Dec. 11, 1962 R. M. NEEL ETAL 3,067,491

FABRICATION OF HOLLOW ARTICLES

Filed Dec. 10, 1956

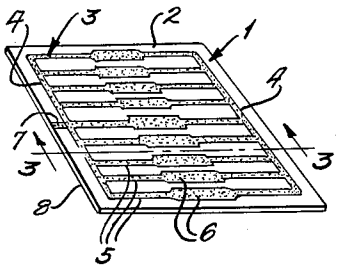


FIG.1

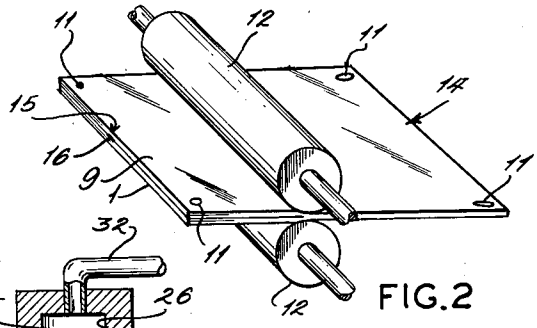


FIG.2

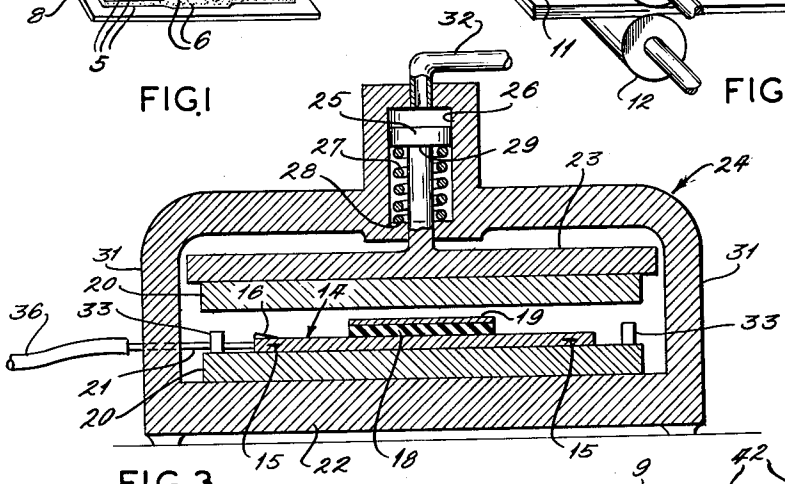


FIG.3

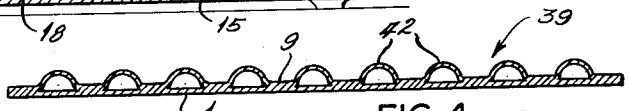


FIG.4

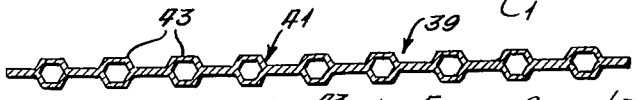


FIG.5

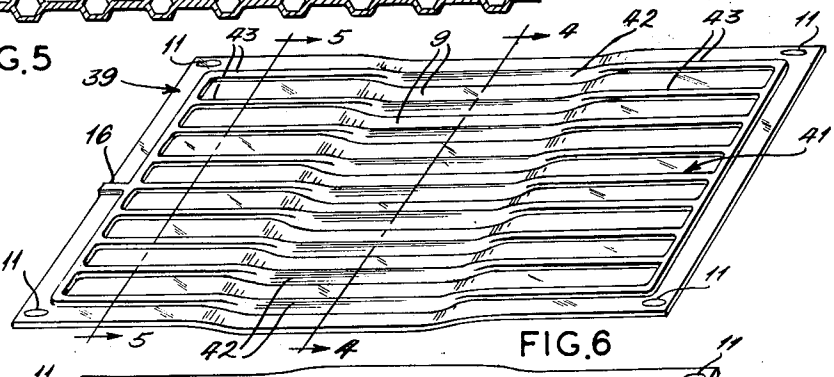


FIG.6

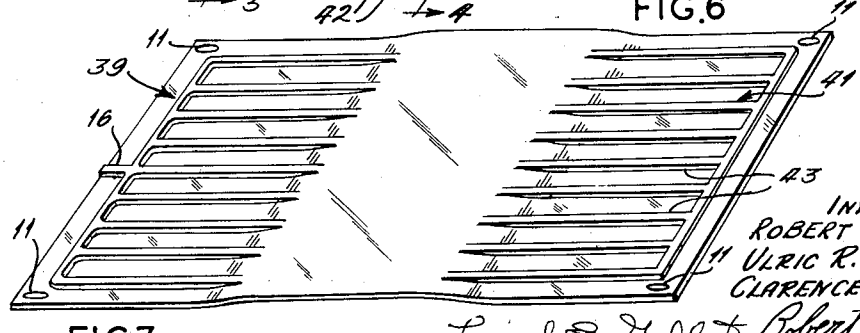


FIG.7

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3,067,491

FABRICATION OF HOLLOW ARTICLES

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4 Claims. (Cl. 29—157.3)

This invention relates to the fabrication of hollow articles and more specifically to forming the hollows in such articles.

In the fabrication of hollow sheet metal panels by one 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 secured together to prevent relative slippage and are then welded together in their adjacent areas not separated by the weld-inhibiting material, in any suitable manner, such as by 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 blank, a fluid conveying circuit of the type required in refrigerator heat exchanger panels. The aforementioned process is more fully described in U.S. Patent 2,690,002, issued September 28, 1954.

This invention is directed to the fabrication of hollow articles having a partially smooth side and an opposite fully distended side, by welding together sheets having different strength characteristics, or differentiable elastic properties and if necessary adequately differentiating the elastic properties prior to expanding the blank. The blank thus formed is clamped between a pair of spaced-apart hard pressure pads with a compressible pressure pad inserted between a portion of the unjoined area of the blank and one of the hard pressure pads, or preferably a compressible pad next to the blank and a hard shim between the compressible pad and the hard pressure pad, and then expanding the blank by injecting into the unjoined portion thereof a fluid pressure of sufficient magnitude to permanently distend the blank into firm engagement with the spaced-apart hard platens. The