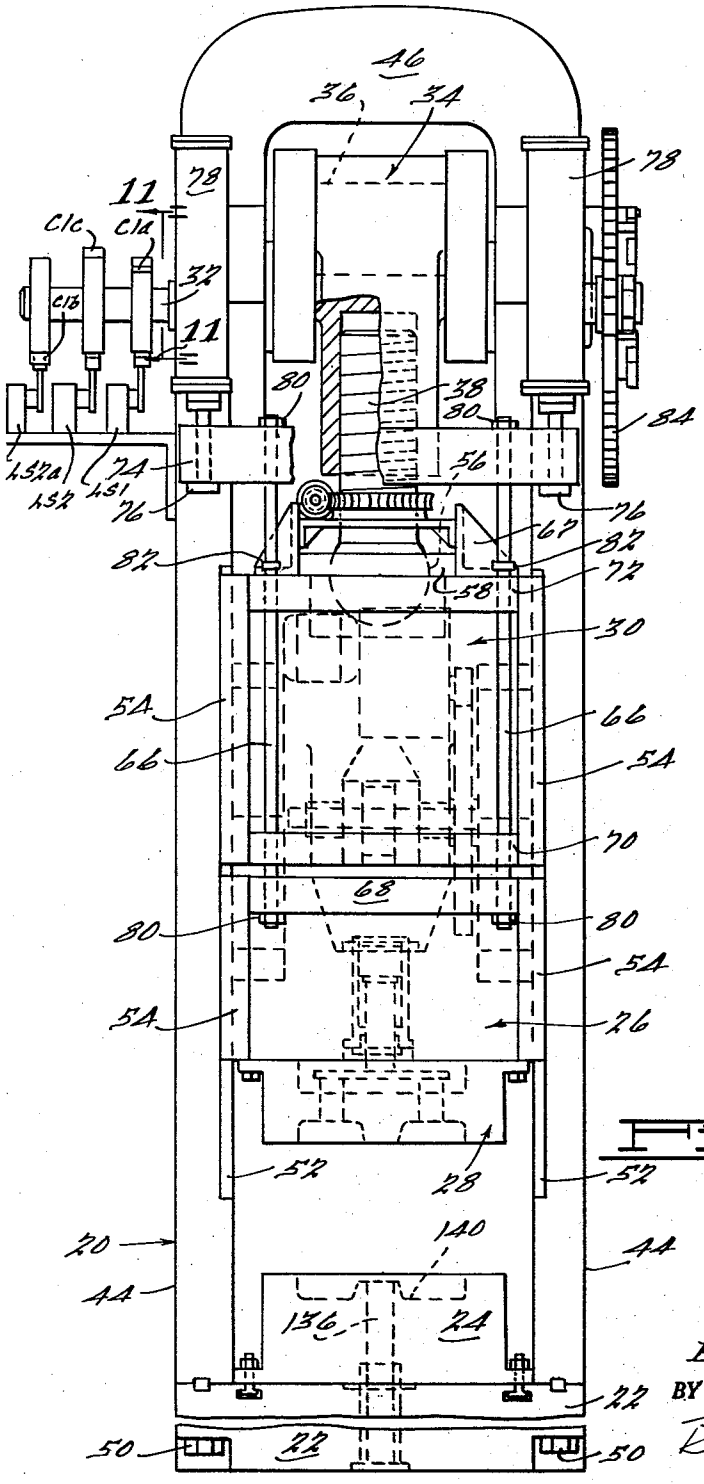
Oct. 16, 1962 E. CANNON 3,058,179

DIE CASTING MACHINE

Filed April 20, 1959 8 Sheets-Sheet 1



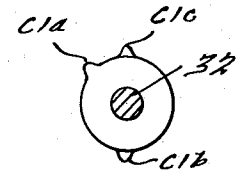


FIG. 11.

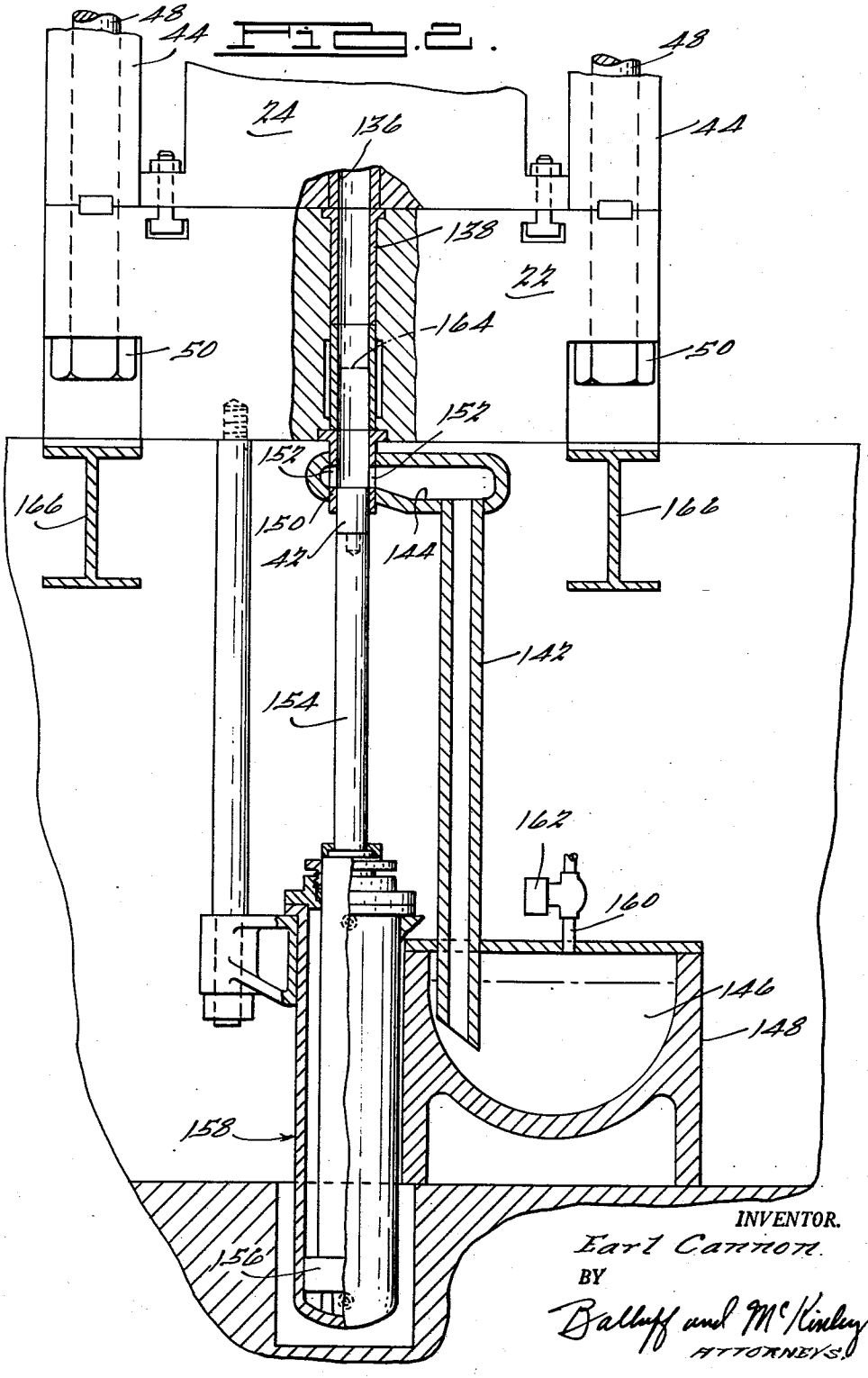
FIG. 1.

