

[54] **METHOD OF ELECTROFORMED MOLDS**[76] Inventor: **Frank J. Nussbaum**, 220 Miller Rd., Hicksville, N.Y. 11801[22] Filed: **Mar. 6, 1970**[21] Appl. No.: **17,252****Related U.S. Application Data**

[63] Continuation-in-part of Ser. No. 752,518, Aug. 14, 1968, abandoned, and a continuation-in-part of Ser. No. 884,896, Dec. 15, 1969.

[52] **U.S. Cl.** 264/45, 264/225, 264/226, 264/227[51] **Int. Cl.****B29c 1/02**[58] **Field of Search** 18/47 R, 47 C; 264/219, 225, 264/226, 227, 255; 204/6[56] **References Cited****UNITED STATES PATENTS**

3,249,672	5/1966	Richards	264/219
2,969,544	1/1961	Di Marco	264/45
3,285,835	11/1966	Farrow	264/219 X
2,679,473	5/1954	Swartz	204/6
2,734,243	2/1956	Lips	264/219 X
3,539,144	11/1970	Krug	18/47 C X
2,834,052	5/1958	Hunn	264/219 X
2,865,821	12/1958	Jonke	204/6
2,846,377	8/1958	Ross	204/6
1,757,543	5/1930	Ord	264/219
3,239,590	3/1966	Trimble	264/226

Primary Examiner—Philip E. Anderson*Assistant Examiner*—Paul A. Leipold*Attorney*—John R. Ewbank[57] **ABSTRACT**

A pattern for a pair of separable metal molds for a giant plastic article is prepared by a method in which a parting frame at the location of the contemplated parting line is secured to two sections representing the two parts of the mold. The pattern is immersed in an electrolyte and a metallic envelope is electroformed about the pattern. Insulated protrusions extending from the parting frame are not coated, whereby accurate identification of various zones of the envelope is feasible. Copper is a preferred metal for the major thickness of the electroformed molds, but nickel is desirably first plated onto the pattern and thus is the metal contacting the hot plastic. The surfaces of the envelope are modified to permit construction of heat transfer conduits, desirably by a second stage of electroforming. The periphery of the parting frame is removed, thereby permitting the two portions of the electroform to function as two portions of a mold. Each portion is anchored into a box. A polyurethane foam insulating foundation is positioned between a box wall and a contoured wall of the mold. The relatively thin contoured walls of the electroformed halves of the mold are not readily distorted because they are anchored into their boxes.

