June 30, 1953 J. H. STELLING 2,643,862

STEAM REHEATER

Filed Feb. 18, 1949 6 Sheets-Sheet 1

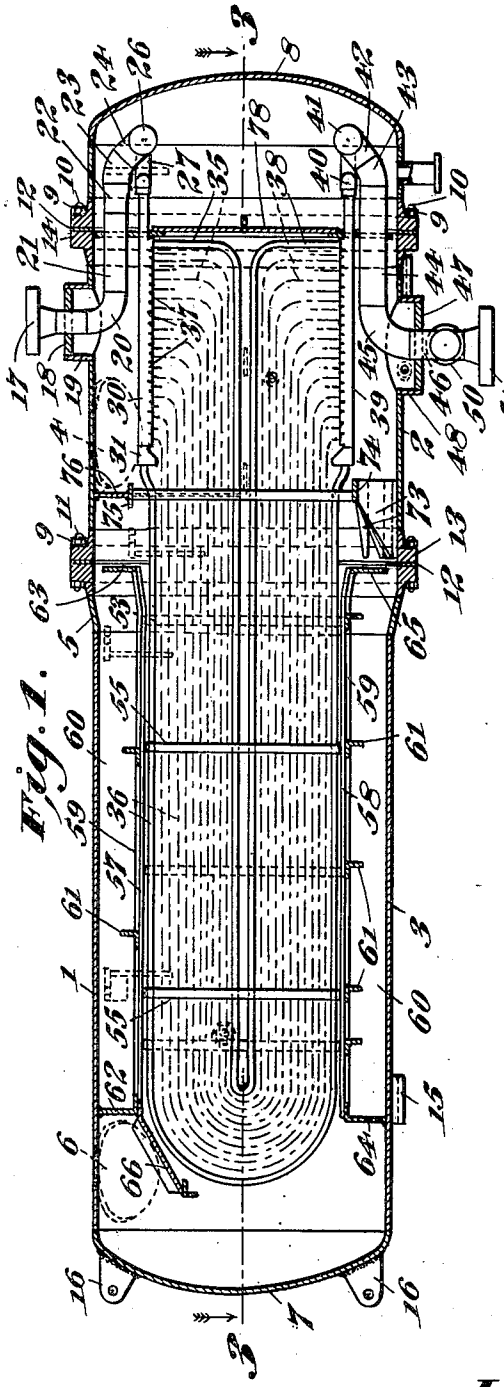


Fig. 1.

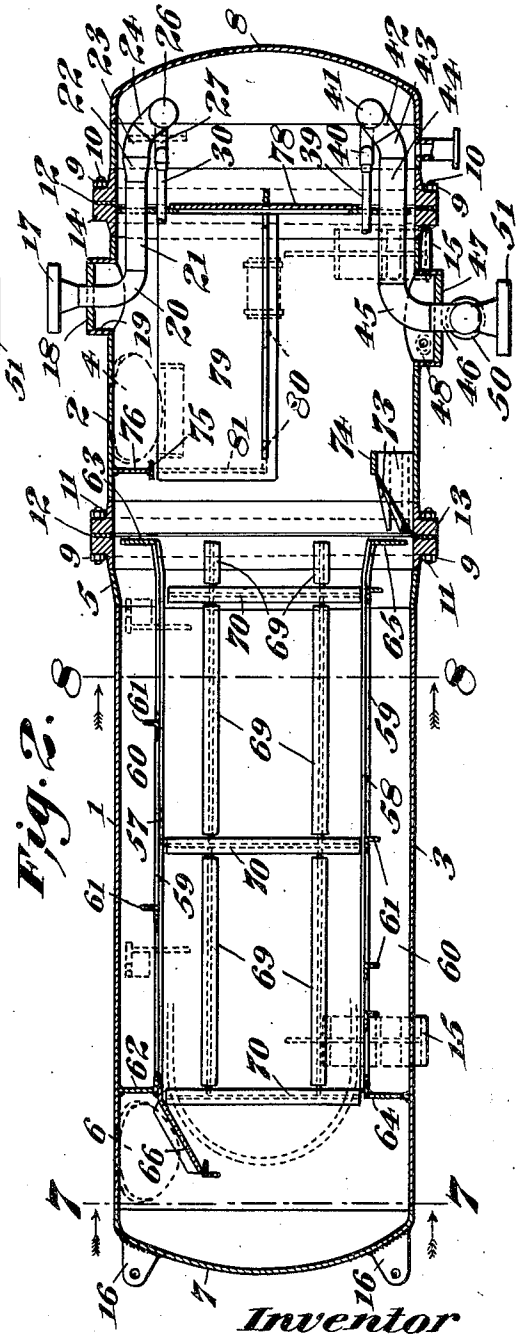


Fig. 2.