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Oct. 16, 1962 E. CANNON 3,058,179

DIE CASTING MACHINE

Filed April 20, 1959 8 Sheets-Sheet 2



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Oct. 16, 1962 E. CANNON 3,058,179

DIE CASTING MACHINE

Filed April 20, 1959 8 Sheets-Sheet 3

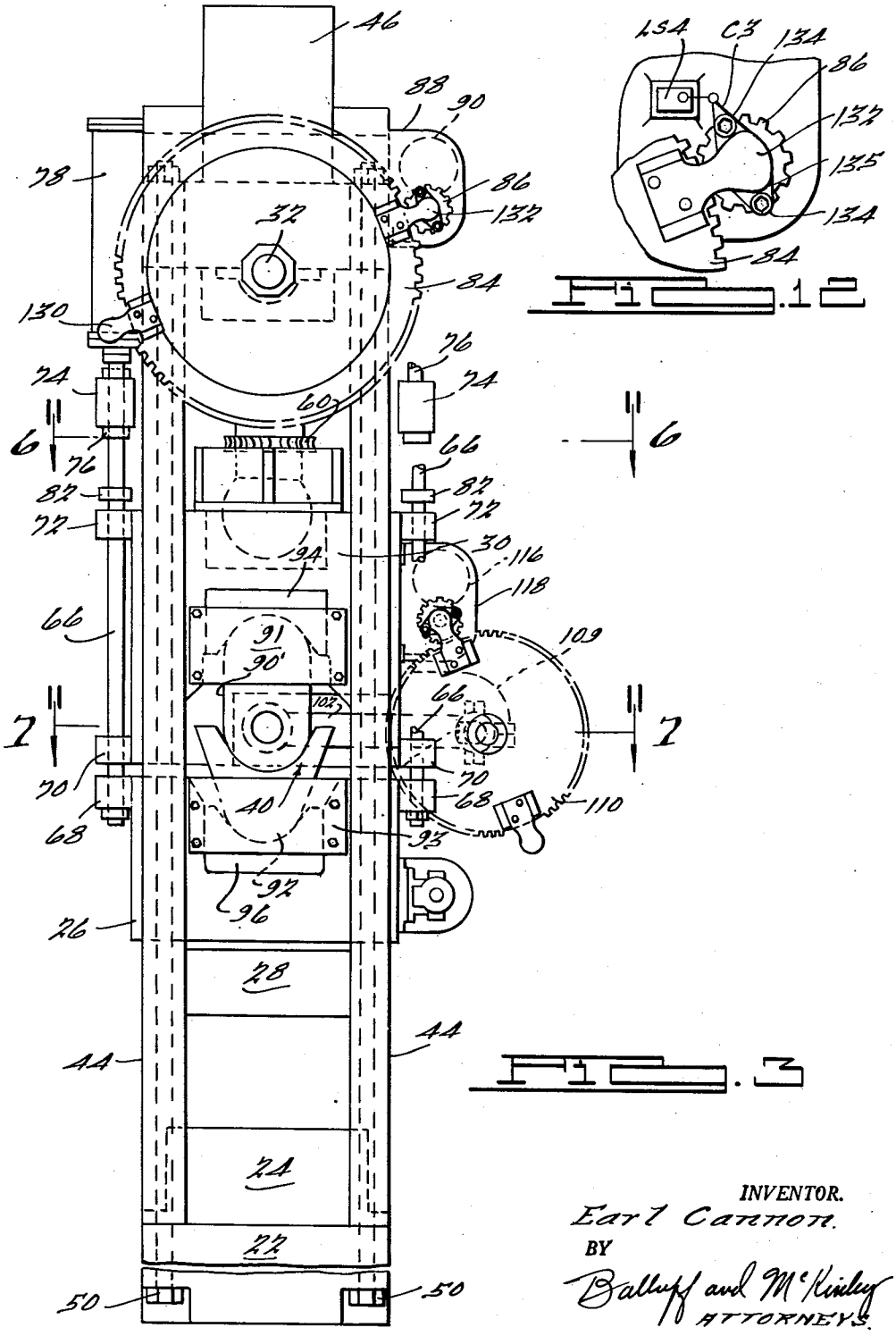


FIG. 1

FIG. 3

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Oct. 16, 1962 E. CANNON 3,058,179

