May 16, 1967 G. A. ANDERSON 3,319,322

METHOD OF MAKING A FINNED HEAT EXCHANGE PANEL

Filed June 3, 1964 2 Sheets-Sheet 1

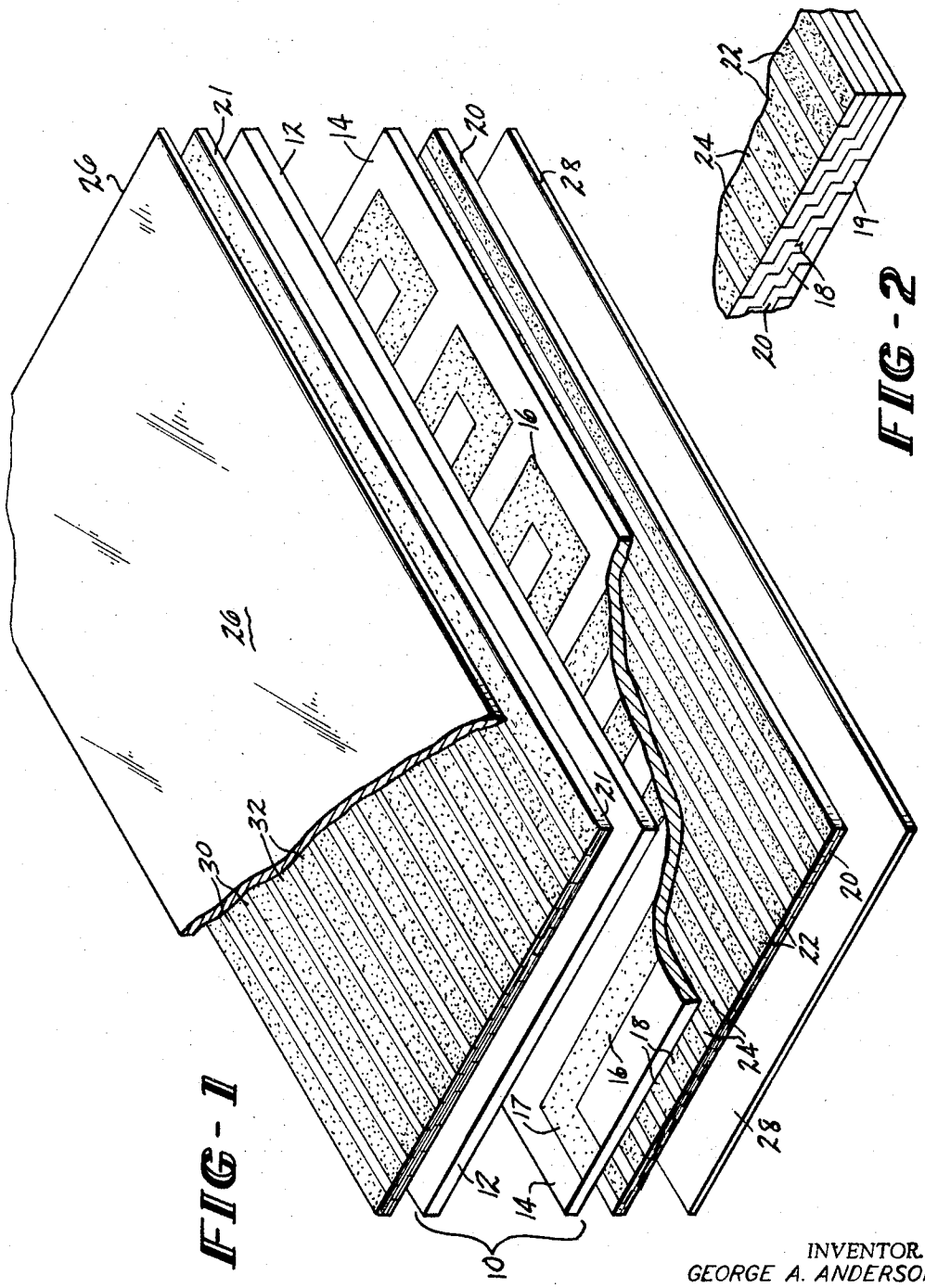


FIG - 1

FIG - 2

INVENTOR.
GEORGE A. ANDERSON

BY Robert H. Backman

ATTORNEY

May 16, 1967 G. A. ANDERSON 3,319,322

METHOD OF MAKING A FINNED HEAT EXCHANGE PANEL

Filed June 3, 1964 2 Sheets-Sheet 2

FIG-3

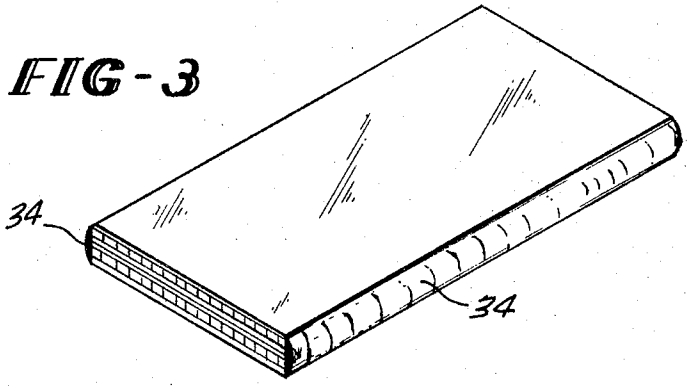


FIG-4

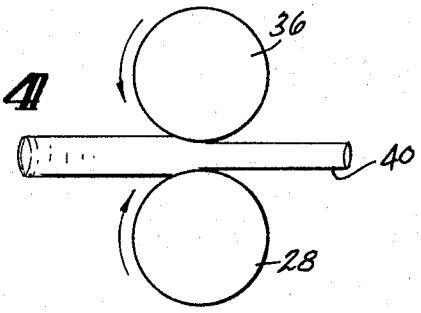


FIG-5

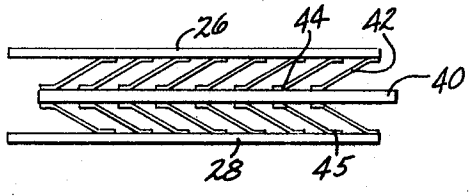
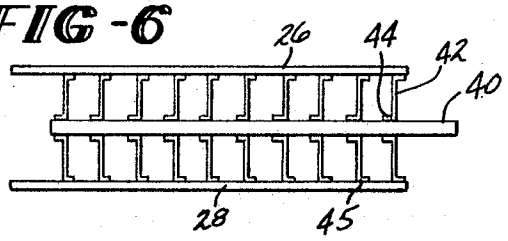


FIG-6



INVENTOR.
GEORGE A. ANDERSON

BY Robert H. Backman

ATTORNEY

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METHOD OF MAKING A FINNED HEAT EXCHANGE PANEL

George A. Anderson, Northford, Conn., assignor to Olin Mathieson Chemical Corporation, a corporation of Virginia

Filed June 3, 1964, Ser. No. 372,246
5 Claims. (Cl. 29—157.3)

This invention relates generally to the manufacture of finned heat exchange devices and other finned metal articles. More particularly, the invention relates to a novel method of forming fins on sheet metal, or on a composite metal article, in which the fins and composite article are forge welded into a unitary element in a single continuous or non-continuous operation.

As is well known in the art, finned heat transfer or heat exchange devices, either with or without internal hollow passageways for containment of a heat transfer medium, find a wide variety of applications in the general field of heat exchange, transfer, or conduction. For example, such articles are frequently employed as radiator panels for internal combustion engines in which a finned panel is utilized to increase the heat distribution contact surface to a cooling medium passing thereover, usually air. Similarly, these articles find application as radiant heaters for home use in which a heating core is confined within a hollow internal passageway and heat is distributed by means of integral fin contact surface. Also, in the fields of refrigeration and air conditioning condensers and forced air evaporators, a demand exists for a wide variety of finned heat exchange devices combined with internal passageway systems to accommodate flow of a heat transfer medium to facilitate exchange of heat from the one medium to a second external heat dissipating medium.