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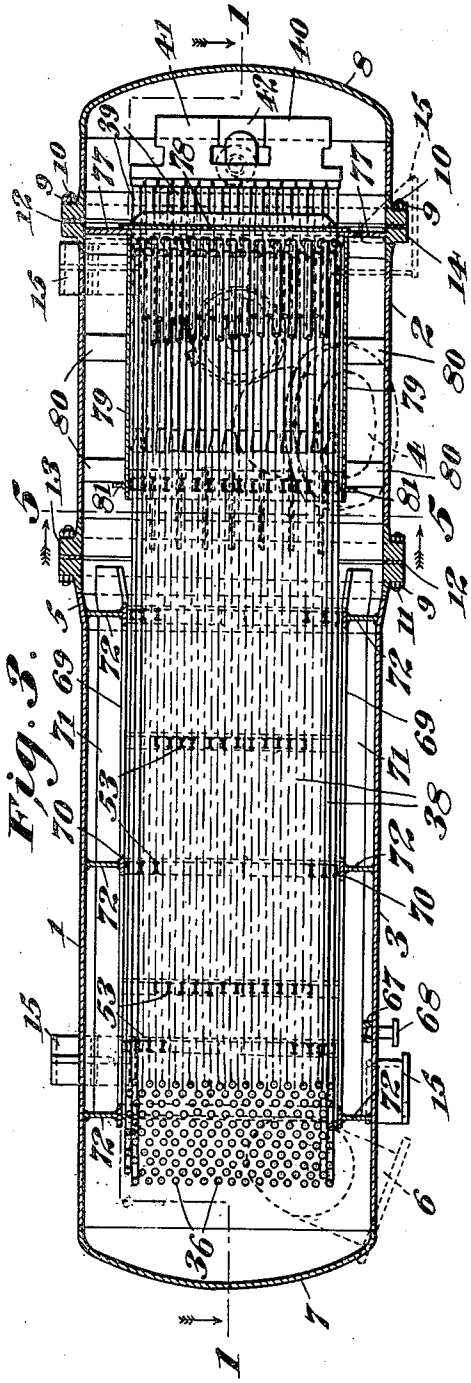


Fig. 3.

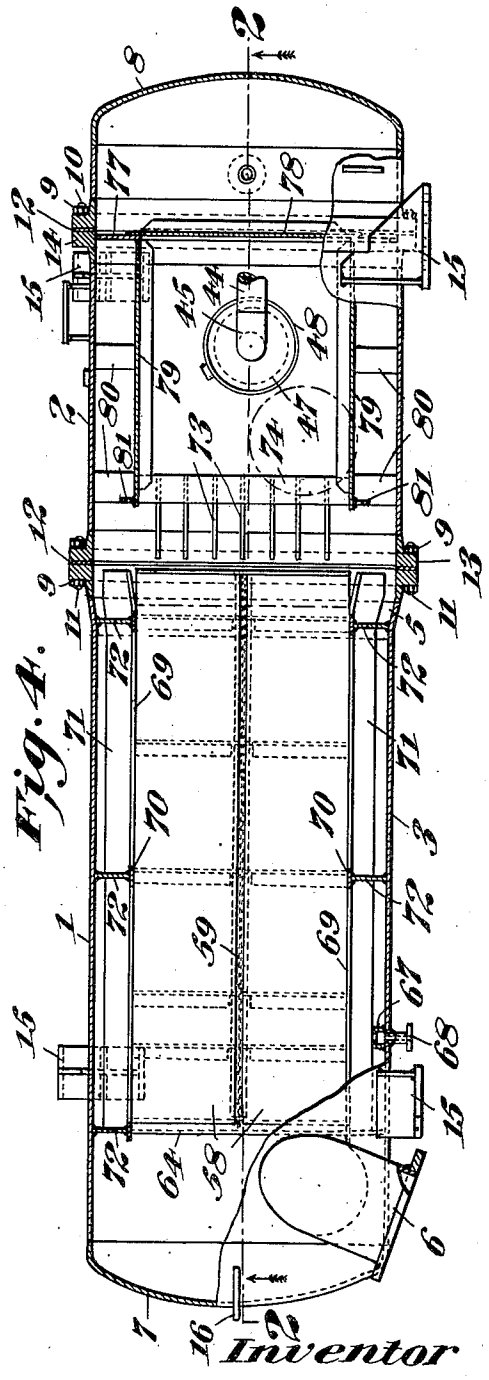


Fig. 4.

