Oct. 29, 1963 R. M. NEEL 3,108,361

FABRICATION OF HOLLOW ARTICLES

Filed March 20, 1956

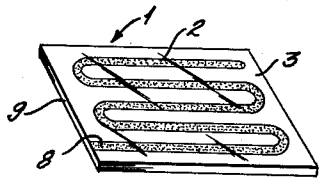


FIG.1.

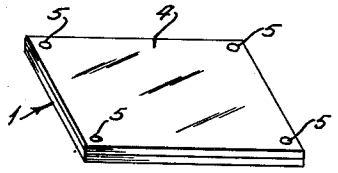


FIG.2.

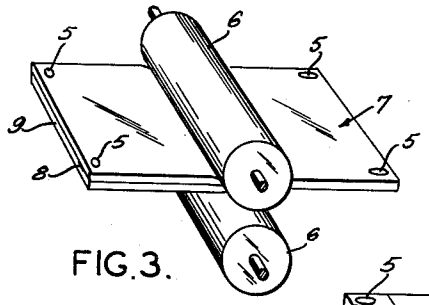


FIG.3.

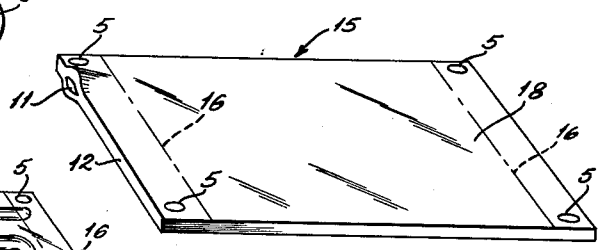


FIG.5.

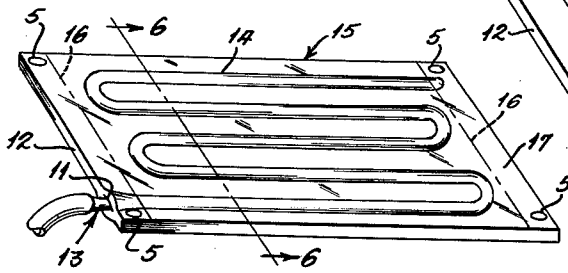


FIG.4.

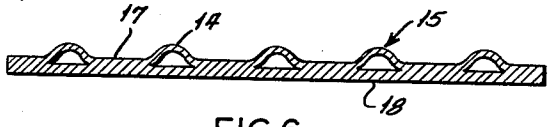


FIG.6.

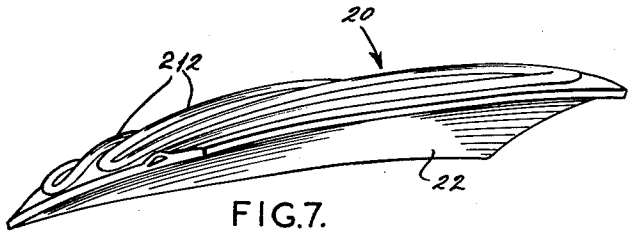


FIG.7.

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FABRICATION OF HOLLOW ARTICLES

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This invention relates to the fabrication of hollow articles and more specifically to the fabrication of hollow articles which are smooth on one side.

In the fabrication of hollow sheet metal panels by a well known process two sheets of metal are arranged in stack-like fashion with a design of weld-inhibiting material applied to a portion of one of the adjacent faces of the sheets. The sheets are then welded together in their adjacent areas not separated by the weld-inhibiting material by any suitable manner such as hot rolling. As the sheets are being welded together by hot rolling they are elongated in the direction of rolling and therefore the design of weld-inhibiting material must be foreshortened in the intended direction of rolling when it is applied to the sheet. After the sheets are welded together they are usually softened as by annealing and the unjoined portion to which the weld-inhibiting material has been applied is outwardly expanded as by injecting therein a fluid pressure of sufficient magnitude to permanently distend the sheets in the area adjacent to the weld-inhibiting design. The weld-inhibiting design may assume any desired configuration, for example, a design which will define, after expansion of the panel, a fluid conveying circuit of the type required in refrigerator heat exchanger panels. The aforementioned process is fully described in the patent to Grenell, U.S. 2,690,002 issued September 28, 1954. The teaching of this patent requires the use of dies in fabricating flat sided panels.

