July 20, 1948. R. E. BUCKHOLDT 2,445,471

HEAT EXCHANGER

Filed May 9, 1944 3 Sheets-Sheet 1

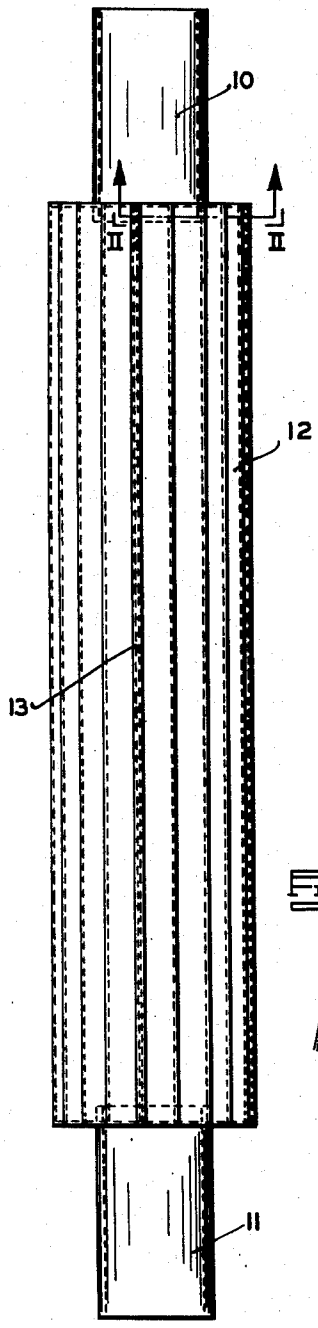


Fig 1.

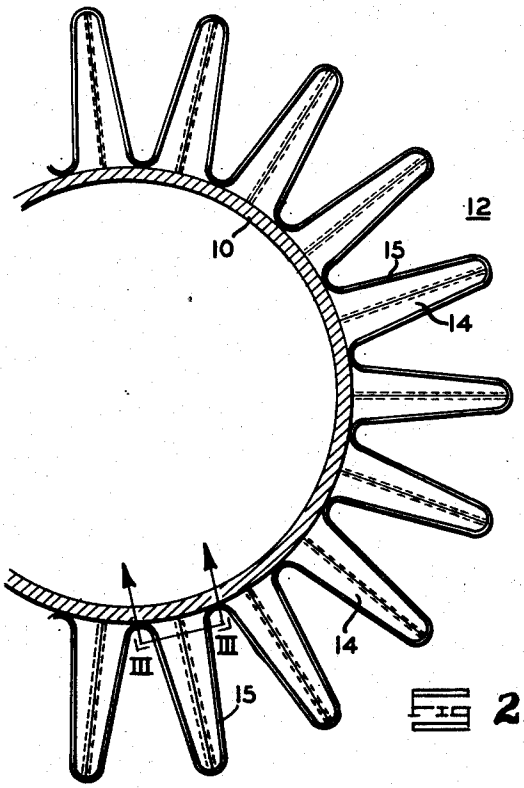


Fig 2.

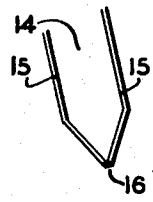


Fig 3.

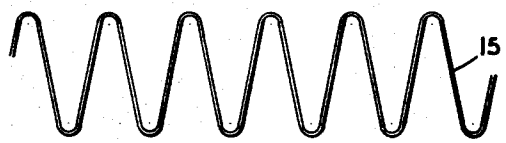


Fig 4.

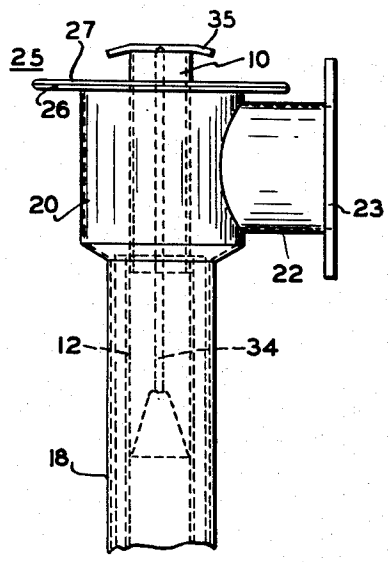
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HEAT EXCHANGER

Filed May 9, 1944 3 Sheets-Sheet 2



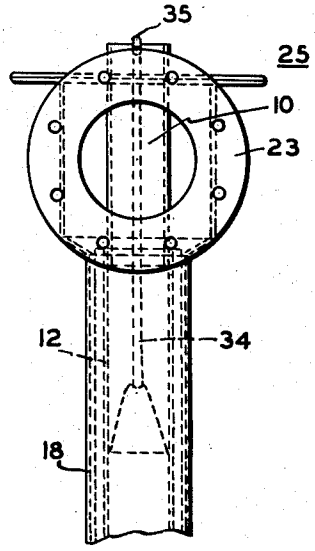


Fig. 5.

