

Sept. 22, 1959

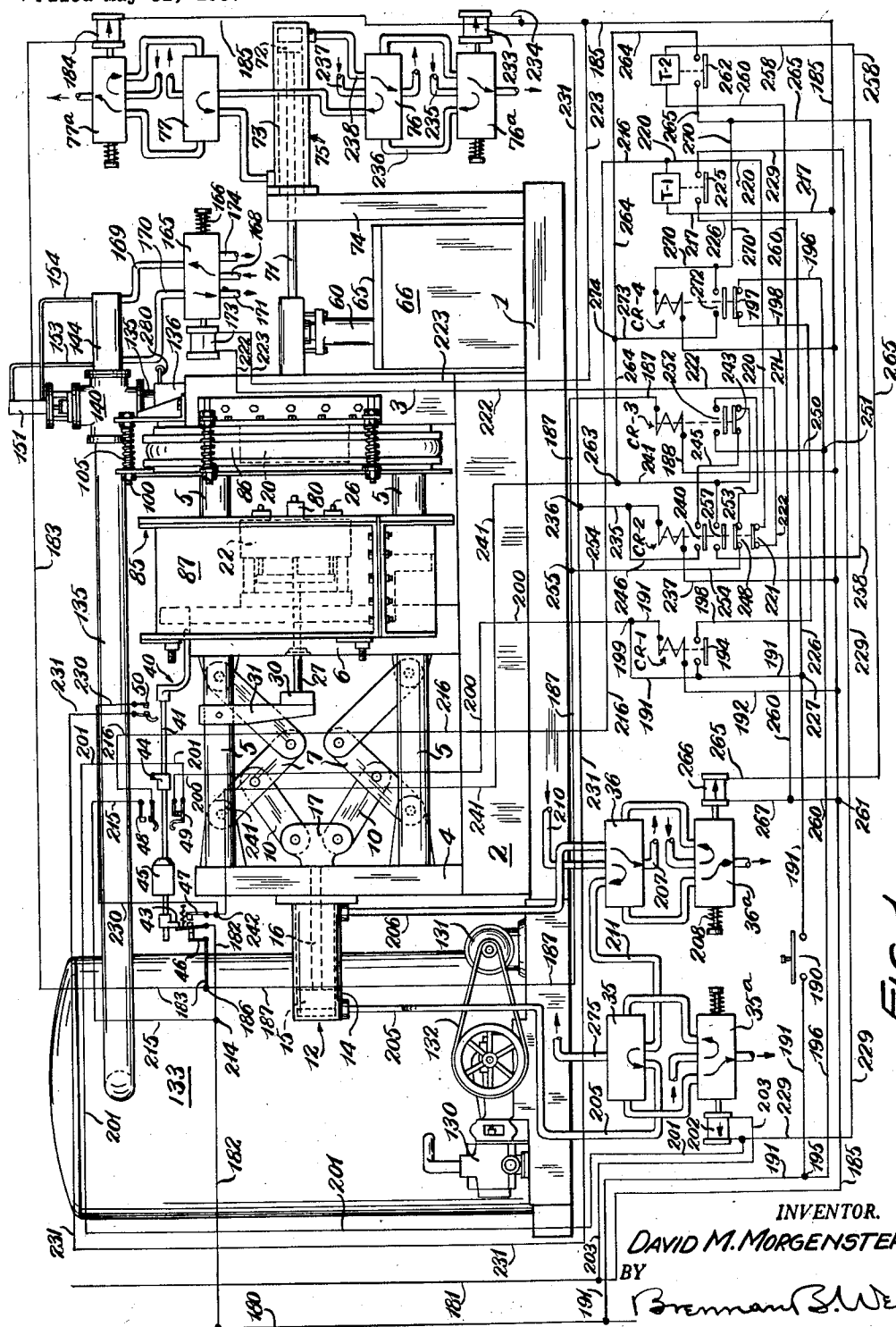
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2,904,861

APPARATUS FOR AND METHOD OF DIE CASTING UNDER VACUUM

Filed May 31, 1957

5 Sheets-Sheet 1



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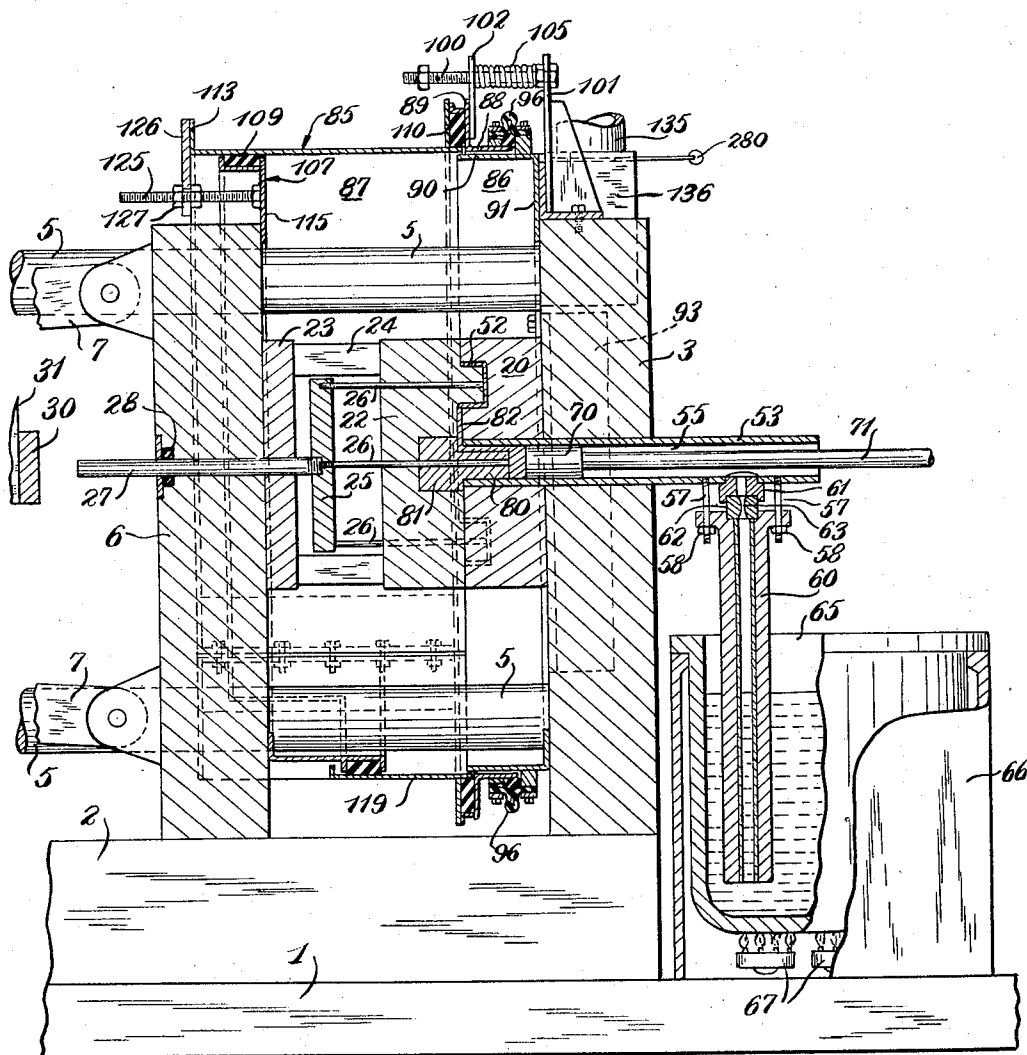


FIG. 4

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Filed May 31, 1957

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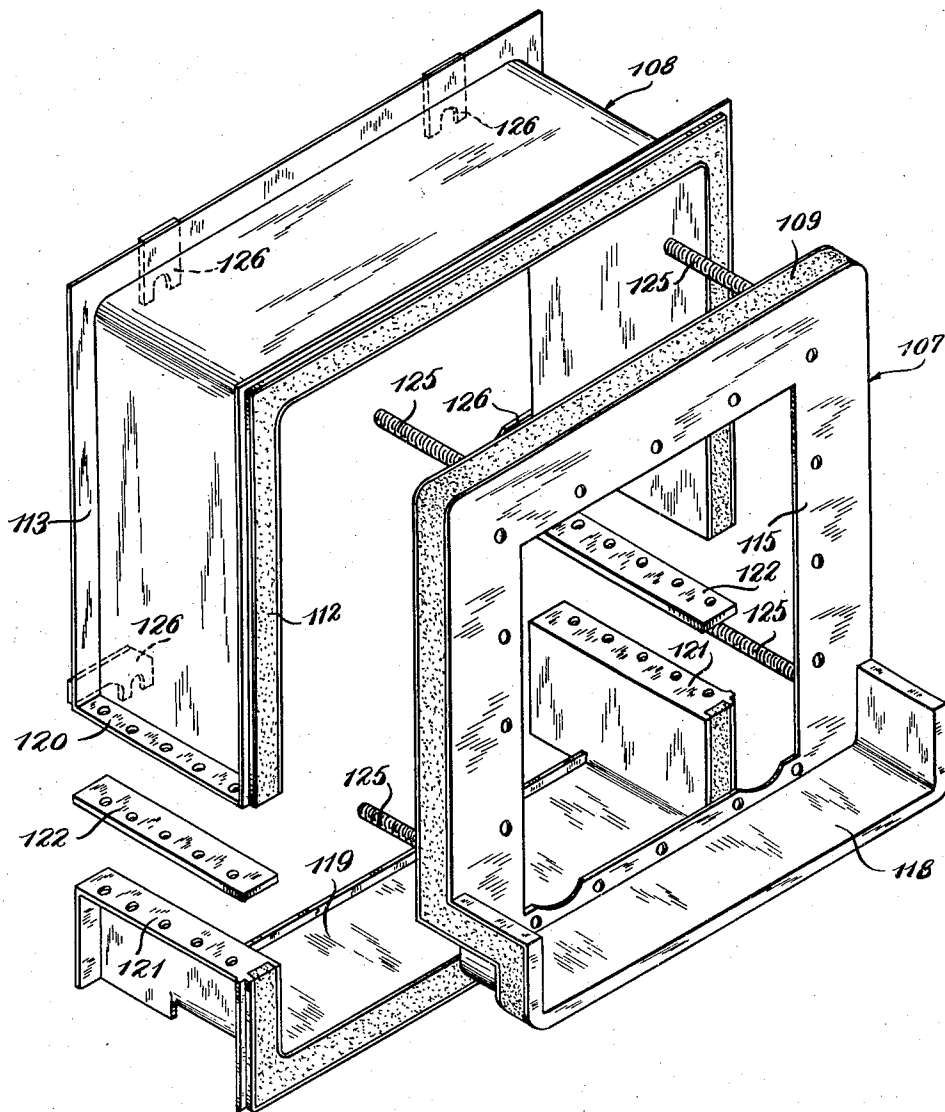


