

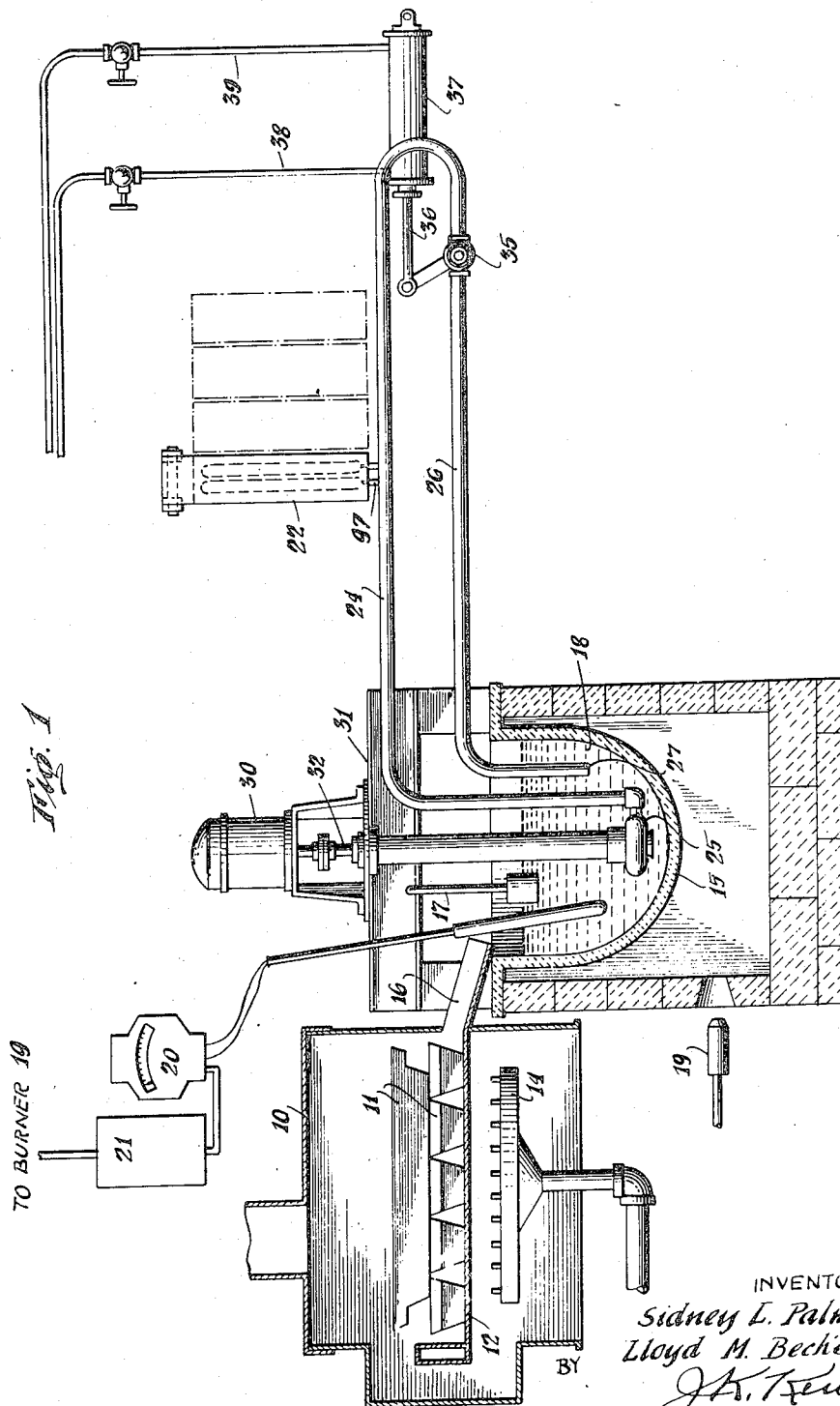
Jan. 25, 1949.

