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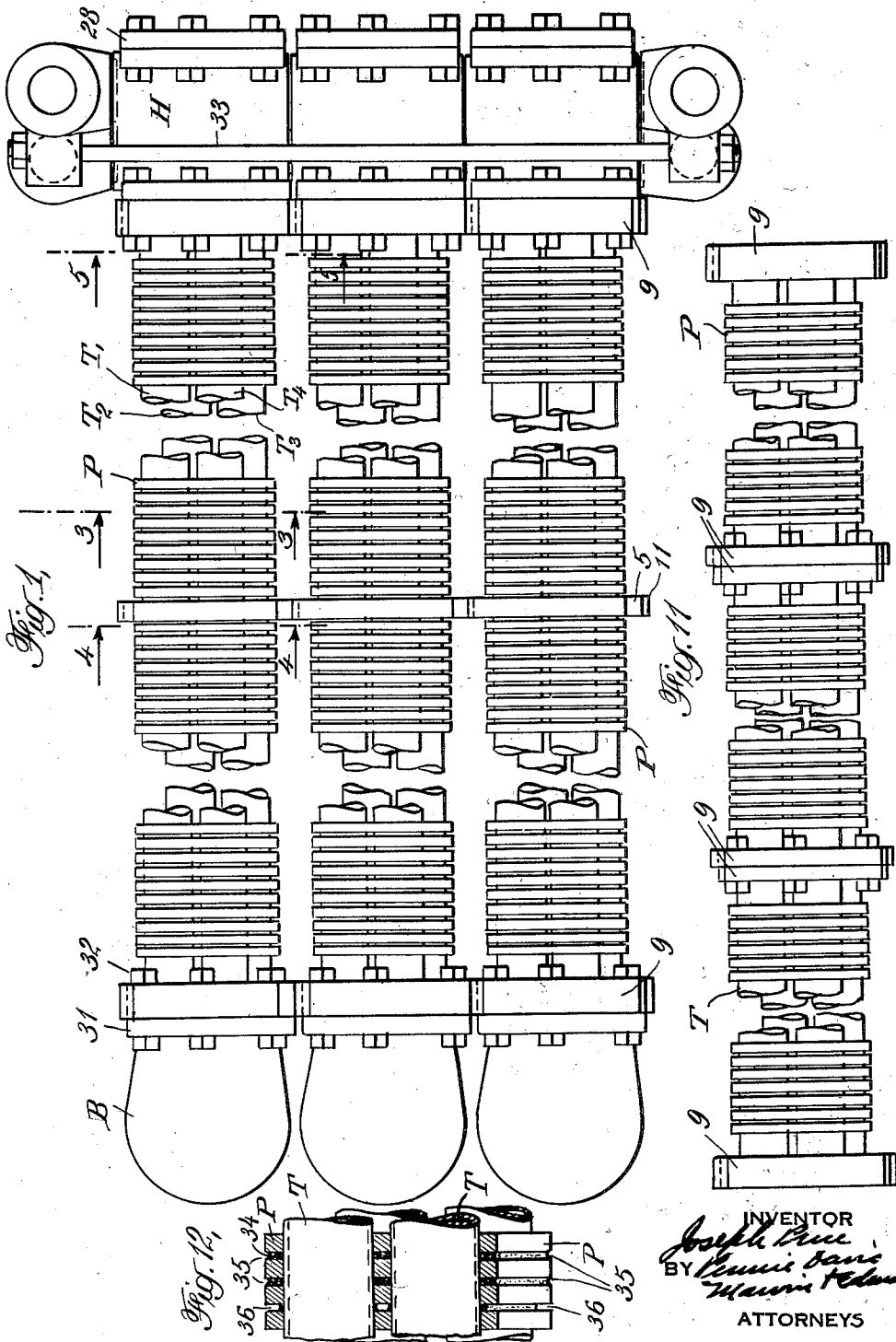
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HEAT EXCHANGER

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HEAT EXCHANGER

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19 Claims. (Cl. 257—242)

This invention relates to heat exchanging apparatus and more particularly concerns an improved and simplified construction of heat exchanger. This application is a continuation in part of my application, Serial Number 245,826, filed January 11, 1928.