DIE CASTING MACHINE

Filed April 20, 1959 8 Sheets-Sheet 4

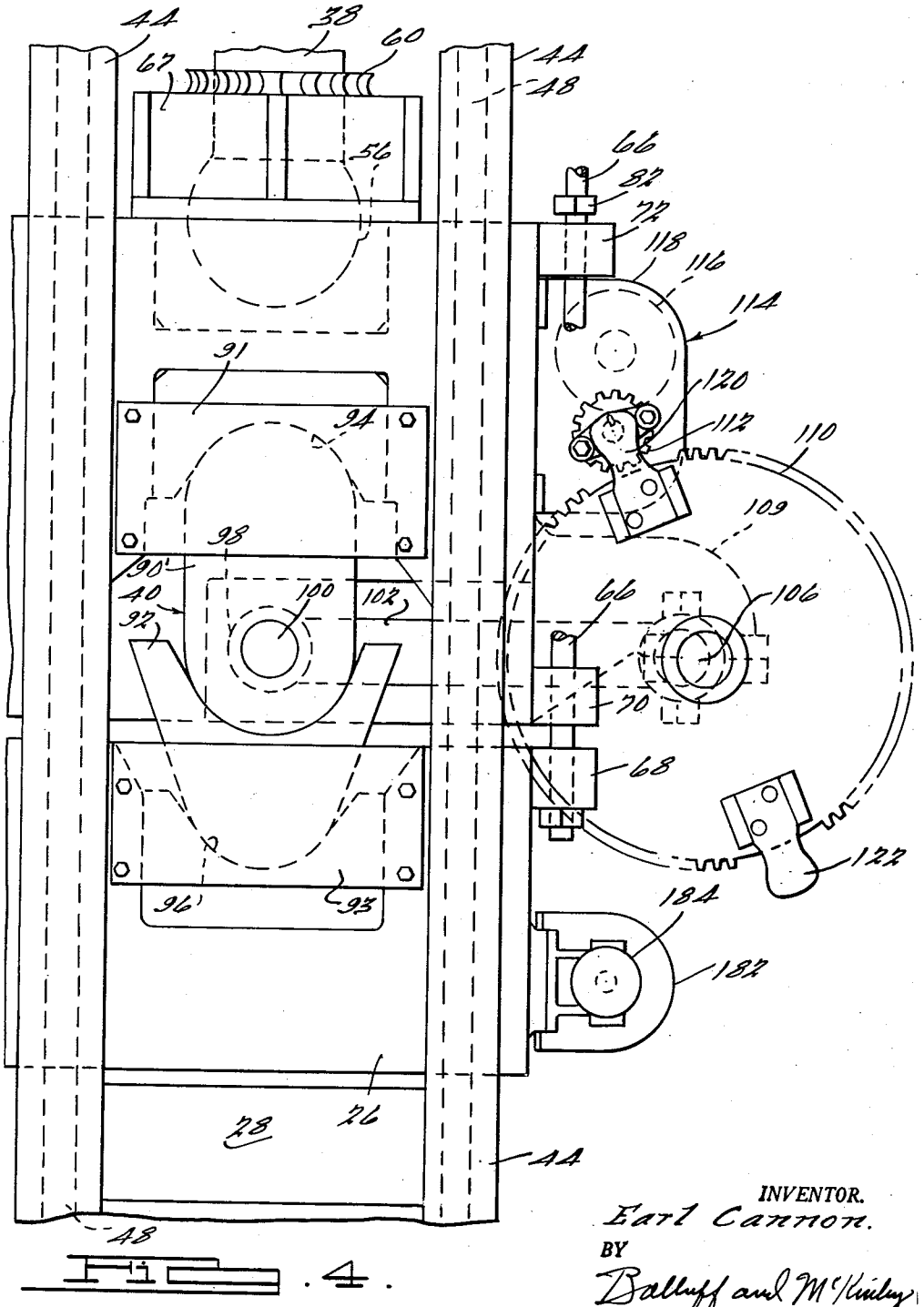


Fig. 4.

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Oct. 16, 1962 E. CANNON 3,058,179

