

[54] **METHOD AND APPARATUS FOR CONTROLLING LOW PRESSURE DIE CASTING**

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[58] Field of Search..... 164/4, 154, 155, 119, 306, 164/309, 156, 131, 133

[56] **References Cited**

UNITED STATES PATENTS

2,786,234 3/1957 Beyer..... 164/154

FOREIGN PATENTS OR APPLICATIONS

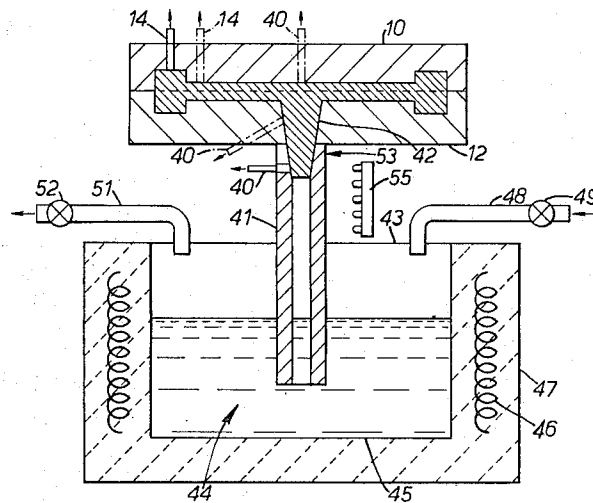
384,308 4/1963 Japan..... 164/306

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[57] **ABSTRACT**

A casting method and apparatus is disclosed for low pressure die casting of metals. The molten metal is formed through an inlet passage into a die cavity under gaseous pressure. A temperature sensor is used in sensing when the casting material has solidified in the inlet passage, and this is used to terminate the application of gaseous pressure. The die opening sequence is then initiated after a timed period or independently under the control of another temperature sensor in the die cavity.

7 Claims, 4 Drawing Figures



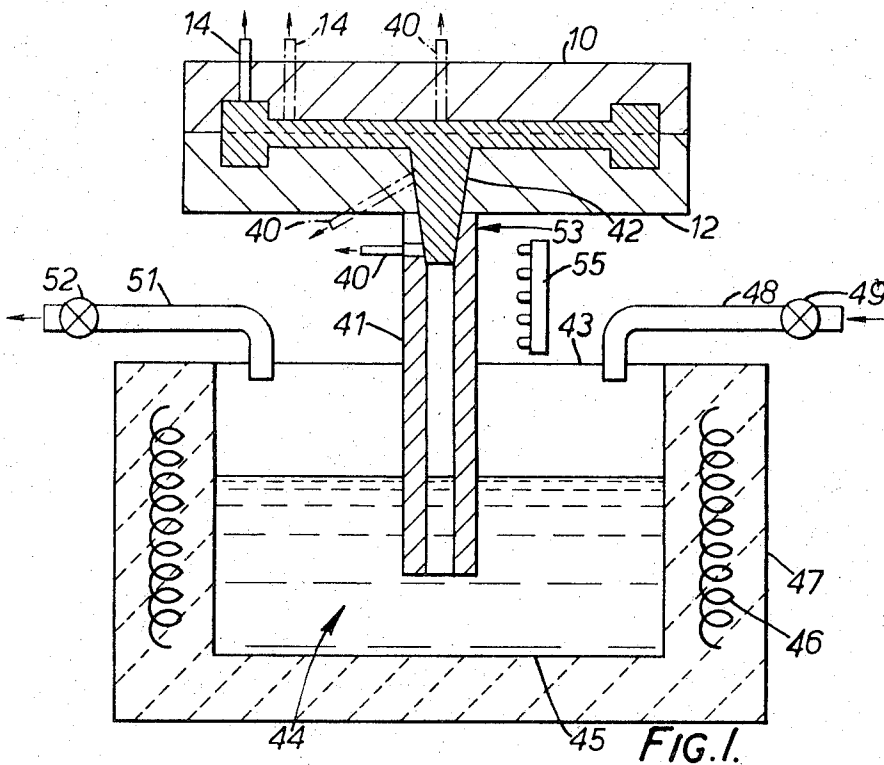


FIG. 1.

