APPARATUS FOR THE MANUFACTURE OF LAMPS AND THE LIKE

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This invention relates to the manufacture of composite articles having a fragile part and a molded plastic part, and more particularly to electrical devices such as lamps, radio tubes, heater tubes, photo-electric cells, and the like, which comprise a sealed glass envelope combined with a base.

In accordance with prior practice the base, whether made of metal, as in an ordinary lamp, or of insulation as in the case of a radio tube, is made separately and subsequently cemented to the envelope, after which the lead wires from the envelope must be soldered to appropriate contacts on the base. It is extremely difficult to satisfactorily cement the glass envelope to the base. In the case of an ordinary lamp the metallic base must be made in two parts mutually insulated from one another and to which the lead wires must be separately soldered.

The object of my invention is to generally improve the manufacture of composite articles and electrical devices, and more specifically to form a base directly on a glass envelope by molding the base around part of the envelope. In this manner the parts are permanently secured together and in all practical respects are combined to form an integral structure.

In accordance with a further feature and object of my invention, the base is preferably molded by transfer or extrusion, the molding material being preliminarily placed in a pressure chamber and subjected to heat and pressure in order to plasticize the same and to extrude the same in a relatively thin free-flowing stream into the mold for the base. A part of the glass envelope is itself caused to act as one wall of the mold cavity, and this is made possible without breakage of the glass envelope largely because the molding material does not enter the mold until it is in a free-flowing condition.

Another object of my invention is to further guard against the possibility of breakage or injury to the glass envelope, even when using a molding material such as synthetic resins of the permanently insusflusibly thermosetting type ("Durite", "Bakelite", "Durez", etc.), which materials require substantial pressure for polymerization. To this end, I extrude the material from the pressure chamber under a high pressure, but limit the maximum pressure within the mold to a comparatively low pressure insufficient to injure the glass envelope. The pressure is thus limited and relieved by automatic opening of the mold for discharge of excess molding material when the molding pressure exceeds the permissible or desired pressure.

The glass envelope ordinarily includes a reentrent tube or stem through which lead wires pass. One object of my invention is to prevent the molding material from filling the reentrent tube. Another object of my invention is to facilitate the provision of suitable connections or terminals for contact with a conventional socket.

To the accomplishment of the foregoing and other objects which will hereinafter appear, my invention consists in the improved method and apparatus elements and their relation to the other as hereinafter described in the specification and sought to be defined in the claims. The specification is accompanied by drawings, in which:

Fig. 1 is a partially sectioned elevation of a press equipped with apparatus for practicing my invention;

Fig. 2 is an enlarged section taken through the pressure chamber and mold;

Fig. 3 is an enlarged section through the mold;

Fig. 4 is a detail of a washer or stopper for blocking the open end of the reentrent tube;

Fig. 5 is a perspective view of the mold in open condition;

Fig. 6 is a partially sectioned elevation through apparatus including multiple pressure chambers feeding multiple mold cavities; and

Fig. 7 is a side elevation of a completed lamp bulb made in accordance with my invention.

The present application is a continuation in part of my earlier copending application Ser. No. 340,605 filed Feb. 16, 1929, now Patent 1,993,342, in which I disclose molding apparatus including a pressure chamber for heating and plasticizing and thereby transferring synthetic resinous material in a free-flowing condition into a communicating mold. I there explained that the pressure can thus be reduced to so low a point that it is possible to mold the material in mold cavities defined in glass, and that makes possible the molding of lamp bases and radio tube bases directly onto the glass tube enclosing the operating elements; and, further, that this dispenses with the operation of first forming a separate base and subsequently cementing such base to the glass bulb, which is altogether an undesirable process in that a wholly satisfactory job of cementing cannot be done.

The present application is also a continuation in part of my prior copending application Ser. No. 423,160 filed Jan. 24, 1930 now Patent 1,997,874, in which I disclose a transfer press.
somewhat as above described but modified to provide a pressure differential between the pressure chamber and the mold so that a small-diameter pressure chamber may be used, if desired, for the extrusion of molding material under super-hydraulic pressure, while at the same time the molding pressure may be limited to be relatively low and comparatively safe, thus making it possible to use relatively weak molds which are incapable of withstanding the high pressure developed in the pressure chamber.

