Jan. 18, 1966 N. A. KEITH 3,229,766

FINNED HEAT EXCHANGER

Original Filed Dec. 11, 1961 4 Sheets-Sheet 1

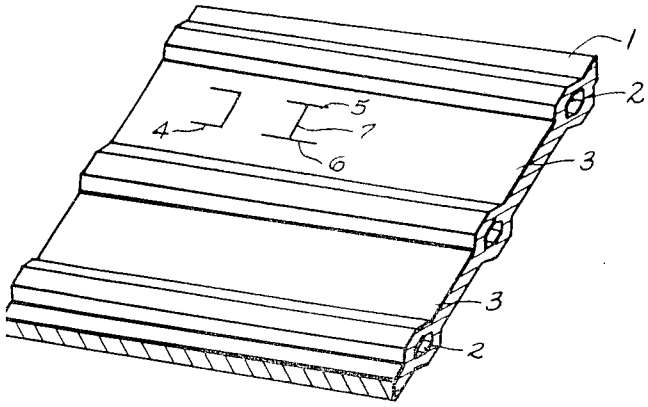


FIG - 1

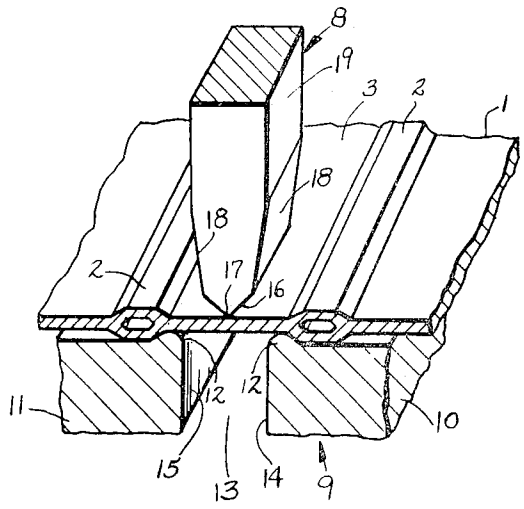


FIG - 2

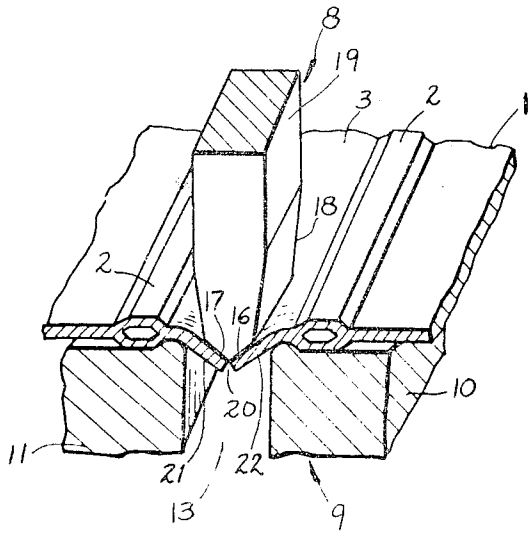


FIG - 3

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FINNED HEAT EXCHANGER