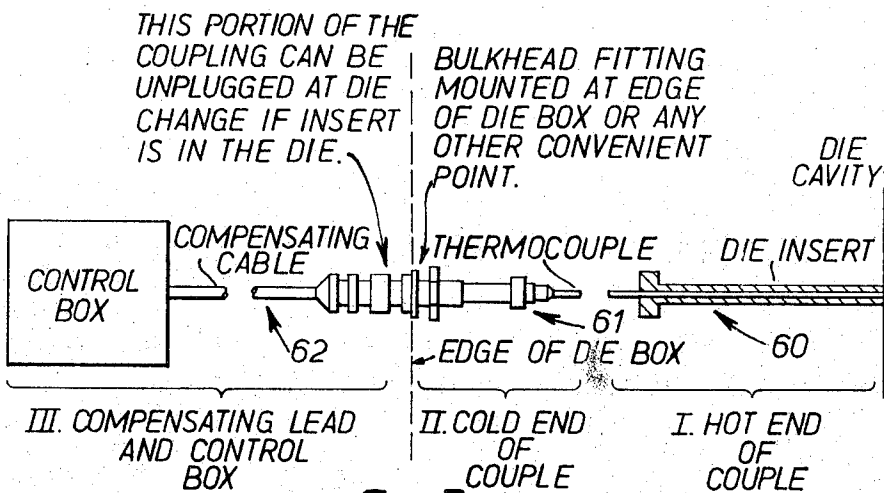


FIG. 3.

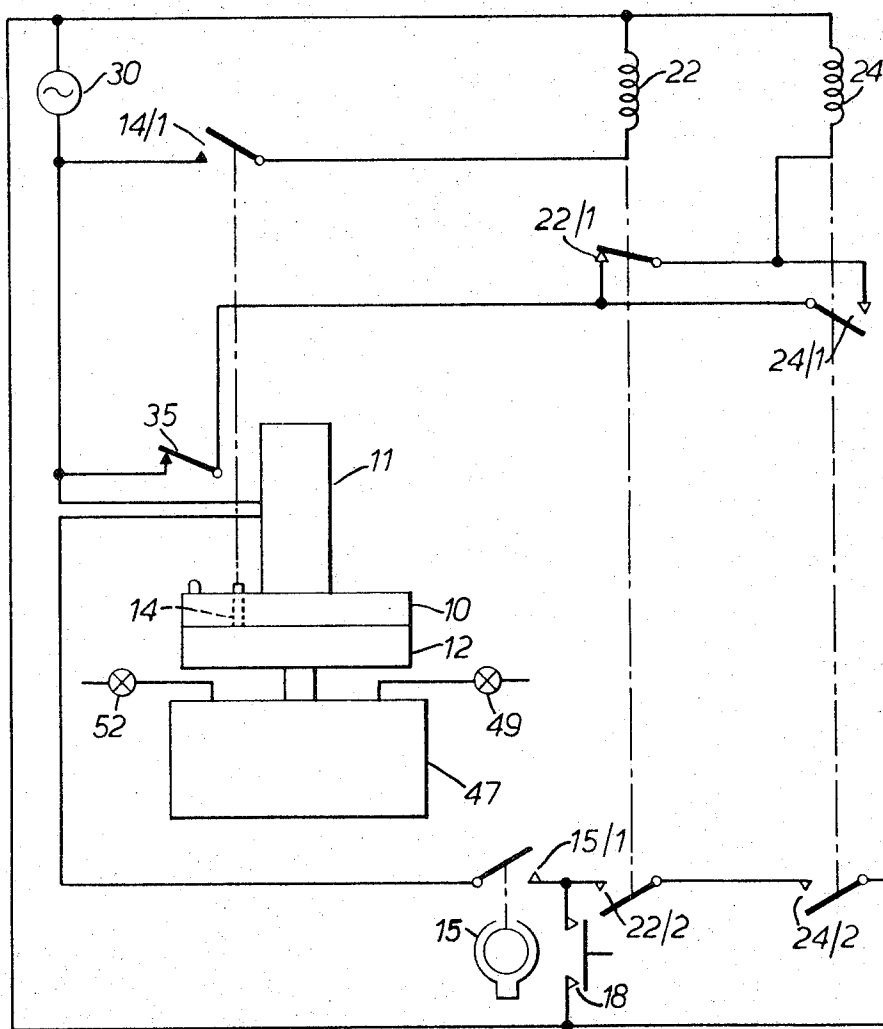


FIG. 2.

