Nov. 8, 1966 J. H. MOORMAN ETAL 3,283,372

VACUUM DIE CASTING APPARATUS

Filed Feb. 28, 1964 2 Sheets-Sheet 1

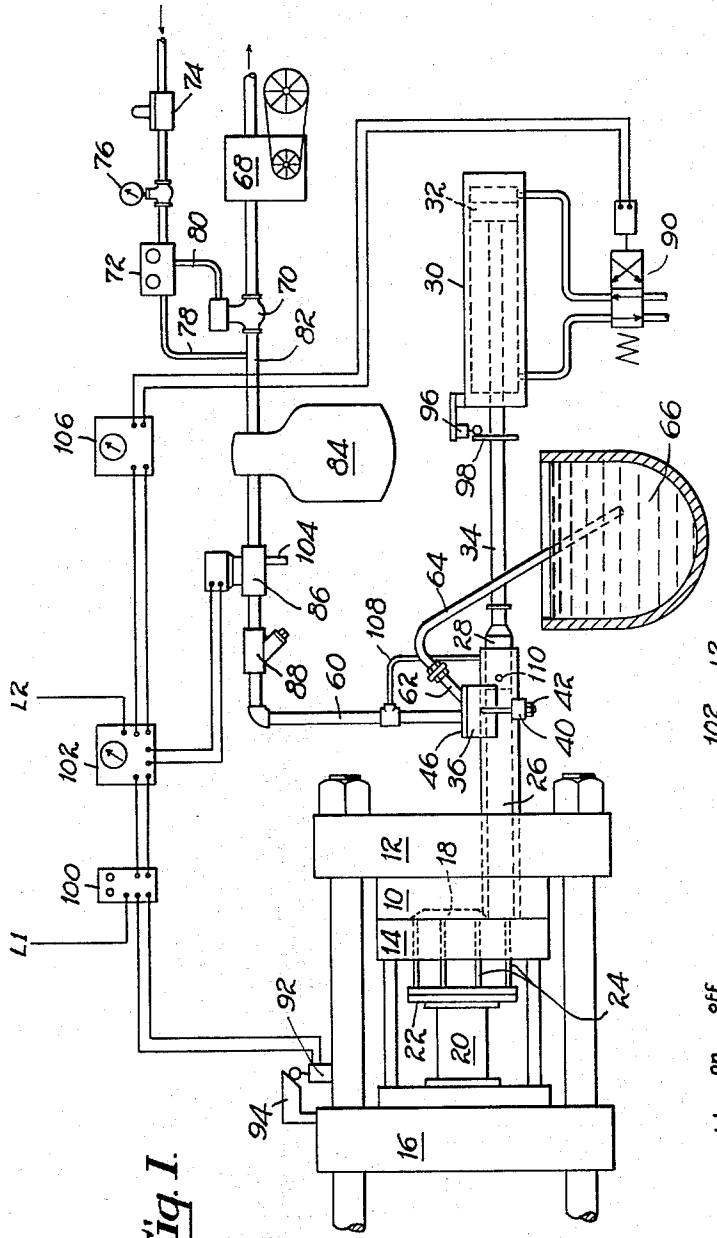

Fig. 1.

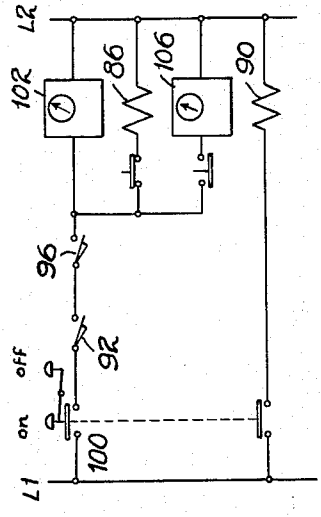

Fig. 2.

