

Dec. 24, 1940.

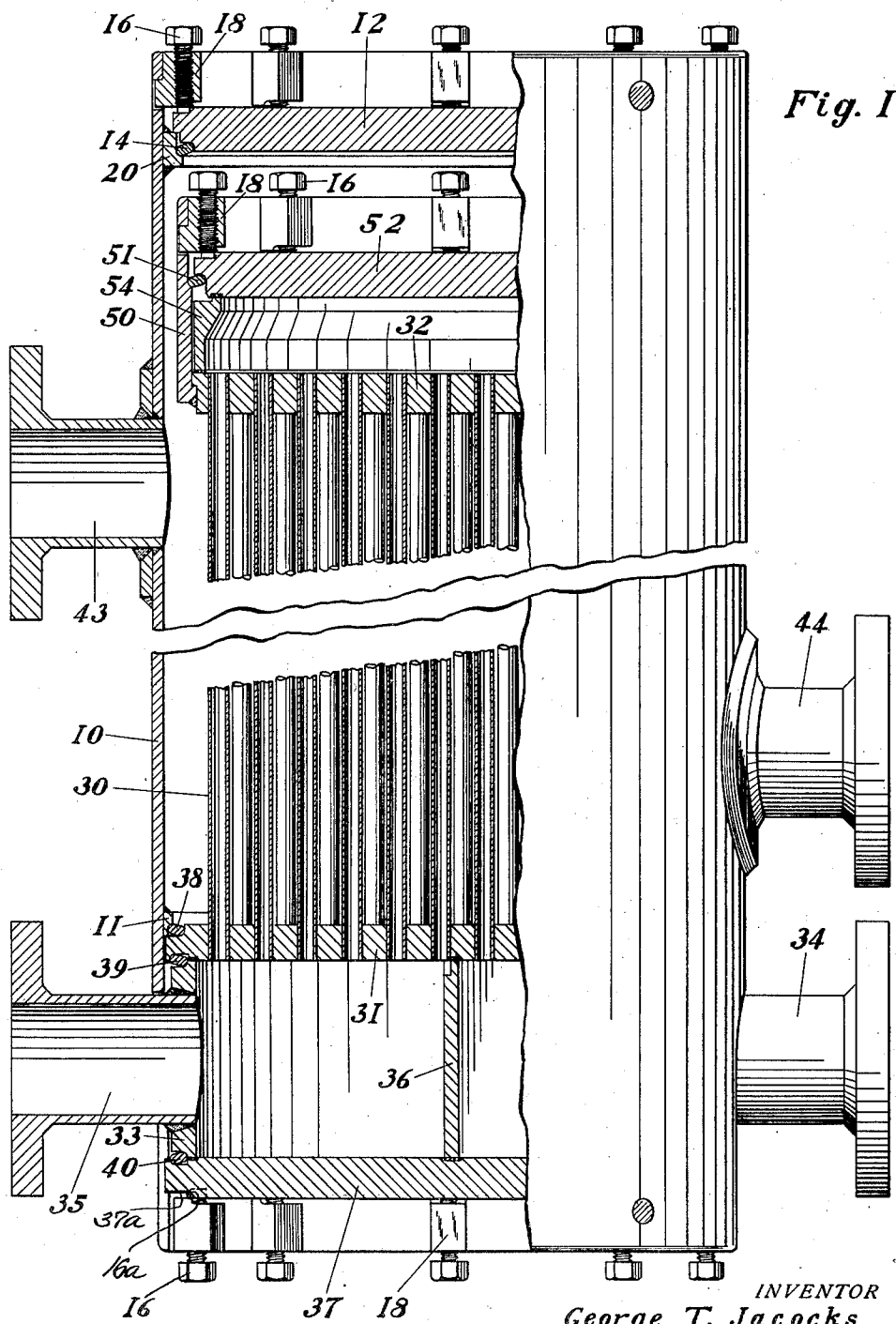
G. T. JACOCKS

2,226,494

PRESSURE VESSEL

Filed Nov. 3, 1937

3 Sheets-Sheet 1



INVENTOR
George T. Jacocks
BY *Nathan*
ATTORNEY

Dec. 24, 1940.