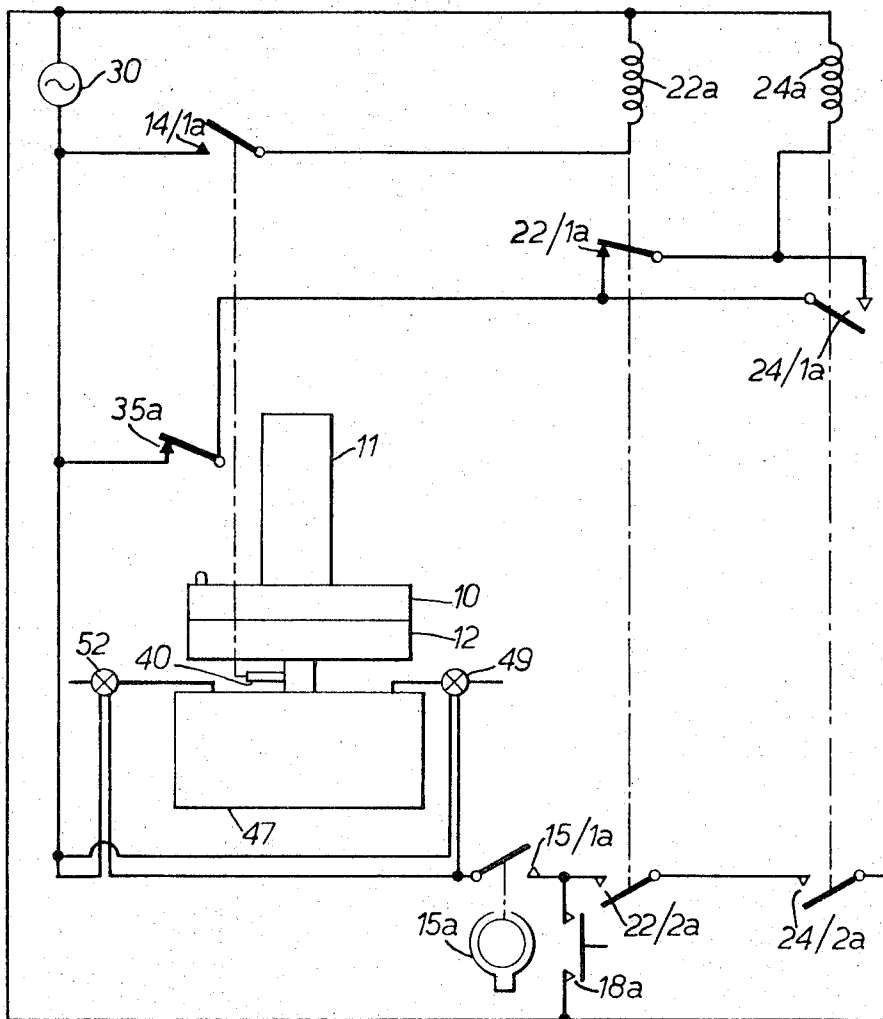


FIG. 4.

METHOD AND APPARATUS FOR CONTROLLING LOW PRESSURE DIE CASTING

The present invention relates to a method of casting and to apparatus for carrying out the method and in particular to methods in which the material being cast is introduced into the die or mould cavity by the action of air or gas pressure.

The invention has been developed with the problems of low pressure die casting in mind and will be described with reference thereto. However it will be appreciated that it is applicable to other casting techniques and also to injection moulding techniques for plastics in which the casting material is acted on by air pressure and this causes it to be introduced into the die.

In conventional low pressure die casting the die is arranged above a melt holding pot and a tube extends from inside the side down into the pot so that its end is below the level of the melt. An air pressure supply line passes through a gas tight cover into the air space above the melt in the pot. Casting is achieved by forcing air e.g. at 4 or 5 p.s.i., into the air space in the pot. This forces the molten metal up the tube into the die cavity. Conventionally the operator determines by trial and error a safe period for maintaining the air pressure to ensure solidification of the casting and also of the top end of the column of metal in the tube, the sprue, and after that period switches off the air pressure supply. The remainder of the still molten metal in the tube then falls back into the pot. A timer is started by the operator or automatically to control a further delay before the die opening sequence begins to ensure that the solid casting has sufficient strength to survive ejection from the die.

