June 29, 1965 F. A. LOEBEL ETAL 3,192,131

MULTI-STAGE FLASH EVAPORATOR WITH REMOVABLE STAGES

Filed June 20, 1960 2 Sheets-Sheet 1

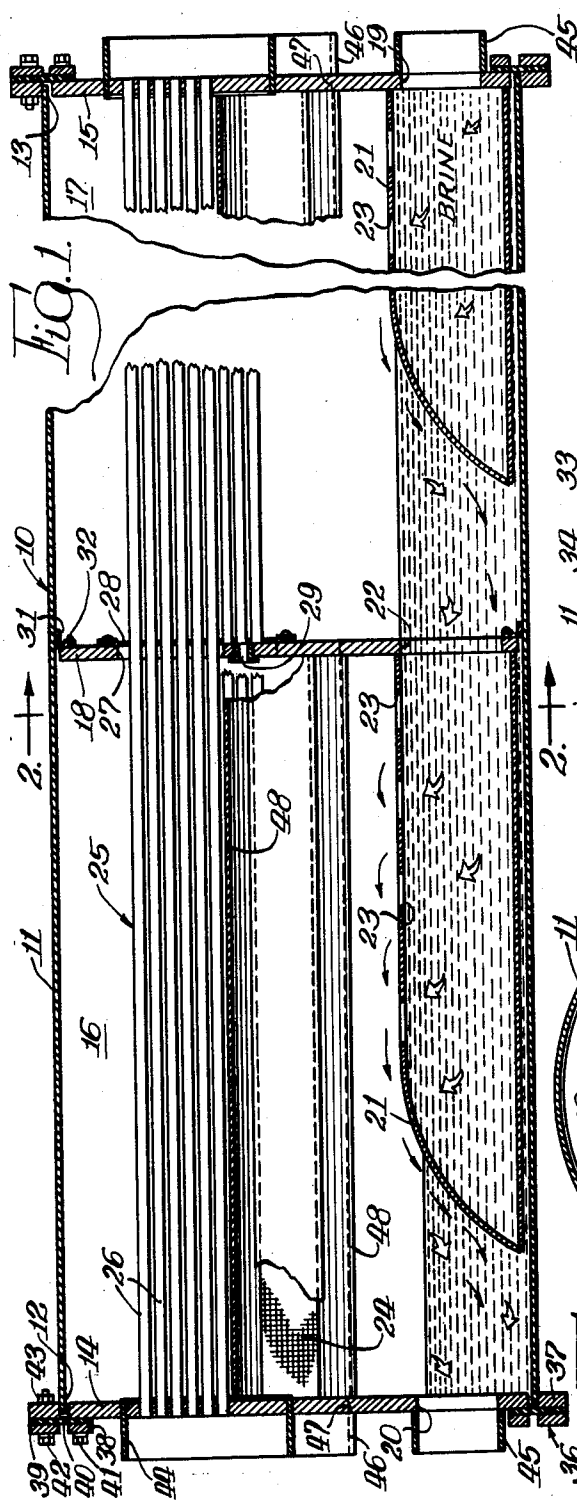

Fig. 1.

