May 2, 1944. W. E. McCULLOUGH 2,347,957

HEAT EXCHANGE UNIT

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Fig. 1.

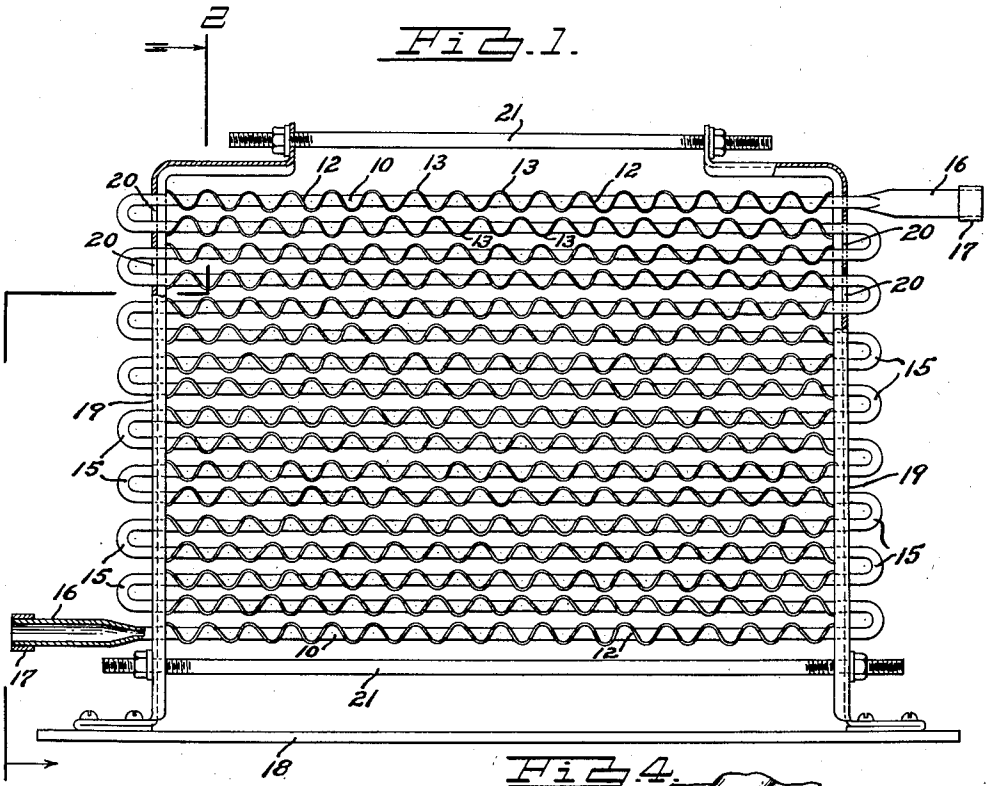


Fig. 4.

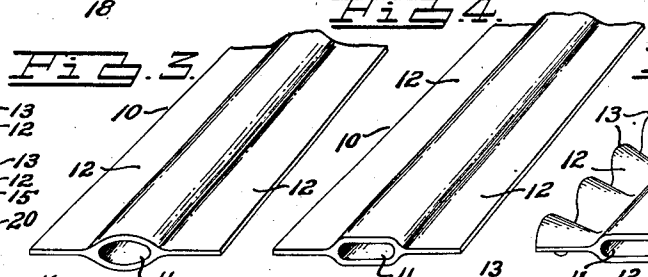


Fig. 3.

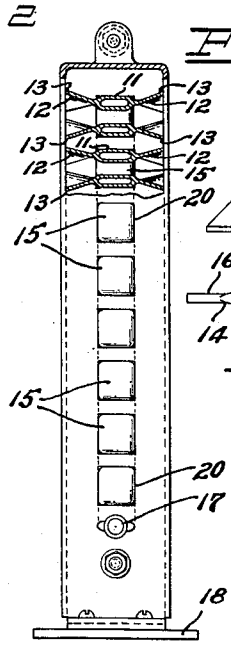


Fig. 5.

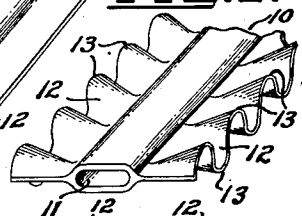


Fig. 6.



