Dec. 16, 1969 F. M. HEYN ET AL 3,483,920

HEAT EXCHANGERS

Filed Jan. 29, 1968 2 Sheets-Sheet 1

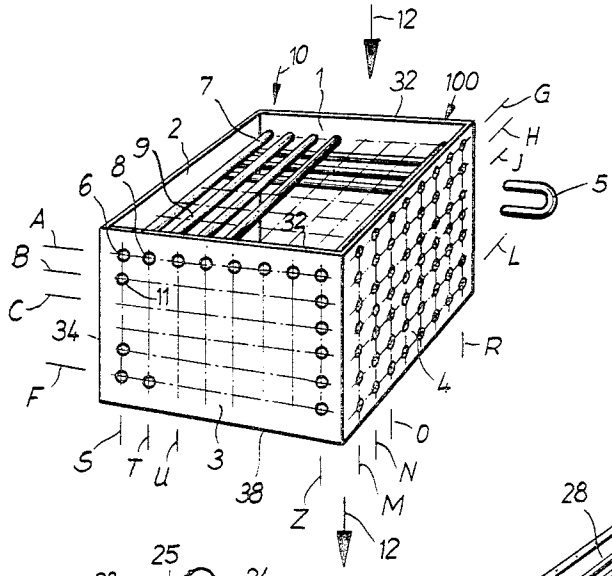
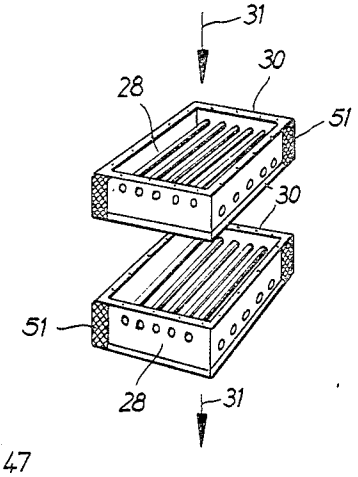


