

Feb. 14, 1967

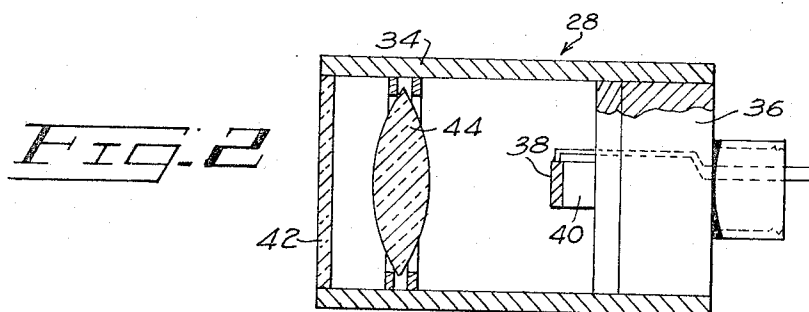
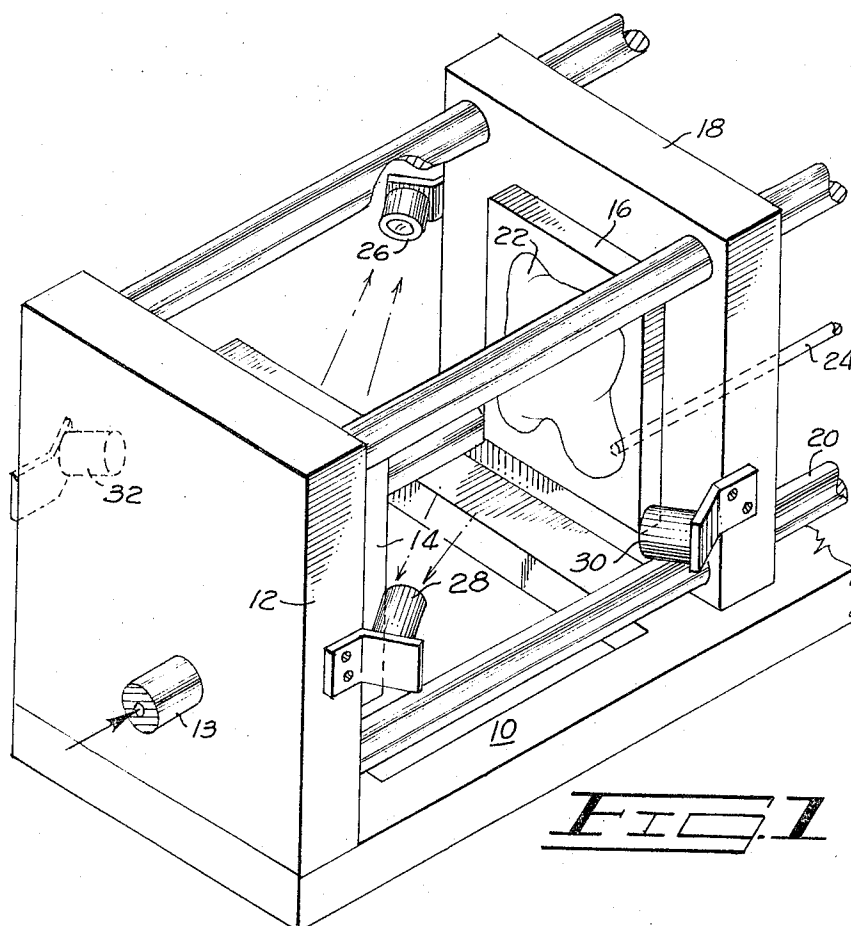
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SAFETY EJECTION CONTROLS FOR CASTING MACHINES

