Feb. 28, 1950 J. C. SHAW ET AL 2,498,827

OVAL OIL COOLER CONSTRUCTION

Filed Oct. 1, 1945 3 Sheets-Sheet 1

Fig. 1

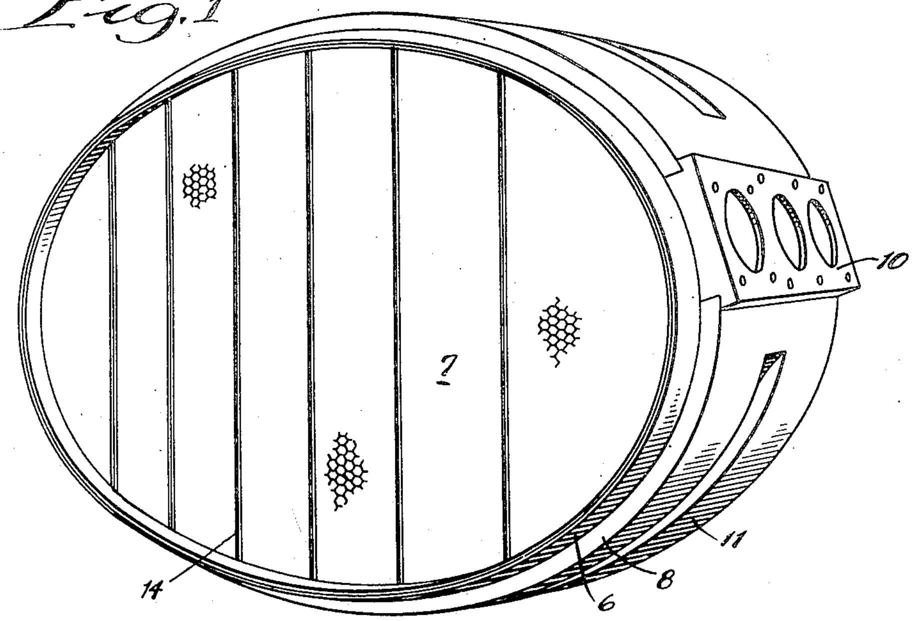
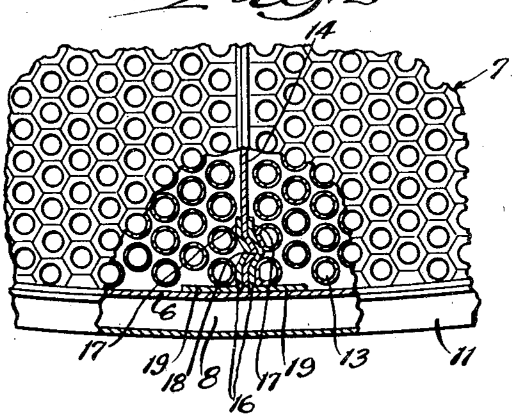


Fig. 2



Inventors:
Joe C. Shaw and
Earl H. Kidd.

By Soans, Pond & Anderson
Attorneys.