There have been numerous attempts made to produce a finned heat transfer or heat exchange article which is suitable for the above exemplary uses as well as others. In the search for a suitable way of manufacturing these articles, three major obstacles have been encountered. One of these is the problem of providing a satisfactory way of attaching the fins to the heat transfer panel with sufficient strength and rigidity that the fins will withstand at least the normal handling and wear and tear to which the article may be subjected. Another is the problem of achieving a suitable intimacy of contact between the adjacent surfaces of the fin and panel where these surfaces are coincident in order to achieve maximum efficiency of heat transfer from the panel to the fin. Still another problem is that of the cost involved in the often complicated and numerous steps involved in the more conventional procedures for making finned heat exchangers which usually require the association together of a great many individual components to fabricate the finished article.

These problems, as well as others not herein specifically mentioned, are overcome to a surprising extent by the process of the present invention which produces a finned heat exchange article possessing the advantages of practically and functionality obtained by similar prior art devices and yet does not suffer the disadvantages and difficulties mentioned above, thereby achieving a degree of efficiency and economy far exceeding many comparable prior art devices. To this end the method of this invention comprises in one of its broadest aspects the formation by more or less conventional means of a multiple sheet composite having a patterned layer of weld preventing material sandwiched therebetween, the formation by any of a variety of means more fully described hereinafter of a layer of collapsed or embryonic fin elements which have been separated by stop weld material

and preferably coated on both sides therewith, except for a narrow border strip where the fin is to be bonded to the composite panel, and which have been stepped at specific intervals across the width thereof so as to nest when stacked on the panel. The layer of embryonic fin elements is superposed on one or both sides of the composite and the entire assemblage or blank is then forge welded as by hot rolling to form an integrated unitary structure with the composite sheets being welded to one another except in the areas of the pattern of stop weld material, and with the layer of collapsed fin stock elements being integrally joined to the surface of the composite in the areas of the edge strips which are free of stop weld material. The now unified composite or panel blank is expanded by injecting fluid under pressure into the unjoined areas between the sheets of the composite to inflate and expand these areas thereby forming internal hollow passageways suitable for passage therethrough of a fluid heat transfer medium.

Subsequently thereto the unjoined stacked fin stock elements are lifted in a variety of ways more fully described below to form errect or outstanding fins which assume a position substantially perpendicular to the plane of the panel and which are integrally unified therewith.

Having thus described in general terms a preferred manner of the practice of this invention, it becomes a principal object thereof to provide a method of making a finned heat exchange panel which obviates or eliminates many of the problems associated with prior art manufacture of similar devices.

It is another object of the present invention to provide a method of making a finned heat exchange article in which both the integration of a heat conducting or transfer medium panel or core, and the integration of fins to this panel or core are carried out simultaneously.

It is still another object of the present invention to provide a method of making a finned heat exchanger in which a layer of preformed and prenested fin elements are disposed as a unit on a heat exchange panel or core and integrated thereto simultaneously with integration of the panel or core.

It is a still further object of the present invention to provide a method of making a finned heat exchange article having integrally unified means for both further increasing heat dissipating surface and conveniently raising all of the fins on a given panel simultaneously, with the integration of this latter means occurring simultaneously with that of the rest of the article.

It is yet another object of the present invention to provide a method of making a finned heat exchange device which facilitates the manufacture of the device on a continuous production basis.

It is another object of the present invention to provide a method of making a finned heat exchange article which is highly efficient in operation, easy to initiate and maintain, and economical in operation.

These and other objects and advantages of the present invention will in part become apparent, and in part be pointed out, in the following detailed description of the invention particularly when considered in conjunction with the accompanying drawings in which:

FIGURE 1 is a fragmentary, exploded view in perspective of the components necessary to form one example of a sheet metal composite;

FIGURE 2 is a fragmentary perspective view on an enlarged scale of the stacking arrangement of the flattened fin elements, and illustrating the application of stop weld material;

FIGURE 3 is a view in perspective of the assembled composite of the elements of FIGURE 1 indicating the rolling direction relative to the association of the components;

FIGURE 4 is a side view of the assembled composite during the rolling operation;

FIGURE 5 is a side view showing the unified composite illustrating the fin elements at a stage of partial raising; and

FIGURE 6 is a view similar to FIGURE 5 showing the fins fully raised.