This invention comprehends fabricating a laminated sheet metal panel from sheets having differentiable elastic properties and, if necessary, adequately differentiating the elastic properties and expanding the panel at a pressure between the elastic limit and ultimate rupture strength of one of the sheets, and below the elastic limit of the other sheet.

As used herein the term "smooth" means a surface devoid of depressions or protrusions in the overall general configuration of the surface. The term "elastic limit" refers to the maximum stress that a material will withstand without permanent deformation.

It is, therefore, an object of this invention to fabricate a hollow panel in which one side is smooth and the other side is distended.

Another object of this invention is to fabricate a panel having formed therein a hollow portion, such as fluid carrying conduits defined by a smooth surface and an opposite surface having protrusions conforming to the distentions of the hollow portion.

Another object of this invention is to provide a method of fabricating panels of the general type disclosed in the aforementioned patent to Grenell, U.S. 2,690,002 in which one of the outer surfaces has a high degree of smoothness.

This invention is directed primarily to the fabrication of metal panels, but in part it is equally applicable to panels fabricated from materials other than metal, such as various plastics, and to panels fabricated from dissimilar materials such as a metal and a plastic joined together with an unjoined portion between the sheets.

Additional objects and advantages will be apparent from the following description and drawings in which:

FIGURES 1–3 indicate schematically a process for fabricating a blank from which a hollow smooth sided panel is formed, and more specifically:

FIGURE 1 is a perspective view of a sheet of metal having applied to a surface thereof a pattern of weld-inhibiting material;

FIGURE 2 is a perspective view of the sheet shown in FIGURE 1 with a second metal sheet superimposed thereon in laminar fashion and tacked thereto as by spot-welding, with the pattern of weld-inhibiting material sandwiched between the sheets;

FIGURE 3 is a perspective view of the sheets of FIGURE 2 being welded together in a rolling mill to form a blank;

FIGURE 4 is a perspective view of one side of the finished panel subsequent to distension of the blank by a fluid pressure injected into the unjoined portion thereof through an injection nozzle, the broken lines indicating areas to be trimmed from the ends of the panel;

FIGURE 5 is a perspective view of the reverse side of the panel shown in FIGURE 4 with the areas to be trimmed from the ends of the panel again indicated by broken lines;

FIGURE 6 is a sectional view of the panel taken on the line 6—6 in FIGURE 4; and

FIGURE 7 is a perspective view of the finished arched panel with the ends cut off.

The fabrication of a flat sided hollow article by the subject method requires that two sheets of material having differentiable elastic limits be arranged in stack-like fashion and welded together with an unjoined portion therebetween, and then adequately differentiating the elastic limits and injecting into the unjoined portion a fluid pressure of sufficient magnitude to permanently distend the sheet having the lower elastic limit but of insufficient magnitude to permanently distend the sheet having the higher elastic limit.

Such a blank is fabricated by welding together two sheets having different inherent elastic limits. Two sheets of material may be selected which possess the required difference in strength characteristics and which require the same effective treatment for each of the joined sheets to adequately differentiate these characteristics, or the joined materials may each require a particular differentiating treatment, such as special annealing or heat treating to sufficiently differentiate the inherent strength characteristics of the materials.

Referring to the drawings, FIGURE 1 shows a sheet of metal 1 with a design of weld-inhibiting material 2 applied to a clean surface 3 thereof. The design is foreshortened in the intended direction of subsequent rolling. The surface of the sheet is cleaned in any conventional manner as by brush-scrubbing.