Clearly with different dies the period required will vary. Also if the pressure is switched off too soon molten metal would run out of the casting leaving cavities in it. Thus the pressure is usually left on for longer than is strictly necessary to provide a margin of safety. This reduces the casting rate and increases the wastage of metal by producing larger sprues than are really necessary.

It is an object of the present invention to provide an improved method and apparatus for reducing these problems and provide a higher casting rate and better control over the casting operation.

Thus according to the present invention a casting method comprises introducing a molten casting material into a die cavity under gaseous e.g., gas or air pressure, sensing when the casting material has reached a desired temperature, e.g., when it has solidified, this instant will be called the datum point, and thereby generating a signal and using this signal to terminate the application of gaseous pressure preferably automatically and preferably also to initiate the die opening sequence either immediately or after a set delay period.

The datum point of the casting material is conveniently sensed by measuring the temperature of the casting at one or more selected sensing points, e.g., the temperature of the sprue can be measured or the temperature at a point or points in the die cavity can be measured or any combination of these can be measured. The method can then consider the datum point as being the instant when each of these measured temperatures has fallen below a value, predetermined by reference to the casting material and the particular die

configuration, or when the average of any pair or more of the measured temperatures has fallen below such a predetermined value.

The die opening sequence can be initiated at the moment the datum point is reached or more usually after a delay allowing the casting to harden. At the datum point the sensor can be used to start a timing period and at the end of that period initiate the die opening sequence e.g., removal of any cores followed by actual opening of the dies.

Clearly in order to achieve the maximum rate of casting the air pressure supply will be cut off at the datum point.

Instead of using a timer delay running from the datum point a sensor in the die cavity itself can be used directly initiate the die opening sequence when the temperature has dropped to a still lower value i.e., without direct reference to the datum point. This will ensure that the castings are all ejected at about the same temperature and thus with very closely similar dimensions independent of changes in ambient conditions e.g. variations in cooling water flow rate or temperature or in initial die temperature.

With low pressure die casting of metals and alloys the datum point is preferably measured at the top end of the sprue or feed tube and at least one additional temperature measurement is made in the die and this independently controls the starting of the die opening sequence.

According to another aspect of the present invention a die casting or injection moulding machine, incorporating dies defining a die cavity, has air or gas pressure injection means for forcing the casting material into the die cavity, and temperature sensing means adjacent the die cavity or the inlet thereto providing an input signal to control means adapted to terminate the application of gas or air pressure to the casting material when predetermined temperature conditions are sensed.

The temperature sensing means are preferably located adjacent the inlet to the die cavity so as to sense the temperature of the sprue. However the sensing means could be located alternatively in the casting cavity itself or additional sensing means could be located in the casting cavity.

The control means are preferably arranged to operate only when the temperature has risen above a predetermined value and thereafter fallen below such a value, the datum point referred to above. Such means may be re-set by contacts responsive to opening of the dies.

Various forms of controlling means may be employed but in one convenient arrangement the control means comprise an electrical circuit including a primary relay having a coil connected across a supply through a temperature-sensitive contact which closes when the sensor temperature is below a predetermined value, and a secondary relay having a coil connected across the supply through a contact which closes when the pressure injection means are switched on, in series with a normally closed contact of the primary relay shunted by a normally open holding contact of the secondary relay, the switching off of the pressure injection means being under the control of two normally open operating contacts, one of each relay, connected in series.

The control means may also incorporate timer means which are started when the datum point is sensed and

control the moment of the initiation of the die opening sequence.

However use of timing only to control die opening can result in the actual temperature of the casting at ejection from the die varying from casting to casting during a production run and this will result at the very least in variations in dimensions between the castings.

It is thus preferred for a similar thermocouple or array of thermocouples to be located in the die cavity and their output signals used (either averaged or absolutely) to provide an input signal to similar control circuitry to cause the die opening sequence to be initiated when a predetermined preset temperature condition is sensed.