Referring now to the drawings, it will be seen that one manner of practicing the instant invention comprises firstly the formation of a composite sheet metal-stop weld material sandwich **10** such as that illustrated in exploded form in FIGURE 1. More particularly, it is seen that two sheets of metal **12** and **14**, such as aluminum, copper, or alloys of these and other metals suitable for pressure welding, are positioned together, with at least one of the sheets having a pattern of stop weld material **16** applied to the confronting face of the sheet. The stop weld material may be applied in any desirable pattern to suit the needs and requirements of the particular application or use intended for the finished article and is generally applied in the conventional continuous pattern. The pattern will extend to an edge of the sheet composite in at least one location such as **17** to facilitate later fluid pressure inflation as more fully explained hereinbelow. Alternatively, the pattern may be found at the edge by shearing, if necessary, in accordance with standard practice. Also, the stop weld material may be applied in any suitable manner well known in the art such as, for example, by squeezing through a silk screen, painting through a stencil, or spraying through masking die. It should be pointed out that prior to the application of the stop weld material, the sheets **12** and **14** are thoroughly cleaned by degreasing and/or wire brushing, and otherwise prepared for subsematerial, however, is that it possesses a high thermal conventional practice.

Sheets **12** and **14** are positioned adjacent one another with the pattern of stop weld material interposed therebetween. The composite may then, if desired, be secured together in any suitable manner such as by clamping, tack welding, spot welding, etc., to prevent relative slippage between the sheets.

A sheet of suitable fin stock, is severed by any desirable means into a plurality elongate but relatively narrow rectangular fin elements as indicated by the reference numeral **18** in FIGURE 2. These elements are stepped, for example, in the manner illustrated in FIGURE 2 so that when they are stocked one upon another in overlapped fashion, they form a completely rectangular smooth sided and nested stack **20** in which each fin element **18** constitutes a distinct layer whose end or edge portions **19** extend beyond the corresponding end or edge portions of adjacent layers, with the stack at any given point comprising a plurality of such layers. The method described for making the nest of fins is preferred, but of course there are other methods which may be employed. The fin stock material may be formed of the same metal or alloy as that of the sheets **12** and **14** of the composite, or of any alloy compatible therewith and suitable for pressure welding operations. An essential characteristic of the fin stock material, however, is that is possesses a high thermal conductivity.

Before being formed into the stack **20** in nested fashion, each fin element **18** is coated on both sides thereof with a layer of stop weld material indicated in FIGURES 1 and 2 by the numeral **22**. The stop weld material is applied to the entirety of both surfaces of the fin elements except for a relatively narrow strip **24** adjacent a longitudinal edge of the fin element on either one or both outer surfaces thereof where the fin element is to bond either to the composite **10** or to an additional cover sheet as more fully described below. It will be apparent that the strip **24** free of stop weld material may be achieved either by initially coating the entire surface of each element **18** prior to stacking, and then removing the stop weld material in the areas of the strips **24**, or by initially applying the stop weld material to each fin element **18** in such manner as to leave the strip **24** free of stop weld material, after which the elements are nested and formed into the stack **20**.

In either event, the stack **20** is associated with the composite **10** with that side of the stack having the stop weld free strips **24** adjacent the sheet **12** or **14** depending upon which side of the composite **10** the fins are to be applied. It should be noted at this point that there are a number of ways of assembling the various components depending upon the particular type of ultimate finned article desired. For example, if it is desired to have an article composed simply of a composite with outstanding fins on one side only, then but a single stack **20** of fin elements is associated with the composite **10** of FIGURE 1, with the stack and composite associated as described above. On the other hand, if it is desired to have fins outstanding from both sides of the composite, then similar stacks **20** and **21** of fin elements are applied to both sides of the composite, each with that side of the stack having the stop would weld material free strips **24** adjacent the outer surface of the composite **10**. It will be observed from FIGURE 1 that there are stacks **20** and **21** of fin elements positioned adjacent both sides of the composite **10** and it is to be understood that each stack has its stop weld material free strip side in contact with the sheet **12** or **14** of composite **10**.