FIGURE 2 shows a second metal sheet 4 superimposed on the surface 3 of the first sheet to which the weld-inhibiting material 2 has been applied. The surface of the second sheet 4 adjacent the first sheet 1 has been previously cleaned in a manner similar to the cleaning of the first sheet. The two sheets are lightly secured together as by spot welding 5 to prevent relative slippage between the sheets as they are welded together in their adjacent areas not separated by the weld-inhibiting material. After being tacked together the sheets 1 and 4 are usually heated to assure welding together of the sheets as they pass through the mill rolls 6.

FIGURE 3 shows the two sheets 1 and 4 passing between a pair of mill rolls 6 and being welded together to form a blank 7 having an unjoined area defined by the weld-inhibiting material 2. During the rolling operation the sheets are elongated in the direction of rolling and reduced in cross-sectional thickness. The initial width of the sheets remains substantially unchanged. The degree of heating, if any, and the reduction in thickness of the sheets depends on the inherent characteristics of the metals being welded together and such practice is well known in the rolling art. Following the initial

rolling operation, the blank may be softened as by annealing and cold rolled in keeping with the teaching of the aforementioned patent.

Prior to expansion of the blank it is subjected to a special sheet differentiating treatment. When the blank has been fabricated of materials having different inherent strength characteristics, a controlled annealing process may be required in which one of the sheets is fully annealed whereas the other sheet is substantially unaffected. With certain composite copper or aluminum blanks an annealing to soften one of the sheets may be required along with a heat treatment to harden the other sheet. Such methods of sheet differentiating treatments will be more fully discussed hereafter.

For any given pair of sheets the necessary sheet differentiating treatment may be determined from an appropriate handbook such as, "Metals Handbook," 1948 edition, published by The American Society For Metals, Cleveland, Ohio. In addition to copper and aluminum, steel and stainless steel of the same or different characteristics are particularly suitable for the fabrication of smooth sided hollow metal panels. In any event, the resultant blanks have one weak side which may be permanently distended at a pressure too low to permanently distend the other stronger side.

The blank 7 is then expanded by injecting into the unjoined portion thereof a fluid pressure. Referring to FIGURE 1, a strip of weld-inhibiting material 8 is applied to the surface 3 of the sheet 1 from the design 2 to an edge 9 of the sheet. Thus an unjoined inlet 11 connects the unjoined design with an edge 12 of the finished blank 7. The inlet 11 is forced open and a hollow injection nozzle 13 is inserted therein and is firmly held in place in various manners, for example, as taught in the copending U.S. patent application of Adams, Serial Number 445,108 filed July 22, 1954. Other methods of expanding the blank are known, such as applying a weld-inhibiting material which releases a gas at a certain temperature with the resultant gas pressure distending the blank, or by drilling through a face of the blank directly into the unjoined portion and injecting the expansion fluid into the unjoined portion through the resultant aperture.

In FIGURE 4 the unjoined portion of the blank 7 has been expanded to define conduits 14 and form a hollow panel 15. The nozzle 13 is still in the inlet 11. The dashed lines 16 on the right and left ends of the panel 13 indicate the portions of the panel which are to be trimmed off. Conduits 14 protrude from only one side 17 of the panel 15. FIGURE 5 shows the other side 18 of the hollow panel 15 which is smooth. The distension of the panel on only one side may be clearly seen in FIGURE 6.

FIGURE 7 shows an arched panel 20 after it has been expanded to form hollow tube distension 21 on one side and a smooth arched surface 22 on the opposite side. The panels may be arched, curved or flat. An arched or curved panel may be shaped by stamping a blank fabricated in the usual manner in a press in the manner taught in the following patents: U.S. 562,309 granted June 16, 1896 or U.S. 1,267,591 granted May 28, 1918, or in any other appropriate manner.

