Jan. 21, 1964 J. A. OLSON 3,118,497

HEAT EXCHANGER

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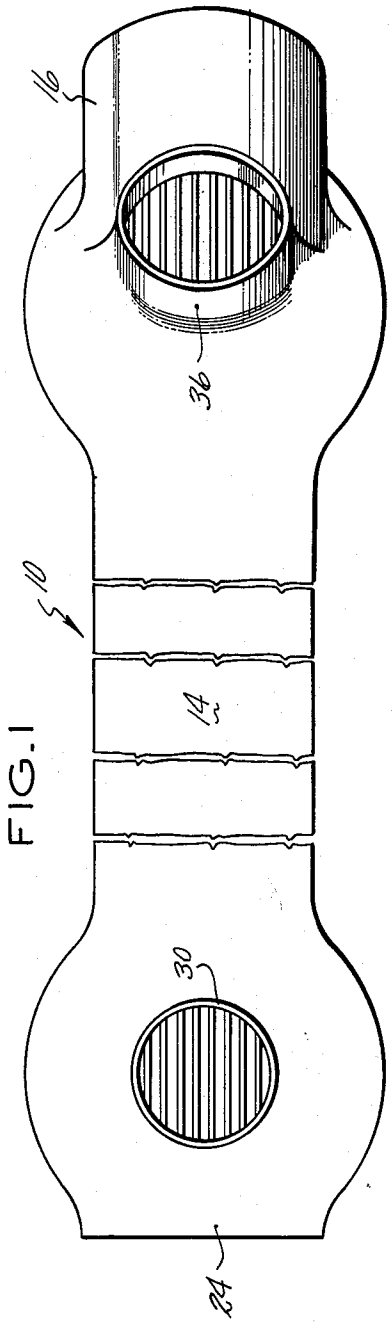