S. L. PALMER ET AL
METAL CASTING APPARATUS

2,459,892

Filed Dec. 14, 1945

5 Sheets-Sheet 1



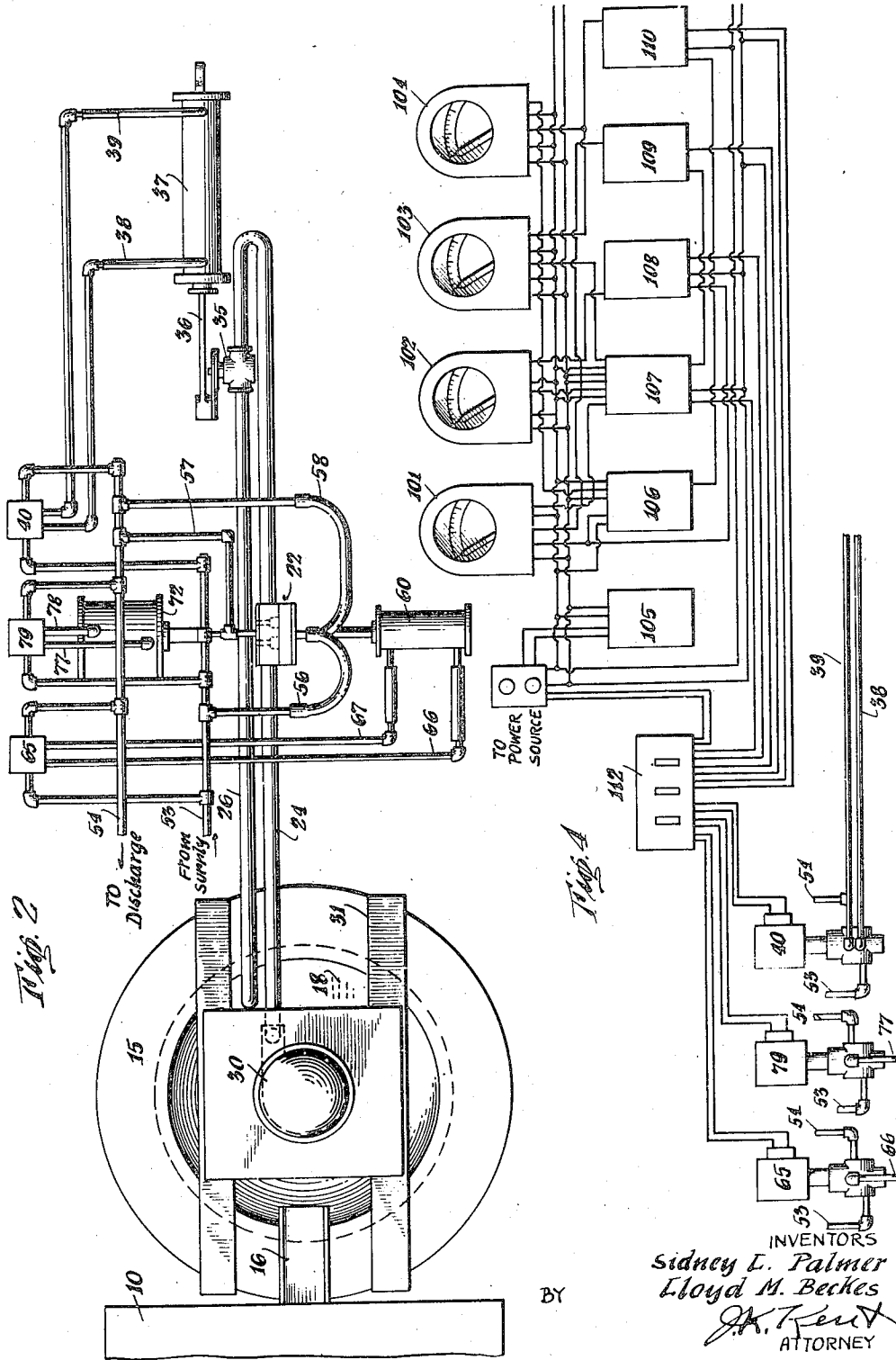