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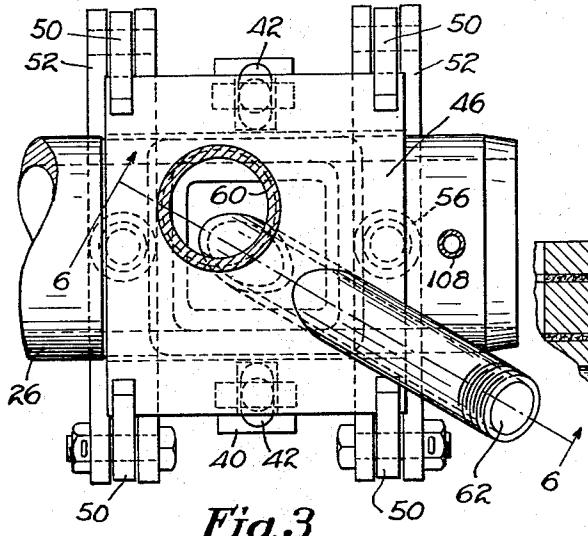

Fig. 3.

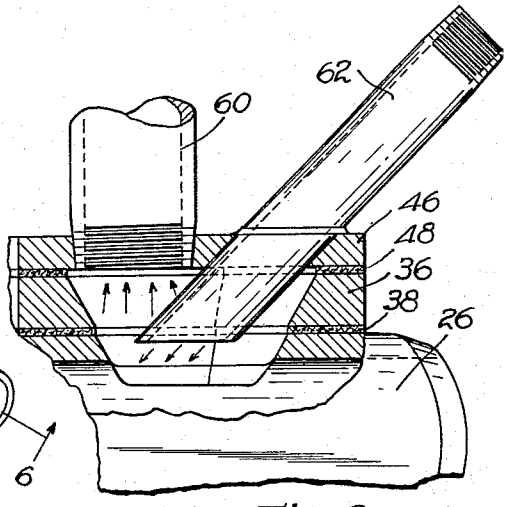

Fig. 6.

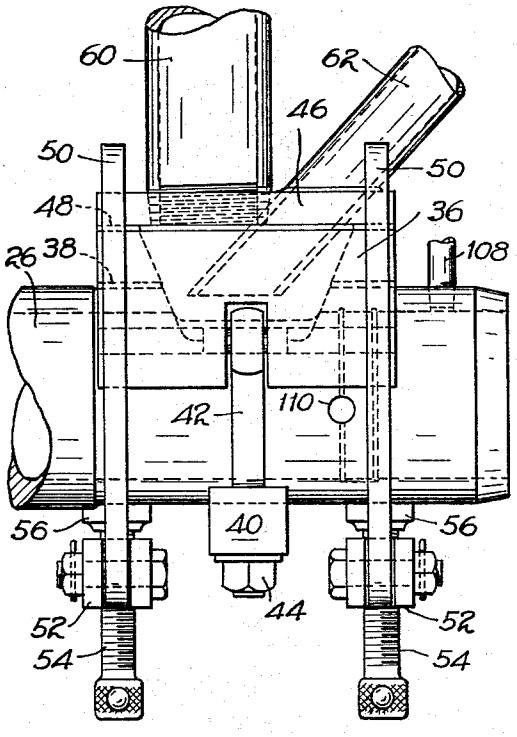

Fig. 4.

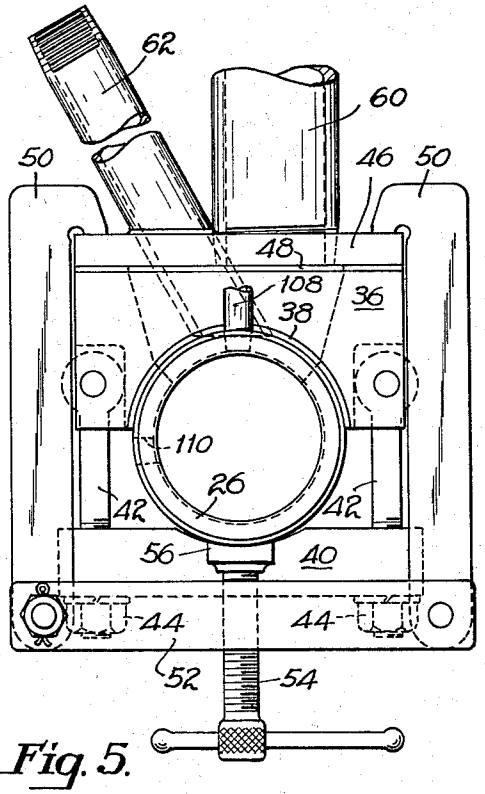

Fig. 5.