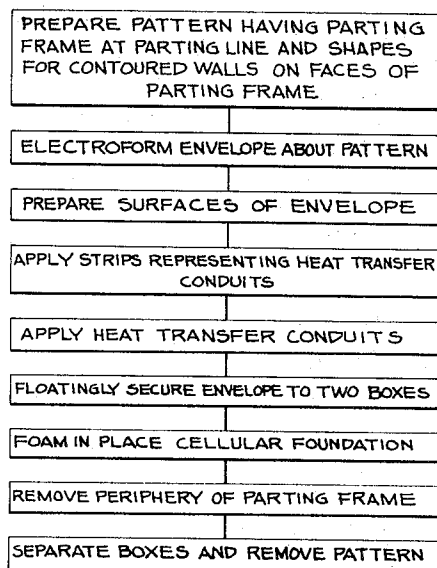
6 Claims, 14 Drawing Figures

Fig. 1

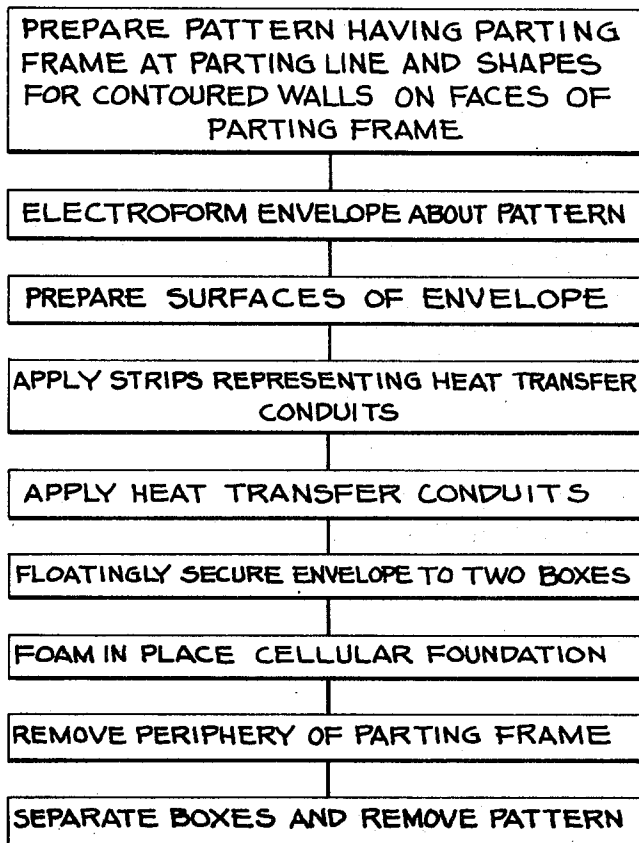


Fig. 2

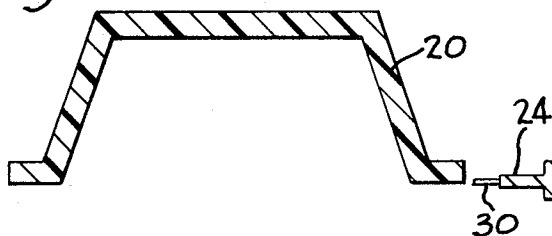


Fig. 3

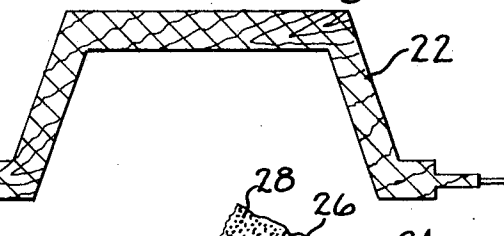


Fig. 5

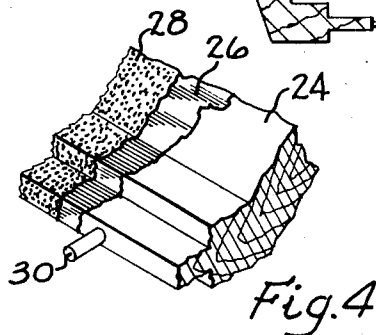
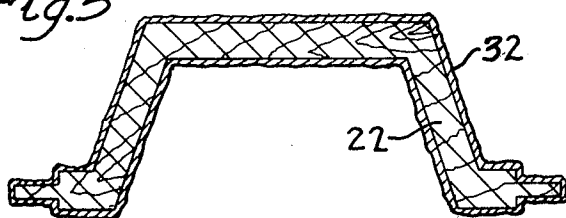
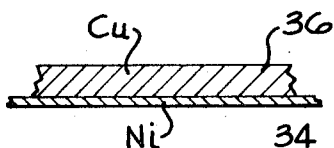


Fig. 6

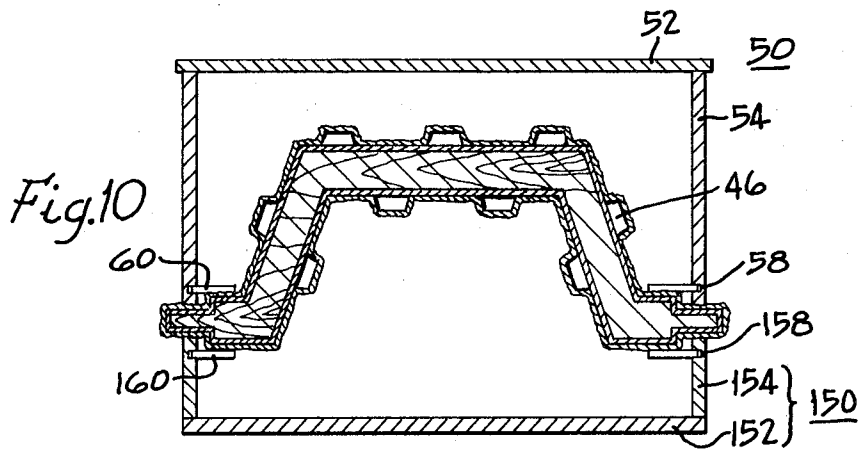
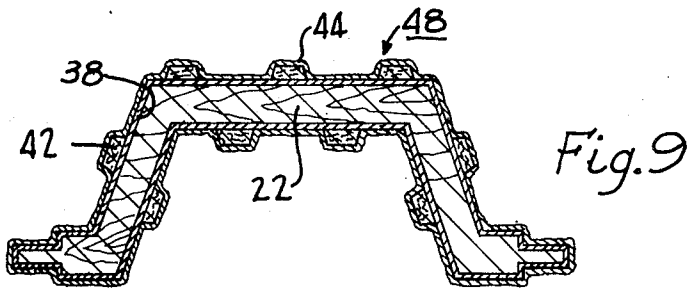
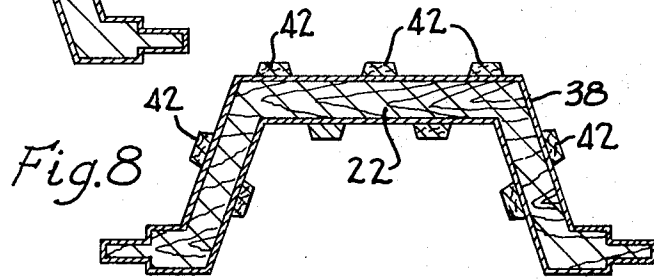
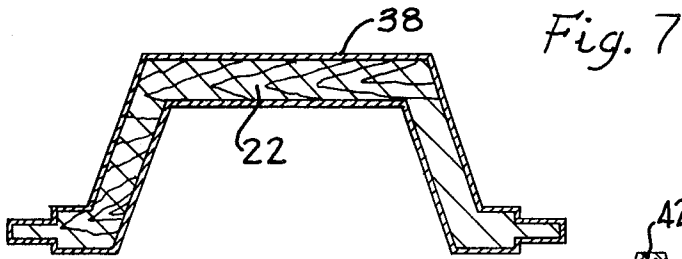