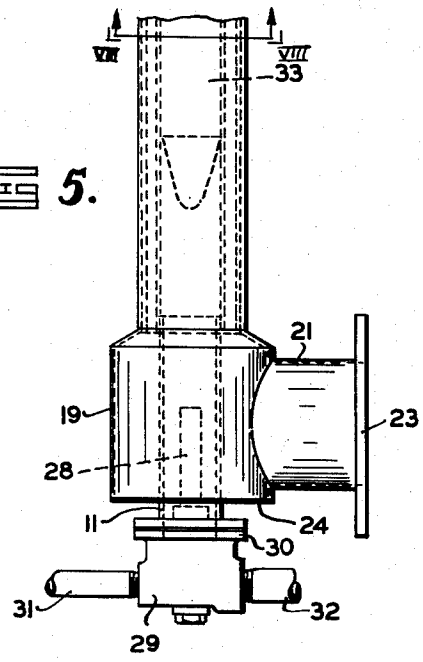
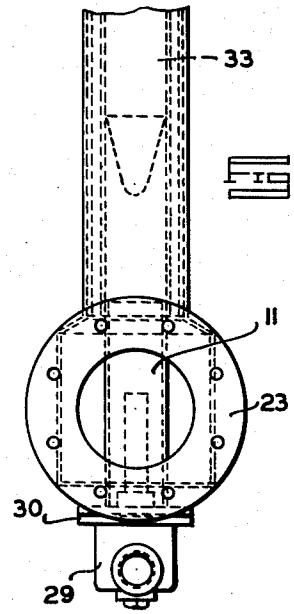


Fig. 6.



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HEAT EXCHANGER

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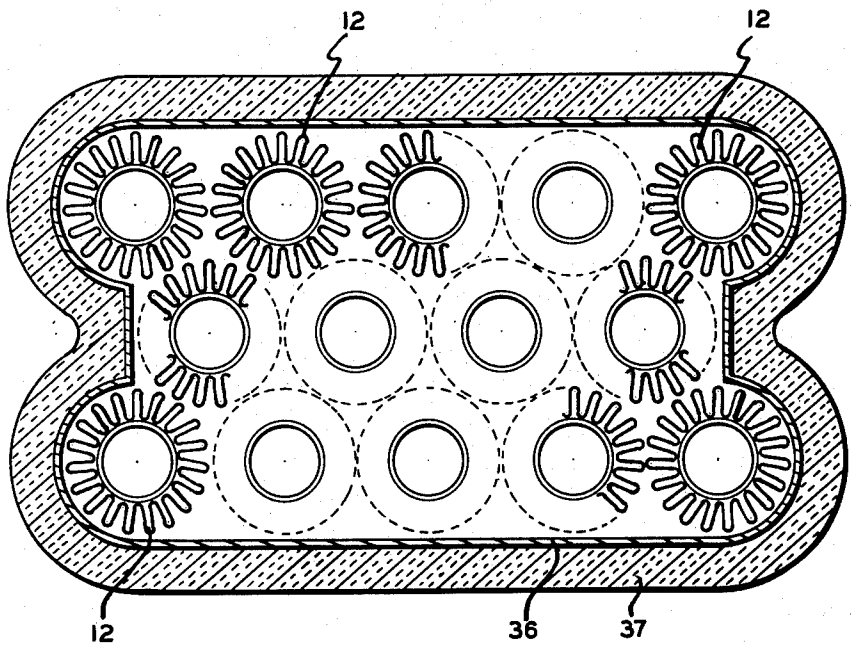


Fig 7.