Filed April 7, 1964

2 Sheets-Sheet 1



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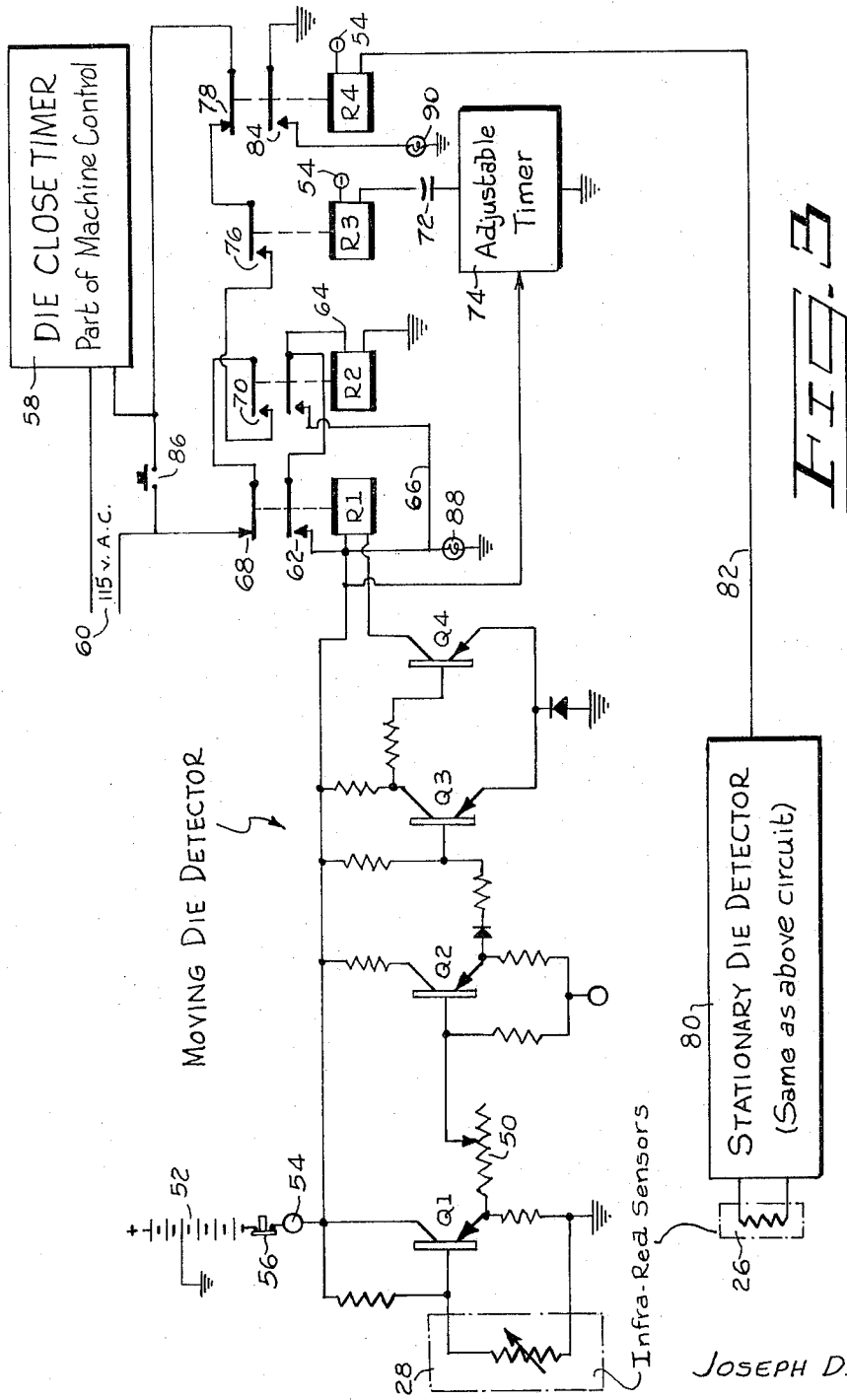
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2 Sheets-Sheet 2



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SAFETY EJECTION CONTROLS FOR CASTING MACHINES

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Filed Apr. 7, 1964, Ser. No. 357,956
8 Claims. (Cl. 22-94)

This invention pertains to casting machines or presses of the die-casting type, and particularly to arrangements by which the cyclic operation of the machine will be automatically interrupted upon certain failures or disturbances in the normal sequence of events associated with each casting or molding cycle; specifically, upon failure of complete ejection of the cast piece from between the platens.