The form of molding press for practicing my invention is shown in Fig. 1 of the drawings hereinafter referred to and is briefly stated that the apparatus comprises a pressure chamber C mounted on a vertically movable platen 12 and cooperating with a plunger P stationarily mounted on the fixed upper head 10 of the press. The pressure chamber and plunger cooperate to extrude molding material into a two-part mold M which, in accordance with the present invention, has an open side closed by the glass envelopel 5 of an electrical device, in this case a lamp. The entire press is operated by upward movement of a main ram R, which moves the mold M against pressure chamber C, and then moves the pressure chamber against plunger P. The upward movement of chamber C is preferably yieldably resisted by auxiliary rams A, thus limiting the force with which mold M is held closed.

The molding material forced from the pressure chamber into the mold is molded into a lamp base formed directly around the end of the glass envelope, resulting in a lamp of the general type illustrated in Fig. 7 and comprising a glass envelope E having molded directly on the stem end 12 thereof a base 14 made wholly of a moldable insulating material, preferably a synthetic resin. Two lead wires extend from the lamp filament through the lamp stem and through an insulating base 14. One of these wires is connected to a terminal 18 at the bottom of the base, while the other wire is connected to a terminal 18 at one side of the base. Terminal 18 is preferably located at the upper surface of one of the threads 20 on the base, thereby insuring firm contact against the terminal when the lamp is screwed into a socket.

The mode of lamp assembly may be described in greater detail with reference to Figs. 2 through 5 of the drawings, and referring to these figures the mold M is a two-part separable mold comprising a lower part 22 and an upper part 24. Between is located a plunger P mounting the mold 28 (Fig. 5) conforming to the configuration of lamp base 14. Part 24 is provided with passages 28 and 30 (Fig. 5) dimensioned to receive the lead wires 32 and 34 of lamp filament 30. The outer walls of the mold are preferably recessed at the bottom of passages 28 and 30, as indicated at 38 and 40, thereby providing room for any excess length of lead wire (see Fig. 3).

To prevent the molding material from entering reentrant tube 42 of the envelope, I stop the end of the reentrant tube with a suitable insulating member 43, as shown in Fig. 4. The washer is provided with small holes 45 dimensioned to receive the lead wires, and a larger hole 48 dimensioned to receive the evacuation tube or pump stem 60. The holes 45 and 48 are dimensioned to fit snugly, and the washer 44 is held in place until molding material enters the mold cavity, at which time the washer is pressed firmly against the end of the envelope and under pressure is compressed more tightly around the terminal wires and stem, thus effectively stopping any flow of molding material into reentrant tube 42 of the lamp. The presence of molding material in the reentrant tube might be thought by some to be objectionable in appearance or in operation or for wastage of material. I have found that certain grades of phenolic laminated sheet material possess the punchability, resilience, strength, electrical insulating properties, and resistivity at an elevated temperature needed for a washer of this type, but it will be understood that other materials may be used.

In operation, the lamp envelope E is preliminarily provided with washer 44 which is slipped into place over lead wires 32 and 34. The envelope is then applied to the open side of the mold, lead 32 being guided through passage 28, and lead 34 being guided through passage 30. If excessively large, the ends of leads 32 and 34 are bent over, but the leads are not pulled with unnecessary tightness. The mold and lamp assembly is then prepared and placed in the press by setting the same in heated angle plate 85, and the lamp envelope is held in place by a pressure foot 84 (Fig. 2) yie'dably urged against the outer end of the envelope. In the present case the pressure foot 84 is bent over so as to supply pressure to the mold chamber C by a pressure foot 84 housed in a cylinder 86 and bearing against the inner end of a plunger 88 reciprocable in cylinder 88. The pressure foot may be retracted during the loading or unloading of the lamp and mold by means of a manually operable handle 82 having a camming end 84 pivotted on a block 90 carried on a rod 98 connected to plunger 88. Block 86 is adjustably held on rod 88 by locked nuts 90. The pressure of spring 96 is preferably adjustable in order to control the relief pressure limit for the molding operation, and in the present case this adjustment is obtained by the use of a suitable number of loading washers 72. When the mold and lamp assembly is placed on an angle plate 82, handle 82 is moved downwardly from horizontal to vertical position, thereby releasing pressure foot 84 to bear against glass envelope E.

