Aug. 17, 1965 C. A. HEUER 3,200,480

HEAT EXCHANGER

Original Filed Sept. 30, 1959 3 Sheets-Sheet 1

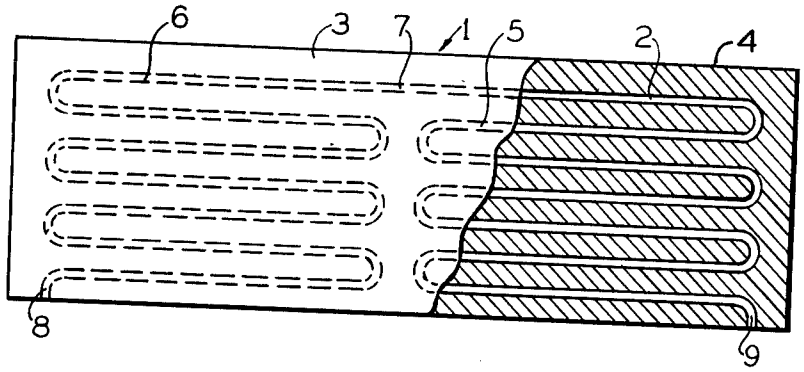

FIG - 1

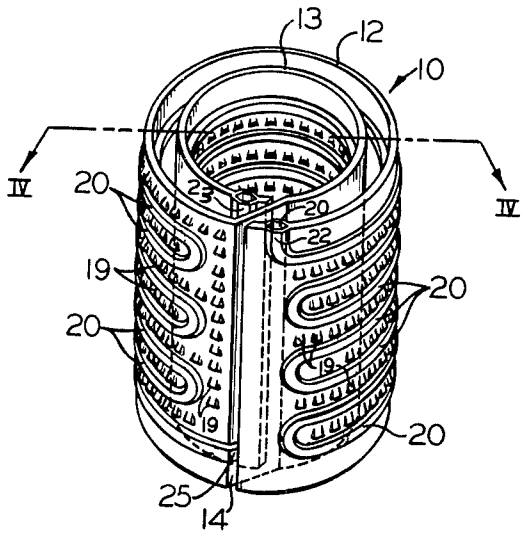

FIG - 3

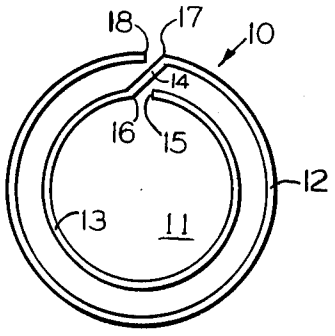

FIG - 2

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Aug. 17, 1965 C. A. HEUER 3,200,480

