July 16, 1963 J. H. INGLESBY 3,097,398

APPARATUS FOR MAKING PLASTIC BOTTLES

Filed April 10, 1961

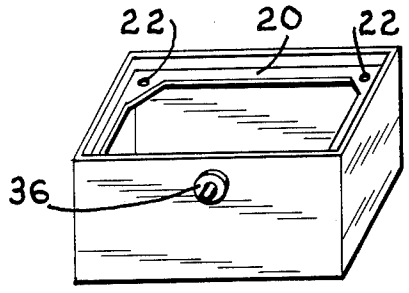


FIG. 1

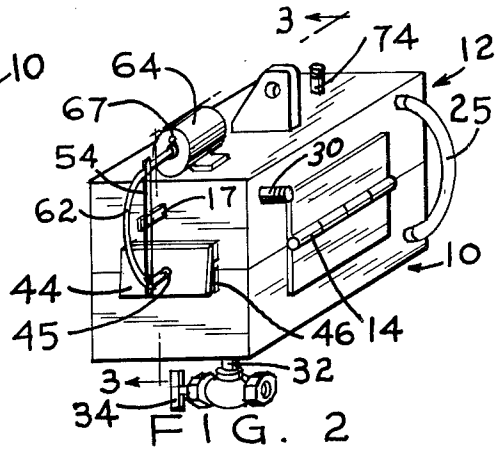


FIG. 2

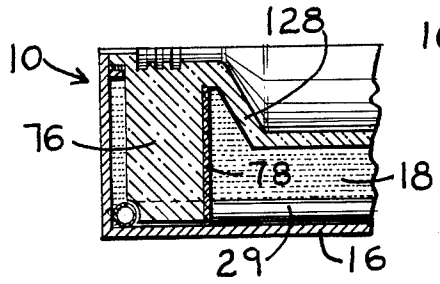


FIG. 4

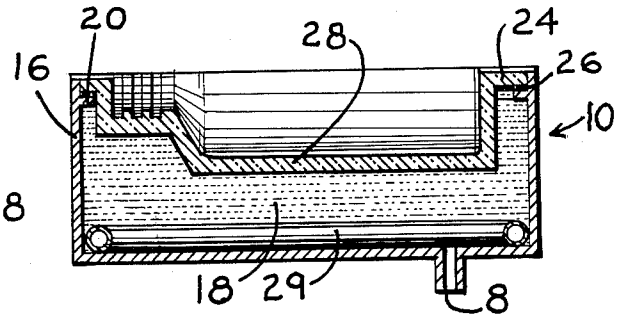
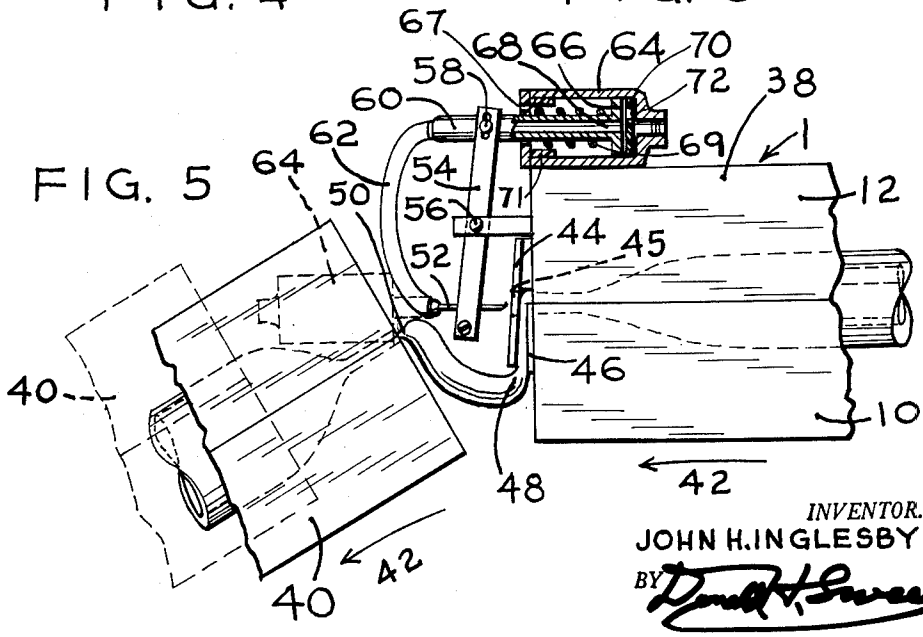