A charge of molding material is placed in pressure chamber C and is heated by a heating medium passing through conduits 76. Plunger P may then be in motion by means of a motor 74 on a heated plate 78, in which case a layer of heat insulating material 76 is preferably interposed between plate 76 and press head 80. It will be understood that upon relative movement of plunger 88 and pressure chamber C, the molding material is plasticized and extruded through a relatively tiny discharge opening 82 at the bottom of the pressure chamber. The lower end of plunger P and pressure chamber C are preferably mately tapered, as is indicated at 84, and the wall of the 84, as is indicated at 84, thereby forming a sealing ring which holds with molding material and thereby seals the plunger against leakage even at very high pressure, although for the present purpose it is not necessary to use superhydrulic pressures.

The lamp is molded through outlet 82 flows directly into a feeder channel 88 preferably formed between the parts 22 and 24 of the mold, as is best shown in Fig. 5. Feeder channel 88 registers with outlet 82, this registration being insured by dowels 89 mating with dowel holes 82 at the top of the mold. Channel 88 preferably diverges, as shown in Fig. 5, thereby affording a rapid transfer of the molding material from the
pressure chamber into the mold, and at the same time facilitating removal of the molding material from the feeder channel as well as the mold cavity upper surface. Referring to Figs. 3 and 5, this complete removal and emptying of the mold and passages leading thereto is essential when dealing with a permanently setting resin.

Referring to Figs. 3, 4, and 5, it will be noted that the feeder channel 56 opens into an annular space forming a cup-like recess 56 at the bottom of the lamp base. This recess facilitates a subsequent drop-soldering operation for the center lamp terminal 46 shown in Fig. 7. The feeder channel or gate 56 is preferably located at the outer end of projecting lip 54, as shown, because this facilitates subsequent removal of the gate and grinding of any surplus material at the junction point.

The molding material enters the mold cavity in a plastic free-flowing condition and spreads around the lead wires, against the stop washer 44, around the end 100 of glass envelope E, and accurately fills out the thread grooves 58. The end 100 is preferably ridged as indicated at 102, or otherwise shaped to form undercutting so that the envelope and base are inseparably locked together. When the pressure in the mold builds up to a value greater than the permissible value determined by compression spring 56, the glass envelope moves outwardly with pressure foot 54, and the excess molding material is forcibly discharged around the periphery 104 of the mold cavity. The charge of molding material initially placed in the pressure chamber is preferably only slightly greater than needed to form the base, and when the excess flows from the mold, the glass envelope is instantly restored to initial position, thereby cutting off the excess material at mold periphery 104. The material is severed sharply, and the base is given a well-defined cleanly molded lip requiring little if any trimming or finishing.

The permissible outward movement of the glass envelope is preferably limited to a relatively slight amount by stop means, here exemplified by an ear 105 on pressure foot 54 cooperating with an adjustable stop screw 108 the adjustment of which is locked by nut 110. This limitation of movement is desirable in order to prevent stress on the lead wires.

At the end of the molding operation, it is merely necessary to elevate the pressure chamber from the mold; retract pressure foot 54 by means of handle 62, thereupon remove the lamp and mold from angle plate 52, with the assistance, if desired, of an ejector rod 112; open the mold by separating part 24 from part 22; and extract the lamp, with its molded base and projecting lead wires, from the mold. It was previously mentioned that a recess 95, is formed in the base around lead wire 32, and it may now be re marked that a recess 114 is similarly formed around lead wire 34. The present base is a threaded base intended for use in a conventional threaded lamp socket, and the lamp is held in the base by the threaded part of the socket. To complete the lamp, the ends of leads 32 and 34 may be clipped off at recesses 96 and 114, and metallic contact terminals may be formed by simply dropping molten solder in recesses 96 and 114. Because of surface tension, the molten metal takes the form of a contouring the outline of 16 and 18 in Fig. 7. While the location of terminal 16 may be varied with respect to the thread struc-
ture, I believe it preferable to locate the same at the upper part of a thread, as shown, so that the upward pressure caused when the lamp has been screwed into a socket elevates terminal 16 against the immediately superjacent socket thread.