INVENTOR
FRANK J. NUSSBAUM

BY *John R. Ewbank*

ATTORNEY

SHEET 2 OF 3



INVENTOR
FRANK J. NUSSBAUM

BY *John R. Ewbank*
ATTORNEY

Fig. 11

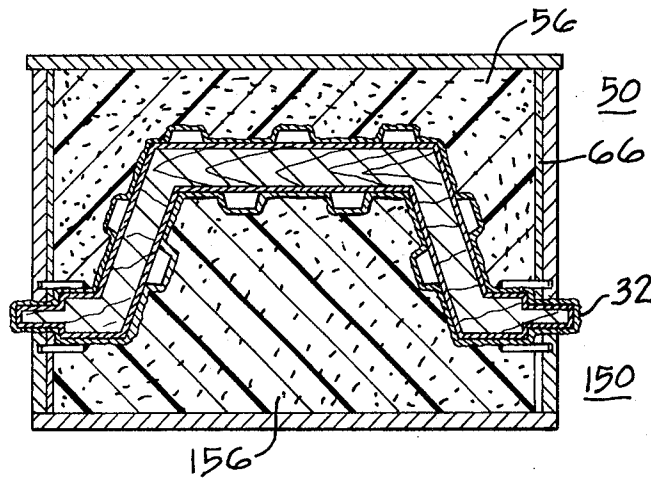


Fig. 12

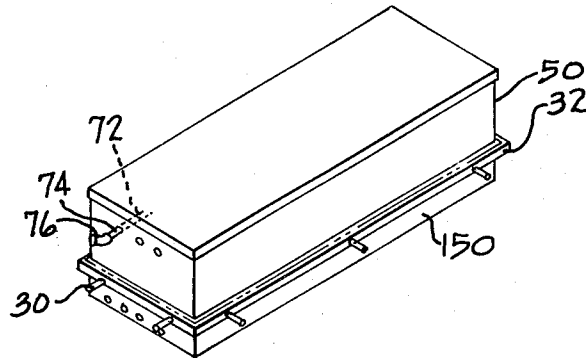


Fig. 13

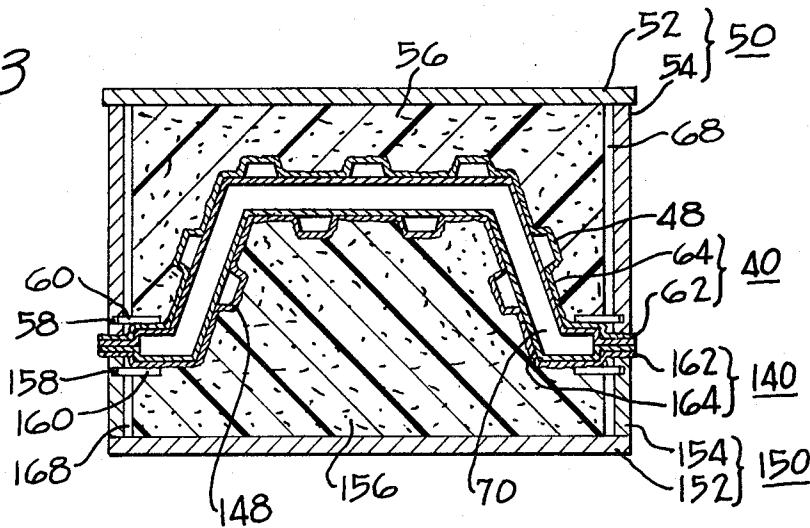
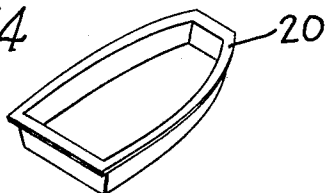