It will also be apparent from FIGURES 1 and 6 that the heat exchange device produced by the method of this invention can be provided with an outer cover sheet bonded to the ends of the fins remote from the composite panel **10** on either one or both sides thereof. Referring to FIGURE 1, this is accomplished by disposing a pair of cover sheets **26** and **28** on the exposed surface of fin element stacks **21** and **20** respectively. It is to be understood that where the outer cover sheets are employed, it is necessary to apply the stop weld material to the outer surfaces of the fin element stacks **20** and **21** in the same manner as it was applied to the inner surfaces thereof that are in contact with the sheets **12** and **14** of the composite **10**, that is, there are bands or strips **30** which are free of stop weld material adjacent a longitudinal edge of each fin, while the remaining exposed portion of the fin is coated with stop weld material as indicated by the strips **32** on the outer surface of fin element stack **21**. It will be understood that a similar pattern of stop weld material and stop weld free strips is present on the outwardly facing surface of the fin element stack **20** against which the cover sheet **28** is disposed.

If it is desired not to have the cover sheets bonded to the outer ends of the fins in the finished article, then the outer surfaces of the fin element stacks **20** and **21** would be completely coated with stop weld material.

It will therefore be apparent that the principles of this invention are equally applicable to the disposition of fin element stacks on one or both surfaces of the composite **10** thereby resulting in either a single or double surface finned heat exchanger, and they are equally applicable to the incorporation or elimination of cover sheets over the fin element stacks.

After the various components of the heat exchanger assemblage or blank have been associated together, the number of components depending upon the nature of the desired article as explained above, they are secured together by suitable means, for example, by welding along the longitudinal edges as illustrated at **34** in FIGURE 3. The blank is then heated to the required temperature conventional for pressure welding and appropriate for the particular alloy being utilized, after which the blank is formed into an integral unitary structure such as by pressure rolling as illustrated in FIGURE 4 by being placed between pressure rolls **36** and **38**, which weld the several components together except in the areas covered by stop weld material. More specifically, the sheets **12** and **14** forming the composite **10** are integrally welded together except in the areas covered by pattern **16** of stop weld material.

In addition, the stacks **20** and **21** of fin elements are integrally welded to the outer surfaces of sheets **14** and **12**, respectively, in the areas or strips **24** which are free of stop weld material. Finally, if cover sheets **26** and **28** are employed to provide outer sheets bonded to the outer ends of the fins in the finished article, these sheets are integrally bonded to the stacks **21** and **20** respectively in the areas of the stop weld material free strips **30** disposed on the outer surfaces of the fin element stacks.

Subsequent to the rolling and welding operation, the unified panel may be annealed or otherwise heat treated to develop desirable metallurgical characteristics. In addition, cold rolling may take place for size (length) control. The unified panel is then inflated by conventional practice, which generally comprises inserting a nozzle or inflation needle into that portion of the stop weld pattern indicated as **17** in FIGURE 1 which extends to the edge of the sheet **14** on which is found at the edge of the sheet by shearing. A fluid under appropriate pressure is injected through the nozzle to inflate the sheets **12** and **14** in the areas where they are not joined together as a result of the pattern of stop weld material **16**, thereby forming a plurality of internal passageways corresponding in configuration to the pattern **16** of stop weld material.

Subsequent to the inflation operation to form the internal passageways, the unified fins **18** are raised to an erect or vertical position by a number of different procedures. Firstly, in the absence of bonding to any cover sheets **26** and **28**, an air blast is directed against the fins from a suitable nozzle or nozzles disposed above the fins and at an angle to the plane of the integrated structure. This results in a panel in which the unified composite **40** has attached thereto individual fins **42** which are connected to the panel **40** along portions **44** which formerly constituted the uncoated strips **24** of the end portions **19**, all as seen in FIGURE 6.

In an alternative structure, if the cover sheets **26** and **28** are included in the integrated blank, and are bonded to the layer or layers **21** and **20**, respectively, along the outer most uncoated strips **30**, the fins **44** may be raised by injecting a fluid under pressure into the spaces between a layer of fin stock and its corresponding cover sheet **26** and **28**. Still another way of raising the fins with a bonded cover sheet is by gripping the cover sheet from the outside and raising it, such as by means of suction, mechanical gripping means, or the application of a magnetic force if the cover sheet is of a suitable metal, as seen in FIGURES 5 and 6. This raising is effected by oppositely directed outward movement of the cover sheets **26** and **28** as well as lateral movement relative to the composite **40**. Movement of the cover sheets with corresponding raising of the fins is continued until the fins are in substantially perpendicular relationship to the panel **40** as illustrated in FIGURE 6. It is readily seen that this results in a finned heat exchange panel having integrally unified spaced apart cover sheets **26** and **28** secured to the fins **42** in the same manner at **45** as that by which the fins are secured to the panel at **44**. It should be noted that in the practice of this invention in which the cover sheets **26** and **28** are utilized, the integrated but unexpanded structure can be shipped, stacked, and worked with the fins in a collapsed condition. The fins would then be lifted prior to assembly in its intended application. It should also be noted that the fins, if desired, can be raised by any of the abovementioned procedures prior to inflation of the internal tubular passageways formed between sheets **12** and **14** forming the composite.