FIG. 1

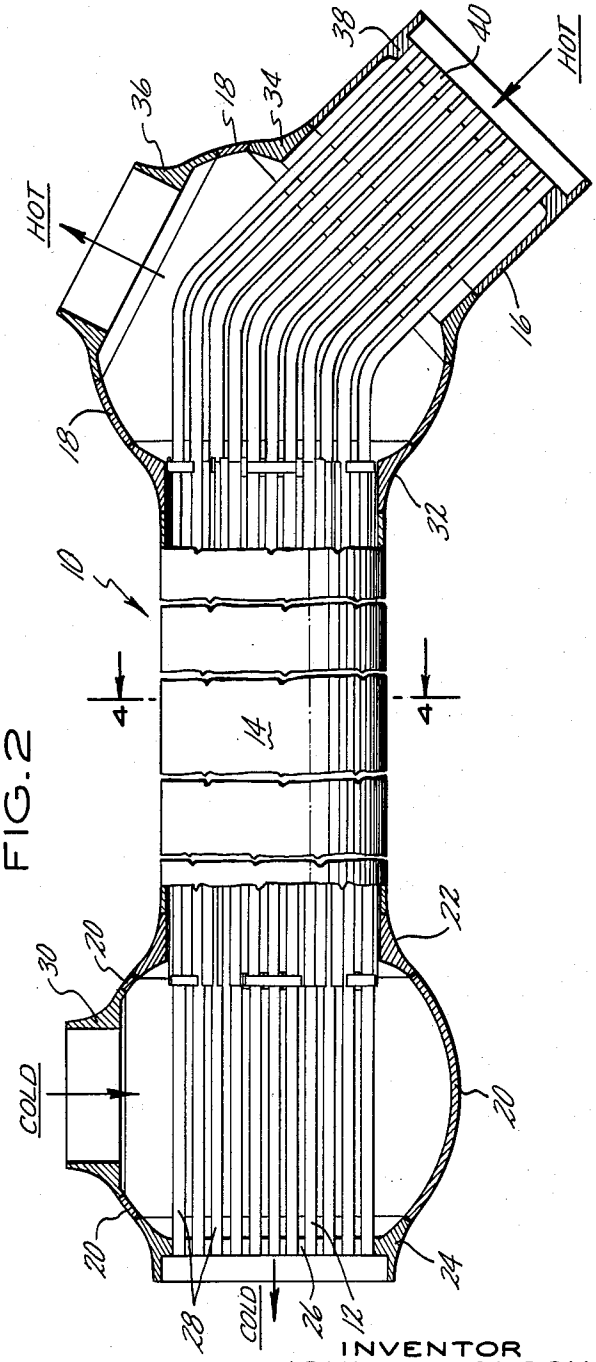


FIG. 2

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FIG. 3

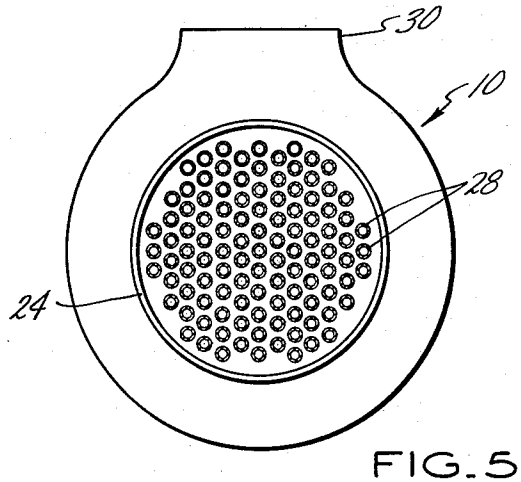


FIG. 4

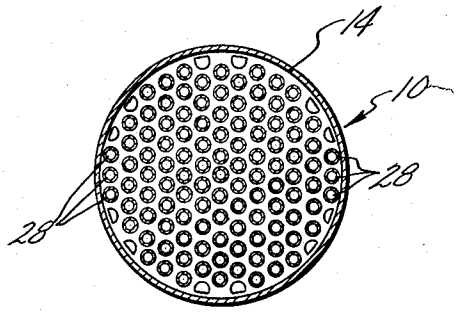


FIG. 5

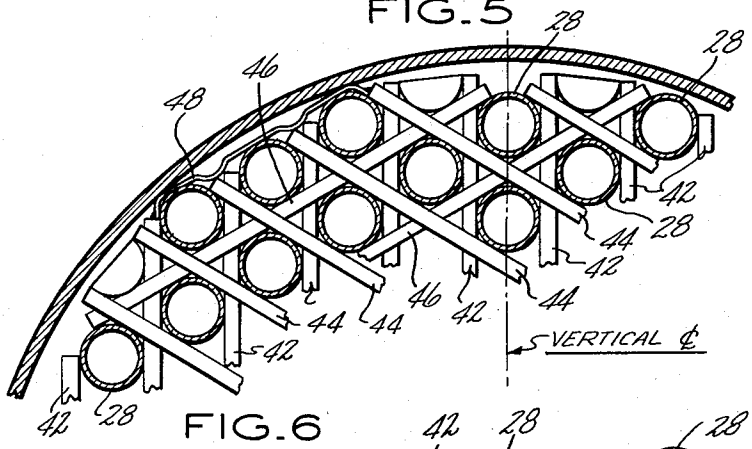


FIG. 6

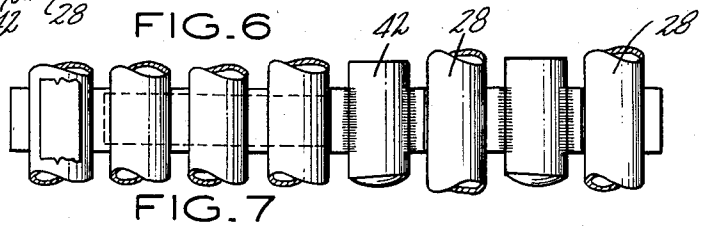


FIG. 7

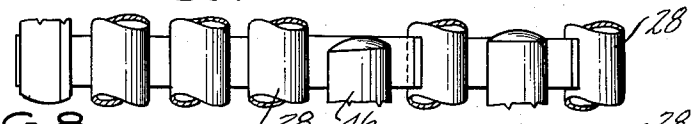
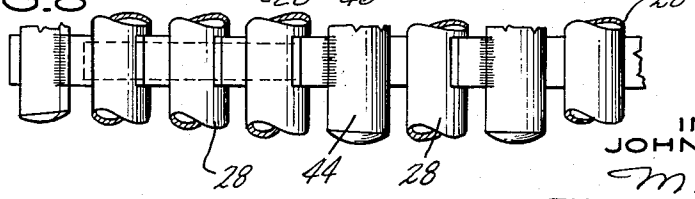