Conventional die-casting presses for the production of molded metal parts include a pair of plates or platens to which are secured respective die members defining the molding cavities. One of these platens, at least, is arranged for movement (usually under hydraulic control) between die-open and die-closed positions, and means are provided for injecting molten casting metal into the cavities during the die-closed part of the cycle. Thereafter, and after a time sufficient for the molded parts to have cooled to solid condition, the dies are separated, and the molded part (or parts, in the case of a multi-cavity die) is ejected in preparation for the next molding cycle.

Machines of this type are resigned to operate at high speeds on an automatic cycle, and it is extremely important that their operation be interrupted upon the occurrence of certain failures in the operation. It is also desirable that a corresponding signal be given, for supervisory purposes. No particular problems are presented in the sensing or verification of stages or events involving the motions or positions of the die blocks or platens, the injection apparatus, and other parts which are permanent and relatively unchanging features of the machine. However, the same machine will from time to time be used to mold a variety of differently shaped parts, by the substitution of different die blocks, and even when this is not a factor, the problem of ensuring that the molded part or parts be fully ejected from the dies is a difficult one.

Failure of the machine to fully eject the molded product, before commencement of the next cycle, can be very serious. Ejection is usually produced by the operation of ejecting pins or strippers which are automatically pushed into the die cavities during the opening (die-separating) movement of the platens. When thus loosened from the cavity, the part may then fall between the platens or dies into a delivery chute or the like. If a molded part is not fully ejected, or if it is broken and only one portion falls free, the un-ejected solid material will usually prevent complete closure of the die blacks during the succeeding cycle, and result in damage to the dies or their cores, and might under some circumstances cause the squirting of hot metal from the machine during the next molding cycle. Even if an un-ejected or broken part remains in the cavity in such a way as not to interfere with the closing of the dies, its presence in the cavity will prevent the making of an acceptable molded piece on the next succeeding machine cycle. The control system further prevents continuation of idle die closing and opening cycles if no parts are being produced; for example if there is a failure of casting metal supply.

Attempts to provide a machine-control system that will meet the above situation have not been successful. For example, systems for sensing or counting the ejected parts as they pass through or along the delivery chute or chan-

nel have been devised, using mechanical feelers or photoelectric sensors. Similar sensors have been arranged to sense the presence of molded pieces or sections in the cavity, after opening of the dies and the operation of the ejecting devices. No dependable sensing system of any of these types has come into use, largely because of their requirement for highly critical adjustment to meet the various situations that can arise (especially when the dies are changed), the impossibility of detecting broken pieces of a molded part by physical contact or optical sensing, and other shortcomings.

The present invention is directed to a system for sensing any failure of the complete ejection of the molded product at the end of each machine cycle, quite independently of the particular shape or configuration of the part or parts, and of the number produced per cycle (that is, for example, by a multi-cavity die). This is accomplished by sensing the radiant energy, particularly heat, proceeding from any molded material retained in or by the dies themselves, during a period following the "ejection" operation. It will be understood that in any machine of this kind, the freshly molded parts, even after they have solidified, are at a higher temperature than the dies themselves, and particularly so for the higher operating speeds in which it is desired to start the next cycle with a minimum of delay after each injection phase. Hence, the retention of a molded part, or any broken piece, either in a cavity or in a partly ejected state, can be sensed by means of properly located sensors that are responsive to anomalies in the temperature or radiant energy pattern resulting from the incomplete ejection of the molded part or parts.

In addition to the increased emission of radiation (heat or infra-red energy) from any unejected parts due to their elevated temperature relative to the die and die cavity surfaces, it has been found that the reflectivity of the molded parts is appreciably greater, especially for energy in the infra-red spectrum, than is the reflectivity of the die and cavity surfaces. The invention therefore further contemplates also the sensing of un-ejected parts by reason of the selective reflection of such energy from their surfaces, when the open dies are flooded or bathed with incident heat rays or infra-red radiation from sources appropriately positioned relative to the open die parts.