DIE CASTING MACHINE

Filed April 20, 1959 8 Sheets-Sheet 5

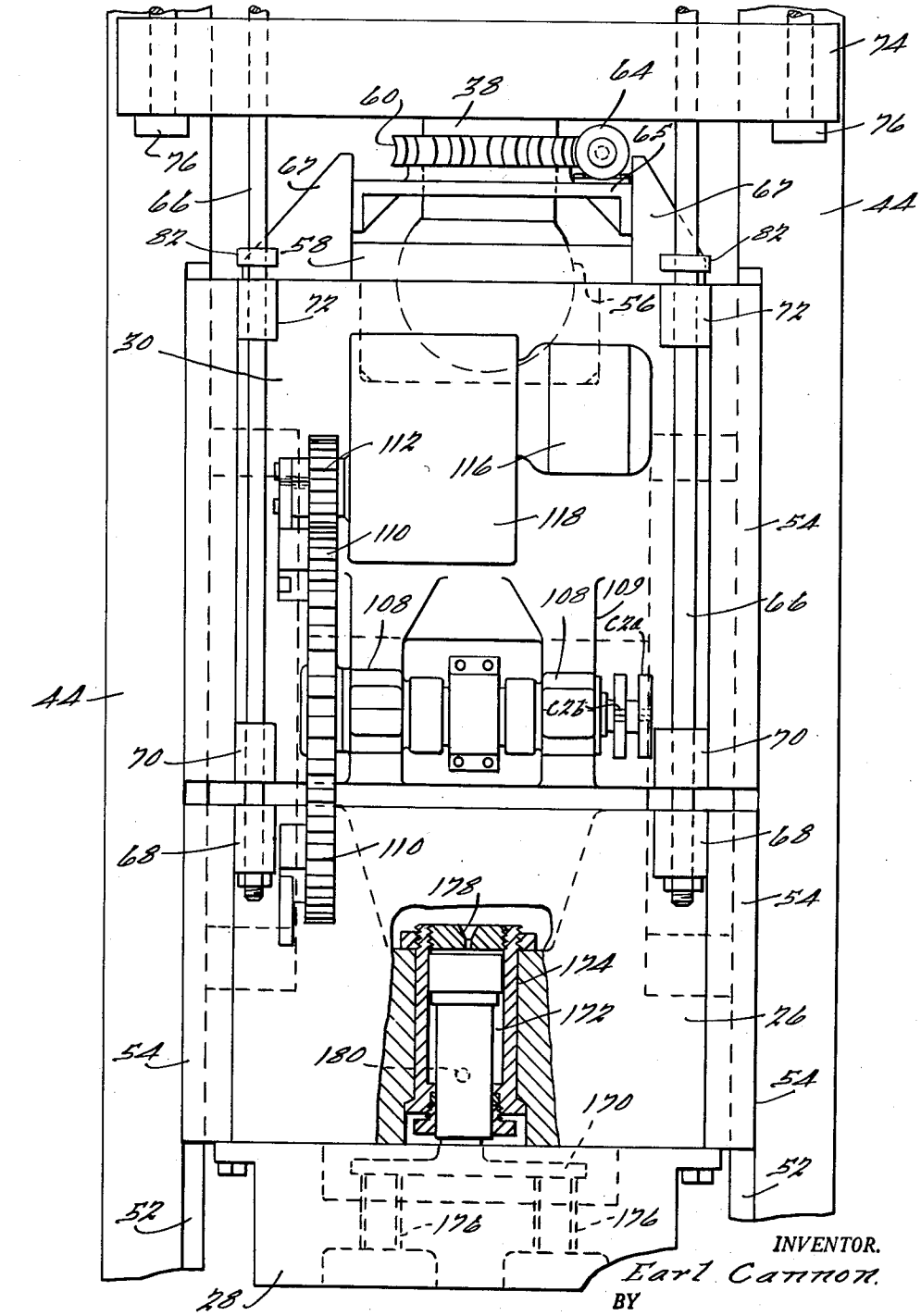


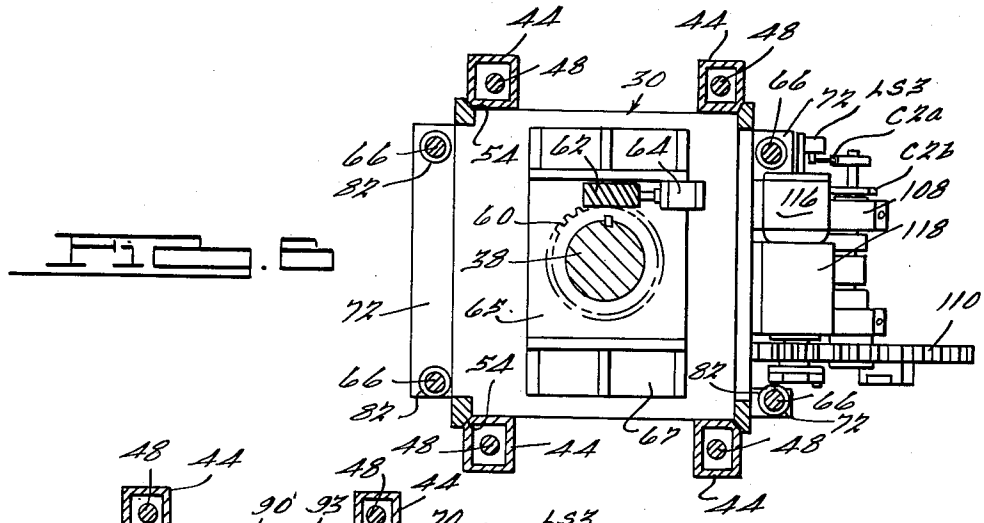
FIG. 5

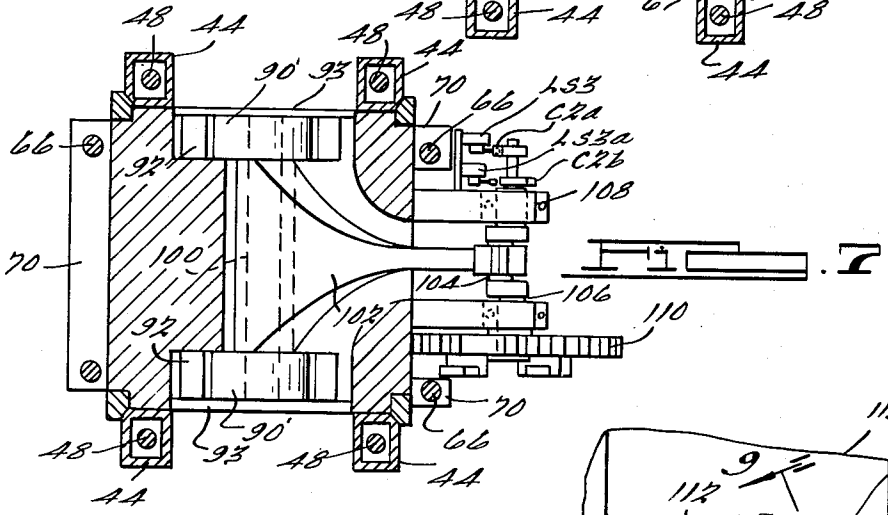
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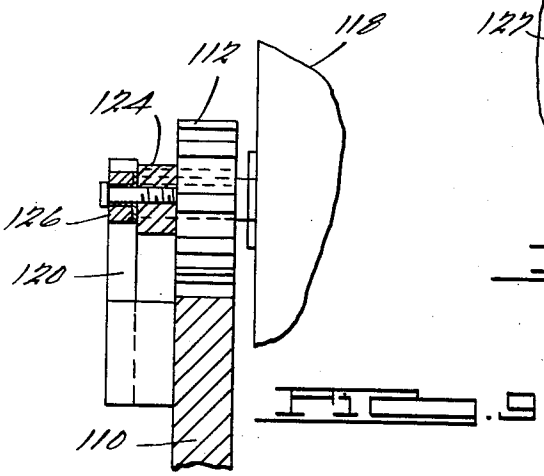
Oct. 16, 1962 E. CANNON 3,058,179

