Dec. 30, 1947. H. F. BRINEN 2,433,731

PROCESS OF MAKING HEAT TRANSFER UNITS

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Fig. 1

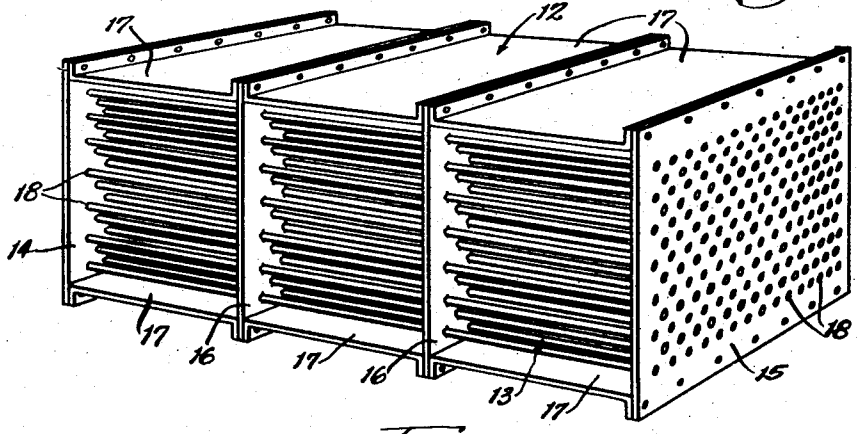


Fig. 2

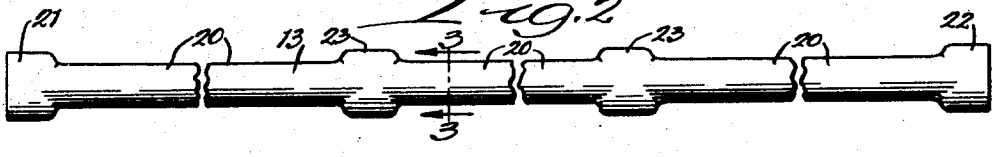


Fig. 3

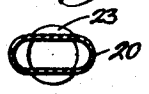


Fig. 4

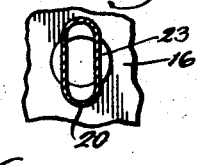


Fig. 5

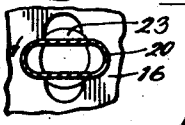
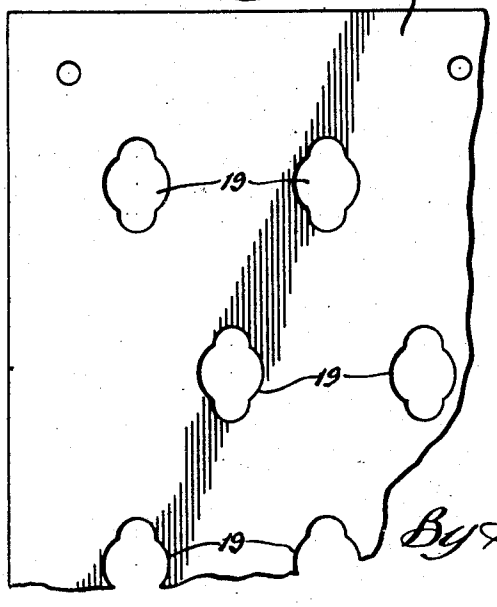


Fig. 7

Fig. 6



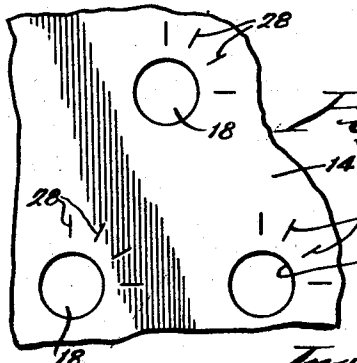


Fig. 8

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PROCESS OF MAKING HEAT TRANSFER UNITS

