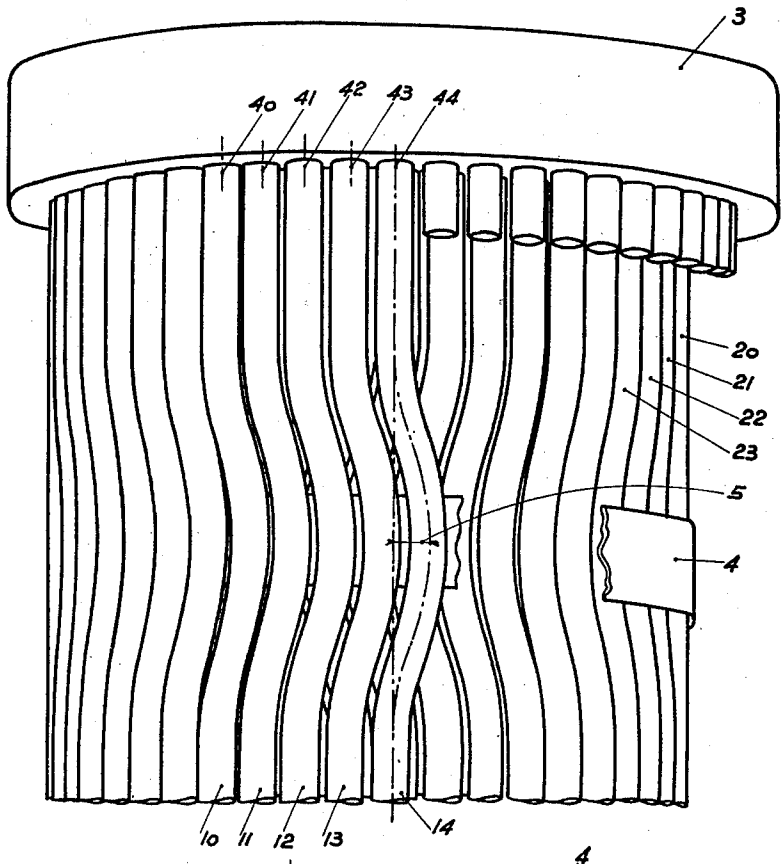
June 23, 1953 H. BONNAUD 2,643,100

HEAT EXCHANGER

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Fig.1



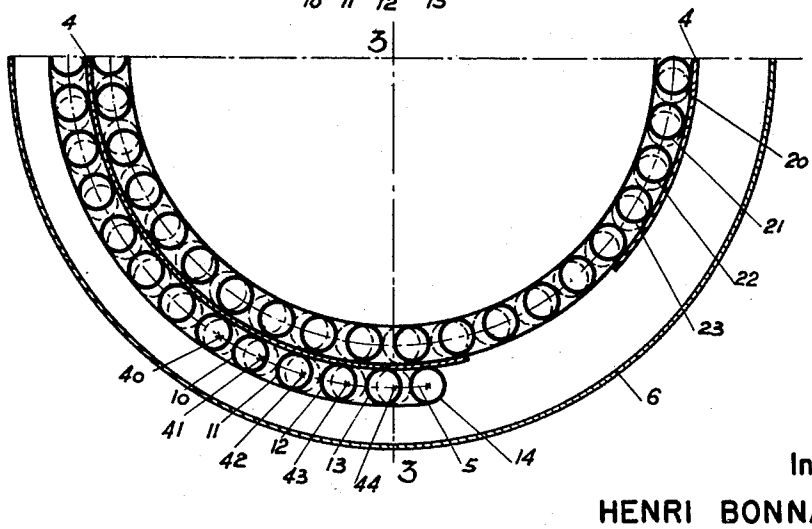


Fig.2

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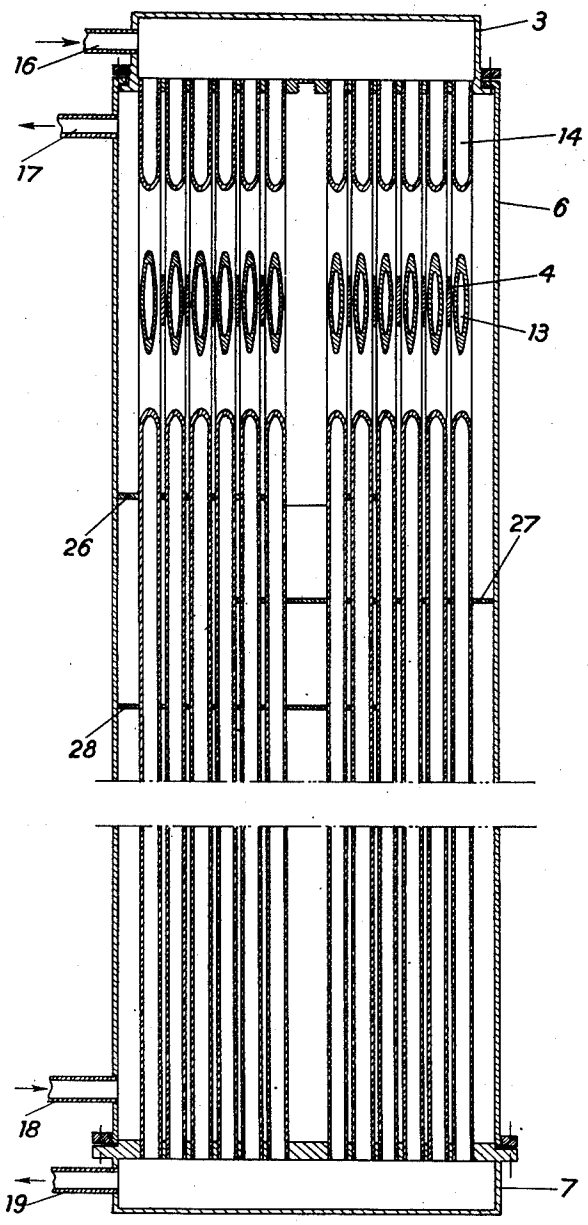
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Fig. 3



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HEAT EXCHANGER

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1 Claim. (Cl. 257—224)

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My invention relates to heat-exchangers comprising a casing and a nest of tubes mounted between two tube-plates fastened to a casing, and specially to heat exchangers in which the tubes are substantially straight and close to one another, as are used, for example, in heat exchangers for the treatment of gases at low temperatures.

The fastening, employed by me, ensures a more certain air-tightness than would be the case where use is made of a sliding joint between the casing and one of the tube-plates. In the case where a sliding joint is not employed, heavy strains result when the expansion coefficient of the tubes is different from that of the casing. Particularly is this true when, during the operation of the exchanger, that one of these former parts: nest of tubes and casing, the coefficient of expansion of which is the greater, attains a temperature farther from that at which the exchanger has been built and assembled, than the other, as for example, in heat-exchangers utilized for the manufacture of oxygen by the air distillation process. In such exchangers, the tubes, which are braced by baffles for the circulation of the outside fluid, are generally made of copper and contain the cooler of the two fluids between which the heat-exchange takes place. Also, in such exchangers, the casing is made of steel and, when operating, the casing shrinks less than the tubes for two reasons; firstly because the expansion coefficient of steel is smaller than that of copper and secondly, because the casing is in contact with the less cool of the two fluids.

