Feb. 8, 1927. 1,617,119

R. C. JONES

BENT TUBE EVAPORATOR

Filed Sept. 16, 1921 4 Sheets-Sheet 1

Fig. 1.

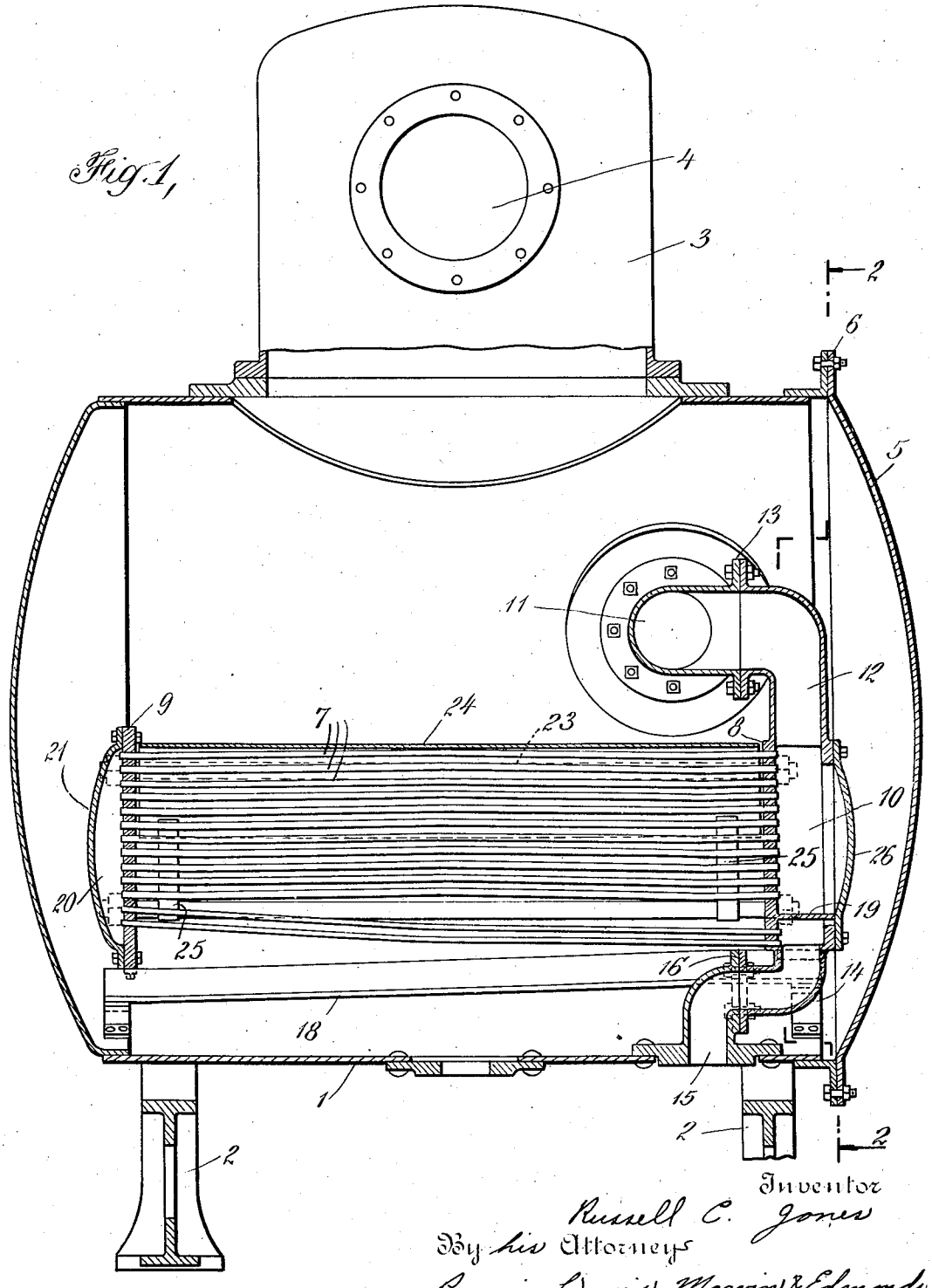

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Fig. 2.