Many combinations of sheets may be joined to form a blank having an unjoined internal portion so that one side will remain smooth when a pressure of sufficient magnitude to permanently distend the other side of the blank is injected into the unjoined portion. The following examples set forth the treatment of but a few of the many possible combinations. The following examples refer to yield strength rather than elastic limit, however, the elastic limit, which is slightly less than the yield strength, may be determined on the basis of the yield strength for any given metal, by methods well understood in the art.

Example 1

A blank is fabricated from two sheets of copper alloy, one of the sheets being an electrolytic tough pitch copper containing: 99.90% minimum copper, 0.05% maximum oxygen, 0.003% maximum phosphorus, 0.03% total or 0.01% each of other impurities, and the other sheet being a high conductivity bronze containing: 94–96% copper, 0.75–1.25% tin, .25% maximum phosphorus, 0.05% maximum lead, 0.01% maximum impurities and the balance zinc. A ⅜ inch wide strip of weld-inhibiting material is applied to a surface of one of the sheets and this surface is then welded to a surface of the other sheet in the areas not separated by the weld-inhibiting material by hot rolling at a temperature of 1700° F., and a reduction of 60% in a single pass through a rolling mill. Subsequently, the welded blank may be fully annealed and then cold rolled to an additional reduction of 30% after which it is in the work hardened state having a hardness of 69 Rockwell B and a yield strength of 55,000 p.s.i. for the high conductivity alloy and a hardness of 87 Rockwell B and a yield strength of 67,000 p.s.i. for the electrolytic tough pitch alloy. The blank is then heated at a temperature of 300° C. for 60 minutes fully annealing the electrolytic tough pitch alloy. This temperature is below the annealing temperature of 650° C. for the high conductivity alloy. The electrolytic tough pitch alloy has then been annealed to a yield strength of about 7,000 p.s.i. The high conductivity alloy retains a yield strength of about 56,000 p.s.i. A finished blank .045 inch thick in which the sheets had the same initial thickness so that the wall thickness on both sides of the unjoined inner portion of the blank is substantially the same is then expanded by a pressure of about 1,200 p.s.i. injected into the unjoined portion. The optimum expansion pressure is dependent on the pattern design involved. This pressure is sufficient to distend the electrolytic tough pitch alloy beyond its elastic limit but is below its rupture strength, thus permanently distending this wall of the unjoined portion of the blank. The pressure is below that which would permanently distend the unjoined high conductivity alloy wall of the blank. The resultant internal tube height is about .045 inch.

Example 2

In a blank fabricated from two sheets of aluminum alloy, the first commercially pure aluminum (1100 alloy), and the second 6061 aluminum alloy, a 7/16 inch wide strip of weld-inhibiting material is applied to the clean face of one of the sheets and this face is welded to a clean face of the other sheet in the areas not separated by the weld-inhibiting material by hot rolling at a temperature of 950 F., and a reduction of 65% in a single pass through a rolling mill. Subsequently, the welded blank is fully annealed and cold rolled at a reduction of 27%. Except for obtaining a weld and a blank of even thickness, the previous annealing step has no effect on the mechanical properties of either side of the blank after the following heat treatments. The blank is solution heat treated by holding the entire mass of the blank at a temperature of 970° F. for 10 minutes, followed by an immediate quenching, within five seconds of being removed from the furnace, in water at a temperature of about 50° F. The 1100 alloy is now fully annealed to a "0" temper and the 6061 alloy has now been solution heat treated to the T–4 temper. The blank is next precipitation heat treated at either a temperature of 320° F. for 16–20 hours, or a temperature of 350° F. for 6–10 hours which yields the same results. The 1100 alloy now has a yield strength of 5,000 p.s.i. and the 6061 alloy now has a yield strength of 40,000 p.s.i. both at an off set of 0.2%. A finished blank .060 inch thick in which the sheets had the same initial thickness prior to rolling so that the wall thickness on both sides of the unjoined inner portion of the blank is substantially the same is then expanded by injecting into the unjoined portion of the blank a pressure of about 1,200 p.s.i. depending on the pattern design. This pressure is sufficient to distend the 1100 aluminum

alloy beyond its elastic limit but below its rupture strength, thus permanently distending this wall of the unjoined portion of the blank. The pressure is below that which will permanently distend the unjoined 6061 aluminum alloy wall of the blank thus leaving this side smooth. The internal tube height of the panel is about .070 inch.

