

Jan. 27, 1942.

EMILIEN BLAIS, COMMONLY KNOWN AS EMILE BLAIR

2,270,864

HEAT EXCHANGER

Filed June 6, 1938

4 Sheets-Sheet 1

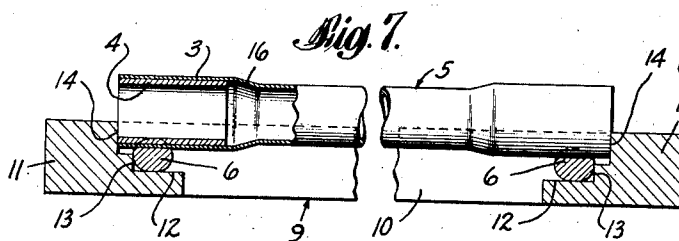
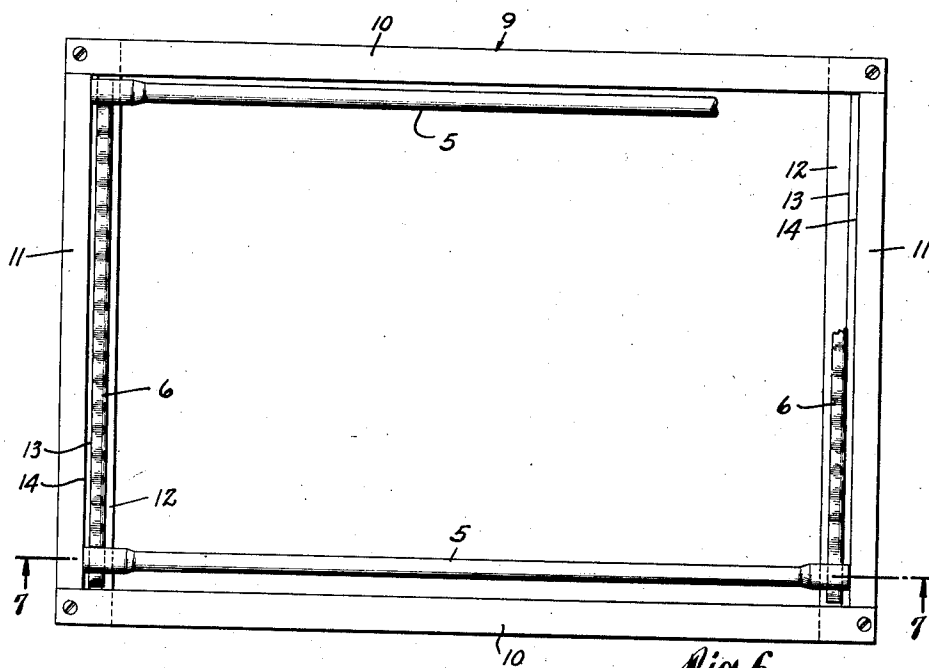
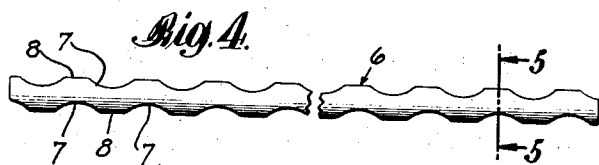
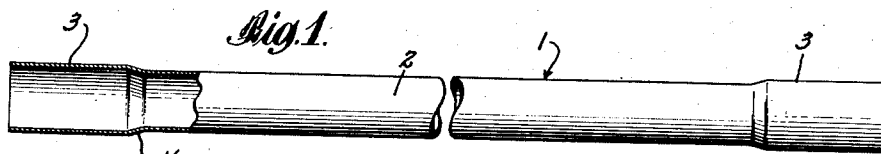


Fig. 6.

