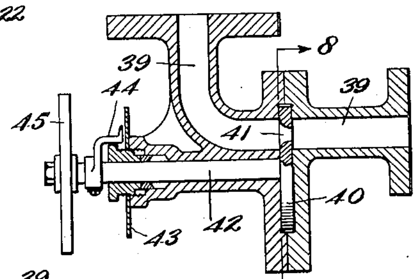
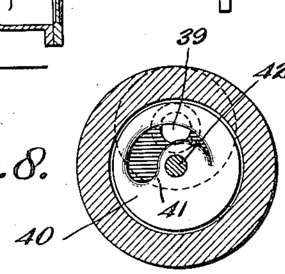


Fig. 8.



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Patented Jan. 2, 1923. 1,440,723

UNITED STATES PATENT OFFICE.

CHARLES W. DYSON, OF THE UNITED STATES NAVY, AND MILTON C. STUART, OF ANNAPOLIS, MARYLAND, ASSIGNORS TO ANDALE ENGINEERING COMPANY, OF PHILADELPHIA, PENNSYLVANIA, A CORPORATION OF PENNSYLVANIA.

EVAPORATOR.

Application filed March 26, 1920. Serial No. 369,114.

To all whom it may concern:

Be it known that we, CHARLES W. DYSON, rear admiral United States Navy, and MILTON C. STUART, both citizens of the United States, respectively residing at Washington, District of Columbia, and Annapolis, county of Anne Arundel, State of Maryland, have invented certain new and useful Improvements in Evaporators; and we 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.

This invention relates to evaporators, especially adapted for use aboard ship, and has for its object to provide a process which will be easily carried out and more efficient in action than those heretofore proposed.

With these and other objects in view the invention consists in the novel steps and combinations of steps constituting the process as will be more fully hereinafter disclosed and particularly pointed out in the claims.

Referring to the accompanying drawings forming a part of this specification, in which like numerals designate like parts in all the views—

Figure 1 is a diagrammatic elevational view partly in section of a first effect evaporator joined to a second effect evaporator made in accordance with this invention;

Figure 2 is a sectional plan view of the second effect evaporator shown in Figure 1;

Figure 3 is a side elevational view partly in section of the second effect evaporator, shown in Figure 2;

Figure 4 is a detail sectional view illustrating one of the coiled tubes in position;

Figure 5 is a plan view of the parts shown in Figure 4;

Figure 6 is an enlarged sectional detail view of one of the drain plugs;

Figure 7 is a sectional view of a micrometer valve employed in this invention; and—

Figure 8 is a sectional view taken on the line 8—8 of Figure 7, looking in the direction of the arrows.

Referring particularly to Figure 1, the numeral 1 indicates the outer shell of a first effect evaporator, 2 a high pressure steam pipe, leading directly from the boilers, not shown, 3 a micrometer valve illustrated in detail in Figures 7 and 8, 4 a drain pipe provided with a micrometer valve 5, and 6, 7, 8, 9, 10, 11 and 12 indicate partitions between the outer wall 13 and the inner wall 14 of the door like members 15 with which the first effect evaporator 1, as well as the second effect evaporator 54 are provided. One of these said door like members 15 is conveniently secured to the shell 54 as at 16, and the other is secured in a similar manner, not shown, to the first effect shell 1.

On the interior of each of the shells 1 and 54 of the evaporators, there are provided a plurality of steam conveying coiled tubes. These tubes may be as numerous as desired, and are preferably arranged in horizontal rows. Three of the top rows of these tubes are numbered 17, 18 and 19, and are best shown in Figures 2 and 3. The open ends of each of the tubes communicate with channels that are formed in the doors 15 by the passages numbered 6 to 12. The top channels in the evaporators 1 and 54 are numbered 20, the next lower channels are numbered 21 and the next succeeding channels are numbered 22. That is to say, as will be understood from Figures 3, 4 and 5, a given coil or tube has its upper end 23 opening into an upper channel such as 20 above a partition such as 6, and the lower end 24 of said tube opens into a lower channel such as 21 below said partition 6. But, as above stated, it is preferred to provide for each of the channels 6 to 12 a plurality of coils as best indicated in Figure 2, and in such case, all their upper open ends 23 will be joined in parallel with an upper channel, while all their lower ends will be joined in parallel with a lower channel.