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Fig. 9

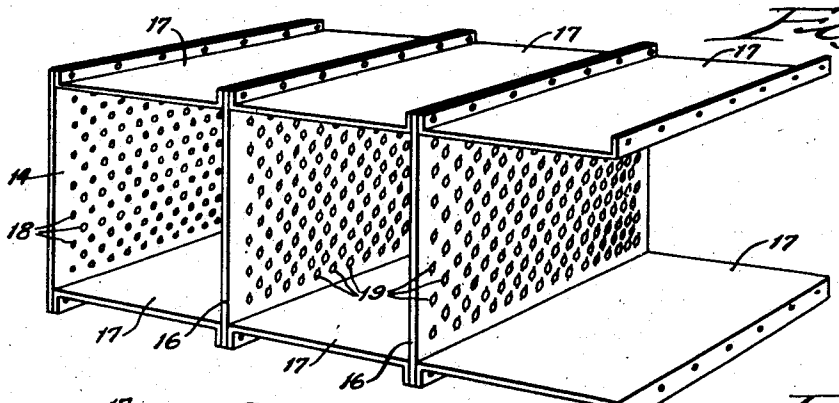


Fig. 10

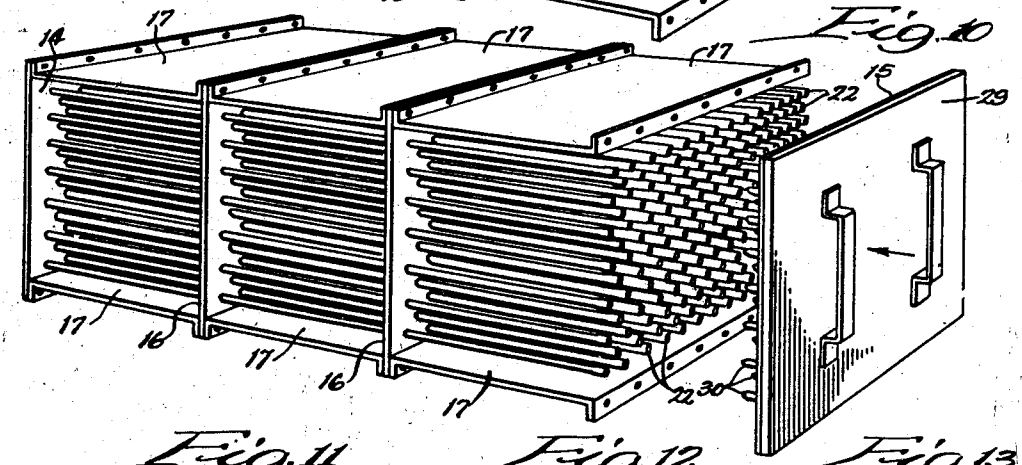


Fig. 11

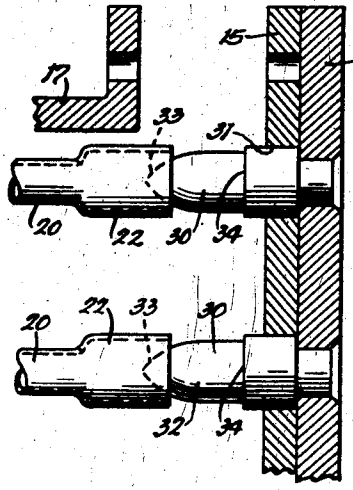


Fig. 12

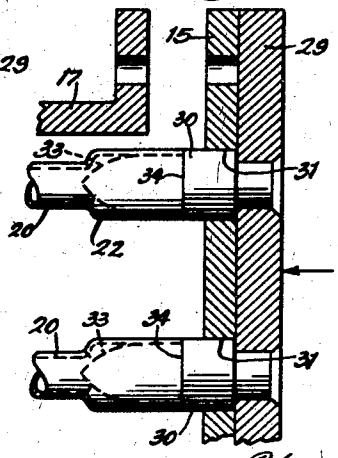
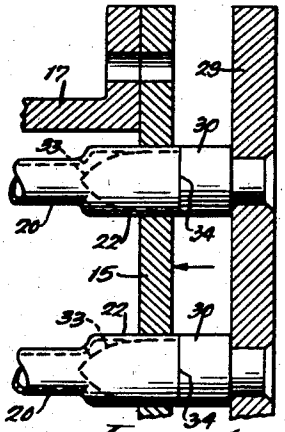


Fig. 13



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UNITED STATES PATENT OFFICE

2,433,731

PROCESS OF MAKING HEAT TRANSFER UNITS

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Application August 20, 1945, Serial No. 611,518

2 Claims. (Cl. 29—157.3)

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This invention relates to the type of heat exchange unit generally known as a supercharger intercooler or aftercooler. The latter qualifying designations are derived from the location of the device in the fluid system wherewith it is used. Primarily, a device of this type is imperative equipment for conditioning the air required for engines used with aircraft operating in rarified atmosphere. However, a device of the character herein presented could be used for conditioning other fluids and under other circumstances. Therefore, the application of this invention to this particular type of aircraft device is not intended to exclude its use with other types of heat exchange apparatus.