HEAT EXCHANGER

Original Filed Sept. 30, 1959 3 Sheets-Sheet 2

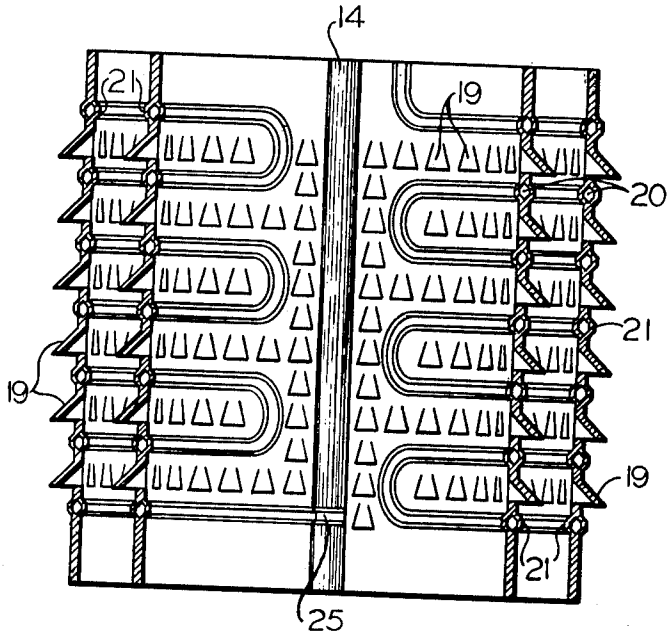

FIG - 4

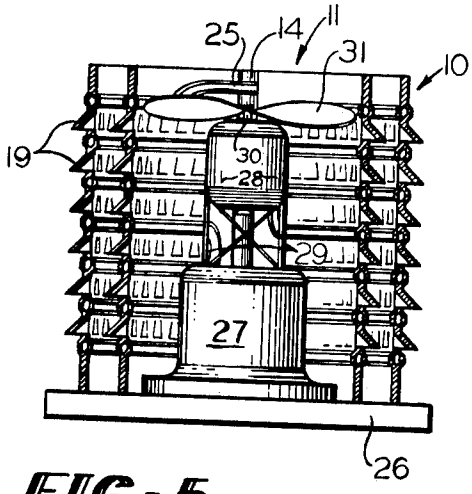

FIG - 5

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HEAT EXCHANGER

Original Filed Sept. 30, 1959 3 Sheets-Sheet 3

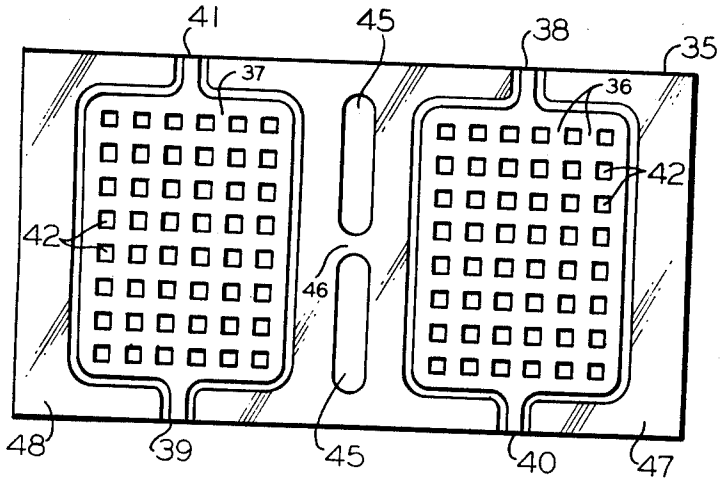

FIG-6

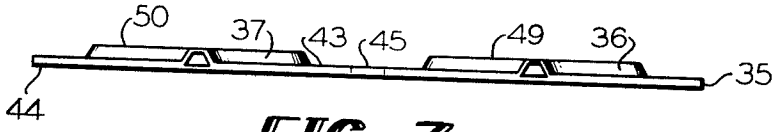

FIG-7

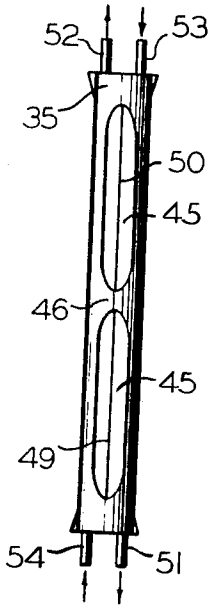

FIG-9

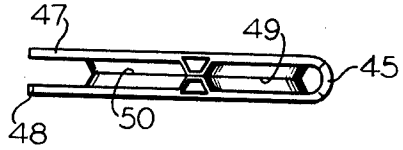

FIG-8

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United States Patent Office 3,200,480 Patented Aug. 17, 1965

3,200,480

HEAT EXCHANGER

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Original application Sept. 30, 1959, Ser. No. 843,483, now Patent No. 3,173,479, dated Mar. 16, 1965. Divided and this application May 27, 1963, Ser. No. 292,176

4 Claims. (Cl. 29—157.3)

This application is a division of copending application Serial Number 843,483, filed September 30, 1959, now U.S. Patent 3,173,479.

This invention relates to heat exchangers and more particularly to a one-piece unitary type of heat exchanger having portions thereof brought into juxtaposed relationship with fluid passage systems in each of said portions constraining fluid to flow in counter-current relationship.