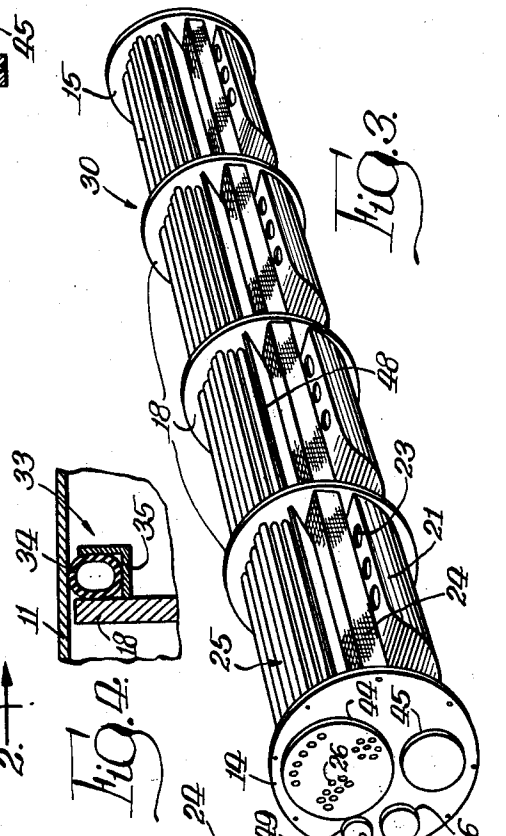

Fig. 3.

Fig. 4.

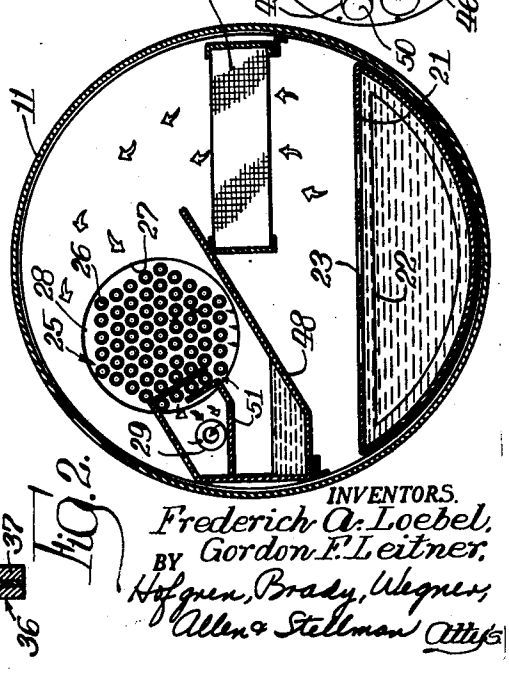

Fig. 2.

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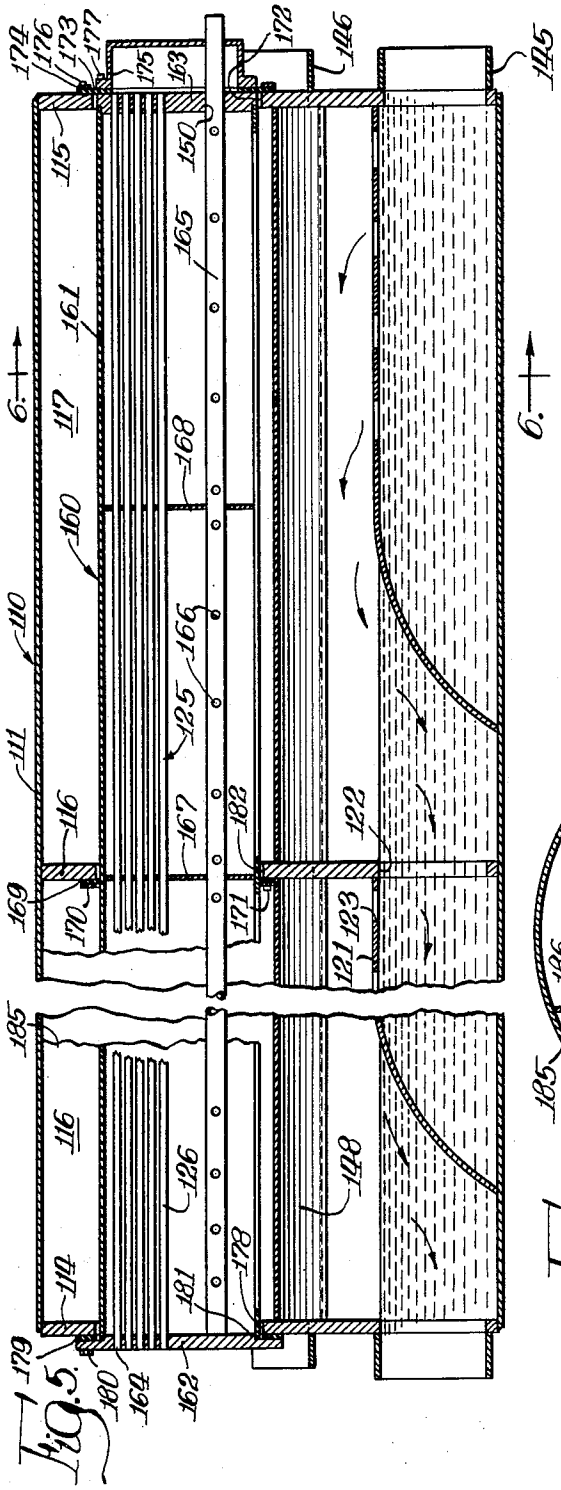