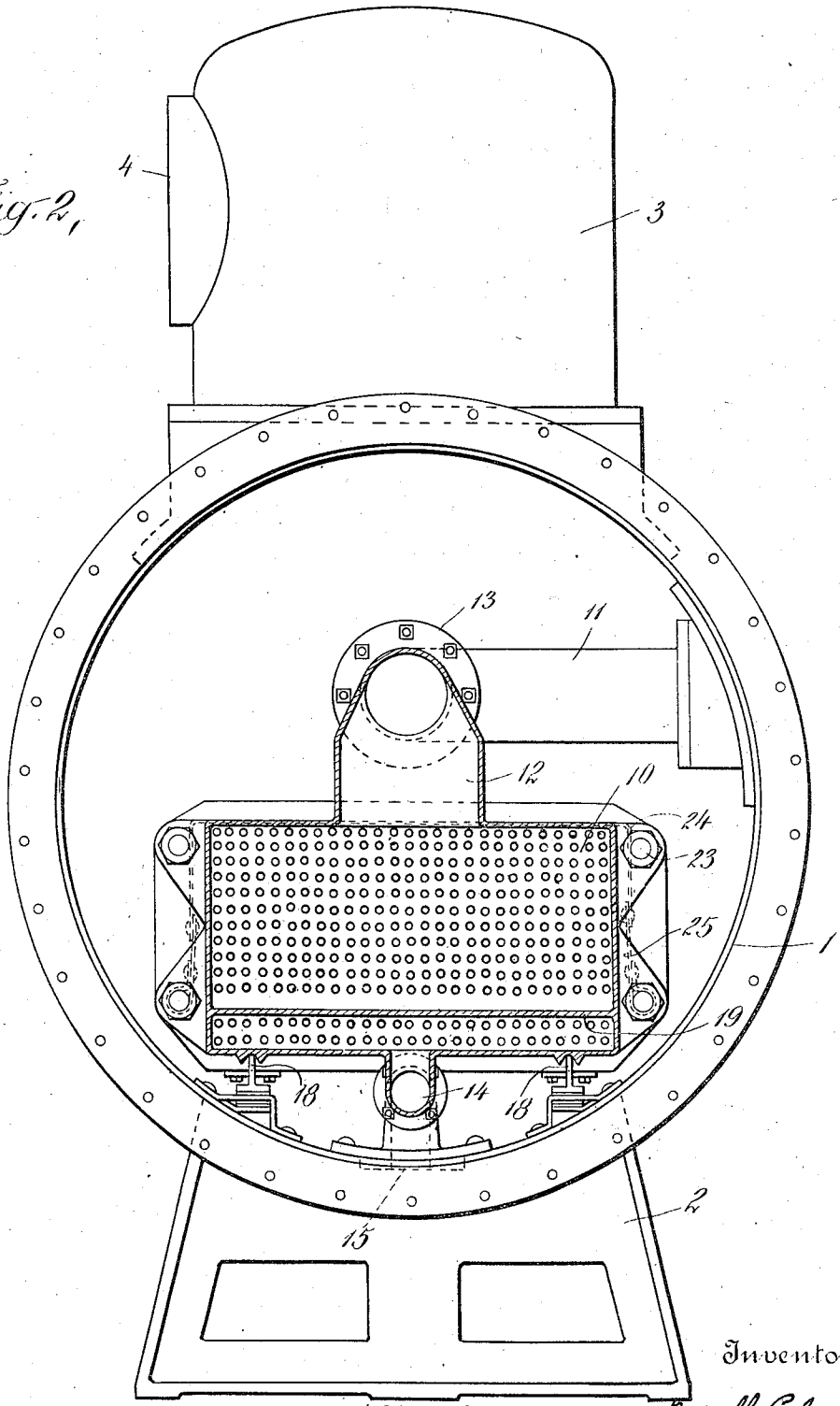

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Fig. 3,