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4 Sheets-Sheet 2

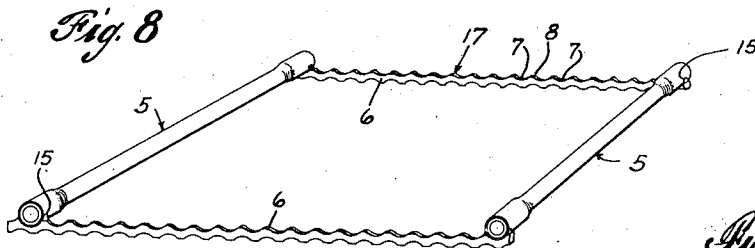


Fig. 9

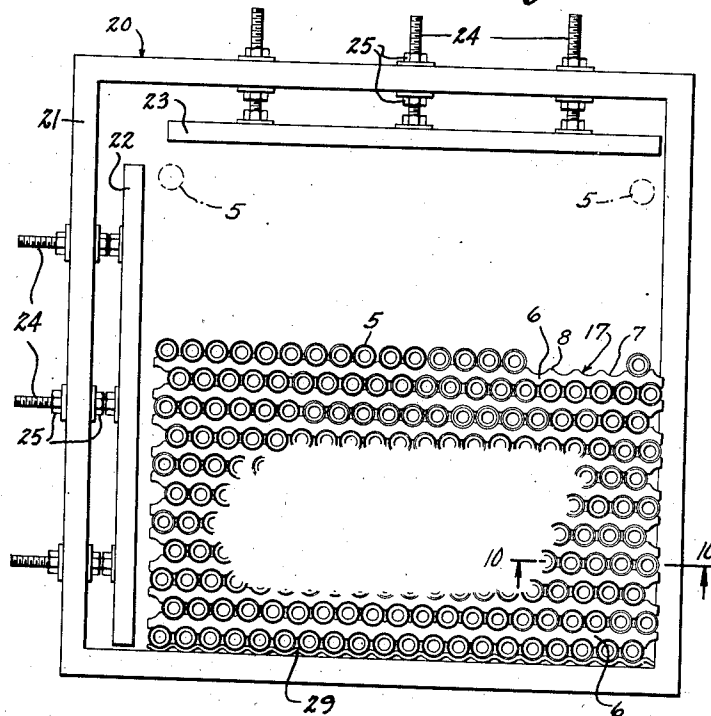


Fig. 10

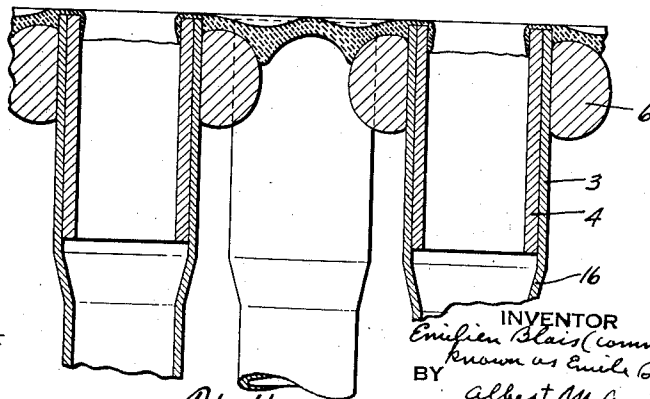
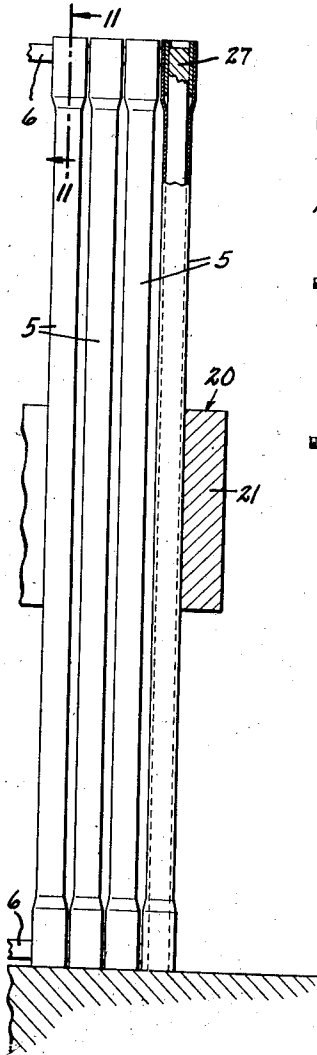


Fig. 11

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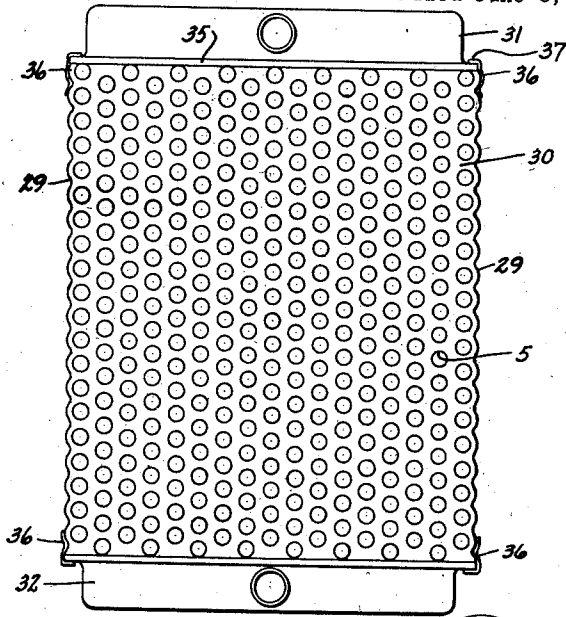