Heat exchangers spirally wound into coils are desired because of their potential capacity and low material cost. In spite of these advantages, such spirally wound heat exchangers have not found favorable reception in the heat industry due to their low efficiency and low heat transfer capacity obtainable heretofore by conventional methods of fabrication.

However, in accordance with this invention, it has been discovered that increased heat transfer characteristics and efficiency may be obtained from spirally wound heat exchangers by providing therein a plurality of spaced fluid passageway systems flowing in successively alternating directions, and bringing adjacent portions of the exchanger, containing successive fluid systems, in juxtaposed relationship with each other. More specifically, this is accomplished by providing within the element a plurality of aligned spaced passageway systems, wherein fluid in successive systems is constrained to flow in alternate directions, with alternate adjacent terminal portions of the systems interconnected to each other. The element is then bent so as to bring adjacent passageway systems into juxtaposed relationship with each other whereby the flow of fluid in one portion of the element will be counter-current to the flow of fluid in an adjacent juxtaposed portion of the heat exchanger element.

Accordingly, it is an object of this invention to provide a novel heat exchanger of unitary construction.

It is another object of this invention to provide a heat exchanger of one-piece construction wherein adjacent juxtaposed portions of the exchanger constrain fluid to flow, in each portion, in counter-current relationship.

Still another object of this invention is to provide a novel heat exchanger adapted for use as a condenser in central air conditioning units, such as in use for home air conditioners.

Other objects and advantages will become more apparent from the following descriptions and drawings in which

FIGURE 1 is a plan view partly in cross-section illustrating an example of a novel sheet-like element employed in one embodiment of this invention;

FIGURE 2 is an elevational view illustrating one embodiment of this invention formed from the element illustrated in FIGURE 1;

FIGURE 3 is a perspective view of the embodiment of FIGURE 2 in a subsequent step of fabrication;

FIGURE 4 is a view taken along the lines of IV—IV of FIGURE 3;

FIGURE 5 is an elevational view partly in cross-section illustrating one novel application of the embodiment illustrated in FIGURE 3;

FIGURE 6 is a plan view of another sheet-like element employed in another embodiment of this invention;

FIGURE 7 is an elevational view of the element illustrated in FIGURE 6;

FIGURE 8 is a plan view illustrating another embodiment of this invention formed from the element of FIGURE 6; and

FIGURE 9 is an elevational view illustrating the embodiment of FIGURE 8.

Referring to the drawings, one embodiment of the heat exchanger contemplated in this invention, is formed from a flat sheet element 1 fabricated from superposed sheets of metal which may be brazed or pressure-welded together to define between them a plurality of individual fluid passageway systems. A preferred method by which such sheet-like elements may be obtained, is disclosed in a patent issued to Grenell, U.S. 2,690,002, granted on September 28, 1954. In accordance with the method of the aforesaid patent, a pattern of weld-inhibiting material is interposed between superposed sheets 3 and 4, such as aluminum, copper and the like, which are thereafter conveniently secured together, such as by spot-welding at the corners, to prevent relative movement between them. The sheets are then welded together at the adjacent surfaces not separated by the weld-inhibiting material by hot rolling the secured sheets. Hot rolling of the sheets results in reducing the thickness of the combined sheets and elongating the resultant welded sheet element in a direction of rolling while the width of the element remains substantially the same as the initial width of the component sheet. Welding of the superposed sheets in accordance with this method results in a substantially solid sheet having an internal configuration of laminations corresponding to the pattern of weld-inhibiting material employed.

The resultant sheet element may be further treated as by rolling to the ultimate thickness desired, and/or by annealing to soften it and thereby render it more amenable to inflation upon injecting within its unwelded portion sufficient fluid pressure for permanent distention thereof.