G. T. JACOCKS

2,226,494

PRESSURE VESSEL

Filed Nov. 3, 1937

3 Sheets-Sheet 2

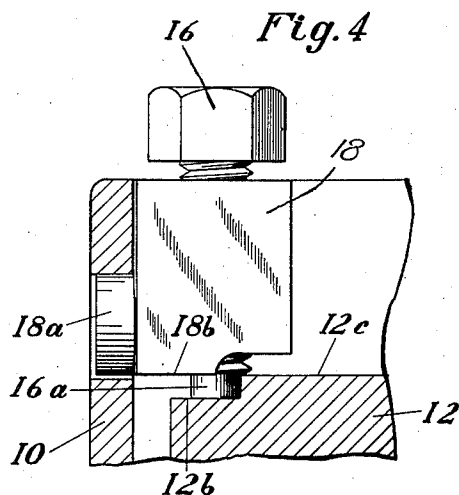
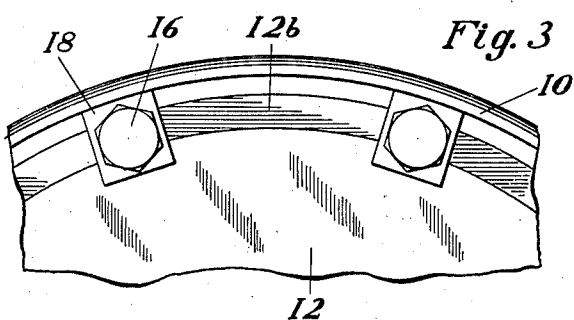
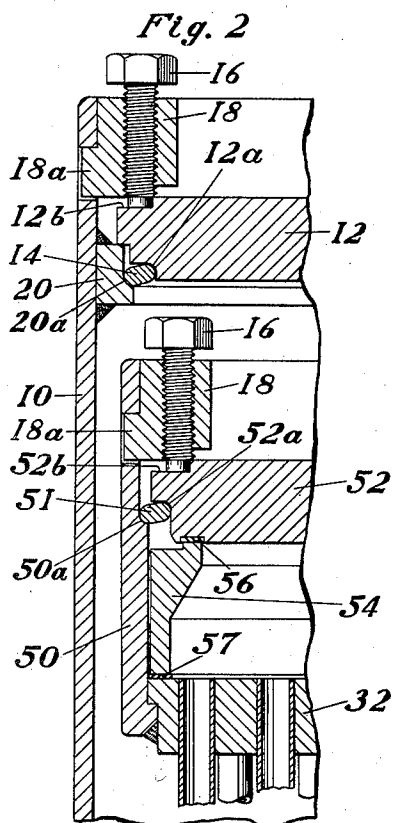
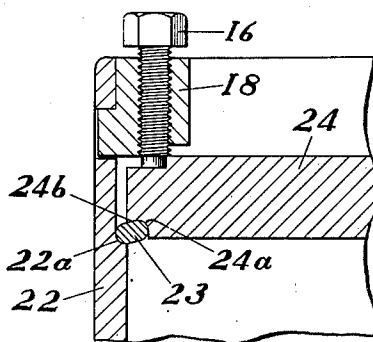
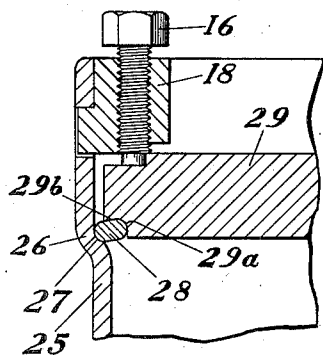


Fig. 6

Fig. 5



INVENTOR
George T. Jacocks
BY
Nathaniel Ely
ATTORNEY

Dec. 24, 1940.