In addition to the foregoing embodiments of the method of this invention, the nature of the article produced is such that it is readily susceptible to being produced on a continuous production line basis. In this procedure there is involved firstly the continuous formation by conventional practice of the unified composite in strips of indefinite length by providing two supplies of composite stock suitably disposed to be continuously fed or passed through a device for applying a plurality of weld preventing material patterns to the confronting face of at least one of the strips. The strips are thereafter associated together, temporarily secured together such as by tack welding or punching, and then severed into lengths convenient for subsequent handling which lengths may be determined by the length of a single weld preventing material pattern. Simultaneously a suitable supply fin stock material is continuously passed between a pair of forming rolls which impart a plurality of the necessary stepped configurations across the width of the strip, the number of such configurations depending upon the number of fins to be obtained from a single piece of the fin stock. The formed fin stock is then passed through a suitable weld preventing material coating apparatus which applies the weld preventing material in the alternate bands and uncoated strips as described hereinabove. The fin stock is then passed through a suitable drying oven and a slitting mechanism which longitudinally severs the fin stock along appropriate lines to divide the fin stock into strips of individual fins which now have the weld preventing material applied to both sides thereof except for the uncoated strips disposed adjacent to one or both longitudinal edges as desired. These strips are then sheared or otherwise severed laterally to a length corresponding to the length or width of the aforementioned composite depending on whether it is desired to dispose the fins perpendicular or parallel to the direction of subsequent pressure rolling.

The individual fins and composites are conveyed to a stacking station at which the fins are stacked as illustrated in FIGURE 2 by any suitable means and the stack or layer is placed upon the composite with the uncoated strips in contact therewith. A cover sheet is then placed upon the layer of fins, and the entire assembly then welded or otherwise suitably secured together to prevent relative movement between the various components. If it is desired to provide fins, with or without cover sheets, on both sides of the composite, the assembly is inverted and another stack or layer of fins is disposed on the opposite side of the composite, and this assemblage is suitably welded or otherwise temporarily secured together to prevent relative movement.

The now completed panel blanks are continuously passed into a suitable heating furnace and thereafter pressure welded in conventional manner to integrate or weld all of the components together except in those areas previously coated with the weld preventing material. Subsequent to pressure welding, the weld preventing material pattern interposed between the sheets of the composite is expanded by the injection thereinto of a fluid under pressure to provide the internal hollow passageways, after which, or prior thereto if desired, the fins are raised by any of the aforementioned procedures. It will therefore be apparent that the various aforementioned modifications of the method of this invention may be suitably employed on a continuous production line basis to facilitate rapid and efficient mass production of the various heat exchange panels.

It will be apparent from the foregoing description and accompaning drawings that there has been provided a method of making a finned heat exchange panel which provides solutions to the foregoing problems and achieves the aforementioned objects. It is to be 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, but rather is intended to encompass all such modifications as fall within the spirit and scope of the invention as set forth in the appended claims.

In addition, the present process allows bonding of thin, e.g., down to 0.005 inch, height fins at close spacing, e.g., down to 0.062 inch. Previous processes made thicker fins, had wider spacing limits, and/or necessitated variable height fins across the same heat exchanger panel.