Feb. 28, 1950 J. C. SHAW ET AL 2,498,827

OVAL OIL COOLER CONSTRUCTION

Filed Oct. 1, 1945 3 Sheets-Sheet 2

Fig. 3

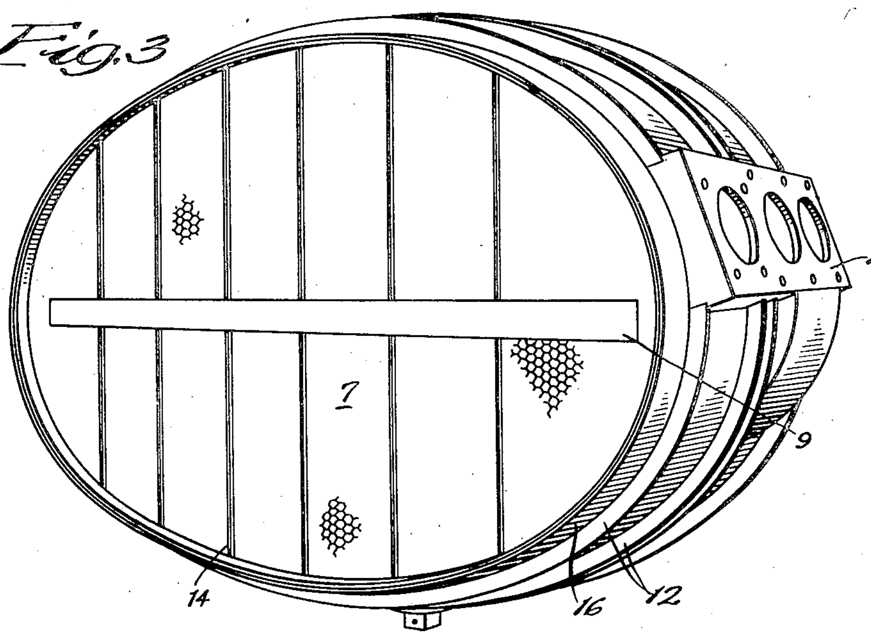


Fig. 5

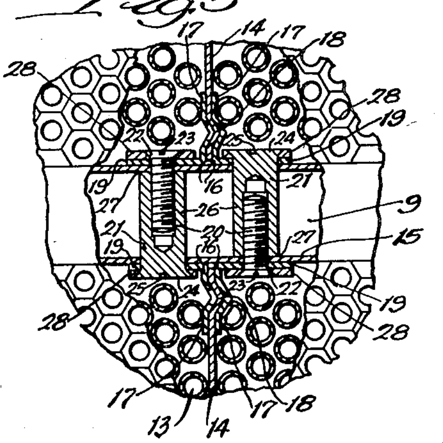
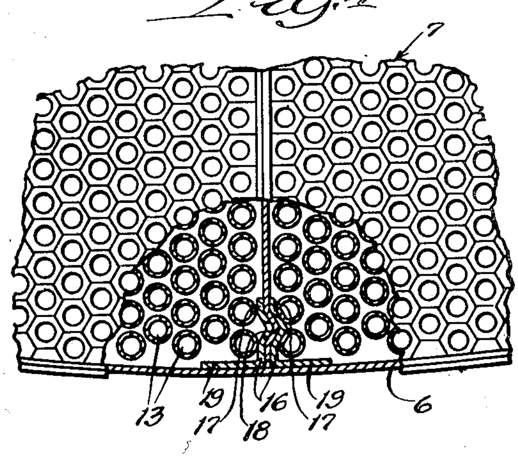