Original Filed Dec. 11, 1961 4 Sheets-Sheet 2

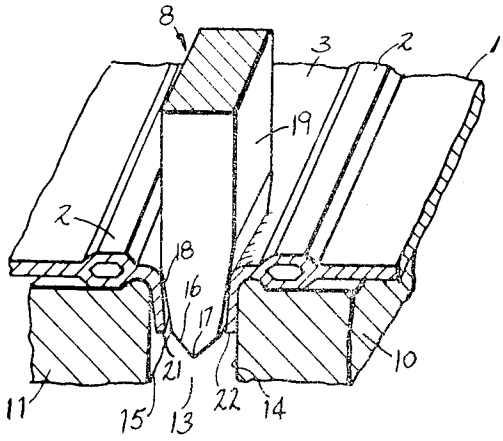


FIG - 4

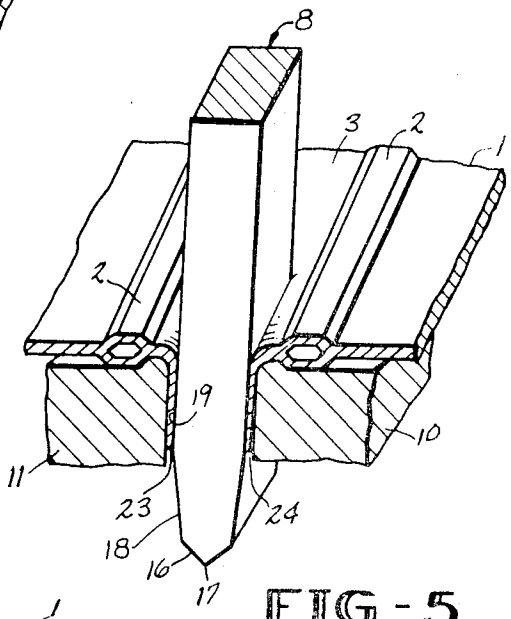


FIG - 5

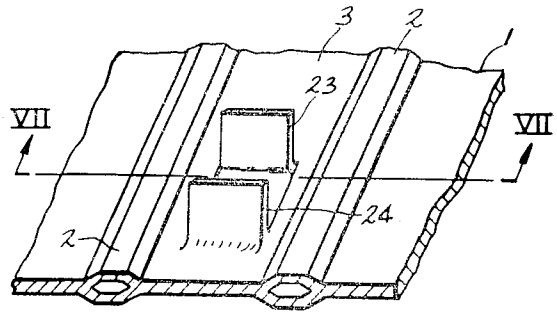


FIG - 6

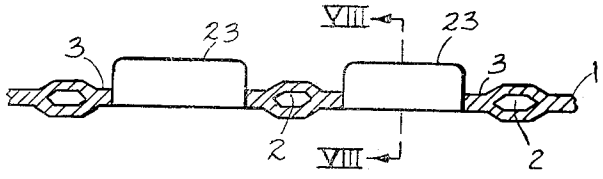


FIG - 7

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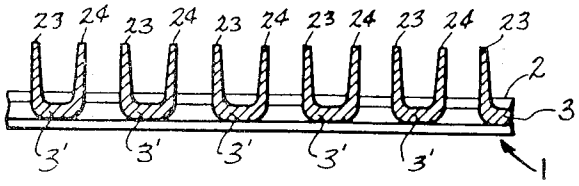