Fig. 12

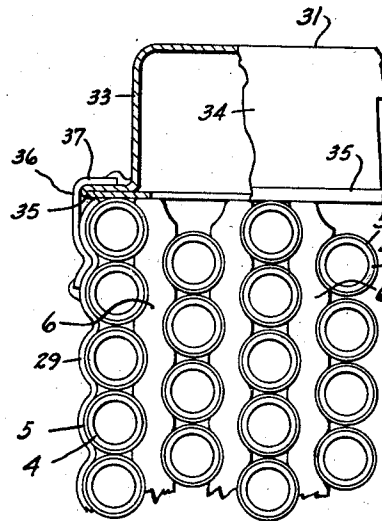


Fig. 13

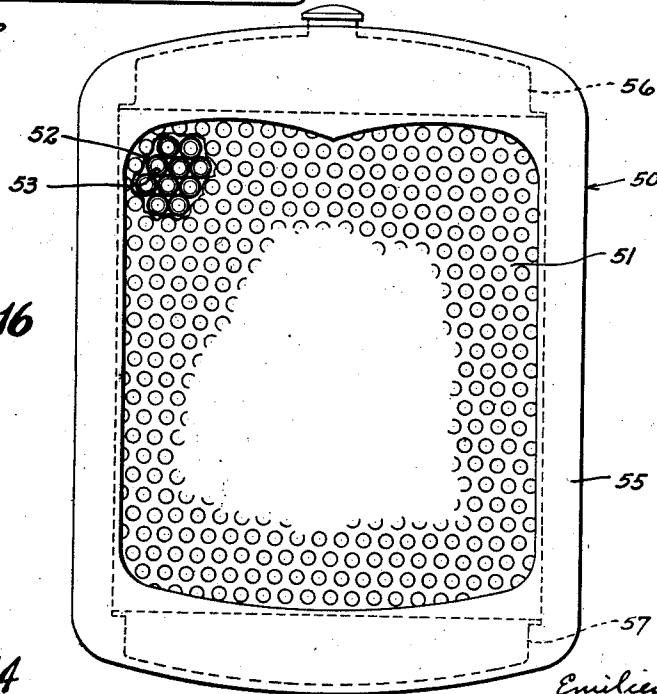


Fig. 16

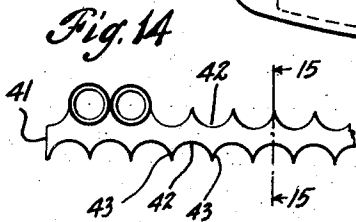


Fig. 14



Fig. 15

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Fig. 17

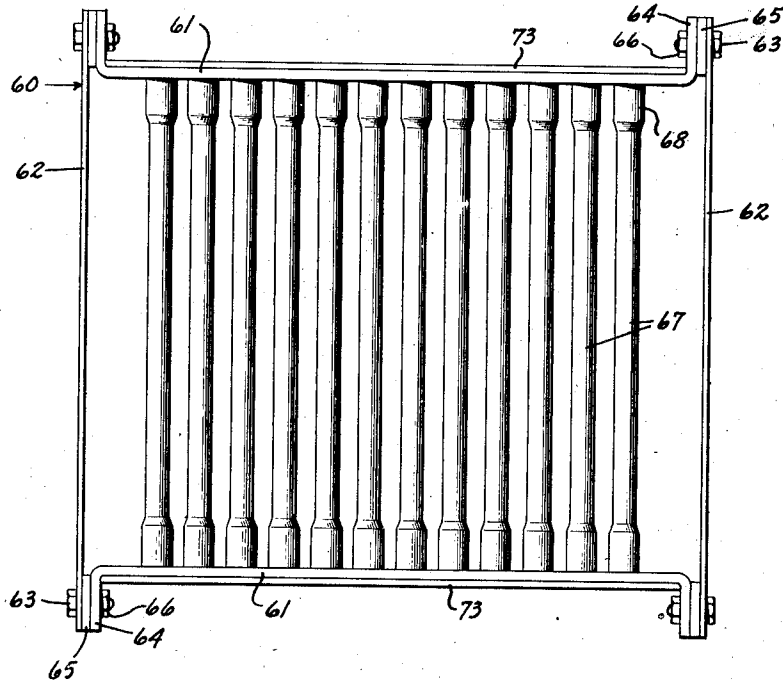


Fig. 19

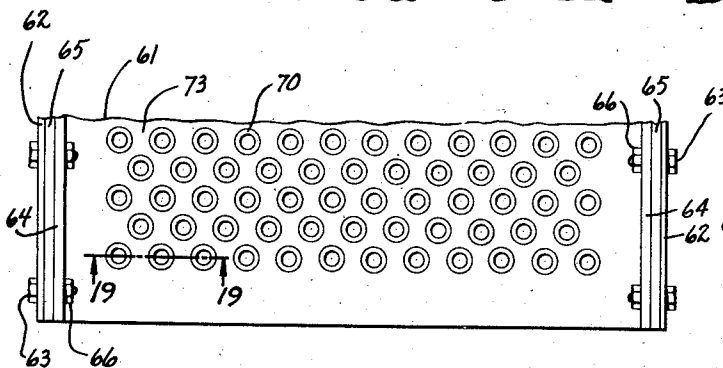
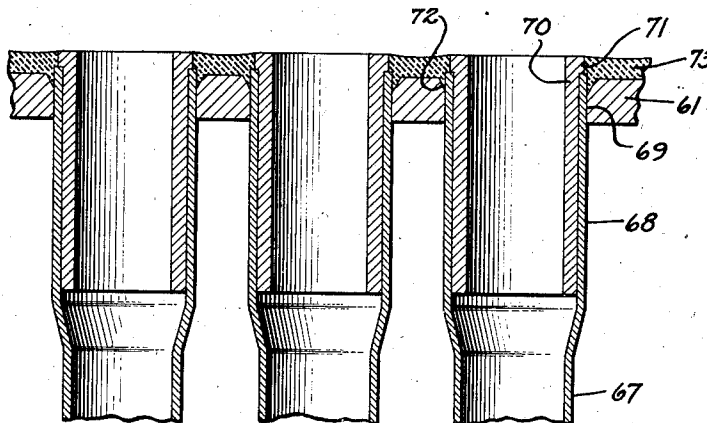


Fig. 18

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UNITED STATES PATENT OFFICE

2,270,864

HEAT EXCHANGER

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poration of Delaware

Application June 6, 1935, Serial No. 211,979
In Great Britain May 23, 1935

2 Claims. (Cl. 257—128)

This invention relates generally to heat exchangers and to a method for making the same. More particularly, the invention relates to heat exchangers of the type constituted by a plurality of tubes which are secured together to provide a plurality of passages for one of the fluids and which have at least their body portions spaced apart to provide a space for the passage of another fluid around the tubes.

In constructing heat exchangers of the type to which the present invention relates, it is desirable that the tubes be connected to form the core in such a manner that they will be permanently and securely fastened together, the ends of the core will be completely sealed around the tubes, and the bond between the tubes will be resistant to heat, corrosion, vibration and other destructive effects. Ordinary solder is unsuited for this use because it does not have sufficient mechanical strength and, for many uses, does not have a sufficiently high melting point. Certain fusible metallic bonding materials have the desired properties but require the application of so much heat to fuse them, that the tubes are so annealed or softened as not to have the desired rigidity and resistance to deformation.

In accordance with the present invention, a plurality of thin wall tubes of suitable shape and material are assembled into substantially the shape of the core to be formed and a fusible metallic bonding material of relatively high mechanical strength and relatively high melting point is applied to the end portions of the tubes to secure them together and to provide a seal