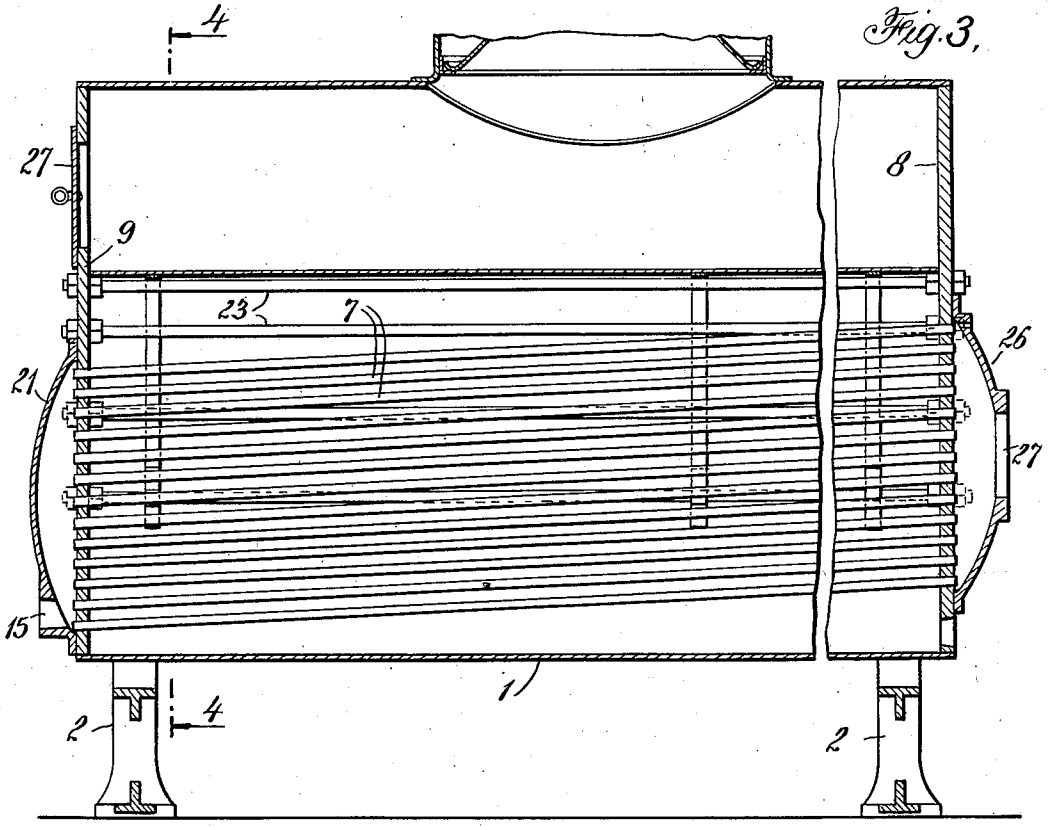
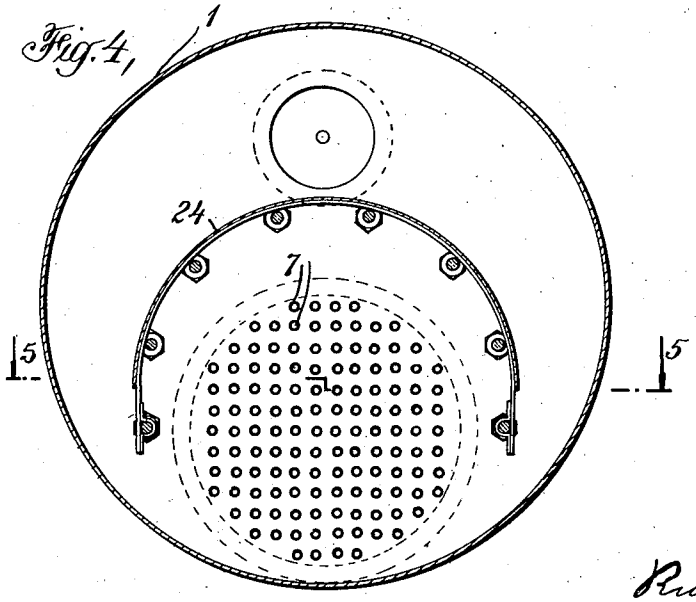