FIG. 5

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5 Sheets-Sheet 5

FIG. 6

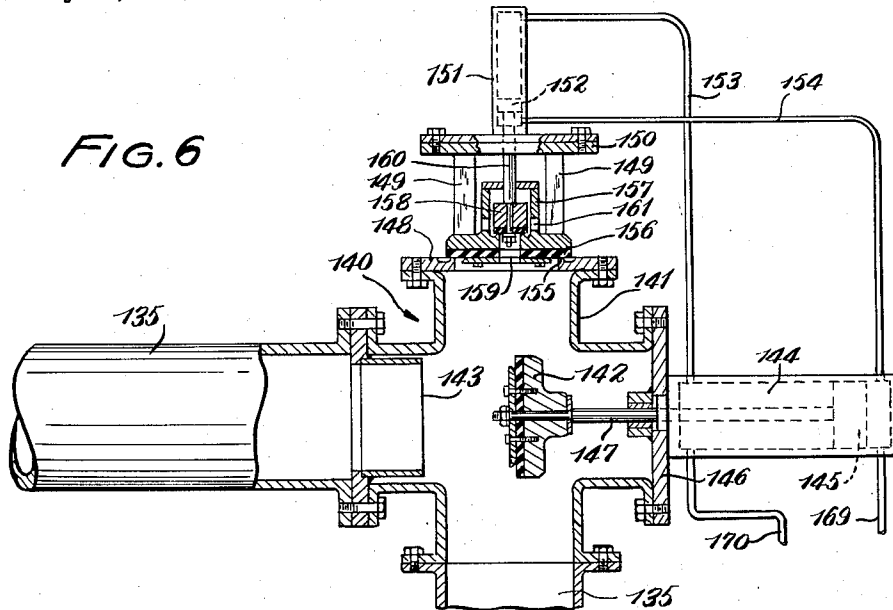
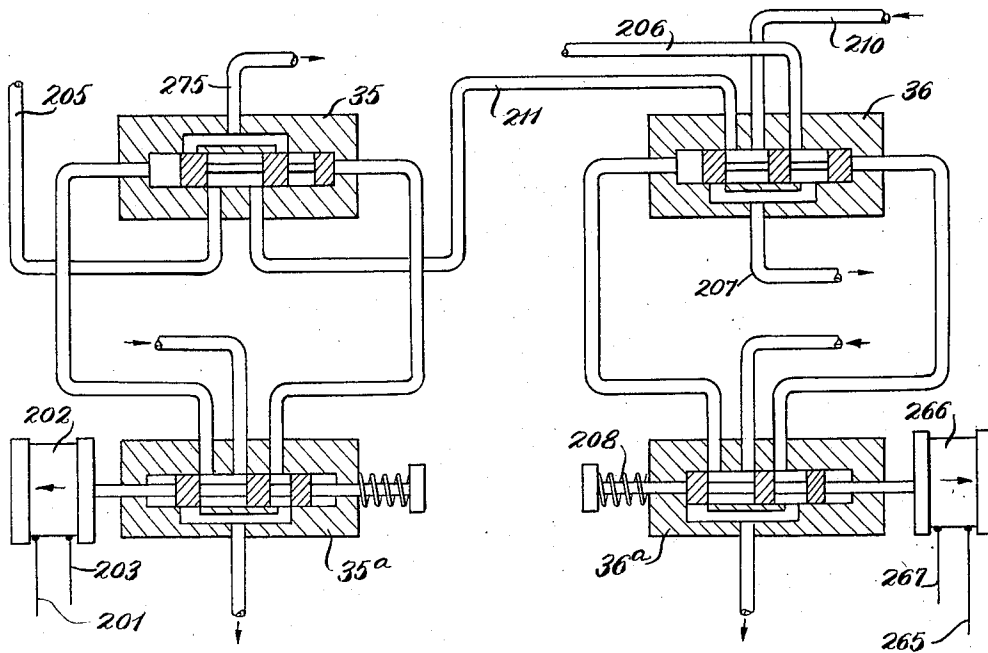


FIG. 7



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APPARATUS FOR AND METHOD OF DIE CASTING UNDER VACUUM

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Application May 31, 1957, Serial No. 662,888

19 Claims. (Cl. 22—73)

This invention, like those that constitute the subject matter of copending applications Serial No. 403,565, filed jointly by Alfred P. Federman and myself on January 12, 1954, now Patent No. 2,799,066, issued July 16, 1957, and Serial No. 543,832, filed by me alone on October 31, 1955, now Patent No. 2,864,140, issued December 15, 1958, relates to the art of die casting under vacuum; and it resides in further improvements in both method and apparatus.

As regards the apparatus, it is my desire, as in the former cases, to adapt my improvements, insofar as it is practicable, to incorporation in die casting machines of prevailing type, although it is to be understood that the invention, in many of its aspects, is not limited in its embodiment to conventional die casting equipment.

Like the more recent of the predecessor inventions, the present one follows the so-called "cold chamber" procedure in the feeding of the molten material to the die cavity, minus, however, the earlier practice of pouring the molten material into the charging chamber by means of a ladle. In the present case, as in the prior one just mentioned, the charging chamber communicates with a crucible that is situated at a lower elevation than said chamber through a conduit or passage desirably including a metering orifice. Where the passage opens into the charging chamber it forms the inlet port of said chamber, and a ram operates in the charging chamber to force molten material therefrom into the die cavity, the ram serving to close the inlet port at the very beginning of its working stroke, thereafter, according to my present preference, opening said port to the atmosphere. As will presently appear, one phase of the instant invention is tied in with the feeding of the molten material from the crucible to the charging chamber by reason of a pressure differential between the two locales.

A device common to the present and predecessor inventions is a hood or enclosure that surrounds the dies and is so constructed as to facilitate its being opened and closed. As known to those familiar with die casting machines of the usual sort, the dies are relatively movable toward and from each other, and a die cavity is defined by and between them when they are in engagement. The hood is adapted to be closed and rendered substantially airtight, and then evacuated by subjecting its interior to suction that is sufficiently powerful and enduring to immediately create and maintain in the hood and in all spaces communicating therewith a vacuum of relatively high degree, the foregoing taking place while the dies are relatively moved toward each other and finally into engagement so as to close the die cavity and entrap therein a part of the rarified atmosphere prevailing in the hood. Another phase of the present invention pertains to unique features of the hood or enclosure.

A fundamental purpose of my present invention is to provide improved die casting means and method that will speed up production and/or produce superior castings as compared with the production rate and quality of product of the predecessor inventions.

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Two other highly important and related objects of the present invention are, first, to utilize atmospheric pressure for feeding the molten material from the crucible to the charging chamber, and, secondly, to take advantage of the draft incident to the evacuation of the hood or enclosure while the charging chamber is in communication therewith for carrying off gases liberated from the molten material while it reposes in the charging chamber and is exposed to the rarified atmosphere. The attainment of the first of these objects contributes to speedier production, and the attainment of the second improves the quality of the casting by further reducing porosity beyond that accomplished by the predecessor inventions where evacuation of the die cavity alone was depended upon for such purposes. It will become more apparent as this disclosure unfolds that die castings of denser molecular structure, smoother surface, and greater strength and malleability; and die castings susceptible to thinner wall formations, result from my present improvements.

It may be pointed out as a further advantage of evacuating the charging chamber and die cavity, that less opposition is offered the ram in impelling the material into the die cavity and, therefore, the action of the ram is accelerated.

Another object of my invention is to provide a two-section vacuum hood for die casting machines wherein at least one section is adjustable and/or a part thereof removable to afford easier access to the enclosed die and thus facilitate the changing of dies, and better adapt the hood to dies of different depths.

More limitedly, an object of the invention is to provide a vacuum hood for die casting machines that is composed of two sections for attachment, respectively, to the relatively movable platens, and wherein the section associated with one platen is composed of an inner member that attaches to said platen, and an outer member that surrounds and is slidable upon a continuous peripheral bearing and sealing part of the inner member for movement with respect to the latter in an axial direction.