Fig. 4



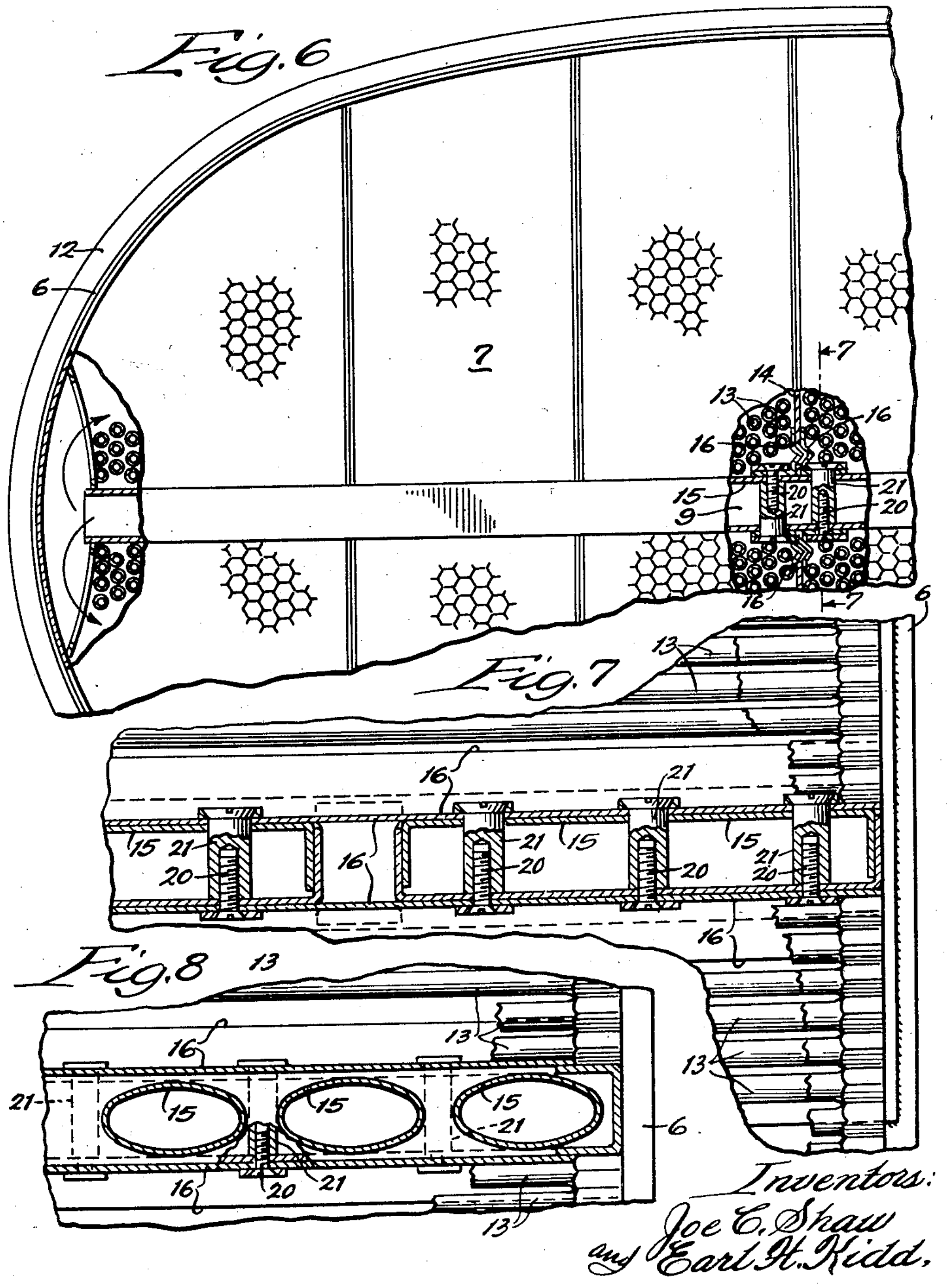
Inventors:
Joe C. Shaw and
Earl H. Kidd,

By Soans, Pond & Anderson
Attorneys.

Feb. 28, 1950 J. C. SHAW ET AL 2,498,827

OVAL OIL COOLER CONSTRUCTION

Filed Oct. 1, 1945 3 Sheets-Sheet 3



Inventors:
Joe C. Shaw
and Earl H. Kidd.

By Soans, Pond & Anderson
Attorneys.

Patented Feb. 28, 1950 2,498,827

UNITED STATES PATENT OFFICE

2,498,827

OVAL OIL COOLER CONSTRUCTION

Joe C. Shaw and Earl H. Kidd, Racine, Wis., assignors to Young Radiator Company, Racine, Wis., a corporation of Wisconsin

Application October 1, 1945, Serial No. 619,668

4 Claims. (Cl. 257—128)

1

This invention relates to heat exchange devices of the type wherein a battery of parallel tubes are arranged in radially-spaced relationship with their ends bonded together to form a core unit which, when sealed within a housing or shell, provides a labyrinth within said housing around said tubes for the flow of a coolant, the temperature of which is to be regulated by the temperature of a cooling medium passing through the tubes. Devices of this type are extensively used for conditioning the temperature of lubricating oil required for power-producing 'units, particularly those employed for aircraft.

The core unit may be made up in either of two ways.

Generally the tubes for such heat exchange core units are circular in cross section throughout their length except for the end portions, which are hexagonally expanded. When these tubes are assembled, the hexagonal heads hold the circular sections in spaced relationship and thus form the desired labyrinth around the tubes. The labyrinth is closed at its ends by bonding together the interfitting hexagonal tube ends and sealing the juncture of the perimetrical row of tube ends of the core unit with the housing or shell. The bonding of the tube ends is effected by soldering, brazing, or welding, as circumstances may require.

