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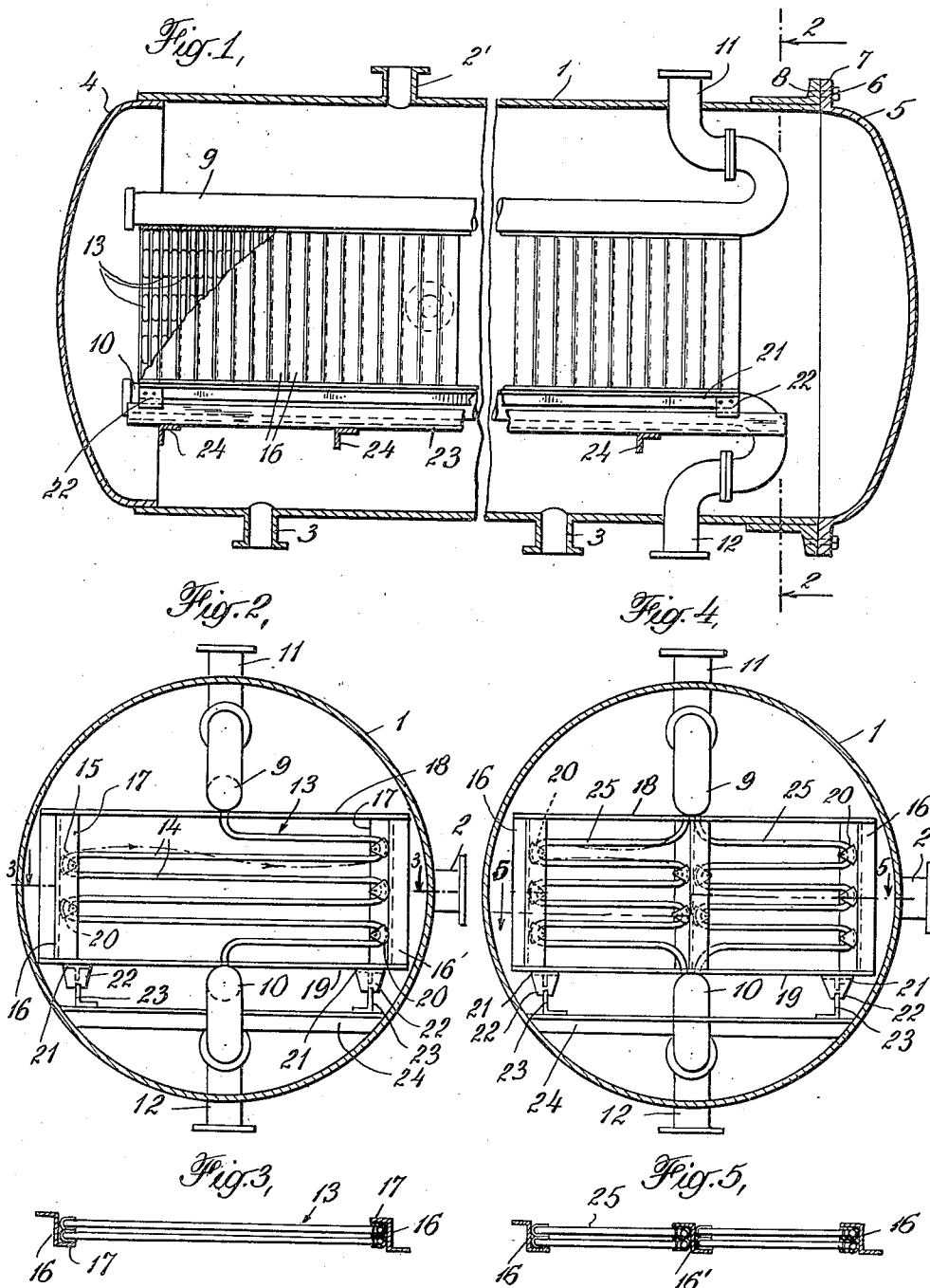
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HEAT EXCHANGER

Filed Nov. 26, 1930

4 Sheets-Sheet 1



INVENTOR
Joseph Price
BY
Cennis Davis Warren & Edmonds
ATTORNEYS

Aug. 30, 1932.