FIG - 8

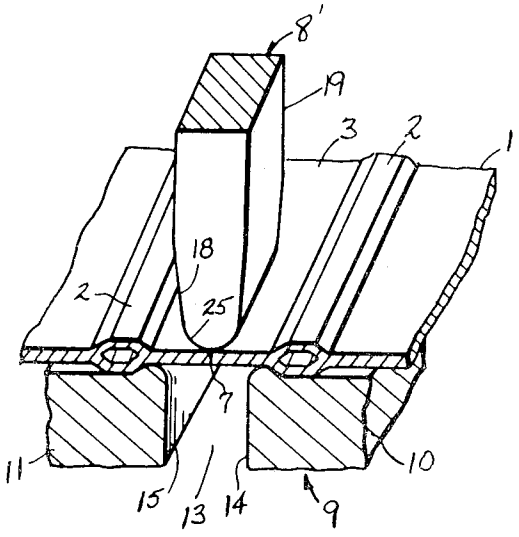


FIG - 9

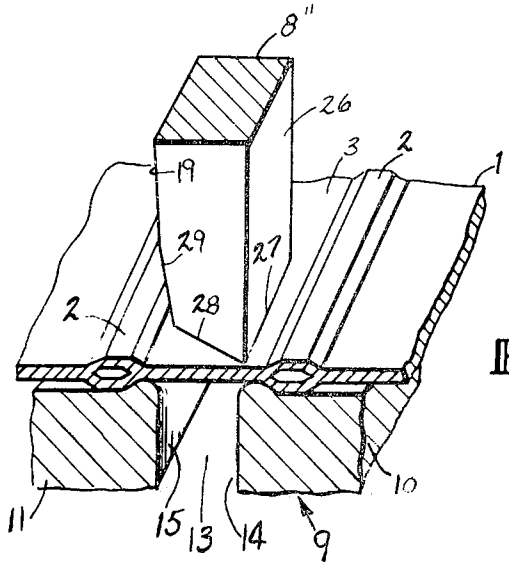


FIG - 10

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FINNED HEAT EXCHANGER

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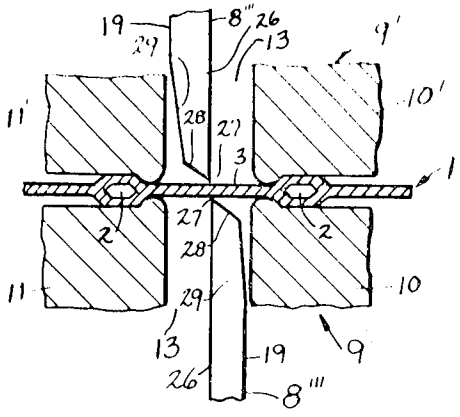


FIG - 11

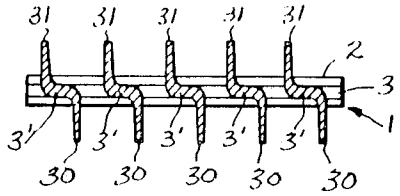


FIG - 12

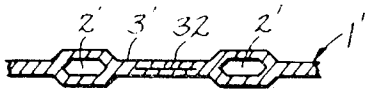


FIG - 13

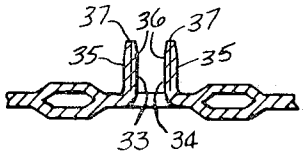


FIG - 14

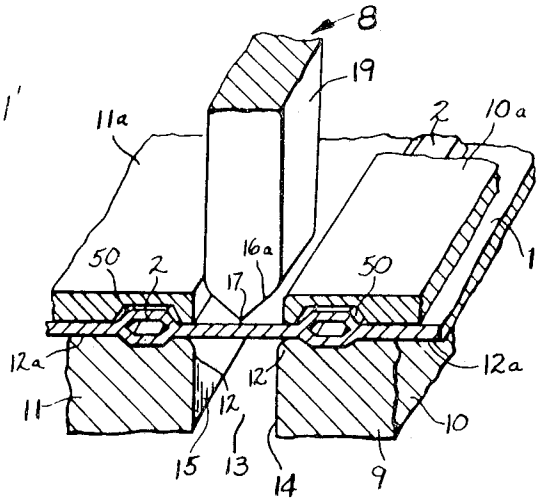


FIG - 1A

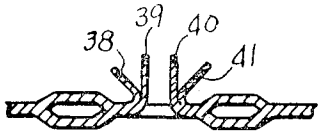


FIG - 15

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United States Patent Office

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3,229,766

FINNED HEAT EXCHANGER

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Original application Dec. 11, 1961, Ser. No. 158,612, now Patent No. 3,178,806, dated Apr. 20, 1965. Divided and this application May 22, 1963, Ser. No. 292,174

14 Claims. (Cl. 165—170)

This application is a division of copending application Serial No. 158,612, filed December 11, 1961, now U.S. Patent No. 3,178,806, issued April 20, 1965.

This invention relates to a hollow sheet metal article and more particularly to hollow articles, such as heat exchangers and the like, of sheet metal having integral fins extending externally therefrom.

In the manufacture of hollow articles such as refrigerator panels, condensers and the like, of sheet metal, it is desirable that such structures be provided with external fins for facilitating the transmission or dissipation of heat. Heretofore, such heat transfer fins were usually brazed or soldered on the structure posing a difficult manufacturing problem particularly where the article is a flat or oblong sheet metal thin walled tubing. This involves not only a complicated and time consuming operation, but in addition is an expensive procedure which frequently fails to result in a rigid and efficient joint between the elements. Such a procedure or operation is further complicated by the need for making good contact between the tube sheet and the fins for proper heat conduction as well as securely assembling the parts. Despite precautions taken for the efficiency and operation of the resultant product, the brazed or soldered joint is nevertheless of reduced heat exchange efficiency for lack of unimpeded heat transfer through the joint.

