This invention relates to heat exchangers of the shell and tube bundle type, and the principal object of the invention is to provide a heat exchanger of this type having generally improved characteristics, and particularly alleviating the difficulties encountered with such heat exchangers because of the expansion and contraction of the tubes and shell and the forces produced thereby. It has heretofore been common practice to provide heat exchangers wherein the entrance and discharge ports for both the hotter and colder fluids are arranged at one end of the apparatus so that the metal of the shell and also the metal of the tubes is free to expand longitudinally away from the end of the heater having the intake and outlet ports. However, in handling fluids at comparatively high temperatures, particularly when a large temperature change occurs in the passage of the fluids through the apparatus, the expansion of the tubes and shell on opposite sides of the central plane of the exchanger will be different, thereby producing in the apparatus a tendency toward lateral distortion with resulting strains on the metal, and particularly on the joints between the shell and the header as well as on the tubes in the header. In the apparatus forming the subject-matter of this application this difficulty is avoided even when handling fluids at high temperature and with a difference of several hundred degrees between the entrance and exit temperatures of the fluids being treated.

The essential feature of my improved heat exchanger lies in the provision of means whereby, although the metal of the tubes and shell on opposite sides of the longitudinal axes of the heater are subjected to fluids of widely different temperatures, the longitudinal extension of the tubes and shell due to heat expansion will be substantially the same.

One particular object of the present invention is to provide an improved construction of tube and shell heat exchanger wherein all thermal expansion stresses are substantially compensated for in the heat exchanger itself and the provision of flexibility in the piping to the exchanger is obviated.

Another object of the invention is to provide a tube and shell heat exchanger construction in which no temperature gradient exists circumferentially of the shell.

A further object of the invention is to provide a tube and shell type of heat exchanger in which the stresses produced by thermal expansion are negligible.

The invention will be understood through reference to the accompanying drawings which show, by way of example, a preferred embodiment of the invention and one modification thereof. In these drawings:

Fig. 1 is a view in vertical longitudinal section through the preferred construction of heat exchanger; and

Fig. 2 is a similar section of the right-hand end portion of the exchanger illustrating a modification.

Referring first to Fig. 1 of the drawings, the heat exchanger comprises two legs of unequal length indicated generally by reference numerals 1 and 2, respectively. Leg 1 has a shell 3 preferably cylindrical in cross section and made of suitable metal, such, for example, as steel. The shell 4 of leg 2 is similar to shell 3 but is substantially greater in length for a purpose which will be more fully explained below. The right ends of shell sections 3 and 4 are permanently mounted in apertures in a heavy metal plate 5 in which they may be secured by welding, as indicated.

The ends of the two shell sections are interconnected by means of a hollow dome-shaped header 6 which is provided with a supporting flange 7 in order that it may be secured to the outer periphery of plate 5 by means of a series of bolts 8. Thus, the interiors of shells 3 and 4 are placed in communication with one another, making in effect a single heat exchanger shell having a length equivalent to the combined lengths of the two shell sections.

As the shell of the heat exchanger is divided into two unequal legs or sections as above described, so also is the tube bundle of the heat exchanger. That is to say, the heat exchanger tube bundle is divided into two unequal length sections indicated generally by reference numerals 9 and 10, respectively. These tube bundle sections correspond in length with the effective lengths of their respective shells 3 and 4, that is, the length of these shells from about the center of header 6 to the respective tube sheets 11 and 12 in which the left-hand ends of the tube bundle sections 9 and 10 are respectively mounted. The tubes are of metal such as steel or a non-ferrous alloy. In the preferred form of the apparatus as shown in Fig. 1, tube bundle sections 9 and 10 are formed by a bundle of U-tubes with the return bends thereof indicated generally by numeral 13, arranged within the header 6, the shorter legs of these U-tubes forming the tube bundle section 9 and the longer legs, tube bundle section 10, these tube bundle sections being interconnected by means of the return bends 13. Tube sheets 11 and...
3 2 are preferably welded to the interior of shell sections 3 and 4, respectively. The hot fluid is introduced into the short leg of the heat exchanger and the cold fluid into the longer leg of the exchanger, the two fluids passing through the exchanger in countercurrent relation. The hot fluid may be sent through the tube-side or the shell-side of the exchanger, as desired. As shown in Fig. 1, the hot fluid is introduced into the tube-side of the exchanger through a flange T-connection 14 or welded construction and which is welded onto the outer side of tube sheet 11. The inlet is through the side passage of T-member 14 and the longitudinal passage is closed by a cover plate 15 which may be removed for the purpose of cleaning or removing the tubes connected to tube sheet 11. Similarly, the outlet for the tube side of the exchanger, which is at the left end of the longer leg 2, consists of a second flanged T-member 16 which is welded to tube sheet 12 and closed by a cover plate 17.

