April 16, 1968 L. J. TRANEL 3,377,683

METHOD OF MAKING A HEAT EXCHANGER

Filed Aug. 24, 1965 2 Sheets-Sheet 1

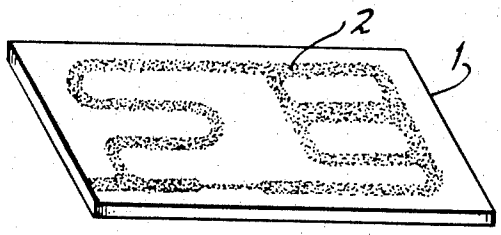

FIG-1

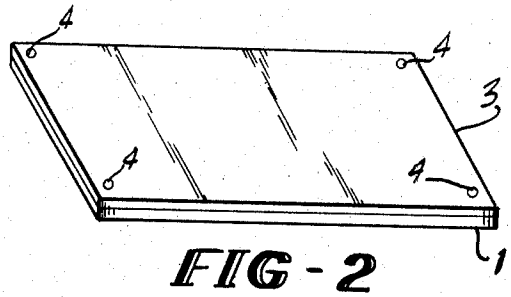

FIG-2

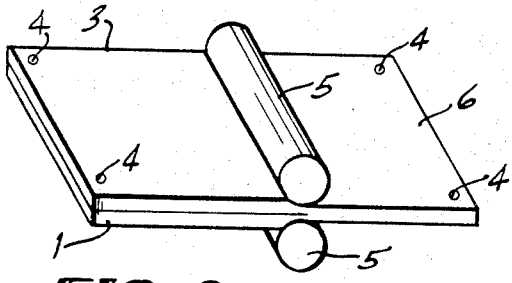

FIG-3

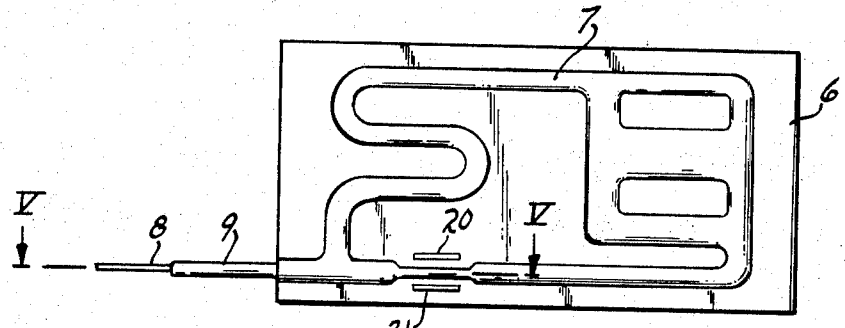

FIG-4

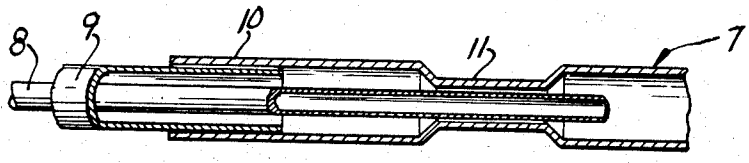

FIG-5

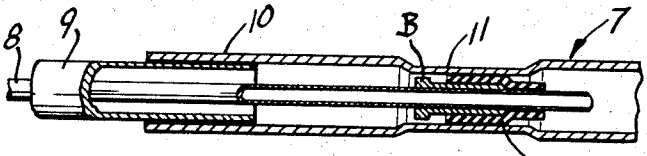

FIG-5A

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April 16, 1968 L. J. TRANEL 3,377,683

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Filed Aug. 24, 1965 2 Sheets-Sheet 2