An alternative practice is to mount tubes of circular cross section throughout their length in header plates, the holes in the header plates which support the tubes being spaced apart so as to provide for the desired radial spacing between the tubes.

The general practice has been to make these oil cooling devices cylindrical for the reason that a cylindrical housing is less likely to have its contour distorted by excessive internal pressure. However, there has been a growing demand for oval or elliptical oil coolers in order to make better use of the space limitations in aircraft construction.

Notwithstanding their vulnerability to distortion, the oval oil cooler is expected to meet the current requirements of governmental specifications for round oil coolers. These specifications require the device to withstand a maximum air pressure of 100 p. s. i., a maximum pressure oil flow test which will permit cold oil to be forced through the core to a maximum pressure of 80 p. s. i., and a pressure cycle test. Of these tests, the most exacting is the pressure cycle test. This consists in immersing the oil cooler in a bath of hot oil at about 300° F. and alternately applying

2

and releasing air pressure inside the cooler. The pressure is brought up to 60 p. s. i. and then exhausted down to about 0 to 3 p. s. i. at a rate of 6 complete cycles per minute. The cooler design and construction, in order to be satisfactory, must have been able to withstand 50,000 such pressure cycles. The 300° F. temperature to which the cooler is subjected is so high that tin-lead solder is very much weakened. This solder will melt at 350° F. and its strength will go from a ratio of about 17,000 lbs. per square inch for low temperature to about 5,000 or 6,000 lbs. per square inch by the time the solder reaches the temperature of 300° F. Obviously, the cooler must be very well built in order to withstand such a cycle test. The other pressure tests mentioned above are not as severe because they are of short duration only, although the pressure in each case is somewhat higher. All three of these tests include a factor of safety so that the cooler is actually better and stronger than it needs to be to meet the minimum durability requirement in aircraft use. This is necessary, of course, in order to protect the airplane, pilot, passengers, and cargo.

The tendency of an oval or elliptical-shaped device, when subjected to such internal pressure, is to assume a round shape, if possible. For this reason an oval-shaped device requires internal tension bracing or reinforcement in order to retain the required shape for satisfactory operation. Obviously, if the external shell should pull away from the core, it might fracture the joint or the bond between the tubes and the shell and cause disastrous leaks. Also, if the shell pulls away from the core to a certain extent, without fracturing the solder bond between the tube ends and the shell, it is very possible that a considerable gap may be formed between the edge of the baffle and the inside of the shell, allowing excessive bypassing of oil, oil which would not get cooled, thereby causing overheating of the oil and perhaps even engine failure due to lack of proper lubrication.

The method of reinforcing the shell heretofore used has been to fasten the ends of baffle plates to opposite sides of the shell in the rather flat portion of the periphery. These baffles thus serve as supporting members in tension to the strain of the internally applied pressure. It has been the practice to fasten these baffles to the shell by means of brazing, silver soldering, riveting, or bolting. Of these various methods, each one has a particular drawback. Brazing or silver soldering requires a very high temperature in order to melt the bonding alloys. The great amount of heat applied to the shell and to the baffle causes excessive warping and annealing of the shell and the baffle and consequently difficulty in assembly and loss of capacity in performance, as well as weakening the structure. If the baffles are fastened by bolts or rivets there is always a possibility of having a certain amount of leakage around the bolts or rivets to the outside. Moreover, the operation is rather expensive and difficult to perform.

The main objects of this invention, therefore, are to provide, improved tensioning means for elliptical housings used in heat exchange devices that are likely to be subjected to excessive internal pressure; to provide improved means for anchoring to the opposite sides of the housing the ends of the transverse baffle plates used in the construction of the tubular core unit; to provide improved anchoring means of this kind especially suited for use with the elliptical-shaped housings for the oil cooler units required for modern aircraft; to provide an improved baffle-plate anchoring means of this kind which can be used with an elliptical housing having either an external or an internal warm-up chamber; and to provide improved baffle-plate anchoring means of this kind which is simple to construct, easily secured in place, and highly effective in use.