The control circuit for the die opening can thus conveniently comprise an electrical circuit including a primary relay having a coil connected across a supply through a temperature-sensitive contact which closes when the sensor temperature is below a predetermined value, and a secondary relay having a coil connected across the supply through a contact which closes when the dies are closed, in series with a normally closed contact of the primary relay shunted by a normally open holding contact of the secondary relay, the opening of the dies being under the control of two normally open operating contacts, one of each relay, connected in series.

The invention may be put into practice in various ways and one specific embodiment will be described by way of example with reference to the accompanying drawings in which:

FIG. 1 is a diagrammatic side elevation cross-sectional view of a low pressure die-casting machine;

FIG. 2 is a circuit diagram of a control circuit for use with the die sensor of the casting machine shown in FIG. 1,

FIG. 3 is a side elevation of a temperature sensor for use in the machine shown in FIG. 1, and

FIG. 4 shows a circuit for controlling valve operation.

The low pressure die casting machine shown diagrammatically in FIG. 1 has a die assembly consisting of a fixed die 12 and a movable die 10 under the operation of a hydraulic ram 11 (not shown). The moving die is fitted with suitable ejector pins (not shown).

The fixed die 12 is connected to a furnace tube 41 e.g., of cast iron of 4 to 5 inches diameter and 1 inch wall thickness. The taper on the sprue passage 42 is somewhat exaggerated.

The tube 41 passes through a gas tight cover 43 into a furnace pot 45 in which is contained the melt 44, the lower end of the tube 41 being below the surface of the melt. The furnace pot is surrounded by heating elements 46 enclosed within an outer insulating vessel 47. Air under pressure e.g. 4 or 5 p.s.i. is supplied to the interior of the pot 45 by a pipe 48 via a valve 49 from a compressed air supply. The pipe 48 passes through the gas tight cover 43. An exhaust pipe 51 also passing through the cover 43 provides an exhaust outlet under the control of a valve 52. Clearly a two way valve located in the position of valve 49 could be used instead of the two valves 49 and 52.

A thermocouple temperature sensor 40 is located in the top end of the furnace pipe 41 with its tip at the inside surface of the pipe in the flared sprue region 53. The top end of the furnace pipe above the cover 43 is

provided with gas burners 55 so that it can be heated if necessary.

A thermocouple temperature sensor 14 can also be located at the centre of the moving die 10 with its tip very close to the surface of the die cavity.

FIG. 2 shows a control circuit for the sensor 14. As mentioned above the movement of the die 10 is effected by a hydraulic ram 11 under the control of a timing device 15 which serves to energise a solenoid-controlled valve (not shown) from an electric current supply 30. In applying the present invention two contacts 22/2 and 24/2 of a temperature-sensitive controller, shunted by a manual switch 18, are connected in series with the normally-open contact 15/1 of the timing device 15 which can either be short-circuited or set to a low time period in order that the control may be temperature dependent.

The temperature sensitive controller is operated by a sensor 14, such as a thermocouple, placed at the surface of the cavity or in an insert protruding into the cavity. The output from the sensor 14 will rise rapidly when the metal is injected and thereafter fall as the casting cools, rapidly at first, then more slowly.

The circuit of the controller is arranged to close the operating circuit only when the temperature has risen above a predetermined value and thereafter falls below such a value. If desired the timing device 15 may be relied upon to prevent the temperature sensor from operating prematurely, but in the arrangement shown it is effected by a circuit comprising two relays, a primary relay 22 and a secondary relay 24, of which the latter has a holding circuit. Each relay has a normally open operating contact (i.e., open when the relay is de-energised), the two operating contacts 22/2 and 24/2 being connected in series, so that the mould will be opened when both relays are energised. The primary relay 22 has a coil connected across the supply 30 through a temperature-sensitive contact 14/1 which closes when the sensor temperature is below a predetermined value. The secondary relay 24 has a coil connected across the supply through a contact 35 which closes when the dies are closed, in series with a normally closed contact 22/1 of the primary relay 22, shunted by a normally open holding contact 24/1 of the secondary relay 24.

Thus the operation is as follows. Assuming that when the instrument is switched on the sensor temperature is below the chosen value the primary relay 22 will be energised and open its contact 22/1 (and incidentally close its normally open contact 22/2). When the dies close they will close the contact 35 in series with the secondary relay 24 but this relay will not be energised since it is also in series with the contact 22/1. When the temperature rises above the predetermined value opening the contact 14/1, the primary relay 22 will be de-energised, closing its normally closed contact 22/1 (so that the secondary relay 24 is now energised) and opening its contact 22/2. The secondary relay closes its operating contact 24/2 but since the operating contact 22/2 is now open, the operating circuit is still not completed.