On the other hand, said channels or steam coil elements 6 to 12 have no communication with each other except through drain orifices and said coiled tubes.

It therefore follows that if we count, from the top row down, the said coils or tubes are joined in series, as will be evident when we note that the steam entering the ends 23 of the coil 17 for example, in the channel 20, will be discharged from the ends 24 of said coils 17, into the next lower channel 21, whence the said steam immediately enters the upper ends of the coils 18, and discharges from the lower ends of said coils into the succeeding lower channel 22 and so on down to the last channel in the first effect 1, or in the second effect 54. The coils or tubes are firmly held in position by their ends being rolled or expanded into the walls 14 of each of the doors 15, and are attached at their rear portions to a plurality of braces 27, some of which are preferably provided with the flanged plates 270, see Figures 2 and 3, and which braces are secured to the doors 15 by the tie rods 28 as illustrated. So firmly do said braces and tie rods hold the coils that the rear portions of the latter are not moved to any substantial extent upon changes in temperature, and therefore, movements due to expansions and contraction are taken up by the convolution of the coils, as will presently appear. As above stated, the steam passes through the coils in each channel in multiple, and passes through said coils, when considered in vertical rows in series, but as the steam flows through the successive coils, part of it is condensed in each coil, due to the loss of heat to the water being evaporated, in the spaces 29 of each evaporator 1 and 54. In order to drain off this condensed steam there is provided in each channel 6 to 12 the drain plug 30, as best shown in Figures 1 and 6. Each plug is provided with a hole 31, so small that no appreciable amount of live steam can escape therethrough, while at the same time the condensed steam or water can be forced through said hole by the pressure of the live steam in the coils; said plugs 30 are preferably located in depressions 32 provided in the channels, so that a water seal 33 formed by said condensed steam will usually overlie each hole 31. A plug 34 for cleaning and inspection purposes may be provided over each plug 30 as illustrated.

It will be clear that the condensed steam through each plug 30 will drain into the channel next below, until it reaches the drain pipe 4. These depressions 32 and plugs 30 constitute an important feature in raising the efficiency of the apparatus, and in keeping it at a high standard over comparatively long periods, for they coact to keep the coils drained of water and therefore to cause only dry steam to fill said coils and to contact with the walls thereof. Not only may high pressure steam be utilized in the first effect evaporator 1, through pipe 2, but exhaust steam from any convenient source or sources may be led in through pipe 37 provided with the micrometer valve 38 when it is not desired to use high pressure steam. In either case, the steam supply to the evaporator may be so regulated by adjusting the micrometer valves 3 and 5, (as will be presently explained), that it is substantially all condensed in the coils, and therefore, only condensed steam passes out the drain pipe 4, or if any live steam should pass into the pipe 4, the micrometer valve 5 may be so adjusted as to prevent it, as will likewise be explained below.

The construction of the micrometer valves 3, 5 and 38, as well as others which will be mentioned hereinafter, will be clear from Figures 7 and 8, wherein 39 represents a steam passage to be controlled, 40 a disk movable across said passage, and provided with the expanding curved crescent shaped slot or opening 41 adapted to adjustably throttle said passage. Said opening 41 is curved in cross section on the left, as seen in Figure 7, and is flat or provided with the rather sharp edges on the right as seen in said figure. The purpose of this construction is to increase the velocity of the steam passing through the coils, thus insuring a better contact with the walls of the latter, and a more efficient heat exchange. 42 represents a stem on which said disk is mounted, 43 a graduated disk, 44 a pointer, coacting with the graduations on the disk 43, and 45 means for moving said pointer over said disk 43. It is evident that by properly adjusting the pointer 44, any desired proportion of the area of the passage 39 can be cut off and therefore, the steam may be throttled with certainty to any desired degree. The peculiar curvature of the tubes or coils such as 17, 18, and 19 in both the first and second effect evaporators constitutes an important feature of this invention in that said curvature causes a more efficient scaling action than does other forms of curvature and thus maintains the coils more free from scale. This latter fact aids in maintaining a high efficiency of the heat exchange over relatively long periods of time. That is to say, said coils being immersed in sea water the well known scale, due to such water, soon forms thereon but owing to each coil being continuously curved and reversely curved from end to end, without having any straight portions at all, it is evident that any expansions or contractions, due to changes in temperature will aid in frequent loosenings the scale at every point of each coil. The scale loosening effect is further multiplied by securing the coils firmly against bodily movement by means of the braces and rods 27 and 28, as above explained. In other words, owing to the peculiar curvature of these said coils they can be made very much longer than heretofore, and a relatively slight change in temperature will produce a relatively large movement, or change, in curvature of said coils, and thus the scale is broken off with a frequency and an efficiency heretofore unattained.