Fig. 4,



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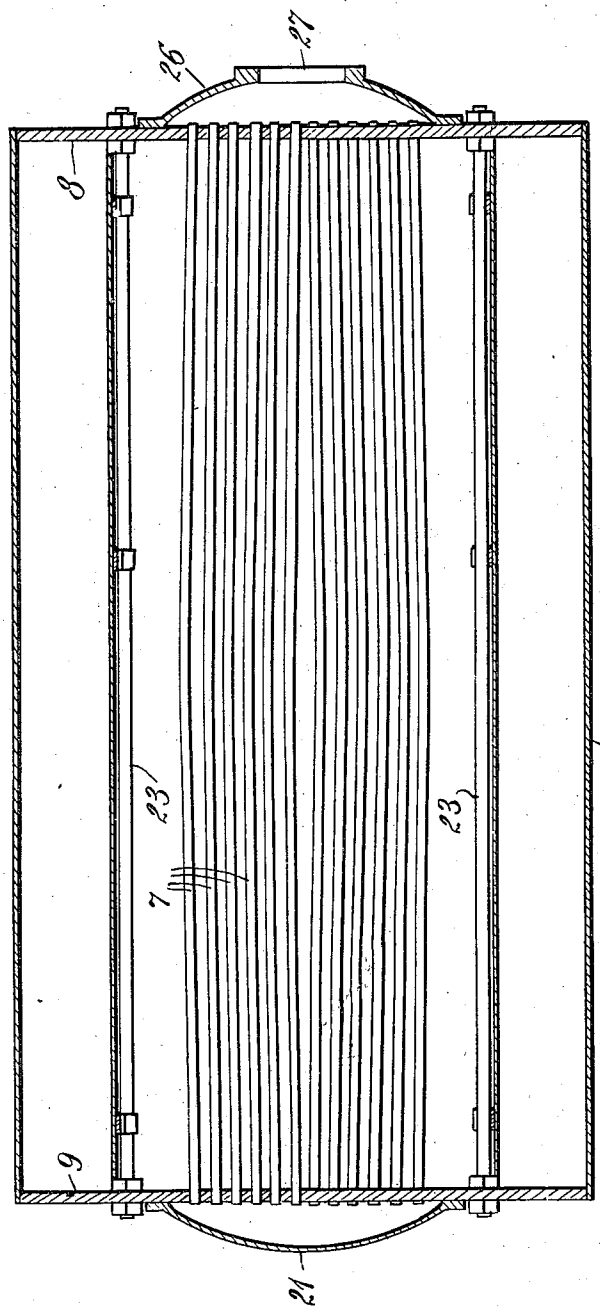

Fig. 5.

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UNITED STATES PATENT OFFICE.

RUSSELL C. JONES, OF BRONXVILLE, NEW YORK, ASSIGNOR TO THE GRISCOM RUSSELL COMPANY, OF NEW YORK, N. Y., A CORPORATION OF DELAWARE.

BENT-TUBE EVAPORATOR.

Application filed September 16, 1921. Serial No. 501,058.

This invention relates to evaporators of the kind employed principally for evaporating sea water or other impure water to obtain pure water for boiler feed or other purposes.