Because it is desirable to limit the outward or venting movement of the glass envelope to a slight amount, I prefer to further safeguard the glass envelope against blow back, as in the event of an excessive charge of molding material being placed in the pressure chamber, by affording additional pressure relief by separation at the parting face of the mold. This result is best accomplished by using a press arrangement such as I have illustrated in Fig. 1, and referring to that figure it will be seen that the press comprises a stationary bed 120, and a stationary upper head 80 mounted above bed 120 on four posts or strain rods 122. A lower head 124, vertically reciprocable on strain rods 122, is carried by a main operating ram R the hydraulic cylinder for which is not shown in the drawings. A support plate 126 is mounted on head 124 and carries angle plate 52 as well as the assembly for pressure foot 54 and ejectors 112 (the operating mechanism for which is not shown).

Pressure chamber C is mounted on a vertically reciprocable plate 128 guided by strain rods 122 and carried by piston rods 130 located between the front and rear strain rods and connected to auxiliary or opposed hydraulic cylinders A which are mounted on stationary head 80. Plate 128 is constantly but yieldably urged downwardly by hydraulic mechanism A, and the downward movement of the plate when the press is opened is limited by stop collars 132. In the drawings, the press is shown in open condition but plate 128 is elevated above stop collars 132 in order to more clearly show the manner in which the plate is mounted on piston rods 136. When the press is open, the bottom head 124 is in lowest position, and the lamp and mold are readily placed between angle plate 52 and pressure foot 54. The plate 128 is in intermediate position, and is dropped well below plunger P, thus facilitating the deposit of a measured charge of molding material in the pressure chamber. The press is closed by lowering main ram R, thereby bringing the mold against the bottom of the pressure chamber and forming a continuous flow passage from the pressure chamber into the mold. At the same time stop mechanism 106, 108 becomes effective. The mold is held closed by a force dependent on the area of and pressure applied to the pistons in auxiliary cylinders A. Main operating ram R continues its upward movement, thereby carrying the mold and pressure chamber assembly upwardly against plunger P, which, of course, ejects the charge of molding material from the pressure chamber into the mold. Injury to the lower ends of the plunger and pressure chamber may be prevented by the use of appropriate stop blocks 134.

It should be appreciated that mold M is held closed yieldably rather than fixedly, and when ever the pressure in the mold cavity exceeds a predetermined desired or permissible value, the halves of the mold may separate, thus affording prompt pressure relief at the parting face of the mold. Reverting to Fig. 5, it will be seen that I provide overflow channels 136 following or contouring the outline of 16 and 18 as well as the assembly for overflow channel 138 at the upper face of the mold immediately adjacent 16.
feeder channel 88. When the mold pressure is relieved by momentary opening or chattering of the mold assembly, the separation may take place along facing of the mold or the parting face between the mold and the pressure chamber, or both, and excess material is correspondingly discharged into the overflow channels 136 or 138 or both. If desired, the relief pressure determined by pressure foot 54 may be given a different value than that determined by auxiliary cylinders A, preferably a lower value so that ordinarily the pressure relief takes place around the glass envelope alone. With such an arrangement, the additional pressure relief made possible is intended to become operative only when the pressure is incapable of being relieved sufficiently fast around the envelope.

Upon completion of the molding operation, ram R is lowered, thereby first separating the pressure chamber from the plunger, and thereafter separating the mold from the pressure chamber. Pressure foot 54 is retracted and the mold and lamp removed from the press. The mold is a portable or hand mold, and a plurality of molds are provided. One may be loaded with a lamp envelope to be provided with a base, while another may be in the press undergoing the molding operation, and a third may have been removed from the base and be having the lamp with its freshly molded base removed from the mold. This, of course, speeds up the molding operation.

To further this end, a number of mold cavities may be fed from a single pressure chamber, or a series of mold cavities may be fed from a plurality of pressure chambers. An arrangement of this kind is illustrated in Fig. 6 in which I show the mold as comprising separable upper and lower parts 140 and 142 defining a plurality of mold cavities 144, each open at one end, just as has heretofore been described. Molding material is fed to the mold cavities from a plurality of pressure chambers 146 mounted in a common heated bed plate 148. The pressure chambers cooperate with mating plungers 150. The mold and pressure chambers are aligned by suitable pins 152, while the upper and lower mold parts are aligned by pins 154. The molding material is fed into a common lateral feeder channel 156 recessed in the top face of the upper mold portion 140 and underlaying and directly connected with the outer face of the pressure chambers. The mold cavities have individual and preferably diverging feeder channels 160 which connect with lateral feeder channel 156. It will be understood that the arrangement is generally like that heretofore described except that the mold is elongated in a direction transverse to the drawings when looking at Figs. 1, 2, and 3. The mold is accordingly similarly placed on a heated angle plate attached to the lower head of the press, and several molds may similarly be made inter-changeable with one another, thus permitting the use of one in the press during the molding operation while another is being separated from or assembled with the lamp envelopes. During the molding operation, the several lamps are held in position in the mold by a multiplicity of means that heretofore described. While I show one pressure chamber for each two and a half mold cavities, it will be understood that I am not limited to this specific construction, but may make such arrangement of pressure chambers and mold cavities with interconnecting feeder channels as may suit my purpose.