In brief, the invention accomplishes its objects by providing one or more infra-red sensing devices mounted on the molding press platens so as to respond to the heat energy or effective temperature of the die and cavity surfaces, and of any molded material therein or therebetween, in combination with circuits for utilizing the output signals of such devices only during the proper portion of the machine cycle (that is, following the opening of the dies and the operation of the normal ejection or stripping instrumentalities) for shutting down the machine when any molded material has not been fully ejected; and optionally for giving an appropriate signal to the machine operator.

The invention will now be described in connection with a typical and presently preferred illustrative embodiment thereof, given by way of example and not for purposes of limitation, and illustrated in the accompanying drawings, in which:

FIG. 1 is a fragmentary perspective view of a typical installation of the sensing system applied to a conventional die casting machine.

FIG. 2 is a sectional view of one of the infra-red sensing devices used in the invention.

FIG. 3 is a schematic wiring diagram of the chosen form of arrangement.

Referring first to FIG. 1 of the drawings, the framework of a typical die-casting press is indicated by refer-

ence numeral 10, said framework supporting the usual fixed platen 12 provided with T-slots for supporting thereon one of the die blocks 14. The complementary die block is indicated at 16, mounted upon the moving platen 18, it being understood that the die blocks contain or define the molding cavity into which the molten casting metal is injected under high pressure by conventional means which are not shown since they are well known to those familiar with such presses. Numeral 20 indicates one of the usual tie rods which support and guide the moving platen during its movements to open and close the die blocks, under the driving force of other conventional parts which are also omitted for simplicity and clarity of the drawing. The injection of molten metal occurs under the control of a machine programming device, usually a form of timer or the like, and it is immaterial whether the metal is injected via a nozzle such as indicated at 13, leading through a passage in one of the die blocks and its associated platen, or through some different channel.

The platens 12 and 18 in FIG. 1 are shown in their separated or "open" position, in which the retraction of platen 18 has carried the molded or die-cast piece 22 to a position at which it would normally be ejected or stripped from the mold cavity in die block 16 as by a set of ejecting pins 24 fixed relative to the machine framework or resiliently mounted thereon so as to project into the die cavity when the platens separate, to engage and dislodge the molded piece which would then be removed from beneath the die blocks in preparation for the succeeding closure of the dies and the molding of the next piece. As is apparent from the drawing, the molded piece 22 has not been thus removed, and it is necessary to advise the operator of this fact, and also to prevent the initiation of the next molding cycle, as by interrupting the further advance of the machine cycle programmer.

The invention accomplishes the sensing of the continued presence of an unejected workpiece by means of one or more, preferably several, heat or infra-red radiation sensors 26 and 28, mounted upon the respective platens 12 and 18 as by brackets bolted to them or to the existing T-slots thereof, but so arranged as not to physically interfere with the platen motion. Each of these sensors has a radiation-receiving axis, and responds to the infra-red radiation which it receives along such axis. Depending upon the shape and size of the pieces being molded, and whether only one or both of the die blocks are such as might retain a molded piece against effective ejection, the sensors may be positioned and supported by one or both of the platens. In the typical installation shown in FIG. 1, one of the sensors is supported by each platen, and directed so as to receive predominately the infra-red radiation from the exposed surface of the die block carried by the opposite platen. It will be obvious that each sensor will receive radiation from the die block, whether or not the molded piece has been ejected; however, since the die blocks themselves are always well below the melting temperature of the metal being cast, and since they open relatively soon after the solidification of the injected metal, it will always be true that any unejected workpiece will have a considerably higher temperature than the surface of the empty die block, so that the sensors will produce a substantially greater output signal in the instances where failure of ejection has occurred. For the same reason, if only a part of a cast workpiece is ejected, leaving a residual portion in a cavity or between the die blocks, its presence will likewise produce a higher signal output from one or both of the sensors.