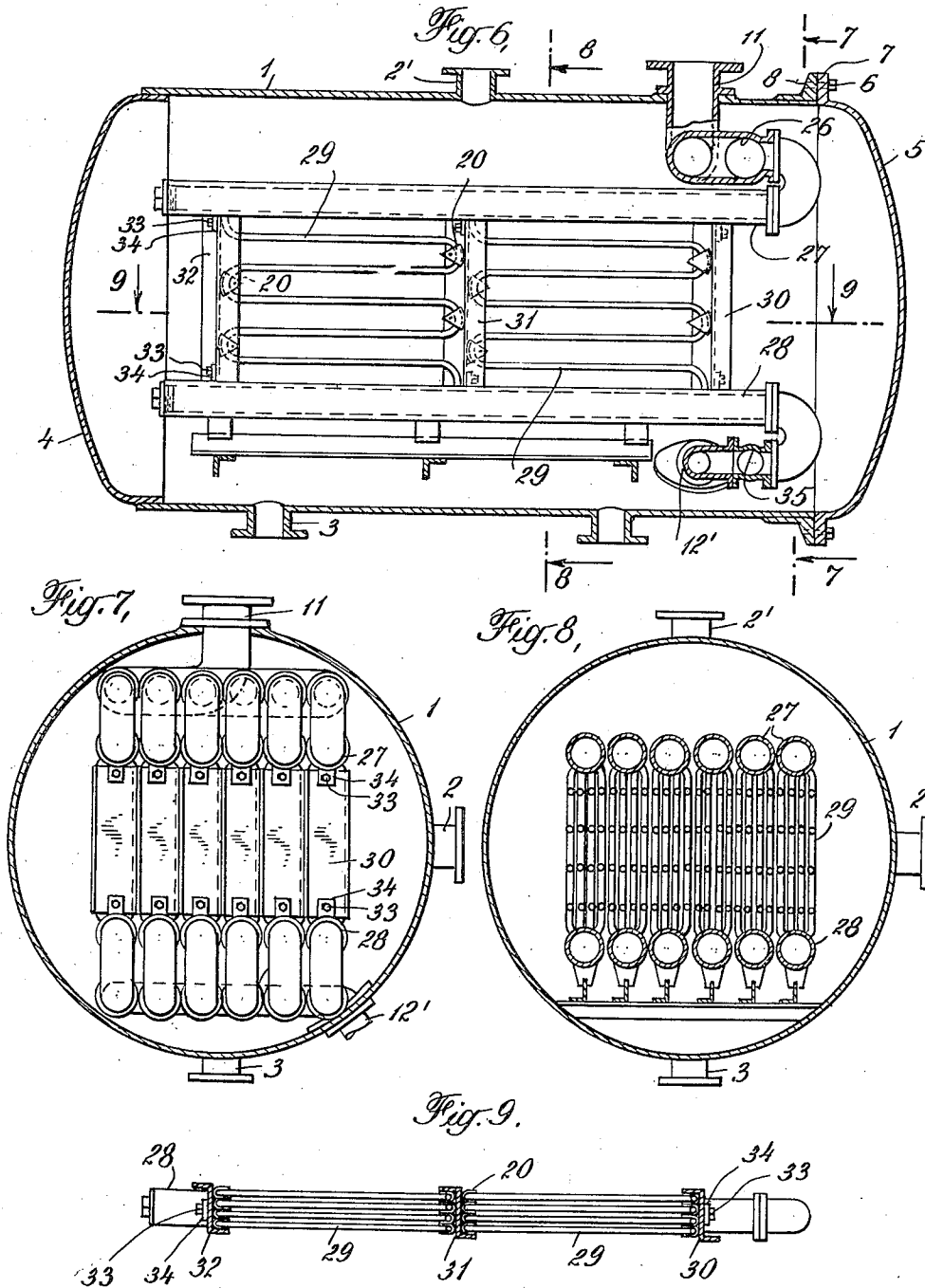
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HEAT EXCHANGER

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4 Sheets-Sheet 2



INVENTOR
Joseph Price
BY *William Harris Martin & Edmunds*
ATTORNEYS

Aug. 30, 1932.

