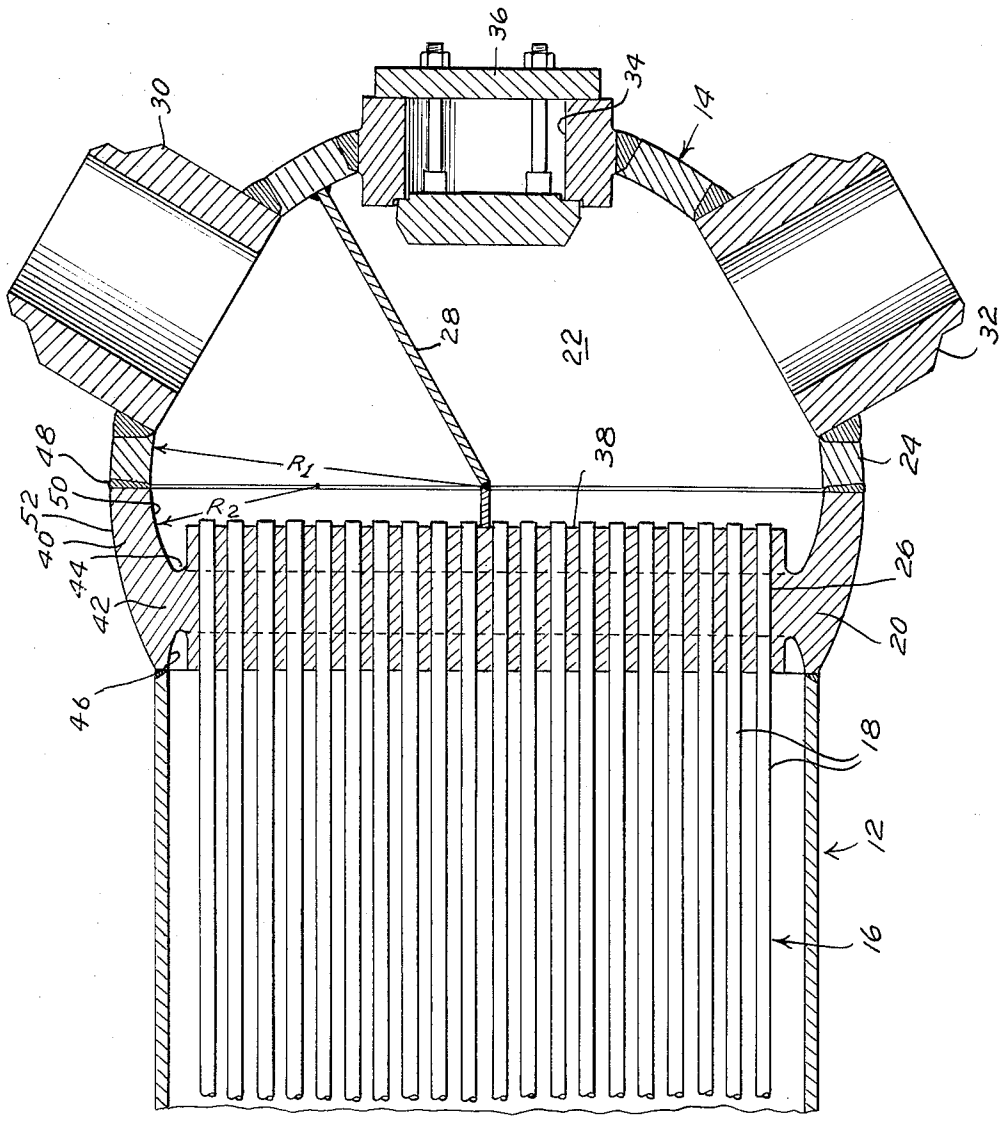
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SHELL AND TUBE HEAT EXCHANGER

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SHELL AND TUBE HEAT EXCHANGER

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This invention relates to a novel heat exchanger of the shell and tube type, and in particular to a method and apparatus for construction of the heat exchanger.