In numerous industrial operations, it is desirable or essential that heat be efficiently transferred from a comparatively hot fluid to a fluid of lower temperature. Thus, for example, in oil refinery work, the efficient operation of the plant often depends to a large extent upon the completeness with which the heat content of different fluids is interchanged at different stages of their flow. The mechanical construction of the heat exchanging device employed for this purpose is an important item since this construction determines the thermal efficiency as well as the adaptability of the device to various installations.

In general, an efficient heat exchanging device should be designed to provide the maximum thermal efficiency consistent with a reasonable cost and should be constructed to provide for control of expansion strains, easy cleaning of the fluid passages and fluid-tight joints between the component parts thereof. In certain processes, it is desirable or essential that one or both of the fluids between which an exchange of heat is desired be handled at a comparatively high temperature and pressure and accordingly, the heat exchanging device should be capable of withstanding high pressures at high temperatures without danger of leakage or rupture.

In accordance with the present invention, it is proposed to provide an improved heat exchanger for effecting the efficient transfer of heat between various kinds of fluids. It is further proposed to provide a heat exchanger having fluid passages which are readily accessible for cleaning.

A further object of the invention resides in the provision of a device of the type described which, although of simple and comparatively inexpensive construction, is capable of handling fluids under very high pressures and temperatures without danger of leakage or rupture.

A still further object of the invention comprises the provision of an improved method of constructing the novel heat exchanging device.

In general, the objects of the invention are carried out by providing a plurality of tubes or pipes for carrying the different fluids between which an exchange of heat is to be effected, and by binding these pipes together in substantially parallel relation by means of a suitable element

or elements capable of effecting an efficient transfer of heat between the tubes. In one preferred form of the invention, the tubes are suitably fixed within openings in a plurality of parallel transverse plates, the plates being closely spaced along the tubes. The plates act not only to mechanically connect the tubes in a unitary structure but also to conduct heat from one set of tubes to the other and to reinforce the tube walls in order that they may withstand high pressures while heated to high temperatures without danger of distortion and rupture. In a modified form of the invention, it is preferred to employ a mass of heat conducting material in the spaces between the adjacent plates and tubes, this material acting as a heat transferring medium and supplementing the heat conductive function of the plates.

According to the invention, the improved heat exchange device may be formed by using comparatively thin metal tubes of steel or other suitable metal and by passing such tubes through openings in a plurality of metal plates, the plates being then spaced closely and uniformly along the tubes. The tubes are then expanded into intimate and rigid heat exchanging contact with the plates by drawing expanding elements through the tubes or by the application of hydraulic pressure to the interiors thereof.

The invention will be best understood by reference to the accompanying drawings in which certain modifications thereof have been shown. In the drawings:

Fig. 1 is an elevation of a plurality of heat exchanger units embodying the invention;

Fig. 2 is a plan view one of the units shown in Fig. 1;

Fig. 3 is a sectional view taken along the line 3—3 of Fig. 1;

Fig. 4 is a sectional view taken along the line 4—4 of Fig. 1;

Fig. 5 is a sectional view taken along the line 5—5 of Fig. 1;

Fig. 6 is a left end view of one of the units shown in Fig. 1;

Fig. 7 is a right end view of the heat exchanger shown in Fig. 1;

Fig. 8 is a sectional view taken along the line 8—8 of Fig. 7;

Fig. 9 is a sectional view taken along the line 9—9 of Fig. 6;

Fig. 10 is a sectional view taken along the line 10—10 of Fig. 6;

Fig. 11 is an elevation of a sectionalized heat exchanger unit embodying the invention;

Fig. 12 is an enlarged partial sectional view of a further modification of the heat exchanger of the invention; and

Fig. 13 is a partial sectional view on an enlarged scale, of a heat exchanger unit embodying the invention and provided with comparatively thin plates.