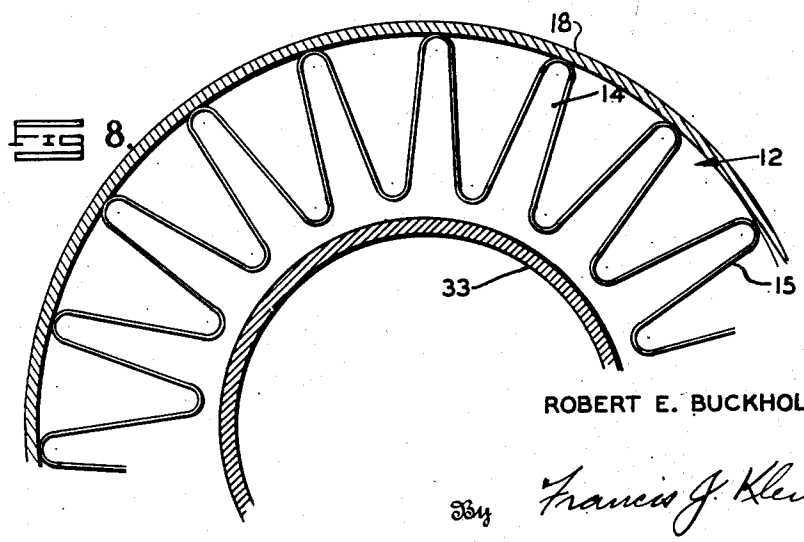


Fig 8.

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UNITED STATES PATENT OFFICE

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HEAT EXCHANGER

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Application May 9, 1944, Serial No. 534,723

2 Claims. (Cl. 257—246)

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This invention relates to heat exchangers and methods of making the same and more particularly to an improved heat exchanging tube and method of producing such tube as well as to improved complete heat exchanging assemblies utilizing such tube either singly or in multiple.

The primary object of the invention is the provision of an improved heat exchanging tube which may be readily constructed of readily available and inexpensive stock materials but which, nevertheless, is highly efficient in its normal and intended use and which possesses certain novel and advantageous characteristics as will be more fully explained hereinafter. In accordance with the preferred embodiment of this aspect of the invention, I construct the heat exchanging tube by first corrugating, doubling or pleating a metallic sheet or strip, and the material so treated is thereafter bent around a cylindrical form and fastened together in such manner as to form a complete tube having walls of uniform thickness and of deeply corrugated or fluted character. In this manner I provide as inherent features of the side wall of the tube a multiplicity of circumferentially spaced but longitudinally extending passages both inside and outside of the tube, a dividing wall between the inside and outside of uniformly thin and high heat conducting character, and box-like sections which contribute to the strength and rigidity of the completed tube. A further object of the invention is the provision of improved complete heat exchanging assemblies including confining passages for fluids both inside and outside of the primary heat exchanging tubes which utilize tubes of the general character outlined above.

These and other objects and advantages of the invention will become apparent upon consideration of the following detailed specification and the accompanying drawing wherein there is specifically disclosed certain preferred embodiments of the invention.

In the drawing:

Figure 1 is a side view of a heat exchanging tube constructed in accordance with the principles of the invention;

Figure 2 is a transverse sectional view of the tube of Figure 1, the view being taken along the line II—II of Figure 1;

Figure 3 is a fragmentary longitudinal section taken along the line III—III of Figure 2;

Figure 4 is an end view of bent or preformed stock preparatory to its fabrication into the principal body portion of the tube of Figure 1;

Figures 5 and 6 are side and plan views, respectively, of a heat exchanging assembly utilizing the heat exchanging tube of Figure 1;

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Figure 7 is a transverse sectional view of a modified form of heat exchanging assembly utilizing tubes each constructed in the manner illustrated in Figures 1, 2 and 3; and

Figure 8 is a sectional view taken along the line VIII—VIII of Figure 5.

In the drawing which illustrates the tube of the invention in its preferred form and which illustrates the preferred method of fabricating the tube, reference numerals 10 and 11 designate lengths of conventional steel tubing which is of the seamless type or other type of good quality. These lengths are aligned along their longitudinal axes but are spaced from each other along the common axis as indicated more clearly in Figure 1. The purpose of the lengths 10 and 11 is merely to provide a convenient arrangement for connecting either end of the tube of the invention to suitable fluid conducting means as will be readily apparent. Interconnecting the inner portions of the tube lengths 10 and 11 is a tubular structure 12 which is formed by wrapping a length of sheet metal which has previously been bent into sinusoidal or pleated form (as indicated in Figure 4) about a suitable form or about the inner portions of the tube lengths 10 and 11 with the meeting edges of the piece being welded along a seam as indicated at 13 in Figure 1. It is proposed to make the side wall of the tube 12 of stainless or other heat resisting steel and any suitable artifice may be resorted to to place the waves or pleats in the sheet material before the same is bent around to form the side wall structure of the complete heat exchanging tube. Also it should be understood that a multiplicity of circumferentially extending sections may be employed in completing the tube in place of the single piece illustrated in the drawing.