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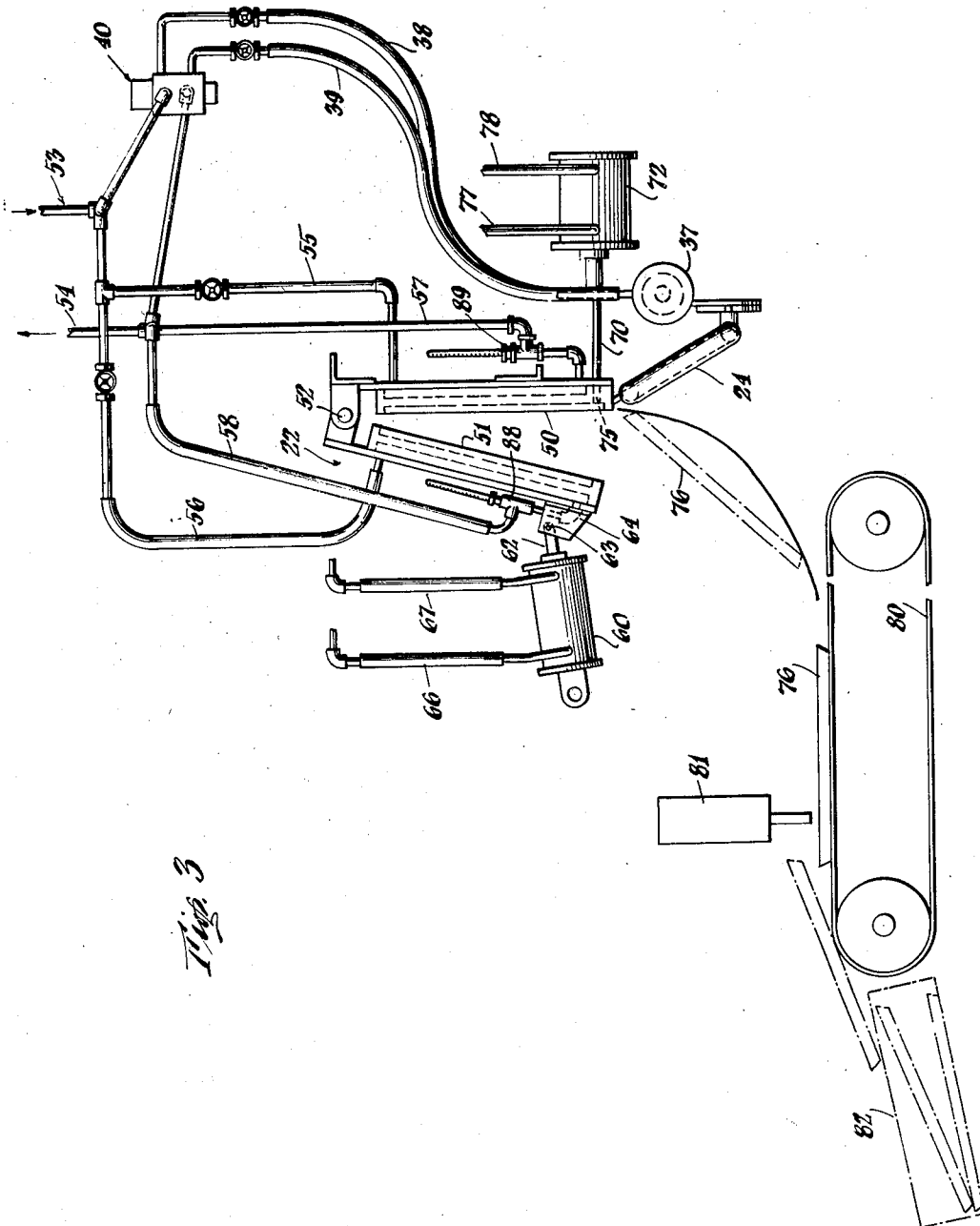
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