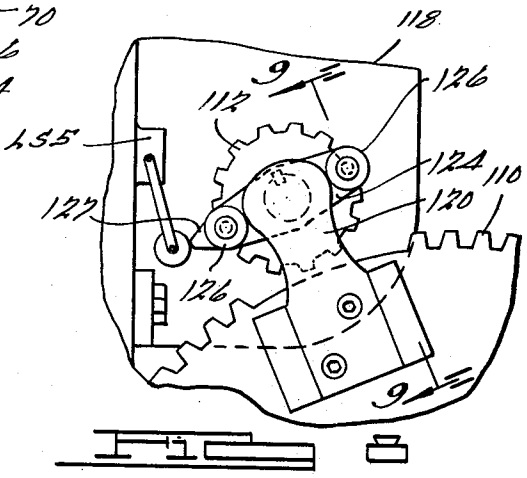
DIE CASTING MACHINE

Filed April 20, 1959 8 Sheets-Sheet 6









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DIE CASTING MACHINE

Filed April 20, 1959 8 Sheets-Sheet 7

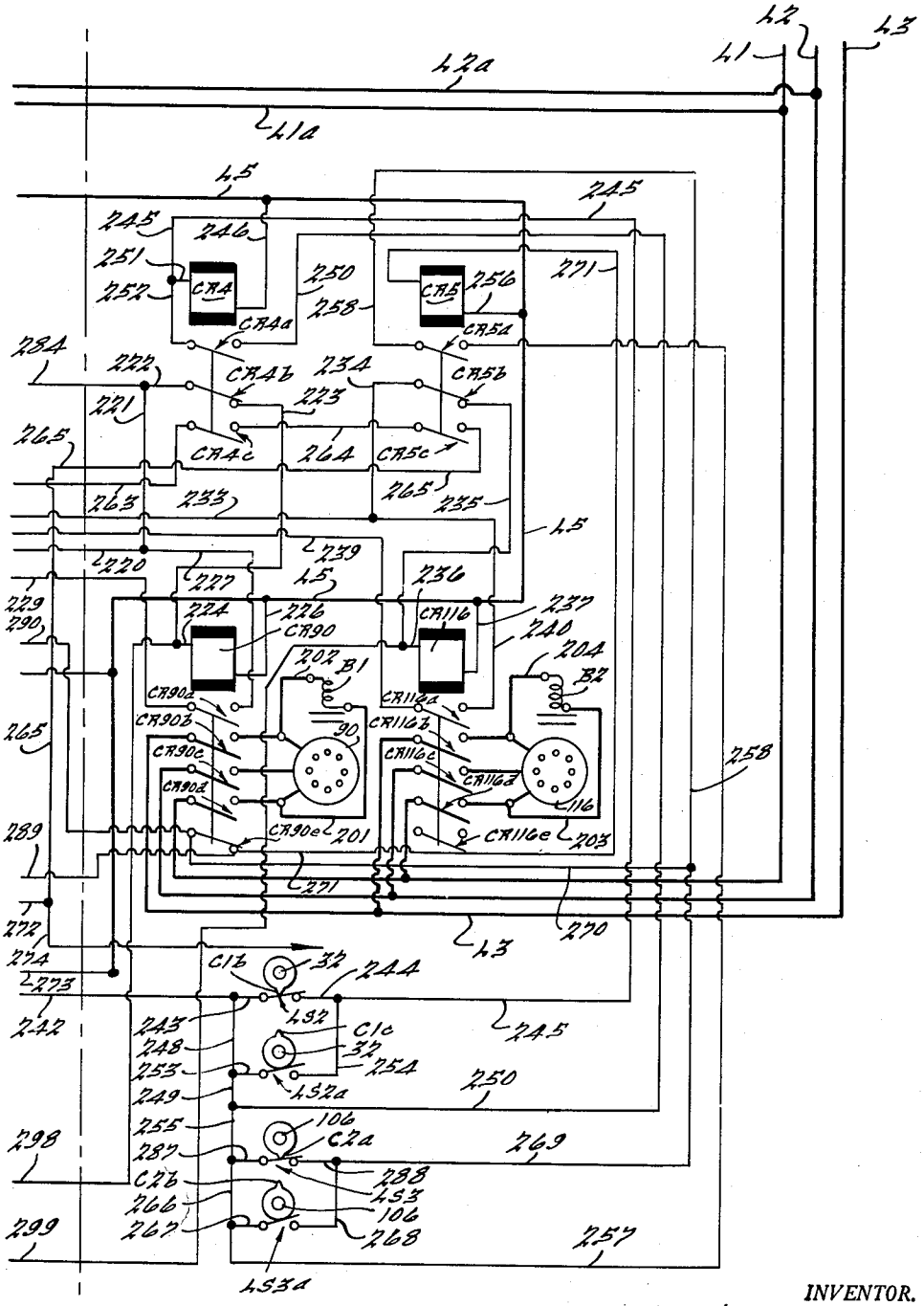


FIG. 10B.