Fig. 1

Fig. 2

Fig. 4



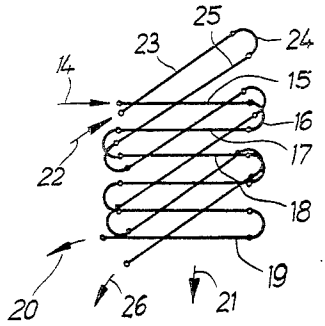


Fig. 3

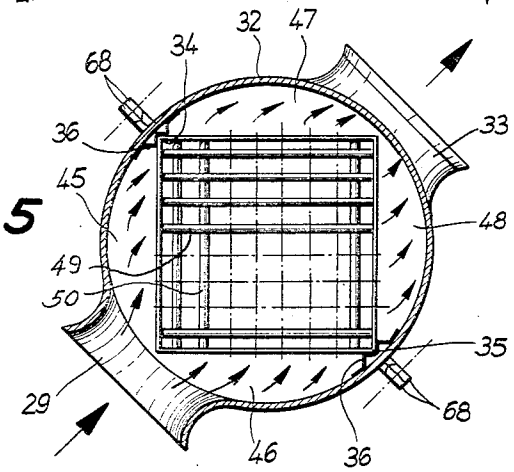


Fig. 5

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HEAT EXCHANGERS

Filed Jan. 29, 1968 2 Sheets-Sheet 2

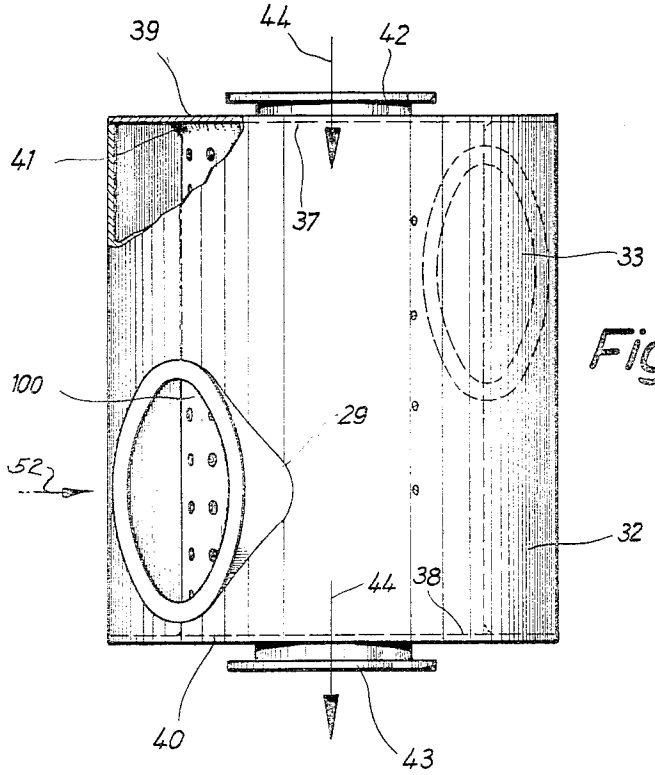


Fig. 6

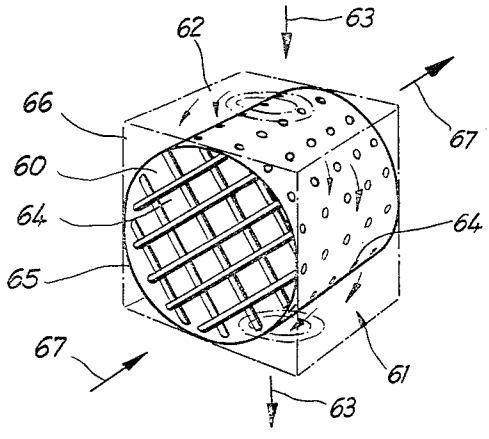


Fig. 7

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HEAT EXCHANGERS

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U.S. Cl. 165—165 9 Claims

ABSTRACT OF THE DISCLOSURE

A heat exchanger is provided having tubes arranged in latticed pattern and serving to conduct a medium to be heated or cooled, the ends of said tubes being held in end walls and the heating or cooling gas flowing through the exchanger transversely to the longitudinal direction of the tubes.

This invention relates to heat exchangers and particularly to a heat exchanger having tubes which are arranged in a latticed pattern and serve to conduct the medium that is to be heated or cooled, the ends of said tubes being held in end walls, and the heating gas flowing through the heat exchanger vertically to the longitudinal direction of the tubes.

There are known heat exchangers in which parallel tubes are combined into tube bundles, the ends of the tubes being held in end walls which run parallel to one another and vertically to the longitudinal direction of the tubes. Tubes arranged in a latticed pattern are also known (Chemie-Ingenieur-Technik 1964, pages 247–260) in which the ends of the tubes are set into corresponding side walls.

It is the purpose of the invention to create a heat exchanger of the type mentioned in the introduction by means of which it will be possible to increase the transfer of heat and to reduce the pressure losses. The invention is further intended to create favorable heat transfer conditions from the one medium to the other medium, in particular to afford possibilities for variations in order to produce variations in the rate of flow of the medium which is to be heated or cooled and accordingly in the velocity of flow of the medium, thereby varying the exchange of heat. The ratio of the heat transfer efficiency to the size of the structure is to be a favorable one.

To achieve this aim, the invention provides a heat exchanger of the above mentioned type in which the ends of the tubes in accordance with the invention are held in a polygonal or round frame which is open on two sides, at at least one tube end being connected to an adjacent tube end in the same frame wall by means of an elbow, a chamber, or the like, and/or the frame being disposed in a cylinder or box-shaped housing having an inlet and an outlet for the medium which is to be heated or cooled, and the said frame on its inside wall abutting snugly against or being connected to two diametrically opposed edges or longitudinal lines. The disposition of the frame in the housing is so designed that the medium that is to be heated or cooled will be split up so that one portion of the medium which is to be heated or cooled will flow through one portion of the tubes while the other portion of the medium that is to be heated or cooled will be guided through tubes disposed at right angles to the first mentioned tubes. The frame with its tubes together with the inside wall of the housing or box form a distribution chamber and a similar collector chamber, the cold or heated medium being conducted in conventional manner by way of an inlet to the distribution chamber and being withdrawn from the collector chamber by way of an outlet. For this purpose the frame is disposed on the inside