In expanding smooth sided panels by the aforementioned process and excessive distention of the weaker side of the panel may cause the stronger side to be pulled in slightly in the area at which the two walls of the hollow portion of the panel unite. Should this occur, the effect can be eliminated by expanding the weaker side to a lesser degree. In any event, the stronger side of the panel will not have a permanent outward distention if the force exerted within the unjoined portion of the panel is not of sufficient magnitude to distend the stronger side past its elastic limit. Although in the technical sense some materials will receive a permanent set even when they are stressed within their elastic limit such a permanent set is very minute and of no practical importance and this invention is intended to include application of the process to such materials.

The same type of procedures may be followed in inflating blanks fabricated of other different metals and of metal and plastic adhesively joined together.

Although the invention has been described with particular reference to certain specific embodiments, materials, techniques and details, various changes and modifications will be apparent to one skilled in the art and the invention is therefore not to be limited to such embodiments, materials, techniques or details except as set forth in the appended claims.

I claim:

1. In a process for fabricating a hollow panel having a smooth side and an opposite side having protrusions formed by distentions conforming to the hollow portion of said panel, the steps comprising forming a blank by superimposing a first sheet on a second sheet having an elastic limit differentiable from the elastic limit of said first sheet, joining a portion of said sheets together to define an enclosed unjoined area between adjacent surfaces of said sheets, expanding said blank to form a panel by injecting within said unjoined area a fluid pressure of sufficient magnitude to distend one of said sheets having the lower elastic limit but of insufficient magnitude to distend the other of said sheets having the higher elastic limit, said one sheet with said lower elastic limit having a thickness relative to the thickness of said other sheet having the higher elastic limit such that said one sheet having the lower elastic limit will distend at a lower fluid pressure injected into said unjoined area than said other sheet having the higher elastic limit whereby said panel is permanently distended on one side and smooth on the other side.

2. In a process for fabricating a hollow panel having a smooth side an an opposite side having protrusions formed by distentions conforming to the hollow portion of said panel, the steps comprising providing a plurality of sheets having differentiable elastic limits forming a blank by superimposing a first sheet on a second sheet having an elastic limit differentiable from the elastic limit of said first sheet, joining a portion of said sheets together to define an enclosed unjoined area between adjacent surfaces of said sheets of which one of said sheets has an elastic limit lower than the elastic limit of the other of said sheets with said one sheet having a thickness relative to the thickness of said other sheet such that the said one sheet having the lower elastic limit will distend at a lower fluid pressure injected into said unjoined area than said other sheet having the higher elastic limit, metallurgically treating said joined sheets to increase the difference in the elastic limits of said sheets for purposes of subsequent distention, and expanding said blank to form a panel by injecting within said unjoined area a fluid pressure of sufficient magnitude to permanently distend one of said sheets having the induced lower elastic limit but of insufficient magnitude to permanently distend the other of said sheets having the induced higher elastic limit, whereby said panel is permanently distended on one side and smooth on the other side.