around the tube ends. The tubes are spaced at least at their body portions to provide space for one of the fluids. This is accomplished by expanding the ends of the tubes, or by providing additional spacing members between rows of tubes or by inserting the tubes in spaced openings in one or more header plates. Before the tubes are bonded, bushings or ferrules are applied to the ends in heat exchange relation therewith to absorb or dissipate sufficient of the heat of bonding to prevent annealing of the tubes.

In certain cases, as for example, where a large number of tubes are assembled, a greater heat dissipation during bonding is desirable. In such cases, the heat is absorbed by inserting removable metal rods in the tubes during the application of the heat, or by causing a fluid cooling medium such as air to flow past and around the tubes.

Imperforate, preferably corrugated, side plates, which also reinforce the core, and ducts or tanks

of suitable construction are assembled with the core, and are joined thereto by a bonding operation preferably similar to that employed in joining the tubes.

5 The invention also provides a novel heat exchanger core wherein the tubes are firmly and rigidly secured together and the spaces between the tube ends are positively sealed. The bushings or ferrules serve to strengthen and reinforce the ends of the core. Where the tubes are assembled without end header plates, the bushings, together with the tube ends and bonding material—and spacing strips when these are used—constitute a rigid sealing end wall around the ends of the tubes. These end walls, together with the reinforcing side walls, provide a strong, rigid core construction.

10 An object of the present invention is the provision of a method for assembling heat exchanger cores from tubes wherein the tubes are secured in the core by a relatively high melting point bonding material, without annealing or softening the tubes.

15 Another object of the invention is the provision of a heat exchanger core of the tube type wherein the tubes are secured together at their ends without a header plate, and individual reinforcing members are provided which form, together with the tube ends and bonding material, a rigid sealing end wall.