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Oct. 16, 1962 E. CANNON 3,058,179

DIE CASTING MACHINE

Filed April 20, 1959 8 Sheets-Sheet 8

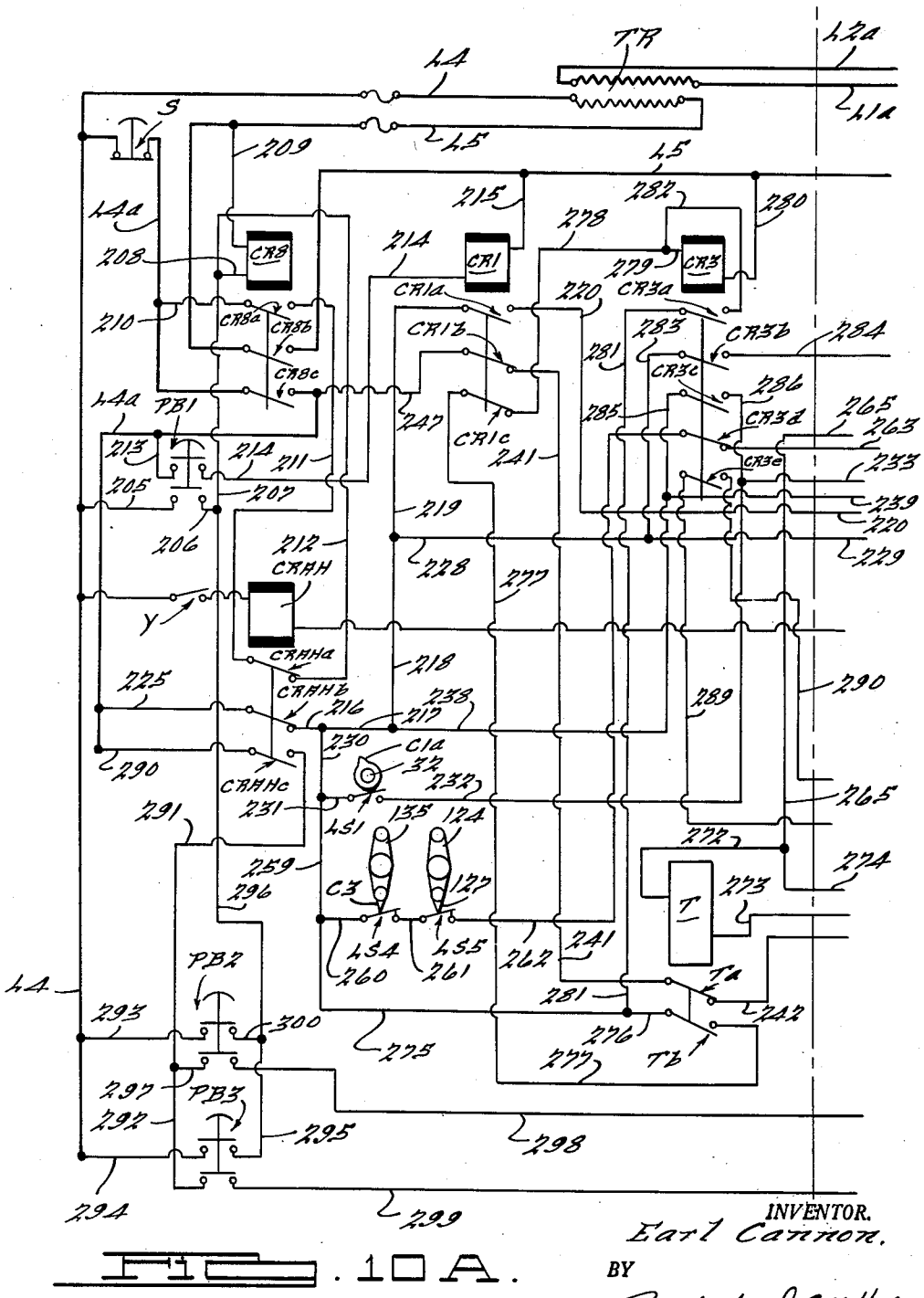


FIG. 10A.

United States Patent Office

3,058,179

Patented Oct. 16, 1962

3,058,179

DIE CASTING MACHINE

Earl Cannon, 1094 Suffield Road, Birmingham, Mich.

Filed Apr. 20, 1959, Ser. No. 807,660

5 Claims. (Cl. 22—68)

This invention relates to die casting machines of the cold chamber type and has particular reference to a large vertical die casting machine adapted to efficiently make large die castings.

Die casting machines in use today are open to a number of serious objections, and in addition are inadequate for efficiently and accurately making large die castings, such for example as multiple cylinder engine blocks for automotive engines. The present invention overcomes many of the objections inherent in conventional die casting machines and makes possible the construction of large vertical die casting machines suitable for the efficient production of large die castings.

The invention contemplates a die casting machine of the cold chamber type incorporating a simple, compact, mechanical mechanism for efficiently opening and closing the dies and locking the same in their closed position, and a unique means for feeding die cast metal to the die cavity. According to the invention, a gear driven crank and pitman are employed to advance the movable die to closed position under no-load conditions, and a motor driven mechanism movable with the movable die plate is employed to actuate a toggle for locking the dies in their closed position.

A principal object of the invention is to provide a new and improved die casting machine of the cold chamber type.

Another object of the invention is to provide a vertical die casting machine capable of efficiently producing accurate large die castings.

Another object of the invention is to provide a large die casting machine in which simple and efficient mechanical means are provided for rapidly opening and closing the dies and for locking the same in their closed position.

Another object of the invention is to provide an efficient mechanical die casting machine with means for accurately controlling the operation thereof.

Another object of the invention is to provide a die casting machine which is capable of a very fast time cycle.

Other and further objects of the invention will be apparent from the following description and claims and may be understood by reference to the accompanying drawings, of which there are eight sheets, which by way of illustration show a preferred embodiment of the invention and what I now consider to be the best mode of applying the principles thereof. Other embodiments of the invention may be used without departing from the scope of the present invention as set forth in the appended claims.

In the drawings:

FIG. 1 is a front elevational view of a vertical die casting machine embodying the invention and showing the machine in its open position;

FIG. 2 is an enlarged view illustrating the means for feeding molten die cast metal to the dies of the machine;

FIG. 3 is a side elevational view of the machine as shown in FIG. 1;

FIG. 4 is an enlarged side elevational view of the upper and lower slides;

FIG. 5 is a rear elevational view of the apparatus shown in FIG. 4;

FIG. 6 is a horizontal sectional view taken along the line 6—6 of FIG. 3;

FIG. 7 is a horizontal sectional view taken along the line 7—7 of FIG. 3;

FIG. 8 is an enlarged view of one of the "beaver tail" stop mechanisms;

FIG. 9 is a view taken along the line 9—9 of FIG. 8;

FIGS. 10A and 10B are schematic wiring diagrams of a control circuit for the die casting machine shown in open position;

FIG. 11 is a view taken along line 11—11 of FIG. 1, showing the relation of the circuit controlling cams on the crankshaft; and

FIG. 12 is an enlarged fragmentary view of the "beaver tail" cam and switch for the crankshaft drive.