Fig. 5.

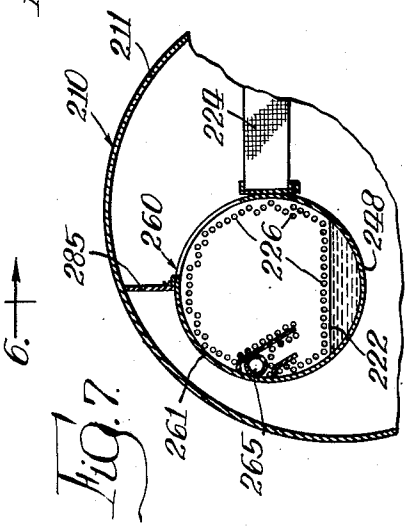

Fig. 7.

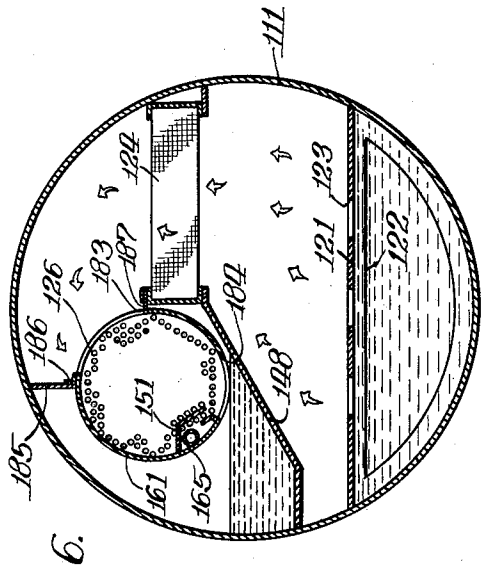

Fig. 6.

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MULTI-STAGE FLASH EVAPORATOR WITH REMOVABLE STAGES

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12 Claims. (Cl. 202—173)

This invention relates to flash evaporators and in particular to long tube multi-stage flash evaporators.

In the long tube multi-stage type of flash evaporator, a long cylindrical shell is divided by suitable partition means into a series of longitudinally related flash chambers through which the liquid to be flashed, such as brine, is successively passed. Such long tube evaporators provide improved efficiency of evaporation and, thus, comprise a highly desirable structural arrangement. However, where relatively small capacity evaporators are utilized, the diameter of the evaporator shell may be in the order of approximately 20 inches. Such an evaporator may have approximately 24 stages and, thus, a serious problem arises in construction of the internal elements, particularly in the innermost portions of the evaporator. Further, in such evaporators, it is desirable to apply protective coatings on the internal elements, requiring surface treatment of the elements such as sand blasting and pickling. In all sizes of such integral design evaporators, such coating is difficult and costly; and where the structure is relatively complex, such coating is often impracticable.

The present invention is concerned with facilitating the construction and/or protective coating of such evaporators. A principal feature of the present invention is the provision of such an evaporator having a new and improved readily installable internal structure.

Another feature of the invention is the provision of such an evaporator having new and improved internal structure arranged to be assembled exteriorly of the shell and installed as a unit therein.