A known expedient for lessening the strains in a tube is to give the tube one or more strong waves, so as to impart to it elasticity enough for the strains to remain under the elastic limit of the metal it is made of. This expedient, however, results in a greater manufacturing cost and in a big increase of the bulk of each tube.

One object of my invention is to provide a heat-exchanger of relatively small bulk and low cost.

A further object of my invention is to provide a heat-exchanger of long life and lasting air-tightness.

A still further object of my invention is to provide a heat-exchanger in which each tube, substantially straight and placed very close to the neighbouring tubes, is given at least one bow, the deflection of which is substantially included between 3 and 10 centimetres, this deflection being headed in a way substantially parallel to the tangent to the line of drilling of the tube, at the spot where the tube in question is fastened to the tube-plate, the bows of the tubes being headed in an opposite direction when passing from one row of tubes, corresponding to one same line of drilling, to the neghbouring row, corresponding to the neighbouring line of drilling, the metal of the tubes working, when the exchanger is operating, at rates of which the maximum is over the elastic limit of the metal at the temperature to which it is then brought.

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Preferably, each bow is approximately sinusoidal in form and the length of its chord is comprised between 4 and 8 times the deflection of the bow.

These and other objects of my invention will become more apparent from the following detailed description of a preferred embodiment thereof when read in connection with the accompanying drawings, in which:

Figure 1 is a side elevational view of the upper end of a vertical nest of tubes according to my invention, seen from a direction a little below the horizontal; a portion of the parts is broken off and the casing is not represented, in order to allow what is behind to be seen.