Fig. 8.

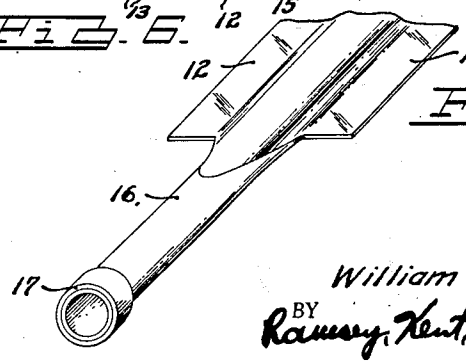


Fig. 2.

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Fig. 7.

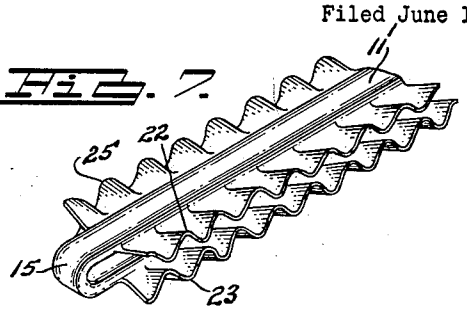


Fig. 10.

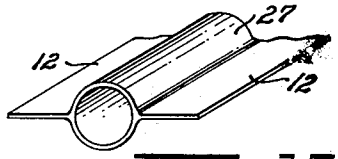


Fig. 9.

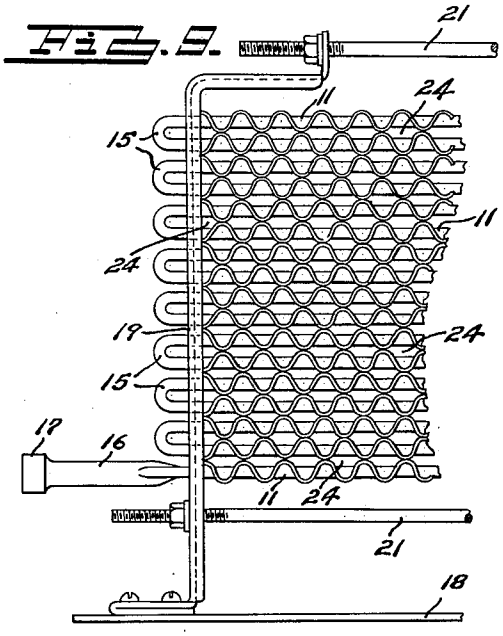


Fig. 14.

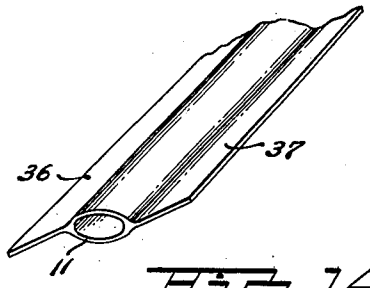


Fig. 15.

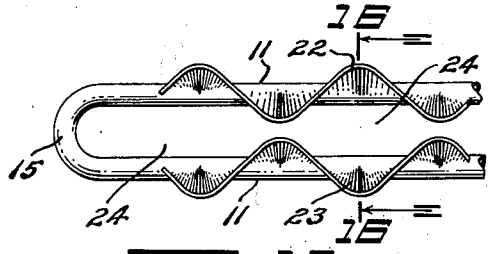


Fig. 16.

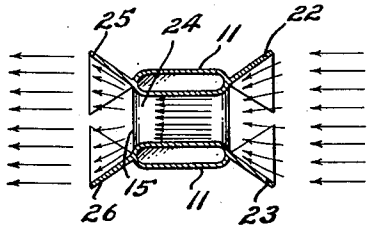
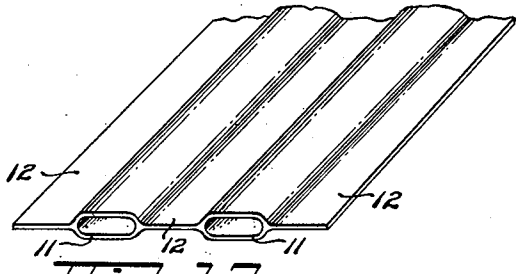


Fig. 12.