One of the chief difficulties with evaporators of this class is due to the fact that sea water and waters generally of such impurity that they must be distilled before use as boiler feed have marked scale-forming properties so that the surface of the heating tubes in the evaporator rapidly loses its efficiency due to accumulated scale unless the evaporator is shut down and the tubes cleaned at frequent intervals.

The principal object of my present invention is to provide an evaporator in which the tubes are self-cleaning, or substantially so, whereby the evaporators may be kept in substantially constant use with their heat-transferring surfaces at high efficiency.

A further object of the invention is to provide an evaporator of this class in which a large area of heating surface may be provided in an apparatus of moderate size, thereby increasing the vapor output in relation to the size and weight of the apparatus. This feature of the invention is of particular importance in evaporators for use on shipboard where the conservation of space is a factor of greatest importance.

A further object of the invention is to provide an evaporator which is of simple design and low manufacturing cost and which may be readily taken down for the replacement of a defective tube or other purpose.

With the above objects in view, my invention consists of the construction shown and described in the accompanying drawings, wherein—

Fig. 1 is a vertical longitudinal section of an evaporator constructed according to my invention;

Fig. 2 is a transverse section on line 2—2 of Fig. 1;

Fig. 3 is a longitudinal vertical section of a modified form of apparatus embodying my invention;

Fig. 4 is a transverse sectional view taken on line 4—4 of Fig. 3; and

Fig. 5 is a longitudinal view taken on line 5—5 of Fig. 4.

Referring to the drawings, 1 indicates the evaporator shell, here shown as of the horizontal type and supported on frames 2 at the ends thereof. The shell 1 is provided with the usual vapor dome 3 which may contain a separator of any preferred construction and from which the vapor is delivered through the outlet port 4. The front end 5 of the evaporator is detachably connected to the shell by bolts 6 in the flanges to give access to the interior of the shell and permit the withdrawal of the heating tubes, etc.

The heating surface is provided in the form of a large number of slightly bowed horizontal tubes 7, the tubes being preferably arranged in a bundle as indicated in Fig. 2. The tubes are preferably arranged in horizontal and vertical rows and are supported at each end in tube sheets 8 and 9, respectively. The tube sheet 8 forms the rear wall of a manifold chamber 10 which receives the steam from the seam main 11 passing through the side wall of the shell, as shown in Fig. 2, and connected with an upper dome-like extension 12 of the manifold chamber 10. The dome 12 connects with the steam main by a flanged coupling 13 arranged to have its line of separation in a vertical plane. Also, the drain connection 14 for the tube bundle is attached to the drain line 15 of the shell by a similar flanged coupling 16, whereby when it is desired to withdraw the tube bundle it is necessary merely to detach the two flanged couplings 13 and 16 and withdraw the tube bundle through the open front end of the evaporator shell, the tube bundle being for this purpose preferably supported on inclined rails 18 attached to the bottom of the shell.

All of the tubes 7 are connected to the steam manifold 10 which is divided by a transverse partition 19 into an upper and a lower chamber, the lower chamber having an open connection with the drain line 14 as shown in Fig. 1.

At the rear end of the tube bundle all of the tubes connect with a common chamber 20 formed between the tube sheet 9 and the concave cover plate 21, the arrangement being such that all the tubes except the two bottom rows serve as condensing surfaces for the live steam from the steam main 11, while the two bottom rows serve principally as drain returns for the condensed steam which collects in the tubes of the upper division and is blown by the steam pressure into

the chamber 20 whence it drains through the bottom tubes into the lower chamber of the manifold and thence into the drain line.

The tubes 7 are of small bore, which not only gives them a large surface in proportion to their cross sectional area, but keeps that surface active by reason of the fact that the water of condensation which would collect in the lower part of a tube of larger diameter is blown through the tube by the steam pressure. Due to the fact that this steam pressure keeps the tubes free from water of condensation, the tubes of the main steam passage may be mounted horizontally, but the return or drain tubes on the bottom must be given a slant sufficient to insure drainage by gravity. The tube sheet 9 does not form a floating head for the tube bundle as is commonly the case, but instead is connected to the manifold chamber 10 by tie-bolts 23 of sufficient strength to resist elongation under the pressure resulting from the expansion of all the tubes in the tube bundle.