It is known in heat exchangers to provide an all welded hemipherical-shaped head construction designed for high pressure service wherein the hemispherical shape of the head permits the use of materials of substantially reduced thickness over conventional designs. Generally, the hemispherical head is welded directly to the flat tube sheet, and in the process of welding, substantial heat is transmitted through the tube sheet. This requires that installation of tubes in the tube sheet follow the welding of the head to the tube sheet rather than before. In most head designs, the clearance provided permitting use of tools and installation of tubes when the head is welded in place is limited making such installation difficult.

Accordingly, it is an object of the invention to provide a method and apparatus by which a heat exchanger of the shell and tube type can be constructed taking advantage of the hemipherical shape design and strength offered thereby, and at the same time, by virtue of which, construction and assembly of the heat exchanger is greatly simplified.

These and other objects are accomplished in accordance with the invention by providing a forged or otherwise integrally formed tube sheet having a flat plate portion to which the tubes are connected and an annular lip, the lip consisting of a continuous neck extending radially outward from the sides of the tube plate and an annular flange or shoulder flaring upwardly and outwardly away from the neck. A hemispherical channel is welded to the rim of the flange, preferably with an external girth weld. The hemipherical channel and flange or shoulder define, following assembly, a head having a generally spherical configuration, although the radius for the flange may be different from that for the head. The dimensions of the neck and height and flare of the flange may vary, but should be sufficient to accomplish the objectives of the invention.

The invention and advantages thereof will become apparent upon consideration of the following description with reference to the accompanying drawing, in which:

The figure thereof shows part of the heat exchanger of the shell and tube type and a head portion of the exchanger constructed in accordance with an embodiment of the invention.

Referring to the figure, there is illustrated, as an embodiment of the invention, a portion of a heat exchanger comprising a cylindrical shell 12, a head 14, and a tube bundle 16, the tubes 18 of the bundle protruding through a tube sheet 20 from the shell side of the exchanger to a chamber 22 defined by the head 14. The head 14 comprises two portions, the tube sheet 20 and a hemipherical channel member 24. The tubes 18 extending or protruding through openings 26 in the tube sheet are expanded on the inner or chamber side of the tube sheet, or may be otherwise affixed to the tube sheet. Also provided, within the head, is a pass partition plate 28 separating the chamber 22 into outlet and inlet portions in communication with outlet and inlet ducts 30 and 32. An access opening 34 containing a manhole cover 36 provides access to the chamber.

In accordance with the invention, the tube sheet 20 is forged and milled or otherwise formed into a flat plate area 38 through which the tubes 18 extend, and an annular continuous lip including a flange 40 flaring upwardly and outwardly away from a neck 42, the latter extending peripherally outward and away from the sides of the tube sheet. An annular groove 44 milled in the top of the tube plate defines the upper surface of the neck.

On the shell side of the tube sheet, an annular groove 46 may also be provided adjacent the tube sheet to shell girth weld, a purpose of both grooves being to reduce stresses as will be described hereon.

The hemipherical channel member 24 is welded to the flange 40 of the tube sheet lip by an externally applied circular girth weld 48. In this respect, the diameter of the rim of the flange is made equal to the diameter of the opening of the hemipherical channel member 24.

It is contemplated that by the invention, the tubes can be installed in the tube plate either before or after the final closing weld 48 of the head. If the tubes are to be installed in the tube plate following the closing weld, the dimensions and flare of the neck and flange should be sufficient to provide clearance permitting installation of the tubes. On the other hand, for smaller units where the tubes are installed in place prior to the closing weld, the dimensions of the flange and neck should be sufficient to provide a heat barrier which will dissipate heat resulting from welding the channel to the flange, and from stress relieving the same, at a rate sufficient to avoid an adverse affect of the heat on the tube-to-tube plate joints. In addition, the dissipation of heat should be sufficient to avoid generating a temperature differential in the tube plate from which locked-in stresses in the plate could develop.