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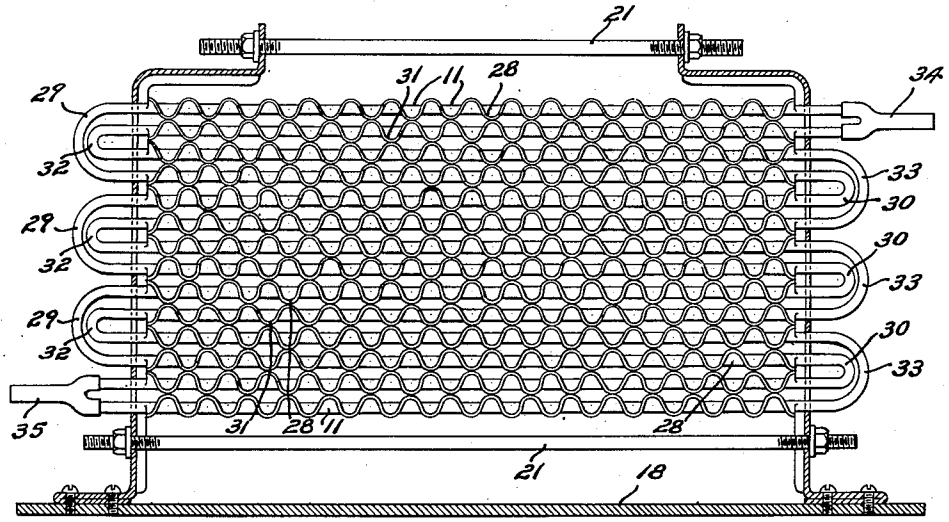


Fig. 11.

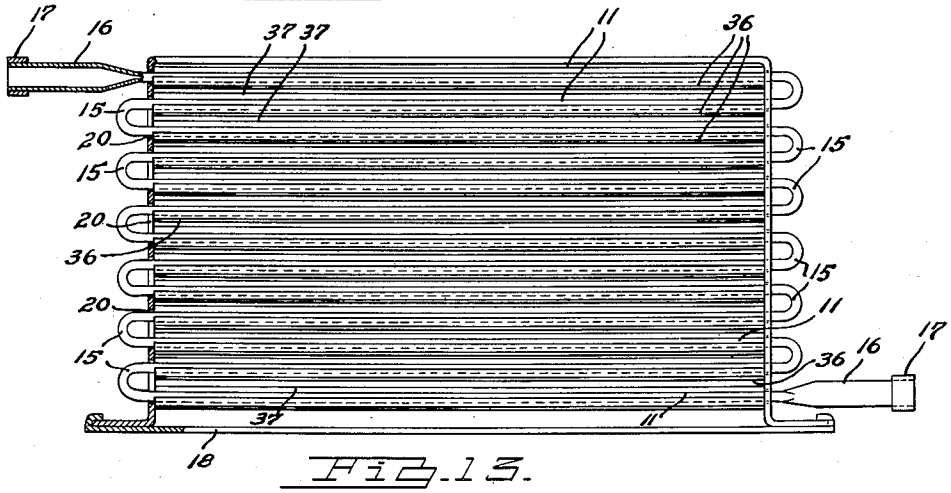


Fig. 13.

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2,347,957

HEAT EXCHANGE UNIT

William E. McCullough, Detroit, Mich.

Application June 17, 1939, Serial No. 279,617

6 Claims. (Cl. 257—149)

This invention relates to a heat exchange device, and aims to produce an economical and efficient unit that can be adapted to a wide variety of installations.

Important features of the invention reside in the fact that the unit is formed from a single continuous length of extruded stock that can be subjected to some of the fabricating operations in mill lengths, and that in the finished unit the parts are disposed so as to make efficient use of air currents flowing transversely of the unit.

Another important feature of the invention resides in the fact that the tube section is extruded with straight lateral fins homogeneous therewith and that these fins are subsequently bent beyond the width of the tube section, preferably by being crimped or ruffled.

The fins are removed from portions of the tube to prepare the ends for attachment to other tubing, and from intermediate portions to facilitate bending.