It should be apparent that a tube constructed in the manner outlined above is provided inherently with a multiplicity of circumferentially spaced but radially outward extending spaces (indicated on the drawing by reference numeral 14) each in open communication with the principal space inside the tube. In order to close off the ends of the spaces 14 the side walls (15) of each space 14 are bent together at their ends and welded or otherwise suitably joined along their meeting edges as at 16. Whether the tube structure 12 is formed directly over the tube lengths 10 and 11 or is assembled on a suitable mandrel, etc., and subsequently transferred onto the tube

lengths 10 and 11, the edges of the inwardly directed end portions of the walls 15 which abut against the outer surfaces of the tube lengths 10 and 11 are seam welded to the tubes 10 and 11 so that a permanent fluid-tight joint is obtained between the tube structure 12 and each of the tube lengths 10 and 11.

It should be understood that the construction above described provides a heat exchanging tube in which the fluid contained within the tube is in effective heat exchanging relation with all of the inner surface area of the sheet metal making up the body of the tube. Since this sheet metal is doubled or pleated and has a substantial number of area components extending radially outward a substantial distance from the general inner circumference of the tube structure there is a materially increased surface area of metal in direct heat exchanging contact with the fluid contained within the tube. Also, because of the uniform thickness of the metal wall contiguous to or providing such surface area a uniform temperature gradient between the inside and outside of the metal or vice versa as measured from any point on the inside (or outside) surface is effected whereby the metal of the tube is utilized to the maximum and the tube has equal heat exchanging efficiency in either direction. Moreover, since the metal wall or walls dividing the fluids inside and outside the tube is uniformly thin a maximum rate of heat transfer results. Another singular advantage of the disclosed construction is that the circumferentially spaced walls 15 defining the spaces 14 form in themselves box-like beams and cooperate with each other to provide a box-like structure of substantial strength and rigidity. This arrangement reduces the weight of the metal required in the construction of the tube. It should readily be apparent that any stress tending to bend, deflect, or collapse the tube will be resisted by a number of webs (provided by the walls 15) which lie in the plane or substantially in the plane of the line of thrust.

Referring to Figures 5 and 6, which illustrate a representative use of the heat exchanging tube structure of Figures 1 through 4, reference numeral 18 designates an outer shell or housing which is adapted to snugly receive a heat exchanging tube constructed as illustrated in Figures 1 through 4. Thus, the general outer diameter of the heat exchanging tube 12 is only slightly smaller than the inner diameter of the housing 18. Housing 18 may preferably be provided by a length of seamless tube and as shown in the drawing it is provided at either end with enlarged fittings 19 and 20 from which extend in a lateral direction tubes 21 and 22, respectively. The latter are each provided with an integral connecting flange 23 to facilitate connection of the assembly to other fluid conducting elements.

As shown, the tube length 11 which is connected to the body member 12 of the heat exchanging tube in the manner described above in connection with Figures 1 through 4 projects outwardly of the fitting 19 and a disk 24 apertured to receive the tube 11 is welded about its periphery to the fitting 19 and about its aperture to the tube 11 to form a gas-tight connection as will be understood. Similarly the tube length 10 which is connected in a gas-tight manner to the opposite end of the heat exchanging tube 12 projects outwardly of the fitting 20 and to provide for a fluid-tight seal between the tube 10 and the open outer end of the fitting 20 while allowing for the longitudinal movement of the tube 10 relative to the fitting 20 as would be occasioned by the expansion and contraction of the heat exchanging tube 12 I provide a metallic bellows arrangement 25 which consists of a disk 26 of substantially greater diameter than the diameter of the fitting 20 and which is welded in a fluid-tight manner to the outer edge of the fitting 20. The bellows 25 includes a second disk 27 apertured to receive the tube 10 and welded about its periphery to the periphery of the disk 26 and about its aperture to the tube 10.

The structure described immediately above provides an efficient heat exchanging assembly in which heated or cooled fluid passing through the inner tube 12 may impart heat to or absorb heat from a fluid which is circulated through the outer tube or housing 18 by means of the connecting spurs 20 and 22. It should be observed that, in conformance with the principles explained above in connection with the tube 12 per se that substantial areas of heat exchanging walls are presented to both the fluid passing through the inner tube and the fluid passing through the housing 18. Moreover, this wall is uniformly thin throughout the whole of its area so that a maximum rate of total heat transfer is effected. Also, by reason of the even circumferential distribution or spacing of the interstices between the radially outward extending sections of the tube 12 the fluid streams passing both inside and outside of this tube are stratified throughout the whole of the lengths of the tube so that equal heating (or cooling) will be effected on all component parts of the streams. In this manner maximum utilization is had of the metallic wall surfaces of the principal heat exchanging element.