A heat exchange device of the type under consideration involves a battery of tubes through which one current of air is required to flow and around which in a cross-wise direction another current of air is caused to flow. The major concern in all such tubular structures is to secure the maximum transfer or exchange of heat between the two air currents passing respectively through and around the tubes. A minor concern is to provide such a union and support of the tubes and the supporting plates as will insure a high degree of rigidity for the tubes and so firm a bonding thereof with the supporting plates that there can be no vibration of the tubes and no fluid leakage between the two sets of passages.

The efficiency of heat transfer or exchange in a unit of this kind is materially affected by the shape of the tubes. Flat tubes are more efficient by far than circular tubes. However, the tubes have to be of a seamless type since it is not possible otherwise to provide an absolutely leakproof unit. Moreover, when these units are used with aircraft it is most desirable to reduce the weight as greatly as possible. Accordingly, structures of this kind preferably must be made of aluminum.

The expense of forming seamless flat tubes is materially greater than forming seamless round tubes. The former have to be bench-drawn whereas the latter, at least with aluminum, can be formed by what is commonly known in the industry as the "impact extrusion" or Hooker process. This process reduces seamless tube manufacturing cost about one-third under any other method. However, the latter process is limited to the formation of round tubes.

Although flat or elliptical tubes are more efficient from the standpoint of heat exchange or transfer, former methods of securing flat tubes to the header and intermediate reinforcing plates has been difficult and expensive from a manufacturing standpoint.

The main objects of this invention, therefore, are to provide an improved method of constructing a supercharger intercooler or aftercooler wherein the tubes are of a flat construction between the supporting plates; to provide an improved method of forming a flat tube with circular ends and intermediate circular portions; to provide an improved method of fabricating the tubes thus formed with reinforcing and header plates; and to provide a supercharger intercooler or aftercooler of this type which is simple and inexpensive to manufacture, which possesses maximum structural rigidity, and which is highly efficient in operation.

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In the particular embodiment shown in the accompanying drawings:

Fig. 1 is a perspective view of a completely assembled supercharger intercooler or aftercooler;

Fig. 2 is an enlarged side view of one of the tubes which has been flattened for use in connection with a supporting plate assembly in accordance with this invention;

Fig. 3 is a cross-sectional view taken on the line 3—3 of Fig. 2;

Fig. 4 is an enlarged cross-sectional view of the tube showing it in the position, with regard to an aperture or perforation in the reinforcing plate, wherein it is inserted through said plate;

Fig. 5 is a similar view showing the tube turned 90° which is permissible when the circular part thereof is in registration with the reinforcing plate and whereupon the tube becomes locked in place;

Fig. 6 is an enlarged fragmentary elevation of one corner of one of the intermediate reinforcing plates showing the form and arrangement of apertures, or perforations therein;

Fig. 7 is a perspective of the hand tool used to turn the tubes after they have been inserted through the reinforcing intermediate plate and one header plate;

Fig. 8 is a fragmentary part of one header plate showing the scorings wherewith the pointer on the hand tool registers for indicating the angle of the long dimension of the corresponding tube;

Fig. 9 is a perspective view of the fabrication of all the plates, except one header plate, which go to make up the assembly wherein the tubes are supported;

Fig. 10 is a similar view with all of the tubes in place and showing a mandrel base member whereon is placed the other header plate preparatory to its being placed upon the exposed ends of the tubes; and

Figs. 11, 12, and 13 are enlarged fragmentary views showing the successive steps in registering the mandrels on the mandrel base member with the respective exposed tube ends and subsequently shifting the header plate off from the mandrels onto the circular tube ends.

The particular structure wherein this invention has been embodied comprises a fabrication or assembly 12 of plates and a battery of tubes 13 so arranged that the passage of one fluid through

the tubes is exposed in heat exchange relationship with the passage of another fluid transversely around and across the battery of tubes.

The fabrication or assembly 12 as herein shown comprises header plates 14 and 15 and one or more intermediate reinforcing plates 16, all of which are secured together in their desired spaced relationship by a series of oppositely arranged transverse interconnecting plates 17. The header plates 14 and 15 and the intermediate reinforcing plates 16 are apertured in order to receive the tubes 13. The apertures 18 in the header plates 14 and 15 are circular so as to receive the circular ends of the tubes 13. The apertures 19 in the intermediate plates 16 are constituted of intersecting circular and elliptical punchings or drillings, the former conforming with the circular portions of the tubes 13, and the latter conforming with the flat portion of the tubes 13, as will more clearly hereinafter appear.