3. In a process for fabricating a hollow panel having a smooth side and an opposite side having protrusions formed by distentions conforming to the hollow portion of said panel, the steps comprising forming a blank by superimposing a first sheet on a second sheet having an elastic limit differentiable from the elastic limit of said first sheet, joining a portion of said sheets together to define an enclosed unjoined area between adjacent surfaces of said sheets, metallurgically treating said joined sheets to reduce the elastic limit of the sheet initially having the lower elastic limit and to raise the elastic limit of the sheet initially having the higher elastic limit of which one of said sheets has an elastic limit lower than the elastic limit of the other of said sheets with said one sheet having a thickness relative to the thickness of said other sheet such that said one sheet having the lower elastic limit will distend at a lower fluid pressure injected into said unjoined area than said other sheet having the higher elastic limit, and expanding said blank to form a panel by injecting within said unjoined area a fluid pressure of sufficient magnitude to permanently distend said one of said sheeets beyond its said lowered elastic limit but less than that required to permanently distend the other of said sheets beyond its raised elastic limit whereby said panel is permanently distended on one side and substantially smooth on the other side.

4. In a process for fabricating a hollow sheet metal panel having a smooth side and an opposite side having distentions formed by the hollow portion of said panel, the steps comprising forming a blank by applying to a portion of a surface of a first sheet a design of weld-inhibiting material, positioning adjacent said surface a surface of a second sheet having an elastic limit different than said first sheet, welding said sheets together in the areas of said adjacent surfaces not separated by said weld-inhibiting material, and expanding said blank to form a panel by injecting between said sheets in the area separated by said weld-inhibiting material a fluid pressure of sufficient magnitude to distend one of said sheets having the lower elastic limit but of insufficient magnitude to distend said other sheet having the higher elastic limit, whereby upon release of said pressure said panel is permanently distended on one side and smooth on the other side, said one of said sheets with the lower elastic limit having a thickness relative to the thickness of said other sheet having the higher elastic limit such that said one sheet having the lower elastic limit will distend at a lower fluid pressure injected in said area separated by said weld-inhibiting material than said other sheet with the higher elastic limit.

5. In a process for fabricating a hollow sheet metal panel having a smooth side and an opposite side having distentions formed by the hollow portion of said panel, the steps comprising forming a blank by applying to a portion of a surface of a first sheet a design of weld-inhibiting material, positioning adjacent said surface a surface of a second sheet having an elastic limit differentiable from said first sheet, welding said sheets together in the areas of said adjacent surfaces not separated by said weld-inhibiting material of which one of said sheets has an elastic limit lower than the elastic limit of the other of said sheets with said one sheet having a thickness relative to the thickness of said other sheet such that said one sheet having the lower elastic limit will distend at a lower fluid pressure injected into said unjoined area than said other sheet having the higher elastic limit, metallurgically treating said joined sheets to increase the difference in the elastic limits of said sheets for purposes of subsequent distention, and expanding said blank to form a panel by injecting between said sheets in the area sepa-

rated by said weld-inhibiting material a fluid pressure of sufficient magnitude to distend said one of said sheets beyond its induced lower elastic limit but of insufficient magnitude to distend said other sheet beyond its induced higher elastic limit whereby upon release of said pressure said panel is permanently distended on one side and smooth on the other side.

6. In a process for fabricating a hollow sheet metal panel having a smooth side and an opposite side having distentions formed by the hollow portion of said panel, the steps comprising forming a blank by applying to a portion of a surface of a first sheet a design of weld-inhibiting material, positioning adjacent said surface a surface of a second sheet having an elastic limit different than said first sheet, welding said sheets together in the areas of said adjacent surfaces not separated by said weld-inhibiting material, metallurgically treating said joined sheets to reduce the elastic limit of the sheet initially having the lower elastic limit and to raise the elastic limit of the sheet initially having the higher elastic limit of which one of said sheets has an elastic limit lower than the elastic limit of the other of said sheets with said one sheet having a thickness relative to the thickness of said other sheet such that said one sheet having the lower elastic limit will distend at a lower fluid pressure injected into said unjoined area than said other sheet having the higher elastic limit, and expanding said blank to form a panel by injecting between said sheets in the area separated by said weld-inhibiting material a fluid pressure of sufficient magnitude to distend said one of said sheets beyond its induced lower elastic limit but of insufficient magnitude to distend said other sheet beyond its induced higher elastic limit whereby upon release of said pressure said panel is permanently distended on one side and smooth on the other side.