Fig. 14



INVENTOR
FRANK J. NUSSBAUM

BY

John R. Ewbank
ATTORNEY

METHOD OF ELECTROFORMED MOLDS

CROSS REFERENCE TO ANCESTOR APPLICATIONS

The present application is a continuation-in-part of application Ser. No. 752,518 filed Aug. 14, 1968 and now abandoned and Ser. No. 884,896 filed Dec. 15, 1969, each by Frank J. Nussbaum, and all the disclosure of each application is deemed here reiterated.

GENERAL BACKGROUND

Molds for small plastic parts have previously been made by a variety of procedures, including the conventional carving out of a cavity from a block of metal. Attempts to electroform molds have sometimes been unsatisfactory by reason of a propensity of the thin electroform to become distorted because of various stresses occurring during the electroforming operation. Different methods of molding have involved various temperature and pressure requirements. Relatively thin and fragile molds, such as gypsum or electroformed molds, are suitable in the ambient temperature casting of polyurethane foam, but much stronger molds suitable for withstanding high pressure and elevated temperatures have been required in conventional high pressure injection molding. The cost of mold making has sometimes been a factor discouraging use of injection molding for making articles, particularly those weighing more than a few ounces. Conventional high pressure injection molding has ordinarily been unsuitable for the production of giant articles weighing more than two kilograms. Various approaches toward low pressure injection molding have recently pioneered new possibilities for the production of giant plastic articles. The problems of preparing molds for low pressure injection molding has received little attention.

SUMMARY

In accordance with the present invention, a two part mold for a giant plastic article is prepared by designing a pattern having appropriate portions of the shape of the article on each side of a rectangular parting frame having parallel faces around its rectangular periphery. Nickel and then copper are electroformed onto the pattern. The surfaces of the metallic envelope are prepared, and then wax strips are applied along the paths desired for heat transfer conduits. The heat transfer conduits are applied over the wax strips. At some stage the wax is melted and the wax removed to permit flow through such conduits. Two boxes, each having peripheral frames and rear plate, are employed. At some stage the outer portion of the parting frame is removed to separate the envelope into two members, each having a contoured wall extending from a rectangular flat frame. At some stage, each member comprising the contoured wall is anchored into its box. At some stage an insulating foundation is positioned between the exterior surfaces of the conduit carrying contoured wall and the rear plate of its box.

DESCRIPTION OF DRAWINGS

For the purpose of illustrating the invention, an embodiment is schematically shown in the drawing.

FIG. 1 is a flow sheet of the method. FIGS. 2, 3, 4, 5, 7, 8, 9, 10, 11, and 13 are very schematic, generally

cross-sectional views illustrating the preparation of a boat of FIG. 14 by some of the steps of the method of the flow sheet.

FIG. 2 is a cross-sectional view of the boat of FIG. 14.

FIG. 3 shows the pattern having a pair of appropriate shapes secured to opposite faces of a parting frame.

FIG. 4 shows protrusions extending from portions of the parting frame.

FIG. 5 shows the metallic envelope electroformed about the pattern.

FIG. 6 is a representation of the combination of a nickel face backed up by a greater thickness of copper wall.

FIG. 7 shows the preparation of smoother surfaces on the metallic envelope.

FIG. 8 shows the application of wax strips to the prepared surfaces of FIG. 7.

FIG. 9 shows the application of conduits at the locations indicated by FIG. 8.

FIG. 10 shows the positioning of two boxes on opposite faces of the parting frame of the envelope.

FIG. 11 shows the application of a foam foundation to the structure of FIG. 10.

Of particular importance is FIG. 12, showing the cutting of the periphery of the cutting frame to separate the metallic envelope into two portions of the mold.