If, in practice, as is contemplated, the tube sheet with the neck and flange are formed by first forging a flat plate and then cutting out excess metal to obtain the design and shape desired, the invention offers advantages over that of a previous application, assigned to the assignee of this application, filed by George P. Moran, Frank A. Fedosh, and Carl A. Maxwell, Serial No. 296,629 (filed July 22, 1963) for Shell and Tube Heat Exchangers. By the invention of the prior application, a heat exchanger was provided in which an annular shulder flared upwardly and outwardly away from the flat plate area of the tube sheet to form a cup-shaped design. To accomplish the objectives of that invention, which were the same as those of the present invention, the shoulder had to flare upwardly and outwardly for a considerable distance. If the shoulder were made from a forged flat plate, considerable metal had to be cut from the plate and the latter had to be relatively thick. By the present invention, the tube sheet can be made from a forged plate substantially thinner than that required for the prior design.

It will also beome apparent that the design offers stress advantages. The neck, shoulder and tube plate define the annular groove **44** around the upper face of the tube plate which distributes stresses induced by counter rotational forces resulting from normally high pressures within the feed water heater channel. This permits the use of a shoulder of reduced thickness.

The particular radii and dimensions for the feed water head construction depend upon design considerations, for instance the amount of clearance space required, assembly sequence, pressures, stress analyses, overall dimensions, materials used and the like.

Generally speaking, the inside radius for the groove **44** will first be determined, dictated by stress analyses, thickness of the tube plate and other factors known to those skilled in the art. This, in effect, determines the dimensions for the neck **42**, and the point at which the neck **42** and flange **40** inside surfaces join. The inside radius R_1, for the hemisphere **24** is limited in part by standard sizes offered by manufacturers, and is dictated in part by the diameter of the flange at the free edge thereof. The latter in turn is provided with a radius R_2 which, because of stress analyses, intersects the tube plate **38** about half way between the head side and the shell side of the plate, and which is, at the closing weld **48**, tangent to the hemispherical channel. It is evident that this radius is a function, at least, of the tube sheet thickness.

The outside radius for the flange **40** can vary. It should be tangent with the outside surface of the hemispherical channel at the closing weld **48**, should also intersect the shell **12** at an angle for minimum stress in the shell to tube sheet weld, and should provide the channel thickness required in the area of the neck **42**, i.e., in the area of connection between the flange **40** and tube plate **38**.

Thus, many designs, geometric and stress considerations are involved and balanced in arriving at particular radii, dimensions and configurations in accordance with the invention, keeping in mind that the dimensions of the flange and shoulder are sufficient to accomplish the objectives of the invention, i.e., clearance if the tubes are installed subsequent to the closing weld, or heat dissipation if installed prior to the closing weld.

In a typical large unit where the tubes are installed in the tube sheet after welding the hemispherical head **24** to the flange **40**, the hemispherical channel may have a diameter about 60 inches, with a design pressure of about 3000 p.s.i. within the head. For this design pressure, the tube sheet will be about 12 inches in thickness, and the flange will extend above the head side of the tube sheet about 3 inches. The radius for the groove **44** may be about 1 inch, necking the flange away from the tube sheet a distance of about 2 inches or somewhat less. This and the tube sheet thickness dictate the radius R_2, which, in this example, is about 8 inches. An important aspect is that the neck dimension and outward flare of the flange will provide approximately 4 inches clearance between the edge of the tube plate and the inside surface of the flange in the area of the closing weld, for welding or rolling tools.

It should further be noted that by providing the tube sheet with an annular flaring shoulder which is in the shape of a segment of a sphere, the head consisting of the shoulder and the hemispherical channel has a generally spherical configuration with a maximum diameter greater than that of the tube plate (**38**) proper. This permits the the use of a thinner material in the channel and flange over conventional designs.