What I claim and desire to secure by Letters Patent is:

1. The method of making a finned heat exchange panel comprising the steps of

(A) forming a composite of a pair of sheets of metal, one of said sheets having on a confronting surface thereof a pattern of weld preventing material,

(B) forming from metal sheet fin stock a substantially flat stack of a plurality of overlapped and stepped layers with oppositely facing end portions of each layer extending beyond the ends of adjacent layers, said layers being coated with weld preventing material on both sides thereof except for a relatively narrow uncoated strip adjacent at least one longitudinal edge of said layers on the outer surface thereof, said uncoated strip being disposed on at least one of said oppositely facing end portion,

(C) forming a blank by superposing said stack on said composite with said uncoated strips of said layers in contact with said composite,

(D) forming an integrated unitary structure by pressure welding said sheets of said composite together except in the area of said pattern of weld preventing material and simultaneously pressure welding said stack to said composite in the areas of said uncoated strips,

(E) inflating the unjoined portions of said composite by injecting thereinto a fluid under pressure thereby forming interior hollow passageways, and

(F) raising the unjoined portions of said layers thereby providing integral erect fins overlying said hollow passageways.

2. The method of making a finned heat exchange panel comprising the steps of

(A) forming a composite of a pair of sheets of metal, one of said sheets having on a confronting surface thereof a pattern of weld preventing material,

(B) forming from metal sheet fin stock a substantially flat stack of a plurality of overlapped and stepped layers with oppositely facing end portions of each layer extending beyond the ends of adjacent layers, said layers being coated with weld preventing material on both sides thereof except for a relatively narrow uncoated strip adjacent both longitudinal edges of said layers on the outer surfaces thereof, said unicoated strips being disposed on said oppositely facing end portions,

(C) superposing said stack on said composite with one set of end portions in contact with said composite,

(D) forming a blank by superposing another sheet of metal on said stack and in contact with the other set of end portions of said stack,

(E) forming an integrated unitary structure by pressure welding said sheets of said composite together except in the area of said pattern of weld preventing material and simultaneously pressure welding said stack to said composite and said other sheet to said stack in the areas of said uncoated strips of said sets of end portions,

(F) inflating the unjoined portions of said composite by injecting thereinto a fluid under pressure thereby forming interior hollow passageways, and

(G) raising the unjoined portions of said layers of said stack thereby providing integral erect fins overlying said hollow passageways and disposing said other sheet in substantially parallel spaced relationship with said composite.

3. The method as set forth in claim 2 wherein said raising of said layers of said stacks is accomplished by effecting a relatively outward and lateral movement between each of said outer sheets and said composite.

4. The method of making a finned heat exchange panel comprising the steps of

(A) forming a composite of a pair of sheets of metal, one of said sheets having on a confronting surface thereof a pattern of weld preventing material,

(B) forming from metal sheet fin stock a pair of substantially flat stacks of a plurality of overlapped and stepped layers with oppositely facing end portions of each layer extending beyond the ends of adjacent layers, said layers being coated with weld preventing material on both sides thereof except for a relatively narrow uncoated strip adjacent both longitudinal edges of said layers on the outer surfaces thereof, said uncoated strips being disposed on said oppositely facing end portions,

(C) superposing said stacks on opposite sides of said composite with one set of end portions in contact with said composite,

(D) forming a blank by superposing another sheet of metal on each of said stacks and in contact with the other set of end portions of said stack,

(E) forming an integrated unitary structure by pressure welding said sheets of said composite together except in the area of said pattern of weld preventing material and simultaneously pressure welding said stacks to said composite and said other sheets to said stacks in the areas of said uncoated strips of said sets of end portions,

(F) inflating the unjoined portions of said composite by injecting thereinto a fluid under pressure thereby forming interior hollow passageways, and

(G) raising the unjoined portions of said layers of said stacks thereby providing integral erect fins disposed on opposite sides of said composite and overlying said hollow passageways and disposing said other sheets in parallel spaced relationship with said composite.

5. The method as set forth in claim 4 wherein said raising of said layers of said stacks is accomplished by effecting relative outward and lateral movement between each of said other sheets and said composite.

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JOHN F. CAMPBELL, *Primary Examiner.*

P. M. COHEN, H. D. HOBART, *Assistant Examiners.*

UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,319,322 May 16, 1967

George A. Anderson

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 3, lines 33 to 35, strike out "subse- material, however, is that it possesses a high thermal conventional practice" and insert instead -- subsequent roll forging operations all in accordance with conventional practice --; column 4, line 20, strike out "would"; column 7, line 45, for "unicoated" read -- uncoated --.

Signed and sealed this 12th day of November 1968.

(SEAL)
Attest:

Edward M. Fletcher, Jr.
Attesting Officer

EDWARD J. BRENNER
Commissioner of Patents