As mentioned earlier in this description, the sensors 26 and 28 will respond to infra-red or heat radiation they receive, regardless of whether it is generated by the hot workpiece itself, or some unejected portion thereof, or whether it is reflected by such workpiece or part from an external source of such energy. That is, the cast metal itself has a higher reflectivity for infra-red or heat radi-

ation than do the surfaces of the die blocks and any cavities therein. Therefore, it is sometimes desirable to augment the detecting action by providing the machine with specific additional sources of infra-red energy directed towards the sensed areas of the die block or blocks. Such sources are shown in FIGURE 1 as heat lamps or projectors 30 and 32, likewise supported on the machine platens or framework out of the travel paths of the machine parts, and energized by any convenient source such as the usual 115-volt supply circuit. Preferably, the directional orientation of these sources is adjusted relative to the sensors 26 and 28 so that a maximum percentage of the applied infra-red radiation will be reflected, in a more or less specular manner, into the directional receiving axes of such sensors.

FIG. 2 shows in a longitudinal sectional view a typical one of the infra-red sensing devices, comprising for example a cylindrical casing 34 within which is mounted, as upon the inner surface of the electrical connector body 36, an infra-red sensing cell 38 such as a cadmium sulfide or equivalent type whose resistance changes in response to its exposure to infra-red radiation. Numeral 40 designates an optional cooling or refrigerative mount for the sensitive cell to increase its sensitivity of response, and may be of the thermoelectric type or may include a circulating coolant if desired. In order to make the device relatively insensitive to light in the visible region, and thus to avoid false responses due to fortuitous changes in the ambient illumination, a selective infra-red transmitting filter 42 may be added, and a condensing lens 44 of suitable infra-red transmitting glass is preferably provided, as shown, to limit the acceptance angle of the detector to radiation arriving predominately along the preferred sensitive axis of the device.

In order to integrate the ejection sensing circuits into the program controlling devices or timer of the press itself, a circuit arrangement as shown in FIG. 3 may be employed. As an aid in understanding this diagram, it should be kept in mind that in most installations, the physical ejection pins or stripping means of the casting machine will be associated with only one of the platens, the dies being designed to cause the molded part to follow a specific one of them during the die-opening movement. Thus, during normal operation, the molded part should never stick in the opposite die, and if it should happen to do so at any point in the opening travel of the moving platen, the machine cycle must be interrupted to prevent re-closure and a succeeding cycle. On the other hand, since the molded part will normally travel with the other die block for at least a portion of its platen travel before the piece is subjected to the force of the ejection mechanism, interruption of the cycle by sensing of that die should be inhibited until after such a delay as would ordinarily allow the molded piece to be ejected; in this way, stoppage of the machine is not produced unless the molded piece, or a portion of it, remains in the die after the normal period for operation of the ejecting devices. Likewise, the operation will definitely be interrupted unless the molded piece is sensed during die-opening movement; this prevents recycling if no piece at all has been produced, as can happen if the injection apparatus fails.

Referring now specifically to FIG. 3, the detector 28 which is aimed at the moving die block 16 is indicated at the left as an infra-red sensitive variable resistance connected between the base and emitter of transistor Q1, with suitable bias resistors constituting it as an emitter-follower amplifier coupled through an adjustable resistance 50 to a second-stage emitter-follower transistor Q2, these amplifiers serving to raise the D.C. level change, due to irradiation of sensor 28 (when it senses a hot casting or fragment), to a value suitable for control of the typical Schmitt trigger formed by interconnected transistors Q3 and Q4.