7. In a process for fabricating a hollow panel having a smooth side and an opposite side having protrusions formed by distentions conforming to the hollow portion of said panel the steps comprising forming a blank by applying to a portion of the surface of a first sheet a design of weld-inhibiting material, said weld-inhibiting material being capable of releasing a gas at high pressure when heated to an elevated temperature, superimposing a second sheet having an elastic limit differentiable from said first sheet on said first sheet, joining said sheets together in the areas of their adjacent surfaces not separated by said weld-inhibiting material of which one of said sheets has an elastic limit lower than the elastic limit of the other of said sheets with said one sheet having a thickness relative to the thickness of said other sheet such that said one sheet having the lower elastic limit will distend at a lower fluid pressure injected into said unjoined area than said other sheet having the higher elastic limit, metallurgically treating said joined sheets to increase the difference in elastic limits of said sheets for purposes of subsequent distention, and heating said joined sheets to an elevated temperature whereby said weld-inhibiting material generates a gas of sufficient magnitude to permanently distend one of said sheets having the induced lower elastic limit, but of insufficient magnitude to permanently distend the other of said sheets having the higher elastic limit.

8. In the fabrication of a hollow panel from a blank having an unjoined interior portion adapted to contain a fluid under pressure for expansion of said blank, the method of forming said blank comprising the steps of superimposing a first sheet on a second sheet having an elastic limit differentiable from the elastic limit of said first sheet, joining a portion of said sheets together to define an enclosed unjoined area between adjacent surfaces of said sheets, and metallurgically treating said unjoined sheets to increase the difference in the elastic limit of said sheets with one of said sheets with the induced lower elastic limit having a thickness relative to the thickness of the other of said sheets such that said one sheet having the lower elastic limit will distend at a lower fluid pressure injected into said unjoined portion than said other sheet having the higher elastic limit.

9. In a process for fabricating a hollow panel having a smooth side and an opposite side having protrusions formed by distentions conforming to the hollow portion of said panel, the steps comprising forming a blank by superimposing a first sheet on a second sheet having an elastic limit differentiable from the elastic limit of said first sheet, joining a portion of said sheets together to define an enclosed unjoined area between adjacent surfaces of said sheets, metallurgically treating said joined sheets to reduce the elastic limit of the sheet initially having the lower elastic limit and to raise the elastic limit of the sheet initially having the higher elastic limit an amount different from the amount of said reduction in elastic limit of which one of said sheets has an elastic limit lower than the elastic limit of the other of said sheets with said one sheet having a thickness relative to the thickness of said other sheet such that said one sheet having the lower elastic limit will distend at a lower fluid pressure injected into said unjoined area than said other sheet having the higher elastic limit, and expanding said blank to form a panel by injecting within said unjoined area a fluid pressure to permanently distend said one of said sheets beyond its induced lower elastic limit but less than that required to permanently distend the said other of said sheets beyond its induced higher elastic limit, whereby said panel is permanently distended on one side and smooth on the other side.

10. In the fabrication of a hollow panel from a blank having an unjoined interior portion adapted to contain a fluid under pressure for expansion of said blank, the method of forming said blank comprising the steps of superimposing a first sheet on a second sheet having an elastic limit differentiable from the elastic limit of said first sheet, joining a portion of said sheets together to define said unjoined interior portion between adjacent surfaces of said sheets, fully annealing said joined sheets, and metallurgically treating said joined sheets to differentiate the elastic limits of said sheets with one of said sheets with the induced lower elastic limit having a thickness relative to the thickness of the other of said sheets such that said one sheet having the lower elastic limit will distend at a lower fluid pressure injected into said unjoined portion than said other sheet having the higher elastic limit.