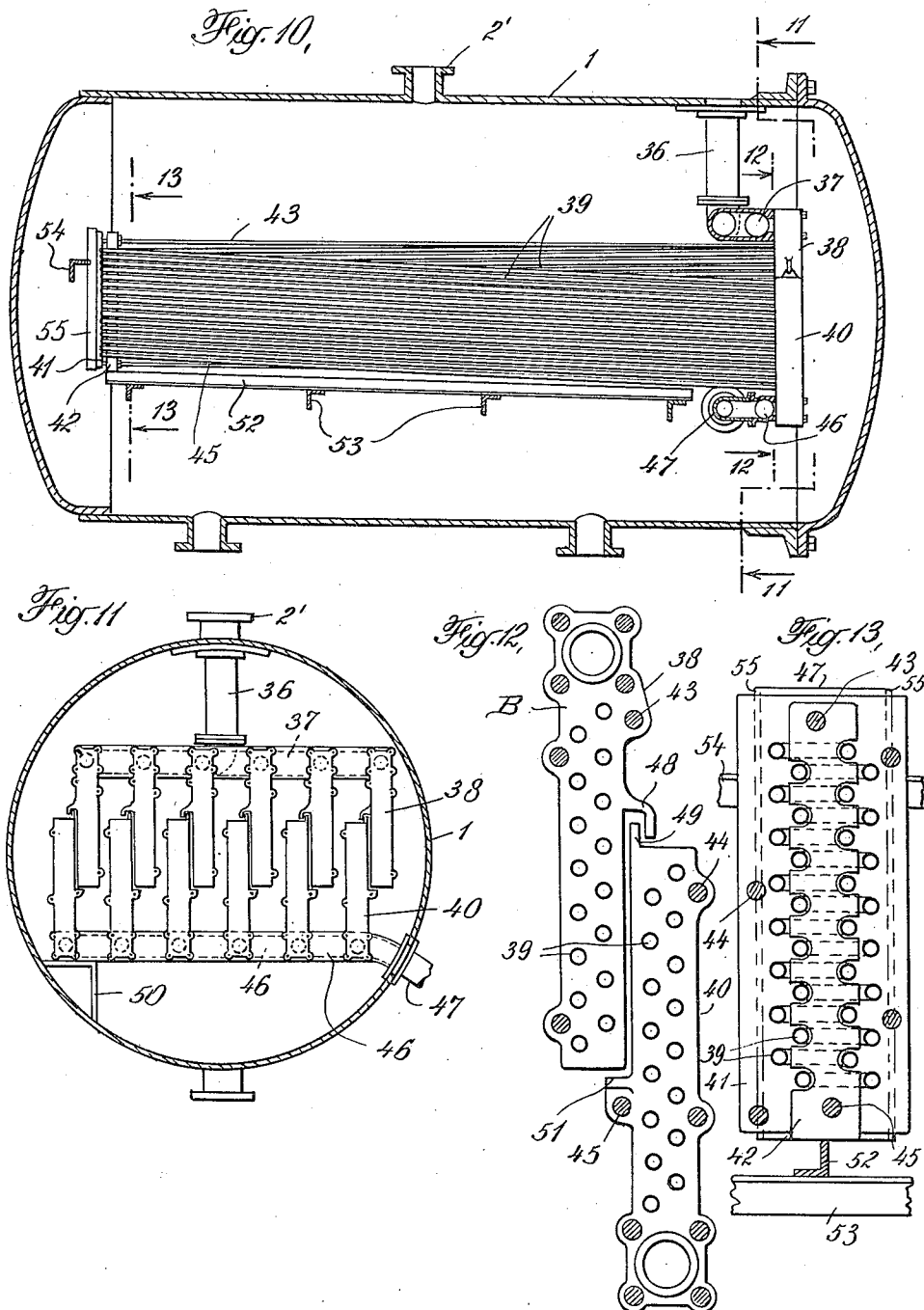
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HEAT EXCHANGER

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4 Sheets-Sheet 3



INVENTOR
Joseph Price
BY
Conrad Davis Harris & Edwards
ATTORNEYS

Aug. 30, 1932.

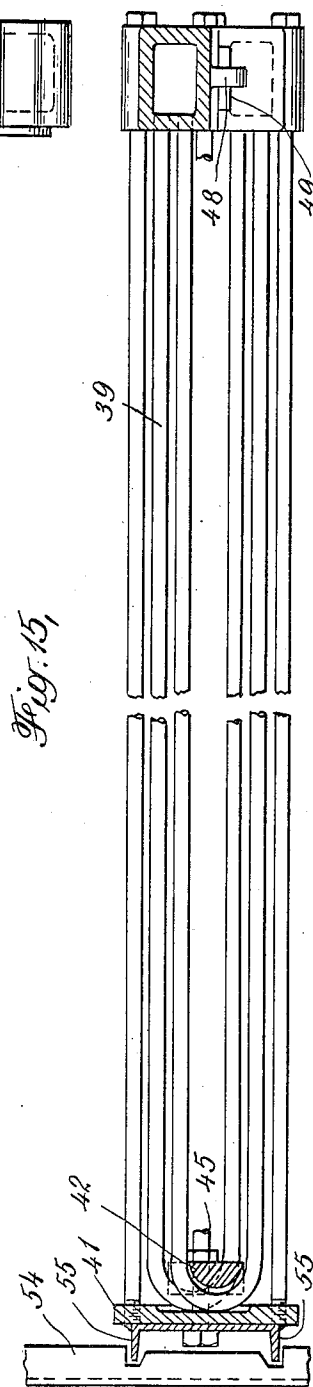
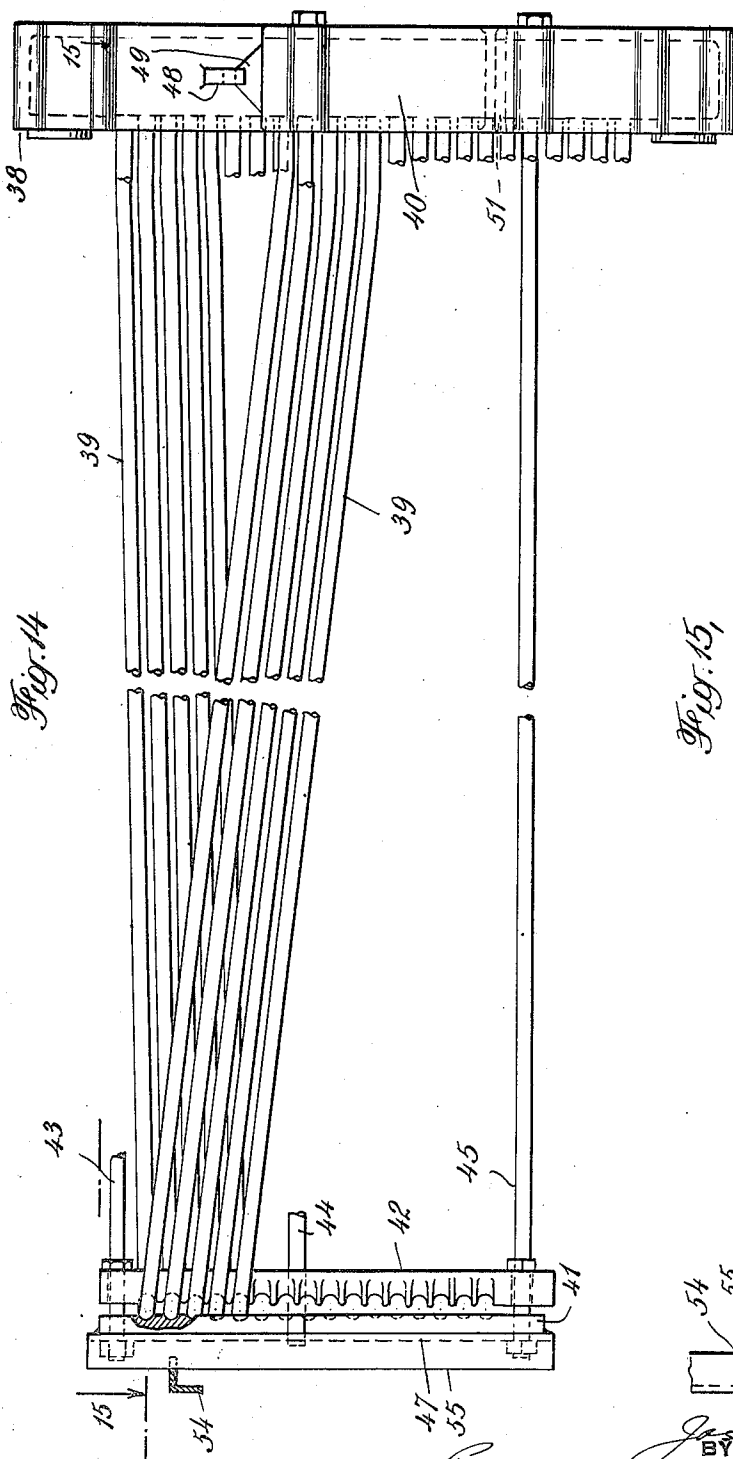
J. PRICE