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VACUUM DIE CASTING APPARATUS

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This invention relates in general to casting equipment and its operation, and is more specifically concerned with die casting machines or apparatus for producing cast products from molten metal or equivalent readily flowable and castable materials, such as the commercially available plastics.

It is conventional practice to provide casting equipment incorporating a shot-receiving or cold chamber in advance of the die cavity from which flowable material therein to be cast is plunger-charged into the mold or die cavity of the equipment.

It is also common practice to apply vacuum of appreciably high intensity on the die cavity of such conventional die casting apparatus to draw a charge of flowable material into the cold or shot chamber remote to the application of vacuum thereon for subsequent plunger-charging thereof into the die cavity or matrix of such equipment.

Such acknowledged and conventional equipment has given rise to many operating difficulties foremost among which have been the inability to provide tight seals between the cavitied mold sections forming the die matrix, which incidentally must be vented; the intensity or level of vacuum required to draw a charge or shot of the flowable material from its supply reservoir into the cold chamber against the leakage of atmospheric pressure in direct communication from the vented die cavity to the cold chamber; and because of the further fact that each change in die structure can necessitate modification or complete substitution for the vacuum connection thereto.

The present invention is hereinafter described in terms of its adaptation to a conventional die casting machine having a cold or shot chamber which would normally be manually charged with flowable material to be cast and thereafter manipulated in conventional manner to advance a plunger axially through the cold chamber to charge the die cavity with the flowable material from the cold or shot chamber. In contrast to such conventional equipment, the invention is concerned with providing, in integrated unitary assembly, an accurate molten metal, or equivalent, metering system and automatic controls therefor which permit employing low intensity or level of vacuum for delivering predetermined charges or shots of castable materials to the cold chambers of casting equipment and to thereby substantially reduce or even eliminate the aforesaid difficulties and inefficiencies associated with existing conventional casting apparatus.

It is therefore one of the objects of the invention to provide accurately regulated vacuum induced delivery mechanism for charging molten or liquid flowable material into the cold chamber of a die casting machine under conditions and location substantially isolated from the effects of atmospheric leakage into the cold chamber through vented or otherwise poorly sealed mold sections constituting the die cavity of the equipment.

Another object of the invention is to provide an integrated electrically energized and sequentially timed circuit for controlling the cycle of operation of a cold chamber die casting machine which removes the human error and premature freezing of the materials being cast normally associated with the operation of conventional cold chamber die casting equipment.

A still further object of the invention is to provide cold chamber die casting equipment, and automatic controls therefor, which lend themselves to a wide range of adjustment and regulation without regard to changes in volume in the die cavity thereof.

Other additional objects and advantages will be appreciated by those skilled in the art to which the invention appertains on consideration of the following description and appended drawings, in which:

FIG. 1 represents a side elevational view of an integrated die casting machine falling within and illustrative of the scope of the invention;

FIG. 2 represents a diagrammatic wiring diagram of electrical circuitry employed in cyclic control of automatic operation of the installation illustrated in FIG. 1;

FIG. 3 represents a fragmentary top plan view to enlarged scale and more detail of a portion of the injection cylinder or cold chamber of the mechanism of FIG. 1;

FIG. 4 represents a front elevational view of the illustration in FIG. 3;

FIG. 5 represents an end elevational view of the illustration of FIG. 4; and

FIG. 6 represents a fragmentary sectional elevation taken on the plane **6—6** of FIG. 3.

