This invention relates to tube and header-plate assemblies for heat exchange units, particularly of the type wherein a plurality of flat thin metal tubes, supporting a series of closely-spaced parallel heat-dispersing "fin" plates, span a pair of spaced header-plates and have their ends inserted in openings therein and subsequently solder-sealed to said plates.

In constructions of this kind, thin sheets of metal are doubled over and welded or brazed along an interlocking seam so as to form flat tubes of elongated cross section the sides of which are parallel and the lateral edges of which are rounded. A battery of these tubes are inserted transversely through a series of perforated parallel sheets of even thinner metal, usually called "fins," which serve to disperse or dissipate the heat from the fluid flowing through the tubes. Such a battery of "finned" tubes are arranged between a pair of spaced header-plates with the tube ends inserted through openings in and solder-sealed to the header-plates.

The openings in the header-plates are stamped out. The metal thus extruded is split and turned to form a flange around the perimeter of each opening. The practice heretofore has been to have the size and shape of the openings conform or less exactly with the interior cross-sectional contour of the tubes. As a consequence, the exterior tube peripheries have not always fit snugly against the opening perimeters. Moreover, the flat parallel parts of the tube at times became pressed inwardly. In either case there was likely to be more than the desired space between the tube sides and the perimetrical portions of the openings in the tube-plates and the flanges therefor. Solder being used to seal the tubes to the header-plates, and solder, not having a very great tensile strength, often proved incapable of holding the two pieces of metal together as desired, when the heat exchange unit was subject to excessive strains incident to the use of these units, especially on automotive equipment.

The main objects of this invention, therefore, are to provide an improved tube and header-plate assembly for heat exchange units wherein a tube end, when inserted into the flanged header-plate opening, is forced to have a materially greater proportion of the external periphery of the tube in firm contact with the perimetrical surface of the flanged header-opening; and to provide an improved form of flanged opening in the header-plate which, upon the insertion of a tube into an opening will cause the sides of the tube to bow outwardly to increase the exterior peripheral contact of the tube with the perimetrical surface of the flanged header-plate opening.

A preferred embodiment of this invention is shown in the accompanying drawings, in which:

- Fig. 1 is a perspective view of a section of a heat-exchange unit embodying this invention;
- Fig. 2 is an enlarged fragmentary perspective view of one end of one of the header-plates shown in Fig. 1;
- Fig. 3 is a further enlarged fragment of the header-plate showing the shape and size of one of the flanged openings formed therein;
- Fig. 4 is an end view of a tube, drawn to the same scale as the opening shown in Fig. 3;
- Fig. 5 is a cross-sectional detail of the fragment shown in Fig. 3 with the tube end positioned preparatory to being forced into the header opening;
- Fig. 6 is a plan view of the parts as shown in Fig. 5;
- Fig. 7 is an enlarged cross-sectional view, taken vertically through the tube and transversely through the header-plate, on the line 1—1 of Fig. 1, showing how the solder seals the tube to the header-plate;
- Fig. 8 is a transverse sectional view of the same taken on the line 8—8 of Fig. 7.

Heat-exchange units, of the type wherein this invention may be readily incorporated, comprise a plurality of tubes inserted through a series of thin, perforated heat-dispersion plates and spanning the distance between a pair of spaced header-plates in which have been punched a series of openings adapted to receive the ends of the tubes whereby the tubes and plates may be solder-sealed together to form a device of the general character shown in Fig. 1. Devices of this kind are variously used for the transferring of heat from a fluid of one temperature flowing through the tubes to another fluid of a different temperature flowing around the tubes in the spaces between the heat-dispersion plates. To that end the header-plates are connected to headers (not shown) which have
conduits connected therewith to convey the fluid of the one temperature to and from said headers for transmission through said tubes. 3. The fluid of the other temperature is generally air forced through the spaces between the "fins" 9 and around the tubes.

The tubes 8 generally are each formed from a thin sheet metal strip doubled upon itself and soldered along an interlocking seam, as shown in Figs. 4 and 5. The tubes are accordi

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ingly of elongated form, as shown in the drawings, the sides being very closely if not precisely parallel, and with the lateral edges of the tube rounded, as clearly shown in Figs. 4 and 5.

Header-plates 10 and 11, involving this invention, have openings 15 punched therein. The metal extruded, in order to form the openings is slit and upset transversely of the plate to form flanges 14 around the perimeters of the openings 13.

These openings 13 are punched in the header-plates 10 and 11 so that they are of elongated or elliptical form. The longitudinal dimension of each opening 13 is slightly less than the exterior longitudinal cross-sectional dimension of the tube 8. The central transverse dimension across the openings and between the opposed faces of the flanges 14 is slightly greater than the corresponding exterior dimension between the parallel sides of the tubes 8. Moreover, the metal at the ends of the opening 13 is rounded as shown at 13a so as to form cam-like surfaces to the tube end.