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HEAT EXCHANGER

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4 Sheets-Sheet 4



INVENTOR
Joseph Price
BY
Census Harris Merritt & Edmunds
ATTORNEYS

UNITED STATES PATENT OFFICE

JOSEPH PRICE, OF WEST NEW BRIGHTON, NEW YORK, ASSIGNOR TO THE GRISCOM-RUSSELL COMPANY, OF NEW YORK, N. Y., A CORPORATION OF DELAWARE

HEAT EXCHANGER

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This invention relates to heat exchangers and particularly to apparatus of this character which is especially suitable for use in locations where the water supply contains scale forming impurities.

This invention relates to heat exchanger apparatus of the type comprising a plurality of tubes the walls of which serve as a medium for transferring heat from one fluid to another. My invention involves improvements in such apparatus whereby the same is rendered more useful in all cases where it is necessary to use water or other fluid containing scale forming impurities.

The self scaling heat exchangers heretofore provided include one or more bundles of tubes, the opposite ends of which are mounted in tube sheets. These tubes, although approximately straight, are nevertheless slightly bowed during normal use and the ends of the tubes are prevented from being further separated by expansion of the tubes whereby elongation of the tubes changes the curvature of the same sufficiently to crack off any scale which may have accumulated on the tubes. Likewise, contraction of the tubes produces a corresponding change in the curvature of the tubes and this produces exfoliation of the scale.

For some purposes it is desirable to use heat exchanger tubes which are reversely curved or bent. The use of serpentine or U-shaped tubes or, in general, heat exchanger tubes having reversely bent portions, is desirable in such cases; but heretofore heat exchangers employing such elements have not been inherently self-scaling and therefore not well adapted for use in locations where the water contains large quantities of scale-forming materials. According to the present invention such heat exchangers can be rendered inherently self-scaling and in general this is accomplished by restricting or preventing relative displacement of the extremities of the heat exchanger tubes, such extremities including one or more curved or bent portions.

The use of serpentine tubes, or other tubes having reversely bent or curved portions is advantageous, not only in order to conserve

space, but it simplifies the construction of the heat exchanger in that the number of sealed joints is reduced at least in some cases, and the maintenance requirements are less. In making a heat exchanger in accordance with my invention inexpensive parts can be employed and the various parts can be assembled and maintained in good working condition with a minimum of labor. The self-scaling characteristic is of great importance for it insures good operating efficiency at all times and greatly reduces the amount of work required in maintaining the apparatus in good working condition. It is not necessary to take the apparatus apart periodically to remove scale from the tubes.