FIG. 8



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3,118,497
HEAT EXCHANGER

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Filed Jan. 19, 1962, Ser. No. 167,232
5 Claims. (Cl. 165—157)

This invention relates to tube- and shell-type, counterflow heat exchangers especially adapted for use with fluids which have very high operating temperatures, such as liquid metals.

It is an object of this invention to provide an improved radiator of a modified Z-bend combined with spherical diffuser means at the bend. The modification to the radiator involves making the shell and the tubes at one end of the radiator long and straight, and at the other end bending the shell and the tubes obliquely to provide a short, straight section. A spherical diffuser is provided at the free end of the elongated straight portion and a second spherical diffuser is provided at the junction of the straight and oblique sections, the cold inlet for the second fluid being at the spherical diffuser at the free end of the elongated section and the hot outlet for this fluid being at the diffuser located at the bend. The hot counterflow fluid is admitted at the free end of the short oblique section and is discharged at the cold free end of the elongated straight section.

It is, therefore, another object of this invention to provide a spherical diffuser at the bend in such a radiator having one sphere axis coinciding with the axial center line of the long straight section of the radiator with another axis of the sphere coinciding with the axial center line of the short, oblique section of the radiator.

It is another object of this invention to provide a radiator of this type in which all the welded joints between the straight cylindrical sections of the radiator shell and the spherical diffusers are circular and the distribution of stresses are uniform.

A further object of this invention is to greatly simplify the welding problems in making a radiator of this type. A still further object of this invention is the provision of a heat exchanger of this type in which the envelope size, flow area and expansion area are of optimum size.

A yet further object of the invention is the provision of a radiator shell including a diffuser in which an enlargement in shell diameter of the heat exchanger decreases the ratio of sphere diameter to case diameter, thus allowing enlargement of the heat exchanger without encountering the problem of a diffuser of unmanageable size.

A still further object of this invention is generally to improve heat exchangers.

These and other objects and advantages of this invention will be obvious or will be pointed out in connection with the following detailed description of one embodiment of the invention shown in the accompanying drawings. In these drawings:

FIG. 1 is a plan view of a heat exchanger embodying the invention, parts being broken away to facilitate illustration;

FIG. 2 is a sectional side elevation of the heat exchanger of FIG. 1;

FIG. 3 is a left-hand end view of FIG. 1;

FIG. 4 is a section on line 4—4 of FIG. 2;

FIG. 5 is a detail view showing the tube spacer array; and

FIGS. 6, 7 and 8 are detail views of the spacers shown in FIG. 5.

Referring particularly to FIGS. 1 and 2, the heat exchanger includes a generally tubular outer shell 10 and a tube bundle 12 which extends from end-to-end of shell 10. The shell consists of an elongated cylindrical section 14 and a short cylindrical section 16 which is oblique to section 14. The two sections are connected by generally spherical diffuser 18 having one of its sphere axes coinciding with the axial center line of shell section 14 and having another sphere axis coinciding with the axial center line of the short shell section 16.