It is believed that the method of my invention, as well as the construction and operation of the apparatus for practicing the same, and the many advantages thereof, will be apparent from the foregoing detailed description. The lamp base is essentially a single-piece insulation base molded directly around the envelope and permanently secured thereto. While not essential, even so high-grade an insulating material as the permanently insuffused thermostatic synthetic resins may be used. The material is molded directly around the glass envelope without injury or breakage of the glass envelope. Electrical terminals for connection to the lead wires are obtained in convenient manner. The lamp base has molded thereon any necessary means for cooperating with a conventional socket, the most common example, of course, being the use of threads, but inserted bayonet pins or bottom prongs, or the like may also be molded in place for use with special sockets. It will be apparent that while I have shown and described my invention in preferred forms, many changes and modifications may be made without departing from the spirit of the invention, defined in the following claims.

I claim:

1. Apparatus for molding a plastic composition base directly around the lower end of a sealed fragile glass envelope, said apparatus comprising a mold defining a mold cavity for producing a base, said mold being open at one side corresponding to the top of the base and being dimensioned to receive the lower end of the glass envelope, means to hold the glass envelope in the opening of the mold, passages in said mold for receiving the ends of lead wires projecting from the glass envelope, a pressure chamber in flow communication with said mold, means to heat the pressure chamber, and a plunger movable in said chamber for extruding molding material therefrom into said mold, and means to prevent the pressure in the mold from exceeding a low pressure incapable of breaking the envelope, regardless of the pressure reached in the pressure chamber.

2. Apparatus for molding a plastic composition base directly around the lower end of a sealed glass envelope, said apparatus comprising a mold defining a mold cavity for producing a base, said mold being open at one side corresponding to the top of the base and being dimensioned to receive the lower end of the glass envelope, protruberances in the mold cavity at the lead wire passages to form drop solder rese cences on the base, stop means to limit the movement of the yieldable means, a pressure chamber in flow communication with said mold, a plunger movable in said chamber for extruding molding material therefrom into said mold, and means to prevent the pressure in the mold from exceeding a low pressure incapable of breaking the envelope regardless of the pressure reached in the pressure chamber.

3. Apparatus for molding a base directly on a sealed glass envelope, said apparatus comprising a mold defining a mold cavity for producing a base, said mold being open at one side corresponding to the top of the base and being dimensioned to receive the lower end of the glass envelope,
yieldable means to hold the glass envelope in the opening of the mold, passages in said mold for receiving the ends of lead wires projecting from the glass envelope, a pressure chamber in flow communication with said mold, a plunger moveable in said chamber for extruding molding material therefrom into said mold, means for causing relative movement of the plunger and pressure chamber, and yieldable means for holding the mold closed during the molding operation, the parts being so adjusted that the yieldable means holding the envelope in the mold and the yieldable means holding the mold open afford opening and discharge of excess material from the mold at a relatively low pressure insufficient to injure the glass envelope.

6. Apparatus for molding a base directly on a sealed glass envelope, said apparatus comprising a two-part mold defining a mold cavity for producing a base, said mold being open at one side corresponding to the top of the base and being dimensioned to receive the lower end of the glass envelope, yieldable means to hold the glass envelope in the opening of the mold, passages in said mold for receiving the ends of lead wires projecting from the glass envelope, a pressure chamber in flow communication with said mold, a plunger movable in said chamber for extruding molding material therefrom into said mold, means for causing relative movement of the plunger and pressure chamber, and yieldable means for holding the mold closed during the molding operation, the parts being so adjusted that the yieldable means holding the envelope in the mold and the yieldable means holding the mold open afford opening and discharge of excess material from the mold at a relatively low pressure insufficient to injure the glass envelope.