As illustrated in FIGS. 1, 2 and 3, a vertical die casting machine embodying the invention comprises a frame 20 which includes a horizontal stationary bed or die plate 22 adapted to support a stationary die casting die 24, a die plate or head 26 reciprocably mounted on the frame above the bed 22 and adapted to support a movable die casting die 28, a slide or head 30 reciprocably mounted on the frame above the head 26, a crankshaft 32, a pitman 34 connected to the crank 36 of the shaft 32, an adjusting screw 38 interconnecting the pitman 34 and the upper slide 30, a toggle 40 between the upper slide 30 and the lower slide or head 26, and means (FIG. 2) including a reciprocable plunger 42 disposed beneath the bed 22 for supplying molten die cast metal under pressure to the cavity formed by the dies 24 and 28 when the dies are in locked position.

The frame 20 includes the bed or plate 22, four corner pillars or columns 44 supported on the plate 22, a cap or crown 46 mounted on top of the columns 44 and held together by the tie rods 48 extending through the columns 44, the die plate 22, and the crown 46. A nut 50 is threaded on each of the ends of the rods 48 for securing the crown 46, the pillars 44, and the die plate 22 rigidly together to form a frame capable of taking torsional strains and side thrust and permitting accurate guiding of the movable die plate 26.

Suitable vertically extending guides or surfaces, such as the guide surfaces 52 on pillars 44, are provided for cooperation with guide surfaces 54 on the die plate 26 and on the upper slide 30 for accurately guiding the same in their movement so that when the dies 24 and 28 are in their locked position they will be accurately aligned. The adjusting screw 38 at its lower end is provided with a ball head 56 which has a swivel fit within a socket in the upper slide 30. A retainer plate 58 through which the screw 38 extends overlies the ball head 56 and is suitably secured to the upper slide 30 whereby the latter is dependingly supported from the screw 38. A worm gear 60 affixed to the screw 38 is arranged to be driven in either direction by a worm 62 driven by a reversible motor 64. Motor 64 and worm 62 are mounted on plate 65 which oscillates with screw 38 due to crank motion but is prevented from rotating by brackets 67 mounted on slide 30. Thus upon operation of the motor in a selected direction, the screw 38 will be rotated, lengthening or shortening the effective length of the pitman 34 so as to adjust the closed positions of the upper and lower slides 26 and 30.

The lower slide or die plate 26 is retracted and supported in its open or retracted position by the rods 66, the lower ends of such rods passing through lugs 68 on the lower slide 26. The rods 66 extend upwardly freely through aligned openings in lugs 70 and 72 on the upper slide 30 and are secured at their upper ends to cross heads 74. Each of the cross heads 74 is supported on the downwardly projecting stems or rods 76 of the pistons (not shown) of a pair of air cylinders 78. The rods 66 have nuts 80 secured to the upper and lower ends thereof and in addition have collars 82 fixed thereon a short distance above the upper lugs 72 on the upper slide or head 30 so that if there should be any failure of the air pressure supporting the pistons in the air cylinders 78, the collars

82 by engagement with the upper lugs 72 on the upper slide 30 will serve to support the die plate 26 and the die 28 carried thereby. This arrangement for supporting the lower slide or die plate 26 permits movement thereof relative to the upper slide 30 when the latter is in its closed or lowermost position, for locking the dies 24 and 28 in their locked position.

The crankshaft 32 is turned by a gear 84 fixed thereon which in turn is driven by a pinion 86 on the output shaft of a motor drive unit which includes a speed reduction gearing 88 and a motor 90 suitably mounted on the frame of the machine. The motor drive unit and the gearing driven thereby turn the crankshaft 32 so as to position the pitman 34 and the parts connected therewith including the slides 26 and 30 in their open position as shown in FIGS. 1 and 3, or in their closed position wherein the slide 30 is in its lowermost position and the slide 26 positions the movable die 28 so that it almost seats on the stationary die 24. The pitman 34 is locked on dead center when the slide 30 is in its closed position so as to take the reaction of the load upon the closing of the toggle 40 to lock up the dies.

As the crank 36 of the shaft 32 is shifted to its position opposite that shown in FIG. 1, the pitman 34 will lower or advance the upper and lower slides against the counterbalancing force exerted by the air cylinders 78. The gear 84 and the pinion 86 are provided with a "beaver tail" stop mechanism which locks the crank 36, the pitman 34, and the upper slide 30 in either open position as shown or in closed position, that is, the lowermost position of the slide 30 with the die 28 almost seating on the die 24. The toggle 40 is operatively disposed between the upper and lower slides 26 and 30 and is shown in its closed position. However, when the slides 26 and 30 are in their open position as shown, the toggle actually is in its open position so that it can react as it closes on the upper and lower slides 26 and 30 when in their closed position so as to advance the lower slide 26 for locking up the dies 24 and 28 for the reception of a shot of molten die cast metal.