Section 14 of the shell is also provided with a spherical diffuser 20 at its free end having one of its sphere axes aligned with the axial center line of section 14. The diffuser 20 is connected to shell section 14 by an adapter 22 which is welded to the tubular section 14 at one end and to a circular opening in the spherical diffuser at its other end. A similar adapter 24 is provided at the extremity of the spherical diffuser which is also welded to a circular opening in the diffuser. The adapter 24 also has a tube sheet header 26 to receive the ends of the tubes 28 comprising the tube bundle. Diffuser 20 also has an inlet adapter 30 which is at right angles to the longitudinal axis of section 14. This adapter is also welded to a circular opening in the spherical diffuser 20. The spherical diffuser 18, which connects the two shell sections, is connected to shell section 14 by an adapter 32 which is welded at one end to section 14 and at its other end to a circular opening in the spherical diffuser 18. Similarly, the short shell section 16 is connected to the spherical diffuser by welding an adapter 34 to shell section 16 at one end and to a circular opening in the spherical diffuser at its other end. The diffuser 18 also has a tubular outlet adapter 36 which is welded to a circular opening in the spherical diffuser and which lies on an axis which is oblique both to the longitudinal axes of shell section 16 and shell section 14. It will be noted that by the arrangement of the shell sections, spherical diffusers and adapters, all welds in the shell are circular, thus simplifying the operation of welding and also eliminating stresses due to expansion and contraction of shell parts. The short shell section 16 is also provided with a flanged header tube 38 which has an integral tube header sheet 40 to receive the ends of the tubes comprising the tube bundle 12.

The tubes are supported in the shell in spaced relation, one to another, by means of a plurality of vertical rods 42 which are placed between the vertical stacks of tubes 28 and by oppositely oblique rods 44 and 46. The rods are held in place by peripheral bands 48 which are welded to the rods and to the shell at their points of contact. In this way passages between the tubes are provided for the relatively cold liquid metal entering adapter 30 and flowing through outlet adapted 36. The hot counterflowing liquid metal enters the adapter tube 38, flows through the tubes, and discharges through adapter tube 24 as a relatively cold fluid.

As a result it will be evident that the hot end of the heat exchanger is at the end having the oblique bend in the tubes. Consequently, most of the tube expansion is taken up at this hot end where the expansion occurs. It

will also be evident that by having all the welded joints between the shell and the spheres circular, a uniform distribution of stresses occurs and welding problems are simplified. Also, the use of the spherical diffuser means gives the optimum of shell size, flow area and expansion area. As the shell diameter increases, the ratio of sphere diameter to shell diameter decreases. This means that the size of the heat exchanger can be enlarged without encountering the problem of a diffuser of unmanageable size.

This particular configuration has the advantage that the inside diameter of shell 14 may be machined to close tolerances since it may be merely slipped over the tube bundle during assembly. With the use of fluids of high conductivity in particular, channeling of fluid flow is a big problem. With a Z-bend radiator, having a bend at both ends, shell 14 would have to be divided longitudinally on one diameter and put on in two pieces, requiring two longitudinal welds. It is virtually impossible to control the weld shrinkage in such a case to hold the inside diameter within the tolerances desired.

It is another advantage of this configuration that the inlet opening in the side of the shell (cold side) may be positioned at any rotational angle about the axial center line of the tube bundle. Additionally, the fluid outlet on the side of the shell (hot side) may be rotated through a limited angle about the axial center line of the tube bundle.

While only a single embodiment of the invention has been shown herein, it will be understood that various changes in the construction and arrangement of the parts may be resorted to without departing from the scope of the invention as defined in the following claims.

I claim:

1. A heat exchanger comprising, a tubular shell, said shell including a main straight section of considerable length and a short straight section at one end of said main section having its longitudinal axis oblique with respect to the longitudinal axis of said main section, a generally spherical diffuser at the junction of said shell sections having one of its axes coinciding with the longitudinal axis of said main section and another of its axes coinciding with the longitudinal axis of said short section, and a second spherical diffuser at the other end of said main section, a tube bundle extending through said shell from end-to-end including both shell sections and both diffusers, fluid connections for a first fluid located at each end of said shell including tube header sheets, and adapters on said spherical diffusers providing fluid connections for a second fluid.

2. A heat exchanger comprising, a tubular shell, said shell including a main straight section of considerable length and a short straight section at one end of said main section having its longitudinal axis oblique with respect to the longitudial axis of said main section, a generally spherical diffuser at the junction of said shell sections having one of its axes coinciding with the longitudinal axis of said main section and another of its axes coinciding with the longitudinal axis of said short section, and a second spherical diffuser at the other end of said main section, a tube bundle extending through said shell from end-to-end, including both shell sections and both diffusers, the tubes in said bundle having a bend in said first spherical diffuser, fluid connections for a first fluid located at each end of said shell including tube header sheets, and adapters on said spherical diffusers providing fluid connections for a second fluid.