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STEAM REHEATER

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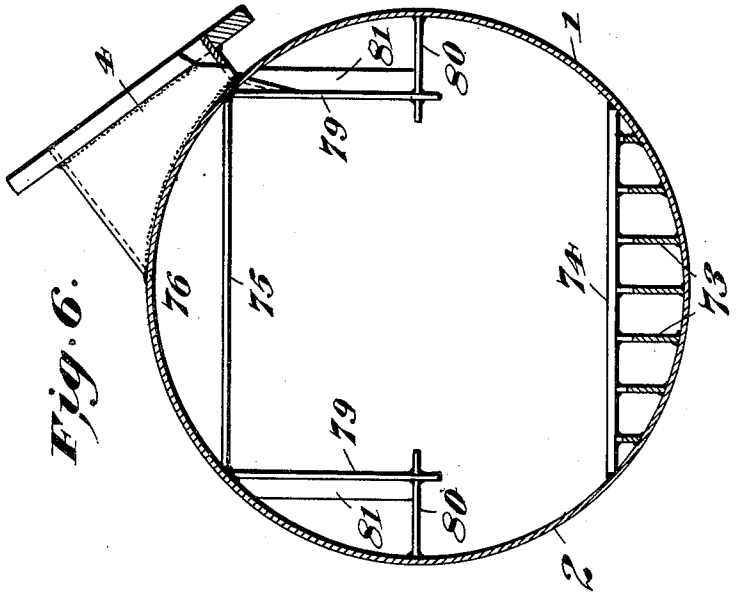


Fig. 6.

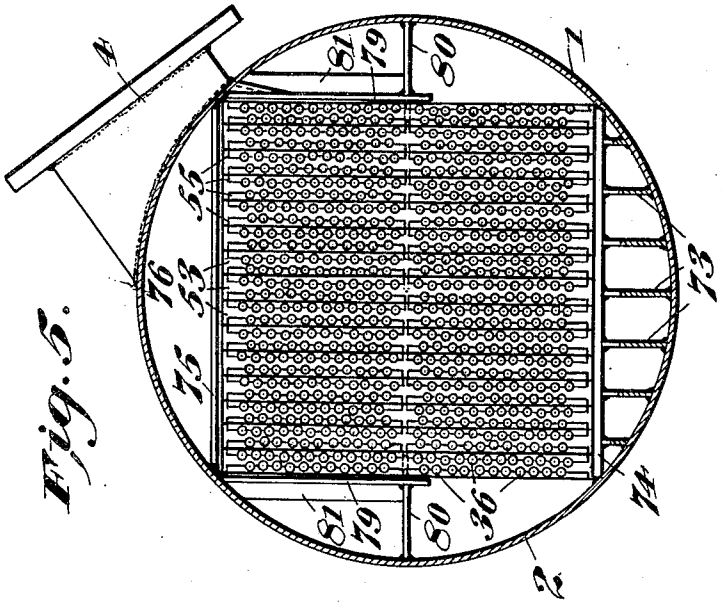


Fig. 5.

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Fig. 8.