In general terms, improved mechanisms illustrative of the invention comprise modified conventional or newly constructed cold chamber, plunger-injection die casting or equivalent machines in which accurately timed and controlled low level vacuum raised molten metal, or similar flowable and castable materials, is delivered in predetermined metered quantities or shots to the cold chamber of such equipment in timed relationship to subsequent transfer and charging of the so-delivered shot or shots into a die cavity in direct communication with the cold chamber, operation of the aforesaid delivery and casting cycle being automatically controlled and executed by a single manually operated switch device.

Referring to the appended illustrations for a more detailed description of a successful commercial installation of the invention, **10** represents the stationary half or section of a mold detachably and rigidly secured to the fixed platen **12** of a conventional cold chamber die casting machine. A second cooperating section or half **14** of the mold is detachably supported and carried by the rectilinearly translatable platen **16** of the machine, whereby the mold halves **10** and **14** can be brought into abutting closed and separated open condition. At least one of the mold sections **10** and **14** is cavitied, as at **18**, to provide a die matrix or cavity in accordance with the exterior configuration and weight or volume of the article to be cast.

The translatable platen **16** supports a conventional fluid-operated ejector cylinder **20** the piston of which carries an ejector plate **22** provided with one or more ejector pins **24** extending forwardly therefrom through aligned apertures in the mold section **14**, the purpose of which ejector mechanism is to forcibly free a finished casting from adherence within or contact with the translatable mold section **14** on completion of a casting operation.

The cold chamber or injection cylinder **26** of the machine is fixedly secured in respect to the stationary platen **12**, communicates at its inner end with the mold cavity or matrix **18**, and is open at its outer opposite end to receive an injection plunger or piston **28** slidably supported therewithin. The injection cylinder **26** is preferably horizontally disposed and a double acting fluid-operated cylinder **30** in axial alignment therewith, through the medium of its enclosed piston **32** and rigdly carried connecting rod **34**, is employed to reciprocate the injection plunger **28** over the axial length of the cold chamber **26**.

The cold chamber die casting machine thus far described is more or less conventional in its design and

structure and machines of this general type are in regular commercial use with an opening or charging gate in the upper surface of the injection cylinder **26**, in advance of the plunger **28**, serving as the entrance for a molten or flowable liquid charge of material to be cast into the injection cylinder **26** prior to advancing the injection plunger **28** to fill the die **18** therewith.

The present invention departs from the above-described conventional die casting equipment by providing a new and novel vacuum metering system in integrated combination and assembly therewith.

The incorporated metering mechanism or system comprises a generally box-shaped housing or hopper **36** in registered assembly over the normally provided entrance or charging aperture in the upwardly directed surface or wall of the cold chamber or injection cylinder **26**. In conversion of existing conventional cold chamber die casting machines, as hereinabove described, the hopper **36** is configurated on its underside surface to accurately match and conform to the exposed surface of the injection cylinder **26** immediately surrounding the opening therethrough and a gasket **38** of preferably elevated temperature resisting material is employed between the aforesaid matching surfaces before drawing the hopper into tight sealing unitary assembly on the exposed surface of the cold chamber or injection cylinder by means of a clamp bar **40** engaging the underside exposed surface of the injection cylinder **26** and secured by eye bolts **42** fixedly suspended from the hopper **36** and extending through the bar **40**, where they receive strain washers and nuts **44** adjustable to exert the required seal-tight assembly clamping force.

The otherwise open top of the hopper **36** is also sealed closed by a cover plate **46** and interposed gasket **48**. The cover plate **46** is secured in unitary assembly on the upper edge surface of the hopper **36** by means of four corner hook-shaped members **50** engaging the outer exposed surfaces of the plate **46** at their upper hooked ends and having their lower ends pivotally pin or bolt-connected in pairs to end bifurcated cross bars **52** below and transverse to the longitudinal axis of the injection cylinder or cold chamber **26**. A centrally disposed adjustable bolt member **54**, threaded through each of the cross bars **52** and provided on its normally unheaded end with a cylindrically concaved pedestal washer **56**, provides attainment of seal-tight clamping pressure between the corner hook-shaped members **50**, cover plate **46**, interposed gasket **48**, and upper edge surface of the housing or hopper **36**.