A further feature of the invention is the provision of such an evaporator wherein substantially the entire internal structure of the evaporator may be assembled exteriorly of the shell and the entire assembly inserted therein.

Still another feature of the invention is the provision of such an evaporator structure wherein the tube bundle structure comprises an assembly readily removably installed in the evaporator.

A yet further feature of the invention is the provision of such an evaporator including an elongated tubular shell having open ends, and assembly removably installed in the shell including end walls extending across the ends of the shell, a partition wall extending across the interior of the shell intermediate said ends to define a pair of longitudinally related flash chambers, means for conducting fluid to be flashed successively through said flash chambers, a tube bundle extending successively through said walls for conducting coolant therein through said flash chambers, means for conducting distillate successively from said flash chambers, means sealingly readily removably supporting said partition wall in said shell, and means sealingly readily removably supporting said end walls on said ends of the shell.

Yet another feature of the invention is the provision of such an evaporator including an elongated tubular shell, end walls extending across the ends of the shell, the end walls having aligned openings in the upper portion thereof, a partition wall extending across the interior of the shell intermediate the ends to define a pair of longitudinally related flash chambers, the partition wall having an opening in an upper portion thereof aligned

with the end wall openings, means for conducting fluid to be flashed successively through the flash chambers, a tube bundle, a support at each end of the tube bundle extending across the openings of the end walls and supporting the tube bundle to extend through the partition wall opening, means for conducting distillate successively from the flash chambers, and means sealingly, readily removably securing the support on said end walls of the shell.

Other features and advantages of the invention will be apparent from the following description taken in connection with the accompanying drawing wherein:

FIG. 1 is a fragmentary longitudinal section with portions broken away of an evaporator embodying the invention;

FIG. 2 is a transverse section thereof taken substantially along the line 2—2 of FIG. 1;

FIG. 3 is a perspective view of an internal assembly structure thereof;

FIG. 4 is a fragmentary longitudinal section of a modified form of sealing means for use therein;

FIG. 5 is a fragmentary longitudinal section with portions broken away of another form of evaporator embodying the invention;

FIG. 6 is a transverse section taken along the line 6—6 of FIG. 5; and

FIG. 7 is a fragmentary transverse section of still another form of evaporator embodying the invention.

In the exemplary embodiment of the invention as disclosed in FIGS. 1–3 of the drawing, a long tube flash evaporator generally designated 10 is shown to comprise an elongated shell 11 having a first open end 12 and an opposite open end 13. Open end 12 is closed by an end wall 14 and open end 13 is closed by a corresponding end wall 15. Intermediate the end walls, the interior of the shell 11 is divided into a plurality of flash chambers such as flash chamber 16 and flash chamber 17 by a plurality of partition walls such as partition wall 18. To facilitate the illustration of the invention, only three such partition walls are shown; it should be understood that any desired number of such partition walls may be provided commensurate with the length of the shell 11. In illustrating the invention, it will be assumed that the evaporator 11 is arranged for providing distilled water from brine, or sea water. The brine is admitted to the evaporator through an inlet opening 19 in a lower portion of the end wall 15 and passes through the successive stages defined by the successive flash chambers to pass from the illustrated portion of the evaporator through an outlet opening 20 in the end wall 14. In entering each of the flash chambers, the brine passes firstly into a hollow separator 21 connected at the upstream end to the upstream wall to have communication interiorly with the upstream wall opening such as inlet opening 19 in wall 15 and opening 22 in partition wall 18. An upper portion of the separator is provided with a plurality of openings 23 permitting the brine to pass upwardly from the separator and flow thereover into the adjacent lower portion of the flash chamber from which portion the brine may then flow to the next flash chamber or through outlet 20 as the case may be.