Referring to the drawings, the heat exchanger unit of the invention comprises generally a plurality of tubes or pipes T lying in substantially parallel relation and united mechanically and thermally by a plurality of transversely extending plates P of heat conductive metal. Certain of the tubes T, usually two or more of these tubes, are arranged for carrying a comparatively hot fluid while another tube or tubes of the group carries a comparatively cool fluid, and the plates P serve as a heat transferring medium for efficiently carrying heat from the hot tubes to the cooler tubes.

Referring now more in detail to the construction of the disclosed embodiment of the invention, each unit of the heat exchanger shown comprises four tubes T₁, T₂, T₃ and T₄. These tubes are preferably comparatively thin walled and may conveniently comprise seamless drawn tubes of steel or other suitable metal. The plates P which mechanically unite and thermally connect the tubes may take various shapes, and as shown in Fig. 3, may comprise oblique parallelograms with rounded corners having four symmetrically disposed openings 1, 2, 3 and 4 there-through for the respective reception of the tubes T₁, T₂, T₃ and T₄. The plates P may be formed of any suitable heat conductive metal such as iron or steel. Plates of approximately one-eighth inch thickness have been found suitable for this use and thin plates of this type have been shown in Fig. 13. The plates P are uniformly spaced along the tubes and fixed in intimate heat conductive contact therewith by shrinking the plates about the tubes or expanding the tubes within the plates as hereinafter described. When comparatively thick plates are used, they are preferably spaced apart a distance appreciably less than the thickness of the plates, as shown in Figs. 1 and 2. Thus, when plates of approximately one-half inch thickness are used, these plates may be spaced approximately one-eighth of an inch apart. The plates P may be economically produced by punching them from sheet metal since the edges and surfaces of the plates need not be accurately finished.

When the heat exchanger unit is of considerable length, means are preferably provided for supporting the unit at one or more points intermediate its ends. This may be conveniently accomplished by providing one or more wide transverse supporting plates 5 at suitably spaced points and connecting such plates to any suitable supporting structure. In the disclosed embodiment, a single transverse supporting plate 5 has been shown disposed at substantially the mid-point of each unit, this plate being somewhat thicker than the plates P. The supporting plates 5 are preferably provided with arms 6 which extend outwardly beyond the edges of the heat conducting plates P and are provided with interengageable lugs 7 and recesses 8, as shown in Fig. 4, whereby the plates 5 may be interconnected when a plurality of heat exchanger units are assembled in parallel relationship, as shown in Fig. 1. If desired, the supporting plates 5 may be dispensed with and the units may be connected to suitable supports by welding the sup-

porting members directly to the plates P at the desired points.

The heat exchanger units of the invention may be integral, as shown in Fig. 1, or sectional, as shown in Fig. 11. Suitable end flanges 9 are fixed to the opposite ends of each unit to facilitate the interconnection thereof and the connection of the return bonnets and stationary heads thereto. The end flanges may take any desired shape and are provided with openings 10 for the reception of the tubes T, as shown in Fig. 5. The end flanges 9 may be sealed to the tubes T by welding, by expanding the tubes into the flange openings or in any other suitable manner. Suitable cooperating lugs 11 and recesses 12 are preferably formed on the opposite edges of the end flanges 9, and when a plurality of units are assembled in parallel relation, these lugs and recesses interengage to unite and connect the units in substantially parallel alignment, as shown in Figs. 1 and 5.

It is generally preferred to employ each unit of the exchanger as a double pass heat exchange device, although this arrangement is not essential to the invention. Thus, in the disclosed embodiment, means are provided for passing a comparatively hot fluid through the tubes T₂ and T₄ of the unit, and for passing a comparatively cool fluid through the tubes T₁ and T₃ thereof. When diagonally opposite tubes are respectively employed to carry the hot and cool fluids, there is a balance of the expansive and retractive forces set up in the unit by the heating and cooling of the two sets of tubes, and the unit is heated uniformly, thereby eliminating any tendency to warp the unit by heating the tubes on one side thereof and cooling the tubes on the other side.