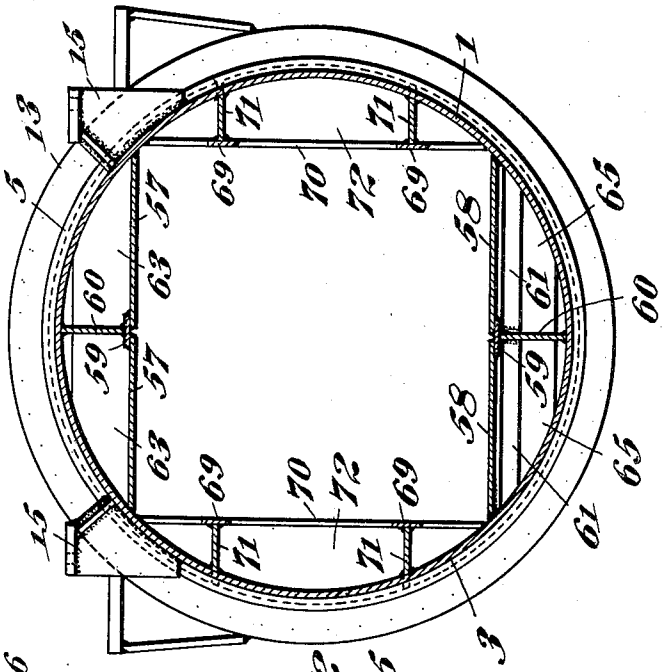
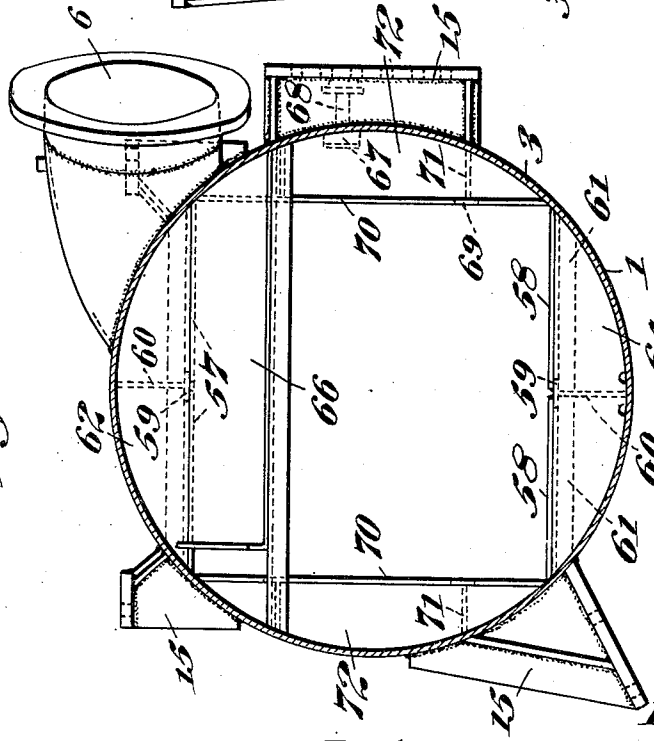


Fig. 7.



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Fig. 12.

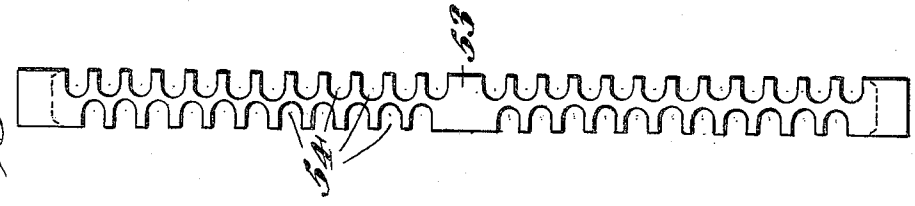


Fig. 13.

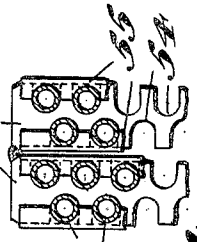


Fig. 15.

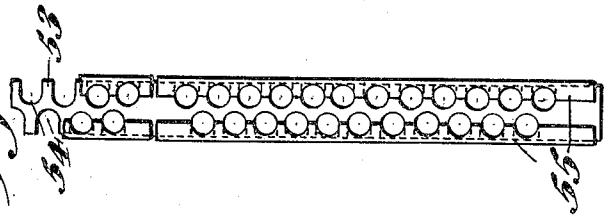


Fig. 11.



Fig. 14.

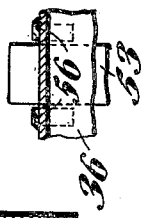


Fig. 16.

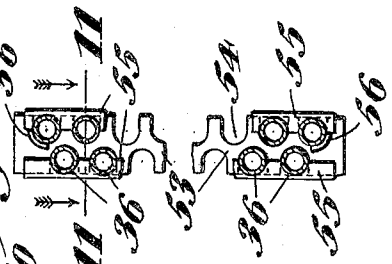
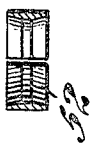


Fig. 10.

Fig. 9.