Power supply for the transistors is provided from a current source (battery or rectifier system, a battery being

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shown for convenience of illustration) 52 to terminal 54 over a pair of contacts 56 arranged as a limit switch to be operated by the movement of the moving die platen 18; the arrangement is such that the contacts 56 close in advance of the casting ejection instant, and remain closed at least until completion of the ejection-sensing period. These contacts serve to interrupt the power circuit long enough, following each cycle of relay operations, to allow any relays held operated by holding circuits to drop out, or become de-energized, in preparation for the next sensing cycle. The sensing circuit is so arranged that when sensor 28 receives infra-red energy in excess of a level predetermined by the adjustment of resistor 50, transistor Q3 is biased "off" or non-conducting, regeneratively switching transistor Q4 "on" and conducting current from source 52 through the coil of relay R1 to operate the same.

The "Die Close" timer 58 is a part of the casting machine control, and may consist of a timer motor or a delay solenoid operating a set of contacts which control the operation of closing the platens, as well known in the art, so that closure can commence only a pre-set time following their opening, to allow time for ejection of the molded piece. Preventing closure of the circuit of the timer 58 will therefore prevent the timer from commencing the next closing movement of the platens, and such prevention is provided in the present arrangement by a series arrangement of the contacts of relays R1, R2, R3 and R4, all in series with the normal 115 volt A.C. supply line 60 of the timer 58.

Thus, as the moving die commences to open, contacts 56 close and energize the supply circuits of the transistors. Sensor 28 initially senses the hot or reflective casting 22 in the moving die as the dies begin to separate, and before the ejection mechanism becomes effective; transistor Q4 conducts, and relay R1 is energized, its normally open contacts 62 closing a supply circuit 64 for relay R2, and the latter operates and is held operated by the holding circuit 66. As the dies continue to separate, the molded piece will normally be ejected from die 16, and relay R1 will release, but relay R2 will remain operated due to its holding circuit. However, and even though contacts 68 of R1 and 70 of R2 are both closed, the series circuit to the timer 58 will not be completed until a third relay R3 is operated, by a momentary "sensing" pulse delivered to its coil from the condenser 72, via an adjustable timer 74 which operates momentarily, following each operation of contacts 56, at a time at which ejection of the molded piece would normally have been accomplished. Since relay R3 will thus be operated momentarily only at the proper sensing time, it will prevent the molding cycle from recommencing even if relay R1 should drop out as a stuck casting cools down. R3 acts as a "gating circuit" to define the time interval during which the sensing is effective to establish either a "go" or "no go" condition, regardless of changes occurring outside this interval.

When relay R3 operates as described, and if contacts 68 and 70 are closed as above described, the circuit of timer 58 is completed through the now-closed contacts 76 of relay R3 and the normally-closed contacts 78 of relay R4, and a closing cycle of the platens is initiated. Obviously, if the molded piece had become stuck in the stationary die as the dies opened, relay R1 would not have been operated at all, and relay R2 would also have not been energized, and the next closing cycle would be inhibited at contacts 68 and 70. If, as sometimes happens, the molded piece is broken, and a part only is carried along in die 16 as it opens, the die-closing cycle might be initiated as above described, but in this case, the stationary die detector 26, and its associated circuitry 80 (a duplicate of the transistor portion of the moving die detector circuit) would energize relay R4 over conductor 82, preventing completion of the timer 58 circuit at contacts 78. A holding circuit for relay R4 is shown over

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its contacts 84, to maintain the interruption of the timer circuit until for example, a new cycle is initiated, after an operator clears the obstruction by a manual momentary-operated switch 86 overriding the interruption of the circuit of timer 58.

Warning lamps 88, 90 may be connected for energization by the relays or any of them to signal to the operator the reason for any interruption of the closing cycle of the machine, and to provide adequate supervision for the system. It will be observed that the arrangement described provides a substantial measure of fail-safe protection, in that completion of the circuit of timer 58 requires that, at the commencement of each opening of the dies, relay R1 first be operated to cause relay R2 to lock up. Without this preliminary operation of these relays, the timer circuit could not be completed at all, because contacts 70 would remain open. Hence, a failure of the sensing device 28, or the transistor circuits, will also prevent reclosure of the dies in a positive manner.