As illustrated in FIGURE 1, the weld-inhibiting material 2 was applied in two distinct and similar patterns 5 and 6 in alignment with each other and interconnected to each other; it will be seen that the patterns 5 and 6 are substantial mirror images of each other, for reasons to become evident. Each of the patterns 5 and 6 traverses its respective portion of the panel sinuously transverse their direction of alignment. The adjacent terminal portions of patterns 5 and 6 are interconnected together at 7 by an unwelded strip also contained within sheet element 1. The passageway system 6 is also provided at its free terminal portion with an unwelded strip 8 extending to the edge of the sheet to form an inlet for the interconnected systems within sheet element 1. In similar manner, the pattern of passageway 5 is also provided at its free terminal portion with a connecting unwelded strip 9 extending to the edge of the sheet element to form an outlet for the interconnected systems within the sheet element. As can be clearly seen the fluid in pattern 6 will flow sinuously in its respective portion counter-current to the direction in which the liquid will sinuously flow in the portion of the panel containing pattern 5.

Although a specific design passageway has been illustrated in FIGURE 1 it is to be understood that the internal system of cavitations, formed upon subsequent distention of the unwelded portions, should preferably occupy substantially all of the major portion of the panel in which its respective pattern of weld-inhibiting material is contained. In addition, it is also preferred that the cross-section of tubular cavitations be maintained relatively small so as to permit the distribution of greater length of conduiting within their respective portions of the sheet unit element 1.

Subsequent to pressure-welding sheet element 1 is then

bent with any convenient forming tool to spirally wind the element, about a central opening 11, into a coil 10 having a number of convolutions equal to the desired number of systems defined by the plurality of spaced patterns of weld-inhibiting material. In this manner each successive convolution substantially embraces between its terminal portions successively spaced passageway systems.

Accordingly, for the sheet element illustrated in FIGURE 1, the spirally wound coil 10 has two convolutions 12 and 13 each embracing between its terminal portions, one of the interconnected patterns of passageways 5 and 6. Also, it is preferred that portions of the sheet element between adjacent convolutions, which with the exception of an interconnecting means such as strip 7 are substantially free of any unwelded portions, be provided with an offset 14 to bring the terminal portions of 15 and 16, and 17 and 18 of each convolution into a substantially abutting relationship with each other. In this form, each convolution is provided with a substantially cylindrical configuration with the most outwardly convolution 12 forming a substantially cylindrical surface about the spirally wound coil 10. If additional structural support is desired in a spirally wound coil of FIGURE 2 the abutting terminal portions of each convolution may be appropriately secured to each other as by welding, or brazing.

As will be noted, each passageway system will lie substantially athwart the longitudinal extent of its respective convolution. Also, the passage of fluid through the system of passageways provided in one convolution will be constrained to flow, both, in a direction transverse the direction of coiling and in a direction counter-current to the flow of fluid in the passageway system provided in an adjacent convolution. Although an offset is preferred between the terminal portions of adjacent convolutions, in the spiralled coil, and has been indicated as preferred, it may be omitted with advantage in certain applications where an external fluid medium is desired to flow in a spiral direction between adjacent convolutions toward the central opening 11.

In its preferred form the sheet element is also provided with a plurality of louvered transfer openings 19, forming an integral part of an arrangement of the heat exchanger. Such louvered openings 19 may be formed by providing a plurality of aligned and spaced slits with the intermediate portions of the element between them deformed, with appropriate shaping, to extend at an angle out of the face of the element. Preferably these intermediate portions are deformed to flare outwardly, for example in a semi-conical form, out of the face of the sheet element with their enlarged openings directed toward a lateral edge of the element. These louvers may be in uniform sequence or in any staggered relationship desired with their flared ends directed in any single or multiple direction depending on the type and degree of turbulence required for a specific application in order to control the flow of an external fluid medium through the transfer opening and its impingement against successive convolutions of the coil.

Thus, in accordance with this invention in the specific embodiment of FIGURES 2 and 3, the passageway system defined by pattern 5 will be entirely contained in the outer convolution 12 with an outlet 22 extending to an edge of the convolution. Similarly the system of passageways defined by pattern 6 will be entirely contained in the inner convolutions 13 with an inlet portion 23 extending to an edge at the free terminal portion of the inner convolution. Each system of passageways and its respective convolutions are interconnected together at the bottom lateral edge 24, of the spiral coil, by a tubular conduit 25 extending through the offset portion 14, between the inner and outer convolutions.