The hot and cool fluids may be conducted through the tubes T by the use of a stationary head H at one end of each unit and a return bonnet or cap B at the other end thereof. Each stationary head includes two separate inflow channels 15 and 16 extending from the bossed ingress ports 13 and 14 on the upper face of the head to the egress ports 17 and 18 on the side face thereof, as shown in Fig. 8. Two separate outflow channels 19 and 20 are also provided in each head H and extend respectively from the ingress ports 21 and 22 on the side face of the head to the bossed egress ports 23 and 24 on the lower face thereof. The inflow channel 15 preferably supplies comparatively cool fluid to the tube T₁ and the outflow channel 20 carries this fluid out of the tube T₃. The comparatively hot fluid passes through the inflow channel 16 to the tube T₂ and flows from the tube T₄ out of the outflow channel 19. The head H is provided with oppositely disposed end flanges 26 and 27, the flange 26 being fixed to an end flange 9 of the heat exchanger unit by suitable means such as bolts and the end flange 27 being closed by a cover plate 28, similarly fixed thereto.

The return bonnet B comprises a casting having a return chamber 29 for connecting the hot fluid tubes T₂ and T₄ and a U-shaped return passage 30 overlying the chamber 29 and extending at right angles thereto for connecting the cool fluid tubes T₁ and T₃. The bonnet B is provided with a flange 31 machined to fit the end flange 9 of the heat exchanger unit and the flanges 31 and 9 may be clamped in fluid-tight engagement by the bolts 32 passing therethrough or by any other suitable means.

When the tubes T of a unit are equipped with a head H at one end and a return bonnet B at the

other end, the hot fluid is introduced through the port 14 in the stationary head H and flows through the channel 16 therein to the hot tube T₂ and thence through the return chamber 29 of the return bonnet B to the hot tube T₁, and back to the stationary head H, flowing out through the channel 19 and the port 23. The cool fluid enters the port 13 in the head H, is introduced through the channel 15 to the cool tube T₁ and flows through this tube through the return passage 30 of the return bonnet B back through the cool tube T₂ and out through the channel 20 and port 24 of the stationary head H.

In the description above, both fluids flow downwardly through the heat exchanger unit, but if desired, the flow may be upwardly or counter-current.

As shown in Figs. 1 and 7, any desired number of the above described heat exchanger units may be assembled to form a unitary heat exchange device. Thus, a plurality of such units may be assembled in series relation by connecting the upper and lower ports of the successive stationary heads by means of bolts 33 engaging the end heads, as shown in Figs. 1 and 7. In this manner, the hot and cool fluids are successively carried through the adjacent units as explained above. The units so connected are substantially laterally aligned and connected by means of the interengaging lugs 7 and 11 and recesses 8 and 12 on the supporting plates 5 and end flanges 9 thereof, as shown in Fig. 1. The heat exchange device may also be extended lengthwise of the units by adding one or more sections thereto as indicated in Fig. 11. In this manner, the units may be employed to form heat exchangers of widely varying shapes and dimensions.

Although in the described embodiment, two tubes are provided for hot fluids and two for cool fluids, it is obvious that the number of tubes employed for each fluid may be varied as desired and the invention is not limited to the number of cool and hot tubes shown. Thus, the units may be of the single pass type with one or more tubes for each fluid and no return flow. When a plurality of passes is to be employed, two or more tubes are employed for the hot fluid and two or more tubes for the cool fluid. Different numbers of tubes may obviously be used for the different fluids. For example, the unit may comprise three tubes for carrying one fluid and six tubes for carrying the other.

When greater heat conductivity between the hot and cool tubes than that provided by the plates P alone is desired, it is preferred to immerse the tubes in a suitable fluid or solid which will occupy the spaces between the plates P and serve as a more efficient heat transferring medium than the air gaps between these plates. As shown in Fig. 12, a mass of heat conductive material 34 may be packed between the plates P and the tubes T for this purpose. Various heat conductive solids such as a low melting point metal, rosin or a carbon deposit may be employed as the heat conductive material 34 between the plates. The heat conductive material 34 may extend from the tubes T to the outer edges of the plates P, as shown at 35, thus completely filling the spaces between the plates, or this material may be packed about the tubes and in contact with the plates adjacent the roots of the plates only, as shown at 36. With the spaces between the plates completely filled with the material 34, as shown at 35, the material 34 itself conducts heat directly between the tubes T, whereas when

the material 34 is confined to the roots of the plates, as shown at 36, it serves to increase the heat conductive contact between the plates and the tubes.