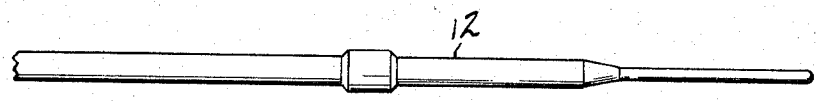

FIG-6

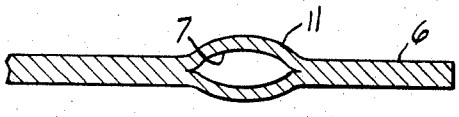

FIG-7

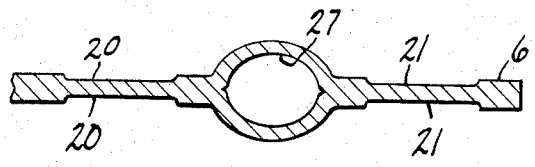

FIG-8

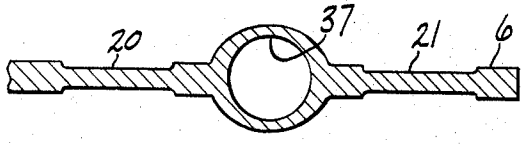

FIG-9

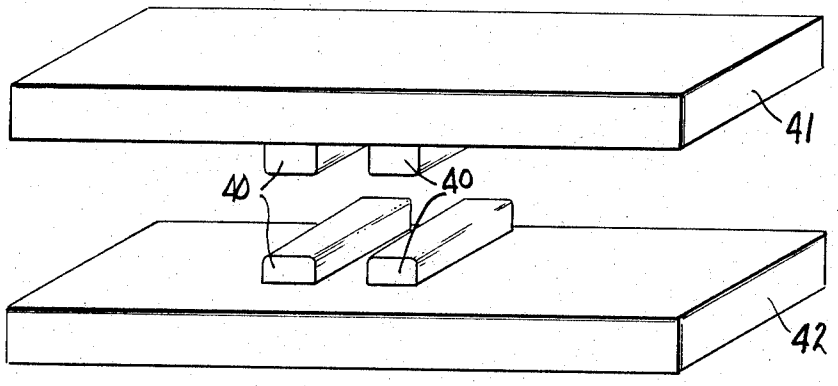

FIG-10

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METHOD OF MAKING A HEAT EXCHANGER

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5 Claims. (Cl. 29—157.3)

This invention relates generally to the fabrication of hollow articles and more specifically to a method of accurately expanding a hollow article adapted for use as a heat exchanger.

As is known in the art, a sheet-like structure having internal hollow passageways is well adapted for use as a heat exchanger wherein a heat exchange medium is to be circulated throughout the structure. One method which is particularly well adapted to producing such devices is that disclosed in U.S. Patent No. 2,690,002, issued Sept. 28, 1954, and known in the art as the Roll-Bond process. In the practice of the invention disclosed in the aforesaid patent, a structure is provided to which necessary connections may be made for the circulation of heat exchange media. Such connections, for example those required for circulation of a refrigerant, are desirably of a precise configuration so that standard connections may suitably fit the heat exchange structures. For example, in U.S. Patent 2,822,151, issued Feb. 4, 1958, there is disclosed a plate-like heat exchanger to which a single connection may be made for both entry and exit of the circulating refrigerant.

In an application such as in a household refrigerator, it has been found desirable to produce the heat exchanger with one side harder than the other. The harder side may then be positioned where severe treatment is to be expected, such as from ice-cube trays or sharp instruments used in removing ice. Thus, the heat exchanger, and accordingly the hollow passageways within the heat exchanger, may be of a bi-alloy construction, with one side thereof of a hardness different from the other side. As examples of materials that may be used in such a bi-alloy heat exchanger, the hard side may be an X8040 alloy, and the soft side an aluminum alloy such as 1100 alloy. Such construction causes production difficulties in precisely expanding, or "sizing," the internal passages so as to closely receive standard connections. Specifically, the use of known expedients in sizing a bi-alloy heat exchanger produces uneven distension of the internal passageways on the two sides thereof. For example, were such a bi-alloy heat exchanger to be expanded by fluid pressure, or by the use of a standard sizing tool, the unequal hardness of the two sides of the device would of course result in unequal distension on each of the sides.

Another method of sizing such passageways which has been suggested is the use of a non-symmetrical tool which, when used with a bi-alloy heat exchanger, is calculated to yield a symmetrical configuration of the passageway. Such tools are of high fragility, and it is necessary to very accurately locate the tool with respect to the hard side of the restrictor.

According to the instant invention, it has been found that the sizing of the passageways within such a bi-alloy heat exchanger may be accomplished by the standard sizing tools if the expanded passageway is first further expanded beyond the extent achieved by inflation of the panel forming the heat exchanger. This further expansion is most expeditiously done by forcing the material of the panel on either side of the passageway to flow into the passageway walls; this may be accomplished, for example, by coining the panel areas on each side of the passageway to reduce the thickness thereof. Such further expansion reshapes the passageway more nearly to the desired cross-sectional configuration, and materially reduces the amount of force required by the sizing tool in forming the precise configuration.

This invention is directed primarily to the expansion of metal panels from blanks fabricated with unjoined interior portions, but the invention is equally applicable to similar panels fabricated from materials other than metals, such as various plastics, and to panels fabricated from dissimilar materials such as metal and a plastic joined together with an unjoined portion between the sheets.

It is accordingly an object of this invention to provide an improved method of fabricating hollow articles.

It is a further object of this invention to provide a method of fabricating such hollow articles having hollow pasageways therein comprised of materials of different hardness.

It is a further object of this invention to provide a method of producing such a device wherein the internal passageway may be appropriately sized to receive standard connections for circulation of heat exchange media.