wall of the housing in a vertical or approximately vertical plane to the influent or effluent direction of flow of the medium that is to be heated or cooled. Thus, no supplementary inlet and distribution chamber, nor a corresponding collector and outlet chamber are any longer required, since the housing forms these chambers in the manner described above. In this arrangement the frame is not only impermeably joined to the inner wall of the housing at its opposed edges or longitudinal lines, but it also abuts snugly with its longitudinal ends against both floors of the housing or box in which the inlet and outlet ports are provided for the heating gas which flows through the housing at right angles to the rows of tubes.

By using elbows or chambers on the ends of the tubes it is possible to allow the medium that is to be heated or cooled to pass through any desired number of tubes preferably in the same row. In other words, the path of the medium that is to be heated can be varied as desired according to the requirements, it being necessary to equip only a portion of the tubes with elbows or chambers at their ends, another portion being left without any such elbows or chambers.

Thus, for example, those tubes of the tube bundle formed by the rows of tubes and the frame which are the first tubes in the direction of flow may be without such elbows or chambers at their ends, while tubes disposed behind these first tubes in the direction of flow may be equipped with elbows or chambers positioned at their ends.

In the actual embodiment the frame is square and the housing round, or vice versa.

In another preferred embodiment of the invention the frame is subdivided into smaller frame segments connected to their adjacent frame segments by means of flanges. These flanges carry sealing members in order to properly seal off the frame in the housing and to form the previously described distribution and collector chambers for the medium that is to be heated. Thus the same frame segments may be used in different numbers for housings of different sizes.

Preferably the housing may also be subdivided into sections or segments not only to facilitate the assembling of the recuperator, but also to permit a recuperator to be erected in any desired size on the principle of unit construction.

The tubes may be held in the walls of the square, round, or oval frame in conventional manner to allow for expansion of the tubes. For example, the tubes may be held in the frame walls by means of compensators or expansion joints, as is already known to the art.

In the drawings exemplifying embodiments of a heat exchanger according to the invention are shown with their essential parts.

FIGURE 1 shows a box-shaped frame with the tubes lying in rows at right angles to one another;

FIGURE 2 shows an elbow for the tube ends which serves as a transfer member;

FIGURE 3 is a schematic showing a possible path of travel through the frame for the medium that is to be heated and for the heating gases, and shows the tubes of two rows of tubes which are disposed at right angles to one another;

FIGURE 4 shows two frame segments which may be assembled into one frame as in FIGURE 1;

FIGURE 5 shows a tube equipped frame within a housing, in other words, a cross-section through one embodiment of an exchanger according to the invention;

FIGURE 6 is a side elevation of the heat exchanger shown in FIGURE 5; and

FIGURE 7 is another embodiment using a drum-type frame and a box-shaped housing.

With reference to FIGURE 1, the tubes of the heat exchanger of the invention are held at their ends by a frame **100** formed by walls **1**, **2**, **3**, and **4**. The tubes are arranged in rows in such a manner as to form horizontal rows A, B, C . . . F and vertical rows S, T, U . . . Z. Thus, the tubes of these rows of tubes lie adjacent to one another and above one another in the same direction and also parallel to one another, and they all extend from the one frame wall **1** to the parallel frame wall **3**.

At right angles to the said rows of tubes, horizontal tubes rows G, H, I . . . L extends from frame wall **2** to frame wall **4** and simultaneously form vertical rows M, N, O . . . R. The rows of tubes in walls **1** and **3** are positioned either higher or lower than the rows of tubes in walls **2** and **4** in such a manner that the tubes of the corresponding rows of tubes cross either above or below one another, as illustrated in FIGURE 1 with reference to the first two rows of tubes, row A and row G.