Accordingly, it is an object of this invention to provide novel finned heat exchangers eliminating disadvantages of the prior art. Another object of this invention is to provide a novel heat exchanger having an extended heat transfer surface.

Still another object of this invention is to provide novel thin walled relatively flat metal tube sheets having a plurality of integral fins projecting from an external surface of the tube sheet.

It is also an object of this invention to provide a simple, low-cost but improved heat exchanger.

A still further object of this invention is to provide a novel thin walled relatively flat sheet metal heat exchanger having a plurality of projecting integral fins and having improved heat transfer efficiency.

Other objects and advantages of this invention will become more apparent from the following description and drawings in which:

FIGURE 1 is a perspective view illustrating a portion of a heat exchanger construction from which the finished units of this invention may be fabricated;

FIGURE 1A is a perspective view illustrating a refined modification of the embodiment of this invention illustrated in FIGURE 1;

FIGURE 2 is a partial sectional view in perspective illustrating a sheet metal heat exchanger in conjunction with metal forming tools adapted for treating the illustrated heat exchanger in accordance with this invention;

FIGURE 3 is a partial sectional view in perspective illustrating an intermediate phase in the preparation of the heat exchanger of the present invention;

FIGURE 4 is a partial sectional view in perspective illustrating an intermediate phase in the preparation of the heat exchanger of the present invention subsequent to that shown in FIGURE 3;

FIGURE 5 is a partial sectional view in perspective illustrating an intermediate phase in the preparation of the heat exchanger of the present invention subsequent to that shown in FIGURE 4;

FIGURE 6 is a partial sectional view in perspective of a sheet metal heat exchanger of this invention;

FIGURE 7 is a cross-sectional view taken along lines VII—VII of FIGURE 6;

FIGURE 8 is a cross-sectional view taken along lines VIII—VIII of FIGURE 7;

FIGURE 9 is a partial sectional view in perspective illustrating another embodiment of this invention;

FIGURE 10 is a partial sectional view in perspective illustrating a still further embodiment of this invention;

FIGURE 11 is a sectional view in elevation of still another embodiment of this invention;

FIGURE 12 is a cross-sectional view in elevation of a finned sheet metal heat exchanger treated in accordance with the embodiment of FIGURE 11;

FIGURE 13 is a cross-sectional view of a sheet metal heat exchanger adapted for treatment in accordance with still another embodiment of this invention;

FIGURE 14 is a cross-sectional view of a sheet metal heat exchanger illustrating an intermediate phase in the treatment of the heat exchanger of FIGURE 13 in accordance with this invention; and

FIGURE 15 is a cross-sectional view in elevation of a sheet metal heat exchanger processed in accordance with the last said embodiment of this invention.

Referring to the drawings, a typical heat exchanger adapted for processing in accordance with this invention is indicated by the numeral 1, in FIGURE 1, and comprises a substantially solid sheet of metal having extending internally thereto a plurality of fluid passages or conduits 2 separated by substantially solid web sections 3 bounding tubes 2 so as to adapt them for containiment of a fluid. Briefly, one method for fabricating the heat exchanger 1 is disclosed in U.S. Letters Patent No. 2,690,002, granted to Grennel on September 28, 1954. This method, as fully disclosed in the aforesaid patent, comprises the application of a pattern of weld inhibiting or stop-weld material to a clean surface of a sheet of metal. A clean surface of a second sheet of metal is superimposed on the first said surface and the two sheets are secured together to prevent relative movement therebetween. Thereafter, the two sheets are welded together by hot rolling so that the adjacent areas of the sheets which are not separated by the stop-weld material become unified together. The hot rolling of the sheets results in reducing the thickness of the two sheets and elongating the resultant blank in a direction of rolling while the width of the resultant blank remains substantially the same as the initial width of the sheets. Following the hot rolling operation, the resultant blank is usually softened, as by annealing, to make it more pliable, and if desired it may then be cold rolled to the final gauge desired and again softened as by annealing. The stop-weld material results in the retention of an unwelded portion which extends internally within the interior of the blank between its outer surfaces. After softening the blank, the unjoined portion is expanded by injecting therein a fluid pressure of sufficient magnitude to permanently distend the blank in the areas of the unwelded portion to form the desired pattern of passageways. However, it is to be understood that other methods may also be employed in the manufacture of the sheet metal heat exchanger 1 illustrated in the drawings. For example, such a sheet metal heat exchanger may be made by the process disclosed in U.S. Letters Patent No. 2,779,086, granted to Rieppel et al. on January 29, 1957.