The vapor from the salt water in the first effect evaporater 1 may pass off through the pipe 45, having the micrometer valve 46, to the distiller, not shown. Or, all, or a portion of said vapor may pass through the pipe 48 having the micrometer valve 49, to the vapor separator 50, wherein any salt water vapor present may be extracted. From the separator 50, the pipe 51 conveys said distilled vapor through the micrometer valve 52, to the chamber or channel 20 of the said second effect evaporator 54. Said second effect or lower pressure evaporator 54 is constructed substantially like the first effect evaporator and therefore duplicate parts in each evaporator are designated, by similar numerals.

The operation of said second effect evaporator is similar to said first effect apparatus, the main differences being the provision of the partition 53 which separates the vapor delivered through the pipe 51 from that delivered through pipe 55, as will presently appear. The vapors from the sea water contained in the space 29 of said second effect evaporator may be carried off by any suitable means similar to the pipe 45', in the first effect evaporator, but is not illustrated.

It is evident however, that vapors coming through the pipe 51 into the second effect evaporator may be so controlled by the micrometer valve 52 that they will all be substantially condensed by the time they reach the channel 57, in said second effect evaporator whence their condensate may be drained off through the micrometer valve 58 and pipe 59 to the distillers. It thus results that whether the evaporated sea water is led directly to the distillers through the pipe 45, or is further carried through the second effect evaporator to rob it of its heat, it is not contaminated by condensed steam, nor is there any loss of said evaporated water in the procedure.

The condensate from the first effect apparatus 1 is carried by the pipe 4 to the lowest coils 60 of the second effect 54, which coils may be joined in series as shown, and said condensate is then drained off through the micrometer valve 61 and pipe 62, to the fresh water tanks.

66 represents a micrometer valve and 63 a drain to a trap, not shown, but which may be maintained at atmospheric pressure. 64 indicates a micrometer valve and 65 a pipe conveying high pressure steam to the pipe 55. The operation of this evaporating system will be clear from the foregoing but may be briefly summarized as follows:—

Sea water being placed in the first effect evaporator 1, and in the low pressure evaporator 54, high pressure steam, may be conveyed through the pipe 2 or auxiliary exhaust steam from donkey engines, or other auxiliary power plants may be conveyed into said first effect evaporator through pipe 37. In either case, the micrometer valves 3 or 38 may be so adjusted that all the steam entering said evaporator 1 and passing through its coils 17, 18, 19, etc., will be condensed by the time it reaches the drain pipe 4; and further, the micrometer valve 5, in said pipe 4, may be so adjusted that any steam that may pass into said pipe will be throttled off. The hot fresh water thus produced is carried over to the second effect of low pressure evaporator 54 and through the coils 60, in order to abstract any surplus heat it may possess. From the coils 60 said condensate is drained off through the valve 61, and pipe 62, to the fresh water tanks. At no time is any fresh water condensate lost, nor is it ever contaminated with salt water vapor nor is a trap necessary for its recovery. In the meantime, it is evident that a maximum of heat is extracted from the original steam. In order to still further increase the efficiency of the system, all, or a portion of the vapor from the salt water in the first effect evaporator may be conducted through the pipe 48, the steam separator 50, the micrometer valve 52, and coils 17, 18, 19, etc., of the second effect evaporator to and through the valve 58. This said vapor thus evaporates an additional quantity of salt water in the low pressure apparatus 54, and at the same time all the salt water condensate is saved, as above pointed out, by passing it through the pipe 59 to the distillers.