FIG. 13 shows the completed two-part mold made by the method of FIGS. 1-12.

FIG. 14 is a perspective view of the boat made in the mold of FIG. 13.

DESCRIPTION OF EMBODIMENTS

A two passenger boat 20, as shown in FIG. 14, is an example of a giant article weighing more than 2 kilograms. The method of the present invention is appropriate for any of a great variety of giant articles which can be produced by low pressure injection molding. As shown in FIG. 3, a pattern 22 is prepared, making use of a parting frame 24 at the contemplated parting line of the two part separable mold. In the finished mold, it is important that when the mold parts are brought together, there should be a matching together of the flat face portions framed around the rectangular periphery of each part of the mold. The plastic would escape through any openings attributable to any non-matching of the flat face portions framed around the peripheral portions of the two parts of the mold. Because the periphery of the parting frame 24 of the pattern 22 includes faces which are parallel, the desired matching of the flat face portions of the two parts of the mold can be assured. For some articles it is possible to prepare a pattern by forming a master identical to the shape of the desired article, cutting the master along the parting line, and adhering the two parts to opposite faces of a panel serving as the parting frame. In other instances, the shape of the pattern can be planned by engineers using other procedures.

A pattern may be made of any suitable material, such as wood, plaster, or metal. If the material is porous or corrodable, a coating 26 is provided to protect it from the action of the electrolyte. A urethane enamel is a suitable protective coating. If the material or coating are not conductive, then a conductive coating 28 is applied to assure the electroconductivity of the main portion of the pattern.

A plurality of identifying protrusions or reference guides 30 are positioned about the periphery of the parting frame 24 as shown in FIG. 4, and are insulated so that they do not accumulate any metal during the electroforming. Such protrusions 30, permit the accurate location of various portions of the interior of the envelope during the period prior to the removal of the peripheral portions of the parting frame.

The properly prepared pattern is transferred to a tank and immersed in the electrolyte of an electroforming system. Initially the electrolyte is adapted to deposit a layer 34 of nickel, which is a suitable metal for contacting hot plastic. After a thickness of about 0.01 inch has been deposited, the electroforming system is changed to copper deposition, and a layer 36 having a thickness about nine times greater than the nickel is deposited. FIG. 6 shows the nickel and copper layers. The average thickness of the electroformed wall is designed to permit satisfactory molding, so that different molds have walls of different thickness. Certain variations in the thickness of the metal can be expected, but the efforts are directed toward maintaining a minimum thickness of about one-sixteenth inch and a maximum thickness of about one-fourth inch and an average thickness of about one-eighth inch.

Particular attention is directed to the fact that the copper and nickel are deposited as an envelope 32 entirely around the pattern. Accordingly, the electroformed metal is not readily distorted, but has the strength attributable to the strength of the pattern about which it is enveloped.

After the initial electroforming has achieved the desired thickness of metal, the electroformed envelope 32 is removed from the electrolyte, rinsed, and the surfaces are prepared for the application of strips of wax. Such preparation may include reducing the thickness of excessively thick walls, strengthening zones requiring additional strength, and removing surface roughness. Such surface improvement provide a surface 38, as indicated in FIG. 7. The identifying protrusions 30, which are not coated during the electroforming operation are helpful in identifying the precise location of the various portions of the pattern within the envelope during intermediate operations, such as smoothing a surface.

The two parts of the mold for a boat can be designated as a male mold and a female mold. Each part comprises a contoured wall, and it is possible to identify on the envelope that which can eventually become a contoured wall 140 for the male mold and a contoured wall 40 for the female mold. It is convenient to designate portions of the male mold by numbers 100 greater than the number for the corresponding part of the female mold.

After the exterior surfaces of the envelope have been adequately prepared, strips of wax 42 are positioned on the exterior of the contoured wall 40 at the locations at which heat transfer conduits are desired. This step is shown in FIG. 8. Some of the heat transfer conduits may be manifolds for the supply or collection of liquid to or from a plurality of other heat transfer conduits. The envelope with the wax-coated strips is then subjected to the step of applying the heat transfer conduits over the wax and envelope. FIG. 9 shows conduit walls 44 secured to contoured wall 40. Passageways 46 for the flow of heat transfer fluid in conduits 48 result after the wax has been melted and removed.

In one embodiment of the invention, the conduit walls 44 are applied by spraying a silicone rubber composition over the wax strips and curing the composition to provide strength for the conduits 48.

In a preferred embodiment the conduit walls 44 are applied by a second stage of electroforming to provide conduits 48.