The cover plate **46** is drilled or otherwise provided with an aperture to receive and secure therewithin a vacuum pipe or conduit **60** in direct communication with the interior of the hopper **36** and cold chamber **26** in direct communication therewith. A second aperture is also provided through the cover pate **46** to receive an angularly compound directed pipe or delivery conduit **62** which extends some distance below the underside of cover plate **46** in which flat plane the aforesaid vacuum line or conduit **60** had been terminated. The angularly directed conduit **62** is preferably connected through a union to one end of an inverted U curvilinearly bent length of conduit **64** extending downwardly below the exposed surface level of castable flowable material within a reservoir **66** of such material. In the case of molten metal, as distinguished from other flowable liquid materials responding to die casting practice, such as many of the commercial plastics, the reservoir **66** would preferably be a crucible or similar molten metal holding device.

Any one of several commercially available vacuum sources has been successful in providing the required induced vacuum in the line or conduit **60**. A typical vacuum source has been illustrated in FIG. 1 and comprises a vacuum pump **68** in direct circuit connection through a valve **70** and vacuum regulator **72** which responds under atmospheric pressure, controllably reduced by a pressure reducing valve **74**, to a desired vacuum level established by predetermined setting of the regulator **72**, as registered on a gauge **76**. Fluctuations in the vacuum level developed and established by this system, as by leaks into the vented die cavity **18** and cold chamber temperature variations, are sensed and automatically corrected by providing the bypass conduits or lines **78** and **80** which supply negative pressures to open or close a diaphragm incorporated within the vacuum valve **70** to return the vacuum level to equilibrium and the vacuum differential in the main vacuum line **82** to zero. The surge vessel **84** may be, and preferably is, included in the vacuum system, as well as a three-way spring-return solenoid operated vacuum controlling valve **86** to be hereinafter described in more detail, and clean-out trap **88**. A four-way spring-return solenoid operated valve **90** is also provided, and will be explained more fully hereinafter, for fluid-pressure actuation and control of the previously identified injection plunger actuating cylinder **30**.

Automatic operation of the improved die casting mechanism of the invention is provided through the integrated incorporation therewith of electrically energized and responsive accurately timed electric units and circuitry. On specific reference to FIGS. 1 and 2, it will be observed that the stationary frame and movable platen **16** of the die casting machine support a microswitch **92** and cam contact **94**, respectively, across the power supply lines L_1 and L_2. In similar fashion, a microswitch **96** is rigidly mounted on the forward or connecting rod end of the stationary cylinder **30**, with its cooperating contact **98** carried by the translatory connecting rod **34**. The closed position of the microswitches **92** and **96**, as illustrated in FIG. 1, insures safe closed charge-receiving condition of the mold sections **10** and **14** and retracted position of the injection plunger **28** in readiness for the performance of a metering and cavity charging casting cycle.

Closing of the manually operated switch **100** across supply lines L_1–L_2 causes simultaneous energization of high precision adjustable electronic timer **102**, as well as energizing the three-way spring-return solenoid vacuum controlling valve **86**, to connect the vacuum line **60** with the above-explained and described vacuum source to thereby initiate evacuation of the cold chamber or injection cylinder **26** and die cavity **18** in direct communication therewith. The thus initiated and induced vacuum also reacts through the upper open end of the delivery conduit **62** and its contiguous portion **64** with the result that atmospheric pressure on the exposed surface of the flowable material in the reservoir **66** forces the same upwardly through the contiguous delivery conduit **64–62** into the cold chamber **26**. The selected size or uniform cross-section of the delivery conduit **62–64**, coupled with the level or intensity of the vacuum established by the vacuum regulator **72**, determines the rate of flow of the molten or flowable material delivered to the cold chamber **26**. Also, the energized time interval set by the adjustable timer **102** is controlling of the amount or quantity of flowable material delivered from the reservoir **66** to the cold chamber **26**. By adjusting the time interval of timer **102**, any desired and accurately metered predetermined quantity of flowable castable material can therefore be delivered to the cold chamber **26** to accommodate any particularly selected capacity of die cavity **18**.