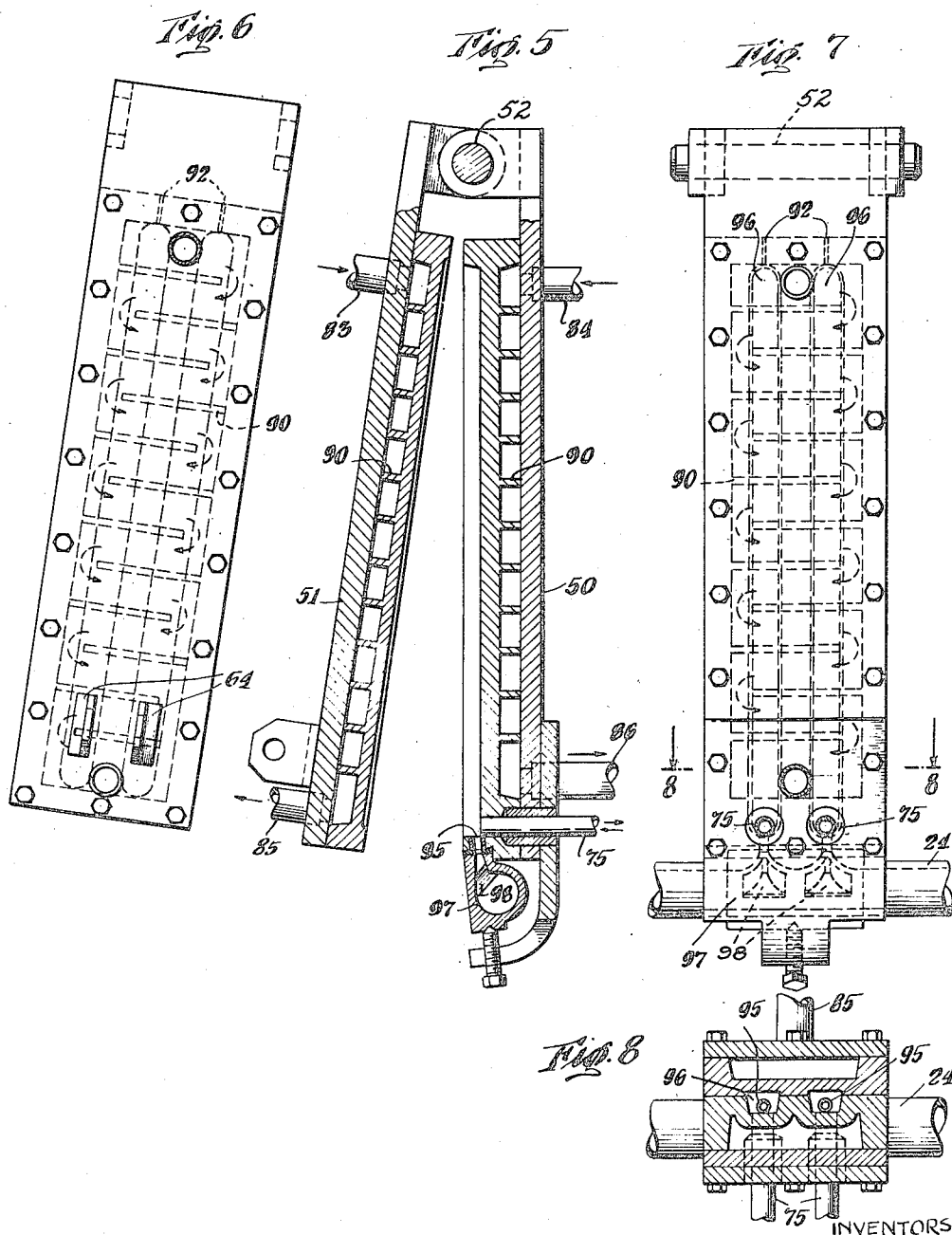
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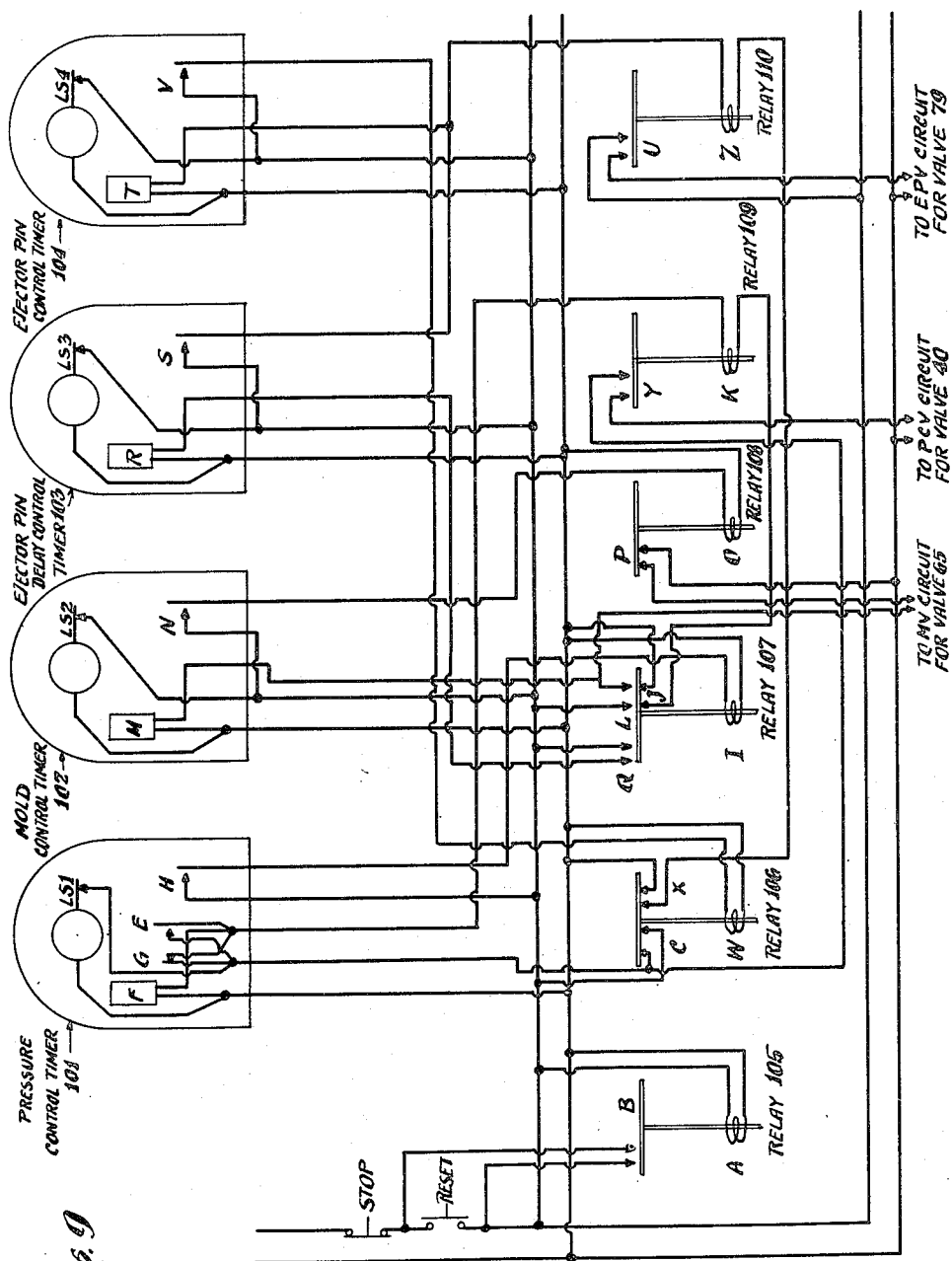