By reason of this difference in the dimensions of the tubes 8 and the header-plate openings 13, the tubes 8 have to be forced into the openings 13. Such forcing of the tube ends into the openings 13 slightly shortens the longitudinal cross-sectional dimension of the tube and causes the otherwise parallel sides of the tubes 8 to be bowed outwardly against the faces of the flanges 14 and the peripheral part of the openings, causing tension of tube wall to header opening. This materially increases the probabilities of a close contact between these peripheral surfaces, and completely obviates the necessity of opening tubes so as often has to be done with former designs. This is a very important and vital factor in such tube and header-plate assemblies, since it is necessary to seal the tubes and plates at these points of contact. The most practical sealing medium is solder. This, of course, has to be applied in a molten state.

The sealing of these joints with molten solder can be accomplished by either of two practical methods; melting a solder foil laid on the header-plates around the tubes, or dipping the header-plates, with the tubes in place, in a solder bath. The first of these methods involves laying a solder foil on the inside face of the header-plate before the tubes are inserted. The foil is perforated to provide openings slightly larger than but registering with the openings 13 in the header-plates. After the tubes are inserted in a foil-covered header-plate the foil is melted by means of a flame applied by a torch, as is well-known in the manufacture of heat-exchange units of this kind. The molten solder naturally spreads over the surface of the plate, and, because of the curved perimeters of the openings 13, runs into contact with the exterior surfaces of the tubes 8.

The other method involves dipping the header-plates, one at a time, in a solder bath to a depth sufficient to not only immerse the protruding ends of the tubes but the flanges 14.

In the first of these methods the capillarity of the opposed exterior faces of the tubes 8 and the flanges 14 and the perimetrical area of the openings 13, plus the force of gravity, will cause the molten solder to run down the tubes beyond the edges of the flanges 14, as indicated in Fig. 7. In the second of these methods the capillarity of these abutting surfaces causes the molten solder to be drawn up along the tubes to the opposite face of the header-plate. In either case the tubes 8 are firmly sealed to the header-plates 10 and 11.

It will be readily understood that the capillarity of these abutting tube and header-plate surfaces will be increased in proportion to the reduction in space between them. Not only will the closer spacing of these peripheries enhance the capillary action on the molten solder, but it will make for a stronger union of these surfaces than is possible where the periphery of the tube is not forced so firmly into contact with the header-plate opening and flange. Therefore, there is less likelihood for the joints in this structure to become weakened or broken when the heat-exchange unit is subject to the strains of normal use, particularly on automotive equipment.

It is a general practice in producing heat-exchange units of this kind to have the tubes 8 coated with a thin film of solder prior to the tubes being inserted through the header-plates 9. After the assembly of the fin-plates 9 on the tubes, and prior to the header-plates 10 and 11 being pressed over the ends of the tubes, the assembled tubes and fin-plates are placed in an oven at a temperature of around 600° F. This causes the film of solder on the exterior surface of the tube to melt and effect a sealed union between the tubes and the perimetrical flanges around the openings in said fin-plates.

Other variations and modifications in the details of structure and arrangement of the parts may be resorted to within the spirit and coverage of the appended claims.

I claim:
1. A tube and header plate assembly for heat exchange units comprising a plurality of parallel tubes of thin sheet metal of distinct cross-section having substantially parallel opposite walls and rounded corners interconnecting the same, a plurality of longitudinally spaced multi-apertured fins disposed on and maintaining said tubes in a predetermined relationship with the tubes disposed through the apertures in the fin and a header plate having a plurality of elliptical openings therein corresponding in number and disposition to the number and disposition of said tubes with the major axes of said openings being slightly less than the major axes of said tubes and the minor axes of said openings being greater than the minor axes of said tubes, the ends of the tubes being disposed within the openings with the opposite walls adjacent thereto being bowed outwardly in substantial flush contact with the perimetrical edges of the respective openings, whereby the ends of the tubes are in contact to the shape of the openings and which ends have slightly less cross sectional area than said openings permitting said flush contact.
2. A tube and header plate assembly as defined in and by claim 1 and including means permanently bonding the fins to the tubes and the tube ends to the header plate.
3. A tube and header plate assembly as defined
in and by claim 1, in which the transverse cross sectional shape of the perimetrical edges of the openings in the header plate is arcuate.

4. A tube and header plate assembly for heat exchange units including at least one tube of thin sheet metal of flat elongated cross section having substantially parallel opposite walls and rounded corners interconnecting the same, and a short header plate having at least one elliptical opening therein having a major axis slightly less than the major axis of said tube and the minor axis of said opening being greater than the minor axis of said tube, the end of the tube being disposed within the opening with the said opposite walls adjacent thereto being bowed outwardly in substantial flush contact with the perimetrical edge of the opening, whereby the end of the tube only conforms to the shape of the opening and which end has slightly less cross sectional area than said opening permitting said flush contact.

5. A tube and header plate assembly as defined in and by claim 4, in which the transverse cross sectional shape of the perimetrical edge of the opening in the header plate is arcuate.

6. A tube and header plate assembly as defined in and by claim 4, and including means permanently bonding the end of the tube to the plate.

Donald A. Hisey.

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Certificate of Correction

Patent No. 2,488,627

DONALD A. HISEY

November 22, 1949

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows:

Column 1, line 28, for the word "interior" read exterior;

and that the said Letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 11th day of April, A. D. 1950.

[SEAL]

THOMAS F. MURPHY,
Assistant Commissioner of Patents.