Other objects and advantages will become apparent to those skilled in the art as a detailed description of a particular embodiment proceeds with reference to the drawings which form a part hereof, and in which:

FIGURES 1–3 depict schematically a process for forming a blank from which a heat exchanger according to this invention may be formed;

FIGURE 4 is a plan view of a heat exchanger expanded from the blank produced by the process of FIGURES 1–3, and showing a suitable connection for circulation of a heat exchange medium;

FIGURE 5 is a cross-sectional view of a portion of FIGURE 4 taken along the lines V—V thereof;

FIGURE 5A is a cross-sectional view similar to FIGURE 5 illustrating a modification thereof;

FIGURE 6 is a perspective view of a suitable tool used in sizing the passageway of the heat exchanger of FIGURE 4;

FIGURES 7, 8 and 9 are exploded cross-sectional views of a portion of the expanded blank of FIGURE 4, illustrating various steps in the instant method; and

FIGURE 10 is a perspective view of a suitable apparatus which may be employed in the instant invention.

Referring to the drawings, FIGURES 1–3 depict by way of example one method by which a plate-like heat exchanger having internal passageways may be produced. While the instant invention is applicable to any sheet-like structure having internal passageways, the method of production disclosed in the aforementioned U.S. Patent No. 2,690,002, is preferred. In accordance with such teachings, a first sheet of material **1** may have applied to one face thereof any desired pattern of stop-weld material **2**, as shown in FIGURE 1. A second sheet of material **3** may then be superimposed upon the first sheet **1**, as shown in FIGURE 2, and secured together as by spot welding **4** to prevent relative slippage of the adjacent surfaces of the sheets **1** and **3** during a subsequent welding operation. The sheets **1** and **3** may then be welded together throughout their contacting faces not separated by stop-weld material. For example, the superimposed sheets may be treated by hot rolling as shown in FIGURE 3. The superimposed sheets are first heated and then passed through rolls **5** between which they are reduced in thickness and elongated in the direction of rolling. The resultant blank **6** having an unjoined inner portion corresponding to the pattern of stop-weld material **2** may then be softened in any appropriate manner as by annealing, and thereafter the blank may be cold rolled to provide a more even thickness and again annealed.

As is known in the art, such a method of producing a heat exchanger requires that a portion of the stop-weld

material be adjacent an edge of the sheet so that the internal passageway desired may be expanded by introduction of fluid pressure therethrough. As disclosed in the aforementioned U.S. Patent No. 2,822,151, it is particularly advantageous to form the pattern of stop-weld material so that the resulting expanded passageway may circulate a heat exchange medium which both enters and exits at the same point. Such a device is depicted in FIGURE 4 of the drawings and may comprise a blank **6** produced according to the method indicated above, in which the pattern of stop-weld material **2** has been inflated by introduction of fluid-distending pressure in a manner known in the art to form a system **7** of internal hollow passageways. Concentrically oriented tubes **8** and **9** may then be inserted for appropriate circulation of a refrigerant through the passageway **7**.

Such an expedient is shown more in detail in the cross-section of FIGURE 5. As can there be seen, the passageway **7** may include an enlarged portion **10** near an edge of the sheet and a connecting restricted portion **11**. The inner of the concentric tubes **8** may then be inserted into the restricted portion **11** and employed for introduction of the heat exchange medium, for example a refrigerant. The refrigerant is then circulated throughout the passageway **7**, returning within the portion **10** from which it may exit through the outer tube **9**. It will be evident that the tubes **8** and **9** may take any desired form, those shown being merely exemplary. It is necessary that the tube **8** mate correctly with the interior of the passageway **11** to prevent "leak-back" of the refrigerant; such leak back may cause poor performance and collection of moisture on the outlet tubes as the refrigerant goes through its cycles of off and on. Accordingly, if so desired, a grommet and bushing may be employed to ensure an effective seal. Such an expedient is illustrated in FIGURE 5A, wherein a cylindrical bushing B, which may be of metal, with a surrounding cylindrical grommet G, which may be of a sponge rubber tubing, is inserted approximately midway of the restricted portion **11** prior to insertion of the tube **8**. In any event, it is necessary that the passageway be correctly expanded so as to fit with the connection which is intended to be employed in any particular application.