Fig. 9

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METAL CASTING APPARATUS

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1

This invention relates to casting machines and more particularly to casting apparatus of the closed split-mold type into which molten metal is introduced and cooled to produce cast shapes, the mold being opened and the casting ejected after solidification.

Briefly, the invention provides improvements in casting machines of the type comprising a vessel or receiver for holding a supply of molten metal to be cast and an initially closed mold which is in communication with the receiver and into which molten metal from the receiver is pumped. Operation of the casting machine to effect filling of the mold, opening of the mold, ejecting of the cast shape and closing of the mold, is electrically controlled and performed automatically.

The present invention provides a machine of the aforesaid type for casting bars and shapes of uniform dimension, appearance, composition and weight automatically. As a result, castings can now be produced at lower cost and at a much higher rate than has been possible heretofore employing conventional hand labor methods. The invention also makes it possible, as a commercial operation, to standardize the shape, size and appearance of castings. Although the invention has been utilized for casting white metal alloys, for example, in the production of bar solder, rods, etc., it is equally applicable for casting other metals and alloys, such as used to make weights, sinkers and the like.

In operating the machine of the invention, molten metal is introduced into the mold and chilled to form the casting under controlled conditions, the temperature and pressure being regulated during casting to bring about filling of the mold and to provide for shrinkage feeding as the metal cools and solidifies. The sequence of operations performed during the casting cycle is controlled by suitable electrical timing mechanism as hereinafter described.

The invention will be particularly described in connection with the casting of solder bars but it will be understood that this is merely illustrative of the invention and not limitative thereof. Other objects and features of the invention will appear from the following detailed description of one embodiment thereof taken in connection with the accompanying drawings, in which the same reference numerals indicate similar parts, wherein:

Fig. 1 is a vertical section view of the casting machine, illustrating diagrammatically the melting furnace, molten metal receiver, molds and

2

interconnecting molten metal manifold system; Fig. 2 is a plan view of the machine illustrated in Fig. 1, the melting furnace being shown partly broken away;

Fig. 3 is a view in elevation of the mold and associated mechanism for opening and closing the mold and handling the finished casting;

Fig. 4 is a view illustrating schematically the electrical system for controlling the casting operations;

Fig. 5 is a detailed view in section of the split-mold, the mold being shown in open position;

Fig. 6 is a plan view of the movable mold cover;

Fig. 7 is a similar plan view of the complementary mold half which is held stationary during casting;

Fig. 8 is a view in cross-section of the mold taken on the line 8-8 of Fig. 7 and looking in the direction of the arrows;

Fig. 9 is an electrical diagram showing the layout of the general timing and control system.

Referring to the drawings, Figs. 1 and 2, the numeral 10 designates a furnace for melting pig metal 11 from which castings are to be produced, the metal being melted on a hearth 12, suitably heated by a burner 14 arranged therebeneath, as illustrated in Fig. 1. Molten metal in the melting furnace flows from the hearth 12 into a receiver or vessel 15 through a charging spout or ladle 16.

A float 17 positioned in the melt 18 operates through conventional mechanism, not shown, to control the fuel supply to burner 14, whereby a relatively constant amount of molten metal is maintained in the receiver 15 during casting. Thermostatic control of the burner 19 is provided by the thermostat 20 which operates through associated mechanism 21 to vary the setting of the burner which in turn maintains the melt 18 at the desired operating temperature. Where it is desired to limit the degree of oxidation of the metal during melting, the atmosphere in the furnace is suitably controlled.

Molten metal is pumped from the receiver 15 to the casting mold, generally designated by reference character 22, through a manifold pipe line 24 by a submerged centrifugal pump 25, the pump being suitably supported while submerged in the melt and connected to the manifold, as illustrated in Fig. 1. Excess molten metal entering the manifold is returned to the receiver through pipe 26, being discharged beneath the surface of the melt as shown at 27. By this arrangement, a closed molten metal circulating system is provided whereby oxidation of the metal during casting is held to a minimum.