Embodiments of our invention applicable to two types of warm-up chamber oil coolers are shown in the accompanying drawings, in which:

Fig. 1 is a perspective view of an elliptical oil cooler with an external warm-up chamber;

Fig. 2 is an enlarged fragmentary view, partly elevation and partly sectional, showing the improved anchoring means for a baffle plate serving as a tension member;

Fig. 3 is a perspective view of an elliptical oil cooler equipped with an internal warm-up chamber;

Fig. 4 is a view similar to Fig. 2 illustrating that in the oil cooler with an internal warm-up chamber the baffle plates are anchored to the shell in the same manner as in the oil cooler with the external warm-up chamber;

Fig. 5 is an enlarged fragmentary partly-sectional and partly-elevation view showing how the anchoring means for the baffle plates are mounted on the tubes which form the internal warm-up chamber;

Fig. 6 is a fragmentary view, partly in section, showing how the transversely-disposed rectangular-shaped tubes, that constitute one form of the internal warm-up chamber, are mounted on the shell;

Fig. 7 is a transverse sectional detail of the same; and

Fig. 8 is a similar view but showing how the baffle plates are anchored at their inner ends when elliptical tubes are used for internal warm-up chamber.

A heat exchange unit of the oil cooler type, to which this invention is particularly adapted, comprises a housing or shell 6 within which is supported a core unit 7 and with which is incorporated either an external warm-up chamber 8 or an internal warm-up chamber 9. A valve block 10 is suitably secured to the housing 6 to support a valve mechanism adapted to automatically control the flow of oil through said core unit 7 and/or said internal warm-up chambers 8 and 9.

In either modification of the oil cooler herein shown, the shell 6 is of the conventional sheet metal construction.

The external warm-up chamber is formed by bonding a channel member 11 to the outer surface of the housing 6. This channel member also serves as a reinforcement to the housing or shell 6.

The internal warm-up chamber is formed by a plurality of tubes 15 extending transversely diametrically across the long inside dimension of the shell 6. At one end these tubes 15 communicate with the inlet in the valve block 10, and at the other end are connected by a header which permits communication between these tubes, which header is provided with openings which also permit communication between these tubes 15 and the labyrinth of the core unit 7. These tubes may be rectangular in form as shown in Figs. 6 and 7 or elliptical in shape as shown and described in the co-pending application of Shaw-Schlapman, Serial No. 508,104, filed October 29, 1943 now Patent No. 2,480,675 issued August 30, 1949. In such a structure the housing has strips of metal bonded to the outer face thereof to provide external reinforcement bands.

For either type of oil cooler the core unit 7 is of standard construction, comprising a battery of tubes 13 sealed within the housing 6 with the tubes disposed axially of said housing. The tubes 13 are of conventional design, being cylindrical in cross section throughout their length except at their ends, which are expanded and formed hexagonal. This permits the tubes to be arranged in radially-spaced relationship so that when the ends of the tubes are bonded together and the core unit 7 is sealed in the housing 6 a labyrinth is formed within the housing and around the tubes through which oil is permitted to flow in order that the temperature thereof may be regulated by the air or other cooling medium passing through the tubes 13. The bonding of the hexagonal heads of the tubes together and the sealing of the core within the housing may be either by the process of soldering, brazing, or welding. In the formation of these core units it is a general practice to place baffle sheets 14 between the groups of tubes so as to cause a circuitous flow of the coolant through the labyrinth.

When the oil cooler of the external warm-up chamber type is used, the tubes 13 occupy the entire space within the perimeter of the housing 6. For the internal warm-up chamber type of cooler the tubes 15 replace a few rows of tubes 13 through the middle of the core unit 7.

Heretofore oil coolers constructed with a housing or shell 6 of elliptical form have presented a problem in providing tensioning means to secure the housing against possible distortion by reason of the internal pressures to which the housing may sometimes be subjected. It has been more or less the usual practice to employ the baffle plates 14 as tensioning means. However, as hereinbefore pointed out, all of the previous methods by which the baffle plates 14 are anchored to the housing 6 have proved defective in one way or another.