For smaller units, construction of the heat exchanger may take the following sequence. The forged plate is first machined to provide the tube plate (**38**) proper, the neck **42**, and flange **40**, with grooves **44** and **46**. Following this, the tubes may be affixed to the tube sheet

plate by inserting them through the openings **26** of the plate and expanding or otherwise securing them to the tube plate. Subsequently, the hemispherical channel **24** is welded to the flange rim and and the weld area locally stress relieved.

By the invention, it is evident that the lip, comprising the flange and neck can be made of sufficient length to provide a barrier to the heat resulting from the welding and stress relieving against injury to the tube-to-tube plate joints.

A further important aspect is that the heat barrier avoids setting up of locked-in stresses in the tube plate, resulting in possible stress failure.

Even for maintenance purposes, the construction provides space not available in conventional designs.

The principles set forth also are applicable to the design of the annular groove **46** on the shell side of the tube plate. In addition, this groove provides a means for X-raying the tube sheet to shell weld.

Further the pressure in chamber **22** causes the tube plate or sheet **38** to bend concavely causing a rotation of the periphery of the tube sheet **38** and its girth **20, 42**. By providing the grooves **44, 46**, communication of this rotation to the shell **12** and head **24** is avoided.

Although the invention has been described with respect to a specific embodiment, many modifications will be apparent to those skilled in the art and within the scope and spirit of the invention as defined in the following claims.

What is claimed is:

1. A heat exchanger including a head comprising a tube sheet, a hemispherical channel member welded to the tube sheet, the tube sheet including a flat plate area to which the tubes of the heat exchanger are connected, an annular lip, the lip comprising a peripheral neck portion extending radially outwardly from the sides of the tube plate, a flange portion flaring upwardly and outwardly away from the neck portion, the neck portion being grooved with an inside radius between the flange portion and the tube plate for minimum stress concentration, the flange portion having a free edge of approximately the same diameter as the hemispherical channel member, the channel member being welded to the flange portion by an external girth weld.

2. A heat exchanger according to claim **1** wherein the flange portion and channel member define in cross-section a generally spherical configuration.

3. A heat exchanger according to claim **2** wherein the free edge of the flange portion extends above the head side of the tube plate, the inside surface of the flange portion being tangent to the inside surface of the hemispherical channel at the channel-to-flange weld and having a radius which intersects the tube plate about half way between the head side and shell side of the plate.

4. A heat exchanger comprising a shell having a circular cross section; a forged tube sheet welded to the shell, the tube sheet comprising a circular tube plate, an annular lip integrally formed therewith, the lip including a free edge raised above and outwardly of the tube plate, a neck protruding radially outward from the sides of the tube plate, an annular shoulder flaring upwardly and outwardly from the neck, the neck being grooved with an inside surface radius between the shoulder and the tube plate for minimizing stress concentration, a hemispherical channel member, the channel member having a free edge of generally the same diameter as the free edge of the upstanding flange, the hemispherical channel member being welded to the flange.

5. A heat exchanger according to claim **4** wherein the length of the lip between the free edge thereof and the tube plate is sufficient to present a heat barrier against the transfer of heat from the weld joint to the tube plate during the welding of the channel member and the flange in an amount sufficient to adversely affect the tube-to-tube

plate joints and to cause the formation of locked-in stresses in the tube plate.

References Cited by the Examiner

UNITED STATES PATENTS

1,963,337	6/1934	St. Clair	29—157.4
1,963,338	6/1934	St. Clair et al.	29—157.4
2,366,617	1/1945	Harris	220—3
2,766,903	10/1956	Boni	220—67
2,920,789	6/1960	Tinker	220—46
3,176,761	4/1965	Anderson et al.	165—178 X

FOREIGN PATENTS

516,828 1/1953 Belgium.

OTHER REFERENCES

German printed application, 37,896, October 1955.

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