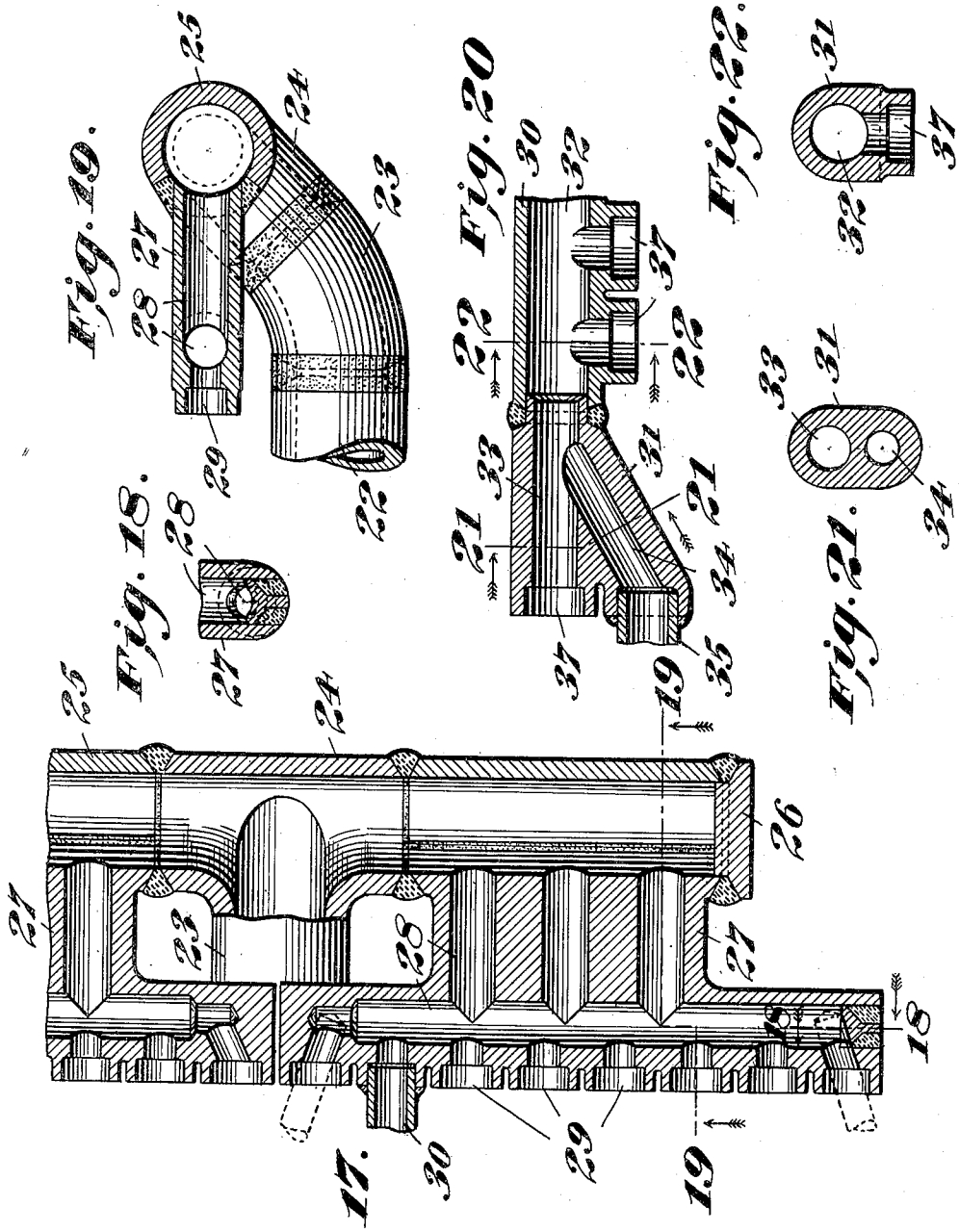


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STEAM REHEATER

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Patented June 30, 1953

2,643,862

UNITED STATES PATENT OFFICE

2,643,862

STEAM REHEATER

John Henry Stelling, Quincy, Mass., assignor to Bethlehem Steel Company, a corporation of Pennsylvania

Application February 18, 1949, Serial No. 77,257

4 Claims. (Cl. 257—239)

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My invention relates in general to a heat exchanger, and more particularly to a turbine steam reheater adapted for marine use.

The steam reheater is a heat exchanger of the shell and tube type designed to receive the exhaust from a steam turbine in a saturated or wet condition and to dry out and superheat this exhaust at substantially constant pressure before passing it on to the inlet of the next turbine in the set. In the modern high pressure, high temperature reheat cycle type of marine propulsion installation, three turbines and two reheaters are often employed. The reheater located between the high and intermediate pressure turbines is designated as the high pressure reheater and that between the intermediate and low pressure turbines as the low pressure reheater. The turbine steam to be reheated flows across and outside of a bank of steel tubes which are heated by superheated steam at boiler pressure.

In a typical marine installation of this type, the high pressure reheater receives steam at approximately 191 p. s. i. g. pressure and 384° F. temperature with 2.5% moisture from the exhaust of the high pressure turbine and heats it to 565° F. temperature before passing it to the intermediate pressure turbine. The low pressure reheater receives steam at about 17 p. s. i. g. pressure and 254° F. with 0.5% moisture and heats it to 565° F. temperature before passing it to the low pressure turbine. Both reheaters receive heating stem from the main boiler superheater outlet at 1500 p. s. i. g. pressure and 750° F. temperature.