20 Another object of the invention is to provide a heat exchanger having a core of the type constituted by a plurality of tubes, in which heat exchanger, the several parts are secured together by a bond of high mechanical strength.

25 Another object of the present invention is the provision of a heat exchanger core of the tube type having a novel reinforcing side and end wall construction.

30 The invention further consists in the new and novel features of operation and the new and original arrangements and combinations of steps in the process hereinafter described and more particularly set forth in the claims.

35 The invention also consists in forming a product having the general characteristics, the new and useful applications, and the several original features of utility hereinafter set forth and claimed.

40 Other features, objects and advantages of the present invention will in part be pointed out and in part become apparent in connection with the following detailed description of certain illustrative forms of construction, reference being had to the accompanying drawings, wherein

55

Fig. 1 is a side elevational view of a tube suitable for forming a heat exchanger core in accordance with the present invention;

Fig. 2 is a longitudinal cross-sectional view through a bushing or ferrule suitable for employment in practising the invention;

Fig. 3 is a longitudinal sectional view through a tube having bushings inserted therein;

Fig. 4 is a side elevational view of one form of spacing strip suitable for use in practising the invention;

Fig. 5 is a transverse cross-sectional view taken along line 5—5 of Fig. 4;

Fig. 6 is a top plan view of an assembly frame suitable for use in assembling the tubes and spacing strips, which view shows two spacing strips and two tubes in position in the frame;

Fig. 7 is a fragmentary, enlarged cross-sectional view taken along line 7—7 of Fig. 6;

Fig. 8 is a perspective view showing an assembly comprising a pair of spacing strips and tubes;

Fig. 9 is a front elevational view of a clamp suitable for use in maintaining the tubes in assembled relation for bonding, the view showing a number of tubes and assemblies in the frame;

Fig. 10 is an enlarged fragmentary cross-sectional view taken along line 10—10 of Fig. 9 and illustrating particularly one of the heat dissipating rods within one of the tubes, the assembled tubes being shown as standing on end on a supporting surface;

Fig. 11 is an enlarged fragmentary cross-sectional view taken along line 11—11 of Fig. 10 but showing the condition of a portion of the structure after the bonding operation, the thickness of the solder being somewhat exaggerated on the inside of the tube for clearness;

Fig. 12 is a front elevational view of one form of cartridge-type heat exchanger constructed in accordance with the invention;

Fig. 13 is an enlarged fragmentary view of a corner portion of the structure of Fig. 12, certain of the parts being broken away to show the interior construction;

Fig. 14 is a fragmentary side elevational view of a modified form of spacing strip and showing a plurality of tubes associated with the spacing strip;

Fig. 15 is a cross-sectional view taken along line 15—15 of Fig. 14;

Fig. 16 is a front elevational view of an automobile radiator and illustrative of a cartridge type heat exchanger core in which no spacing strips are employed between the rows of tubes;

Fig. 17 is a side elevational view of still another embodiment of the invention, wherein the tubes are secured in header plates;

Fig. 18 is a fragmentary top plan view of a portion of the structure shown in Fig. 17; and

Fig. 19 is an enlarged fragmentary cross-sectional view taken along line 19—19 of Fig. 18.

In the following description and in the claims, various details will be identified by specific names for convenience, but they are intended to be as generic in their application as the art will permit. Like reference characters denote like parts in the several figures of the drawings.

In accordance with the invention, there is provided a suitable number of seamless tubes of the desired shape and size and formed from a suitable material. The tubes preferably are formed from copper but in certain cases, may be formed from other metal having the desired properties, such as good heat conductivity, sufficient ductility to permit the necessary working, sufficient

resistance to rust and corrosion, sufficient mechanical strength, and the like.

In accordance with an illustrative embodiment of the invention, a tube 1 (Fig. 1) is provided having an elongated cylindrical body 2 and enlarged cylindrical ends 3. The tube may be formed in any suitable manner, but it is important that the metal be sufficiently hard and rigid to resist undesired deformation. Preferably, the tube is formed by extruding a blank of metal into a cylinder, trimming the cylinder to the proper length, straightening the cylinder, when necessary, and expanding the ends of the cylinder.

Preferably, any adherent foreign matter is removed from the tube, after forming, by means of a "bright-dip" which consists in immersing the tube in a suitable cleansing material, as for example, one containing equal parts of commercial nitric and sulphuric acids, and quickly removing the tube, whereafter it is rinsed in water.

