May 4, 1965 C. V. BELANGER 3,181,606

HEAT EXCHANGER BUNDLE

Filed July 9, 1962

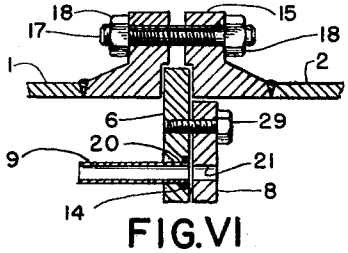


FIG. VI

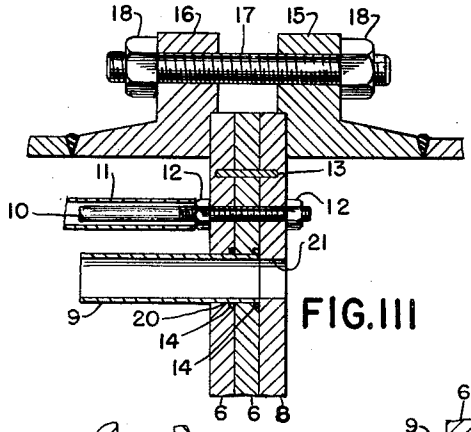


FIG. III

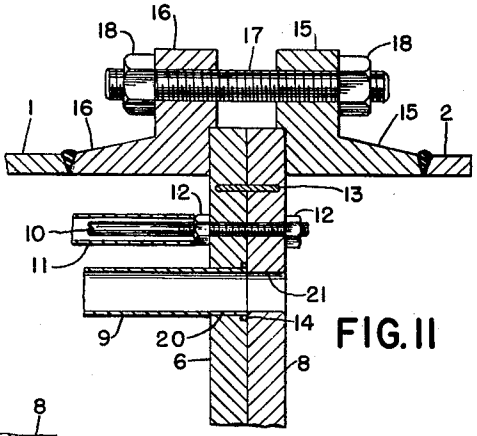


FIG. II

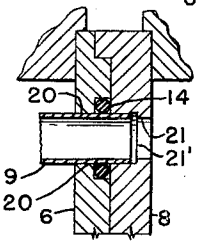


FIG. V

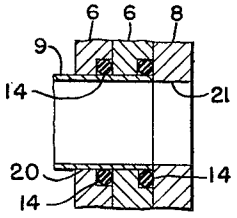


FIG. IV

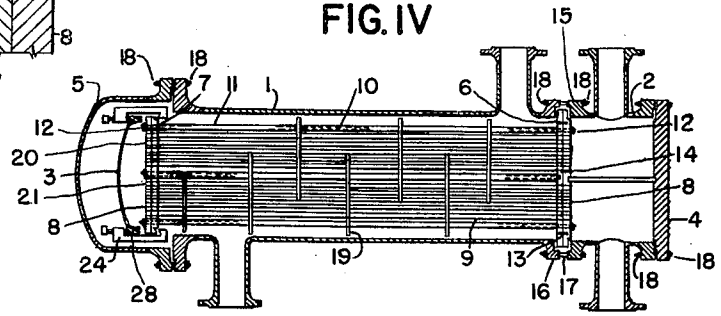


FIG. 1

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3,181,606

HEAT EXCHANGER BUNDLE

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3 Claims. (Cl. 165—158)

My invention relates in particular to a tubular type heat exchanger of the classes usually referred to as floating head, hairpin, fixed tube sheet, etc., which are used in refining and chemical industries and steam generating plants.