A further object is to provide simple means, convenient of manipulation, for accomplishing and retaining the desired adjustment of the outer member of the hood section relative to the inner member.

A still further object is to construct the outer member of said hood section of upper and lower parts that are detachably connected together along the opposite sides of the section so that the upper part may be disconnected from the lower part and retracted as far as necessary or removed to permit unobstructed access to the enclosed die as well as to such elements as may be associated therewith, i.e., ejecting mechanism, movable cores, and conduits and connections of a coolant system, all relatively common in die casting machines.

The foregoing objects and advantages, with others that will appear as this description proceeds, are attained in the embodiment of the invention illustrated in the accompanying drawings, and by means of which my improved method may be practiced.

In the drawings:

Fig. 1 represents, in side elevation and of simplified construction, a conventional die casting machine equipped with my improvements that render it capable of producing die castings under vacuum, the present view showing the working parts in the positions they occupy between cycles, and being largely schematic;

Fig. 2 is an enlarged vertical sectional view of the hood and adjacent parts of the machine, showing the hood and associated working parts as they appear soon after the start of a cycle, with the hood closed and the dies apart but with the dam extended a short distance

into the charging chamber and with a charge of molten material reposing in said chamber;

Fig. 3 is a fragmentary transverse section on the line 3—3 of Fig. 2;

Fig. 4 is a view, similar to Fig. 2, showing the extensible hood section contracted and the dies engaged with each other and the ram advanced to the position it occupies when the charge of molten material has been injected into the die cavity;

Fig. 5 is an exploded perspective view of the adjustable hood section;

Fig. 6 is a sectional view of a valve means by which the evacuation of the hood is effected at one stage of a cycle of operation, and by which admission of atmospheric air to the hood is accomplished at another stage of the cycle, and

Fig. 7 is an enlarged detail view, partly in section, of the master and pilot valves, and the electrical actuator of the latter, that control the operation of the hydraulic power unit that operates the movable platen, this being representative of similar control means operatively associated with the power unit that reciprocates the ram, the illustration being somewhat schematic.

I have shown my improvements incorporated in a die casting machine of a well known type, simplified for the purpose of the present disclosure by the omission of some of the usual structural features of the machine, and by a schematic illustration of others.

Throughout the several views of the drawings, like parts are designated by like reference characters, and referring to Fig. 1, an elongated flat bed 1 supports intermediate its ends the machine base 2. Secured to and rising from the front end of the base 2 is the stationary platen 3, and a tie plate 4 rises from the opposite end of the base and is suitably fastened thereto. Four relatively heavy tie bars 5, familiar in this type of machine, are supported by and between the stationary platen 3 and the tie plate 4. Movable along these tie bars and reciprocally supported by the base 2 is the movable platen 6. Toggle joints 7 have their opposite ends connected through suitable brackets to the movable platen 6 and the tie plate 4, and they are operated in the usual manner, by a power unit 12. Said power unit, in the present instance, consists of a cylinder 14, carried by the tie plate 4, and a piston 15 that operates in said cylinder and has connection, through its rod 16 and a head 17 and links 18, with the toggle joints 7.

Fastened, as in the usual manner, to the stationary platen 3 is a die 20, and a mating die 22 is attached to the movable platen through a plate 23 and a plurality of posts 24 (Fig. 2), thereby to provide a space between the die 22 and the plate 23 for the accommodation of parts of ejecting mechanism. This mechanism includes a head 25 and ejector pins 26 that are reciprocable in bores in the die 22. A plunger 27 has its forward end secured to the ejector head 25 and operates within aligned bores of the plate 23 and the platen 6, the joint between the plunger and said platen being shown as sealed by an O ring 28. When the movable platen 6 is retracted and closely approaches the limit of its rearward movement, the plunger 27 engages a stop 30 that is supported, through brackets, from the upper tie bars 5, one of which brackets is shown in Fig. 1, where it is designated 31. This results in stoppage of the ejector head 25 while the platen continues to move the remaining short distance and, through the ejector pins 26, dislodge the casting from the movable die.

Operatively associated with the power unit 12 are a master die-closing valve 35 and a master die-opening valve 36; and the operation of these master valves is effected through the respective pilot valves 35^a and 36^a. The general character and mode of operation of these valves will be apparent from Fig. 7, and valves substan-

tially identical with these are shown and described in the above identified applications.

Mention may here be made of a switch actuator, designated generally by the reference numeral 40, that is shown (Fig. 1) as directly connected to the movable platen 6 so as to move in unison therewith. The actuator includes a rod 41 that carries, in properly spaced relation to one another, switch engaging fingers 43 and 44, and a switch operating cam 45. In the path of movement of the fingers and cam are a ram-return switch 46 that is biased to open position, but which is held closed by the finger 43 between cycles; a die-open limit switch 47, which is biased to closed position and is held open by the finger 43 between cycles, said switches including an intermediate oscillating blade common to both and which is the part engaged by said finger; a so-called "evacuating" switch 48 that is biased to open position; a die-dwell switch 49 that is biased to closed position, and a die-close limit switch 50, that is biased to open position.

A die cavity 52 is defined by and between the dies 20 and 22. 53 is a housing or shell that encloses a charging chamber 55 that is desirably cylindrical. Said chamber opens through the face of the die 20, and, in the present construction, the forward end of the housing or shell 53 projects through and is sealed in aligned openings of the stationary platen 3 and the die 20.

The housing or shell 53 extends rearwardly some distance beyond the front face of the stationary platen 3 and has secured to it, by studs 57 and nuts 58, means for delivering a charge of molten material to the charging chamber comprising a supply pipe or conduit 60. Shown (Fig. 2) interposed between the supply pipe or conduit and the housing or shell 53 are a thimble 61 and an insert 62 having a metering orifice 63. This insert is interchangeable with others having metering orifices of different capacities, selected according to the quantity of molten material that is to be delivered to the charging chamber, as will hereinafter more fully appear. The thimble 61 is shown as reduced at its upper end to fit within an opening in the wall of the housing or shell 53, the thimble having a bore that, in the present instance, constitutes the inlet port of the charging chamber. The opposed faces of the thimble 61 and conduit 60 are shown as recessed to receive the ends of the insert 62. The supply pipe or conduit 60 may be made of cast steel, desirably lined with a durable material that is capable of withstanding very high temperatures without deterioration, such as that commonly known as Spanish whiting; or the pipe or conduit may be made, in whole or in part, of some material having the above mentioned properties, such as carbon, especially the end portion that dips into the molten material. The pipe or conduit is shown as extending downwardly into a crucible 65 to near the bottom of the latter, and said crucible is suitably supported within a furnace casing 6, shown as having gas burners 67 located therein below the bottom of the crucible. The crucible 65 is open at its upper end to the atmosphere.

A ram 70 (Fig. 2) operates within the charging chamber 55 and has connection, through a rod 73, with a piston 72 (Fig. 1) that is reciprocable in a cylinder 73, supported by an end plate 74 of the machine, said piston and cylinder constituting a power unit designated generally by the reference numeral 75 by which the ram 70 is advanced and retracted. It may be explained that when the piston 72 is at the right hand end of the cylinder 73, as the parts are viewed in the drawings, the ram 70 uncovers the inlet port of the charging chamber constituted of the bore of the thimble 61, as shown in Fig. 2, and due to the length of travel of said piston, the ram 70 is capable of being advanced to the extreme discharge end of the charging chamber. As will more fully appear hereinafter, the operation of the power unit 75 is under the control of master valves 76 and 77, and the

operation of these master valves is effected through the respective pilot valves 76^a and 77^a.

An important element of the invention is a dam 80 that is carried by the movable die 22 and projects from the face thereof in axial alignment with the charging chamber 55. The dam is fixed with respect to the die 22 and enters the discharge end of the charging chamber while the die cavity is open and well in advance of the final engagement of the dies and the consequential closing of the die cavity, as will more fully appear as the description proceeds. The dam is shown as having an enlarged base 81 that is secured within a recess of corresponding size and shape in the face of the die 22, and the length of the dam in any case is proportional to the depth of the die cavity. The charging chamber 55, adjacent the top thereof, communicates with the die cavity 52 through a runner 82, shown as a channel extending along the top of the dam and across the base thereof and across the adjacent portion of the face of the die 22.

A two-section vacuum hood or enclosure designated, generally, by the reference numeral 85 (Fig. 1), surrounds the dies 20 and 22. The respective sections 86 and 87 of the hood are secured to the stationary platen 3 and the movable platen 6. The hood section 86 is made up of telescoping parts, one part including a peripheral wall 88 (Fig. 2) and a flange 89 that extends outwardly at right angles from the front edge of said peripheral wall. The other part of the hood section 86 includes a peripheral wall 90 that is surrounded and partly overlapped by the wall 88, and extending inwardly from the rear end of the wall 90 at right angles thereto is a marginal rear wall 91. The hood section 86 is properly positioned with respect to the stationary platen 3, and is secured to said platen along the top and sides thereof, by angles 93 that are shown as fastened by bolts 94 to said marginal wall, and by screws 95 to said platen. A flexible wall section or bellows 96 has its front and rear edges respectively secured by suitable means and in leakproof manner to the telescoping peripheral walls 88 and 90 of the hood section 86, a gasket 97 being shown as carried by the wall 88 for sliding engagement with the wall 90.