A bushing or ferrule is inserted in each end of the tube for a purpose which will hereinafter appear. Each bushing 4 (Fig. 2) is of tubular form and preferably is of relatively greater thickness than the wall of the tube. The bushing 4 corresponds in shape and diameter to the interior of the enlarged end of the tube and is adapted to fit snugly within the tube end, so as to be in heat exchange contact therewith. Preferably, the bushing 4 is of such length that when inserted in the tube and flush with the end edge of the tube, it terminates short of the tapered shoulder 16 of the tube. Thus, when the bushing 4 is pressed into the tube, it will not be forced against the shoulder 16 and will not cut, collapse, or otherwise injure the tube.

The end of the tube may have a cross-sectional shape other than round, in which case the bushing or ferrule is shaped to fit the tube. For example, the tube end may be of hexagonal cross-section and have a hexagonal bushing therein; the interior of the bushing may be hexagonal or circular.

In certain cases it may be found desirable to dispose the bushing or ferrule on the outside of the tube end instead of within the same; in which case the bushing, or ferrule, is formed to fit around the tube end. Where the bushing or ferrule is disposed on the outside of the tube end it is possible, in some cases, to eliminate the operation of expanding of the tube end, in which case the bushing or ferrule is formed to fit snugly onto the unexpanded end of the tube. Generally, however, it is preferable to expand the tube and insert the bushing within the tube as described.

A plurality of spacing members 6 (Fig. 4) or "spacing strips" are provided, which may take the form of strips, rods, bars or the like. Two opposite sides or edges of each spacing strip 6 are provided with a series of recesses 7 and interposed humps 8 formed in any one of various ways. For example, the strip 6 may be given a generally corrugated shape by pressing a straight rod of metal between dies of suitable shape; and may be slightly flattened as indicated, if desired. Another form of spacing strip is illustrated in Figs. 13 and 14 wherein the strip 41 is formed with a series of arcuate notches 42 having cusplike points 43 therebetween, which fill the spaces between adjacent tubes.

The bushed tubes 1 and spacing strips 6 may be conveniently assembled by arranging two or more spacing strips 6 in spaced, parallel, relation

and joining two or more bushed tubes 5 thereto to form a generally frame-like assembly 17, as illustrated in Fig. 8. This can be conveniently accomplished by providing an assembly frame 9, comprising side rails 10 and end rails 11. The end rails 11 are provided with floor portions 12 for receiving the spacing strips 6, adjacent shoulders 13 for positioning the spacing strips 6 at the desired relative position and shoulders 14 for positioning the bushed tubes 5. It will be understood that the core may be made in various other shapes than here disclosed, in which case the frame 9 will be shaped as required.

Spacing strips 6 are laid on the floor portions 12 and bushed tubes 5 are disposed in corresponding recesses 7 of the spacing strips, as illustrated in Fig. 6, the tubes preferably being disposed in the endmost recesses 7 of the spacing strips 6. The tubes 5 are secured or "tacked" to the spacing strips 6 by applying a small amount of a suitable bonding material 15 thereto, by a bonding operation hereinafter more fully described in connection with the bonding of the tubes.

For the purpose of holding the tubes and spacing strips during bonding, they are assembled in the general shape of the core to be produced and are held in position by a suitable clamp 20. One such clamp is illustrated in Fig. 9 and comprises a frame 21 having presser bars 22 and 23 adjustably carried on adjacent sides of the frame by screws 24 which can be locked in position by lock nuts 25.

A corrugated side plate 26, of rigid construction and having its corrugations corresponding to the desired spacing of the tubes in the rows, is disposed in the clamp 20. Individual bushed tubes 5 are disposed in the grooves of the side plate 26 to form the first row of tubes. Thereafter, one of the assemblies 17 is disposed in the frame with the lower recesses 7 of the spacing strips 6 receiving the tubes 5 of the first row and additional individual tubes are disposed in the upper recesses 7 of the spacing strips 6. A second assembly 17 is disposed on the second row of tubes 5 with the recesses 7 of the spacing strips receiving the tubes 5 of the second row, and additional tubes 5 are placed in the recesses of the second spacing strips. Additional assemblies and tubes are stacked in a like manner until all of the tubes and strips which are to form the core are assembled, whereafter a second side plate (not shown) is disposed on the top row of tubes. The presser bars 22 and 23 are then adjusted to secure the tubes and assemblies firmly in position.

The bushings or ferrules are in many cases of sufficient heat absorbing and dissipating capacity to keep the temperature of the tubes below the annealing temperature of the tube metal, during bonding. However, when the bushings or ferrules are insufficient, for this purpose, additional heat absorbing and dissipating means is provided. For example, heat absorbing and dissipating members may be inserted in some and preferably all of the tubes.