Except for its somewhat larger size, the low pressure reheater will generally be similar to the high pressure unit, so that a description of the former will suffice for both. The conventional reheaters have been of the shell and tube type, with one pass of U-tubes expanded into a heavy steel tube sheet forged integrally with the steam chest. Characteristic features, therefore, have been the very thick tube sheet (necessitated by the very high steam pressure), the close spacing of the tubes and correspondingly thin ligaments in the tube sheet, and the type of head joint which consists of a flexible diaphragm sealed by a gasket bolted to the steam chest and backed up by a very thick cover plate.

In marine service, this type of construction has developed two major faults. The high pressure joint between the steam chest and the cover plate, which is subjected to steam of 1500 p. s. i. g. pressure and 750° F. temperature and which under some operating conditions may be subjected to the cooling effect of drains, caused a great deal of trouble from leakage. Several modifications of joint designs and gasket types have been tried with only partial success, and seal welding the joint makes access to the tube sheet for repairs extremely difficult.

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The second fault involved the failure of a large number of the joints between the tubes and the tube sheet, and here also it has been found ultimately necessary to seal weld the tube ends to the tube sheet.

The features which have caused so much trouble have been used on land, in central station and industrial practice, with apparently good results. Differences between marine and stationary operating conditions, such as the drainage and temperature fluctuations during maneuvering and in the more frequent warm-up and shut-down cycles of a marine plant, are undoubtedly responsible.

One object of my invention, therefore, is to provide an arrangement of welded tubes, elements, element headers, element header manifolds and supply and drain headers in such a way as to form the equivalent of a standard staggered pitch tube bundle without the tube sheet and high pressure steam chest cover joint associated with the usual reheater design.

Another object is an arrangement of the element tube supporting plates in such a way that when the individual elements are assembled to form a complete tube bundle the element supporting plates align themselves to form a desired baffle pattern for directing the steam to be heated back and forth across the tube bank in the most efficient manner.

A further object is a construction permitting ready removal of any tube element without disturbing the remaining elements.

Still another object is an arrangement of the element headers with their axes parallel to the axes of the tubes which they serve.

Other objects, purposes and advantages of my invention will appear hereinafter in the specification and in the appended claims.

In order to render my invention more clearly understood, I shall now refer to the attached six (6) sheets of drawings forming a part of this specification and in which like characters of reference designate like parts:

Figure 1 is a vertical section of my reheater taken on the line 1—1 of Fig. 3;

Fig. 2 is a vertical section on the line 2—2 of Fig. 4;

Fig. 3 is a longitudinal horizontal section on the line 3—3 of Fig. 1;

Fig. 4 is a top plan view with the shell partly broken away to show the interior arrangement;

Fig. 5 is a transverse vertical section on the line 5—5 of Fig. 3;

Fig. 6 is a transverse vertical section also on the line 5—5 of Fig. 3, but with the tube elements omitted;

Fig. 7 is a transverse vertical section on the line 7—7 of Fig. 2, with tubes similarly omitted;

Fig. 8 is a transverse vertical section on the line 8—8 of Fig. 2, also with tubes omitted;

Fig. 9 is a vertical section of a chill ring such

as is used in welding the heating steam drain;

Fig. 10 is a detail vertical section of the heating steam drain;

Fig. 11 is a transverse horizontal section on the line 11—11 of Fig. 16, and showing the assembly of a tube support plate with tubes and retaining plate;

Figs. 12 to 16 inclusive are additional detail views of the tube support assembly;

Fig. 17 is a horizontal section of the inlet header manifold;

Fig. 18 is a fragmentary vertical section on the line 18—18 of Fig. 17;

Fig. 19 is a vertical transverse section on the line 19—19 of Fig. 17;

Fig. 20 is a longitudinal vertical detail section of the terminal end of an inlet element header;

Fig. 21 is a vertical section on the line 21—21 of Fig. 20; and

Fig. 22 is a vertical transverse section on the line 22—22 of Fig. 20.