In addition to this salt water vapor auxiliary exhaust steam may be simultaneously, or independently used in said evaporator 54, by passing said auxiliary steam through the coils, 17, 18, 19 etc., located on the right hand side of the partition 53, as seen in Figure 1, and located above said partition 53, as seen in Figure 2. Said auxiliary steam is conveniently introduced through pipe 55 and is so throttled by a micrometer, valve 56 as to cause it all to be condensed by the time it reaches valve 66. If, however, any portion of it remains uncondensed when valve 66 is reached, said valve may be so adjusted as to throttle off the live steam, whereupon the condensed steam or water will pass through the pipe 63 to any convenient trap maintained at atmospheric pressure.

The partition 53, in the second effect evaporator prevents the condensates passing through the pipes 51 and 55, from mixing. Owing to its possible contamination with oil the condensate passing through the pipe 63 is not mixed with that passing through the pipe 62. Should it be desired to employ high pressure steam in the second effect evaporator such may be introduced through the pipe 65, and valve 64, and in such case said second effect evaporator will operate in so far as its coils on the right hand side of the partition 53 are concerned, in the same manner as does the first effect evaporator.

On the other hand, if it is desired to employ live steam simultaneously with the condensed vapor through pipe 51, it can also be employed that way. In other words, it will be observed that the second effect evaporator may be run independently, precisely as is the first effect evaporator, or it may be run simultaneously with the employment of vapor from the first effect evaporator through pipe 51.

It will now be clear that with the foregoing evaporator system, the folowing advantages contributing to its high efficiency are readily attained.

1. One is enabled to provide a relatively very long path of travel for the steam through the coils;

2. The micrometer valves afford a ready means for controlling the operation as well as the capacity of the system. In fact, the capacity of the system may be virtually controlled by the valves 3 and 38. That is to say, it is evident that as the steam passes the valve 3, which really constitutes an expansion nozzle, it expands into the coil elements with a relatively low pressure and a relatively high velocity of flow. In other words, the well known law of Napier, governs the flow of steam, which shows that a constant weight of steam will pass per unit of time through this said nozzle valve 3 into said coil elements until the pressure on the low pressure side of the said valve 3 equals about 58% of the pressure on the high pressure side of said valve. It further results from this that as the deposits, or scale, accumulate on the evaporator coils the rate of transmission of heat from said coils falls off, but the weight of steam flowing into said coil elements remains constant under said law of Napier, so the pressure builds up in the convolutions, and the temperature therein increases.

It therefore results that the transmission of heat through the walls of the coils to the liquid remains practically constant. In other words, it is clear that by this construction one is enabled to obtain a very high efficiency of operation until a certain thickness of scale is present, after which the efficiency will rapidly fall off. But when this thickness of scale is reached, steam will appear at the end of the final convolution before the valve 5 is reached, and the temperature of the combined drainage from the convolutions will also rapidly rise. These phenomena will indicate to the operator that the scale on the convolutions should be removed.

3. The drain plugs 30 constitute a means for draining off the condensate from each coil as it is formed so that only dry steam enters the coils. When desired automatic float valves such as 70, see Figure 6, may be employed in connection with the openings 31, but in practice such valves are not found to be necessary in many cases;

4. The micrometer valves 5, 58 and 66 constitute a means for controlling the discharge of condensate from each group of coils, so that only condensed steam may escape from the coils, thus insuring a highly efficient heat exchange.

5. The pipe 4 constitutes a means for further abstracting heat from the condensate from the high pressure steam, and thus still further increases the efficiency of the apparatus;

6. The pipe 55 and partition 53 constitute a means for utilizing low pressure exhaust steam in the same apparatus that is utilizing low pressure vapor from said salt water;

7. The pipe 65 and partition 53 constitute a means of using high pressure steam in the same apparatus that is using low pressure vapor from salt water;

8. Owing to the relatively long coiled tubes, the high velocity of the steam, and to the micrometer valves insuring a complete condensation of the steam, the use of traps or drain pots may be done away with.