While preferred forms of the apparatus and method are disclosed herein for purposes of illustration, various changes may be made therein without departing from the spirit of the invention as herein set forth and claimed.

In the drawings:

Fig. 1 is a side elevation of a heat exchange unit embodying the invention.

Fig. 2 is a view partly in section and partly in elevation, taken on line 2—2 of Fig. 1.

Fig. 3 is a perspective of one form of stock as extruded.

Fig. 4 is a perspective showing the stock after the tube section has been flattened.

Fig. 5 is a perspective showing the stock after the fins have been ruffed.

Fig. 6 is a plan view of a length of stock after parts of the fins have been removed.

Fig. 7 is a perspective illustrating the bends in the finished unit.

Fig. 8 is a perspective of one end of the stock after the tube section has been prepared for attachment to other tubing.

Fig. 9 is a fragmentary side elevation illustrating a modification.

Fig. 10 is a view similar to Fig. 3 showing a modified form of extruded tubing.

Fig. 11 is a side elevation illustrating a further modification.

Fig. 12 is a perspective of a modified form of tubing stock as extruded.

Fig. 13 is a side elevation illustrating an additional modification.

Fig. 14 is a perspective of part of one of the tubes of Fig. 13.

Fig. 15 is an enlarged fragmentary elevation of the structure of Fig. 1.

Fig. 16 is an enlarged diagrammatic section on line 16—16 of Fig. 15.

Referring to the drawings more particularly, Fig. 1 shows as a preferred form of the invention a heat exchange unit adapted for use as a condenser for a mechanical refrigerator. As clearly shown in this figure, the main part of the unit is a continuous length of tubing stock 10. The details of the structure shown in Fig. 1 will be understood best by following the operations by which the tubing stock is given its final form.

This tubing stock is preferably extruded from aluminum alloy, which is a suitable material because it has a high coefficient of heat conductivity; lends itself readily to extrusion and to the other operations of manufacture; and resists corrosion by the ordinary refrigeration fluids. Other materials having desirable properties could of course be used for the tubing stock.

The tubing stock is extruded, as illustrated in Fig. 3, with a central tube section 11 and thin lateral fins 12. The central tube section originally has the shape of an oval with the major axis of the oval lying in the plane of the fins 12, this shape being used because it approximates the flattened shape desired in the finished unit. The tubing stock illustrated can be continuously extruded in any convenient mill lengths.

In the next operation the tubing stock is run through rolls, or other suitable apparatus, by which the central tube section is flattened to a flat-sided tube as illustrated in Fig. 4. This final shape is preferred because it lends itself readily to forming the close bends required in the unit, and because it provides a minimum depth of tube with a thin fluid column that is efficient for heat transfer. If desired, the flattening may be done only at the parts to be bent, leaving the other parts in the shape as originally extruded.

Either subsequently to, or simultaneous with the flattening operation, the edges of the fins 12 are crimped or ruffled by rolling or stamping, so that in the finished unit the part of each fin attached to the tube section 11 is straight, while its free edge has a sinuous curve or ruffle, as clearly shown in Fig. 5. The ruffling is sufficiently deep that the crest 13 of each crimp or ruffle lies beyond the normal width of the tube section 11, and the ruffles on both sides of the strip are alined, that is, the crest of one ruffle is the same distance from the end of the tube as the crest

of the ruffle on the other side of the tube. This ruffling has several advantages, some of which are that it increases the area of the fins while reducing their thickness, thus enhancing the heat-transfer capacity of the fins, and that it makes efficient contact with air currents flowing across the tube section.

In the next operation the tubing stock is subjected to a stamping operation by which part of each fin 12 is cut off at 14, adjacent each end of the piece of stock, and at 15, points corresponding to the bends of Fig. 1. This stamping operation may be carried out by a stamping press or by suitable cutting rolls.

The length of tubing stock is then ready to be bent. During the bending precautions must be taken to prevent collapse of the tube section 11 at the bends, and this is conveniently done by drawing into the tube a flexible supporting element having a shape corresponding with the inner contour of the tube section and preferably built up from pieces of flexible shim stock. The flexible support is drawn to a position inside one of the de-finned sections 15 and that section is then bent into a flat U bend as illustrated in Fig. 7. The flexible support is then drawn on to the next bend.