Referring now more particularly to Figs. 1 to 4 of the drawings, the elongated steel shell 1 of my reheater preferably comprises two cylindrical sections, a forward or header section 2 and a rear or tube-enclosing section 3, the former section being slightly larger circumferentially and having an outlet connection 4 therefor and the latter section being flared outwardly as at 5 to correspond and having an inlet connection 6 for steam from the turbine. The ends of the shell are closed by the dished heads 7 and 8, the rear head 7 being permanently secured in place by welding or the like. Suitable means such as standard hex nuts 9 on studs 10 and bolts 11, compressing standard metallic-asbestos or "Flexitallic" type gaskets 12, between the pairs of annular flanges 13 and 14, removably secure the shell portions and the front head 8 together in axially assembled relation. Welded support brackets 15 and lifting lugs 16 are also provided in conventional manner.

The inlet nozzle 17 passes the high pressure (1500 p. s. i. g.) heating steam through the disc plate 18 mounted by means of the ring plate 19 on the top of the shell and within the shell is connected by means of the 90° L 20, pipe 21, reducer fitting 22, 45° L 23, and T 24 to the transversely arranged horizontal steam supply header pipes 25. Welded into said header pipes 25 are end pieces 26 and a pair of inlet element header manifolds 27, which are forgings specially machined and provided with drilled passages 28 and sockets 29 as shown in Figs. 17, 18 and 19 to distribute the heating steam to fifteen longitudinally arranged horizontal inlet element headers 30. Said inlet element headers 30 are welded into the sockets 29 of the element header manifolds by means of standard socket welding procedure.

Each of the fifteen aforementioned inlet element headers 30 (the bifurcated outer end piece 31 of one of which is shown in Figs. 20 to 22 inclusive) in turn distributes steam through drilled channels 32, 33 and 34 to the inlet legs 35 of twenty-three tubes 36, which are similarly welded into the sockets 37 of the element headers 30 by means of socket welds. Said tubes 36 are of U-shape with vertically disposed inlet legs 35 as aforesaid and outlet legs 38 (see Fig. 1) alternately offset to permit arrangement in staggered pairs and with progressively enlarged radii of end curvature to permit their nesting together in an interfitting relationship.

The outlet legs 38 of said tubes 36 are connected in the same manner to a parallel assembly of fifteen horizontal outlet element headers 39, transversely disposed outlet element header manifolds 40, drain header pipe 41, drain header T 42, 45° L 43, pipe 44, 90° elbow 45, and a heating steam drain connection 46 on disc plate 47 mounted on ring 48. A small vent 49 is provided on the drain connection to vent air and non-condensable gases from the system, also a gage glass connection 50 and flange 51, as shown in Fig. 10. Welding is facilitated by removable chill rings 52 (Fig. 9).

A unit consisting of the two element headers 30 and 39 and twenty-three heating tubes 36 is called, for purposes of designation, an element. The tubes of each element have attached to them tube support plates 53 (Fig. 13) having outward slots 54 which serve to support the tubes and maintain them in the desired relationship to each other. The tubes are retained in these support plate slots 54 by correspondingly inwardly slotted side retaining strips 55 (Figs. 11, 12, 15 and 16) and welded stop strips 56 (Figs. 14 and 16).

It will be observed that the tubes of each element are arranged in such a way that when all the elements are assembled, a cross-section of the tube bundle (Fig. 5) finds the tubes in a conventional close staggered pattern, which serves to promote heat transmission and conserve space.

The tube support plates 53 of a number of adjacent elements are welded together in groups at top (see Fig. 12) and bottom, preferably with a very slight open space left between them, to form in effect vertical transverse baffles. As shown in Fig. 3, the location of these groups of plates on the elements is such that when the elements are assembled into a complete tube bundle the aligned support plates 53 form a tortuous baffle system directing the flow of turbine steam transversely back and forth across the tubes for maximum contact and most efficient transmission of heat.

In order to confine the turbine steam to the path across the tube bundle, thereby increasing its velocity and preventing longitudinal bypassing of the tubes, the segments of the shell above and below the tube bundle are closed off by the upper and lower horizontal baffle plates 57 and 58, welded to longitudinally disposed flat bars 59 and stiffeners 60, and to transverse angle bars 61, and which run parallel practically the entire length of the rear section 3 of the shell. Transverse short upper and lower vertical end pieces 62, 63, 64 and 65 prevent steam from flowing through the void spaces and thus bypassing the tubes. An impingement baffle 66 in way of the turbine steam inlet prevents erosion of the tubes by the wet steam entering the unit, and there is also a smaller impingement baffle 67 for low pressure turbine drain connection 68.

Horizontally and vertically disposed flat guide bars 69 and 70, at the sides of the tube bundle, and strengthened by horizontal and vertical stiffeners 71 and 72, assist in maintaining tube alignment between the top and bottom baffle plates. At the header end, support brackets 73, transverse horizontal lower and upper flat bars 74 and 75, and an upper baffle plate 76 are welded as shown in Fig. 5 to support the initial group of tube support plates 53. There are also provided end plate 77 with removable cover plate 78, and side half-baffle plates 79 braced by flat bars 80 and additional stiffeners 81.