FIG. 3

FIG. 5



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APPARATUS FOR MAKING PLASTIC BOTTLES

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My invention relates to the manufacture of one piece plastic bottles, currently made of polyethylene, or a more dense and rigid plastic called linear polyethylene. It includes among its objects and advantages the reduction of the capital investment in molds for the mass production of such bottles in large quantities; the reduction in changeover time on equipment using such molds; securing precise temperature control, with different cooling rates for different portions of the product when desired; compactness and better clearance in the complete equipment, especially in connection with removing regrind material; and reinforcement for epoxy-aluminum molds, to facilitate their use for production purposes as distinguished from temporary molds for getting out samples.

Other objects and advantages of the invention will become apparent as the description proceeds.

In the accompanying drawings:

FIGURE 1 is a perspective of the outer shell of the lower half of a mold assembly according to the invention;

FIGURE 2 is a similar perspective of a complete assembled mold unit;

FIGURE 3 is a longitudinal section in a central vertical plane as on line 3—3 of FIGURE 2;

FIGURE 4 is a partial section similar to FIGURE 3, indicating a modified construction;

FIGURE 5 is a partial diagram showing two molds in functional relationship.

In the embodiment selected to illustrate the invention, the complete assembly includes a lower half **10** and an upper half **12** hinged together at **14**. The lower half **10** includes the shell **16** for holding a charge of heat transfer liquid **18**. The shell is provided with a peripheral flange **20** having corner apertures at **22** to receive fastening bolts for clamping a casting representing half of the assembled mold, which casting has a peripheral flange **24** spaced from the shelf **20** by a sealing gasket **26**.

In FIGURE 3 I have indicated a conventional bottle shape defined by the inner surfaces of the mold **28**. The upper half **12** of the assembly is a complementary replica of the lower half **10**.

Means are provided for keeping the mass of heat transfer liquid **18** at the appropriate temperature throughout use of the mold. I have indicated a cooling coil **29** in FIGURES 3 and 4 and a flexible tube **25** to establish a complete circulating connection with a duplicate cooling coil in the top of the upper section **12**. The coolant may enter at **30** and leave at **32**, after passing through both the cooling coils, and the outlet **32** is provided with an adjustable valve at **34** for regulating the rate of flow of the coolant. I also provide an electric thermo-couple **36** (see FIGURE 1) for observing the temperature of the heat transfer liquid **18**.

As is well known in the prior art, a plurality of such mold assemblies, usually eight, are mounted on a rotary support and move in a circular path while one half of the assembly, such as **10**, is rigidly connected to the wheel and the other half **12** is opened and closed by suitable cams. As the open mold assembly passes a predetermined point, a thick walled tube of hot plastic is deposited between the halves and subsequent closure of the mold assembly pinches off the tube at both ends to leave a sausage like hollow mass, or capsule, of plastic inside the closed mold.

Means are provided for inflating the hollow capsule thus

formed inside the mold to expand it out against the walls of the mold, while the air inside the mold and outside the capsule escapes through the peripheral crack where the top and bottom halves of the assembly abut. In FIGURE 5 I have indicated one mold assembly **38** and a preceding mold assembly at **40**. Both assemblies move in a circular path, indicated by the arrows **42**. The upper half of the assembly carries a cut-off plate **44** and the lower half a cooperating plate **46**. As the halves come together the plate **44** impinges on the tube protruding from between the halves and the tube is flattened by the halves and forced down in the narrow clearance space between the plates **44** and **46**. The final result is a gob of mutilated material, beginning at **48** (see FIG. 5), and extending up to the rear end of the preceding mold assembly at the point **50**.

After the mold has closed, a hypodermic needle **52** is employed to penetrate the caged sausage axially and blow compressed air into the interior thereof. A small hole **45** in the plate **44** affords access to the stretched plastic, where the needle moves in. I have indicated an actuating lever **54** pivoted at **56** and carrying the needle **52**. The upper end of the lever has a pin-and-slot connection at **58** with a piston rod **60** connected to the needle **52** by a flexible tube **62**.