In passing through each flash chamber, a portion of the brine evaporates into the low pressure space in the upper portion of the shell 11. In passing upwardly, the vapors first pass through a wire knit entrainment separator 24 secured at its opposite ends to the walls defining the opposite ends of the flash chamber, illustratively in flash chamber 16 one end of the entrainment separator is secured to the end wall 14 and the other end of the entrainment separator is secured to the partition wall 18. The vapor from which entrained droplets have been removed passes upwardly from the separator to flow past a

tube bundle 25 extending longitudinally through the shell 11 in the upper portion thereof. As best seen in FIG. 1, the opposite ends of the tubes 26 of bundle 25 terminate in the opposite end walls 14 and 15 to open outwardly from the shell. The partition wall 18 is provided with an opening 27 through which the tube bundle may pass, the opening 27 being sealingly closed by a rubber tube sheet 28 which further supports the tubes at the partition wall. A vent orifice 29 is provided in the partition wall adjacent the opening 27.

As indicated briefly above, the invention comprehends the provision of such an evaporator 10 wherein the entire internal structure, namely that structure disposed within shell 11 is readily installable and removable as a unit. Thus, the internal assembly generally designated 30 as shown in FIG. 3 is arranged to be inserted into the tubular shell 11 through an open end thereof. In the preferred embodiment, the partition walls 18 are sealed to the shell 11 by means of a resilient annular seal 31 secured to the periphery of the partition walls by suitable means such as bolts 32 to be flexed longitudinally of the shell into positive sealing engagement with the shell. Where such sealing means are employed, it is preferable that the insertion of the assembly 30 into shell 11 be through open end 13 of the shell permitting the seals to slide against the inner surface of the shell to the final position thereof as shown in FIG. 1. An alternative seal generally designated 33 is illustrated in FIG. 4 as comprising an inflatable annular tube 34 carried in an annular, L-section bracket 35 secured to the periphery of the partition wall 18, the tubes 34 being inflatable hydraulically or pneumatically as desired by means of suitable supply conduits (not shown). Thus, the evaporator internal assembly may be installed through either open end of the tubular shell with the seal 34 deflated, and when fully installed, the seal may be inflated to engage the shell 11 and the partition wall 18 sealingly as shown in FIG. 4.

The end walls 14 and 15 of the internal assembly 30 are sealingly secured to the opposite ends of the shell 11 by means generally designated 36 permitting ready assembly and disassembly of the evaporator. More specifically, as best seen in FIG. 1, each end of the shell is provided with an annular flange 37 extending radially outwardly therefrom. The end wall is secured to the flange by means of a pair of concentric retaining rings 38 and 39 and an annular gasket 40. A bolt 41 extending through the inner retaining ring 38 and the inner portion of the gasket 40 is threaded to the peripheral portion of the end wall to secure sealingly the inner portion of the gasket thereto. A bolt 42 extends through the outer retaining ring 39, the outer portion of the gasket 40 and the flange 37 to co-operate with a nut 43 in securing the outer portion of the gasket to the flange. Gasket 40 is preferably resilient and, thusly, comprises an expansion joint accommodating expansion of the internal assembly 30 relative to the shell.

Suitable connecting means may be provided on each of the end walls for connection to the different portions of the internal assembly 30. More specifically, a tubular water box 44 may be provided for providing connections to the tubes 26, an annular flange 45 may be provided at the brine inlet opening 19 and outlet opening 20 for delivery and discharge of the sea water, an annular flange 46 may be provided at a pair of openings 47 at the opposite ends of a distillate collecting trough 48, and an annular flange 49 may be provided at an opening 50 in the end walls for venting the evaporator. As best seen in FIG. 2, a suitable baffle 51 may be provided to extend between the transverse walls of the internal assembly 30 in alignment with vent opening 50 and vent openings 29.

As best seen in FIG. 3, the entire internal assembly 30 may be assembled with substantially free access to all portions thereof substantially facilitating and reducing the cost of the assembly. The entire assembly 30 may then be inserted in the shell 11 through an open end thereof to the final position as shown in FIG. 1. The retaining rings 38 and 39 and gasket 40 may then be installed as discussed above to sealingly secure the internal assembly 30 within the shell.