G. T. JACOCKS

2,226,494

PRESSURE VESSEL

Filed Nov. 3, 1937

3 Sheets-Sheet 3

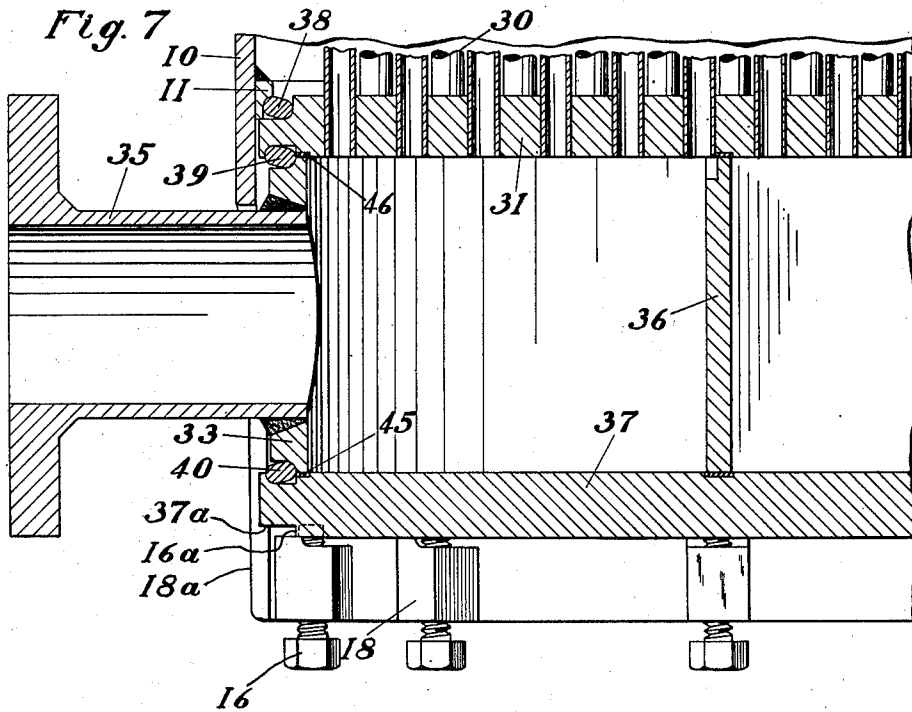


Fig. 8

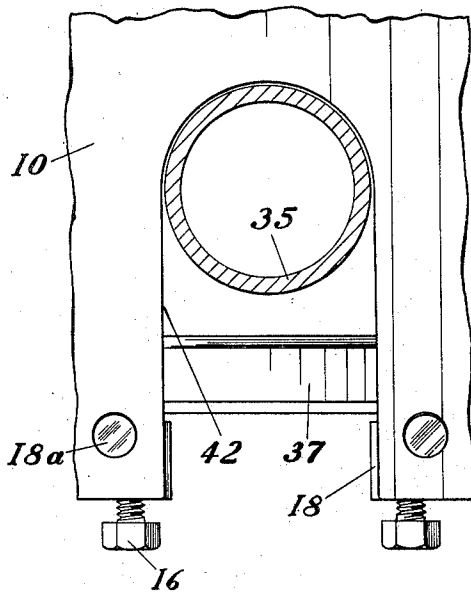
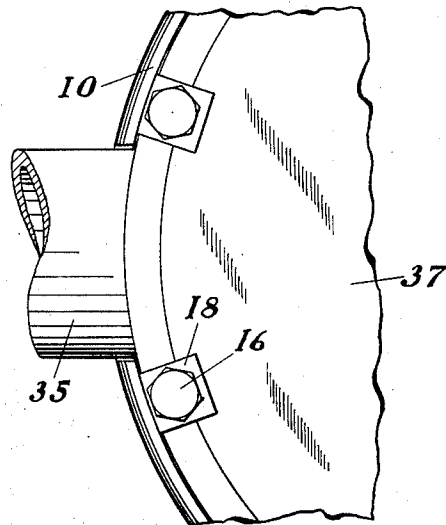


Fig. 9



INVENTOR
George T. Jacocks
BY *Nathaniel Ely*
ATTORNEY

UNITED STATES PATENT OFFICE

2,226,494

PRESSURE VESSEL

George T. Jacocks, Larchmont, N. Y., assignor to
The Lummus Company, New York, N. Y., a corporation of Delaware

Application November 3, 1937, Serial No. 172,567

5 Claims. (Cl. 257—225)

This invention relates to improvements in pressure vessels for high pressure and high temperature service and it more particularly relates to improvements in heat exchangers, although many of the features are suitable for general application.

Heretofore heavy duty pressure vessels, such as tanks, etc., and especially heat exchangers for chemical processing, such as in petroleum refining, have been extremely costly due to the difficulty of fabrication of the detachable parts by which internal cleaning and inspecting may be carried out. Common practice has been to provide large projecting flanges at each joint, and with a heat exchanger, having a tube bundle, there were at least three flanges required. Furthermore, the covers for the channel and the shell were extra large for attachment to these flanges, with the result that the flanges, plus the enlargement of the attaching part, materially increased the weight and cost of the equipment. This has been conservatively estimated to be about twenty-five percent of the total heat exchanger cost.

The principal object of my invention is to provide an improved pressure vessel, the shell of which may be of continuous diameter with all cover plates, channels, etc., sealed to the interior, thereby making it possible to use cover plates, etc., of smaller diameter than the outer diameter of the shell, eliminating all flanges and materially reducing the cost of construction.