The interconnecting plates 17 are flanged along their lateral edges whereby they may be suitably secured to the opposed faces of the plates 14, 15, and 16. This attachment of the plates may be by means of any suitable form of welding, rivets, or bolts and nuts.

The tubes 13 are first formed by the impact extrusion or Hooker process and are obviously of circular cross section throughout their length. Subsequently, the circular tubes are placed in a press equipped with suitable dies so as to flatten the tubes as most clearly shown at 20 in Figs. 2 to 5, leaving circular the ends 21 and 22 and the short intermediate portions 23 thereof. The spacing of the circular portions 21, 22, and 23 from each other is such that when the tubes 13 are inserted into the fabrication 12, the circular ends 21 and 22 extend into and slightly through the apertures 18 in the plates 14 and 15, respectively, whereas the intermediate circular portions 23 are in the planes of the intermediate reinforcing plates 16.

The process or method of forming the several parts and assembling them is a progression of the following steps:

The first step involves the formation of the tubes 13, the forming and punching of the plates 14, 15, and 16 and the forming of the plates 17. Obviously, the formation of these parts may be carried on simultaneously, or in seriatim.

The tubes 13, after their formation by the impact extrusion or Hooker process, are placed in a press containing a suitable die whereupon they are flattened except for the circular end portions 21, 22, and the intermediate circular portions 23.

The header plates 14 and 15 have the longitudinal and transverse series of circular apertures formed therein and the intermediate reinforcing plates 16 have the longitudinal series of partially circular and partially elongated apertures 19 punched or otherwise formed therein.

With the required parts thus formed, the second step involves fabricating one header plate 14 and one or more of the required intermediate reinforcing plates 16, together with the interconnecting plate 17, as shown in Fig. 9.

The third step involves the insertion of the tubes through the intermediate reinforcing plates 16 with the ends 21 inserted through the apertures 18 in the header plate 14. To effect this insertion, the tubes are obviously inserted through the plates 16 with the flat part vertically disposed to conform to the shape of the appropriate part of the apertures in the plates. When the ends 21 of the tubes 13 have been inserted through the

apertures 18 in the header plate 14, the intermediate circular portions 23 are brought into registration with the plates 16. Thereupon the tubes are turned so that they become bonded in the intermediate plates 16. The amount of turning depends upon circumstances of structure and objectives. Generally, the turning of the tubes is 90° so as to bring the flat part parallel to the plane of the connecting plates 17. Such an arrangement secures the tubes firmly in place in the reinforcing plates 16 and prevents their vibration or distortion, or their longitudinal shifting relative to the plates.

In order that the tubes 13, following their initial insertion into the openings of the partially fabricated plates, may be given the desired amount of turning, a tool 24 is preferably used. This tool comprises a handle 25 on which is formed a shank 26 and a pointer 27.

The shank 26 of the tool 24 is of a cross-sectional form to conveniently fit into the flattened portion of the tubes 13 after being passed through the circular end. It is of a length which will permit it to extend a considerable distance into the tube thereby providing an extensive area of contact between tool and tube to insure so adequate a grip between the parts as will permit the turning of the tube with little or no danger of distortion even in cases where the tube may encounter considerable frictional resistance in the holes in the respective plates.

The pointer 27 and the handle are positioned with respect to the shank 26 and each other so that the pointer and the handle 25 are in vertical alinement when the shank 26 is inserted into the tube preparatory to turning the tube. The pointer thus registers with scorings 28 (see Fig. 8) concentrically arranged about the circular apertures 18 on the header plate 14 and thus indicate to the workman the angular position of the long dimension of the flattened tube.

Once all of the tubes 13 on the assembly are properly positioned, the tube ends 21 are suitably bonded to the header plate 14. This may be done by spinning over the ends if they extend at all beyond the face of the header plate, or by expanding the tube ends into the header plate apertures, or by some suitable welding or brazing process.

With all of the tubes 13 thus bonded in place, the next step is to insert all of the tube ends 22 through the apertures 18 in the header plate 15. Due to their cantilever-like projection beyond the reinforcing plate 16, some of the tubes 13 are likely to sag. On the other hand, the insertion of the tubes or their turning may have warped them a bit from perfect axial alinement. All of this would combine to make it rather difficult to insert the many tube ends 22 into the many corresponding apertures 18 of the plate 15, unless some sort of guiding means were used.