The improved method of producing the novel heat exchanger of the invention will now be described. The plates P are first cut or punched from a sheet of iron, steel or other metal having the desired heat conductive properties, and the openings 1, 2, 3 and 4 are formed in the plates by punching, drilling or in any other suitable manner. A plurality of tubes T are then passed through the corresponding openings in a plurality of the plates P, and the plates are uniformly spaced along the tubes. The tubes T are preferably formed of seamless drawn metal and are comparatively thin walled, as shown in Figs. 3, 4 and 5. The openings in the plates are preferably formed slightly larger than the outside diameter of the tubes, whereby the plates may be moved along the tubes before being secured thereto. As explained above, the plates P are disposed relatively close together, and the clearance between adjacent plates may conveniently comprise approximately one-eighth of an inch or less. If supporting plates 5 are employed, one or more of these plates is passed over the tubes at the desired point or points along the unit, and is spaced from the adjacent plates P a distance approximately equal to the interval between the successive plates P.

The plates P are next fixed to the tubes in any suitable manner. It is preferred to unite the tubes and the plates by expanding the tubes into rigid clamping engagement and heat conductive contact with the plates by employing outward pressure to the tube walls. Thus, a ball or roller expander may be passed through each tube T at a uniform rate to expand the wall thereof into intimate contact with the walls of the openings in the plates P, or a suitable liquid under comparatively high hydraulic pressure may be confined in each tube to effect the expansion thereof. If desired, the end flanges 9 of the units may be passed over the ends of the tubes T before the tubes are expanded and both the flanges 9 and the plates P may be fixed in place by the expansion of the tubes. However, since the end flanges 9 must form a fluid-tight joint with the tubes T whereas the plates P need not be as tightly connected to the tubes, it is preferred to weld the end flanges 9 to the tube ends after the plates P have been fixed in place.

Although it is preferred to fix the plates P to the tubes T by the expansion of the tubes, it is also feasible to form the desired connection by shrinking the plates about the tubes. When this procedure is followed, the openings in the plates are made slightly smaller in diameter than the outside diameter of the tubes and the plates are heated to a comparatively high temperature whereby they expand to such an extent that they may be passed over the tubes. The tubes T are maintained at a low temperature by passing water or any other cooling fluid there-through while the hot plates are being assembled thereon. After the hot plates have been assembled in proper relation on the tubes, the plates are permitted to cool and so shrink into rigid engagement with the tubes.

After the plates P and end flanges 9 have been fixed in place on the tubes T, the heat conductive material 34 may be deposited in the spaces between the plates. The method by which the material 34 is applied will vary in

accordance with the nature of the material used. If a low melting point metal is employed as the heat conductive material 34, this metal is preferably reduced to a molten state and poured into the spaces between the plates P, suitable forms being used to confine the metal to these spaces until it solidifies.

The heat exchanger unit of the present invention presents numerous advantageous features. The tube walls are effectively reinforced by the plates and fluids under high pressures and at high temperatures may be passed through the tubes without danger of rupture or distortion. Due to the effective reinforcement provided by the plates, very thin walled tubing can be used and the weight and cost of the unit is consequently comparatively low. The pressure resistant qualities of the improved exchanger make it particularly adaptable for use in the oil refining or coal tar refining industries where pressures of 3,000 lbs. per square inch or more together with temperatures as high as 800° F. are often encountered in both fluids passing through the heat exchanger.

The improved construction of the novel heat exchanger lends itself admirably to the different requirements of different installations. Thus, a plurality of heat conductive plates, cut to proper size, may be kept in stock and assembled as desired on tubes formed of metals particularly adapted to handle the fluids to be treated in a given installation. If non-corrosive fluids are to be handled, the tubes may be formed of steel, iron or other comparatively inexpensive metals, whereas tubes of corrosion-resistant metal may be employed when fluids containing acids or other corrosive materials are to be passed there-through.