Another important object of the invention is to provide an improved seal for an internally secured cover for a pressure vessel which includes a frusto-conical gasket extending between opposing shoulders formed respectively on the cover and shell, such gasket exerting a sealing pressure of a toggle nature independent of the pressure required to hold the cover against internal pressure, and in excess thereof.

A still further object of the invention is to provide an improved form of pressure vessel in which a plurality of separate members such as the channel, channel cover and fixed tube sheet of a heat exchanger, may be simultaneously sealed internally of the shell by a plurality of separate gaskets held by a single series of securing devices.

A still further object of the invention is to provide a heat exchanger with an entirely internal channel which may be readily sealed to the interior of the shell, and readily removed therefrom, with the removal of but a single se-

ries of short compression screws, which in turn, are detachably secured to the interior of the shell.

A further object of the invention is to provide an improved heat exchanger having a continuous shell having greater heat transfer surface for the same shell size, and with a fully removable tube bundle, and separately removable floating cover, such heat exchanger being of relatively much lower cost than heretofore possible.

Further objects and advantages of my invention will appear from the following description of a preferred form of embodiment thereof, when taken in connection with the attached drawings illustrative thereof, and in which:

Fig. 1 is an elevation of a heat exchanger with parts broken away and parts in section;

Fig. 2 is an enlarged sectional view of the floating tube sheet end of the heat exchanger;

Fig. 3 is a partial top plan of the heat exchanger showing a form of securing devices;

Fig. 4 is an enlarged vertical section showing the securing lug details;

Figs. 5 and 6 are views similar to Fig. 4 but showing modified forms of shell construction;

Fig. 7 is an enlarged vertical section of a part of the channel end of the heat exchanger;

Fig. 8 is a partial elevation of the shell, adjacent the channel connection; and

Fig. 9 is a partial bottom plan showing the attachment of the channel cover to the shell.

In accordance with my invention, I have shown a heat exchanger as a specific form of pressure vessel to which my improved sealing device is applicable, it being understood that the invention is applicable to many forms of apparatus although of special value in heat exchangers and that heat exchangers embodying my invention are novel and of great utility. The invention will thus first be described as applied to pressure vessels in general, and thereafter, the invention will be described as applied to heat exchangers of the heater, cooler, condenser or other type.

As shown in Fig. 1, the pressure vessel is comprised primarily of a shell 10 within which a fluid under pressure is to be maintained. Normally, this is accomplished by securing a cover to the open end and in this form of embodiment of my invention, the cover 12 is not only of less diameter than the diameter of the shell 10, but it is secured and sealed within the shell by means wholly within the shell. By such means, external flanges, and large covers are unnecessary.

The preferred sealing device is a ring gasket 14 which is of annular, frusto-conical form, having generally rounded edges and it is adapted to extend between shoulders 12a and 20a on the cover and the shell respectively. These shoulders are formed by any suitable means and are suitably rounded to cooperate with the edges of the gasket. The shoulders are of different diameters and the ring makes an oblique angle therewith, which in the normal, unsealed position may be approximately twenty to forty degrees with respect to the greater axis of the gasket.

As shown in Figure 4, the cover 12 is adapted to be secured to the shell 10 by adjustable screw means 16 which are screw threaded in separate detachable lugs 18, each of which have projecting portions 18a engaging within openings in the shell wall. The screws are adapted to engage a recessed portion 12b on the cover and preferably the bottom 18b of the lugs 18 is in alignment with the top surface 12c of the cover so that the tip 16a of the screws 16 is in shear, thereby reacting against forces which would tend to turn the lug 18 out of the opening in the shell.

The shoulder 12a for the gasket 14 is directly below the recess 12b, as shown in Fig. 2, with the result that if the cover is secured to the shell, the securing force of the respective screws 16 will pass directly through the gasket. There is a minimum amount of metal between the gasket and the bottom of the screws, and comparatively short screws can be used with not only a reduction of metal, but a material reduction of possible expansion and contraction of the parts under temperature changes. Furthermore, the loading being directly on the gasket, the seal will be accomplished with a minimum size of screws.

The action of the gasket is of a toggle form in that the application of force on the cover tends to rotate the gasket or change its angular relation to the respective shoulders and this in turn sets up a high sealing force against each of the respective shoulders. With suitable tolerance and a suitable size gasket, any desired degree of sealing can be effected, it being understood that the change in effective diameter of the gasket between the shoulders depends upon the angular change and the normal major diameter of the cross section of the gasket. If a large tolerance is desired, the angular relation may be increased even as high as 40°, as it is preferable that the gasket be not closed to less than 10° so there is no possibility of the gasket turning out and so that it will be effective in unsealing the shell when the pressure is relieved.