In general I provide heat exchanger tubes having bent or curved portions, and the extremities of the tubes, including one or more of the curved portions, abut against bars, or the like, which are so mounted or interconnected as to prevent the extremities of the tubes from separating when the tubes expand.

The various objects and advantages of my invention will be more apparent upon considering the following detailed description of certain illustrative embodiments thereof shown in the accompanying drawings wherein

Fig. 1 is a sectional elevation of an evaporator embodying my invention;

Fig. 2 is a transverse sectional view taken on line 2—2 of Fig. 1;

Fig. 3 is a horizontal sectional view taken on line 3—3 of Fig. 2 showing a portion of the apparatus of Fig. 2;

Fig. 4 is a transverse sectional view of apparatus similar to that shown in Figs. 1, 2 and 3, except for the construction and arrangement of the tubes within the evaporator shell;

Fig. 5 is a horizontal sectional view taken on line 5—5 of Fig. 4 showing details of construction;

Fig. 6 is a sectional elevation of an evaporator embodying my invention in a form somewhat different from that illustrated in Fig. 1;

Fig. 7 is a transverse sectional view taken on line 7—7 of Fig. 6;

Fig. 8 is a transverse sectional view taken on line 8—8 of Fig. 6;

Fig. 9 is a horizontal sectional view taken on line 9—9 of Fig. 6 showing the construction of a portion of the apparatus;

Fig. 10 is a sectional elevational view illustrating still another embodiment of my invention;

Fig. 11 is a transverse sectional view taken on line 11—11 of Fig. 10;

Fig. 12 is an enlarged transverse sectional view taken on line 12—12 of Fig. 10 showing details of construction of a portion of the apparatus;

Fig. 13 is an enlarged transverse sectional view taken on line 13—13 of Fig. 10 showing details of construction;

Fig. 14 is a side elevation of one of the units shown in Figs. 10 and 11, parts being cut away to show details of construction and

Fig. 15 is a longitudinal section view taken on line 15—15 of Fig. 14.

In the accompanying drawings I have illustrated various embodiments of my invention as applied to evaporators. It will be understood however that my invention is not limited to such applications thereof but may be applied generally in the heat exchanger art, for various features of my invention will be found useful in all cases where the water employed contains scale-forming impurities which make it necessary to take some precautions with regard to the formation of scale deposits on the exchanger tubes.

In Figs. 1 and 2 of the accompanying drawings I have illustrated an evaporator shell 1 having a feed inlet 2, a vapor outlet 2' at the top thereof, and suitable discharge connections 3 at the bottom thereof. One end of the shell is closed by a header 4 permanently secured thereto and the other end of the shell is enclosed by a removable header 5 detachably secured to the shell by any suitable means such as studs 6 passing through a flange 7 on the header 5 and extending into threaded holes in an annular flange 8 carried by the shell.

A pair of manifolds 9 and 10 are disposed within the shell 1. The manifold 9 communicates with a steam inlet 11 passing through the shell, and the discharge manifold 10 communicates with a suitable drain pipe 12 at the bottom of the apparatus.

A plurality of heat exchanger tubes 13 are arranged between the manifolds 9 and 10 with the ends of the tubes expanded into or otherwise secured to the walls of the manifolds. The tubes 13 may be regarded as serpentine tubes for each tube comprises a plurality of substantially straight portions 14 communicating with curved or reversely bent portions 15. Each tube may be integral from end to end, or, if desired, the straight portions may be interconnected by suitable couplings at the ends. In either event each serpentine tube

may be regarded as consisting of a plurality of U-shaped sections and it will be understood that the tubes are in direct communication with the manifolds 9 and 10.

At the lateral extremities of the tubes illustrated in Figs. 1, 2 and 3, I have provided Z bars 16, the web portions of which abut against the extremities of the tubes and it will be noted that each of these bars has a single flange 17 projecting toward the opposite Z bar and that these flanges of each pair of Z bars extend on opposite sides of the tubes engaging the flange webs. The web portions of the bars constitute abutments engaging the tube extremities either directly (or indirectly as hereinafter explained) and accordingly, by interconnecting each pair of bars with suitable members such as the metal strips 18 and 19, as best illustrated in Fig. 2, the abutments are maintained in relatively fixed positions and serve to prevent the extremities of the tubes from separating when the tubes expand. Accordingly, whenever expansion of the tubes occurs the relatively straight portions of the tubes are flexed or bowed and this bending of the tubes serves to crack off any scale which may have accumulated on the surfaces of the tubes. The arrows shown in Fig. 2 illustrate the manner in which elongation of the tubes produces flexure of the tubes. This bowing of the tubes is exaggerated in Fig. 2 for purposes of illustration, for it will be understood that the scale is removed efficiently by a slight bowing of the tubes.