Broadly speaking, in accordance with one aspect of this invention, the heat exchanger **1**, of FIGURE 1, may be formed into a finned structure by application of an appropriate tool which exerts a force at an angle to the web section sufficient to pierce the metal in this web section while simultaneously striking and severing a tab-like portion in projection from the panel, followed by drawing this tab-like portion sufficiently to both thin it and to elongate it in a direction of its projection from the panel.

In accordance with another aspect of this invention the panel **1** may be fabricated into a fin structure by appropriately slitting the web section **3** to define a tab-like portion therein. For example, the slitting may take the shape of a C-shaped line of cut **4**, or the piercing may take the form of a plurality of cuts shown on panel **1** adjacent to the C-shaped cut **4** and which may comprise a pair of parallel cuts **5** and **6** and a perpendicular cut **7** between and interconnecting cuts **5** and **6** intermediate their ends. In any event, one or more tab-like portions **21** and **22** will be formed which may then be conveniently bent out of and into an angle with the panel. Thereafter, these projecting tab-like portions **21** and **22** may be drawn sufficiently to thin and elongate them in the direction of their projection from the panel, as best illustrated in FIGURES 3 and 4.

More specifically, the invention contemplates the accomplishment of the piercing and drawing operations on panel **1** by means of a punch **8** and a die **9**. As illustrated in FIGURE 2, the die **9** comprises two spaced die portions **10** and **11** on which panel **1** is placed with the spacing **13** defined between die surfaces **14** and **15** of these portions disposed below that portion of web section **3** which is to be pierced and drawn. As will be understood die portions **10** and **11** may coextend with the length of web section **3**, or die portions **10** and **11** may comprise a plurality of pairs with each pair being disposed relative to each other to provide a spacing immediately below corresponding portions of the web section to be pierced and drawn. Although not required each die portion **10** and **11** is provided with a shoulder **12** which abuts against the adjacent protrusion or bulges of adjacent passageways **2**.

Punch **8**, as illustrated in the drawings, is arranged in vertical alignment with space **13** between die portions **10** and **11** in cooperating relationship therewith. Although punch **8** may be manipulated manually, this punch is preferably adapted by conventional means for reciprocal movement toward and away from cooperating relationship with die portions **10** and **11**. Although various configurations for the punch may be employed and will be apparent in the art, the specific punch illustrated in the drawings comprises a beveled chisel-shaped forward end or nose portion **16** with a cutting edge **17**, a tapered working portion **18** having the desired slope necessary for drawing of the fins, and a body portion **19**. The dimension in width of the body portion **19**, of punch **8**, normal to die surfaces **14** and **15** is such that it will be spaced from each of die surfaces **14** and **15** an amount equal to the desired thickness of the ultimate fins desired. As shown in the drawing, the body portion **19** is extended to the forward or nose portion **16** by means of the tapered working portion **18** which is provided with sufficient slope to facilitate the desired extrusion of the desired fin elements. As regards the length or dimension of punch **8**, in its body portion **19**, in a direction parallel to die surfaces **14** and **15**, it may be made of any magnitude desired provided it extrudes the struck tab-like portion to the corresponding length of the fin element formed.