After being bent into a spiral form the unwelded portions or laminations of the sheet element are inflated by subjecting them to sufficient fluid pressure so as to permanently distend them. These unwelded portions upon distention form a tubular conduit system 20 corresponding to the interconnected patterns of lamination provided in sheet element 1. Such distention of the unwelded portions of the sheet element 1 may be unrestrained or the spiral coil may be placed within a die provided with appropriate recesses which present opposed rigid surfaces in spaced relationship to the corresponding faces of each convolution. Alternately, sheet element 1 may also have its unwelded portions distended prior to being spirally wound into the coil, and as with its spiral form, the sheet element, may be distended freely or between opposed rigid platens. As will be understood, distention between opposed rigid surfaces provides a flat-top configuration 21 to the conduit system 20.

The distended spiral coil heat exchanger as illustrated in FIGURES 2 and 3 may be utilized as a condenser suitable for use in central air conditioning units by mounting the condenser with other conventional components of a refrigerant system, FIGURE 5, and with its inlet and outlet at the bottoms, is mounted on base 26 on which is also mounted a conventional sealed motor-compressor unit 27 within the central opening 11 of the condenser. This motor-compressor unit serves to discharge compressed refrigerant by a suitable conduit system, not shown, into inlet 23 of the spirally wound condenser 10. As in conventional refrigerator systems the motor-compressor unit and condenser 10 are further connected with a conventional evaporator plate, for example such as those disclosed and discussed in the aforesaid U.S. Patent 2,690,002, so that, together, the various components provided a series flow relationship, from the motor-compressor unit to condenser to evaporator plate, for a refrigerant fluid therein. In this arrangement, the compressed refrigerant gases are discharged, from the motor-compressor, into the inlet 23 of the spiral condenser 10 for cooling and condensation therein. Thereafter, cooled and liquefied refrigerant gases are discharged as a liquid from outlet 22, of the spiral condenser 10, into an evaporator plate wherein the refrigerant is evaporated and returned to the motor-compressor unit.

Also, in the embodiment contemplated by this invention, the spiral condenser 10, of FIGURE 5, has also disposed within its central opening 10 a fluid impeller 28 structurally supported therein by any suitable manner, as, for example, upon a conventional electrical motor having an extended shaft 30 on which are mounted conventional fluid moving blades 31.

In operation the compressed refrigerant gases from the motor-compressor unit, are discharged into the inlet 23 of the inner convolution wherein they are constrained to flow in a sinuous or serpentine manner upwardly in the inner convolution; the gases then enter, by means of the internal conduit portion 25, the upper terminal portion of the conduit system provided in the outer convolutions through which they flow downwardly in a sinuous or serpentine manner to be discharged as the refrigerant liquid from outlet 22 at the lower edge of the outer convolutions. As will be noted, the gases in each convolution flow in counter-current directions whereby succeeded portions of the inner convolution confine a progressively hotter fluid adjacent portions of the outer convolution confining a progressively cooler fluid.

As the compressed gases flow through the spiraled condenser 10, the fluid impeller 28 draws an external cooling medium, such as air, through louvered transfer openings 19 which appropriately direct the cooling medium over the condenser and the motor-compressor unit 27 into the central opening 11 from which the cooling medium is discharged.

Thus, the spirally wound condenser of this invention provides a very compact unit in conjunction with a motor-compressor unit, as illustrated in FIGURE 5, which is highly desirable from an installation standpoint, and,

which, in addition, provides a higher degree of heat transfer and higher efficiency. As will be understood, modifications of the passageway systems may be made to give other condensing conditions depending on the specific application involved. For example, the condenser unit may be provided in each convolution with a series of lateral tubes laterally spaced within each convolution and interconnected by a header, or, as aforesaid, a greater or a lesser number of tube passes may be provided within each convolution.