Where the tubes are made of relatively soft metal, or where the walls of the tubes are very thin, it is sometimes desirable to protect the curved extremities of the tubes with shoes such as those illustrated at 20. These shoes have inner curved surfaces engaging the curved portions of the tubes and the shoes are adapted to engage the webs of the Z bars. In such cases the Z bars may be regarded as engaging the tube extremities indirectly, to prevent the separation of the tube extremities when the tubes expand.

The flanges 17 of the Z bars 16 restrict lateral movement of the tubes and thereby serve to maintain the tubes in proper position. Although these flanges may be integral with the other portions of the bars 16, yet they do not interfere with the assembly of the tubes, or with their removal for the purpose of repairing the apparatus and this is true because these flanges extend on opposite sides of the unitary tube bundle engaging the flange webs. The construction and arrangement of the parts is such that the tubes can be readily removed from their normal position between the pairs of Z bars. The construction of the Z bars is such that they are inherently rigid and accordingly well adapted to the purpose of providing rigid abutments for engaging the curved extremities of the tubes.

The tubes 13, illustrated in Figs. 1 and 2, may be regarded as serpentine tubes the planes of which extend at right angles to the two parallel manifolds 9 and 10 and each tube projects laterally on each side of the plane defined by the tube manifolds. Each pair of Z bars may engage one or more tubes and for purposes of illustration I have shown each Z bar web as being disposed opposite the curved ends of two adjacent tubes. Accordingly, rows of Z bars extend on opposite sides of the manifolds and these bars, or the links 18 and 19 interconnecting the same, may be supported upon any suitable members such as the T bars 21. These T bars are secured to grooved supports 22 which rest upon tracks 23. These tracks are carried on suitable bracket supports 24. Accordingly, it will be understood that by removing the header 5 from the shell 1 and disconnecting the manifolds 9 and 10 from the steam inlet pipe 11 and the drain pipe 12, the whole interior assembly including the manifolds, the heat exchanger tubes, Z bars and interconnecting members, can be withdrawn as a unit from the evaporator shell. This unit is slidably mounted on the tracks 23.

The embodiment of my invention illustrated in Figs. 4 and 5, is similar in many respects to that illustrated in Figs. 1, 2 and 3, and accordingly I have employed the same reference characters for designating the shell 1, the steam inlet 11, the feed inlet 2, the manifolds 9 and 10 and other parts such as the tracks 23, track supports 24, the T bars 21 and the T bar supports 22. The heat exchanger tubes 25 of Figs. 4 and 5 are similar to the tubes 13 of Figs. 1, 2 and 3 in that they are serpentine tubes, but they are arranged differently in that each tube extends only on one side of the plane defined by the manifolds 9 and 10 instead of on both sides as shown in Figs. 1 to 3 inclusive. The outer extremities of the pairs of tubes 25 are shown as provided with shoes 20 and as abutting against Z bars 16 in the same manner as described in connection with Figs. 1, 2 and 3. Z bars 16' are provided for engaging the inner extremities of the pairs of tubes, as best illustrated in Fig. 5. It will be understood that the Z bars are interconnected by metal strips 18 as previously described and that they serve to prevent the extremities of the serpentine tubes from separating when the tubes expand. Accordingly, elongation of the tubes produces a flexure or bending as indicated in dotted lines in Fig. 4, which exfoliates the scale. It will be noted that for the same shell diameter, the substantially straight portions of the tubes 25 are much shorter than the corresponding portions of the tubes 13 shown in Figs. 1, 2 and 3. This provides a degree of flexibility in the design of a heat exchanger for any particular installation, which is entirely sufficient for the

accommodation of special conditions of operation. Where it is desirable to employ tubes having relatively long sections free to bow, the construction shown in Figs. 1 to 3 may be employed, whereas, in the event short bowing sections are desired, the construction shown in Figs. 4 and 5 may be more suitable. Furthermore, the construction shown in Figs. 4 and 5 is more compact and rigid than that shown in Figs. 1, 2 and 3 and this may be advantageous for some installations. In either case the interior mechanism can be assembled to form a unitary structure which can be inserted into the shell.

The embodiment of my invention illustrated in Figs. 6 to 9 inclusive is in many respects similar to the embodiment previously described and where appropriate I have employed the same reference characters to designate corresponding parts. The principal differences between the apparatus shown in Figs. 6 to 9 inclusive and that shown in Figs. 1 to 3 inclusive are the provision in the apparatus of Figs. 6 to 9 inclusive, of a plurality of tube manifolds, and the individual heat exchanger tubes extend in planes parallel with the tube manifolds instead of at right angles thereto. In Figs. 6 and 7 the steam inlet 11 communicates with a manifold chamber 26 which in turn communicates with a plurality of tube manifolds 27. Corresponding discharge manifolds 28 are arranged in the lower part of the apparatus and the heat exchanger tubes 29 interconnect the vertically arranged pairs of manifolds. The Z bars 30, 31 and 32 that engage the curved extremities of the tubes are secured directly to the tube manifold by means of bolts 33 passing through lugs 34 on the manifolds. The discharge manifolds 28 communicate with a manifold chamber 35 and this in turn communicates with the discharge pipe 12'. Each vertically arranged pair of manifolds, with the tubes interconnecting the same, constitutes a unit which, if desired, can be removed separately for purposes of repair without disturbing the other units within the shell.