The medium that is to be heated or cooled may be conducted through the individual tubes and rows of tubes as desired. In order to turn the medium that is to be heated or cooled around elbows **5** may be used which form a bridge between the two ends of adjacent tubes. For example, an elbow may connect tube end **6** of tube **7** to tube end **8** of tube **9** when the medium that is to be heated or cooled is fed into tube **7** in the direction indicated by arrow **10**. However, end **6** of tube **7** may also be connected to end **11** of the tube disposed below tube **6**. In similar manner any desired number of tubes may be connected to their adjacent tubes, thus making the path of the medium which is to be heated either long or short. In the direction of flow of the heat transmitting medium (arrow **12** in FIGURE 1), the first tubes may be connected differently to one another at their ends than the tubes which are disposed outside of the frame at the discharge end of the heating gas or the cooling agent.

FIGURE 3 is a schematic illustration of the path of travel of the heating gas or cooling agent and of a partial stream (or flow) of the medium that is to be heated or cooled. The heating gas or coolant flows in the direction of arrow **12** and flows out in the direction of arrow **21**. One partial stream of the medium that is to be heated or cooled flows in the direction of arrow **14** into first tube **15**, by way of elbow **16** into tube **17** disposed therebelow, from tube **17** into tube **18** and finally into tube **19** and emerges from the pipeline at **20**. A second partial stream may flow in the direction of arrow **22** into tube **23** and reach tube **25** by way of elbow **24**. This partial stream is led off in the direction of arrow **26**. Tubes **15** and **23** are connected to two entry collectors, while tubes **19** and **25** are connected to two exit (or discharge) collectors.

In order to form the frame shown in FIGURE 1, a number of frame segments **28** may be used. These segments are provided with flanges **30** by means of which the frame segments may be joined to one another. In these frame segments the rows of tubes also run at right angles to one another, thus again providing a crosswise arrangement of successive tubes in the direction of flow of the heating gas or coolant (direction of flow of the heating gas or coolant is indicated by arrows **31** in FIGURE 4).

A tube-equipped frame **100** or a frame composed of box members **28** is set into a housing **32** as shown in FIGURES 5 and 6. This housing is equipped with a discharge duct **33** for the medium that is to be heated or cooled. Frame **100** is mounted in housing **32** in such a way that the diametrically opposed longitudinal edges **34** and **35** of the frame abut tightly against the interior wall of the cylindrical housing and are held in seal-tight manner by approximately W-shaped holders **36** which extend over the height and length of the box. Edges **37** and **38** of the frame (FIGURE 6) are sealed off against ends **39** and **40** of the housing at **41**. No connection is required since the frame is held in the housing by its longitudinal edges **34** and **35**. Ends **39** and **40** are provided with inlet **42** and outlet **43**, respectively for the heating gas or cooling agent that flows into frame **100** through the pipe lattice in the direction of arrows **52**.

The square frame and cylindrical housing **32** form two distribution chambers, **45** and **46**, and two collector chambers **47** and **48** into which inlet duct **29** and outlet duct **33** open. From distribution chamber **45** the medium that is to be heated or cooled enters tubes **49** while from distribution chamber **46** the medium that is to be heated or cooled flows into tubes **50** disposed vertically thereto. Both the inflow from the distribution chambers into the said tubes as well as the outflow from these tubes into the discharge pipe of outlet duct **33** is greatly enhanced by the position of the tubes in relation to the curvature and by the said curvature of the walls of housing **32**.

The flow through tubes **49** and **50** may be varied as desired, as has already been explained in connection with the description of the frame shown in FIGURE 1. The elbows **5** shown in FIGURE 2 may be used as desired for this purpose. Without changing the housing or the frame it is possible to alter the manner of the flow as desired, i.e. the length and velocity of the flow and thereby the heat transmission and also the pressure ratios. In view of the added advantage of being able to assemble both frame **100** and the housing from individual members, thus permitting unit construction, there are indeed many possibilities for variations in the construction of the heat exchanger.