It is apparent from the construction described that the hood section 86 is extensible. Its axial elongation or expansion is limited by bolts 100 that are fixed to brackets 101 that extend upwardly and laterally from the rear of the hood section 86 and the said bolts are slidable through apertures in brackets 102 that are attached to and extend upwardly and laterally from the flange 89. Springs 103 surround the bolts 100 and tend to retain the hood section 86 extended.

The hood section 87 is composed of an inner member 107 and an outer member 108, the latter consisting of a longitudinally extending wall that is slidable in an axial direction on a peripheral bearing part 109 of the inner member, said part being composed of sealing material, such as rubber of a suitable nature, so as to seal the joint between the members. A flange 110 surrounds and extends outwardly from the wall of the outer member in spaced relation to the front edge of said wall, and an angle 111 is applied to the front face of said flange adjacent the outer edge thereof which, with the opposed edge portion of the aforesaid wall, provides a channel within which is secured a sealing strip 112 of rubber or the like, arranged for contact with the flange 89 of the hood section 86. A flange 113 is shown as extending outwardly from the top and sides of the rear end of the longitudinal wall of the member 108.

The inner member 107 of the hood section 87 is a frame-like unit, as best appears from Fig. 5. Said member includes a transversely disposed marginal wall 115 that is secured to the inner face of the movable platen 6 by screws engaged through apertures in the wall 115 and threaded into the platen. The member 107 has a forward offset 118 that extends across the bottom and

a short distance up the sides of the member, and the aforesaid peripheral bearing part 109 follows the edge of the marginal wall 115 above the offset 118 and then continues across the top and front edges of said offset. This formation of the inner member 107 is made necessary by the fact that the bottom portion of the longitudinal wall of the outer member 108, where it is designated 119 in Figs. 2 and 5, is shortened to accommodate the lower end of the movable platen 6.

The outer member 108 is divided into top and bottom parts in the horizontal plane of the upper edges of the forward offset 118 of the inner member 107. The adjacent ends of the divided side walls of the outer member are provided with flanges 120 and 121 between which are compressed gaskets 122 when the flanges are drawn together by bolts 123 that are engaged through aligned holes in said flanges and gaskets. This construction enables the top part of the hood section 87 to be disconnected from the bottom part and fully retracted or, as an alternative, lifted from the platen 6, in either event to facilitate the changing or mounting of the die that is carried by said platen.

The axial adjustment of the hood section 87 better adapts it to dies of different depths and dams 80 of proportional lengths. For the purpose of such adjustment, and to hold the outer member 108 in the desired adjusted position with respect to the inner member 107, threaded studs 125 are secured to and extend rearwardly from the marginal wall 115 of the inner member in properly spaced relation across the top and down the sides thereof, and notched lugs 126 are secured to the flange 113 of the outer member 108 and straddle the studs. Nuts 127 and 128 are threaded upon each of the studs 125, and the corresponding lug 126 may be clamped between said nuts in any position to which it is adjusted along the stud and, in fact, by running one of the nuts along the stud to the desired position, the other nut may be employed for urging the lug into engagement with the former nut in the adjustment of the hood section. It will be observed that the notches of the lugs 126 open downwardly so that, if desired, the nuts 127 and 128 may be relaxed and the top part of the hood section 87 lifted from the machine, as hereinbefore mentioned.

The means for evacuating the hood 85 is shown in Fig. 1. It comprises a vacuum pump 130, driven by an electric motor 131, through a flexible driving element or belt 132, and a vacuum tank 133. The vacuum tank 133 has connection through a conduit 135 of relatively large diameter with a box-like fitting 136. Said fitting is joined to the rear wall 91 of the hood section 86 and communicates with the interior of the hood through a slot 137 (Fig. 3) in said wall.

In the conduit 135 is valve means designated generally by the reference numeral 140, shown in sectional detail in Fig. 6. Within a cruciform casting 141 of said means operates a vacuum valve 142 that is moved toward and from a seat 143 by a power unit comprising a cylinder 144 within which a piston 145 reciprocates. The cylinder is carried by an end plate 146 that is fastened to the front horizontal branch of the casing 141, the opposite branch having communicative connection with that portion of the conduit 135 that leads to the vacuum tank 133. The vacuum valve 142 is carried by an extension of the piston rod 147. An apertured plate 148 is fastened to the top of the casing 141, and attached to and spaced above said plate, by posts 149, is a member 150 that mounts a power unit consisting of a cylinder 151 and a piston 152. The inner end of the previously mentioned cylinder 144 is placed in communication with the outer end of the cylinder 151 by a pipe 153, while a pipe 154 communicatively connects the inner end of the cylinder 151 with the outer end of the cylinder 144. Cooperating with an upwardly facing seat 155 that surrounds the aperture of the plate 148 is a relatively large disc valve 156 that is surmounted by a casing 157 of an auxiliary valve

158, the latter valve cooperating with a seat that surrounds a central opening 159 in the disc valve 156. The valve 158 is connected to the rod 160 of the piston 152, and said auxiliary valve is limited in its retraction by the top of the casing 157. The casing 157 is open to the atmosphere through perforations 161.

It is apparent from the nature of the communicative connections between the cylinders 144 and 151 that the respective pistons within said cylinders will simultaneously move in reverse directions. Accordingly, when the vacuum valve 142 is urged into contact with seat 143 to interrupt communication between the hood 85 and the tank 133, the auxiliary valve 153 will first be raised from its seat to allow air to enter through the perforations 161, thereby to relieve suction on the disc valve 156, and further movement of the auxiliary valve will engage it with the top of the casing 157 that is attached to the disc valve 156 and lift the disc valve from the seat 155 as the piston 152 completes its upward movement.

The power units associated with the valve means 140 are operated by pressure fluid, preferably compressed air, and the supply of pressure fluid to said units is controlled by a valve 165 (Fig. 1). This valve is shown as a spool valve of common and well known character. Stems of the spool extend from the ends of the valve casing, and a spring 166 operatively connected to one stem tends to retain the spool in a position wherein the valve directs the pressure fluid from a suitable source (not shown) through pipes 168 and 169 to the outer end of the cylinder 144, thereby to move the piston 145 in a direction to engage the vacuum valve 142 with the seat 143, the fluid from the other end of the cylinder escaping through pipes 170 and 171. At the same time pressure fluid flows from the outer end of the cylinder 144 through the pipe 154 to the inner end of the cylinder 151, thereby to retract the piston in the last mentioned cylinder and lift the valves 158 and 156 from their respective seats and admit atmospheric air to the hood 85. It may be explained that while pressure fluid is being delivered in the manner above described to the inner end of the cylinder 151, the fluid from the opposite end of said cylinder escapes via the pipe 153, the inner end of cylinder 144, and the aforesaid pipes 170 and 171. A so-called vacuum solenoid 173 is arranged to move the spool of the valve 165 in opposition to spring 166 and when energized, reverses the conditions above described, thereby to close air valves 156 and 158 and open the vacuum valve 142.

I shall now describe the operation of the die casting machine and the vacuum apparatus wherewith it is equipped. In the course of the description I will introduce the electrical circuits, devices and instruments that make up the control system illustrated diagrammatically in Fig. 1, and by which the actions of the machine and apparatus are so coordinated and governed as to render automatic a complete cycle of operation initiated by the closing of a starting switch.

The main circuit from which the electrical power is derived is represented by conductors 180 and 181, the current flowing from the former and returning to the latter. The wires or conductors that make up the various circuits will be referred to as lines. The oscillating blade that constitutes a part of both the ram-return switch 46 and the die-open limit switch 47, hereinbefore referred to, is connected to the conductor 180 by a line 182. As appears in Fig. 1, wherein the machine is shown between cycles, the ram-return switch 46 is closed, being left in such condition at the conclusion of the previous cycle. Therefore, the current continues on from the ram-return switch 46 through a line 183 to a solenoid 184 that actuates the pilot valve 77^a which, in turn, controls the master valve 77 and causes it to deliver pressure fluid to the power unit 75 that operate the ram 70, the ram, under prevailing conditions, being in retracted position, as shown in Fig. 2. The current returns from solenoid 184 through a line 185 to the side of the main circuit repre-

sented by the conductor 181. At a junction designated 186, a line 187 leads from line 183 to the winding of a relay CR-3, the opposite end of the winding having connection, through a line 188, with the previously mentioned return line 185. It is evident, therefore, that, between cycles, the relay CR-3 remains energized. Obviously, when the machine is to be left idle for an appreciable length of time, the supply of current to the control system may be shut off. However, as long as the system is supplied with current, and the relay CR-3 remains energized, the switches incorporated therein will occupy positions reverse to those shown in Fig. 1.

To initiate a cycle of operation, a starting switch 190, desirably of the push button type and biased toward open position, is momentarily closed. Current then flows from conductor 180 through a line 191 that contains said switch to the winding of a relay CR-1 and thence, through a line 192, to line 185 and back to the return side of the main circuit. Energization of the relay CR-1 results in the closing of a switch 194 that is a part of said relay, and now current flows from a junction 195 of line 191, through a line 196, a normally closed switch 197 that is a part of a relay CR-4, a line 198 to the previously mentioned presently closed switch 194 and then through a part of line 191, the winding of the relay CR-1, and lines 192 and 185 to the return side of the main circuit. The establishment of this second circuit, which occurs substantially simultaneously with the closing of the starting switch, locks in relay CR-1, so to speak, thereby to retain switch 194 in closed condition after release of the starting switch 190.