Figure 2 is a half-section of the casing and of the nest of tubes through a horizontal plane passing through the middle line of the bracing spacing-piece 4.

Figure 3 is a longitudinal section, through the plane 33 of Figure 2.

The heat exchanger comprises chiefly a casing 6, tubes 20, 21, 22, etc., 10, 11, 12, 13, 14, etc. and two tube plates 3, 7. The less cool of the two fluids flows inside the casing, outside the tubes; it enters through the inlet pipe 18 and leaves through the outlet pipe 17. The other fluid enters through pipe 16, flows inside the tubes, and leaves through pipe 19.

In the tube-plate 3, are expanded the tubes 10, 11, 12, 13, etc., 20, 21, 22, 23, etc. in which circulates the cooler fluid. The tubes 20, 21, etc. fastened to the tube-plate along the same line of drilling, form part of the same row, while the tubes 10, 11, etc. form part of the neighbouring row that surrounds the previous row.

For the clearness of the drawings, only the tubes of two rows have been illustrated on Figures 1 and 2, the outside row and the neighbouring row.

Each tube, which is about 3 mm. distant from the neighbouring tubes and the inside and out-

side diameters of which are 6 and 7.5 mm., shows a bow of which the deflection 5 is about 6 centimetres and the chord 30 centimetres; this deflection is insufficient to prevent the metal from going over its elastic limit under the influence of the differences in pressure and temperature, but it gives to the tube a sufficient elasticity so that it may, before cracking, be deformed several hundreds of times under the action of putting them under working temperature and of returning to the surrounding temperature. The precaution has been taken, besides, of providing tubes that are slightly too long, so as to compress them on assembly, the effect of which is to lessen the elongation strain to which they are subjected when they enclose the cooler liquid. The smallness of the deflection lessens the cost of bowing the tubes and assembling the exchanger, and reduces the space occupied by the tubes.

The bow deflection 5 of the tube 14, for instance, extends along a line substantially parallel to the tangent, at the centre 44 of the hole of the tube-plate 3 where is expanded this tube 14, to the line of drilling of the tubes of the same row, that is to say tangential to the circle passing through the similar centres 40, 41, 42, etc. of the holes for the tubes of the same row; the peripheries of the holes inside which the tubes are expanded are indicated in broken lines on Fig. 2 for they are concealed by the bows of the neighbouring tubes. In relation to the axis of the exchanger, the deflection of the bowing is headed in one direction for all the tubes of this row and in the opposite direction for all the tubes of the neighbouring row or rows.

The bowed length of the tubes is short relatively to the total length thereof. This allows perforated baffles such as 26, 27, 28 to be threaded by the tubes and placed in positions convenient for guiding the flow of that fluid which runs around the tubes.

On the figures are shown metal spacing strips such as the one with the reference number 4. These strips are inserted between neighbouring rows of tubes, are positioned along bowed parts of the tubes and are fixed in their position by welding several points thereof to adjacent tubes.

In view of the foregoing description of a preferred embodiment of my invention, it will now be apparent that the heat-exchanger shown has many advantages over devices now in use. It is air tight and it may be subjected a great number of times to cooling to working temperature and heating to ambient temperature before breaking and, moreover, it is easy to manufacture and its bulk is substantially the same as that of exchangers with rectilinear tubes.

While I have shown and described a preferred embodiment of my invention, it will be understood that changes and modifications may be made therein without departing from the principles thereof.

What I claim is:

A heat exchanger, comprising a casing, two spaced tube-plates enclosed in said casing and fastened thereto, a nest of metal tubes arranged in rows and mounted between said tube-plates, inlet and outlet pipes connected to said casing for a heat-exchange medium intended to circulate in said casing and inlet and outlet pipes connected to said tube-plates for another heat-exchange medium intended to circulate in said tubes, the linear expansion coefficient of the metal of the tubes being different from that of the casing, each tube being substantially straight and having at least one bow, the deflection of said bow being substantially directed according to the direction of the row of said tubes in the neighborhood of said bow, the bows of the tubes being headed in an opposite direction when passing from one row of tubes to the neighboring row, the chord subtending said bow being between 4 and 8 times the deflection of said bow, said deflection being greater than 3 centimetres and smaller than 10 centimetres, the bowed portion of the tube extending over less than half the length of said tube and the non-bowed portion being practically directed according to the straight line joining the places where said tube is mounted in the tube-plates, whereby when said heat exchanger is employed in a heat exchange process, each tube will work above the elastic limit of the metal thereof at the temperature prevailing during said heat exchange process.

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