The additional heat dissipating members preferably take the form of rods 27 formed from metal of good heat absorbing capacity such as copper, iron, steel or the like and preferably are approximately the size of the interior of the tubes. In certain cases it is desirable to employ rods of a metal such as iron or steel to which the bonding material will not readily adhere; thus there is less possibility that the rods will be bond-

ed to the tubes and hence can be readily removed therefrom when the bonding operation is completed. The rods preferably are of approximately the same diameter and slightly shorter than the inside of the tubes so that they will be in heat exchange contact with the tubes but can be readily removed after the tubes have been bonded. Preferably, the inside diameter of the bushings is approximately the same as the tube so that the bushings also are in heat exchange contact with the rod.

If desired, the additional heat dissipation may be effected without the use of rods inserted in the tubes. For example, a current of a gaseous cooling medium, preferably of a non-oxidizing nature, may be passed through the space around the tubes. The cooling medium should flow in sufficient quantity to provide the desired cooling but should not be under such high pressure as to interfere with the bonding operation.

The tubes, strips and bushings are bonded together by applying bonding material over the end of the assembly within the frame, as indicated in Fig. 11. The bonding material is applied so that when it solidifies it extends over the ends of the tubes and bushings and fills the spaces between the adjacent tubes and the space between the spacing strips, thus forming with the tubes, bushings and strips a wall or header which provides a complete imperforate seal around the tubes. Thus the tubes, bushings and spacing strips are firmly secured together to form a core structure having a completely sealed end which is entirely imperforate except for the passages provided by the tubes.

The bonding material (hereinafter called "solder") is a fusible metallic material which has relatively high mechanical strength, which is suitably adherent to the members forming the heat exchanger, which is capable of withstanding relatively high temperatures, which is resistant to corrosion and deterioration, which will withstand vibration, shock and other destructive effects, and which is otherwise suitable for the present use. One bonding material which has been found suitable for practicing the present invention is a so-called "silver solder" comprising around 45% by weight of silver, 30% by weight of copper, and 25% by weight of zinc. It is also desirable to employ a suitable flux, which may be any good commercially available flux adapted for use with solder of the composition employed.

The solder is applied by heating the same to a temperature above its fusing temperature and preferably somewhat in excess of 1220° F. For this purpose it has been found desirable to employ an oxy-acetylene flame.

The tubes, spacing strips and bushings at the other end of the core are soldered in a similar manner, the rods removed and the core is then removed from the clamp. Preferably, the side plates are not soldered to the tubes during the above-described soldering operation and hence, can be separated from the tubes when the core is removed from the clamp.

After the core is assembled, as above described, it preferably is cleaned to remove foreign matter, such as carbon deposits, dirt and the like. The core is cleaned by immersing it in a 5% sulphuric acid solution, then rinsing it in cold water to remove the acid, this rinsing being effected by immersing the core in a cold water bath and agitating it or flowing cold water past and through the core. The core is then immersed in boiling water a sufficient period to completely re-

move the acid from the niches or interstices and is dried immediately after removal from the hot water bath in a suitable manner as by placing it in a dry air oven.

The core 30 may be assembled with the side plates and with top and bottom tanks of any suitable construction by a soldering operation. The tanks may take any desired form; and for example, may be constructed similarly to the tanks 31 and 32 illustrated in Fig. 12, as generally similar. The tank 31 comprises a dished metal member having side walls 33, 33 and end walls 34, 34, all of which have outwardly extending flanges 35 formed by rebent edges of the tank. A corner piece 36 having a corrugated body and a flange 37 seated on the flange 35 is attached at each side of the tank.

The tanks 31, 32, side plates 29 and corner pieces 36 are assembled by soldering, in a manner similar to that above described, along the edges of the side plates and the corner pieces. The core 30 is then slid into the space between the tanks 31, 32 and side plates 29, with the tubes in the endmost rows fitting in the grooves in the side plates 29. The core is soldered to the tanks and side plates by applying solder to the adjacent portions of the core, tanks and side plates and the openings around the ends of the tubes are sealed by filling them with solder.

The core as described above is suitable for use in a heat exchanger of the type known as an "intercooler," wherein air is drawn past and around the tubes. The core is assembled with duct members (not shown) of suitable construction which are attached to the core in a manner generally analogous to the attaching of the tanks to the core.

The invention is also well adapted for forming heat exchanger cores wherein the tubes are arranged in a close fitting assembly and no spacing members are employed. There is illustrated in Fig. 16 a radiator for an automobile wherein the core is constituted in this manner. The radiator 50 comprises a core 51, top tank 56, bottom tank 57 and frame 55. The core 51 is constituted by a plurality of tubes 52 each of which is generally similar to the tube 1, previously described and has therein bushings 53, generally similar to the bushings 4.