An anchoring means constructed in accordance with this invention involves the use of angle bars 16 arranged in pairs and bonded to the inner surface of the housing so as to provide a pair of parallel flanges 17 adapted to receive the edge of a baffle plate 14. The flanges 17 and baffle plate 14 are crimped or corrugated, as shown at 18, so as to provide interlocking shoulders. These shoulders are depended upon to secure the baffle plate 14 against separation from the angle bars 16 transversely of the housing 6.

The angle bars 16, after having the flanges 17 crimped or corrugated as shown at 18, are placed on the inner face of the housing 6. The oppositely-disposed flanges 19 are spot- or seam-welded to the housing. This being done by electrical resistance confined to the area of welding, causes no excessive heating of the housing and consequently no distortion thereof, as has been the case when in the past attempts have been made to bond the baffle plate 14 directly to the inner face of the housing 6. In the present invention, the baffle plates 14, after being crimped or corrugated along their opposite edges, may be slipped in edgewise between the flanges 18 and subsequently soldered in place. However, it is not the soldered joint, but the interlocking relationship of the crimped parts of the baffle and flanges that are depended upon to hold the baffle plate against the expansive force caused by the pressures within the housing 6. Hence, even though the temperature of the oil flowing through the core may be close to the melting point of solder, the weakened hold of the solder will not be affected by the strain of the tensional pressures on the baffle plate 14.

In oil coolers of the internal warm-up chamber type, it is impossible to extend the baffle plates 14 from one side of the housing to the other. They have to terminate on opposite sides of the tubes 15. Although the outer ends of the baffles 14 may be anchored to the housing 6, as is done for the oil cooler of the external warm-up chamber type (as shown in Figs. 2 and 4), it is necessary to provide a special anchoring means for the inner edges of these baffle plates adjacent the tubes 15, since it would be impractical to weld the angle bars 16 to these tubes. One very suitable method involves the use of a special bolt and nut arrangement. The bolt or screw 20 is of more or less conventional construction, being provided with a taper head 22 having a kerf 23 formed therein to receive a screwdriver. The nut 21 is likewise formed with a screw-type head 24 having a kerf 25 formed therein but has an elongated shank 26 within which the bolt or screw 20 fits. The length of the shank is sufficient to span the distance between the outer face of the flange 19 and the opposite inner face of the tube 15 (or that of the U-shaped bar which supports and spaces the elliptical tubes shown in Fig. 8) thus providing a shoulder 27 which limits the movement of the bolt or screw 20 relative to the nut 21, and prevents any distortion of the tube 15 or bar when the angle bars 16 are secured in place.

The flanges 19 are apertured, one to receive the bolt or screw 20 and the other to receive the nut 21. Washers are inserted between the heads of the bolts 20 and nut 21 and the respective flanges. Any leakage of oil from the tubes 15 around the bolt and nut connections will only be slight. Since it is inside the housing 6 it will in no wise be detrimental to the operation of the cooler.

An oil cooler of this construction has several advantages. In the first place, tension means are provided capable of withstanding the high pressures to which the housing may be subjected, without the hazard of having it lose its shape with the resultant breaking or deforming of its structure. Moreover, it provides a locating means whereby the size of the cooler is correctly maintained and thus improves the uniformity of construction in units of this type. There is a further advantage that it is not necessary to use high-temperature solder.

Other variations and modifications in the details of structure and arrangement of the parts may be resorted to within the spirit and coverage of the appended claims.

We claim:

1. A heat exchange unit of the class described comprising, an elliptical housing adapted to enclose a core unit formed of a battery of tubes disposed axially of said housing and located on the opposite sides of a plurality of transversely-extending tubes spanning the long dimension of said housing and forming an interal chamber, a baffle plate interposed between said axially disposed tubes and extending transversely of and between said housing and said transversely extending tubes, a pair of angle bars having their oppositely-disposed flanges bonded to the inner face of said housing so as to position the parallel flanges thereof in abutting engagement with the opposite faces of said baffle plate along the outer edge thereof, and a second pair of angle bars having their oppositely-disposed flanges anchored to said transversely extending tubes to position the parallel flanges in abutting engagement with the opposite faces of said baffle plate along the inner edge thereof, said pairs of interfitting angle bar flanges and said baffle plate being crimped to form interlocking shoulders offset from the respective planes thereof whereby said baffle plate and angle bars are secured against relative movement transversely of said housing.