The inlet and outlet for the shell side of the exchanger are shown, respectively, as flanged connections 18 and 19. Main tube section 18 is welded in an aperture in shell 4 adjacent tube sheet 12, and connection 19 is welded in an aperture in shell 2 adjacent tube sheet 11.

The shell side of the exchanger is preferably provided with spaced transverse baffles plates. These are shown at 20 for short leg 1 and at 21 for long leg 2. They are suitably perforated and the perforations are staggered to produce a crosswise flow of the shell fluid somewhat as indicated by the arrows.

Under conditions frequently met with in practice the relative temperatures of the hotter fluid and the colder fluid, as well as the actual temperatures of these fluids, are such that the temperature of metal shell 3 of the shorter leg 1 will be considerably higher than that of shell 4 of the longer leg 2. This is also true of the tube metal temperatures of the two tube bundle sections 8 and 10 of the short and long legs, respectively. Accordingly, the lengths of these short and long legs 1 and 2, both the shell lengths and the tube bundle section lengths, depends upon the increase in average metal temperature above the temperature of fabrication and the coefficient of thermal expansion of the metal used for the shell and for the tubes, as the case may be.

The length of the legs is so chosen that the product of length times the coefficient of thermal expansion times the increase in average metal temperature above the temperature of fabrication is the same for both legs. The rate of expansion of the shell and tube metal of the shorter and cooler leg will be greater than for the longer and hotter leg. However, the actual extension in the lengths of the two tube bundle sections when the heat exchanger is brought to operating temperature is substantially equal. Hence, although the right-hand end of the exchanger tends to move away from the respective left-hand end portions of the two heat exchanger legs, the amount of movement of the return bends 13 which interconnect the tube bundle sections 9 and 10 is substantially the same as the amount of movement of the header 6, so that there is very little, if any, relative movement between the tubes of bundles 9 and 10 and their respective shell ends.

With this arrangement of the heat exchanger, the flanged inlet and outlet connections 14, 16, 18 and 19 remain fixed in position so that no provision for flexibility in the piping connecting these members is necessary or desirable. Also, no packed gland for a floating head is required, nor any expansion joints in the heat exchanger shell. Moreover, since the hot fluid enters one leg of the shell and the cold fluid enters the other leg, these connections are separated from one another so that there is no temperature gradient circumferentially of any part of the shell.

In Fig. 2 there is shown merely a modification of the means of interconnecting the right-hand ends of the two tube sections of said tubes. Instead of employing U-tubes connected by the return bends 13 as in Fig. 1, the two tube bundle sections 8a and 10a of Fig. 2 are connected together at their right ends by means of an internal header 22. The right ends of the tubes in the two tube bundles are mounted in a common tube sheet 23 to which header 22 is removable secured by means of a series of bolts 24. It will be understood that the remaining parts of the heat exchanger are constructed as previously described. This modification, just as in the construction shown in Fig. 1, is obtained without additional length.

The principal advantage of my improved heat exchanger is obtained when designed as above described with one leg shorter than the other to compensate for unequal heat expansion, the structure is also useful when constructed with legs of equal length. The two separate shell sections of small diameter have structural advantages over a single shell section of a diameter large enough to receive both branches of the U-tubes. Also the temperature change is more uniform through the entire circumference of the small shells than can be obtained with a single shell divided by baffles or otherwise.

It will also be understood that the invention is not limited to the precise forms of construction illustrated, as changes may be made within the scope and spirit of the invention as set forth in the appended claim.

I claim:

A heat exchanger for fluids having two legs of unequal length, each including a shell section with a tube bundle section therein, a header for interconnecting said shell sections at one end, means within the header for interconnecting said tube bundle sections, said legs being separated from one another to permit independent longitudinal extensions resulting from thermal expansion, the shell section of said legs and the header forming a continuous passage for a fluid about the tubes, the tube bundles and the means interconnecting the tubes forming a continuous passage within the tubes and connecting means therefor for a second fluid, means for introducing the hotter fluid into one of said passages in the shorter leg and discharging it from said passage from the longer leg, and means for introducing the colder fluid into the other passage in the longer leg and discharging the respective fluid from said passage from the shorter leg, the respective lengths of said legs being such that at a predetermined operating temperature there will be substantially equal extension of the lengths of the legs due to thermal expansion.

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