3

To operate the centrifugal pump 25, a variable speed motor 30 is suitably mounted over the melt on a supporting frame structure 31 and is drivingly connected to the vertically disposed pump propeller shaft 32, as illustrated in Fig. 1. For controlling the pressure of the molten metal supplied to the mold from the manifold, a throttle valve 35 is placed in line 26. This throttle valve is operated by a piston actuated rod 36 working in a hydraulic cylinder 37. Fluid under pressure for actuating the piston in cylinder 37 flows through pipe lines 38 and 39 which are, in turn, connected to a pressure control valve 40, the control valve being operated electrically in accordance with the setting of the general timing and relay system shown schematically in Fig. 4. The pressure of the molten metal flowing to the mold may also be varied by changing the speed of motor 30 using similar electrical timing mechanism. These two methods of pressure control may be used singly or in unison, as desired.

The general arrangement of the mold and associated operating mechanism is illustrated in Fig. 3. The mold 22, which is suitably supported vertically, comprises a base or mold proper section 50 and a complementary cover section 51 supported for movement into closed and open position. In the preferred form, illustrated in Fig. 3, the mold cover 51 is hinged to the base mold half 50 at its upper end, the mold base portion being rigidly supported while the cover is pivotally secured thereto as at 52.

In the embodiment illustrated, water under appropriate pressure is utilized to actuate the moving parts of the casting apparatus and cool the mold, being supplied through pipe line 53 from a suitable source and discharged through line 54 after use. Cooling water is conducted from the supply line 53 to the mold halves 50 and 51 by conduits 55 and 56 respectively, and from the mold to the discharge line 54 by conduits 57 and 58, as illustrated in Figs. 2 and 3. A flexible hose connection is used for water lines 56 and 58 to permit movement of the mold cover 51 during operation of the casting machine. Where it is desired, other and independent fluid pressure means, such as air, steam or oil, may be used to actuate the moving parts of the casting apparatus, cooling water for the mold being supplied through a separate line.

For opening and closing the mold, a hydraulically operated cylinder 60 is utilized, as illustrated in Fig. 3. A piston rod 62 working in the cylinder 60 is pivotally connected at its outer end, by a pin 63, to the pair of angle sections 64 which are bolted to the mold cover 51 as shown in Figs. 3, 5 and 6. Hydraulic fluid for actuating the piston is conducted from the control valve 65 to the cylinder by conduits 66 and 67. A similarly piston operated rod 70, working in the hydraulic cylinder 72, is provided to actuate the ejector pin 75 and eject the casting 76 upon opening the mold. Fluid pressure for operating the ejector-pin-actuating cylinder 72 is conducted through the pipes 77 and 78 which are connected to the control valve 79. Suitable handling, marking and packaging mechanism for the casting may be provided, such as illustrated diagrammatically at 80, 81 and 82 respectively, in Fig. 3.

The detail construction of the molds is illustrated in Figs. 5, 6, 7 and 8. The mold half 50 and hinged cover section 51 are each provided with a water cooled back portion which is designed to provide differential cooling between the upper and lower ends of the mold. The lowest tem-

4

perature is maintained at the top of the mold by introducing the cooling water at the upper end, as indicated at 83 and 84, and withdrawing it at the bottom, as shown at 85 and 86. Thermostats 88 and 89 are placed in the outlets 85 and 86, respectively, which operate to increase or decrease the amount of cooling water admitted in accordance with the temperature variation of the water leaving the mold. For example, when the temperature of the discharge water exceeds a pre-set value, the thermostat operates to allow more water to flow through the water jacket and vice versa. To provide a more accurate control of this temperature gradient throughout the mold length, suitable baffles 90 are cast in the water cavity to direct the water flow in a zig-zag path downwardly through the cooling chamber, as indicated by the arrows in Figs. 6 and 7.

Molten metal during casting, is admitted at the bottom of the mold under low pressure to avoid splashing and squirting, the mold being filled as the pressure in line 24 is increased by closure of valve 35. Air vents 92 are provided near the top of each mold cavity as illustrated in Figs. 6 and 7, to assist in rapidly evacuating the mold of air when it is being filled. Where it is desired, a neutral or reducing atmosphere may be employed in the mold, as for example, when casting oxygen-free metal. As the molten metal rises in the mold, it cools due to contact with the mold, the coldest metal being always at the top of the mold. By utilizing the mold construction and arrangement illustrated, the temperature gradient during cooling of the cast metal is such that the directional solidification of the casting is opposite to the flow of the metal entering the mold.

As the mold fills and solidification progresses molten metal at the lower end of the mold, being under maximum pressure, continues to flow into the mold during solidification of the casting filling shrinkage voids produced as the freezing progresses downwardly to the end of the mold. This results in the production of a casting which is free from shrinkage voids. After the metal in the mold has completely solidified and there is no further flow of the metal to the mold cavity, freezing progresses slightly into the entry port or gate 95. A similar port is provided at the lower end of each mold cavity 96, as shown in Fig. 7. The mold illustrated comprises only two pockets or mold cavities 96, with associated ejector pin means 75, but it will be appreciated that this is merely exemplary and that molds may be used, in practicing the invention, having any desired number of cavities depending upon the type of castings being made, sizes, and capacities required.