An additional feature in the nature of a fail-safe provision results from the positive requirement that relay R1 operate (pull up) prior to the instant or period (set by timer 74) when the go/no-go condition relative to casting ejection is determined. Thus, the sensors 26 and 28 are looking at the dies even before they open. If the die temperatures themselves vary too widely from the desired values, machine cycling will also be stopped. For example, if the die temperature itself rises too high, R1 will be energized continuously while 56 is closed, and the die closing timer or control 58 will not be energized. Likewise, if the die temperature should decrease too much, R2 cannot operate even though contacts 68 of R1 will then have remained closed. The desired range of sensing control is set by the value of resistor 50 relative to the supply voltage, and particular circuit parts and parameters employed.

While the invention has been described herein in considerable detail in connection with a preferred embodiment, it is to be understood that such details are explanatory and not limiting, and that the scope of the invention is as defined in the appended claims.

What is claimed is:

1. In a casting machine of the type having a pair of relatively movable platens adapted to carry molding die blocks between open and closed positions, injection means for supplying casting material to a cavity defined by said die blocks, and a machine program control for opening said die blocks for ejection of a molded part and for thereafter closing said die blocks in preparation for a succeeding molding cycle, the improvement comprising:

- (a) radiant energy sensing means mounted relative to said platens to respond to the radiant energy flowing from the separated surfaces of the opened die blocks, and from any cast material in or between said blocks,
- (b) a normally-open sensing circuit connected to said sensing means,
- (c) means controlled by said program control for closing said sensing circuit only during an interval following substantial completion of the opening movement of said die blocks, and
- (d) means responsive to the output of said sensing circuit for signalling the presence of unejected molded material in or about a cavity formed by said die blocks.

2. A casting machine in accordance with claim 1, in which said radiant energy sensing means is selectively sensitive to infra-red radiations.

3. A casting machine in accordance with claim 1, including at least one source of infra-red radiation mounted on said machine in position to irradiate the parting face of one of said die blocks.

4. A casting machine in accordance with claim 1, in which said normally-open sensing circuit includes in series the normally-open contacts of at least two relays, one

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operated in response to the output of said radiant energy sensing means, and the other operated in timed relation after the expiration of a normal ejecting period following separation of said die blocks.

5. A casting machine in accordance with claim 1, including means controlled by said sensing circuit, when completed, for interrupting further operation of said machine.

6. A casting machine in accordance with claim 4, including an additional relay (R1) connected for operation by said sensing means during an initial phase of the opening of said die blocks, said additional relay when operated completing an operating and holding circuit for said one relay (R2).

7. In a casting machine of the type having a pair of relatively movable platens adapted to carry molding die blocks between open and closed positions, injection means for supplying molten material to a cavity defined by said die blocks, and a machine program control for opening said die blocks for ejection of a molded part and for thereafter closing said die blocks in preparation for a succeeding injection and molding cycle, the improvement comprising:

- (a) radiant energy sensing means mounted relative to said platens to respond to the infra-red energy flowing from the separated surfaces of the opened die blocks, and from any hot cast material in or between said blocks,
- (b) a normally-open sensing circuit connected to said sensing means,
- (c) means controlled by said program control for closing said sensing circuit only during an interval fol-

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lowing substantial completion of the opening movement of said die blocks, and in dependence upon the output of said sensing means, and

(d) means responsive to the output of said sensing circuit for signalling the presence of unejected molded material in or about the cavity of said die blocks.

8. In a casting machine of the type having a pair of relatively movable platens adapted to carry molding die blocks between open and closed positions, injection means for supplying molten material to a cavity defined by said die blocks, and a machine program control for opening said die blocks for ejection of a molded part and for thereafter closing said die blocks in preparation for a succeeding injection and molding cycle, the improvement comprising:

- (a) radiant energy sensing means mounted relative to said platens to respond to the temperature of at least one of said die blocks, and
- (b) means responsive to the output of said sensing means for signalling a departure of the temperature of the sensed die block away from a predetermined range.

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