At the time current is being supplied to the relay CR-1, current will flow from a junction 199 of the line 191 through a line 200 to the normally closed die-dwell switch 49 and thence, through a line 201, to what I shall term the die-close solenoid 202. From said solenoid the current flows through a conductor 203 to the return side of the main circuit. When the die-close solenoid 202 is energized, it will cause the pilot valve 35^a to so condition the master valve 35 that pressure fluid will be delivered through a conduit 205 to the outer end of the cylinder 14, moving the piston 15 forwardly. Through the operative connections already described between said piston and the platen 6, said platen will be moved forwardly until the sealing strip 112 of the hood section 87 engages the flange 39 of the hood section 86, thereby to close and substantially seal the hood 85. The relation of the dies at this stage is illustrated in Fig. 2. With the dies spaced apart as shown, the forward end of the dam 30 occupies the discharge end of the charging chamber 55. Said chamber now communicates, adjacent the top thereof, through the outer end portion of the runner 82, with the interior of the hood.

While the pressure fluid—desirably oil or other suitable liquid under pressure—is being delivered as aforesaid through the conduit 205 to the outer end of the cylinder 14, the fluid or liquid is escaping from the inner end of said cylinder through a conduit 206. The exhausted fluid or liquid is diverted by the master die-opening valve 36 through a pipe 207 to a source of supply, such as a tank (not shown). With the master valve 36 in its present condition, the pressure fluid will be conveyed through a pipe 210, from a source of supply (not shown), through the valve ports, and a conduit 211, to the master valve 35 and through ports of said valve to the previously mentioned conduit 205. It will be understood that the master valve 36 is conditioned to perform as described by the pilot valve 36^a when the latter is in the position to which it is biased by a spring 208. Valve mechanism similar to the above and for performing the same purposes is illustrated and described in the above identified applications.

It will be remembered that the switch actuator 40 is carried by and therefore movable with the platen 6 wherefore at the very beginning of the forward movement of

the platen, the finger 43 of the switch actuator will withdraw from the oscillating blade that forms a part of the switches 46 and 47, and in its released condition said blade will change its position so as to open the ram-return switch 46 and close the die-open limit switch 47.

Upon the opening of the ram-return switch 46, flow of current through the previously described circuits represented by the lines 183, 185 and 187 is interrupted, thereby deenergizing solenoid 184 and the relay CR-3. Energization of said solenoid 184, it will be remembered, resulted in the retraction of the ram 70, in which position it is shown in Fig. 2.

The forward travel of the movable platen 6 is arrested, with the parts positioned as shown in Fig. 2, by reason of the engagement of the cam 45 with the die-dwell switch 49, resulting in the opening of said switch.

Upon the opening of the die-dwell switch 49, the flow of current through the previously described circuit including said switch will cease, causing deenergization of the die close solenoid 202. Upon this taking place, the pilot and master valves will resume normal condition, depriving the power unit 12 of motive fluid, and as a consequence the piston 14 of said power unit will stop before reaching the forward end of the cylinder 15, and the die 22 will be caused to dwell, so to speak, in the position shown in Fig. 2.

Substantially simultaneously with the opening of the die-dwell switch 49, the evacuating switch 48 is closed by the cam 45. Thereupon current flows from the line 182, at the junction 214, through a line 215, switch 48, and line 216 to a so-called vacuum timer T-1 and thence through a line 217 to the previously mentioned line 185 that leads to the return side of the main circuit, represented by conductor 181. At the moment the vacuum timer T-1 was supplied with current, the vacuum solenoid 173 was energized through a circuit represented by a line 220 which is, in effect, a continuation of line 216 beyond the timer T-1, and this line 220 is connected, through a switch 221 of the relay CR-2, with a line 222 that carries the current to the vacuum solenoid 173, the current being conducted from the latter to the return side of the main circuit through lines 223 and 185.

When the solenoid 173 is energized, it conditions the valve 165 to deliver pressure fluid, desirably compressed air, from a suitable source (not shown) through pipes 168 and 170 to the inner end of the cylinder 144 thereby to retract the piston 145 and withdraw the vacuum valve 142 from the seat 143, it being understood that the fluid ahead of the piston will escape through the pipe 169, a port of the valve 165, and the exhaust pipe 174. Simultaneously with the opening of the vacuum valve 142, the air admitting valves 158 and 156 will be seated through reverse action of the piston 152 in the cylinder 151, the pressure fluid continuing on from the cylinder 144 through the pipe 153 to the outer end of the cylinder 151, while the fluid below the piston 152 escapes through the pipe 154, the outer end of the cylinder 142 and thence, as above described, to the atmosphere through the exhaust pipe 174.

Thus, during the interim between energization and subsequent operation of the vacuum timer T-1, and while the dies 20 and 22 are in spaced relation, as illustrated in Fig. 2, the hood 85 is evacuated and, because of the relative capacity of the tank 133 and the largeness of the conduit 135, a vacuum of relatively high degree, for example, 12 to 19 inches Hg, is quickly created in the hood, and this condition is communicated through the runner 82 to the charging chamber 55. Under the atmospheric pressure imposed upon the top of the body of molten material in the crucible 65, a part of said material will rise through the supply pipe or conduit 60, and through the metering orifice 63, to the charging chamber 55, wherein the material will gradually accumulate, being retained in the chamber by the dam 80. While

the molten material reposes in the charging chamber, where it is exposed to the rarified atmosphere, occluded gases will be liberated and carried off through the adjacent end of the runner 82 and the interior of the hood. These conditions will prevail until the vacuum timer T-1 functions.

In accord with the conventional performance of such instruments, after a period of time for which it is set, the timer T-1 operates to close a switch 225 that is incorporated in the timer, thereby to establish a circuit which is a substitute for the former circuit that was made through the presently opened die-dwell switch 49 and that includes the die-closing solenoid 202. The present circuit is represented by a line 226 that connects, through a junction 227, with a part of the line 191 that presently receives current from the line 198 through the switch 194. The line 226 leads to the switch 225, and from said switch there extends a line 229 that supplies current to the die-close solenoid 202, the current continuing to the return side of the main circuit through the line 203.

Under the circumstances just described, the pilot valve 35^a will again be conditioned to operate the master valve 35 and deliver pressure fluid through the conduit 205 to the outer end of the cylinder 14. This will result in moving the piston 15 forwardly for the remainder of its stroke and, through its connections with the toggle joints 7, straighten out said joints to move the platen 6 so as to bring the die 22 into engagement with the die 20 and close the die cavity, as shown in Fig. 4.

Immediately upon the closing of the dies, the finger 44 of the switch actuator 40 engages and closes the die-close limit switch 50, thereby to establish a circuit that receives current through the presently closed die-open limit switch 47 and is represented by a line 230 that leads from said switch 47 to the switch 50, and a line 231 that leads from the switch 50 to a solenoid 233. Current thus delivered to the solenoid returns by way of lines 234 and 185 to the side of the main circuit represented by the conductor 181. Upon energization of the solenoid 233, the pilot valve 76^a functions to receive pressure fluid from a source (not shown) through a conduit 235, ports of the pilot valve, and deliver it through a conduit 236 to the master valve 76, conditioning said master valve to deliver pressure fluid, from a source not shown, through conduits 237 and 238 to the outer end of the cylinder 75, thereby to move the piston 72 forwardly and, through the rod 71, advance the ram 70 in the charging chamber 55 and impel the molten material into the die cavity 52. This advancement of the ram continues until the die cavity and the runner 82 are filled and a slug of the material is left in the charging chamber between the ram and the dam 80, the advance movement of the ram being stopped by the unyielding slug of material. The parts are illustrated in this condition in Fig. 4.

Concurrently with the energization of the solenoid 233, which resulted in the advancement of the ram 70, relay CR-2 is energized by current conducted to the winding thereof through a line 235 that leads, at a junction 236, from the aforesaid line 231, current being conducted from said winding through a line 237, and the former line 185 to the return side of the main circuit. A switch 240, which is a part of relay CR-2, closes when the relay is energized and locks in relay CR-2, so to speak, through a circuit which becomes a substitute for the former one by which said relay was initially supplied with current, after said former circuit is opened. This substitute circuit is represented by a line 241, that leads from a junction 242 with line 230 adjacent die-open limit switch 47 to a switch 243 of relay CR-3; a line 245 that leads to the previously mentioned switch 240 of relay CR-2, and a line 246 that joins an adjacent part of line 235 leading to the winding of the solenoid CR-2, the current being carried thence through the former circuit comprised of lines 237 and 185 to the return side of the main circuit,

It may be mentioned at this point that the current from line 246 divides in advance of relay CR-2, a part of it being presently diverted to solenoid 233 through the intervening parts of lines 235 and 231. Also, upon the energization of the relay CR-2, its switch 221 opens, which interrupts the flow of current through the previously described circuit containing said switch and the vacuum solenoid 173. Therefore, upon the opening of said switch 221 and the resultant deenergization of solenoid 173, the valve 165 is returned to normal position by the spring 166 which conditions said valve to deliver pressure fluid through the pipe 169 to the outer end of the cylinder 144 and the inner end of cylinder 151. As a consequence, the vacuum valve 142 will be closed and the air admitting valves 156 and 158 opened in the manner previously described. At the present time, therefore, atmospheric pressure prevails in the hood so that section 87 thereof may be moved away from section 86 without danger of damage to the sealing strips of the inner and outer members of the hood section 87, which might reasonably be expected if the hood were opened while under an appreciable degree of vacuum.