11. In the fabrication of a hollow panel from a blank having an unjoined interior portion adapted to contain a fluid under pressure for expansion of said blank, the method of forming said blank comprising the steps of superimposing a first sheet on a second sheet having an elastic limit differentiable from the elastic limit of said first sheet, joining a portion of said sheets together to define said unjoined interior portion between adjacent surfaces of said sheets, metallurgically treating said joined sheets to reduce the elastic limit of the sheet having the higher elastic limit below the value of the elastic limit of the sheet initially having the lower elastic limit while substantially holding constant the initial value of the elastic limit of the sheet having the lower elastic limit with one of said sheets with the induced lower elastic limit having a thickness relative to the thickness of the other of said sheets such that said one sheet having the said induced lower elastic limit will distend at a lower fluid pressure injected into said unjoined portion than said other of said sheets.

12. In a process for fabricating a hollow panel having a smooth side and an opposite side having protrusions formed by distentions conforming to the hollow portion of said panel, the steps comprising forming a blank by superimposing a first sheet on a second sheet having an elastic limit differentiable from the elastic limit of said first sheet, joining a portion of said sheets together to

define an enclosed unjoined area between adjacent surfaces of said sheets, metallurgically treating said joined sheets to reduce the elastic limit of the sheet initially having the higher elastic limit below the value of elastic limit of the sheet initially having the lower elastic limit while substantially holding constant the initial value of the elastic limit of the sheet having a lower elastic limit with one of said sheets with the induced lower elastic limit having a thickness relative to the thickness of the other of said sheets such that said one sheet having the said induced lower elastic limit will distend at a lower fluid pressure injected into said unjoined area than said other sheet, and expanding said blank to form a panel by injecting within said unjoined areas a fluid pressure to permanently distend said one of said sheets beyond its said induced lower elastic limit but less than that required to permanently distend the said other of said sheets beyond its elastic limit.

13. In the fabrication of a hollow panel from a blank having an unjoined interior portion adapted to contain a fluid under pressure for expansion of said blank, the method of forming said blank comprising the steps of superimposing a first sheet on a second sheet having an elastic limit differentiable from the elastic limit of said first sheet, joining a portion of said sheets together to define said unjoined interior portion between adjacent surfaces of said sheets, metallurgically treating said joined sheets to reduce the elastic limit of the sheet initially having the higher elastic limit and to raise the elastic limit of the sheet having the lower elastic limit to values wherein the sheet initially having the lower elastic limit has an induced elastic limit greater than the induced elastic limit of the sheet initially having the higher elastic limit, with one of said sheets with the said induced lower elastic limit having a thickness relative to the thickness of the other of said sheets with said induced higher elastic limit such that said one sheet having said induced lower elastic limit will distend at a lower fluid pressure injected into said unjoined portion than said other sheet having the said induced higher elastic limit.

14. In a process for fabricating a hollow panel having a smooth side and an opposite side having protrusions formed by distentions conforming to the hollow portion of said panel, the steps comprising forming a blank by superimposing a first sheet on a second sheet having an elastic limit differentiable from the elastic limit of said first sheet, joining a portion of said sheets together to define an enclosed unjoined area between adjacent surfaces of said sheets, metallurgically treating said joined sheets to reduce the elastic limit of the sheet initially having a higher elastic limit and to raise the elastic limit of the sheet initially having a lower limit to values wherein the sheet initially having a lower limit has an elastic limit greater than the induced value of the sheet initially having the higher elastic limit, with one of said sheets with the said induced lower elastic limit having a thickness relative to the thickness of the other of said sheets with the said induced higher elastic limit such that said one sheet having the said induced lower elastic limit will distend at a lower fluid pressure injected into said unjoined area than said other sheet having the said induced higher elastic limit, and expanding said blank to form a panel by injecting within said unjoined area a fluid pressure to permanently distend said one of said sheets beyond its said induced lower elastic limit but less than that required to permanently distend the said other of said sheets beyond its said induced higher elastic limit.

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2,766,514	Adams	Oct. 16, 1956