My improved evaporator is self-scaling, and this I obtain by having the tubes slightly bowed in the manner shown, the bowing being somewhat exaggerated in order to be readily apparent.

In Fig. 1 I have shown the tubes bowed in vertical planes, the opposite ends of each tube being supported in the tube sheets 8 and 9 at substantially the same height, while the central portion of the tube is bowed upwardly so that liquid condensed along the length of the tube may find its way out at one end or the other under the influence of gravity alone. The tubes should be bent to just a sufficient extent to give a lateral direction to the middle of the tube when the tube is elongated through expansion, and the smaller the degree of bow within such limits as necessary to protect the tubes from rupture, the greater will be the surface distortion of the tubes for the same degree of elongation.

To increase the efficiency of the evaporator I preferably cover the tube bundle with an inverted U-shaped submerged baffle 24 generally similar to that employed in the multi-coil evaporator shown and described in my prior U. S. Patent No, 1,299,955, granted April 8, 1919. This baffle may conveniently be supported on the tie-rods 23 by means of stirrups 25, as shown in Fig. 2.

For facilitating the cleaning of the bores of the tubes, and for facilitating the removal of a defective tube the outer face of the manifold chamber 10 is provided with a cover plate 26 the removal of which, together with the removal of the cover plate 21, gives free access to both ends of the tubes.

Figs. 3 to 5 illustrate a modified form of apparatus embodying my invention. I have illustrated in these figures a type of evaporator in which the tube bundle is built in as an essentially integral part of the evaporator unit, in contrast to the removable tube bundle as illustrated in Figs. 1 and 2. The tube sheets 8 and 9, into which the ends of tubes 7 are secured, are extended so as to completely enclose the shell and thus constitute the end walls of the evaporator, a door 27 being provided in one of the walls affording access to the interior. The sheets 8 and 9 are held in properly spaced relation by means of tie-bolts 23 extending the length of the shell and having their ends rigidly connected to the tube sheets. A chamber head 26 having an inlet 27 is secured to tube sheet 8 and is in direct communication with the inlet ends of tubes 7. Likewise, a chamber 21 having an outlet 15 is secured to tube sheet 9 and is in direct communication with the discharge ends of tubes 7. Steam is admitted at the opening 27 into chamber 26, from whence it divides evenly among the several tubes constituting the heating element of the evaporator and is condensed therein. The condensate and any vapor which may still remain uncondensed is discharged into chamber 21 and is removed by means of outlet 15.

The tube bundle 7 may be rectangular in shape as shown in Fig. 2, or it may be approximately circular in shape, as indicated in Fig. 4, the tube ends being preferably spaced in the tube sheet at equal distances from each other to form a series of horizontal and vertical rows. I have here shown the tubes slanted somewhat from a true horizontal direction to facilitate their proper drainage. As shown in Fig. 5, the tubes of the bundle are bent in transverse planes rather than in vertical planes. All of the tubes may be bowed in the same direction, if desired, but I preferably bow alternate transverse rows in opposite directions as shown for the purpose of equalizing stresses which occur on the tube sheets 8 and 9 during expansion and contraction of the tubes and which would otherwise have to be taken up by the tie-bolts 23.

The tubes are scaled by causing a quick expansion or contraction of the tubes without a corresponding expansion or contraction of the tie-rods. This may be accomplished by filling the evaporator shell with cold water and admitting steam to the tubes, or with the hot water still in the shell the tubes may be flushed with cold water. The elongation or shortening of the tubes will produce a distortion of the tube surface which will crack and loosen the scale so that it will drop off particularly when the heating surface becomes active in the normal operation of the evaporator. The feed lines for the shell and tubes will be provided with suitable cold water connections and valves so that the scaling may be effected without

taking the evaporator down and with only a brief interruption of the operation of the evaporator plant.