Since the heat exchanger tubes 29 of Figs. 6 to 9 inclusive abut against the interconnected Z bars 30, 31 and 32, the substantially straight portions of the tubes are compelled to bow whenever elongation of the tubes occur, and accordingly the tubes are self-scaling as previously described in connection with the embodiments of my invention illustrated in Figs. 1 to 5 inclusive.

In the embodiment of my invention, illustrated in Figs. 10 to 15 inclusive, the shell and other external parts are similar to those previously described, and, where appropriate, the same reference characters have been applied to corresponding parts. This particular embodiment of my invention involves the use of U-shaped tubes, the ends of which

are directly connected to tube sheets and the curved portions of which are maintained in a relatively fixed position with respect to the tube sheets, whereby the intermediate substantially straight portions of the tubes are caused to bow whenever elongation of the tubes occur. The steam inlet 36 of Figs. 10 and 11 communicates with a manifold chamber 37 which in turn communicates with headers 38, a plurality of these headers being provided as best illustrated in Fig. 11. The U-shaped tubes 39 are connected to the headers 38 and the discharge ends of these tubes are connected to corresponding headers 40. A pair of clamping blocks 41 and 42 are secured to the curved portions of the U-shaped tubes by any suitable means and these clamping blocks are secured to the headers 38 and 40 by means of tie rods 43, 44 and 45. The clamping blocks 41 and 42 are grooved to conform with the surfaces of the tubes and to provide a relatively large area of contact with the tubes. It will be understood that the tie rods serve to prevent the extremities of the tubes from being separated when the tubes expand, and accordingly elongation of the tubes produces a bowing of the same which exfoliates the scale on the surfaces of the tubes. The discharge headers 40 communicate with a discharge manifold 46 which in turn communicates with the discharge pipe 47. Lugs 48 and 49 on the headers 38 and 40 loosely interconnect these parts of the apparatus to provide the necessary rigidity while permitting differential expansion and contraction of the headers. One end of the manifold 46 rests upon the shell 1 at the point where it communicates with the discharge pipe 47 and the other end of this manifold is supported on a suitable bracket 50 mounted in the shell. The headers 38 rest on lugs 51 provided on the discharge headers 40. Tracks 52 support the clamping block 42 and these tracks are in turn supported on suitable brackets 53 mounted within the shell. A notched bracket 54 loosely engages webs 55 on the outer clamping block 41 and serves to restrict lateral movement of the tube bundle with respect to the supporting tracks 52, whereby the tube bundle is maintained in proper alignment within the shell.

The several applications of my invention illustrated in the accompanying drawings illustrate typical embodiments of my invention as applied to evaporators. It is to be understood however that my invention is not limited to the particular embodiments thereof described in detail but includes such modifications thereof as fall within the scope of the appended claims.

I claim:

1. In a heat exchanger, the combination of a flexible tube having a substantially straight portion, and having a reversely bent portion at at least one extremity thereof, and means

for holding the extremities of said tube in substantially fixed relative positions, whereby elongation of the tube produces flexure of said substantially straight portion.

2. In a heat exchanger, the combination of a flexible U-shaped tube having a curved portion and substantially straight portions, and means for holding a part of the curved portion of the tube in a substantially fixed position relative to the other extremities of the tube, whereby elongation of the tube produces flexure of said substantially straight portions.

3. In a heat exchanger, the combination of a flexible U-shaped tube having a curved portion and substantially straight portions, an abutment engaging the curved portion of the tube, and means for holding said abutment in substantially fixed space relation with respect to the other extremities of the tube, whereby elongation of the tube produces flexure of said substantially straight portions.

4. In a heat exchanger, the combination of a flexible tube comprising curved portions and an intermediate substantially straight portion, and means for preventing the said curved portions of the tube from being further separated by expansion of the tube, whereby elongation of the tube produces flexure of said substantially straight portion.

5. In a heat exchanger, the combination of a flexible tube having a substantially straight portion, and having a reversely bent portion at at least one extremity thereof, a shoe having a curved surface engaging said bent portion of the tube, and means for holding said shoe in a substantially fixed position relative to the extremity of the tube remote therefrom.

6. In a heat exchanger, the combination of a flexible serpentine tube having curved portions and intermediate substantially straight portions, and means for preventing the said curved portions of the tube from being further separated by expansion of the tube, whereby elongation of the tube produces flexure of said substantially straight portions of the tube.

7. In a heat exchanger, the combination of a flexible serpentine tube having curved extremities and intermediate substantially straight portions, shoes having curved surfaces engaging said curved extremities, abutments engaging said shoes, and means for preventing said abutments from being separated by expansion of the tube, whereby elongation of the tube produces flexure of said substantially straight portions.