7. Apparatus for the manufacture of a composite article having a fragile preliminarily manufactured part and a part made of a moldable plastic, said apparatus comprising a mold defining a mold cavity for producing the plastic part of the article, said mold being open at one side corresponding to the point of connection between the fragile and plastic parts of the article, said opening being dimensioned to receive and to be closed by the fragile part of the article, means to hold the fragile part in the aforesaid mold opening, a pressure chamber in flow communication with said mold, means to heat the pressure chamber, a plunger movable in said chamber for extruding the molding material from the chamber into the mold, and means to prevent the pressure in the mold from reaching a pressure capable of breaking the fragile part of the article, regardless of the pressure in the pressure chamber.

8. Apparatus for the manufacture of a composite article having a fragile preliminarily manufactured part and a part made of a moldable plastic, said apparatus comprising a mold defining a mold cavity for producing the plastic part of the article, said mold being open at one side corresponding to the point of connection between the fragile and plastic parts of the article, said opening being dimensioned to receive and to be closed by the fragile part of the article, yieldable means to limit the movement of the parts of the article, a pressure chamber in flow communication with said mold and a plunger movable in said chamber for extruding molding material therefrom into said mold.

9. Apparatus for the manufacture of a composite article having a fragile preliminarily manufactured part and a part made of a thermosetting plastic moldable under heat and pressure, said apparatus comprising a mold defining a mold cavity for producing the plastic part of the article, said mold being open at one side and being dimensioned to receive and to be closed by the fragile part of the article, yieldable means to limit the movement of the parts of the article, a pressure chamber in flow communication with said mold, and a plunger movable in said chamber for extruding molding material therefrom into said mold, means to heat the pressure chamber, and means to heat the mold.

10. Apparatus for the manufacture of a composite article having a fragile preliminarily manufactured part and a part made of a moldable plastic, said apparatus comprising a two-part mold defining a mold cavity for producing the plastic part of the article, said mold being open at one side corresponding to the point of connection between the fragile and plastic parts of the article, said opening being dimensioned to receive and to be closed by the fragile part of the article, yieldable means to limit the movement of the parts of the article, a pressure chamber in flow communication with said mold, and a plunger movable in said chamber for extruding molding material therefrom into said mold, means to cause relative movement of the plunger and pressure chamber, yieldable means for holding the mold closed during the molding operation, said means being so adjusted as to afford opening and discharge of
excess material from the mold at a relatively low pressure insufficient to injure the fragile part.

11. Apparatus for the manufacture of a composite article having a fragile preliminarily manufactured part and a part made of a moldable plastic, said apparatus comprising a two-part mold defining a mold cavity for producing the plastic part of the article, said mold being open at one side corresponding to the point of connection between the fragile and plastic parts of the article, said opening being dimensioned to receive and to be closed by the fragile part of the article, yieldable means to hold the fragile part in the mold opening, a pressure chamber in flow communication with said mold, a plunger movable in said chamber for extruding molding material therefrom into said mold, means for causing relative movement of the plunger and pressure chamber, and yieldable means for holding the mold closed during the molding operation, the parts being so adjusted that the yieldable means holding the fragile part in the mold and the yieldable means holding the mold closed afford opening and discharge of excess material from the mold at a relatively low pressure insufficient to injure the fragile part.

12. Apparatus for the manufacture of a composite article having a fragile preliminarily manu-
ufactured part and a part made of a moldable plastic, said apparatus comprising a two-part mold defining a mold cavity for producing the plastic part of the article, said mold being open at one side corresponding to the point of connection between the fragile and plastic parts of the article, said opening being dimensioned to receive and to be closed by the fragile part of the article, and yieldable means to hold the fragile part in the mold opening, stop means to limit the movement of said yieldable means, a pressure chamber in flow communication with said mold, means to heat the pressure chamber, a plunger movable in said chamber for extruding molding material therefrom into said mold, means to heat the pressure chamber, a press including a main operating ram for causing relative movement of the plunger and pressure chamber, and auxiliary rams for yieldably holding the mold closed during the molding operation, the parts being so adjusted that the yieldable means holding the fragile part in the mold and the yieldable means holding the mold closed afford opening and discharge of excess material from the mold at a relatively low pressure insufficient to injure the fragile part.

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