As indicated hereinbefore, opposing sides of the described heat exchangers may be of different alloys. Accordingly, initial expansion of the passageway **7**, whether by fluid pressure or by introduction of a mandrel or the like, would yield differing expansion of the two sides of the passageway. As the standard connections for circulation of the refrigerant are of a symmetrical configuration, it is desirable that the portion of the passageway to receive such a connection also be of a symmetrical configuration. In accordance with this invention, a method is provide for facilitating the precise sizing of such a passageway in response to introduction of a usual symmetrical sizing tool, for example that shown in FIGURE 6, and identified by the reference character **12**. Following inflation of the passageway **7**, the expansion of one side would be greater than that of the other. This relationship is illustrated in FIGURE 7, which is an exploded cross-sectional view of that portion of the blank **6** including the restricted portion **11**. As noted hereinbefore, introduction of a standard sizing tool similar to that illustrated in FIGURE 6 would require a high degree of force to achieve the desired cross-sectional configuration and, one side of the passageway being harder than the other, unequal distension on the two sides would result. Such defects may be avoided by first further expanding the passageway **7** by forcing the material of the blank on both sides of the passageway to flow into the passageway walls. Thus, as is illustrated in FIGURE 8, portions **20** and **21** of blank **6** may be decreased in thickness, the excess material flowing into the walls of passageway **7** and accordingly expanding the passageway **7** into a larger passageway **27**. The distension on the two sides of such passageway **27** would still be uneven, but to a lesser degree than that illustrated in FIGURE 7. Additionally, the amount of force required to form the passageway **27** into the desired configuration by introducing a sizing tool such as **12** is materially less for the passageway **27** as compared to the passageway **7**.

Subsequently, the passageway **27** may be formed into the desired cross-sectional configuration, for example that shown at **37** in FIGURE 9. Due to the intermediate expansion step, this final forming is relatively easy to accomplish, and is done without any special equipment other than the sizing tool itself.

Considering now the method by which the areas **20** and **21** of blank **6** are thinned, it will be apparent that any means of reducing the thickness of a material will suffice. One method which has been tested and found to be particularly satisfactory is a coining operation performed on both faces of the blank, as may be seen in FIGURE 8, and on either side of the passageway, as may be seen in FIGURE 4.

A suitable apparatus for performing this operation is illustrated in FIGURE 10. The thinned areas **20** and **21** may be obtained by positioning the blank **6** within a suitable press and subjecting the blank **6** to tools **40**, which may be attached in any desired manner to platens **41** and **42** of the press. It will be evident that in the apparatus illustrated, the passageway is positioned between two adjacent tools **40** and that opposing tools **40** are in alignment to cause the thinned areas **20** and **21** illustrated in FIGURE 8. The force and speed of contact between the tools **40** and blank **6** may be so regulated that the desired expansion of the passageway **7** takes place. For example, it has been found that for a blank .057" thick having the passageway **7** of a height .084", a coining resulting in a thinned area of .053" results in the desired expansion of the passageway **7** to a height of .111".

It should be noted that the apparatus illustrated is merely exemplary, and that the desired coining tools may be incorporated in a press employed for other purposes in processing of the blank.

It is to be understood that the instant invention may be utilized whenever and wherever a precise configuration of hollow passageway is desired. The "single-entry" pattern shown in the drawings is by way of example only. Similarly, the instant invention may be utilized on a blank produced by a method other than the Roll-Bond process. Additionally, the round configuration of the passageway shown is only one which may be achieved by the instant invention. By appropriate expansion of the passageway and choice of the configuration of the sizing tool, any desired configuration may be obtained.

It is to be accordingly understood that the invention is not limited to the illustrations described and shown herein which are deemed to be merely illustrative of the best modes of carrying out the invention, and which are susceptible of modifications of form, size, arrangement of parts and detail of operation, but rather is intended to encompass all such modifications which are within the spirit and scope of the invention as set forth in the appended claims.

What is claimed is:

1. A method of forming to a desired configuration an expanded passageway within a panel, said passageway having opposed sides of materials of different hardness, the method comprising

(A) reducing the thickness of said panel at areas on each side of said passageway to cause the passageway to be further expanded, and

(B) inserting into said passageway a tool having the desired configuration to form said passageway into the desired configuration.

2. The method of claim **1** wherein step (A) is performed by a coining operation on each face of said panel.

3. The method of claim **1** wherein said tool is sym-

metrical about a plane therethrough parallel to the plane of said panel.

4. A method of fabricating a hollow panel having opposed sides of different hardness and an internal passageway of a desired configuration, comprising

(A) superimposing a first sheet upon a second sheet, said first and second sheets being of different hardness,

(B) joining together said first and second sheets throughout their contacting surfaces except for a pattern corresponding to a desired internal passageway, and

(C) expanding said pattern to form said passageway by introduction of fluid pressure,

(D) further expanding said passageway by reducing the thickness of said panel at areas on each side of said passageway to cause the material of said panel to flow toward said passageway, and

(E) inserting into said passageway a tool having the desired configuration to form said passageway into the desired configuration.

5. The method of claim 4 wherein step (D) is performed by a coining operation on each face of said panel.

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2,999,308	9/1961	Pauls	113—118

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