Further, upon energization of relay CR-2, a switch 248 thereof is opened, interrupting the flow of current through a circuit that may be described as comprising a line 250, which receives current from the line 196 at junction 251 and leads to a switch 252 of relay CR-3; a line 253 that leads from said switch to the previously mentioned switch 248 of relay CR-2; a line 254 that leads from the latter switch and joins line 137 at junction 255; a part of said line 187; the winding of the solenoid CR-3, and lines 183 and 185, the latter leading to the return side of the main circuit. Therefore, energization of relay CR-2 opens the circuit just described which supplies, under certain circumstances, current to the relay CR-3, and the latter relay, as will be remembered, is responsible for supplying current to the solenoid 184. Referring again to the energization of relay CR-2, when this occurs it closes a further switch 257 incorporated in said relay and establishes a circuit from line 241, through a short branch leading therefrom to one side of said switch 257, the opposite side of the switch being connected, through a line 258, with a timer T-2. The circuit including the timer T-2 is completed through a line 260 which leads to a junction 261 with line 185 which carries the current to the return side of the main circuit.

After a time interval for which the instrument is set, timer T-2 functions and closes a switch 262 thereof. The closing of this switch establishes a circuit that receives its current from line 241, at a junction 263, and is represented by a line 264 that leads to said switch 262, and a line 265, leading from said switch to a so-called die-open solenoid 266, the current returning from said solenoid through a line 267, an adjacent part of the previously mentioned line 260, and line 185 to the side of the main circuit represented by the conductor 181.

Simultaneously with the closing of the above mentioned circuit which supplies current to the die-open solenoid 266, a further circuit is established through a line 270 that leads from its junction with line 265 to one end of the winding of a relay CR-4, the opposite end of the winding being connected through a line 271 with the return line 185. Energization of this relay effects the closing of a switch 272 of said relay that is in a circuit represented by a line 273 that leads from a junction 274 of line 264 to the part of the previously mentioned line 270 through which current is supplied to the winding of the relay CR-4. By virtue of this last described circuit, the relay CR-4 will remain energized after the switch 262 of timer T-2 opens. Also, by reason of the energization of relay CR-4, the switch 197 thereof will be opened and deprive relay CR-1 of current, resulting in the opening of switch 194 of the latter relay.

The purpose of the timer T-2 is to determine the length of time the die cavity 52 remains closed while the casting

is being chilled. Therefore, at the conclusion of the time interval for which the instrument is set, the timer T-2 functions to open the switch 262 and discontinue the supply of current to the die-open solenoid 266. Deenergization of this solenoid will permit the spring 208 to position the valve member of the pilot valve 36^a so as to condition master valve 36 to deliver pressure fluid through the conduit 206 to the inner end of the cylinder 14 and permit return of fluid from the opposite end of the cylinder through the conduit 205 and ports of the master valve 35 to a conduit 275 that leads back to the source of supply. This will result in the movement of the piston 15 to the outer end of the cylinder 14. By reason of the operative connections between said piston and the movable platen 6 above described, said platen will be retracted to the position shown in Fig. 1. Obviously, this will cause the hood 85 to open since the section 87 thereof is attached to and moves with the platen 6. Similarly, the die 22 will move away from die 20, retracting the dam 80, and as the dam withdraws from the discharge end of the charging chamber 55, the ram 70 will advance to the discharge end of said chamber, pushing the slug of material ahead of it, said slug being connected to the casting by the strip of material that solidified in the runner 82. As the platen 6 nears the end of its return travel, the plunger 27 of the ejecting mechanism will strike the stop 30, arrest movement of the head 25 and ejector pins 26, thereby to strip the casting from the face of die 22 in the final return movement of the platen 6.

During the return trip of the platen 6, effected in the manner above described, the cam 45 of the switch actuator 40 that is carried by said platen will withdraw from the switches 48 and 49, resulting in the opening of the former and the closing of the latter. Opening of switch 48 causes deenergization of the vacuum timer T-1, and the closing of switch 49 reestablishes in part the previously described circuit that includes the die close solenoid 202.

As the platen 6 arrives at the end of its return trip, the finger 43 of the switch actuator 40 closes the ram-return switch 46, and opens the die-open limit switch 47. The closing of the switch 46 reestablishes the above described circuit that includes the solenoid 184, energizing said solenoid so as to effect, through the valves associated therewith, the retracting of the piston 72, and of the ram 70 connected thereto. The closing of the switch 46 also reestablishes the previously described circuit that includes the winding of relay CR-3. Accordingly, this relay and the solenoid 184 are left energized at the conclusion of a cycle, as explained at the beginning of this description of the operation of the apparatus. When the die-open limit switch 47 opens, the supply of current is cut off from the solenoid 233 and from the relay CR-2, deenergizing both. As a result of the deenergization of the relay CR-2, the circuits controlled by the switches 240 and 257 will be opened, and the circuits controlled by switches 248 and 221 will be closed, in preparation for the succeeding cycle.

Now that I have described in detail a complete cycle of operation of the die casting machine and vacuum apparatus, as well as having described the circuits and parts of the control system and the manner in which they perform, I may summarize by reciting, briefly, the sequence of steps that constitute a cycle of operation. The cycle is started by pushing the button 190. Thereupon, the movable platen travels forward until the hood section 87 engages the section 86 and closes and substantially seals the vacuum hood 85. The platen stops with the die members in spaced relation, as shown in Fig. 2, with the dam 80 projected a short distance into the charging chamber 55, which latter now communicates with the interior of the hood through the forward end of the runner 82. The hood is now evacuated, and a charge of molten material is impelled by atmospheric pressure from the crucible through the supply pipe or conduit 60 into the charging

chamber, where it is retained by the dam 80. During its occupation of the charging chamber and its exposure to the rarified atmosphere therein, the molten material is degassed. The platen 6 now resumes its travel and continues to the limit of its forward movement, which results in engagement of the dies and the closing of the die cavity, a part of the rarified atmosphere being entrapped in the latter. The ram 70 is now advanced, forcing the molten material from the charging chamber 55 through the runner 82 into the die cavity 52, filling the die cavity and runner and leaving a slug of the material in the charging chamber. Communication between the vacuum hood and the evacuating means is shut off and atmospheric air is admitted to the hood. The parts remain in the present condition until the material solidifies and chills sufficiently to permit exposure to the atmosphere. Thereupon the movable platen is retracted, withdrawing the die 22 from the die 20, and as the dam 80 leaves the charging chamber it is followed by the solidified slug of material under the impelling force of the ram 70. At the same time the hood section 87 is moved away from the section 86, thus opening the hood. As the platen 6 closely approaches the limit of its return movement, the ejecting mechanism is caused to function by engagement of its plunger 27 with the stop 30, stripping the casting from the face of the die 22 by means of the ejector pins 26, the operator now removing the casting in the usual way.

My improved method, as carried out, for example, by means of the above described apparatus, and in its comprehensive form, comprises the following steps, to-wit: enclosing the dies in a substantially airtight enclosure; damming the lower portion of the discharge end of the charging chamber so as to retain molten material in the chamber without interrupting communication between the chamber and the die cavity; with the dies apart, subjecting the interior of the enclosure to a suction sufficiently strong and enduring to create and maintain a vacuum of relatively high degree in the enclosure and the spaces communicating therewith including said charging chamber, and as a result of which molten material is induced to flow from the container into the charging chamber where occluded gases are liberated and drawn off through the enclosure; restricting, in ways hereinafter explained, the amount of molten material thus delivered to the charging chamber to a size charge that will fill the die cavity and runner and, desirably, leave a slug of the material in the charging chamber; relatively moving the dies into engagement with each other and thus close the die cavity and entrap therein a part of the rarified atmosphere; forcing the molten material from the charging chamber into the die cavity; closing off the hood from the suction and admitting atmospheric air to the hood; chilling the material to solidify it and form a casting; opening the enclosure and moving the dies apart for the removal of the casting, and simultaneously therewith pushing the solidified slug of material from the charging chamber.

The size of the charge, or, in other words, the quantity of molten material delivered to the charging chamber during each cycle of operation, and which, desirably, is somewhat in excess of that required to fill the die cavity 52 and the runner 82, is dependent upon one or more of the following three factors: (1) the size of the metering orifice 63; (2) the amount of time allotted to the feeding of the material to the charging chamber, and (3) the degree of vacuum in the hood 85. This latter factor may be controlled, for example, by a damper 280 in the form of a slide, shown as incorporated in the system between the valve means 140 and the slot 137 through which the fitting 136 communicates with the interior of the hood. The latter way of determining the size of the charge, provided it materially lowers the degree of vacuum, should be used only when the quality of the casting is not of major importance. For the best results as to density and

smoothness of the casting, a vacuum of not substantially less than 19 inches Hg should be used.

Obviously, by combining two or all of the foregoing factors in proper proportion, a charge of the desired size may be obtained. In practice, I have used an insert 62 having a metering orifice of a capacity to measure roughly the amount of molten material required for a charge, and then modified the amount to obtain a charge of the desired size by altering the time factor, the latter being accomplished by adjusting the timer T-1.