Means are provided for moving the lever to activate the injection needle **52**. The cylinder **64** houses a piston **66** having an outlet **68** through the piston rod into the tube **62**. Air pressure of the order of magnitude of from 35 to 100 pounds gauge is delivered to the cylinder inlet **66** and the adjacent end of the passage **68** is covered by a flexible rubber disc **70** which partially covers the passage **68** because its single aperture at **72** is off-set. The initial delivery of pressure is throttled by the small orifice thus defined so that the injection needle is forced home first, at the beginning of the stroke, and after the stroke is completed the full line pressure enters through the injection needle **52** and forces its way along the axis of the sausage-like mass to inflate it.

The use of such a piston for activating an inflating needle constitutes no part of my present invention, having been used before my invention by others. But in the prior art the piston **64** was in the dotted line position indicated in FIGURE 5 and that made it necessary to locate the leading mold assembly **40** in the dotted line position of FIGURE 5. The result was a much larger amount of regrind material left exposed between the two sets of molds. According to my invention the locating of the power cylinder in the position illustrated in FIGURE 5 leaves clearance for positioning the second mold **40** in the full line position, with a greatly reduced amount of the tube cut off and thrown away, so far as the current operation is concerned. The discarding of a substantial amount of material at this point happens to be advantageous in the process involved, because it is removed and ground up again and blended with new material and such removal assists the personnel in compounding the new mix for fresh material. However, with the piston in the dotted line position the amount of regrind material was excessive and a decided disadvantage.

The Temperature Cycle

It is substantially necessary with polyethylene to have the surface of the mold **28** that lies in contact with the plastic material at approximately 110° F. during the forming process, so that the finished product will have a satisfactorily smooth surface. Accordingly, the average temperature of the heat transfer liquid **18** becomes quite important in securing satisfactory operation. As the mold is filled and emptied repeatedly, each filling

delivers an increment of heat, and the shell **28** of the mold transfers that heat into the transfer liquid **18**, from which it is removed by the coolant in the coils **29**. Because the total heat capacity of the transfer liquid **18**, when that liquid is water, is much greater than all the rest of the mold assembly, it is possible to keep that mass at an approximately uniform temperature of say 90° F. Each heat increment will raise it only a few degress and the inside temperature of 110° will provide a 20° temperature difference for heat to pass out through the mold into the transfer liquid, but the amount of heat in each increment is only enough to farm the transfer liquid through a small temperature range. During the rest of the cycle the rate of continuous removal of heat by the coolant coils **29** determines the average working temperature. The operator can observe the temperature of the transfer liquid **18** by means of an electric thermocouple at **36** in the wall of the outer shell and adjust the rate of flow of coolant by means of the valve **34** to secure optimum results continuously even though operating conditions change a little from time to time.

The molds **28** are conventionally made of aluminum, but it is also possible to make such molds of epoxy-aluminum mixture. Such a mixture of powdered aluminum with epoxy resin can be fashioned into the shape of such a mold much more readily than metallic aluminum and is often used for manufacturing a few samples at present. It is found to be practicable to have the transfer liquid **18** fill the space which encloses it completely, with no air pockets at all. The walls of the shell **16** can be made of steel and a very small bulging of all the walls of the chamber can take care of thermal-expansion when necessary. With permanent molds of cast aluminum, this is relatively immaterial, but it is possible to use epoxy-aluminum molds for substantial production runs if the material of the mold itself is provided with the right mechanical support to endure the forces of inflation. Thus, in assembling such a unit for a production run, with the contemplated working temperature for the transfer liquid **18**, 90° F., the assembled mold can be inverted from the position of FIGURE 3 and filled through the inlet **74** completely full with the temperature of the transfer liquid and the shell about 55° F. Subsequent sealing of the fill opening **74** and warming to the working temperature will generate a gentle inward pressure on the mold, and when the mold experiences the outward pressure of inflation, the shell and its trapped water filling is firm and unyielding, and prevents the inflation pressure from deforming the mold. Thus an epoxy-aluminum mold can withstand the repeated service stresses it could not otherwise endure without distortion if it were not squeezed, inwardly on the outside at the same time.

In FIGURE 4 I have indicated a similar mold **128** where the neck of the bottle is materially smaller. Because the material of the finished bottle is much thicker in the neck with such a small neck, it is desirable to have a stronger cooling action at this point. Accordingly I have indicated the material of the mold extended down at **76** into direct contact with the coolant coil **29**, so that a much more rapid local differential cooling action can be applied to the neck of the bottle. An insulating cover at **78** may be provided to increase the differential rate at which the bottle neck can be cooled compared with the thinner walls in the main portion of the bottle.