hard pressure pads are spaced apart a distance such that upon expansion of the unjoined portion of the blank the resultant distended portions firmly engage the hard pressure pads and the portions of the distentions which engage the hard pressure pads are thereby flattened. The resultant distentions on the portion of the side of the blank in engagement with the compressible pressure pad are impressed into the compressible pressure pad. The compressible pressure pad tends to hold the side of the blank opposite thereto firmly against the hard pressure pad and in conjunction with the different strengths of the sheets this is sufficient to prevent outward distention of the unjoined portion of the blank on the side opposite the compressible pressure pad so that this side is smooth. To obtain the maximum volume in the hollow portion of the expanded panel the pressure should be such as to permanently distend the weaker sheet under the compressible pressure pad, between its elastic limit and ultimate rupture strength, but below the combined effect of the elastic limit of the stronger sheet acted upon by the compressible pressure pad and the holding effect of the compressible

pressure pad. It is to be noted as indicated above that this pressure is, however, sufficient to distend the remainder of the hollow portions of the panel, not acted upon by the compressible pressure pad, firmly against the hard pressure pads.

As used herein the term "smooth" refers to 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.

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

It is an object of this invention to fabricate an improved hollow panel with one side partially smooth and the opposite side distended.

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

Another object of this invention is to fabricate a hollow panel in which a portion of one side is smooth and the remaining portion of this side and other side is distended.

Another object of this invention is to provide a method of fabricating hollow panels in which a portion of one of the outer surfaces is smooth in the areas adjacent an unjoined interior area of said panel.