The ever increasing and perplexing problem of fouling on the heat transfer surfaces, especially the external surfaces of the tubes, has been a plague to the industries for years, and the tube bundle combination in this art is such that the tube bundles cannot be adequately cleaned once they become fouled. This fouling occurs in a few months in many processes, and the bundles currently used require costly and tedious time consuming efforts for removal and cleaning, as well as, decreasing efficiency as the cumulative fouling progresses. In many instances costly spare alternates are necessary because the time for cleaning and reinstalling cannot be tolerated process wise. In all instances the fouling materials cannot be completely removed from the external surfaces of the tubes, and in many instances this fouling is cumulative to the extent that complete replacement of the tube bundle is necessary. Furthermore, the undesirable characteristic of distorted tubes and tube sheets is unavoidable and uncorrectable because of handling and cleaning methods. Distorted tubes reduce the efficiency of exchangers because it disrupts the flow pattern of the heat exchange streams, and distorted tube sheets make it impossible to properly fit the bundles in the shells.

The modern art of tube bundle assemblies has remained essentially the same for many years and the present day tube bundles are integral units and mechanically constructed to remain as an inseparable unit throughout its service life. No attempts have been made as an objective to provide an exchanger assembly with the structural characteristics whereby it can be 100 percent cleaned and whereby the tubes and tube sheets are individually detachable at each cleaning without any detrimental effect to any of the parts of the tube bundle assembly. The solution to the fouling problem is and has been beyond the realm of mechanical skill because the present and past art of heat exchanger assemblies has never been and is not at the present suitable to cope with this difficulty.

The mechanical principle of the O-ring which I propose to use for effecting an impervious seal between tube and tube sheet will make it possible to retain all the desirable features of the present day bundles and will add the features which will allow the bundles to be quickly disassembled, cleaned, reassembled and reinstalled at 100 percent efficiency. The complementary arrangements of parts necessary to maintain this impervious seal has never been used in the art of exchanger bundle assemblies. Mechanical packing of the type and the principle of packing glands similar to that used in packing around pump and valve shafts have been used in tube bundle construction, but it functions on an entirely different mechanical principle than the O-ring in effecting an impervious seal between the tube and tube sheet, and has an entirely different assembly of parts than that required by the O-ring principle. The O-ring principle requires a different assembly of parts from the mechanical packing used in prior arts in that it does not require an applied thrust force by a packing gland acting in a direction parallel to the tube; instead, a preponderance of fluid pressure in

either direction causes the elastic material of the O-ring to move or flow longitudinally of a recess or pocket formed as a counterbore in the tube sheet thus sealing effectively the already tightly fitting parts of the tubes and their supporting sheets or baffles.

The primary objective of my invention is to provide a heat exchanger assembly which employs the O-ring mechanical principle of effecting an impervious seal between the tubes and tube sheets, and a heat exchanger assembly, including tubes, tube sheet or sheets, baffles and tie rods, which can be completely disassembled whereby each individual tube and tube sheet and all other parts are separately detachable for cleaning and straightening and reassembling without any detrimental effect to any of the tubes, tube sheets, baffles, tie rods, etc.

FIGURE I is a diagrammatic vertical longitudinal sectional view of a heat exchange embodying the principles of the invention;

FIGURE II is a fragmentary sectional view on an enlarged scale as compared with that of FIGURE I of a portion of the connections between one of the tube sheets, a heat exchange tube, and accessory connections;

FIGURE III is a view similar to FIGURE II illustrating another embodiment of the invention;

FIGURE IV is a fragmentary sectional view on an enlarged scale of the tube connection of FIGURE III;

FIGURE V is a similar sectional view illustrating a still further modification of the invention;

FIGURE VI is a similar view showing a still further variation.

In FIGURE I, there is shown the shell **1**, the channel head **2**, the floating head **3**, channel head cover plate **4**, bell head **5** stationary tube sheet **6**, floating head tube sheet **7**, tube retainer plates **8**, tubes **9**, tie rods **10**, spacer sleeves **11**, tie rod nuts **12**, **12**, dowel pins **13**, resilient and highly elastic O-ring **14**, channel head flange **15**, shell flange **16**, flange bolts **17**, flange bolt nuts **18**, baffles **19**, tube sheet holes **20**, tube retainer plate holes **21**, clamp ring **24**, and floating head flange **28**.