While the heat exchanging assembly described above is obviously susceptible of widely varying advantageous uses I have found the construction particularly suitable for the heating of air or gases and have so illustrated the invention. For this purpose, a gaseous fuel burner 28 is inserted in the tube 11, the burner being carried by a housing 29 which is suitably connected to the outer end of the tube 11 as by means of a coupling 30. Fuel and air conduits 31 and 32, respectively, feed into appropriate channels contained in the housing 29 as is common in such constructions and it should be understood that upon ignition of the mixture issuing from the burner 28 the heat exchanging tube 12 will be filled with hot gaseous products of combustion which ultimately escape from the opposite end of the tube 12 through the tube length 10. The fluid to be heated is circulated over the outside of the tube 12 and within the housing 18 by entering at 22 and leaving at 21 or vice versa as will be understood.

In order to further insure the maximum utilization of the hot gaseous products of combustion (or other heating or cooling fluid) furnished the tube 12 I may provide a core 33 positioned within the tube 12 and having an outer diameter only slightly less than the general inner diameter of the tube 12 as indicated in Figures 5, 6 and 8. Core 33 may be of varying length but is preferably positioned centrally of the ends of the tube 12 and the operation or effect of the core 33 is to force all of the gases or fluid passing through the tube into the radially outward projecting interstices formed in the general outer wall of the tube. In this manner all of the gases or fluid is brought into efficient heat exchanging relation with the thin metallic walls of the tube. The core, which may be either of metallic or refractory material,

has the further advantageous effect of insuring the uniform circumferential distribution of the heating or cooling gases or fluids. Any suitable expedient may be employed to retain the core **33** in its proper position in the tube **12** as, for example, in the embodiment illustrated where the core is suspended by a rod **34** depending downwardly from a transverse rod **35** which spans the open upper end of the tube **10**.

Figure 7 illustrates another possible advantageous use of the heat exchanging tube structure illustrated in detail in Figures 1 through 4. In this assembly an outer metallic casing **36** insulated as at **37** is so formed in cross-sectional outline to snugly receive a multiplicity of the tubes **12** which are preferably staggered or nested so as to provide for maximum stratification and the maximum degree of wiping contact with the outer surfaces of the radially outward extending wall sections (**14** and **15**) of the individual tubes **12**. It should be understood that the spaces within the respective tubes **12** will be supplied with suitable heating or cooling gases or fluids as, for example, the products of combustion from individual burners inserted in the ends of the tubes in the manner illustrated in Figures 5 and 6. Other fluid to be heated or cooled is circulated through the housing **36** outwardly of the spaces within the respective tubes **12**.

It should now be apparent that I have provided improved heat exchanging assemblies and improved methods of constructing the same which fulfill the objects initially set out. By the use of light and thus relatively inexpensive materials I am enabled to readily construct highly efficient heat exchanging assemblies which have a wide range of usefulness. Moreover, the inventions disclosed herein enable complete fluid heating or cooling assemblies including the required fluid passages to be fabricated from stock materials with a minimum of time and effort.

The above specifically described embodiments of the invention should be considered as illustrative only as obviously many changes may be made therein without departing from the spirit or scope of the invention. Reference should therefore be had to the appended claims in determining the scope of the invention.

I claim:

1. Heat exchanging apparatus comprising a tubular structure having a metallic side wall formed of circumferentially spaced portions extending radially outward of the longitudinal center of said structure thereby providing a plurality of circumferentially spaced but axially extending

fluid receiving pockets in open communication with the general space within said structure, a fluid deflecting member comprising an elongated body of refractory material positioned centrally in said structure and being operative to force fluid passing through said structure into said pockets, a fluid conducting casing having end walls enclosing said structure, said structure having fluid conducting components extending through said walls, and an axially yieldable metal seal between one of said components and the adjacent wall of said casing.

2. Heat exchanging apparatus comprising in combination an outer tube, an inner tube closely fitting within said outer tube and having a side wall formed of sheet metal provided with circumferentially spaced but axially extending undulations, the radially outward apices of said undulations lying substantially in contact with the inner surface of said outer tube, metal tube members fitting within the ends of said inner members with the radially inward apices of said undulations being in contact with the outer surfaces of said metal tube members, said metal tube members extending longitudinally outward of said outer tube, a disc interconnecting one end of said outer tube with one of said metal tubular members, a bellows interconnecting the opposite end of said outer tube with the other of said metal tubular members, and inlet and outlet ports in the side wall of said outer tube adjacent the ends thereof.

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