In operation, when the punch **8** is lowered, the cutting edge **17** of nose portion **16** forces the abutted portion of web section **3** downwardly into space **13** between die surfaces **14** and **15** until the nose portion bulges the abutted portion of the web section to a sufficient depth at which point the cutting edge **17**, of punch **8**, splits the abutted web section along a shear line **20** whereby a tab-like portion is struck and severed from the panel **1** to project downwardly therefrom. As the movement of punch **8** continues downwardly, its tapered portion **18** enters and extends through the opening formed by the severed portion of web section **3**. As tapered portion **18**, of punch **8**, continues in its travel through the web section **3**, it draws or "irons out" the tab-like portions **21** and **22** to thin and elongate them in the direction of their projection from panel **1** to the extended length desired. As a result of the travel of the punch **8** through the web section **3**, of panel **1**, the initially struck out and severed tab portions are formed into the desired fin elements **23** and **24** leaving a perforation or opening through the web section **3** from which the fin elements were formed. The resultant product is a novel finned heat exchanger element having a fin matrix which is partially severed from web section **3** being bent along a fold line in the web section so as to project out of and at an angle to panel **1** leaving a perforation in the web section. It will also be observed that this novel heat exchanger element is a finned structure whose dimension on a first line normal to the fold line, upon which it is bent, is greater than the dimension of the resultant perforation along a second line normal to the fold line of the fin elements with each of the lines taken along extensions which intersect each other at the fold lines.

Although the manufacture of a single pair of fin elements in conjunction with single perforations has been described, it will be readily apparent that a plurality of these pairs of fin elements may be provided. Such a multitude of fin elements may be provided by the use of a plurality of punches of the type **8** shown in the drawings, or the panel **1** may be advanced by any suitable means to progressively subject successive portions of web sections **3** to the action of punch **8**. In this regard, although the preceding portions of this application were directed to the formation of fins having their planes substantially parallel with the extensions of tube **3**, a similar panel is illustrated in FIGURE 6 which although obtained in accordance with the aforesaid embodiment, the structure of FIGURE 6 embodies a slight deviation in which the plane of fin elements **23** and **24** extends in a direction normal or transverse to the extension of tubular or fluid passages **2**. As indicated above, although the structure FIGURE 6 is shown with a single pair of fin elements **23** and **24** a plurality of these fin elements may be provided in aligned or in any desired dispersed relationship along web section **3**. Accordingly, presupposing provision of such a plurality of aligned pairs of fin elements **23** and **24**, FIGURE 7 illustrates such a modification of FIGURE 6 taken along the line VIII—VIII. As can be appreciated the formation of fins in accordance with this invention in substance takes portions of web section **3** of panel **1** and extrudes these portions into a construction having a plane intersecting the plane of panel **1**. As regards the formation in accordance with the specific embodiment described above, it can be seen that where a pair of fins are simultaneously formed they coextend with each other in spaced relationship. It will be apparent from the foregoing description that the method of this invention permits the fabrication of fins without need for extraneous or secondary elements requiring additional considerations for unifying them to the heat exchanger structure **1**. Thus, this invention increases the heat exchange services of heat exchanger **1** from the primary surface of the panel in which the thickness of the resultant fin structures is substantially less than the web section from which they were formed, as for example the web section **3'** between adjacent fin structures **23** and **24** as illustrated in FIGURE 8.

It is also noted that the specific embodiment has been described above in conjunction with the most basic elements required in the performance of this invention, and

this embodiment can be advantageously improved by various modifications and refinements, as for example those illustrated in FIGURE 1A. As shown therein the die portions **10** and **11** are provided with supporting surfaces **12***a* which serve as a backup for the web sections **3** of the panel. Also, in order to restrain distortion of the panel, during the formation of the fin structure, the web sections **3** of the panel are clamped against die portions **10** and **11** by means of corresponding rigid pressure pads **10'** and **11'** suitably recessed at **50** to receive and accommodate the tubular passages **2**. The instant embodiment also illustrates a modification in the configuration of punch **8** in which the beveled nose portion **16***a* extends directly to the body portion **19** which performs the desired drawing required in the formation of the fin structure.

Although a specific method for the manufacture of a simultaneous pair of fin elements has been described above, it is pointed out that, as indicated above, these pairs of finned structures may also be formed by a preliminary piercing or slitting of the web section **3** of panel **1** as indicated by cut **4** or cuts **5**, **6**, and **7**, provided in the web section of panel **1**, illustrated in FIGURE 1. This embodiment varies from the preceding embodiment described by the use of a punch **8'** having a rounded forward or nose portion **25** which is disposed so as to be directed against slit **7** of web section **3** when panel **1** is placed upon die portions **10** and **11**. As with the preceding embodiment movement of punch **8'** toward and between the die surfaces **14** and **15** bends the metal encompassed by lines **5**, **6**, and **7**, along fold lines, into projecting tab-like portions which are subsequently extruded by the tapered working portion **18** of punch **8'**.