An electroformed shape can sometimes be distorted at the time when a pattern is removed therefrom, or during early stages of handling such a shape. One procedure for avoiding such distortion problem is to anchor a contoured shape into its box prior to the removal of the pattern. Such retention of the pattern in a contoured wall until it is anchored tends to stabilize its shape. By the method of the present invention, it is greatly preferred to anchor each contoured sheet into its box prior to the cutting of the envelope and accordingly prior to the removal of the pattern from the contoured wall. Even in those modifications of the invention in which the envelope is cut prior to the anchoring, it is advantageous to use the stabilizing presence of the pattern in the contoured wall until after the anchoring of the contoured wall in its box.

An open box 50 includes removable rear plate 52 and peripheral frame members 54. The dimensions of the box 50 are great enough that the total change of dimension resulting from a temperature change (e.g. 70° to 470° F) is quite large. Similarly, contoured wall 40 is so gigantic that it lengthens significantly during a 400° F temperature increase. The contoured wall 40 is heated and cooled by the heat transfer fluid flowing through conduits 40. In accordance with the present invention, the contoured wall 40 is anchored into its box 40 so that the contoured wall 40 and box 50 can independently undergo thermal expansion and thermal contraction. Such anchoring while preserving independent thermal expansion of such portions of the mold is quite different from the conventional practice of transmitting thermal expansion forces between such portions. One of the features making possible the independent thermal expansion capacity is the cellular structure of an insulating foundation 56, best shown in FIG. 11. Desirably foundation 56 is polyurethane foam having a cell volume of about 25 percent. An important advantage of the polyurethane foam insulating foundation is its ability to adhere securely to the rear plate 52 of the box 50 and to the contoured wall 40 while still providing the elasticity and flexibility to permit each to undergo thermal expansion and thermal contraction independently of each other.

Because of the importance of the independent thermal expansion of the contoured wall in the box, it is desirable to anchor the flat frame portion of each contoured wall by floating supports adapted to secure the members together while permitting such independent thermal expansion. Molds for injection molding have previously been prepared so that the contoured wall portion in contact with the hot plastic and the exterior box secured to the molding apparatus were connected so that thermal expansion of one transmitted forces to the other. The concept of associating them for independent thermal expansion (that is, floatingly supporting the contoured wall in its box) is believed to be of greater significance than the particular structure shown in the drawings for achieving such independent thermal expansion.

The interior of each peripheral frame component 54 of the box 50 is provided with a slot 58. A plurality of spaced apart fingers 60 extend from the contoured wall 40 so that the ends of the fingers fit slidably into the slot 58. When initially assembled at ambient temperature and prior to the formation of the insulating foundation 56, the distance from a finger tip at one end of the contoured wall 40 to the finger tip at the other end of the contoured wall is shorter than the distance between the bottoms of the slots 58 into which the fingers fit, and the tolerance is somewhat greater than the greatest conceivable difference in length attributable to thermal expansion. In assembling the unit, it is advantageous to employ a wire temporarily adhered to the bottom of the slot as a shim against which the fingers touch during the initial assembly, and then to remove the wire shim after the casting of the insulating foundation 56, whereby the tolerance about the periphery can be reasonably uniform. Each finger can be secured to the contoured wall by any suitable procedure, such as an adhesive bond. The fingers can be positioned on the contoured wall at the same time that the paths for the conduits are established, and the fingers can be further secured by the second step of electroforming. An operable opposite might be designed to floatingly fit box frame fingers into a slot in the contoured wall. If the floating support were designed to have fingers extending from the box frame 54 into slots around the contoured wall 40, then the supporting strips could be positioned when the conduit paths were laid out, and the supporting strips could be anchored onto the contoured wall by electroforming during the electroforming of the conduit walls.

In order to clarify the functioning of the floating support for the contoured wall, certain structural features were discussed in an order different from the chronology of assembly. Returning now to the method of preparing a mold, and noting that the fingers 60 were secured to the contoured wall 40, there is a step of positioning the fingers in the slot 58 of the frame 54 of the box 50. In this step, it is advantageous to assemble three sides of the frame and slide the fingers along a pair of slots until the slot on the third side is engaged, and then to attach the fourth frame member 54. Such operation can be and desirably is conducted while the pattern is still within and stabilizing the envelope. The fingers 60 desirably have spring-like characteristics to permit a controlled range of flexing while still urging toward a predetermined relationship.