9. Owing to the continuously curved pipe in the coils, and the peculiar bracing and holding means preventing the bodily movement of said coils, the contractions and expansions incident to the changes in temperature greatly aid in keeping the coils free from scale. In fact the efficiency of this apparatus has been demonstrated in practice to be very high and to be capable of being maintained for a much longer period than with other apparatus which have been heretofore proposed. That is to say, we have shown in practice that on opening a micrometer valve to give a desired pressure in the coils, and upon starting to evaporate with clean coils, a certain output of condensate free from steam will be realized through a long period. As the coils become more or less covered with scale the pressure in the coils automatically increases so the rate of evaporation in the shell still holds, through a period of time or until a certain degree of scaling up of the coils occurs.

Then the efficiency begins to fall and this gives an indication as to the time when a scaling of the coils should be had. In an actual test using 30 pounds of steam and 50 feet in a coil of $\frac{5}{8}$ inch pipe we found that every particle of steam was condensed at the outlet from the pipe. In practice we prefer that each vertical element of the sections be made 65 feet in length and of 1 inch pipe, thus insuring a complete condensation of the steam by the time it leaves the evaporator through the drain. Such a maintenance of a high efficiency through a long range of time has never heretofore been attained in similar apparatus in so far as we are aware.

Owing to this high efficiency over relatively long periods of time, the capacity of a given apparatus is greatly increased so that for a given output it may be made smaller aboard ship and space thus saved. Then too, said high efficiency serving to condense all the steam the use of steam traps, steam pots, etc., heretofore found necessary to choke back the drainage from the coils may be done away with.

It will be observed that the drain plugs 30 are omitted from the lowest row of coils in each evaporator, so that the lowest row of coils will conduct all the water that is condensed in the upper coils.

Further, it will be observed that the lowest row of coils may be arranged in series instead of in parallel as is illustrated in Figure 1.

This will expedite the further cooling of the condensate. In all cases, the doors 15, and their attached coils may be readily removed without disturbing the steam connections. Further, owing to the fact that the coils are unusually long, and owing to their peculiar curvature, the manufacturer is enabled to locate the ends of the coils in the plate 14 of each door farther apart than has been heretofore possible, with the same capacity of apparatus, and this results in the important advantage that, when the end of the one coil is being expanded, it does not distort or change the dimensions of the hole, for the end of another coil.

In other words, the holes in the wall 14 accurately fit the coils even after repairs which is not the case when the holes are placed so near together that the expansion of a tube in one hole changes the dimensions of a neighboring hole.

Of course, although the coils have been shown as arranged in parallel, in each channel, yet they may be, if desired, arranged in series, or in any other connections which will best suit the requirements for cooling the condensed steam to a point where it may be discharged without the loss of vapor.

The graduations, not shown, on the disk 43 may be determined by a calibration made at various points with various portions of the slot 40 in the disk, for both water and steam. The micrometer valves in the steam pipes control the capacity of the evaporators while the said valves in the drain pipes control the pressure and temperature of the discharged condensates.

It will now be clear that the tube like elements 17 whether considered singly or in multiple, constitute a convolution, one end of which communicates with the chamber 20, while the other end communicates with the chamber 21, and that the tube like elements 18, 19, etc., constitute additional convolutions, the upper ends of which communicate with upper chambers, and the lower ends of which communicate with lower chambers.

It will further be clear that all of the tube like elements or convolutions are joined in series, so that they in the aggregate constitute a continuous coil, through which the steam passes. That is, the convolutions are joined in series by the chambers, and the steam passes continuously through the same and through the chambers. It is further evident that each convolution alternates with a chamber, and that each preceding upper chamber is drained directly into a succeeding lower chamber.

It is further evident that through a proper manipulation of the valve mechanism shown in Figures 7 and 8, the steam passing through the convolutions and the chambers can be so controlled as to cause it to be all substantially condensed when it leaves the last chamber or the evaporating system.

It is obvious that those skilled in the art may vary the details of the construction as well as the arrangement of parts without departing from the spirit of the invention, and therefore, we do not wish to be limited to the above disclosure except as may be required by the claims.