Operation of the various casting elements is electrically controlled, the general layout of the system being shown in Figs. 4 and 9. Four time switches 101, 102, 103 and 104 and six relays 105, 106, 107, 108, 109 and 110 are electrically connected through a main switch panel 112 as illustrated diagrammatically by Fig. 4. The respective time switches are arranged to energize the solenoid actuated valves 40, 65 and 79, in accordance with a predetermined cycle, and cause the hydraulic cylinders 37, 60 and 72 to actuate the machine elements as required during casting. A complete cycle for casting a bar of metal is described as follows:

Assume that the mold is closed with ejector pins 75 in retracted position flush with, and thus constituting a part of, the mold inner wall, molten metal is flowing under low pressure through manifold 24, and time switches 101,

5

102, 103 and 104 are at zero reading. Molten metal enters the mold cavities 96 through ports 95 from the coupling member or adapter 97, being deflected thereinto by baffle 98 as illustrated in Figs. 5 and 7. As the mold fills, pressure in the manifold 24 is increased by partial or substantial closing of the valve 35, through actuation of the solenoid valve 40, to provide sufficient pressure for filling solidification shrinkage voids. Directional solidification is effected by the cooling water circulated through the back of the mold halves, as previously described, to cause final freezing of the bar at the ports 95.

When the metal in the mold has been completely solidified, the mold cover 51 is withdrawn after the pressure in the manifold line 24 has been decreased by opening of valve 35. Ejector pins 75 are then advanced shearing off the solidified sprue portion formed at the ports 95 and ejecting the cast bars. Ports 95 are kept closed by the ejector pins until the mold cover 51 is replaced. Opening of the throttle valve 35 re-establishes circulation of molten metal in the manifold line 24 and as molten metal flows from the receiver 15 through the line 24 and adapter 97 it is deflected upwardly and against the ports 95 by the baffles 98, which are positioned in the adapter opposite the ports, as shown in Figs. 5 and 7. By this construction and use of the apparatus the solidified sprue portion remaining in the ports 95, after the casting has been ejected, is quickly remelted whereby, upon the withdrawal of the ejector pins 75, molten metal is permitted to again flow through the ports 95 into the mold. Upon closure of the mold, the hydraulic cylinder 72 is actuated to cause retraction of the ejector pins. Thereafter the pressure of molten metal flowing in manifold 24 is increased, by operation of valve 35, causing filling of the mold, thus starting a new cycle.

Utilizing conventional electrical time switches and relays connected as indicated by the diagrams, Figs. 4 and 9, the proper sequence of operation of the machine elements is provided. Utilizing the invention, solder bars weighing 1½ pounds have been cast on a time cycle of 15 to 23 seconds. The cast bars were of uniform size and shape and the maximum weight variation was ½ ounce per bar. In this connection, it will be appreciated that the time cycle may be varied to suit different metals and casting conditions.

The general timing control system, for operating the machine elements in proper sequence is illustrated in Figs. 4 and 9. Using a power line of 115 volts and 60 cycle, as indicated in the wiring diagram of Fig. 9, a casting cycle is initiated by depressing the momentary contact push button marked "Reset," Fig. 9.

Current flowing through undervoltage coil A of relay 105 seals itself in through its normally open interlock B. Relay 106 being de-energized, a circuit is prepared through normally closed pole C for energizing the pressure control timer 101. The pointer of the timer is at zero reading and, accordingly contacts E are closed so that the clutch coil F is energized and the pressure control timer starts timing. Clutch contacts G immediately close, maintaining current to the clutch coil F, after the pointer of the pressure control timer leaves the zero station.

When the pre-set pressure control timer comes to the end of its time period contacts H are closed passing current through the relay coil I picking up the relay 107 whose normally closed pole J

6

opens de-energizing coil K of relay 109. This ends the time period controlled by the pressure control timer 101. At the start of this timer, the normally open contacts Y of relay 109 were closed energizing the solenoid valve coil 40 in the circuit PCV thereby closing the throttle valve 35 whereby molten metal under high pressure is established in line 24 causing mold 22 to be completely filled. At the end of the pressure control timing period, the solenoid coil 40 operating the throttle valve 35 is de-energized, opening this valve and establishing low pressure in line 24.