3. A heat exchanger comprising a tubular shell, said shell including an elongated main section and a shorter section having its longitudinal axis oblique with respect to the longitudinal axis of said main section, a first generally spherical diffuser at the junction of said shell sections, a second generally spherical diffuser at the other end of said main section, a plurality of bent core tubes extending axially through both said shell sections and both said diffusers, a tube header at each end of said tube core including a tube header sheet forming a hot inlet for one fluid to enter said tubes at the free end of said shorter shell section and a cold outlet for said fluid at said second diffuser, an outlet adapter forming an outlet for a second fluid external of said tubes at the end of said first diffuser, an inlet adapter forming an inlet for said second fluid at said second diffuser, said inlet adapter having its longitudinal axis transverse to the longitudinal axis of said main shell section, and said outlet adapter having its longitudinal axis oblique both to the longitudinal axis of said shorter shell section and to the longitudinal axis of said main shell section.

4. A heat exchanger comprising a tubular shell, said shell including an elongated straight section and a short straight section having its longitudinal axis oblique with respect to the longitudinal axis of said main section, a spherical diffuser at the junction of said shell sections having one of its axes coinciding with the longitudinal axis of said elongated shell section and having another of its axes coinciding with the longitudinal shell section of said short axis, said spherical diffuser having an outlet adapter on the oblique angle side of the shell bend through which fluid flowing in said shell is discharged, a second spherical diffuser at the other end of said elongated shell section, said second diffuser having an inlet adapter for admitting fluid into said shell having its flow axis transverse to the longitudinal axis of said elongated shell section, said second diffuser also having a fluid-outlet adapter for a second fluid having its longitudinal flow axis aligned with the longitudinal axis of said elongated shell section, said last-mentioned outlet adapter including a transverse tube header sheet, a fluid-inlet adapter for said second fluid at the free end of said short shell section having its longitudinal axis aligned with the longitudinal axis of said short shell section, said last-mentioned inlet adapter including a transverse tube header sheet, and a plurality of bent tubes connecting said two header sheets at the remote ends of said shell.

5. A heat exchanger comprising a tubular shell, said shell including a main straight section of considerable length and a short straight section at one end of said main section having its longitudinal axis oblique with respect to the longitudinal axis of said main section, a spherical diffuser between the adjacent ends of said shell sections having one of its axes coinciding with the longitudinal axis of said main shell section and another coinciding with the longitudinal axis of said short shell section, an adapter connected at one of its ends to the circular end of said main shell section at said adjacent end of the latter and to a circular opening in said spherical diffuser at the other of its ends, a similar adapter connected at one of its ends to the circular end of said short shell section at said adjacent end of the latter and to a circular opening in said spherical diffuser at the other of its ends, a second spherical diffuser at the end of said main section remote from said short section having one of its axes coinciding with the major axis of said main shell section, an adapter connected at one of its ends to the circular end of said main section and at its other end to a circular opening in said second diffuser, fluid connections located at the remote ends of said shell including header sheets, a tube bundle extending through both said shell sections and both said diffusers from end-to-end of said shell having the ends of its tubes extending through said header sheets at the remote ends of said shell, a fluid connection on said second diffuser for a second fluid, an adapter having one of its ends connected to a circular opening in said second diffuser and having its other end connected to said last-mentioned fluid connection, the axis of said last-mentioned fluid connection being transverse to the longitudinal axis of said main shell section, a fluid connection on said first spherical diffuser for said second fluid, an adapter having

one of its ends connected to a circular opening in said first diffuser and having its other end connected to said fluid connection on said first spherical diffuser, said fluid connections for said first and second fluids all being circular and the connections between them and said adapters and between said adapters and said diffusers being circular welds, whereby stresses due to expansion and contraction of said shell parts are eliminated.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,118,497 January 21, 1964

John A. Olson

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 4, lines 22 and 23, for "shell section of said short axis," read -- axis of said short shell section, --.

Signed and sealed this 9th day of June 1964.

(SEAL)
Attest:

ERNEST W. SWIDER
Attesting Officer

EDWARD J. BRENNER
Commissioner of Patents