8. In a heat exchanger, the combination of two substantially parallel manifolds, a plurality of flexible serpentine tubes interconnecting said manifolds, said tubes having curved portions and intermediate substantially straight portions, a pair of abutments engaging the curved portions of each tube,

and means for preventing said abutments from being further separated by expansion of the tubes, whereby such expansion produces flexure of said substantially straight portions of the tubes.

9. In a heat exchanger, the combination of two substantially parallel manifolds, a plurality of flexible serpentine tubes interconnecting said manifolds, said tubes having curved portions and intermediate substantially straight portions, a pair of abutments engaging the curved portions of each tube, and means for preventing said abutments from being further separated by expansion of the tubes, whereby such expansion produces flexure of said substantially straight portions of the tubes, the planes of said serpentine tubes being at substantially right angles to said manifolds.

10. In a heat exchanger, the combination of two substantially parallel manifolds, a plurality of pairs of flexible serpentine tubes interconnecting said manifolds, said tubes having curved portions and intermediate substantially straight portions, a pair of abutments engaging the curved portions of each tube, and means for preventing said abutments from being further separated by expansion of the tubes, whereby such expansion produces flexure of said substantially straight portions of the tubes, the planes of said serpentine tubes being at substantially right angles to said manifolds, with the tubes of each pair disposed on opposite sides of the manifolds.

11. In a heat exchanger, the combination of a flexible tube comprising bent extremities and intermediate substantially straight portions and a pair of bars engaging said bent extremities, each of said bars having a single flange projecting toward the opposite bar, to restrict lateral movement of the tube.

12. In a heat exchanger, the combination of a flexible tube comprising bent extremities and intermediate substantially straight portions, and a pair of bars engaging said bent extremities, each of said bars having a single flange projecting toward the opposite bar to restrict lateral movement of the tube, said flanges extending on opposite sides of said tube.

13. In a heat exchanger, the combination of a flexible tube comprising curved extremities and intermediate substantially straight portions, and a pair of Z bars the web portions of which engage said extremities.

14. In a heat exchanger, the combination of a flexible tube comprising curved extremities and intermediate substantially straight portions, a pair of bars engaging said curved extremities, each of said bars having a single flange projecting toward the opposite bar to

restrict lateral movement of the tube, and means for preventing said bars from being further separated by expansion of said tube.

15. In a heat exchanger, the combination of a flexible tube comprising bent extremities and intermediate substantially straight portions, a pair of Z bars the web portions of which engage said extremities, and means for preventing said bars from being further separated by expansion of the tube.

16. In a heat exchanger, the combination of two substantially parallel manifolds, a plurality of flexible serpentine tubes interconnecting said manifolds, the planes of said tubes being approximately parallel with said manifolds and said tubes having curved portions and intermediate substantially straight portions, and means for preventing said curved portions of the tubes from being further separated by expansion of the tubes.

17. In a heat exchanger, the combination of a pair of manifolds, a flexible serpentine tube interconnecting said manifolds, said tube having curved portions and intermediate substantially straight portions, a pair of bars engaging the curved portions of said tube, and means for securing said bars to said manifolds.

18. In a heat exchanger, the combination of two substantially parallel manifolds, a plurality of flexible serpentine tubes interconnecting said manifolds, said tubes having curved portions and intermediate substantially straight portions, a pair of abutments engaging the curved portions of each tube, means for preventing the said curved portions from being further separated by expansion of the tubes, a shell enclosing said manifolds and said tubes, said shell having a removable head, a track within said shell and supported by the same, and means for supporting said manifolds and tubes on said track.

19. In a heat exchanger, the combination of a flexible U-shaped tube having a curved portion and substantially straight portions, an abutment engaging the curved portion of the tube, tube sheets secured to the extremities of the tube opposite said curved portion, and means for holding said abutment in substantially fixed space relation with respect to said tube sheets.

20. In a heat exchanger, the combination of a flexible U-shaped tube having a curved portion and substantially straight portions, an abutment engaging the curved portion of the tube, tube sheets secured to the extremities of the tube opposite said curved portion, and tie rods interconnecting said abutment and said tube sheets.

21. In a heat exchanger, the combination of a flexible U-shaped tube having a curved portion and substantially straight portions, a pair of clamping blocks secured to said curved portion of the tube, tube sheets secured to the extremities of the tube opposite said curved

portion, and means for holding said clamping blocks in substantially fixed spaced relation with respect to said tube sheets.

22. In a heat exchanger, the combination of a flexible U-shaped tube having a curved portion and substantially straight portions, a pair of clamping blocks secured to said curved portion of the tube, tube sheets secured to the extremities of the tube opposite said curved portion, and means for holding said clamping blocks in substantially fixed spaced relation with respect to said tube sheets, said clamping blocks being grooved to conform with the shape of the curved portion of the tube to provide a large area of contact therewith.

23. In a heat exchanger, the combination of a flexible U-shaped tube having a curved portion and substantially straight portions, an abutment engaging the curved portion of the tube, a support for said abutment, and means loosely engaging said abutment for preventing lateral displacement of said abutment on said support.

25 In testimony whereof I affix my signature.
JOSEPH PRICE.

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