At the end of the pressure control timing period, relay 107 is energized and one of its normally open poles L energizes the clutch coil M of the mold timer 102. This mold timer immediately starts timing and continues to time as long as contacts H remain closed. Contacts H are maintained closed during the period the clutch coil F is kept energized. When the mold timer 102 starts to time, the solenoid coil of the mold valve 65 is energized, through line connection MV, to hold the mold open. After the pointer of the mold timer 102 has moved through a pre-set time interval its contacts N close energizing mold relay coil O operating relay 108 whose normally closed pole P opens de-energizing the circuit to the mold solenoid valve 65 permitting the mold to close. The mold is held open for a pre-set time interval which starts to run at the termination of the pre-set time interval established by the pressure control timer 101.

When the time interval controlled by the pressure control timer terminates, another open pole contact Q of relay 107 closes energizing clutch coil R of ejector pin delay timer 103. This starts the ejector pin delay timer on its timing interval, the timer starting to run only when the pressure control timer 101 has terminated its timing interval. By adjusting the ejector pin delay timer, the time interval of delay between the instant the solenoid valve coil 65 is energized and actuation of the ejector pin solenoid valve 79 is readily controlled and pre-set.

Upon timing out of the ejector pin delay timer 103, its contacts S close energizing the clutch coil T of the ejector pin timer 104, and starting this timer timing. When the timer 104 starts to time, it energizes the ejector pin solenoid valve coil 79 in line EPV, through contact U which operates to move the pin to "out" position. De-energizing of this coil causes the ejector pin to be moved to "in" or retracted position. The ejector pin timer 104 controls the time interval during which the ejector pin is "out," the interval being pre-set by adjustment of the timer 104.

At the end of the time interval controlled by this ejector pin timer, its contacts V close, energizing coil W of relay 106 whose normally closed pole X opens to de-energize the coil Z of relay 110 whereby the circuit to ejector pin solenoid valve 79 is broken. Through the second normally closed pole of the ejector pin relay 106, the clutch coil of pressure control timer 101 is de-energized. The time-closing contacts H of the pressure control timer 101 open, after sufficient time elapses to permit the pointer to move far enough toward zero position to allow these contacts to separate.

After this occurs, relay 107 is de-energized, and its two normally open contacts return to open position. This action de-energizes the clutch coils of the mold timer 102 and the ejector pin delay timer 103. Upon de-energizing of the ejector pin delay timer clutch coil and the pointer has returned toward zero position sufficiently to

break the time-closing contacts S, then the clutch coil T of the ejector pin timer 104 becomes de-energized. After this happens, and the pointer of the ejector pin timer returns toward zero far enough to break time-closing contacts V, the relay 106 is de-energized. The normally closed contacts of this relay are now closed automatically starting a new cycle. Limit switches LS1, LS2, LS3 and LS4 in the timers 101, 102, 103 and 104, respectively, are normally closed, being adapted to open when the pointer of the timing motor reaches full scale position, thereby protecting the time switches from over travel with possible attendant damage to the instruments.

Utilizing the present invention to cast solder bars, no mold dressing is required, however, it will be appreciated that when the use of mold dressing is necessary, suitable means may be provided for doing this, for example, by arranging to spray the mold with bone-ash slurry, or the like, at intervals to prevent sticking.

While the invention is particularly adapted to the casting of white metals and lead alloys, it will be understood that the principles thereof are applicable generally to the casting of other metals and alloys which present problems similar to those encountered in casting white metal. Further it will be appreciated that various omissions, substitutions and changes may be made by those skilled in the art without departing from the spirit of the invention.

What is claimed is:

1. In a machine for casting metals and alloys having a vessel for holding molten metal to be cast, a split-type mold having a port for admitting molten metal therinto, and a conduit for molten metal interconnecting said vessel and mold via said port, the combination with said mold of a reciprocable pin which in retracted position is clear of the port and mold cavity and in extended position enters the cavity a sufficient distance to constitute both a closure for the port and an ejector of the casting from the mold.

2. In a casting machine of the class described having a vessel for holding molten metal to be cast, a vertically-disposed mold of the split-type hinged at the top and with a port near the bottom for ingress of molten metal to the mold cavity, a pump in said vessel, a conduit interconnecting

said pump and port and returning to said vessel with a valve in the return portion of said conduit, and passageways in said mold so positioned as to effect progressive solidification of the casting from the top downwardly to the port when cooling fluid is circulated therethrough, the combination with said mold of a reciprocable member constituting a part of the mold inner wall when in retracted position, and a combined port closure and casting ejector when in extended position.

3. In metal casting apparatus having a vessel for holding molten metal to be cast, a split-type mold, a pump, a conduit for molten metal having one end connected to said pump and the other end open, both ends being positioned below the metal line of the vessel, said conduit comprising a molten metal supply section and a molten metal return section both extending exteriorly of said vessel, and a coupling member providing a passageway for molten metal between said supply section and the mold cavity, the combination therewith of a throttle valve in said molten metal return section having a valve operating mechanism and timing device associated therewith controlling the closing and opening of said throttle valve in accordance with a predetermined setting of the timing device.

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