Under operating conditions, the above de-

scribed arrangement of element headers with their axes parallel to rather than perpendicular to the axes of the tubes is ideally suited to reheater service, since the quantity of steam required by the tubes is governed by the amount of heat that can be transferred from them to the surrounding turbine steam, which, owing to the low heat transfer coefficient obtaining for this condition, is small and can readily be handled by headers of this type without appreciable pressure drop or requiring excessive initial velocity.

The welded header type reheater completely eliminates both the large diameter high pressure steam chest cover joint as well as the tube sheet with its troublesome rolled-in tube joints. Welding of the tubes into the element headers and of the element headers into the element header manifolds is accomplished by means of standard socket welding procedure, of a type that has been in successful use for a long time in connection with main steam piping. This type of welding is permitted by marine classification and inspection authorities without radiographic examination, a factor which greatly facilitates construction.

A further advantage of this unit is its ready accessibility for inspection and repair. The shell can be opened at two places for inspection of the high pressure parts. Isolation of a defective element can be readily accomplished by removing the shell end head, cutting or burning out a section of the element headers of the defective element and welding plugs into the stubs remaining in the element header manifolds. This will permit the unit to be returned quickly to service. Replacement of the defective element can then be postponed until some convenient time such as in connection with the annual inspection and overhaul of the vessel.

Although I have described and illustrated my invention in considerable detail, I do not wish to be limited to the exact and specific details thereof as shown and described, but I may also use such modifications, substitutions or equivalents thereof as are embraced within the scope of the invention or as are pointed out in the appended claims.

I claim:

1. In a heat exchanger, the combination of a substantially horizontal cylindrical container provided with inlet and outlet connections for the medium to be heated at opposite ends of the container and with vertically spaced inlet and outlet connections for the heating medium at the same end of the container as the heated medium outlet, a pair of substantially horizontal manifolds disposed in parallel relation crosswise of the container and connecting to the heating medium inlet and outlet connections respectively, a plurality of longitudinally disposed parallel element headers connected at right angles to said manifolds, and a plurality of horizontally arranged staggered U-shaped tubes having alternately offset vertical legs interconnecting vertically aligned pairs of element headers.

2. In a heat exchanger, the combination of a container provided with an inlet connection for the medium to be heated at one end of the container, an outlet connection for the heated medium and an adjacent inlet connection for the heating medium at the other end of the container, an outlet connection for the heating medium in vertically spaced relation to the inlet therefor, a plurality of U-tubes connected to the inlet and outlet connections for the heating medium and forming a horizontally staggered tube bundle, tube support plates having outwardly opening slots in alternately staggered relation on opposite side edges, tube retaining U-shaped strips having corresponding inward slots and engaging said plate side edges, and stops welded onto the tubes at opposite faces of the tube support plates, a plurality of assembled tube support plates and retainer strips being welded together and arranged to cause the medium to be heated to pass transversely back and forth through said staggered tube bundle.

3. In a steam reheater, the combination of a horizontal container, an inlet connection for high pressure reheating steam at the top of the container near one end thereof, an outlet connection for said reheating steam located thereunder at the bottom of the container, an inlet connection for the steam to be reheated near the opposite end of the container, an outlet connection for the reheated steam adjacent the reheating steam inlet, a plurality of U-tube elements connected between the inlet and outlet connections for the reheating steam, and recessed vertical plates and cooperating recessed closure members for retaining the U-tube elements in assembled staggered relation, said plates being aligned to coact with the staggered U-tube elements to provide a tortuous baffle system for the steam being reheated.

4. In a steam reheater for marine use, the combination of a horizontal shell divided into two sections removably secured together, an inlet connection for the steam to be reheated in the upper part of one end of the shell, an outlet connection for the reheated steam in the upper part of the opposite end of the shell, an inlet connection for reheating steam adjacent the reheated steam outlet, an outlet connection for said reheating steam in the bottom part of the shell vertically beneath the reheating steam inlet, a plurality of unitary U-tube elements including inlet and outlet manifolds connected to the inlet and outlet connections for the reheating steam and comprising a horizontal tube bundle, tube support means providing a serpentine path for the steam to be reheated across the tube bundle, horizontal plates above and below the tube bundle to confine the steam to be reheated to the desired path, and an impingement baffle interposed between the inlet connection for the steam to be reheated and the tube bundle.

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