In FIGURE II, there is shown a partial side view of the exchanger shell **1**, channel head **2**, tube sheet **6**, tube retainer plate **8**, tube **9**, tie rod **10**, spacer sleeve **11**, tie rod nuts **12**, **12**, dowel pin **13**, resilient and elastic O-ring **14**, channel head flange **15**, shell flange **16**, flange bolt **17**, flange nuts **18**, tube sheet hole **20** and tube retainer plate hole **21**.

FIGURE III is similar in all respects to FIGURE II except that it illustrates multiple resilient and elastic O-rings **14** around a tube **9** extending through multiple tube sheets **6** whose tube holes have a portion enlarged and arranged in a manner to actually form recesses to complement the O-rings **14**—**14** around the said tubes **9**—**9**.

FIGURE IV shows the resilient or elastic multiple O-rings **14** in the multiple tube sheets **6**, **6** and a partial section of tube **9** abutting a partial section of the tube retainer plate **8**.

FIGURE V shows a tube retainer plate **8**, having the hole **21** coaxial with the hole **20** in the tube sheet **6**, and said hole **21** being counterbored and adapted to receive the inserted end portion of tube **9** in a close tolerance, and said hole **21** reducing in cross section to a diameter less than the outside diameter of the tube **9** at a point some distance from the end of tube **9** to form an abutment and a limit to the horizontal movement of the said tube **9**.

FIGURE VI shows the periphery of the tube retainer plate **8** as being inside the inner periphery of the channel head **2** so that the channel head flange **15** abuts the tube sheet **6** instead of the tube retainer plate **8** as shown in the other drawings. The tube retainer plate, shown in partially applied position, is adapted to be secured in place by the stud bolt **29**.

Referring in more detail to the drawings, the tube sheet **6** is provided with holes **20**, **20** that are perpendicular to the tube sheet faces and extend all the way through the sheet with a counterbore from the side of the sheet, commonly referred to as the outside face of the tube sheet. The portion of the hole of the reduced diameter forms a very close tolerance with the outside surface of the tube **9**, protruding therethrough so that an impervious seal is formed between the inside periphery of the counterbore and the outside periphery of the O-ring **14**, and an impervious seal at the point of contact of the inside of the O-ring **14** with the outside surface of the tube **9** when the faces of the tube retainer plates **8**, **8** are in position adjacent to the outside face of the tube sheet **6** and **7**.

The tube retainer plates **8** are provided with holes **21** that are coaxial with the holes **20** and are preferably counterbored especially as shown in FIGURE V, to receive an inserted end portion of the tube **9** in very close tolerance and with the remainder of the hole reducing in diameter less than that of the outside diameter of the tube **9**, and extending all the way through the tube retainer plate coaxial with the counterbored portion of the said hole **21**. The end of tube **9** can abut the tube retainer plates **8** where the holes **21** reduce in diameter, but some distance is allowed between the end of tube **9** and the bottom of the counterbore to allow for thermal expansion or slight variations in the lengths of the tubes, but such horizontal movement of the tube **9** is contained to the extent whereby the said tube **9** cannot slip out of the counterbore in the said tube retainer plate **8**, or out of the O-rings **14** at either end, or be subjected to compressive stresses under any condition. This endwise expansion distance is indicated at **21'** in FIGURE V. It is of importance also that the O-ring itself not be in subjection to axial or longitudinal compression as in the case of an ordinary stuffing box.

The face of the tube retainer plate **8** abuts the face of the tube sheet **6** and is adapted to extend parallel with the tube sheet **6** to be clamped and held dimensionally stable between the channel head flange **15** and shell flange **16**, when nuts **18**, **18** are tightened on flange bolts **17** at the channel head end of exchanger thereby securing the bundle in the shell **1** for heat exchange service.