A still further embodiment of this invention is illustrated in FIGURE 10 when the modification provides for the obtainment of a single tab-like, and the finally extruded fin element from portions of the web section **3** of panel **1**. In this embodiment, punch **8''** is provided with a substantially planar surface **26** which is adapted upon passage through panel **1** to move in very close proximity with die surface **14** of die portion **10**. This punch **8''** also distinguishes by its termination in a cutting edge **27** defined by the bevel **28** extending from the tapered working portion **29**. In this embodiment downward movement of punch **8''** cooperates with die portion **10** to sever or shear the portion of the web section **3** abutted by the cutting edge **27**, with the portion of the web section intermediate a tube or passage **2** and the line of severance struck outwardly by the bevel **28** whereafter is drawn by the tapered working portion **29** to bend and elongate the tab-portions in the direction of their projection out of panel **1** to form the desired finned structure.

FIGURE 11 illustrates a still further modification of this invention in which adjacent fins are caused to project in opposite directions from the face of the panel. In this embodiment the panel **1** is clamped between a pair of cooperating die assemblies **9** and **9'** having aligned openings **13** and **13'** adapted to receive the opposing acting punches **8'''** and **8'''**. These punches **8'''** are similar to the punch **8'** illustrated in FIGURE 10 but adapted upon cooperation with each other to have their planar surfaces **26** pass in close proximity to each other permitting these punches to function in a nature of shears in order to provide the intial line of severance in that portion of web section **3** from which the fin elements are to be constructed. As will be apparent, movement of the punches **8'''** toward each other through the respective openings **13** between the defining die portion projects and draws the resultant tab-like portion into the desired fin structures projecting from opposite sides of heat exchanger panel **1**. The resultant formed finned heat exchanger is illustrated in FIGURE 12, where, as can be seen, portions of the web section **3** are adjacent the line of severance provided by the cooperating punches **8'''** of FIGURE 1 are worked into adjacent fin structures which project from alternate sides of heat exchanger panel **1** and have a greatly reduced thickness relative to the original thickness of web section **3**, as for example illustrated by the portion **3'** of the web section between portions thereof utilized in the formation of the desired fin elements **30** and **31**. In such an embodiment the heat exchanger panel **1** is provided with a plurality of fin elements which successively project from alternate sides of the heat exchanger.

Although the preceding embodiments describe the attainment and provision of substantially solid fin elements on the heat exchanger, it is pointed out that the invention contemplates fabrication of fin structures from web sections of a heat exchanger containing an internal stratum of separation **32** disposed in spaced relationship to a system of fluid conduits. The attainment of such preliminary heat exchangers is known to the art and is illustrated in U.S. Letters Patent No. 2,991,047 granted to C. Bailys on July 4, 1961. The provision of such a stratum of separation **32** is readily amenable to the method described in the aforesaid Letters Patent No. 2,690,002, and can be obtained by the inclusion of a separate secondary pattern of separation material disposed between the superimposed sheets in spaced relationship to the primary pattern which defines the desired fluid conduit system. This secondary pattern is arranged in portions between the superimposed sheets which, after pressure welding, form the web section bounding the desired fluid conduit system and which portions of the web section are utilized in forming the fin elements in accordance with this invention. The formation of fin elements from heat exchanger panel **1'**, illustrated in FIGURE 13, may be obtained in acordance with any of the preceding embodiments of this invention discussed above. For example, where panel **1'** is provided with fin elements in accordance with the first decribed embodiment of this invention, the resultant drawn fin elements **33** and **34** are characterized by a plurality of plies **35** and **36** formed by the subdivision of the preliminary fin elements along a line of separation **37**. In this embodiment, the provision of a plurality of plies in the preliminary fin elements, drawn and formed from the web section, permits the further subdivision of the preliminary fin elements **33** and **34** into a plurality of sub fin structures **38** and **39**, obtained from preliminary fin **33**, and sub fin structures **40** and **41**, obtained from preliminary fin structure **34**. As will be apparent this embodiment permits a substantially greater increase in the heat exchange surface area of the heat exchanger.