The temperature continues to rise and thereafter falls below the set value whereupon the primary relay 22 is again energised. Its normally closed contacts 22/1 open but this does not cause the secondary relay to be de-energised due to the holding circuit through its own normally open contact 24/1. Accordingly both relays

are now energised so that both operating contacts 22/2 and 24/2 are closed, and (since the timer contact 15/1 will already have been closed) the controller operates to open the dies. As the dies open the contact 35 controlled by them opens, so as to de-energise the secondary relay 24 whose holding contact 24/2 accordingly opens and the circuit is ready for the next cycle.

The circuit shown in FIG. 4 (which is similar to FIG. 2) can be used to control the application of pressure to the melt 44 in the pot 45. Here the circuit is under the control of the temperature sensor 40 and operates to close the valve 52 and open the valve 49 to admit air under pressure. The temperature sensor 40 in similar manner to the sensor 14 modifies the circuit state so that the valve 49 is shut again and the valve 52 opened only when the temperature has risen above a predetermined level, the datum point, and then fallen back below it again. The valves 49 and 52 are shown connected in parallel to one another but each is in series with contacts 15/1a.

FIG. 3 shows in diagrammatic form a suitable form of thermocouple 14 or 40. It has three main parts, a hot end 60 which is fixed into the die face, a cold end 61 which affords a socket that can be used at the edge of the die box, and a plug and compensating cable 62 which links the thermocouple with the control circuit. When the die opening is being controlled by a sensor each die can be provided with items 60 and 61 item 62 stays with the machine and be plugged into the thermocouple socket 61.

Alternatively since only low pressures are involved the whole insert could be removed and re-inserted in the new die, provided of course that the dimensions of the insert, and insert hole, in the die are the same.

The thermocouples are preferably mineral insulated nickel-chromium nickel-aluminium thermocouples with 1 mm diameter stainless steel or Inconel (Trade Mark) outer sheaths. These are of the type which are grounded to the outer sheath at the hot junction i.e., earth junctions. The thermocouples can be mounted into inserts with the hot junction at the cavity surface, or simply pushed into holes drilled into the dies or feed tube and cemented, either permanently or removably into position.

The operation of the machine is as follows: Assuming the melt has been brought up to casting temperature and the die coolant is running the valve 52 is closed and the valve 49 is opened. This admits low pressure air which forces the melt up the tube 41 into the die cavity, the sensors 40 and 14 experience a rapid increase in temperature followed by first a rapid drop and then a slower drop. When the temperature in the sprue at the region 53 as sensed by the sensor 40 has dropped below the predetermined preset temperature at which the sprue will have solidified (as shown in FIG. 1) the control circuitry associated with the sensor 40 shuts the valve 49 and opens the valve 52. The pressure in the pot 45 thus drops to atmospheric pressure and the still molten metal in the tube 41 falls back into the melt bringing the system to the state shown in FIG. 1.

The temperature of the casting is meanwhile still falling and when the temperature at the sensor 14 reaches the predetermined preset temperature at which the casting can safely be ejected, the sensor initiates the die opening sequence as described above with reference to FIG. 2. The dies open, the casting is ejected and the dies reclose and reset the circuitry.

Suitable interlocks can be provided between the two circuits to ensure that the dies cannot open before the air pressure has been shut off and the pot vented.

It will be appreciated that the invention is not restricted to the details described. Thus other forms of temperature-responsive control may be employed. Moreover different types of sensor may be relied upon and their position in relation to the casting will depend upon requirements.

It should also be emphasised as mentioned above that the method can be used in other casting systems in addition to low pressure die casting.

Thus it can be used in systems where the melt is forced sideways or downwards into a die cavity as well as in cases where it is forced upwards into the cavity.