When it is desired to remove the internal assembly 30 for any reason, the reverse of the assembling procedure is readily effected by removing the retaining rings and gasket 40 permitting ready movement of the assembly 30 longitudinally from the shell.

Referring now to FIGS. 5 and 6, a modified form of evaporator generally designated 110 is shown to comprise an evaporator generally similar to evaporator 10 but arranged for ready installation and removal of the tube bundle and vent portion of the internal assembly only, the other portions of the internal assembly of the evaporator being fixedly secured therein. More specifically, evaporator 110 includes a shell 111 provided with end walls 114 and 115 and partition walls 116 fixedly secured to the shell by suitable means such as welding. The tube bundle and vent assembly generally designated 160 comprises a tubular housing 161 having a length substantially equal to the length of shell 111 and closed at its ends by a first closure 162 and an opposite closure 163 each provided with a plurality of small openings 164 fixedly receiving the ends of the tubes 126 forming the tube bundle 125. The closure 163 is further provided with an opening 150 through which one end of a vent pipe 165 extends, the vent pipe being provided with a plurality of small openings 166 distributed through the different flash chambers of the evaporator. At spaced intervals corresponding to the width of the respective flash chambers, such as flash chambers 116 and 117, the housing is partitioned by suitable divider walls 167. Additional supports 168 for supporting the tubes in the mid-portion of the flash chambers may be provided as desired.

The housing 161 is sealingly secured to the partition walls 116 by an annular rubber seal 169 and an annular retainer 170 secured to the partition wall by suitable means such as screws 171. The closure 163 is peripherally slightly smaller than the end wall opening 172 across which the closure extends and the closure is sealingly secured to the end wall 115 by means of an annular gasket 173, a retaining ring 174, and a hollow water box 175. The retaining ring 174 is secured to the end wall 115 by suitable means such as bolts 176 and the water box 175 is secured to the closure 163 by suitable means such as bolts 177.

The closure 162 extends across a corresponding opening 178 in the end wall 114. Closure 162 is diametrically slightly larger than the opening 178 and is peripherally sealingly connected to the end wall surrounding opening 178 by an annular gasket 179 and a plurality of bolts 180 extending through the outer peripheral portion of the closure. Each of the closures may be provided with an inwardly facing cylindrical boss portion 181 about which the opposite ends of the housing 161 are fitted to secure the housing in centered position coaxially of the aligned openings 172 and 178 of the end walls and the corresponding opening 182 of the partition walls 116.

Referring now to FIG. 6, the separator plate 121 of the evaporator 110 co-operates with the lower portion of the shell 111 to define the separator means of the evaporator 110. The entrainment separator 124 is arranged to pass the vapors upwardly to the upper portion of the shell for delivery through an opening 183 in housing 161 to the tube bundle 125. The lower portion of the housing 161 is provided with an opening 184 for passing the distillate downwardly from the housing into the distillate collecting trough 148. The vent tube 165 is disposed within a baffle 151 in the lower portion of the housing adjacent the opening 184. Housing 161 is further sealingly connected to a depending support 185 by a rubber seal 186 to preclude direct flow of the vapor to the distillate trough 148 over the upper portion of the housing.

Similarly, the housing may be sealingly secured to the entrainment separator by a suitable seal 187.

Referring now to FIG. 7, another modified form of evaporator 210 is shown to comprise an evaporator generally similar to evaporator 110 but having a housing 261 provided with an imperforate lower portion 248 defining the distillate trough. Thus, the removable assembly 260 is generally similar to the removable assembly 160 of the evaporator 110 except that the assembly 260 includes the distillate collecting means, obviating the need for the separate distillate trough 148 of evaporator 110. In all other respects, the evaporator 210 is generally similar to evaporator 110 and functions in a similar manner. The elements of each of evaporator 110 and 210 which correspond to similar elements of evaporator 10 are identified by numerals 100 and 200 higher respectively, it being understood that the description of these elements as applied to evaporator 10, applies similarly to these elements in the modified evaporator forms.