So that a more practical impression of the invention may be had, I may explain, by way of example, that the die casting machine disclosed herein is of the 400 ton class, or, in other words, "locks the dies in," so to speak, at approximately 400 tons pressure; that the vacuum pump 130 is a 10 hp. pump having a displacement of 250 cu. ft. per minute; that the tank 133 is of 100 cu. ft. capacity, and that the capacity of the vacuum hood 85 is 12 cu. ft. With the machine cycling every nine seconds, in accordance with prevailing procedure, and the pump operating at its prescribed speed, a vacuum of 22 inches Hg will build up in the tank between cycles. Upon the opening of the evacuating valve 142, a vacuum of approximately 19 inches Hg will be effected in the closed hood almost instantly, i.e., in one-half second, the vacuum in the tank "leveling off" to a like value during the evacuating phase.

It is to be understood that the invention, as to certain of its phases, is applicable to the handling of plastics. Therefore, the term "molten material," as herein used, embraces plastics when the latter is in a liquid state, or when in a soft, mobile condition, regardless of how said condition is produced, whether by heat or otherwise, as long as the material is capable of flowing or of being impelled into the die cavity and thereafter solidifying.

Having thus described my invention, what I claim is:

1. In a die casting machine of the type characterized by dies that are relatively movable toward and from each other and by and between which a die cavity is defined; a charging chamber that opens through the face of one die, a dam projecting from the face of the other die and arranged to enter the charging chamber upon relative movement of the dies toward each other, the dam and dies having contiguous parts that conjointly form a runner adjacent the top of the chamber providing the only communication between the chamber and the open die cavity, and the dam being formed to fit the chamber to prevent the flow of molten material therefrom except through the said runner, means for delivering a charge of molten material to the charging chamber, an enclosure that surrounds the dies and is adapted to be opened and closed and that is closed during relative movement of the dies toward each other, evacuating means for creating a vacuum of relatively high degree in the enclosure while the dies are apart and as a result of which occluded gases in the material reposing in the chamber are liberated and carried from the chamber through the enclosure under the influence of the evacuating means, means for relatively moving the dies to engage them with each other and close the die cavity while said enclosure is in evacuated condition, and means for transferring the molten material from said chamber to the die cavity through the said runner.

2. In a die casting machine of the type including dies that are relatively movable toward and from each other and by and between which a die cavity is defined; a charging chamber that opens through the face of one die, a dam projecting from the face of the other die and arranged to enter the charging chamber upon relative movement of the dies toward each other, the dam and dies having contiguous parts that conjointly form a runner that opens into the chamber adjacent the top thereof and through which said chamber communicates with the die cavity, the dam being otherwise formed to fit the charging chamber to prevent the flow of molten material there-

from except through said runner, a two-section enclosure surrounding the dies and relatively movable in the manner of the dies, one section being axially extensible and contractible, means biasing said section to extended condition, the sections engaging to render the enclosure substantially airtight upon initial relative movement of the dies toward each other, means for delivering a charge of molten material to the charging chamber, evacuating means for creating a vacuum of relatively high degree in the enclosure while the dies are apart and as a result of which occluded gases in said material are liberated and carried off from the charging chamber through the enclosure under the influence of the evacuating means, means for relatively moving the dies to engage them with each other and close the die cavity while said enclosure is in evacuated condition, and means for transferring the molten material from the charging chamber to the die cavity when the dies are in engagement with each other.

3. In a die casting machine of the type including dies that are relatively movable toward and from each other and by and between which a die cavity is defined; a chamber in constant communication with the die cavity, means for delivering a charge of molten material to said chamber, further means for retaining the charge of molten material in said chamber while the dies are apart, a two-section enclosure surrounding the dies and the sections whereof are relatively movable in the manner of the dies, one section comprising an inner member that is fixed with respect to the corresponding die and has a continuous outwardly facing peripheral bearing part, and an outer member that surrounds the inner member and is shiftable in an axial direction upon said bearing part, the latter providing a substantially leakproof joint between the members, means for shifting the outer member axially of the inner member, the sections meeting to render the enclosure substantially airtight upon incipient relative movement of the dies toward each other, evacuating means for creating a vacuum of relatively high degree in the enclosure while the dies are apart and as a result of which occluded gases in the material are liberated and carried off from the charging chamber through the enclosure under the influence of the evacuating means, means for relatively moving the dies to engage them with each other and close the die cavity while said enclosure is in evacuated condition, and means for transferring the charge of molten material from the charging chamber to the die cavity.

4. In a die casting machine of the type including dies that are relatively movable toward and from each other and by and between which a die cavity is defined; a charging chamber that opens through the face of one die, a source of molten material at a lower elevation than said chamber and wherewith the chamber communicates, said source being subjected to the influence of atmospheric pressure, a dam projecting from the face of the other die and arranged to enter the charging chamber upon incipient relative movement of the dies toward each other, the dam and dies having contiguous parts that conjointly form a runner that opens into the charging chamber adjacent the top thereof and through which said chamber communicates with the die cavity, the dam being otherwise formed to fit the charging chamber to prevent the flow of molten material therefrom except through said runner, a two-section enclosure that surrounds the dies, the sections whereof are relatively movable in the manner of the dies and which sections are engaged with each other to render the enclosure substantially airtight before the dies are engaged with each other, evacuating means for creating a vacuum of relatively high degree in the enclosure while the dies are apart and as a result of which a charge of molten material is induced to flow from said source into the charging chamber where occluded gases in the material are liberated and carried off through the enclosure under the influence of the evacuating means, means for relatively moving the dies to engage them with each other and close the die cavity while said enclosure is in evacuated

ated condition, and means reciprocable in the charging chamber and acting to shut off the flow of molten material to the chamber and impel the charge of molten material from the chamber to the die cavity.

5. In a die casting machine of the type including dies that are relatively movable toward and from each other and by and between which a die cavity is defined; a charging chamber that opens through the face of one die, a source of molten material at a lower elevation than said chamber and wherewith the chamber communicates, said source being subjected to the influence of atmospheric pressure, an element having a metering orifice in the path of communication between the charging chamber and said source, a dam projecting from the face of the other die and arranged to enter the charging chamber upon incipient relative movement of the dies toward each other, the dam and dies having contiguous parts that conjointly form a runner that opens into the charging chamber adjacent the top thereof and through which said chamber communicates with the die cavity, the dam being otherwise formed to fit the charging chamber to prevent the flow of molten material therefrom except through said runner, a two-section enclosure that surrounds the dies, the sections whereof are relatively movable in the manner of the dies and which sections are engaged with each other to render the enclosure substantially airtight before the dies are engaged with each other, evacuating means for creating a vacuum of relatively high degree in the enclosure while the dies are apart and as a result of which a charge of molten material is induced to flow from said source into the charging chamber where occluded gases in the material are liberated and carried off through the enclosure under the influence of the evacuating means, means for relatively moving the dies to engage them with each other and close the die cavity while said enclosure is in evacuated condition, and means reciprocable in the charging chamber and acting to shut off the flow of molten material to the chamber and impel the charge of molten material from the chamber to the die cavity.

6. Improvements in die casting machines of the type including the following: dies that are relatively movable toward and from each other and by and between which a die cavity is defined; die operating means for moving the dies as aforesaid thereby to open and close the die cavity; a charging chamber that opens through the face of one die and is in communication with a source of molten material at a lower elevation than said chamber, said source being subjected to the influence of atmospheric pressure; a ram reciprocable in the charging chamber for forcing molten material from the charging chamber into the die cavity, and ram reciprocating means; said improvements comprising in combination therewith a dam projecting from the other die and arranged to enter the charging chamber during movement of the dies toward each other, the dam having a channel on the top side thereof that opens through its distal end and the dam being otherwise formed to fit the charging chamber to prevent the flow of molten material therefrom except through said channel, opposed parts of the dies conjointly forming a passage through which said channel communicates with the die cavity, an enclosure encompassing the dies that is adapted to be opened and closed and that is closed during relative movement of the dies toward each other, and evacuating means in communication with the enclosure for creating therein a vacuum of relatively high degree while the dies are apart and as a result of which a charge of molten material is induced to flow from said source into the charging chamber, the die operating means functioning in the course of a cycle of operation of the machine to engage the dies and close the die cavity, and the ram reciprocating means acting to advance the ram and force a sufficient quantity of said material into the die cavity to fill the latter.

7. Improvements in die casting machines of the type

characterized by the following: opposed dies that are relatively movable toward and from each other and by and between which a die cavity is defined; die operating means for so moving the dies thereby to open and close the die cavity; a charging chamber that opens through the face of one die and is in communication with a source of molten material at a lower elevation than said chamber, said source being subjected to atmospheric pressure, and impelling means for forcing molten material from the charging chamber into the die cavity; said improvements including in combination therewith a dam projecting from and fixed with respect to the other die and arranged to enter the charging chamber upon incipient relative movement of the dies toward each other, the dam and dies having contiguous parts that conjointly form a runner through which said chamber adjacent the top thereof communicates with the die cavity, the dam being otherwise formed to fit the charging chamber to prevent the flow of molten material therefrom except through the said runner, an enclosure encompassing the dies that is adapted to be opened and closed and that is closed during relative movement of the dies toward each other, evacuating means in communication with the enclosure for creating therein a vacuum of relatively high degree while the dies are apart, and a control system by which the die operating means is caused to relatively move the dies into engagement with each other and thus close the die cavity; the impelling means is caused to act to force molten material into the die cavity to fill the latter; communication between the evacuating means and the enclosure is discontinued; the material in the die cavity as well as that in the runner and any in the charging chamber is chilled, and the enclosure is subjected to atmospheric pressure; and the dies are moved apart and the enclosure is opened for removal of the casting.