When the timer **102** times out, or its energized time interval expires, the electric circuit including the vacuum controlling solenoid valve **86** is de-energized causing spring-return shifting of the same to open the vacuum line **60** to atmosphere through the exhaust port **104**. Such de-energization simultaneously closes the normally open contacts (FIG. 2) in the electric circuit of a second high precision adjustable electronic timer **106**, herein termed the injection plunger delay timer, to energize the same for a predetermined and definitely established time interval sufficient to permit reverse directional drainage of flowable material therewithin, by syphon action, on termi-

nation of the aforesaid vacuum metering and delivery cycle established by the time interval set by the timer **102**. This additional time interval imposed by timer **106** insures against possible freezing, congealing or dripping of flowable material from an undrained delivery conduit **62–64** into the cold chamber **26** in detrimental interference to subsequent reciprocation of the injection plunger **28** or subsequent vacuum delivery against frozen or congealed material within the conduit **62–64**.

Time out or de-energization of the delayed time interval performed by timer **106** serves to close the normally open contacts (FIG. 2) in the electric circuit of four-way spring-return solenoid valve **90** controlling fluid pressure delivery and exhaust to injection plunger actuating cylinder **30**. It will thus be understood and appreciated that pressure can only be applied to the major power stroke face of piston **32** to advance injection plunger **28** axially through the cold chamber **26** to charge the previously delivered accurately metered shot of flowable material therewithin into the die cavity **18** following complete drainage of the contiguous delivery conduit **62–64**.

It will be observed and understood from the above description of the structure and operation of the integrated mechanism, selected primarily for purposes of illustrating the invention, that accurately metered quantities of castable flowable material, including molten metals, are supplied from a reservoir of the same and delivered to the cold chamber of otherwise conventional die casting equipment in safely locked condition of the mold sections and retracted and inoperative position of the injection plunger within the cold chamber thereof. It will also be observed, and in particular from FIGS. 3–6, that the discharge end of the delivery conduit **62–64** is sufficiently isolated from adjacent areas of the interior walls of the cold chamber **26** to reduce premature chilling and any resulting congelation of the flowable material within the aforesaid delivery conduit or adjacent areas of the cold chamber **26**. The compound angular direction of portion **62** of the delivery conduit entering the cold chamber **26** also directs the material discharged therefrom substantially tangentially to the closest interior wall area of cold chamber **26** to thereby reduce to a minimum any turbulence that would otherwise result.

In addition, the isolated location of the vacuum inducing conduit **60** adjacent and slightly in advance of the retracted injecting plunger **28**, remote to the conventionally vented mold cavity **18**, minimizes and substantially eliminates the effect of atmospheric pressure entering the system through the mold vents and any loose or otherwise faulty sealing surfaces between the mold sections **10** and **14**. In fact, practical demonstrations of the mechanism herein described in commercial production has revealed that selection of vacuum conduit **60** in the form of a 1½ inch inside diameter steel pipe, or tubing, and employing an inside uniform diameter of ⅞ inch for the delivery conduit **62–64**, permitted using a vacuum level within the range 3 to 12 inches of mercury, as compared to a vacuum level above 20 to 25 inches of mercury when the vacuum had been induced by direct connection to the cavitied mold of substantially the same capacity die casting machine, in accordance with many prior art practices. The conventional higher vacuum level die casting machines have been observed to produce considerable turbulence within the cold chambers thereof, as demonstrated by internal voids in finished castings so produced. The higher level prior art vacuum charging systems have also produced greater pressure differentials between the cold chamber, die cavity and outside atmospheric pressure to make such systems more sensitive to pressure variations therewithin caused by leakage.