Except as otherwise noted, the different evaporator forms function similarly and are similarly assembled and disassembled. Each of the evaporator forms provides an improved facilitated assembly and disassembly effectively minimizing assembly and maintenance costs.

While we have shown and described certain embodiments of our invention, it is to be understood that it is capable of many modifications. Changes, therefore, in the construction and arrangement may be made without departing from the spirit and scope of the invention as defined in the appended claims.

We claim:

1. In a multi-stage evaporator provided with an elongated tubular shell having an open end, an assembly arranged to be removably installed in said shell, said assembly comprising an end wall arranged to extend across the open end of the shell, a partition wall arranged to extend across the interior of the shell intermediate the ends of the shell to define a pair of longitudinally related flash chambers in the shell, means for conducting fluid to be flashed successively through said flash chambers, a tube bundle extending successively through said walls for conducting coolant therein through said flash chambers, means for conducting distillate successively from said flash chambers, means for sealingly, readily removably supporting said partition wall in the shell, and means for sealingly, readily removably supporting said end wall on the open end of the shell.

2. The structure of claim 1 wherein said partition wall is provided with an annular L-section bracket defining an annular recess opening radially outwardly toward the shell, and said partition wall supporting means comprises a hollow annular sealing element formed of resilient material extending circumferentially in said recess.

3. The evaporator assembly of claim 1 wherein said partition wall supporting means comprise an inflatable sealing device.

4. In a multi-stage evaporator provided with an elongated tubular shell having an open end, an assembly arranged to be removably installed in said shell, said assembly comprising an end wall arranged to extend across the open end of the shell, a partition wall arranged to extend across the interior of the shell intermediate the ends of the shell to define a pair of longitudinally related flash chambers in the shell, said partition wall having an opening therethrough, means for conducting fluid to be flashed successively through said flash chambers, a tube bundle extending successively through said end wall and said opening for conducting coolant therein through said flash chambers, means supporting the tube bundle at said opening and sealingly closing the opening thereabout, means for conducting distillate successively from said flash chambers, means for sealingly, readily removably supporting said partition wall in the shell, and means for sealingly, readily removably supporting said end wall on the open end of the shell.

5. The evaporator of claim 4 wherein said means supporting the tube bundle at said opening comprises a resilient sheet.

6. In a multi-stage evaporator provided with an elongated tubular shell having an open end, an assembly arranged to be removably installed in said shell, said assembly comprising an end wall arranged to extend across the open end of the shell, a partition wall arranged to extend across the interior of the shell intermediate the ends of the shell to define a pair of longitudinally related flash chambers in the shell, means for conducting fluid to be flashed successively through said flash chambers including a hollow separator in one flash chamber secured at one end to a lower portion of one wall to receive the fluid to be flashed, said separator having an opening in an upper portion thereof to pass the fluid therethrough into the lower portion of the one flash chamber, a tube bundle extending successively through said walls for conducting coolant therein through said flash chambers, means for conducting distillate successively from said flash chambers, means for sealingly, readily removably supporting said partition wall in the shell, and means for sealingly, readily removably supporting said end wall on the open end of the shell.

7. The evaporator of claim 6 wherein such a hollow separator is disposed in each flash chamber and secured to the upstream wall thereof.

8. In a multi-stage evaporator provided with an elongated tubular shell having open ends, an assembly arranged to be removably installed in said shell, said assembly comprising a pair of end walls arranged to extend one each across the open ends of the shell, said end walls having aligned openings in the upper portion thereof, a partition wall arranged to extend across the interior of the shell intermediate the ends of the shell to define a pair of longitudinally related flash chambers in the shell, said partition wall having an opening in an upper portion thereof aligned with said end wall openings, means for conducting fluid to be flashed successively through said flash chambers, a tube bundle extending through said end walls and said opening for conducting coolant therein through said flash chambers, means for conducting distillate successively from said flash chambers, means for sealingly, readily removably supporting said partition wall in the shell, and means for sealingly, readily removably supporting said end wall on the open end of the shell.