Succeeding bends are made in opposite directions, so that in the finished unit the straight runs between bends are disposed vertically above each other and are spaced from each other a sufficient distance to prevent the crests 13 of the ruffles of one run from contacting with the crests of the ruffles of the adjacent run. When all bends have been made the flexible support is removed from the tube section.

After the length of stock has been bent as described each end of the tube section 11 is suitably formed for attachment to the tubes of a system, such as a refrigeration system. In the embodiment illustrated the tube section 11 is expanded into tubular shape as at 16 and its end is upset to form a thickened collar as at 17 in Fig. 8. These prepared ends may conveniently be welded to the copper tubes of the refrigeration system in a known manner.

After the unit formed from the extruded stock has been thus shaped it is preferably mounted in a supporting frame. The frame shown in Fig. 1 comprises a base plate 18 and side members 19. The side members 19 have openings 20 which have a snug fit over the bends 15 of the tube section. Tie rods 21 hold the side members 19 firmly against the tube section.

The condenser unit described above is intended for use with a fan blowing a current of air across the unit to cool and condense warm refrigeration fluids flowing through the tube section 11. The fan would normally be located behind or in front of the unit as positioned in Fig 1 and the air current would flow across, that is at right angles to, the tube section 11.

This construction has a number of advantages. In the first place it consists basically of a single length of tubing having fins homogeneous with the tube. Since a joint of any kind impedes heat flow, the homogeneous construction provides for the most efficient heat transfer from the tube to the fins.

As previously stated, the ruffling of the fins increases the fin area while decreasing the thickness of the fins, thus enhancing the heat transfer capacity of the fins. At the same time the ruffles help to make efficient use of the air stream flowing across the unit in the manner now to be explained.

In Figs. 7 and 15 reference numerals 22 and 23 represent ruffles located on adjacent runs of the tube section, the crests of these ruffles extending away from each other and beyond the width of the tube section 11. Due to this construction each of these ruffles acts as an air scoop, and between them is an opening having a general funnel shape which narrows down to a flat opening 24 between the runs of tube section, and which flares out again in a corresponding funnel shaped opening defined by the matching ruffles 25 and 26 on the rear side of the runs of section 11. The cross-section through these ruffles (Fig. 16) shows that the air stream first impinges forcefully against the fins 22 and 23, then rushes with increased velocity through the Venturi throat 24, and expands to make contact with the ruffles 25 and 26.

It will be clear from Fig. 1 that similar Venturi throats extend over both sides of each interior run of the tubing stock, so that the construction provides for an accelerated flow of air over both sides of the tube section 11, as well as for direct impingement or positive wiping action of the air upon the fins.

Persons skilled in the art will understand that the construction above described is not limited to use as a refrigeration condenser unit, but that it can be used wherever a simple, inexpensive heat-exchange device is required. It may, of course, be mounted with the straight runs extending vertically, and many variations can be made in the construction some of which will now be described.

Fig. 9 shows a modification on which a unit is built up basically like that illustrated in Fig. 1, but with the differences that in Fig. 9 the parallel runs of the tubing stock are spaced closer together so that the projecting ruffles of adjacent runs contact with each other. In this form the ruffles provide venturial openings that are completely closed at their outer ends. However, in this construction the touching ruffles should be prevented from rattling by fastening them together with rivets, clips, welding, soldering or brazing.

The tube stock may, of course, be extruded with any preferred form of central tube section. For example, Fig. 10 illustrates a shape of extruded stock in which the tube section 27 is cylindrical and this section may be left in this shape in the finished condenser unit, or it may be flattened as previously indicated in Fig. 4.

For some installations it may be desirable to pass a larger amount of fluid through the heat exchanger relative to the amount of fin area. One construction for obtaining this result is illustrated in Fig. 11 in which two units of the general type illustrated in Fig. 1 are nested together. One of these units, indicated by reference numeral 28, has relatively wide bends 29 at the left side of Fig. 11 and relatively sharp bends 30 at the right end of Fig. 11. The other unit, indicated by the numeral 31, has relatively sharp bends 32 at the left end of Fig. 11 and relatively wide bends 33 at the right end. Nesting these units together they may be brought to the position illustrated in Fig. 11 in which the ruffles of the units are aligned. The ruffles may touch each other as illustrated in Fig. 11, or may be spaced apart in the manner indicated in Fig. 1.