FIGURE 6 illustrates another embodiment of the invention employing a similar sheet element 35 provided with two separate and distinct hollow configurations 36 and 37 disposed in spaced and aligned relationship to each other in separate portions 47 and 48 of sheet element 35. As was the case with patterns 5 and 6 of FIGURE 1, the configurations 36 and 37 are substantial mirror images of each other. Each of the distended configurations 36 and 37 are provided with inlets 38 and 39, respectively, and with outlets 40 and 41. These configurations are of the type commonly known as a "waffle" pattern obtainable by means well known in the art. Such patterns may be obtained by applying a substantially square or a rectangular pattern of weld-inhibiting material on a sheet of metal which pattern has within it spaced points devoid of any weld-inhibiting material. After the superimposition of the second sheet on the first sheet and pressure-welding of the two sheets together, the resultant sheet element has a plurality of welds 42 disposed at spaced points within patterns 36 and 37. For this particular embodiment sheet element 35 was distended out of only one face 43 with the opposite face 44 remaining substantially flat. The desired sheet element 35 may also be provided with a plurality of aligned slots 45 separated by a substantially solid strap of metal 46. These slots 45 provide a convenient means for the thermal separation of spaced portions of sheet element 35 containing distended hollows 36 and 37. This strip of metal 46 also provides a convenient means for structurally supporting and maintaining adjacent portions of the element in proper relationship to each other.

In accordance with this invention, the sheet element 35 is then bent along a lateral line extending between hollows 36 and 37 so as to fold over adjacent portions 47 and 48 of the sheet element upon themselves and to bring the top of the distended surfaces 49 and 50, of hollows 36 and 37, in contacting juxtaposed relationship with each other. Any suitable inlet tubes 53 and 54 may be inserted within the inlets 38 and 39, respectively, and any suitable outlet tubing 51 and 52 may be inserted within outlets 40 and 41, respectively, and brazed to the formed element for communicating relationship with the distended hollows 36 and 37, respectively. Each of the distended hollows 36 and 37 of the form are then connected by their respective inlets and outlets into separate fluid systems. This embodiment of the invention provides an integral compact one-piece structure for the interchange of heat between the separate fluid systems whereby the separate fluids flow through one of the hollow distentions 36 and 37 in counter-current relationship.

Although the invention has been described with reference to specific embodiments, materials, and details, various modifications and changes within the scope of this invention will be apparent to one skilled in the art and are contemplated to be embraced within the invention.

I claim:

1. The method of making an integral sheet metal heat exchanger of a spirally coiled configuration having a plurality of internal unjoined portions in juxtaposed relationship to each other, the method comprising

(A) interposing a plurality of continuous patterns of stop-weld material between superposed metal sheets, said patterns being in aligned and spaced relationship along the length of said superposed sheets, each of said patterns

(1) having terminal portions disposed adjacent to opposite edges of said superposed sheets, and

(2) having at least one terminal portion joined to one terminal portion of a successive pattern;

(B) joining the adjacent surfaces of said sheets not separated by stop-weld material;

(C) spirally coiling said sheets about an axis transverse the length of said sheets into a coil having a plurality of convolutions in spaced relation to each other, wherein each successive convolution contains one of said patterns in juxtaposed relationship to a successive pattern; and

(D) off-setting said convolutions by bending said sheets between successive patterns on a line passing through the joined terminal portions thereof and extending in a direction transverse the direction of coiling, to bring terminal portions of each of said convolutions into substantially abutting relationship,

whereby fluid flow in said juxtaposed patterns will be constrained to flow in counter-current relationship between their terminal portions.

2. The method of claim 1 wherein each of said patterns is applied to lie substantially athwart the length of its respective convolution and sinuously traverse said respective convolution in a direction transverse the direction of coiling.

3. The method of claim 1 including the steps of providing a plurality of transfer openings in the joined portions of said sheets spaced from said material, and bending said joined portions adjacent said openings to an angle therewith.

4. The method of claim 1 including the step of inflating the unjoined portions within said sheets with sufficient fluid pressure for permanent distension thereof.

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