It is to be understood that while two sub fins are shown in this embodiment, each preliminary fin portion can remain whole or be subdivided into any number of individual fins desired merely by the inclusion of a plurality of superposed layers of weld inhibiting material between a plurality of superimposed sheets of metal in the fabrication of a heat exchanger in accordance with the prior art methods discussed above, as for example, by the method of the aforesaid U.S. Letters Patent No. 2,690,002. Accordingly, by any desired variation in the number of layers of stop-weld material interposed between a plurality of superimposed sheets, the preliminary fin elements can be subdivided into corresponding numbers. Thus, such variation may provide three or any greater number of sub fins which the specific application of the heat exchanger calls for. In addition, it is also to be understood that the heat exchanger panel may be of any varied modification either in the intial thickness of the web section **3**, as for example in accordance with the method disclosed in the copending application of T. F. Pauls, Serial No. 663,062, filed June 3, 1957, now U.S. Patent No. 2,999,308 granted September 12, 1961, or of any tubular configuration such as is disclosed in the aforesaid U.S. Letters Patent No. 2,991,047.

In addition, although a simple internally laminated panel has been described, it is to be understood that the invention is equally applicable to sheets having other

patterns of internal laminations either in a single stratum or a plurality of stratums, or in other configurations, as for example, the panel disclosed in the patent to Adams, U.S. 2,776,514, granted on October 16, 1956.

Accordingly, 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.

What is claimed is:

1. A heat exchange element comprising a metal sheet structure having extending internally therein a fluid conduit system bounded by a web section of said sheet and a fin matrix extending from said sheet, said fin matrix comprising a fin element integral with said web section and projecting out of and at an angle to the plane of said sheet forming a perforation through said sheet, said fin element having a length greater than the corresponding length of said perforation.

2. The heat exchanger element of claim 1 wherein said fin matrix comprises at least two of said fin elements disposed with each of said elements in spaced portions of said web section.

3. The heat exchange element of claim 2 wherein each of said fin elements comprises two plies of said web section separated at an angle with each other.

4. The heat exchanger of claim 2 wherein said fin matrix comprises a plurality of said fin elements disposed in parallel relationship with each other.

5. The heat exchanger of claim 4 wherein a first portion of said fin elements are aligned in a first direction.

6. The heat exchanger of claim 5 wherein a second portion of said fin elements are aligned in a second direction normal to said first direction.

7. The heat exchanger of claim 6 wherein said second portion includes one of said fin elements of said first portion.

8. A heat exchange element comprising a metal sheet having extending internally therein a fluid conduit system bound by web sections of said sheet and a fin matrix extending from said sheet, said fin matrix comprising a pair of adjacent and spaced fin elements integral with said web section and projecting out of and at an angle with the plane of said sheet forming a perforation through said sheet, the sum of the lengths of said elements being greater than the total length of said perforation.

9. The heat exchanger of claim 8 wherein said fin matrix comprises at least two of said pairs of fin elements with each of said pairs of fin elements disposed in spaced portions of said web section.

10. The heat exchange element of claim 9 wherein each of said fin elements comprises two plies of said web section separated at an angle with each other.

11. The heat exchanger of claim 9 wherein said fin matrix comprises a plurality of said fin elements disposed in parallel relationship with each other.

12. The heat exchanger of claim 11 wherein a first portion of said fin elements are aligned in a first direction.

13. The heat exchanger of claim 12 wherein a second portion of said fin elements are aligned in a second direction normal to said first direction.

14. The heat exchanger of claim 13 wherein said second portion includes one of said fin elements of said first portion.

References Cited by the Examiner

UNITED STATES PATENTS

2,375,334	5/1945	Valyi et al.	29—157.3
2,856,162	10/1958	Adams	165—125
3,012,758	12/1961	Lyon	165—166
3,046,758	7/1962	Heuer et al.	29—157.3
3,104,701	9/1963	Jacoby	29—157.3
3,121,940	2/1964	Cospen	29—157.3

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