The core 51 is constructed by inserting the bushed tubes 52 in a clamp, such as the clamp 20 illustrated in Fig. 9. The tubes are stacked in rows, the tubes of each row being disposed immediately upon the tubes of the next lower row and staggered, as illustrated. The assembled tubes are gripped by the clamp and solder is applied over the ends of the tubes and in the generally triangular shaped spaces between the adjacent tubes. The soldering operation preferably is generally similar to that above described. Prior to the soldering operation, rods (not shown) are inserted in the tubes in order to absorb the heat of soldering and prevent annealing of the tubes, or a cooling fluid is employed to maintain the tubes at the desired temperature. Thus the tubes and bushings are securely and rigidly fastened together and an imperforate seal is formed around the tubes. Side plates (not shown) which preferably are corrugated, are secured to the endmost tubes of the rows by soldering similar to the manner above described and the top tank 56 and bottom tank 57 are secured to the core by a similar soldering operation.

The present invention is also adapted for con-

structing heat exchanger wherein the tubes are assembled in header plates to form the core. Referring now to Fig. 17 there is shown one novel embodiment of such a construction.

A frame-like structure 60 is provided which comprises top and bottom header plates 61 to which are secured side plates 62, by bolts 63 extending through the side plates 62 and through suitable flanges 64 on the header plates 61, the bolts being held by nuts 66. Preferably, a sealing gasket 65 of suitable construction is interposed between the flange 64 and side plate 62 to seal the joint.

A plurality of tubes 67 are assembled in the header plates, the tubes being provided with enlarged ends 68 which extend through suitably positioned openings 69 in the header plates. Inserted in the end of each tube is a bushing 70 which preferably is provided with a portion which projects out of the tube 67 and is provided with a flange 71 adapted to seat against the end edge of the tube. A quantity of solder 73 is disposed over the surface of the header plate 61 and against the end of the tube and the projecting portion of the bushing 70.

In order to provide suitable area of contact between the tube end and the solder, the tube may extend beyond the surface of the header plate. If desired, however, the end of the tube may be flush with the header plate and the openings 69 countersunk as indicated at 72 to provide the desired extent of surface contact.

While the invention is applicable to heat exchangers of a large number of various sizes, it is especially well adapted to such devices as radiators, coolers and like equipment for internal combustion engines. The invention is especially valuable in connection with relatively small heat exchangers where the tubes have a very small wall thickness. In one specific illustrative, but not limiting example, the tubes and bushings had the following dimensions: tube length 9 inches, body diameter 0.230 inch, end diameter 0.260 inch, and wall thickness 0.006 inch; bushing, length 0.480 inch, diameter 0.246 inch, wall thickness 0.015 inch.

From the foregoing it will be seen that the present invention provides a method of forming radiator cores wherein thin walled tubes formed from metal, such as copper and the like, can be joined by the use of a fusible bonding material without unduly softening the tubes. The bushings or ferrules effectively prevent overheating and softening of the tubes and the additional heat removing means, where employed, further prevents such undue heating.

The provision of the bushing or ferrule not only insures against overheating of the tube ends but also strengthens and reinforces the ends of the tubes. Thus, not only is the core reinforced but the individual tube ends are so reinforced that even if these portions of the tube should be softened, they will not be readily deformable.

What is claimed is:

1. A heat exchanger comprising a core including a plurality of thin-walled tubes arranged in rows to define substantially parallel passages for one fluid therethrough and having enlarged ends spacing their body portions apart to provide space for the passage of another fluid around the tubes, spacing strips interposed between at least certain of said rows adjacent the ends of the tubes, relatively thick-walled bushings in the ends of said tubes, and bonding material securing said tubes, spacing strips, and bushings to-

gether to define end walls which are closed except for the passage defined by said tubes, corrugated side wall plates extending parallel to said spacing strips in two opposite sides of said core, and duct members disposed at two other sides of said core and secured thereto with their interiors in communication with the space between said tubes.

2. In a heat exchanger of the cartridge type, a core having its main heat transfer portion made up exclusively of a plurality of similar, thin walled copper tubes arranged successively in substantially parallel rows to define passages for one fluid therethrough, said tubes having enlarged ends spacing the body portions apart to provide space for the passage of another fluid around the tubes, relatively thick walled heat absorbing bushings disposed within said enlarged

ends, means including silver solder connecting said enlarged ends, said silver solder securing said bushings in position and securing the enlarged ends of said tubes directly together in at least one direction, said enlarged ends, said bushings and said connecting means constituting built-up headers, enclosing walls surrounding said tubes and connected to said built-up headers, and duct members secured to said enclosing walls with their interiors in communication with the space between said tubes, said silver solder being fusible at a temperature above the annealing temperature of said tubes, said bushings having sufficient heat absorbing capacity to prevent annealing said tubes during the high temperature soldering operation, and strengthening said headers.

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