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

FIGURES 1 and 2 indicate schematically a process for fabricating a blank from which a hollow smooth-sided panel may be subsequently formed, and more specifically;

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

FIGURE 2 is a perspective view of the sheet shown in FIGURE 1 with a second sheet superimposed thereon in laminar fashion and tacked thereto as by spot welding, the sheets having differentiable strength characteristics, with the pattern of weld-inhibiting material sandwiched between the sheets and showing the sheets being welded together in a rolling mill to form a blank;

FIGURE 3 is a longitudinal sectional schematic view of the resultant blank of FIGURE 2, the line 3—3 in FIGURE 1 indicating the portion of the weld-inhibiting pattern shown in FIGURE 3, and showing the blank positioned between a pair of pressure pads;

FIGURE 4 is a transverse sectional view of the resultant hollow panel after the unjoined portion of the blank has been expanded, the section of the panel being indicated by the line 4—4 in FIGURE 6 of the entire finished panel;

FIGURE 5 is a sectional view of another portion of the finished panel taken on the line 5—5 in FIGURE 6;

FIGURE 6 is a perspective view of one side of the expanded panel, and;

FIGURE 7 is a perspective view of the opposite side of the expanded panel shown in FIGURE 6.

Referring to FIGURE 1 of the drawings, a sheet 1, such as aluminum or copper, has applied to a clean surface 2 a design 3 of weld-inhibiting material. The weld-inhibiting design 3 includes a pair of header areas 4 interconnected by conduit strips 5. The strips 5 may have a wide portion 6 at their midportion. The weld-inhibiting design 3 includes a strip 7 interconnecting a portion of the aforementioned design with an edge 8

of the sheet 1. In this instance, the strip 7 interconnects the edge 8 of the sheet and one of the header areas 4. A second sheet 9 of differential strength from the first sheet 1, is superimposed on the surface 2 of the first sheet with the weld-inhibiting pattern 3 sandwiched between the sheets. The two sheets are then tacked together as by spot welding 11 to prevent relative slippage of the adjacent surfaces of the sheets during a subsequent welding operation. After the sheets have been tacked together they are welded together along their adjacent surfaces not separated by the weld-inhibiting material 3. One well known method of welding the sheets together is by hot rolling, in which the sheets are first heated and then passed through mill rolls 12, between which they are reduced in thickness and elongated in the direction of rolling. If desired, the resultant blank 14 having an unjoined interior portion 15 may be softened in any appropriate manner as by annealing and thereafter the blank may be cold rolled to provide a more even thickness and again annealed. The inlet portion 7 of weld-inhibiting material produces an unjoined inlet 16 into the unjoined header and conduit design after welding the sheets together to form a blank.

The sheets 1 and 9 are selected so that one of the sheets will have a greater strength than the other sheet. Either sheet may be the weaker, and sheet 9 will be designated the weaker sheet for purposes of the subsequent description. The sheets may be of the same material but of different thicknesses, and therefore of different strength. 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 by the annealing treatment. 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 effect of heat 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 relatively weaker side which may be permanently distended at a pressure too low to permanently distend the other stronger side.

The following examples set forth the treatment of but a few of the many possible combinations. The 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 may be 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, and 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 pattern 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 60 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.

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 pattern 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 and cold rolling steps have 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 to 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 offset of 0.2%.

Referring to FIGURE 3, a compressible pressure pad 18 is positioned on the top surface of the blank 14 and a hard shim 19 is positioned on top of the pad 18. The blank, compressible pressure pad, and shim are positioned between a pair of hard pressure pads 20, and a fluid pressure conveying nozzle 21 is inserted into the inlet 16 in the blank. The hard pressure pads 20 are respectively secured to a fixed jaw 22 and a vertically movable jaw 23 of a press 24. The movable upper jaw 23 is secured to a plunger 25 received in a cylinder 26 with a fluid-tight sliding fit. The movable jaw 23 is maintained in a raised position in any appropriate manner as by a spring 27 engaging a shoulder 28 on the lower end of the cylinder 26 and a shoulder 29 on the plunger 25. The cylinder 26 is fixed with respect to the lower jaw 22 of the press in any appropriate manner as by arms 31. A fluid pressure conveying conduit 32 opens into the upper end of the cylinder 26 for injecting a fluid into the cylinder thereby forcing the plunger 25 downward and the hard upper pressure pad toward the hard lower pressrue pad and shim 19. The hard pressure pads 20 are spaced from each other. The spacing may be adjusted as by shims 33 and the spacing is such that the upper hard pressure pad does not engage the blank 14. However, the compressible pressure pad 18 and shim 19 are clamped between the blank 14 and the hard upper pressure pad 20. The unjoined portion 15 of the blank 14 is then expanded, in accordance with the invention as described above, by injecting a fluid pressure therein through the nozzle 21 and conduit 36 connected thereto.