When using frame segments **28** shown in FIGURE 4, seals **51** are mounted between the flanges **30** of a box member on its diametrically opposed edges. These seals will abut against W-shaped members **36** in housing **32**.

In the embodiment shown in FIGURE 7 the same principle is used whereby tubes are arranged in criss-cross pattern in a drum-shaped frame **60** disposed in a box-shaped housing **61** whose upper side **62** and lower side are provided with an inlet and an outlet for the medium which is flowing in or out in the direction of arrows **63** and which is absorbing or emitting heat (heat gases in the tube). Drum **60** is again impermeably connected to the inner wall of housing **61** at two diametrically opposed lines **64**, just as the annular bands **65** of the drum abut sealingly against the two floors **66** of housing **61**. Inlet and outlet ports are provided in these floors for the heating gas or cooling agent which flows through frame **60** in the direction of arrows **67**. To avoid confusion the inlet and outlet for the heating gas or the coolant in floor **66** are not shown.

In the embodiment shown in FIGURE 7 the drum-shaped frame **60** may also consist of a number of disc-shaped individual members which are joined together by means of flanges in a manner similar to that employed with frame members **28** of FIGURE 4. Housing **61** may also be constructed of a plurality of members connected by means of flanges just as, for example, the two segments of housing **32** are joined together by means of flanges **68**. Similarly, the embodiment of FIGURE 7 may also be varied by applying the principle of unit construction, the ends of the tubes being connectable with one another by means of elbows just as is the case with the tubes of frames **100** shown in FIGURES 1 and 6.

The heat exchanger of the invention can also be developed as an indirectly heated heater, for which purpose the air that is to be heated, i.e. the compressed air that is to be heated, is conducted through the tubes and the tubes are heated by the flames or the gases of a burner.

In the foregoing specification I have set out certain preferred embodiments of my invention, however, it will be understood that this invention may be otherwise embodied within the scope of the following claims.

We claim:

1. A heat exchanger comprising a plurality of tubes arranged in at least two side-by-side planes to carry at least one fluid for heat exchange, the tubes in one plane being transverse to those of the other plane, said tubes being held at their ends in the sidewalls of one of a polygonal and a round frame open at the two sides transverse to the sidewalls to form an inlet and outlet for a second fluid for heat exchange, and a housing surrounding said frame and having an inlet and outlet, said housing engaging the frame to form with the said housing inlet and outlet a flow path for said at least one fluid through the plurality of tubes in said two side-by-side planes.

2. A heat exchanger as claimed in claim 1 wherein the tubes in said two planes are at substantially right angles to one another.

3. A heat exchanger as claimed in claim 1 wherein the frame is connected to the housing along diametrically opposed edges.

4. A heat exchanger as claimed in claim 1 wherein the frame is connected to the inner wall of the housing in a plane substantially transverse to the direction of flow in the tubes.

5. A heat exchanger as claimed in claim 1 wherein the frame is square in cross-section and the housing is round in cross-section.

6. A heat exchanger as claimed in claim 1 wherein the frame is round in cross-section and the housing is square in cross-section.

7. A heat exchanger according to claim 1 wherein a plurality of frames each carrying tubes in multiples of at least two side-by-side planes, said frames being joined by means of flanges.

8. A heat exchanger according to claim 7 wherein the housing is assembled in units corresponding to the individual frames connected together.

9. A heat exchanger with tubes arranged in a cross-shaped pattern, characterized by the fact that the ends of the tubes are held in the sidewalls of a frame that is open on two sides transverse to the sidewalls to form an inlet and outlet for one heat exchange fluid, and that at least one tube end is connected to an adjacent tube end in the same wall of the frame and that the frame is disposed in a housing having an inlet and an outlet for a second heat exchange fluid that is to be heated or cooled, the frame being connected to the inner edge of the housing at two diametrically opposed edges to form a connection between the inlet and one end of said tubes and the outlet and the other end of said tubes.

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165—157