Two structural features illustrated in FIGS. 1 and 3 through 5, and not heretofore discussed, have been found desirable although not absolutely essential to the success of the apparatus and practice of the invention. One of these two features concerns the relatively small bore bypass conduit line **108** (FIG. 1), which connects into the vacuum drawing source to provide an induced relatively low vacuum around the tip of the injecting plunger **28** to counterbalance atmospheric leakage into the cold chamber **26** resulting from peripheral wear of the plunger **28**. A close tolerance piston or plunger within the cold chamber obviates the need of conduit **108**. The second feature is concerned with the aperture **110** (FIGS. 1, 3, 4 and 5) through the wall of the cold chamber **26** adjacent the injecting plunger **28** in its withdrawn or retracted position. This latter aperture permits introduction of lubricant for plunger **28**, when required, and would be normally sealed off.

It will be fully understood and appreciated that the apparatus selected for purposes of describing the invention is exemplary only, and not limiting, of the scope of the invention hereinafter defined in the appended claims.

We claim:

1. In a die casting apparatus including an atmospherically vented cavitied die, a horizontally disposed cylindrical cold chamber in open communication therewith, a power-operated injecting plunger reciprocal within said cold chamber to charge flowable liquid casting material delivered thereto directly into said cavitied die, and a charging aperture through an upper wall surface of the cold chamber adjacent and in advance of the injecting plunger in its retracted position within the cold chamber remote to said cavitied die, the improvement comprising:

(a) a housing carried by said cold chamber providing an upwardly and outwardly directed sealed chamber in open communication through said charging aperture with the cold chamber and vented cavitied die,

(b) an imperforate wall open ended flowable liquid casting material delivery conduit extending axially coextensively downwardly through and from above an upper wall of said housing and having its open discharge end terminating therewithin isolated from interior walls of the cold chamber and in substantially axially tangential disposition in respect to an interior wall of said cold chamber closely adjacent said charging aperture,

(c) said conduit being curvilinearly downwardly axially contiguously directed to locate its opposite open end below an atmospherically exposed surface of a source of flowable casting material located below the cold chamber,

(d) means for inducing a low level vacuum within said cold chamber in advance of the injecting plunger in its retracted position remote to said cavitied die,

(e) electrically energizable operating circuitry incorporating a pair of electrically responsively timed valves sequentially controlling initiation and duration of the induced vacuum and activation of a source of power initiating the injection stroke of the injecting plunger within the cold chamber in consecutively time-delayed sequence,

(f) energization of one of said valves being timed to expire and cut-off the induced vacuum and a metered quantity of flowable liquid casting material responding to the induced vacuum delivered to said cold chamber through said flowable liquid casting material delivery conduit, and

(g) energization of the other of said valves for initiating the injection stroke of said injecting plunger being set to initiate the injecting plunger charging stroke in selective timed delay following expiration of the induced vacuum controlling valve,

whereby flowable liquid casting material within the delivery conduit is directionally oppositely drained into the cold chamber and source of flowable liquid casting material from opposite open ends of the delivery conduit before initiation of the charging stroke of the injecting plunger.

2. A die casting apparatus in accordance with claim 1 in which the means for inducing low level vacuum is communicatively connected through the upper wall of said housing and is terminated in a plane above the plane of the open discharge end of the flowable liquid casting material delivery conduit within said housing.

3. A die casting apparatus in accordance with claim 1 in which the means for inducing low level vacuum is communicatively connected through the upper wall of said housing above the plane of the open discharge end of the flowable liquid casting material delivery conduit within said housing and in advance thereof towards the cavitied die.

4. A die casting apparatus in accordance with claim 1 in which the electrically energizable operating circuitry incorporates a protective microswitch permitting energization of the electrically energizable operating circuitry only when the cavitied die is conditioned to receive a charge of flowable liquid casting material from the cold chamber.

5. A die casting apparatus in accordance with claim 1 in which the electrically energizable operating circuitry incorporates a protective microswitch permitting energization of the electrically energizable operating circuitry only when the injecting plunger is in fully retracted position within the cold chamber remote to said cavitied die.

References Cited by the Examiner

UNITED STATES PATENTS

2,955,335	10/1960	Morgenstern	22—73
2,985,928	5/1961	Heskett	18—30 X
3,093,871	6/1963	Adams	22—73 X

FOREIGN PATENTS

718,744	11/1954	Great Britain.

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