The total pressure on the screws is substantially less than that heretofore required as the screws need resist only the static pressure within the vessel plus a proportion of the load heretofore required for compressing the gaskets, there being no direct compressive force. Although the total force on the screws is very much reduced, the seal is substantially greater due to the high mechanical advantage possible.

Ordinarily it is desirable that the gasket be of a softer material than the shoulders in the shell or in the cover. It will be apparent that the sealing force exerted by the gasket will be very substantial and will cause an effective flow of metal. This is especially desirable for it firmly seats the gasket on the shoulders and fills any irregularity which may exist. It is, of course, possible, that very hard gaskets may be used and

in such cases, the metal in the shoulder itself will flow away from the gasket. The opposite arrangement is preferred as it is usually easier to replace the gasket than to remachine the other parts.

Normally the shoulder is directly formed in the cover and it may be desirable to provide it with a slightly tapering internal wall so that the cover will be self-centering when applied on the gasket. The shoulder 20a in the shell can be formed as shown in Fig. 1 by a supplemental block 20 welded to the shell in the desired region. Where extremely high pressures are expected, and the thickness of the shell is minimum, the supplemental ring is the preferred construction.

A modified construction is shown in Figure 5 in which the thickness of the shell is such that undercutting is not objectionable, and in this case the shell 22 has the shoulder 22a cut directly into it. The gasket 23 engages the shell shoulder and a similar shoulder 24a in the cover 24.

In Fig. 6 a still further modified form of construction is shown in which the shell 25 has been formed with a bell portion 26 forming a shoulder 27 against which the gasket 28 rests. It is of course to be understood that many forms of construction are possible and even in the form shown in Figure 5, there is little opportunity for destruction to the shell as the gasket 23 seals off the cover with respect to the shell at the thick portion of the shell, and the undercut or thin portion of the shell serves merely as a skirt to which the detachable lugs 18 are secured.

In its broadest aspect, the cover is thus secured to a shell by means internal of the shell and is sealed to the shell by an internal gasket of a toggle form. In this manner the shell may be of continuous cross section without flanges and the cover is of less diameter than the shell with the resulting lower cost of manufacture. Furthermore, the lugs being secured to the interior of the shell not only have a lower maximum load but are also directly in alignment with the gasket for more positive sealing. The cover is quickly detachable from the shell and requires no great degree of machining care as the shoulders are completely filled by the high pressure exerted by the gasket. Such a cover is adapted to any form of pressure vessel and is readily applied to either a cylindrical or other curved form.

In its more specific application, the invention is of particular value as a heat exchanger. A heat exchanger is particularly characterized by an internal tube bundle structure and it is usually necessary to provide removable means for inspection and cleaning of the tubes. Again referring to Fig. 1, the tube bundle is generally indicated at 30 and comprises a series of tubes extending between the fixed tube sheet 31 and the floating tube sheet 32, and as is commonly practiced, a channel 33 is sealed to the fixed tube sheet end and is provided with inlet 34 and outlet 35 with an internal pass baffle 36 and the channel cover 37.

The fixed tube sheet 31 in accordance with my invention, is sealed with respect to the shell 10 by a gasket 38 which is similar to the gasket 14 first mentioned and which engages a cooperating shoulder on the interior of the shell as in ring 11 which is welded thereto. In addition, the channel 33 is sealed to the fixed tube sheet 31 by the gasket 39 and is also sealed with respect to the channel cover 37 by the gasket 40 as shown in Figure 7.

In this construction, the adjustable screws 16

are similarly screw threaded into demountable lugs 18 with the tips 16a similarly in shear and engaging a recessed channel 37a on the outer face of the channel cover 37. It will also be seen that the screws 16 are in direct alignment with the multiple gaskets with a direct reaction through the shell and with a single series of screws adapted to seal simultaneously all of the gaskets 38, 39 and 40. This is possible because of the internal construction of the channel and the toggle action on the gaskets which make it unnecessary to have the screws 16 of excessive size.

It is of course to be understood that the channel inlet and outlet nozzles 34 and 35 are secured to the channel 33 in any desired manner as by welding, and if welded as shown, the shell is bifurcated as shown at 42 in Figure 8 so that the channel and tube bundle can be readily withdrawn, by removing lugs 18, from the shell. If desired, the channel may be integrally secured to the fixed tube sheet 31 or to the channel cover 37 or both, but it is preferably a separate part in order that the tubes may be readily cleaned and inspected. The shell inlet and outlet conduits 43 and 44 are of conventional type and location.