The compressible pressure pad 18 is preferably of a resilient material such as sponge rubber, but any type of rubber-like material is suitable. The pad 18 may be of a nonresilient material such as balsa wood, but unless the pad is resilient, it will not return to its original condition. The hard shim 19 is not mandatory, but if a shim is used

a greater cross-sectional area of the normally expanded portion of the tubes, that is the portions **43** at the ends of the panel in FIGURES 6 and 7, can be obtained while still producing the desired smooth portions. The compressible pad **18** may be a quarter inch thick medium grade soft block stock industrial sponge rubber pad having a density of about 21 pounds per cubic foot, a compressibility of 2 to 5 pounds per square inch to compress the pad to 75% of its original thickness, and a minimum elongation of 250% backed up by a hard shim .030 inch thick, for a 1100 or 2S aluminum blank .060 inch thick, all positioned between hard pressure pads spaced apart .180 inch. The compressible pad may be of solid rubber having similar physical characteristics as the previously described sponge rubber to prevent the compressibility of the pad from being affected by liquid spilled thereon. Since the total outward distention of the expanded portion of the panel in the area of the substantially smooth side is less than the remainder of the expanded portion, the unjoined portion may be wider adjacent the smooth area as indicated by the wider design of the weld-inhibiting material **6**.

FIGURES 6 and 7 show opposite sides of the expanded panel **39**. In FIGURE 6 the conduits **41** each have a wider portion **42** in the area which engages the compressible pressure pad **18**. The wider portion **42** of the conduits corresponds to the wider portion **6** of the weld-inhibiting pattern shown in FIGURE 1. The conduits **41** have flat outer surfaces in the area of engagement with the hard pressure pads **20**. With reference to FIGURE 6, it will be seen that the outer portions **43** distend outwardly to a greater extent than do the wide conduit portion **42**. Therefore, in order to assure an adequate cross-sectional area of the conduits **42** this portion should be wider than the end portions **43**, and therefore the weld-inhibiting design shown in FIGURE 1 has a wider midportion **6**. The reverse side of the panel is shown in FIGURE 7, and it will be noted that the wide portion **42** of the conduits **41** are not distended outwardly and that the midportion of the panel **39** is smooth. During the expansion of the blank, the pressure of the compressible pressure pad **18** causes the adjacent portion of the opposite side of the blank to be firmly held against the lower hard pressure pad **20**.

After expansion of the unjoined portion **15** of the blank **14** to form the hollow portion of the panel **39**, it may be necessary to control the release of the expansion pressure within the hollow portion and the pressure of a resilient pressure pad **18** against the distended portion of the panel, in order to prevent rupturing the panel by the force of the expansion fluid, and to prevent collapsing the extended hollow portion of the panel through the force of the resilient pressure pad. By releasing the pressure in cylinder **26** concurrently with the pressure in the hollow portion of the panel, any tendency of the pad to collapse the hollow portion or for the expansion pressure to rupture the hollow portion of the panel is retarded.

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

I claim:

1. The method of fabricating a hollow article formed from a blank having an interconnected unjoined inner portion defined by walls formed of sheets having different strengths, said method comprising maintaining said blank between spaced apart rigid pressure pads with a compressible pressure pad clamped between one of said rigid pads and the outer surface of the weaker of said sheets throughout and against a limited area of said unjoined portion with said limited area encompassing only a fraction of said unjoined inner portion, applying within said unjoined portion a force to distend said blank in the areas defining said unjoined inner portions, said force being of sufficient magnitude to permanently distend both said sheets in the areas adjacent said limited area and the weaker sheet within said limited area but of insufficient magnitude to permanently distend the stronger sheet within said limited area, whereby the portion of said stronger sheet opposite the portion of said weaker sheet adjacent said compressible pressure pad remains smooth upon expansion of said unjoined portion.