What is claimed is:—

1. The process of evaporating a liquid which consists in immersing in said liquid a plurality of convolutions located one above the other and each alternating with a chamber and joined in series; passing steam successively through said convolutions and chambers; draining any condensed steam from an upper chamber in succession through the lower chambers and into the steam exit from the system; and so controlling the flow of steam through said convolutions and chambers as to cause it to be substantially all condensed as it leaves the system, substantially as described.

2. The process of evaporating a liquid which consists in immersing in said liquid a plurality of tubes comprising convolutions located one above the other and each alternating with a chamber and joined in series; passing steam successively through said convolutions and chambers; draining the condensate of the tubes of a convolution into its corresponding chamber at a plurality of points; draining any condensed steam from an upper chamber in succession through the lower chambers and into the steam exit from the system; and so controlling the flow of steam through said convolutions and chambers as to cause it to be substantially all condensed as it leaves the system, substantially as described.

3. The process of evaporating a liquid

which consists in immersing in said liquid a plurality of convolutions, each alternating with a chamber, joined in series and constituting a continuous coil; passing steam through said coil; draining any condensate from a convolution into its corresponding chamber; draining the condensate from each preceding chamber into a succeeding chamber; and so controlling the passage of steam through the coil and chambers as to cause it to be substantially all condensed before it leaves said coil, substantially as described.

4. The process of evaporating a liquid which consists in immersing in said liquid a plurality of tube like elements alternating with chambers and jointed in series; passing steam successively through said elements and chambers; draining any condensate from a preceding chamber directly into a succeeding chamber; and so controlling the steam passing through said elements and chambers as to cause it to be substantially condensed as it leaves the last of said chambers, substantially as described.

5. The process of maintaining the efficiency of evaporators having a plurality of serially joined tube like elements immersed in liquid to be evaporated and alternating with chambers, which consists in expanding a substantially constant weight of steam in said elements and chambers per unit of time; draining the condensate of each element into its corresponding chamber; draining each preceding chamber into a succeeding chamber; and so controlling the total weight of steam passing through said elements and chambers as to cause it to be substantially all condensed as it leaves the last chamber of the series, substantially as described.

6. The process of maintaining the efficiency of evaporators having a plurality of serially joined tube like elements immersed in the liquid to be evaporated and alternating with chambers, which consists in expanding a substantially constant weight of steam in said elements and chambers per unit of time; draining the condensate of each element into its corresponding chamber at a plurality of points; draining each preceding chamber into a succeeding chamber; and so controlling the total weight of steam passing through said elements and chambers as to cause it to be substantially all condensed as it leaves the last chamber of the series, substantially as described.

7. The process of evaporating liquids which consists in passing steam through coil elements immersed in said liquids and located one above the other; draining any water that may condense in an upper coil element into a lower coil element to maintain the steam in a substantially dry state in said elements; and so throttling said steam as to cause it to be substantially completely condensed as it leaves said elements, substantially as described.

8. The process of evaporating liquids which consists in continuously passing steam through coil elements immersed in said liquids and located one above the other; continuously draining any water that may condense in an upper coil element into a lower coil element to maintain the steam in a substantially dry state in all of said elements; and so throttling said steam as to cause it to be substantially completely condensed as it leaves said elements, substantially as described.

9. The process of evaporating liquids which consists in passing steam through coil elements immersed in said liquids and located one above the other; draining any water that may condense in an upper coil element into a lower coil element to maintain the steam in a substantially dry state in said elements; so throttling said steam as to cause it to be substantially completely condensed as it leaves said elements; and collecting the condensed steam and heating therewith additional quantities of said liquids, substantially as described.

10. The process of evaporating liquids which consists in passing steam through coil elements immersed in said liquids and located one above the other; draining any water that may condense in an upper coil element into a lower coil element to maintain the steam in a substantially dry state in said elements; so throttling said steam as to cause it to be substantially completely condensed as it leaves said elements; collecting the vapors of the evaporated liquids, and heating therewith additional quantities of liquids to be evaporated, substantially as described.

In testimony whereof we affix our signatures.

CHARLES W. DYSON.
MILTON C. STUART.