The opposite or floating end of the tube bundle includes a skirt 50 which is interlocked and welded to the floating tube sheet 32, such skirt projecting above the tube sheet and having a gasket seat 50a for the frusto-conical gasket 51 which engages a suitable shoulder 52a in the floating tube sheet cover 52. As in the previously described structure, the lugs 18 have the adjustable screws 16 which secure the floating tube sheet and tube sheet cover together, such screws engaging in recess 52b. In this structure the spacer 54 is provided to conduct the flow in the tubes from one section to the other, it being apparent that the spacer can be readily removed and another form substituted having different pass baffles so that the number of passes in the heat exchanger can be changed as desired. Independent flat gaskets 56 and 57 are provided against the edges of the spacer for local tightness, such gaskets being similar to the flat gaskets 45 and 46 between the parts of the channel at the other end of the tube bundle.

The effective area of the floating tube sheet 32 can be substantially increased with the internal seal and securing devices as no extended flange is required. For the same size shell, extra tubes are thus possible or with the same number of tubes a smaller shell may be used. Furthermore the floating tube sheet cover can be readily withdrawn from the top of the heat exchanger by removing the fixed cover 12 for temporary inspection and as previously mentioned, the entire bundle may be removed from the other end.

It will thus be seen that all joints are sealed internally of the shell and by gaskets which increase in tightness as they are forced down but that the seal is independent of the securing pressure. On the tube side, all gaskets are further substantially sealed by the flat gaskets which can be utilized, as the frusto-conical gaskets maintain a seal on the edges rather than on the faces and will allow the parts to move into abutting relation. With hot oil vapor condensers, this is an important feature as erosion of the gaskets is totally avoided. High pressures and low cost are important characteristics of my construction.

While I have shown preferred forms of em-

bodiment of my invention, I am aware that other modifications may be made thereto and I therefore desire a broad interpretation of my invention within the scope and spirit of the disclosure herein and of the claims appended hereafter.

I claim:

1. In a pressure vessel having a shell with an internal shoulder, a cover for said shell and lugs secured to the interior of said shell and having adjustable means for securing said cover to said shell, the bottom of said lugs and the top of said cover being in alignment and the adjustable means extending below the top of the cover, said cover having a lateral portion abutting the adjustable means and forming a shear connection to resist removal of the lugs.

2. In a heat exchanger including a shell, a tube bundle including a fixed tube sheet and a channel member and means to secure said fixed tube sheet to said shell including adjustable members interlocked with said shell, gasket members between said fixed tube sheet and said shell and between said channel and fixed tube sheet, said shell, fixed tube sheet and channel having shoulders formed thereon, with said gaskets maintaining an oblique relation between pairs of shoulders, and a common securing means engaging the interior of the shell and the channel member and securing the tube bundle to the shell.

3. In a heat exchanger including a shell, a tube bundle including a fixed tube sheet and a channel member and means to secure said fixed tube sheet to said shell including adjustable members interlocked with said shell, gaskets between said fixed tube sheet and said shell and between said fixed tube sheet and channel member, said shell, tube sheet and channel member having shoulders formed thereon, with said gaskets maintaining an oblique relation between pairs of shoulders, and a common securing means engaging the interior of the shell and the channel member, and securing the tube bundle to the shell, said channel member including a channel and a channel cover, with a frusto-conical gasket between them.

4. In a heat exchanger having a constant diameter shell, a tube bundle having a fixed tube sheet, a channel for said tube sheet, and means to secure the channel and tube bundle to the internal wall of the shell said means including a shoulder on the interior of the shell, gasket means between said shoulder and the fixed tube sheet, all of said parts including the tube bundle, channel and securing means being within the diameter of the shell.

5. A pressure vessel comprising a shell of constant diameter, a cover for said shell, said cover being of smaller diameter than said shell, said shell including an interior support for said cover; a gasket to seal said cover with respect to said supporting means, means to fasten said cover with respect to said supporting means, said fastening means including a plurality of detachable members secured around the periphery of the shell to the inner wall thereof, said fastening means having a shear connection with the interior of the shell and means within the shell to hold the detachable members in shear relation therewith, and members adjustably carried by said detachable members and reacting with said cover whereby on adjustment thereof the cover may be fastened in a desired position.