It is convenient to refer to the contoured wall 40 on one side of the parting frame as a unit while recognizing that it comprises a rectangular flat frame 62 adapted to match with the rectangular flat frame 162 of the other part of the mold and a shaped zone 64 imparting to the plastic article the desired shape. Advantages are achieved by extending the flat frame 62 to near the internal periphery of the frame 54 of the box 50, with at least enough tolerance therebetween to permit the independent thermal expansion of the two components. Alternatively, the flat frame can be extended to the exterior periphery of frame 54 as shown in FIG. 13.

After the contoured wall 40 is centered within box 50, as shown in FIG. 10, preparations can be made for the casting of the insulating foundation 56. Wax spacers 66 can be positioned around the interior of the

box frame 54 so that after the melting and removal of the wax, there can be a gap 68 between the foundation 56 and the frame 54. It is convenient to remove the rear plate 52 from the box and to pour the precursor for the foundation 56 into the box 50 so that the foundation is foamed in place, and the plate 52 can be replaced on the box after the foaming and cutting away of surplus foam. The envelope 32 can be inverted, and the precursor for the insulating foundation 156 poured in place into box 150. Then the envelope 32 can be reinverted to provide a structure, such as shown in FIG. 11, comprising an envelope anchored into two boxes.

It is customary in the production of articles by electroforming to minimize the amount of metal deposited electrolytically and subsequently discarded, because each gram of electroformed metal is more costly than sheet metal, and/or metal prepared by some of the common manufacturing procedures. In achieving the advantageous method of the present invention, it has been necessary to violate the conventional rule against wasting electroformed metal.

That portion of the electroformed envelope 32 around the parting frame 24 extending beyond the desired periphery of the flat frames 62, 162 is metal which is deposited by electroforming and not employed in the mold. This apparent wastage of electroformed metal is quite contradictory to conventional planning of electroforming methods, but is a feature of the stabilization by enveloping about a rigid pattern of the present invention. The box 50 is positioned on the envelope and floatingly secured thereto by the fingers 60 while the contoured wall 40 is stabilized as a part of the envelope around the pattern 22. As shown schematically in FIG. 12, the periphery of the parting frame 24, together with such portions of the envelope 32, are cut away from the envelope at the time when the envelope is converted into two members. The protrusions 30 are also removed by this cutting operation. The cutting is not between and parallel to the flat frames 62, 162, but perpendicular thereto, as indicated in FIG. 12. After the initial cut shown in FIG. 12, it is feasible to separate box 50 from box 150, to remove the pattern 22, and to conduct various finishing and trimming operations, such as further cutting the parting frame members to correctly define the periphery of flat frame 62. The method of mold making conveniently emphasizes the processing of box 50, but all the corresponding operations are also conducted on box 150. When the two part mold is assembled, there is a cavity 70 in which a boat may be injection molded.

In order to conduct the heat transfer liquid into and away from the passageways 46 of conduits 48, there are provided tubes 72 from the conduits 48 to pipes 74 through the box frame 54 to tubes 76 to the circulation system. Thus the path of the liquid is from the circulation system to tube 76, through pipe 76 to the interior of the box frame 54, and thence by tube 72 to the conduit 48, where it exerts its heat transfer function relative to the mold wall and thence through another tube 72, another pipe 74, another tube 76, and back to the circulation system.

In removing molded articles from giant molds, compressed gas is advantageous in applying a force which can overcome the adhering forces without serious damage to the mold or article. Each half of the mold

can be provided with one or more openings (not shown) adapted to permit such use of compressed air for knocking out the molded article from the mold. Such compressed air approach can also be employed in overcoming whatever adhering force may exist between the pattern and the electroformed contoured walls at the time of removing the pattern from its split envelope. A plurality of injection nozzles supply a mixture of gas and molten plastic to the cavity 70, and the nozzles fit into various orifices in contoured wall 40, but such orifices and the wells for the injection nozzles are not shown in the schematic drawings concerned predominantly with other aspects of the mold making.