The arrangement of tubes in a horizontal bundle detachable as a unit in the manner shown in Figs. 1 and 2, is of particular advantage in cleaning the tube bores and replacing a defective tube. In fact, the tubes may be cleaned without removing the bundle from the evaporator by taking off the detachable side of the evaporator shell and the detachable head of the manifold at the end of the tube bundle. The tube bundles may also be made interchangeable so that a ready set-up bundle may be quickly substituted for the bundle in use should more or less extensive repairs be required on the latter.

It is to be noted that I have illustrated a type of evaporator shell in which the tube bundle is provided as a removable unit and also a type of evaporator in which the tubes are built in to the evaporator walls and must be removed individually. I have further illustrated the removable tube bundle as composed of a plurality of tubes bent in vertical planes, but it is obvious that the tubes of this bundle may equally well be bent in horizontal planes. Likewise, alternate horizontal rows may be bent in alternate directions similar to the construction shown in Fig. 5 or alternate vertical rows of tubes may be bent oppositely, provided sufficient slant be given those tubes which are bowed downwardly so that water of condensation may drain freely from the tubes under the influence of gravity alone. Likewise, the type of evaporator employing a built in tube bundle is not confined to the tube construction shown, but may embody a tube bundle in which the tubes are bowed in vertical planes, or in any other desired manner. That is, my invention resides broadly in an evaporator equipped with a tube bundle in which the individual tubes are slightly bowed out of a straight line connecting their ends, the exact manner and direction of bowing as well as the slant imparted to the tubes or the type of individual shell employed being dependent upon conditions affecting each particular installation.

In the accompanying drawings and foregoing description I have disclosed my improved evaporator as of the horizontal type but it will, of course, be understood that the improvements may be applied to other types of evaporators and that the details of construction may be variously modified without departing from the spirit of the invention.

I claim:

1. In an evaporator, the combination of a shell for the liquid to be evaporated having a detachable portion at one end to give access to its interior, a series of heating tubes therein arranged horizontally of the shell and positioned in substantial parallelism, tube sheets in which the opposite ends of said tubes are supported, said tubes and tube sheets forming a unitary tube bundle, an inlet passage at one end of said tube bundle connecting with a large portion of said tubes, a chamber at the other end of said bundle in communication with all of said tubes, and a discharge passage adjacent said inlet passage communicating with those tubes not in communication with said inlet passage, an intake passage provided on said shell for conveying heating fluid to the tube bundle, a discharge passage on said shell for receiving fluid discharged from the tube bundle and detachable connections between the respective inlet and discharge connections on the shell and the inlet and discharge passages carried by the tube bundle, the fluid passage at said detachable connection suffering no change in dimensions or direction.

2. An evaporator for producing purified vapor from liquid containing scale forming impurities comprising a shell for containing the liquid to be evaporated, a heating element at least partly submerged in said liquid and comprising a series of tubes, tube sheets in which the ends of said tubes are supported, said tubes being slightly bowed, and tie bolts extending between said tube sheets for maintaining said tube sheets against free relative movement under the expansion and contraction of said tubes, whereby changes in temperature of the heating tubes will cause an appreciable bending or straightening of the tube to thereby exfoliate the scaly deposit of impurities accumulated on said tubes.

3. An evaporator for producing purified vapor from liquid containing scale forming impurities comprising a shell for containing the liquid, a heating element extending into said liquid and comprising a series of tubes of small bore grouped together in a tube bundle in substantial parallelism along their entire length, a portion of said tubes being slightly bowed in one direction away from a straight axial line, a second portion of said tubes being bowed in another direction away from parallelism with said line, and means independent of said shell for supporting the ends of said tubes and maintaining the ends of the tubes against free relative movement under the expansion and contraction of said tubes, whereby changes in temperature will produce an appreciable flexure along a substantial portion of the length of each tube and thereby exfoliate accumulated scale.