What we claim as our invention and desire to secure by Letters Patent is:

1. In a casting method, the steps of:

introducing a molten casting material into a die cavity through an inlet passage by applying gaseous pressure thereto;

sensing the temperature of the casting material by measuring the temperature of the casting material at at least one location in said inlet passage and at at least one location in said die cavity;

generating a signal in response to the sensing of predetermined temperature conditions in said casting material, said predetermined temperature conditions comprising the situation when each of the measured temperatures has fallen below a predetermined level; and

using the generated signal to terminate the application of said gaseous pressure to the molten casting material.

2. In a casting method, the steps of:

introducing a molten casting material into a die cavity through an inlet passage by applying gaseous pressure thereto;

sensing the temperature of the casting material by measuring the temperature of the casting material at at least one location in said inlet passage and at at least one location in said die cavity, said temperature being measured at at least three locations;

generating a signal in response to the sensing of predetermined temperature conditions in said casting material, said predetermined temperature conditions comprising the situation when at least two of the measured temperatures have fallen below a predetermined level; and

using the generated signal to terminate the application of said gaseous pressure to the molten casting material.

3. In a casting method, the steps of:

introducing a molten casting material into a die cavity through an inlet passage by applying gaseous pressure thereto;

sensing the temperature of the casting material by measuring the temperature of the casting material at at least one location in said inlet passage and at at least one location in said die cavity, said temperature being measured at at least three locations;

generating a signal in response to the sensing of predetermined temperature conditions in said casting material, said predetermined temperature conditions comprising the situation when the average of

at least two of the measured temperatures has fallen below a predetermined level; and using the generated signal to terminate the application of said gaseous pressure to the molten casting material.

4. A method as set forth in claim 1 wherein said predetermined temperature level for said inlet passage is different than said predetermined temperature level for said die cavity.

5. In a casting machine, die means defining a die cavity and an inlet passage to the cavity;

gaseous pressure injection means for applying gaseous pressure to a supply of molten casting material and forcing the same into said cavity through said passage;

temperature sensing means for sensing the temperature of the casting material, said temperature sensing means including sensor means having a temperature actuated electrical contact which is closed when the temperature of the sensor is below a predetermined value;

signal generating means for generating a signal in response to the sensing of predetermined temperature conditions in the casting material by the temperature sensing means; and

means coupled to said signal generating means and said injection means for terminating the application of said pressure to the molten casting material when said signal is generated, said pressure application terminating means including an electrical circuit comprising a primary relay having a normally open contact, a normally closed contact and a coil connected across the supply through said temperature actuated contact, and a secondary relay having a pair of normally open contacts and a coil connected across the supply through a contact which closes when the pressure injection means are actuated, said latter contact being in series with the normally closed contact of the primary relay which is shunted by one of the normally open contacts of the secondary relay, the switching off of the pressure injection means being under the control of the normally open contact of the primary relay and the other normally open contact of the secondary relay, said last mentioned contacts being connected in series, whereby said pressure application terminating means are arranged to operate only when the temperature has risen above a

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predetermined level and has thereafter fallen below such level.

6. In a casting machine, die means defining a die cavity and an inlet passage to the cavity;

gaseous pressure injection means for applying gaseous pressure to a supply of molten casting material and forcing the same into said cavity through said passage;

temperature sensing means for sensing the temperature of the casting material including a temperature sensor located in the die cavity;

first signal generating means for generating a first signal in response to the sensing of first predetermined temperature conditions in the casting material by the temperature sensing means;

means coupled to said first signal generating means and said injection means for terminating the application of said pressure to the molten casting material when said first signal is generated;

second signal generating means for generating a second signal in response to the sensing of second predetermined temperature conditions in the casting material by said temperature sensor independently of the sensing of said first predetermined temperature conditions; and

control means coupled to said second signal generating means and said die means for initiating a die opening sequence when said second signal is generated.

7. Apparatus as set forth in claim 6 wherein said sensor includes a temperature actuated electrical contact which is closed when the temperature of the sensor is below a predetermined value, said control means including an electrical circuit comprising a primary relay having a normally open contact a normally closed contact and a coil connected across a supply through said temperature actuated contact, and a secondary relay having a pair of normally open contacts and coil connected across the supply through a contact which closes when the die is closed, said latter contact being connected in series with the normally closed contact of the primary relay which is shunted by one of the normally open contacts of the secondary relay, the opening of the dies being under the control of the normally open contact of the primary relay and the other normally open contact of the secondary relay, said last mentioned contacts being connected in series.

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