The invention claimed is:

1. In the method of preparing two part metal molds for the processing of giant organic plastic articles, the improvement which includes the steps of:

determining the parting line between the two parts of the mold and designating as the parting frame a rigid rectangular frame having parallel faces, there being a rectangular periphery about the parallel faces;

constructing a pattern in which the two portions of the mold-forming pattern are positioned on opposite faces of the parting frame;

securing identifying protrusions at the periphery of the parting frame;

establishing electrically insulated surfaces of the identifying protrusions and establishing electroconductive surfaces or other portions of the pattern;

transferring the pattern to an electrolyte of an electroforming system;

coating an envelope of nickel onto said pattern by electroforming, the identifying protrusions receiving no significant amounts of the deposited nickel; applying a coating of copper several times thicker than the nickel onto the nickel by electroforming, whereby the thickness of the electroformed envelope is sufficient to provide structural strength to the electroformed contoured walls having an internal shape reproducing that of the mold-forming master portion of the pattern;

withdrawing the copper-enveloped pattern from the electrolyte;

providing two boxes, each having rectangular peripheral frame members and a rear plate;

at some stage cutting through the two parallel faces at the rectangular periphery of the parting frame to remove only outer portions of the parallel matching rectangular frame and to separate the envelope into two members, each having a contoured wall extending from a flat matching parallel face portion having a rectangular periphery;

at some stage anchoring each member comprising a contoured wall and rectangular peripheral flat-faced frame to the rectangular peripheral frame member of its box;

at some stage providing a flowable precursor which foams and cures for positioning an insulating foundation between exterior surface portions of the contoured wall and the rear plate of its box, said foundation being a polyurethane foam having a pore volume of about 25 percent;

at some stage after anchoring in the boxes removing the pattern from the two members formed by the removal of the periphery of the parting frame; and

utilizing the electroformed two part mold for the processing of plastic.

2. The method of claim 1 in which heat transfer conduits are applied subsequent to the withdrawal of the copper-enveloped pattern from the electrolyte by steps including the step of applying wax strips and bonding a copper envelope over the wax strips and copper envelope by a further step of electroforming, and melting the wax to remove the wax from the thus formed heat transfer conduits.

3. A method of preparing a two-section mold for producing a giant organic plastic article including the steps of:

preparing a master having external surfaces corresponding generally to the external surfaces of the giant organic plastic article to be produced;

determining the parting line between the two parts of the mold, and designating a rigid rectangular frame having parallel faces as the parting frame;

cutting the master having the external surfaces corresponding to the external surfaces of the plastic article, such cutting being at the parting line, and securing the two halves of the master to opposite faces of the parting frame, such composite being designated as a pattern;

immersing the pattern in an electrolyte and electroforming a metallic envelope about the pattern to form contoured walls on the interior of the envelope of said electroformed metal, said metal being copper, nickel, or mixtures thereof;

withdrawing the enveloped pattern from the electrolyte;

providing two boxes, each having peripheral frame members and a rear plate;

anchoring the electroformed metallic envelope to the rectangular peripheral frame members of the two boxes;

positioning an insulating foundation having a pore volume of about 25 percent by forming in place a polyurethane plastic foam between exterior surface portions of the metallic envelope and the rear plate of each box;

removing the periphery of the parting frame by cutting through the two parallel faces thereof to separate the envelope into two portions, each portion having a contoured wall extending from a flat matching parallel face portion and being anchored to its box;

removing the two boxes and their contoured walls from the pattern to provide a two section mold.

4. The method of claim 3 in which a plurality of identifying protrusions are secured to the pattern prior to the electroforming and said protrusions are insulated so that they are not electroformed, whereby the processing subsequent to the electroforming until the removal of the pattern from the two section mold can be performed with accurate knowledge of the location of the insulated protrusions and the related locations of various portions of the pattern.

5. The method of claim 3 wherein heat transfer conduits are applied subsequent to the withdrawal of the enveloped pattern but prior to the positioning of the insulating foundation, said application of heat transfer conduits including steps providing a plurality of meltable wax rods positioned on the rear face of each contoured wall, the rods having extensions adapted to align

with openings providing flow paths from the exterior of the peripheral frame member of the box through independent conduits having zones contacting the rear face of the contoured wall to outlets exterior of a peripheral frame member, providing the plurality of heat transfer conduits with the adaptation permitting differential heat transfer of various zones of the contoured wall, applying silicone rubber to the rear of the contoured wall and around the exposed portions of the wax rods, and melting the wax rods to remove the wax and to form the conduits for the heat transfer liquid.

6. A method as set forth in claim 3 wherein heat transfer conduits are applied subsequent to the withdrawal of the enveloped pattern but prior to the positioning of the insulating foundation, said application of heat transfer conduits including the steps of providing wax rods on the exterior surface of the contoured wall, spraying silicone rubber on the wax rods, and melting the wax rods to provide the heat transfer conduits.

* * * * *

15

20

25

30

35

40

45

50

55

60

65