To that end there is provided a mandrel base member 29, on one face of which are mounted a series of mandrels 30 equal in number to the apertures 18 in the header plate 15. These mandrels are rigidly secured to the base member and with the shank 31 equal in diameter to the apertures 18 in the header plate 15. This shank section is slightly longer than the thickness of the plate 15 and supports an extension 32 practically equal in diameter to the interior diameter of the circular end 22 of the tubes 13. The forward end of the extension 32 is tapered at 33 so as to facilitate the entrance of all the mandrels 30 into the tube ends 22 and subsequently bring

each tube end into registration with the shank 31 on its mandrel 30.

Thus, the final step in effecting the assembly is to place the header plate 15 on the mandrels 30 and move the mandrel base into position to bring the tapered ends 33 into engagement with the circular tube ends 22 after which the extensions 32 are pushed fully into the tube ends 22 to bring the shoulders 34 into engagement with the tube ends 22. Thereupon, the plate 15 may be shoved inwardly along the shanks 31 over onto the circular tube ends 22 and the mandrel plate withdrawn.

In effecting this final step of inserting the tube ends 22 into the apertures 18 of the header plate 15, it is obviously necessary to have the completed assembly of tubes in the fabrication 12 placed on a level surface, such as a table or bench, along which the mandrel base may be moved for initiating registration of the tapered ends 33 with the open ends of said tubes.

Due to the total friction encountered in having a great many mandrels engaged with a number of tubes, it may be necessary to employ some force to release the header plate 15 from the mandrels so as to push it onto the tubes. This could be done by tapping with a light hammer or mallet, or by employing long clamps fitted over the two ends of the intercooler. On the other hand it might even be accomplished by hand screws which could be made a part of the assembly jig or table, or a suitable power cylinder could be employed.

After the mandrel base member 29 is removed, the tube ends 22 are suitably bonded to the header plate 15 either by spinning over the ends if they extend at all beyond the face of the header plate, or by expanding the tube ends into the header plate apertures, or by some suitable welding or brazing process.

Changes in the described structure may be made without department from the spirit of the invention, the scope of which should be determined by reference to the following claims, the same being construed as broadly as possible consistent with the state of the art.

I claim:

1. The process of constructing a heat exchange unit which comprises, forming a pair of header plates each with circular perforations therein, forming one or more intermediate reinforcing plates having a longitudinal and transverse series of concentrically intersecting circular and non-circular perforations, forming a plurality of tubes of non-circular cross-section intermediate circular ends and a circular middle portion, passing the tubes through said reinforcing plate by alining the non-circular parts of said tubes with the non-circular parts of said perforations and bringing the middle circular portion of said tubes into registration with said reinforcing plate and thereupon turning said tubes to disaline said non-circular part of said tubes with the non-circular part of said perforations, seating the circular ends of the tubes in the circular perforations of one of said header plates, bonding the ends of said tubes to said one header plate, placing the second perforate header plate on a base member having mandrels corresponding in number with the perforations in said second header plate, inserting the mandrels into the other ends of said tubes, shifting said second header plate from said mandrels onto the other ends of said tubes, removing said mandrel base member, and bonding said other tube ends to said second header plate.

2. The process of forming a heat exchange unit which comprises, flattening circular tubes throughout their lengths except for short portions at the ends and at one or more short portions intermediate of the ends, forming header plates with a longitudinal and transverse series of circular perforations to fit the circular ends of said tubes, forming an intermediate reinforcing plate with a longitudinal and transverse series of perforations circular on one dimension to fit the circular portions of said tubes and substantially elliptical on the other dimension to accommodate the flat portion of said tubes, assembling a header plate and a reinforcing plate with the perforations therein alined, inserting said tubes through said alined perforations with the circular ends of said tubes extending through the perforations in said one header plate and the intermediate circular parts of said tubes in registration with the apertures in said intermediate reinforcing plate or plates, turning said tubes to bring the long dimension of the flat portion at an angle to the plane of the long dimension of the elliptical portions of said reinforcing plate perforations, bonding said tube ends to said one header plate, placing a second perforate header plate on a base member having mandrels corresponding in number with the perforations in said second header plate, inserting the mandrels into the other ends of said tubes, shifting said second header plate onto said other ends of said tubes, removing said mandrel base member, and bonding said other tube ends to said second header plate.

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