The tubes may be readily cleaned by removing the return bonnets B and the cover plates 28 of the stationary heads H and passing a cleaning-tool entirely through the tubes.

The size of the units may be readily varied by using tubes of various lengths, or the units may be supplied in standard sizes and a plurality of unit sections may be connected end-to-end to give the desired amount of heat exchanging surface. Either the sectional or integral units may be extended laterally by assembling a plurality of longitudinal units side by side and connecting the flow paths through the stationary heads as described above.

It should be understood that the embodiments of the invention selected for illustration are but typical of various forms in which the invention may be carried out, and the invention is not limited to the details of construction disclosed except insofar as recited in the appended claims.

I claim:

1. A heat exchanger element comprising at least one tube for carrying a comparatively hot fluid, at least one tube disposed along and substantially parallel to said first tube for carrying a comparatively cool fluid, a plurality of closely spaced separate parallel plates of heat conductive material extending transversely of and surrounding both of said tubes and serving to unite said tubes and to transfer heat between said tubes, means for supplying a fluid to one of said tubes and means for separately supplying to another tube a fluid having an initial temperature different from the initial temperature of the fluid supplied to said one tube.

2. A heat exchanger unit comprising at least two substantially parallel tubes and a plurality of

spaced parallel plates extending transversely of said tubes, each of said plates having at least two openings therethrough for the reception of said tubes and means for separately supplying fluids of different temperature respectively to the two tubes.

3. A heat exchanger unit comprising a plurality of closely spaced parallel plates of heat conductive material having a plurality of sets of aligned openings therethrough, at least one tube for carrying a comparatively hot fluid extending through one set of aligned openings in said plates, at least one tube for carrying a comparatively cool fluid extending through another set of aligned openings in said plates, and lying substantially parallel to said first mentioned tube and means for separately supplying fluids of different temperature respectively to said hot fluid tube and said cold fluid tube.

4. A heat exchanger unit comprising a plurality of closely spaced substantially parallel metallic plates having a plurality of sets of aligned openings therethrough, at least two tubes for carrying a comparatively hot fluid extending through aligned openings in said plates, at least two tubes for carrying a comparatively cool fluid extending through other aligned openings in said plates and means at one end of said tubes for connecting the tubes for carrying the comparatively hot fluid and for separately connecting the tubes for carrying the comparatively cool fluid.

5. A heat exchanger unit comprising a plurality of uniformly spaced substantially parallel metallic plates each having four similarly arranged openings therethrough, four substantially parallel tubes respectively passing through the openings in said plates and fixed therein, and means at one end of said unit for forming separate connecting passages between the diagonally opposite pairs of tubes.

6. A heat exchanger unit comprising a plurality of substantially parallel thin walled seamless metallic tubes, means for conducting a comparatively hot fluid through at least two of said tubes, means for conducting a comparatively cool fluid through at least two others of said tubes and a plurality of comparatively thick plates of heat conductive metal extending transversely of said tubes and provided with openings for the reception of said tubes, said plates being spaced apart a distance appreciably less than the thickness of said plates.

7. A heat exchanger unit comprising a plurality of substantially parallel thin walled seamless metallic tubes, means for conducting a comparatively hot fluid through at least two of said tubes, means for conducting a comparatively cool fluid through at least two others of said tubes, a plurality of comparatively thick plates of heat conductive metal extending transversely of all of said tubes and provided with openings for the reception of said tubes, said plates being spaced apart a distance appreciably less than the thickness of said plates and means at one end of said unit for separately connecting said tubes carrying the comparatively hot fluid and said tubes carrying the comparatively cool fluid.

8. A heat exchanger element comprising at least one tube for carrying a comparatively hot fluid, at least one tube disposed along and substantially parallel to said first tube for carrying a comparatively cool fluid, a plurality of closely spaced substantially parallel plates of heat conductive metal extending transversely of and surrounding both of said tubes and serving to unite

said tubes and to transfer heat between said tubes and a mass of heat conductive material at least partially filling the spaces between said plates and lying in contact with said tubes.