The arrangement of the tube retainer plate **8**, floating tube sheet **7** and tube **9** are identical on the other end of the exchanger except that a clamp ring **24** is shown to clamp the tube retainer plate **8** between the floating tube sheet **7** and the flange of the floating head **3**. The tube retainer plate **8** can be attached to the tube sheet **6** by stud bolt **29**. This type assembly shown in FIG. VI does not require that the tube retainer plate **8** extend with the tube sheet **6** to be clamped between the channel head flange **15** and shell flange **16**. Instead the periphery of the tube retainer plate **8** shall be of less diameter than the inside diameter of the channel head **2** or floating head **3** so that the channel and floating head flanges **15** and **28** respectively can abut the outside faces of the tube sheets **6** and **7**.

The tie rods **10** are provided with threaded ends and are of sufficient length to extend through the coaxial holes in the tube sheet **6** and tube retainer plate **8** at one end of the bundle, and through coaxial holes in the tube sheet **7** and tube retainer plate **8** at the other end of the bundle. The jam nuts **12**, **12**, when tightened in position secure the tube sheets **6** and **7** at both ends of the bundle to their respective tube retainer plates **8**, **8**, which maintains dimensional stability to the length of the bundle.

The spacer sleeve **11** is tubular in construction and sleeves over the tie rod between the baffles **19**, **19**, and are of proper length whereby the ends abut the faces of the baffles **11**, or baffle **11** and tube sheets **6** or **7**, to secure the baffles in a dimensional stable position with respect to the positions of the tube sheets **6** and **7** when the bundle is held secure in position in the shell **1**.

It is obvious that minor variations in details of construction, some of which are illustrated, are possible without departing from the spirit of my invention.

Having fully described the objective and apparatus and its mode of operation, I claim:

1. A fluid heat exchange device comprising, in combination, a casing having inlet and outlet connections for two fluids between which transfer of heat is to be accomplished, a tube bundle disposed for immersion in one of said fluids and through the tubes of which the other fluid is circulated, and means embodied in said bundle to support the tubes in spaced relation and to seal off the interior of the tubes from the first-named fluid, said bundle thus including the following: a tube sheet having holes therethrough through which the ends of said tubes pass, each of said holes being counterbored from the outside of the bundle to provide an annular cavity of rectangular cross-section taken axially of the tube which passes therethrough, a retainer plate applied to the outer face of the tube sheet to complete the enclosure of the cavity, the cavity thus comprising an axially inward wall at the bottom thereof, an outer cylindrical wall formed by the side wall of the counterbore, a radially inner wall comprised by the outer wall of the tube, and an axially outer wall comprised by the inwardly facing surface of the retainer plate; the retainer plate being provided with an opening to fit the tube end; the interfitting of the tube in the main bore of the hole in the tube sheet, the interfitting of the tube in the opening in the retainer plate, and the interfitting of the contacting faces of the tube sheet and the retainer plate all being of close tolerances; an elastic O-ring of uniform circular cross-section entirely contained within but of somewhat smaller cross-section than that of said annular cavity with its inner and outer diametric boundaries in contact respectively with the radially inward and outward walls of said cavity but free of any significant packing compression in the axial direction; whereby upon subjection of the bundle to a preponderance of fluid pressure from the inside of the tube system, the elastic O-ring will flow longitudinally of the cavity and effectively contact and seal the junction of the main bore of the tube hole in the tube sheet and the wall of the tube at the bottom of the cavity, and conversely upon subjection of the bundle to a preponderance of fluid pressure from outside of the tube system, the O-ring will flow longitudinally in the reverse direction and effectively contact and seal both the junction of the tube wall and the opening in the retainer plate and the junction of the faces of the tube sheet and retainer plate at the outer end of the cavity.

2. The device as set forth in claim 1 in which the O-ring is installed with a slight initial radial compression between the radially inward and outward walls of the cavity.

3. The device as set forth in claim 2 in which the opening of the retainer plate into which the end of the tube projects constitutes a counterbore, said counterbore being of sufficient depth to accommodate the maximum longitudinal expansion of said tube, and a shoulder at the bottom of said counterbore provides a limiting abutment to prevent withdrawal of the tube without removal of said retainer plate.

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