9. In a multi-stage evaporator provided with an elongated tubular shell having open ends, an assembly comprising a pair of end walls arranged to extend across the ends of the shell, said end walls having aligned openings in the upper portion thereof, a partition wall arranged to extend across the interior of the shell intermediate said ends to define a pair of longitudinally related flash chambers, said partition wall having an opening in an upper portion thereof aligned with said end wall openings, means for conducting fluid to be flashed successively through said flash chambers, a tubular housing extending from the opening in one end wall, through the opening in the partition wall, and to the opening in the other end wall, said housing having an opening in each flash chamber, a tube bundle, a support extending across each end of the tubular housing and supporting the tube bundle to extend longitudinally through said tubular housing, means for conducting distillate successively from said flash chambers, and means sealingly, readily removably securing said support on said end walls of the shell.

10. In a multi-stage evaporator provided with an elongated tubular shell having open ends, an assembly comprising a pair of end walls arranged to extend across the ends of the shell, said end walls having aligned openings in the upper portion thereof, a partition wall arranged to extend across the interior of the shell intermediate said ends to define a pair of longitudinally related flash cham-

bers, said partition wall having an opening in an upper portion thereof aligned with said end wall openings, means for conducting fluid to be flashed successively through said flash chambers, a tubular housing extending from the opening in one end wall, through the opening in the partition wall, and to the opening in the other end wall, said housing having an opening in each flash chamber, a tube bundle, a support extending across each end of the tubular housing and supporting the tube bundle to extend longitudinally through said tubular housing, means sealingly, readily removably supporting the tubular housing on said partition wall, means for conducting distillate successively from said flash chambers, and means sealingly, readily removably securing said support on said end walls of the shell.

11. In a multi-stage evaporator provided with an elongated tubular shell having open ends, an assembly comprising a pair of end walls arranged to extend across the ends of the shell, said end walls having aligned openings in the upper portion thereof, a partition wall arranged to extend across the interior of the shell intermediate said ends to define a pair of longitudinally related flash chambers, said partition wall having an opening in an upper portion thereof aligned with said end wall openings, means for conducting fluid to be flashed successively through said flash chambers, a tubular housing extending from the opening in one end wall, through the opening in the partition wall, and to the opening in the other end wall, said housing having an opening in each flash chamber, a tube bundle, a support extending across each end of the tubular housing and supporting the tube bundle to extend longitudinally through said tubular housing, a vent pipe extending longitudinally through said tubular housing, said vent pipe having an opening in each flash chamber and having one portion opening outwardly of the shell, means for conducting distillate successively from said flash chambers, and means sealingly, readily removably securing said support on said end walls of the shell.

12. In a multi-stage evaporator provided with an elongated tubular shell having open ends, an assembly comprising a pair of end walls arranged to extend across the ends of the shell, said end walls having aligned openings in the upper portion thereof, a partition wall arranged to extend across the interior of the shell intermediate

said ends to define a pair of longitudinally related flash chambers, said partition wall having an opening in an upper portion thereof aligned with said end wall openings, means for conducting fluid to be flashed successively through said flash chambers, a tubular housing extending from the opening in one end wall, through the opening in the partition wall, and to the opening in the other end wall, said housing having an opening in each flash chamber, a tube bundle, entrainment separators disposed one each in each flash chamber, each separator being secured to said tubular housing, a support extending across each end of the tubular housing and supporting the tube bundle to extend longitudinally through said tubular housing, means for conducting distillate successively from said flash chambers, and means sealingly, readily removably securing said support on said end walls of the shell.

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