2. A heat exchange unit of the class described comprising, an elliptical housing adapted to enclose a core unit formed of a battery of tubes disposed axially of said housing and located on the opposite sides of a plurality of transversely-extending tubes spanning the long dimension of said housing and forming an internal chamber, a pair of alined baffle plates interposed between said axially disposed tubes and extending from opposite sides of said housing to said transversely extending tubes, pairs of angle bars each having one flange thereof bonded to the inner face of said housing adjacent to the outer edge of each of said baffle plates so as to position the other flanges of each pair in parallel abutting engagement with the opposite faces of said baffle plates along said outer edges, other pairs of angle bars located on opposite sides of said transversely extending tubes so as to position the parallel flanges of each said other pair of angle bars in abutting engagement with the opposite faces of said baffle plates along the inner edges thereof, and bolt and nut means extending through said transversely extending tubes and clamping the oppositely-disposed flanges of said other pairs of angle bars to opposite sides of said transversely extending tubes, said baffle plates and interfitting flanges being crimped to form interlocking shoulders offset from the respective planes thereof whereby said baffle plate and angle bars are locked against relative movement transversely of said housing.

3. A heat exchanger of the class described comprising, an ellipitical-shaped housing open at opposite sides thereof, two pairs of angle bars one flange of each of which is crimped to form an offset extending longitudinally of the flange intermediate its longitudinal edges, said pairs of angle bars being bonded to the interior face of said housing at transversely opposite points with the crimped flanges disposed transversely parallel so that the crimped portions face in the same direction and are spaced apart a distance equal to the thickness of the hereinafter mentioned baffle plate, a baffle plate crimped to form offsets extending along and adjacent to the oppo-

site longitudinal edges spanning said housing and having offsets therein nesting in unbonded relationship with the offsets in the opposite pairs of angle bar flanges and thereby forming a tension strut for said housing, and a plurality of tubes disposed axially of said housing and filling the spaces between said housing and said baffle, said tube ends being bonded together and to the edges of said baffle to form a core around said tubes within said housing.

4. The method of producing an oil cooler of the class described which consists in forming a housing open at the opposite sides thereof, crimping one flange of each of two pairs of angle bars to form an offset extending longitudinally of each flange intermediate the longitudinal edges thereof, crimping a baffle plate to form an offset extending along and adjacent each longitudinal edge, placing said pairs of angle bars axially of said housing at transversely opposite points on the interior face of said housing with the crimped flanges disposed parallel and transverse to the face of said housing so that the crimps face in the same direction and are spaced apart a distance equal to the thickness of said baffle plate, welding the oppositely-extending flanges of each of said pairs of angle bars to said housing, placing said baffle plate with one end disposed in the plane of the parallel flanges of the opposite pairs of angle bars with the crimped portions of said baffle plate in registration with the crimped portions of said angle bar flanges and then sliding said baffle plate in its plane axially of said housing to locate the opposite

ends of said baffle plate inwardly of the respective open sides of said housing with the crimped portions of said baffle plate in interlocking engagement with the crimped portions of the parallel flanges of the respective opposite pairs of angle bars, filling the spaces in said housing between said baffle and said housing with tubes disposed axially of said housing, and then bonding the ends of said tubes together and to the ends of said baffle plate to form a core around said tubes within said housing.

JOE C. SHAW.
EARL H. KIDD.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
1,737,759	Harter	Dec. 3, 1929
1,801,468	Van Dusen	Apr. 21, 1931
1,894,675	Dixon	Jan. 17, 1933
2,172,806	Probeck	Sept. 12, 1939
2,315,407	Evans	Mar. 30, 1943
2,358,698	Flath	Sept. 19, 1944
2,396,650	Hannah	Mar. 19, 1946
2,424,795	Burns	July 29, 1947
2,433,454	Hoffman	Dec. 30, 1947

FOREIGN PATENTS

Number	Country	Date
450,060	Great Britain	Oct. 3, 1941