4. In an apparatus for heating and treating water involving the deposit of scale-forming substances from the water, the combination of a vessel, a heating element therein comprising a plurality of heat-transferring tubes arranged in substantial parallel-

ism, tube sheets supporting the ends of said tubes, means independent of said shell for maintaining said tube sheets against separation through the expansion of said tubes, said tubes being slightly bowed out of a straight line, whereby relatively small elongation of the tubes through heat expansion produces a relatively large deformation of the metal of the tube and thereby exerts a loosening action on the deposited scale.

5. In an apparatus for heating and treating liquids involving the deposit of scale-forming materials, the combination of a vessel, a heating element therein consisting of a plurality of heat-transferring tubes arranged in substantial parallelism, said tubes being slightly offset at their middle portions, the extent of such offset being just sufficient for elongation of the tube through heat expansion to produce a further bowing of the tube instead of rupturing it, and means independent of said vessel for holding said tube sheets against the thrust occasioned by the elongation of said tubes.

6. In an evaporator, the combination of a shell for the liquid to be evaporated having a detachable portion at one end to give access to its interior, a removable heating element comprising a pair of tube sheets having a plurality of heating tubes extending therebetween, said tubes being arranged in substantial parallelism along their entire length, and means forming a part of said removable heating element for maintaining said tube sheets against free relative movement under the expansion and contraction of said tubes, said tubes being bowed away from a straight axial line sufficiently to prevent rupture but not sufficiently to prevent a substantial exfoliation of the scaly deposit of impurities accumulated on the tubes by bending or straightening of the tubes under change in temperature.

7. In an apparatus for heating and treating water involving the deposit of scale-forming substances from the water, the combination of a vessel, a heating element therein comprising a plurality of heat transferring tubes arranged in substantial parallelism, tube sheets supporting the ends of said tubes, said tubes and tube sheets being removable as a unit from the vessel, and means forming a part of said removable unit for maintaining said tube sheets against separation through the expansion of said tubes, said tubes being slightly bowed out of a straight line whereby relatively small elongation of the tubes through heat expansion produces a relatively large deformation of the metal of the tube and thereby exerts a loosening action upon the deposited scale.

8. In an apparatus for heating and treating liquids involving the deposit of scale-forming materials, the combination of a vessel, a removable heating element therein consisting of a plurality of heat transferring tubes arranged in substantial parallelism, said tubes being slightly offset at their middle portions, the extent of such offset being just sufficient for elongation of the tubes through heat expansion to produce a further bowing of a tube instead of rupturing it, and means forming a part of said removable heating element for holding said tube sheets against the thrust occasioned by the elongation of said tubes.

9. In an evaporator, the combination of a shell for the liquid to be evaporated having a detachable portion at one end to give access to its interior, a removable heating element comprising a plurality of heating tubes positioned in substantial parallelism, tube sheets in which the opposite ends of the tubes are supported, a header associated with the front tube sheet having inlet and outlet joint surfaces at right angles to the axis of the heating element, said inlet communicating with a large portion of said tubes and said outlet communicating with those tubes not in communication with said inlet, and a chamber at the other end of the removable heating unit in communication with all of said tubes, an intake passage provided on said shell for conveying heating fluid to the apparatus, a discharge passage on the shell for receiving fluid discharged from the apparatus, detachable connections between the respective intake and discharge passages on the shell and the inlet and outlet of the heating element header, a pair of rails within the shell upon which the heating element is slidable to and from its operative position, said detachable connections having joint surfaces positioned in horizontal alignment with the joint surfaces on the heating element header when the heating element is supported on said rails, and the planes of the joint surfaces of said detachable connections being disposed so as to contact with the joint surfaces of the header when the heating element is slid into its operative position within the shell.

In testimony whereof I affix my signature.

RUSSELL C. JONES.