2. The method of fabricating a hollow article having partially smooth side and an opposite side having protrusions formed by distentions conforming to the hollow portion of said article, said method comprising the steps of 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 interconnected unjoined portion between adjacent surfaces of said sheets, maintaining said blank between spaced apart rigid pressure pads with a compressible pressure pad clamped between one of said rigid pads and the outer surface of the weaker of said sheets throughout and against a limited area of said unjoined portion with said limited area encompassing only a fraction of said unjoined portion, and applying a force within said unjoined area to outwardly distend both said sheets in the areas adjacent said limited area and the sheet within said limited area having the lower elastic limit, whereby the portion of said stronger sheet opposite the portion of said weaker sheet adjacent said compressible pressure pad remains smooth upon expansion of said unjoined portion.

3. The method of fabricating a hollow article having partially smooth side and an opposite side having protrusions formed by distentions conforming to the hollow portion of said article, said method comprising the steps of 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 interconnected unjoined portion between adjacent surfaces of said sheets, maintaining said blank between spaced apart rigid pressure pads with a compressible pressure pad clamped between one of said rigid pads and the outer surface of the weaker of said sheets throughout and against a limited area of said unjoined portion with said limited area encompassing only a fraction of said unjoined portion, and applying within said unjoined area a force to distend said blank in the areas defining said unjoined inner portions, said force being of sufficient magnitude to distend both said sheets in the areas adjacent said limited area and the weaker sheet beyond its elastic limit within said limited area but of insufficient magnitude to distend the stronger sheet beyond its elastic limit in the area of said compressible pressure pad, whereby the portion of said stronger sheet opposite said compressible pressure pad remains smooth upon expansion of said unjoined portion.

4. The method of fabricating a hollow article having partially smooth side and an opposite side having protrusions formed by distentions conforming to the hollow portion of said article, said method comprising the steps of 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 of material amenable to a heat treatment affecting the elastic limit of said sheet, said first sheet also being of a material amenable to heat treatment affecting its elastic limit in about the same range of temperature for treating said second sheet, joining a portion of said sheets together to define an enclosed interconnected unjoined portion between adjacent surfaces of said sheets, heat treating said joined sheets to reduce the elastic limit of the sheet initially having the lower limit and to raise the elastic limit of the sheet initially having the higher limit, maintaining said blank between spaced apart rigid pressure pads with a compressible pressure pad clamped between one of said rigid pads and the outer

surface of the weaker of said sheets throughout and against a limited area of said unjoined portion with said limited area encompassing only a fraction of said unjoined portion, and applying within said unjoined portion a force to distend said blank in the areas defining said unjoined inner portion, said force being of sufficient magnitude to distend both said sheets in the areas adjacent said limited area and the weaker sheet beyond its elastic limit within said limited area but of insufficient magnitude to distend the stronger sheet beyond its elastic limit within the area of said compressible pressure pad, whereby the portion of said stronger sheet opposite said compressible pressure pad remains smooth upon expansion of said unjoined portion.

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UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,067,491 December 11, 1962

Robert M. Neel et al.

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.

In the grant, lines 1 to 3, for "Robert M. Neel, of New Douglas, and Ulric R. Jaeger, of Alton, Illinois, and Clarence A. Isbell, Jr., of Ferguson, Missouri," read -- Robert M. Neel, of New Douglas, and Ulric R. Jaeger, of Alton, Illinois, and Clarence A. Isbell, Jr., of Ferguson, Missouri, assignors to Olin Mathieson Chemical Corporation, of East Alton, Illinois, a corporation of Virginia, --; lines 12 and 13, for "Robert M. Neel, Ulric R. Jaeger, and Clarence A. Isbell, Jr., their heirs" read -- Olin Mathieson Chemical Corporation, its successors --; in the heading to the printed specification, lines 3 and 4, for "Robert M. Neel, New Douglas, and Ulric R. Jaeger, Alton, Ill., and Clarence A. Isbell, Jr., Ferguson, Mo." read -- Robert M. Neel, New Douglas, and Ulric R. Jaeger, Alton, Ill., and Clarence A. Isbell, Jr., Ferguson, Mo., assignors to Olin Mathieson Chemical Corporation, East Alton, Ill., a corporation of Virginia --.

Signed and sealed this 18th day of June 1963.

(SEAL)
Attest:
ERNEST W. SWIDER
Attesting Officer

DAVID L. LADD
Commissioner of Patents