As compared with the solid aluminum dies with no heat control or effective temperature stabilization, which are at present in common use, an assembly as in FIGURE 2 according to the invention weighs about one-third as much and has six or eight times as much heat storage capacity, to keep the temperature of the active portion of the mold from fluctuating too much during use. The solid aluminum body involves a much greater capital investment in the metal itself, and the storage of a large assortment of such molds involves considerable expense.

More specifically, a mold **28** of epoxy-aluminum is readily formed from a putty-like mass containing about 80 percent powdered aluminum and 20 percent fluid epoxy resin, just sufficient in amount to cause the mass to form a dough that can be molded. It will also conduct heat about 80 percent as well as solid aluminum. Shortly after molding, the epoxy resin polymerizes and the mold is ready for use, but it does not have sufficient strength to endure the inflation pressures during a production run without mechanical reinforcement. A complete change of molds from one size and shape to another, within the size capacity of the equipment, involves merely changing the small element **28**, and this can be done while the complete assembly of FIGURE 2 remains in place on the machine, whereas changing from one product to another with solid aluminum molds requires the removal of the complete unit of FIGURE 2 and replacement by another complete unit.

Others may readily adapt the invention for use under various conditions of service by employing one or more of the novel features disclosed, or equivalents thereof.

For instance, where the available water contains a good deal of dissolved air, it can be used as is by filling up with water at about 50° F. One or two cubic centimeters of dissolved air will separate out, but at the subsequent working temperature the air will have been compressed up to about 15 pounds per square inch, and an epoxy mold will still have adequate mechanical support. If cool water is not available, a few minutes of boiling will remove the air.

It will be obvious that the well-known practice of having the closed mold with a transverse diaphragm in a plane intermediate the ends, and injection means at both ends of the mold, lends itself with readiness to the practice of invention.

During insertion of the cannula **52**, air in the cylinder **64** passes out through a vent **67** beside the piston rod, and when the air pressure is withdrawn, a spring **69** returns the piston to initial position. A convenient adjustment for the working stroke is an abutment ring **71** at the left end of the cylinder. This could be an adjustable set screw on a machine for a wide variety of operations, but for ordinary work the simple ring **71** is adequate, and permits a standard size cylinder **64** to be assembled on a variety of mold units and adapted at the time of assembly by selecting a ring **71** of the right axial length.

As at present advised, with respect to the apparent scope of my invention, I desire to claim the following subject matter:

1. Equipment for producing plastic bottles, or the like, comprising a twin water bath, each half having one open side adapted to receive a half mold; and cooling means for removing heat from said bath; the mold having a heat capacity not exceeding about 10 percent of the heat capacity of the entire assembly; and means for adjusting the rate of heat removal from the water bath to permit the mold to experience a predetemined temperature cycle repeatedly, with the temperature history of each cycle approximately identical with that of a previous cycle.

2. Equipment according to claim 1 in which said cooling means is a tubular element immersed in said bath, connections for circulating liquid coolant through said element, and adjustable valve means for regulating the flow of the coolant.

3. Equipment according to claim 1 in which one portion of the mold is in thermal contact with the bath; and a different portion of the mold is in direct thermal contact with said cooling means to secure more rapid cooling action for a thick-walled portion of the article.

4. Equipment according to claim 3 in which the last mentioned mold portion is at least partly insulated from the bath.

5. Equipment according to claim 1 in which each half

mold has portions of increased conductivity arranged to lie adjacent to points where the wall of the finished article has relatively great thickness.

6. Equipment according to claim 2 in combination with indicating means for showing the bath temperature, to guide the operator in adjusting said regulating valve means.

7. Mold equipment for producing plastic bottles comprising opposable water receptacles, each having one open side; and opposable half molds; each half mold having a generally concave side shaped to lie juxtaposed to a cooperating generally concave side of the other half mold to jointly define the outer shape of the finished article; each half mold having a generally convex side opposite said generally concave side; said generally convex side being shaped to fit in the open side of one of said receptacles and complete a sealed enclosure for liquid; whereby said half molds may be separably assembled with said receptacles to form a complete mold with a mass of

stabilizing liquid in close thermal conductive relation to the entirety of the assembled mold; said molds being removably mounted in said receptacles, to permit replacement with other molds having identical convex sides but different concave sides defining a different article shape.

8. Equipment according to claim 7 in which said half molds have generally convex sides of identical configuration.

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