The inlet leads of the units 28 and 31 are

joined to a common Y fitting 34, and the outlet ends are similarly joined to a Y fitting 35. In this construction the fin area is the same as for a similar unit having the same number and length of straight tubing runs, but since there are two separate tube sections 11 running through the unit, twice the amount of fluid will pass through the tubes of the unit as would pass through a single tube unit of the same size.

Another construction to obtain an increased fluid flow is illustrated in Fig. 12 in which the tubing stock is extruded in the form of a flat strip having a plurality of tube sections 11 joined by fin 12 and having laterally extending fins 12. In the form illustrated having two tubes 11 the fluid capacity of the section is doubled while the fin area is increased 50%. The outside fins 12 may, of course, be ruffled in the manner heretofore explained, and the central fin may also be crimped to increase its area and to take advantage of the air flow. More than two tubes may, of course, be extruded on a single piece of stock if desired.

Another possible variation of the construction is illustrated in Fig. 13 in which the laterally extended flanges are not crimped but the entire fin is tilted to a position in which it projects beyond the width of the tube section 11 into the air stream between adjacent runs of the tubing stock. Thus the front fin 36 of each run may be bent downwardly and the rear fin 37 may be bent upwardly as indicated clearly in Fig. 14. This form of the device would not make as efficient contact with the air stream as the forms having the ruffled fins, but it may be satisfactory for some purposes. This construction with straight tilted fins may be used in a "nested" unit of the kind shown in Fig. 11.

I claim:

1. A heat exchange unit comprising a single length of extruded aluminum stock having a central flattened seamless tube section and two lateral fins thinner than the tube section and homogeneous therewith and extending from opposite sides of the tube section, the length of stock being bent into successive runs spaced from each other to form a unit adapted for air flow transverse to the runs, the outer edge of each fin being ruffled, the crests of the ruffles of adjacent runs being alined with each other and having their crests extending beyond the width of the tube section in a direction transverse to the normal line of the fin, parts of the stock being formed into simple bends, the lateral fins being removed at the bends, and the ends of the stock having the lateral fins removed.

2. A heat exchange unit as set forth in claim 1 in which the ruffles of adjacent runs touch each other and are joined together by brazing or soldering.

3. A heat exchange unit as set forth in claim 6 in which two separate lengths of tubing are bent and nested together in the same plane to provide a plurality of fluid passages through the unit.

4. In a heat exchange unit of the type in which two runs of tubing stock are located adjacent to each other, the improvement which comprises: each run of tubing stock having two fins that extend at right angles to the plane passing through the centers of the tubing stock, each of the fins having its outer edge ruffled, the crests of the ruffles extending beyond the width of the tubing stock and being alined with the crests of the ruffles of the fins of the adjacent run so as to form Venturi-like openings, the tube portions of the tubing stock forming side walls of the Venturi throats.

5. A heat exchange unit comprising a section of stock having a seamless tube-part and two lateral fins thinner then the tube part, homogeneous therewith and extending from opposite sides of the tube section, both of the lateral fins having their outer edges ruffled, the crests of the ruffles extending beyond the width of the tube in a direction transverse to the normal line of the fin, the crests of the ruffles of one fin being alined with those of the other fin, the section of stock being placed adjacent to another section of similar construction, the crests of the ruffles of the adjacent sections being alined with each other so as to form Venturi-like openings, the tube sections forming the sides of the Venturi throats.

6. In a heat exchange unit of the type in which two runs of tubing stock are located adjacent to each other, the improvement which comprises: the tubing stock being a seamless section of extruded metal having oppositely extending fins homogeneous with the tubing and attached to the tubing along continuous, straight lines parallel with the axis of the tubing, each of the fins being formed with ruffles which commence adjacent the straight edge where the fin is attached to the tube and increase in depth toward the outer sinuous edge of the fin, the crests of the ruffles of one fin of a run being alined with the crests of the other fin of the same run, and with the crests of an adjacent similarly-shaped run.

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