8. Apparatus incorporated in a die casting machine of the kind including a first die, a second die that is movable toward and from the first die, a die cavity being defined by and between said dies, and mechanism for effecting movement of the second die thereby to open and close the die cavity; said apparatus comprising a two-section hood that surrounds the dies, one section being adjustable in length and movable with the second die into engagement with the other section in advance of the meeting of the dies, a charging chamber that opens at its discharge end through the face of the first die, said chamber having an inlet port, a ram reciprocable in the charging chamber past said port, a dam projecting from the face of the second die and arranged to enter the discharge end of the charging chamber early in the movement of said second die toward the first, the dam and dies being constituted to provide a runner through which the charging chamber adjacent the top of the dam communicates with the die cavity, the dam being otherwise formed to fit the charging chamber to prevent the flow of molten material therefrom except through said runner, a crucible for molten material located at a lower elevation than the charging chamber and subjected to atmospheric pressure, communicative connections between the inlet port of the charging chamber and the crucible below the minimum molten material level therein, evacuating means communicating with and for creating a vacuum of relatively high degree in the enclosure after the sections are engaged and before the second die engages the first die, a charge of molten material being induced to flow into the charging chamber under the influence of the rarified atmosphere prevailing therein, and means operating to advance the ram when the dies are together for forcing molten material from the charging chamber into the die cavity.

9. A vacuum hood for use with die casting machines of the kind including two dies that are relatively movable toward and from each other, said hood comprising two sections that surround the respective dies, one section being composed of an inner member that is adapted to be supported in fixed relation to the corresponding die, said

inner member having an outwardly facing substantially continuous peripheral bearing part, and an outer member surrounding the inner member and slidable on said bearing part with a substantially airtight fit, the adjacent ends of the two hood sections being disposed in abutting relation and contacting each other with a substantially sealed joint when the dies are moved toward each other.

10. In a vacuum hood, the combination and arrangement of parts set forth in claim 9, and, in addition thereto, means for relatively adjusting said members in an axial direction.

11. In a vacuum hood, the combination and arrangement of parts set forth in claim 9, wherein said outer member is adjustable in an axial direction with respect to the inner member, and means for securing the outer member in any selected position of adjustment relative to the inner member.

12. A vacuum hood for use with die casting machines of the type including two dies that are relatively movable toward and from each other, said hood being composed of two sections that surround the respective dies, one section comprising an inner member that is adapted to be supported in fixed relation to the corresponding die, said inner member having an outwardly facing substantially continuous peripheral bearing part, an outer member surrounding the inner member and slidable on said bearing part, means rendering substantially airtight the joint between said peripheral part and the surrounding part of the outer member, said outer member consisting of a top shell and a bottom shell, and means for detachably connecting said shells together, the adjacent ends of the two hood sections being disposed in abutting relation when the die members are moved toward each other, and means for sealing the joint between said adjacent ends of the hood sections.

13. A vacuum hood for use with die casting machines of the kind including two platens that are relatively movable toward and from each other, and dies supported in opposed relation to each other by said platens, said hood being composed of two sections that are adapted to be attached to the respective platens and surround the dies supported thereby, one section comprising an inner member that is adapted to be attached with a substantially leakproof joint to one of the platens, said inner member having an outwardly facing substantially continuous peripheral bearing part, an outer member made up of top and bottom shells that are detachably connected together with a leakproof joint at each side of the outer member, the outer member surrounding the inner member and being slidable on said bearing part, means for rendering substantially leakproof the joint between said bearing part and the surrounding part of the outer member, and means for adjusting the outer member axially of the inner member when the sections of the outer member are secured together, and for retracting the top shell of the outer member when the shells are disconnected from each other, the adjacent ends of the two hood sections assuming abutting relation when the platens are relatively moved toward each other, and means rendering the joint between said adjacent ends substantially airtight.

14. A vacuum hood for use with die casting machines of the kind including two dies that are relatively movable toward and from each other, said hood being composed of two sections for surrounding the respective dies, one section comprising an inner member that is adapted to be supported in fixed relation to the corresponding die, said inner member having an outwardly facing substantially continuous peripheral bearing part, an outer member surrounding the inner member and slidable on said bearing part with a substantially leakproof fit for adjustment axially of the inner member, the adjacent ends of the two hood sections assuming abutting relation when the dies are relatively moved toward each other, said adjacent ends being surrounded by flanges that lie in planes normal to the axis of the hood, a sealing gasket at

tached to the flange of one section for engagement with the flange of the other, and a wall disposed in right angular relation to the flange to which the gasket is attached for supporting the gasket against inward displacement.

15. Apparatus incorporated in a die casting machine of the kind including dies that are relatively movable toward and from each other and by and between which a die cavity is defined, and operating means for moving the dies as aforesaid to open and close the die cavity; said apparatus comprising an enclosure that surrounds the dies and is capable of being opened and closed and which is closed during all but the initial and concluding parts of a cycle of operation of the machine, a charging chamber that opens at its discharge end through the face of one die, said chamber having an inlet port, a ram reciprocable in the charging chamber past said port and which opens the said port to the atmosphere when transferring a charge of molten material from the chamber to the die cavity, a dam projecting from the face of the other die and arranged to enter the discharge end of the charging chamber during movement of the dies toward each other, the dam and dies having opposed parts that conjointly form a runner through which the charging chamber adjacent the top of the dam communicates with the die cavity, the dam being otherwise formed to fit the charging chamber to prevent the flow of molten material therefrom except through said runner, a crucible for molten material located at a lower elevation than the charging chamber and subjected to atmospheric pressure, communicative connections between the said inlet port and the crucible including a metering orifice restricting the flow of the molten material from the crucible to the charging chamber during a cycle of operation of the machine to a quantity in excess of the amount needed to fill the die cavity and runner but which will not enter the runner until the ram is operated to transfer the molten material from the charging chamber to the die cavity, evacuating means communicating with the enclosure to evacuate the same whereby to induce the flow of the molten material from the crucible to the charging chamber, and means operating to advance the ram when the dies are engaged to force molten material from the charging chamber to the die cavity.

16. In a die casting machine characterized by dies that are relatively movable toward and from each other and by and between which a die cavity is defined, a charging chamber in communication with the die cavity and arranged to permit the free flow of molten material into the die cavity, means on a die for retaining a charge of molten material in the charging chamber while the dies are apart, a source of supply of molten material in communication with the charging chamber, means enclosing the die cavity and adapted to be opened and closed and that is closed during relative movement of the dies toward each other, evacuating means for creating in the enclosing means a vacuum of relatively high degree while the dies are apart and as a result of which molten material is induced to flow from said source into the charging chamber in sufficient amount to constitute a charge, means for metering the flow of molten material into the charging chamber to provide a charge of desired size while the dies are apart, means for relatively moving the dies into engagement with each other to close the die cavity while the enclosure is in evacuated condition, and means for displacing the charge of molten material from the charging chamber into the die cavity.

17. In a die casting machine characterized by dies that are relatively movable toward and from each other and by and between which a die cavity is defined, a charging chamber in communication with the die cavity and arranged to permit the free flow of molten material into the die cavity, means on a die for retaining a charge of molten material in the charging chamber while the dies

are apart, a source of supply of molten material at a lower elevation than said charging chamber and that is in communication therewith, an enclosure surrounding the die cavity and adapted to be opened and closed and that is closed during relative movement of the dies toward each other, evacuating means for creating in the enclosure a vacuum of relatively high degree while the dies are apart and as a result of which molten material is induced to flow from said source into the charging chamber, means for metering the flow of molten material into the charging chamber to provide a charge of desired size while the dies are apart, means for relatively moving the dies into engagement with each other to close the die cavity while the enclosure is in evacuated condition, and means for displacing the charge of molten material from the charging chamber into the die cavity.

18. In the method of die casting wherein molten material is delivered initially from a container to an interconnected charging chamber and is subsequently delivered to an interconnected die cavity defined by and between two relatively movable die members, the improvement comprising in combination therewith the steps of subjecting the interior of the die cavity to a high degree of vacuum and thereby also subjecting the charging chamber to vacuum to induce flow of the molten material from the container to the charging chamber, simultaneously metering the flow of molten material so as to provide a charge of desired size in the charging chamber while at the same time partially closing communication between the charging chamber and the die cavity so as to retain the molten material in said chamber while the die members are still apart but are moving toward each other, engaging the die members to close the die cavity, forcing the flow of the molten material from the charging chamber into the die cavity, thereafter chilling the molten material in the die cavity to solidify it and to form a casting, and moving the die members apart for the removal of the formed casting.

19. In the method of die casting wherein molten material is delivered initially from a container to an interconnected charging chamber and is subsequently delivered to an interconnected die cavity defined by and between two relatively movable die members, the improvement comprising in combination therewith the steps of surrounding the die cavity with a substantially air-tight enclosure, subjecting the interior of the enclosure to a high degree of vacuum while the die members are separated and thereby also subjecting the die cavity and the charging chamber to vacuum to induce flow of the molten material from the container to the charging chamber, at the same time metering the flow of the molten material from the container to the charging chamber so as to provide a predetermined charge while partially closing communication between the charging chamber and the die cavity so as to retain the molten material in the charging chamber while the die members are still apart but are moving toward each other, moving the die members to close the die cavity while the vacuum prevails, forcing the flow of the molten material from the charging chamber into the die cavity, thereafter chilling the molten material in the die cavity to solidify it and to form a casting, and opening the enclosure and moving the die members apart for the removal of the formed casting.

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