9. A heat exchanger unit comprising a plurality of substantially parallel thin walled seamless metallic tubes, means for conducting a comparatively hot fluid through at least two of said tubes, means for conducting a comparatively cool fluid through at least two others of said tubes, a plurality of comparatively thick plates of heat conductive metal extending transversely of all of said tubes and provided with openings for the reception of said tubes, said plates being spaced apart a distance appreciably less than the thickness of said plates and a mass of heat conductive material at least partially filling the spaces between said plates and lying in contact with the surfaces of said tubes.

10. A heat exchanger unit comprising at least two parallel tubes, a plurality of spaced parallel plates extending transversely of said tubes and provided with openings for the reception of said tubes and a mass of heat conductive material filling the spaces between said plates from the surfaces of said tubes to the edges of said plates.

11. A heat exchanger unit comprising a plurality of spaced substantially parallel metallic plates each having two similarly arranged openings therethrough, two substantially parallel tubes respectively passing through the openings in said plates and fixed therein, and means for separately supplying fluids of different temperatures respectively to the two tubes.

12. A heat exchanger unit comprising a plurality of substantially parallel thin walled metallic tubes, means for conducting a comparatively hot fluid through at least one of said tubes, means for conducting a comparatively cool fluid through at least one of said tubes, and a plurality of plates of heat conductive metal extending transversely of said tubes and provided with openings for the reception of said tubes.

13. A heat exchanger unit comprising a plurality of substantially parallel thin walled metallic tubes, means for conducting a comparatively hot fluid through at least one of said tubes, means for conducting a comparatively cool fluid through at least one other of said tubes, and a plurality of plates of heat conductive metal extending transversely of all of said tubes and provided with openings for the reception of said tubes, said plates being spaced apart a distance appreciably less than the thickness of said plates.

14. A heat exchanger unit comprising a plurality of substantially parallel thin walled metallic tubes, means for conducting a comparatively hot fluid through at least one of said tubes, means for conducting a comparatively cool fluid through at least one other of said tubes, a plurality of plates of heat conductive metal extending trans-

versely of all of said tubes and provided with openings for the reception of said tubes, said plates being spaced apart a distance appreciably less than the thickness of said plates, and a mass of heat conductive material at least partially filling the spaces between said plates and lying in contact with the surfaces of said tubes.

15. A heat exchanger unit comprising at least two parallel tubes, a plurality of spaced parallel plates extending transversely of said tubes and provided with openings for the reception of said tubes and a mass of heat conductive material at least partially filling the spaces between said plates and lying in contact with said tubes.

16. A heat exchanger unit comprising a plurality of substantially parallel tubes, means for conducting a comparatively hot fluid through at least one of said tubes, means for conducting a comparatively cold fluid through at least one of said tubes, and a plurality of plates of heat conductive material extending transversely of said tubes and provided with openings for the reception of said tubes.

17. A heat exchanger unit comprising a plurality of substantially parallel tubes, means for conducting a comparatively hot fluid through at least one of said tubes, means for conducting a comparatively cool fluid through at least one other of said tubes, and a plurality of plates of heat conductive material extending transversely of all of said tubes and provided with openings for the reception of said tubes, said plates being spaced apart a distance appreciably less than the thickness of said plates.

18. A heat exchanger unit comprising a plurality of substantially parallel tubes, means for conducting a comparatively hot fluid through at least one of said tubes, means for conducting a comparatively cool fluid through at least one other of said tubes, a plurality of plates of heat conductive material extending transversely of all of said tubes and provided with openings for the reception of said tubes, said plates being spaced apart a distance appreciably less than the thickness of said plates, and a mass of heat conductive material at least partially filling the spaces between said plates and lying in contact with the surfaces of said tubes.

19. A heat exchanger unit comprising at least two substantially parallel tubes, means for conducting a comparatively hot fluid through at least one of said tubes, means for conducting a comparatively cool fluid through at least one other of said tubes and a plurality of plates of heat conductive material extending transversely of said tubes and provided with openings for the reception of said tubes, the said plates being in intimate contact with said tubes to facilitate the transfer of heat between the plates and the tubes.

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