The toggle 40 includes a pair of links 90' and a pair of links 92, each of the links 90' being arranged to react against a saddle 94 on the upper slide, while each of the links 92 is arranged to react against a saddle 96 on the lower slide 26. Retainer plates 91 and 93 secured to the slides serve to retain the toggle links in operative position on the slides. Each of the lower links 92 is somewhat V-shaped as shown in FIGS. 3 and 4 and forms a seat for a link 90'. One set of the links, i.e., a link 90' and a link 92, is disposed on one side of the slides, and the other set of the links is disposed on the other side of the slides as shown in FIG. 7. Each of the links 90' is provided with a circular boss 98 for receiving the end of a cross shaft 100 which is connected by a connecting rod 102 to the crank 104 of a shaft 106 which is journaled in bearings 108 carried on brackets 109 mounted on the upper slide 30. A gear 110 is fixed to the shaft 106 and is arranged to be driven by a pinion 112 mounted on the output shaft of a motor drive unit 114 which includes a motor 116 and a reduction gearing 118. The gearing and mechanism just described are adapted to position the links of the toggle 40 either in their closed or in their open poistion, and as previously noted, the toggle 40 is open when the slides 26 and 30 are in their retracted or open positions. However, after the mechanism for turning the crank 32 positions the slide 30 in its closed position, the motor 116 and gearing and associated linkage driven thereby mounted on the upper slide are operative to close the links of the toggle 40 for moving slide 26 to its lowest position relative to upper slide 30 and thus lock the dies 24 and 28 in their closed position. At the end of the cycle after the die cast metal in the mold cavity has chilled, the motor 116 initiates movement of the toggle links 90' and 92 toward their open position simultaneously with the initiation of movement of the crank 36 by the motor 90 to retract the slides 26 and 30. As in the case of the driving connection between the motor 90 and the crankshaft 32, the driving connection between the motor 116 and the shaft 106 also includes a "beaver tail" stop mechanism for locking the links of the toggle in either their open or closed position.

The "beaver tail" stop mechanism for the toggle 40 (which is of the same construction as that for the crank 36) is illustrated in FIGS. 8 and 9 and prevents or minimizes inertia shock or impact during operation of the machine. The "beaver tail" stop mechanism includes a pair of cams 120 and 122 radially mounted upon the gear 110, 180° apart. The teeth of the gear 110 are interrupted at each of the cams 120 and 122. A yoke 124 is affixed to the pinion 112 and carries two rollers 126 spaced 180° apart and a switch cam 127. The motor drive unit which drives the gear 112 is driven so that each time the gear 112 stops, one of the "beaver tail" cams 120 and 122 will be located between the rollers 126 as shown in FIG. 8. The rollers on the driving pinion 112 are diametrically opposite each other and their centers are on the pitch circle of the pinion 112. When the beginning of a blank space on the gear 110 reaches the pinion 112 and during approximately the next one-fifth revolution of the pinion 112, one of the rollers 126 moves along the "beaver tail" cam and brings the gear 110 to rest with a harmonic deceleration. Cams 120 and 122 are so shaped that engagement between roller 126 and the cams takes place without shock. The driven gear 110 is locked during the dwell which occurs while the rollers are revolving about a concentric part of the cam 120 and while the rollers 126 are stationarily disposed as shown in FIG. 8. After the dwell, the other roller 126 during approximately a one-fifth revolution of the pinion engages the cam 120 and accelerates the gear 110 until it has the same speed as the pinion 112, when the gear teeth mesh and the ordinary gear drive between the pinion 112 and the gear 110 is resumed. In the arrangement as shown, the gear is stopped twice per revolution—that is, once with the toggle links open and the next time with the toggle links closed. Both starting and stopping are accomplished with harmonic deceleration and acceleration.

The "beaver tail" stop mechanism associated with the drive for the crankshaft 32 is of the same construction as that just described for the drive for opening and closing the toggle 40, and includes "beaver tail" cams 130 and 132 on gear 84 cooperable with rollers 134 carried by a yoke 135 on pinion 86 for locking the crankshaft 32 in its two positions hereinbefore referred to.

As previously noted, the lower stationary die 24 is secured to the bed 22 with the gate 136 in fluid flow relationship with a shot sleeve 138 which in turn communicates at its lower end with a means for supplying molten die cast metal under pressure to the mold cavity 140 through the shot sleeve 138. The shot sleeve 138 is secured in the bed 22. A metal supply conduit 142 communicates at its upper end with a chamber 144 and at its lower end projects into a molten mass 146 of die cast metal in furnace pot 148. The plunger 42 is reciprocable in the shot sleeve 138, the section 150 of which is provided with lateral ports 152 through which molten metal flows from the chamber 144 into the shot sleeve when the plunger 42 is retracted as shown in FIG. 2. The plunger 42 is secured on the forward end of a rod 154 of a piston 156 of an air or hydraulic power cylinder indicated generally at 158. Molten die cast metal is maintained in the pot 148 at a suitable level and, as the dies 24 and 28 are locked up, air or inert gas under pressure supplied through a pipe 160 under the control of a suitable control valve indicated generally at 162 will cause molten die cast metal to flow upwardly through the conduit 142, through the chamber 144, and into the lower end of the shot sleeve 138 to a suitable predetermined level 164. Fluid under pressure is then supplied to the cylinder 158 so as to advance the piston 156 and the

plunger 42, thereby forcing the shot of metal in the lower end of the shot sleeve upwardly through the shot sleeve and the gate 136 under pressure into the die cavity. As soon as the plunger 42 closes the ports 152, the air pressure on the die cast metal 146 in the pot 148 may be released and thus permit the die cast metal in the chamber 144 and the conduit 142 to drain back into the pot 148 before it freezes.

Since the shot cylinder 138 is vertically disposed and molten die cast metal is supplied to the lower end thereof, the shot of die cast metal, whether large or small, will always be in cylindrical form with a minimum of surface exposed to the air and the shot cylinder wall. Hence heat loss will be at a minimum and the shot will be pushed through the shot sleeve by the plunger 42 through the gate 136 in the die 24 without changing its shape and without turbulence. As well understood in the art, the shot of die cast metal must be suficient to completely fill the die cavity under the high pressure to which it is subjected by the plunger 42 but of such a volume that the end of the shot when the plunger 42 is advanced will be well within the gate 136 and above the upper end of the shot sleeve 138. Desirably the volume of the shot is closely controlled, as is well understood in the art. Because of the vertical feeding of die cast metal through the shot sleeve 138 and the solid cylindrical nature of the shot, the cylinder 158 for advancing the shot plunger 42 may be actuated as soon as the dies 24 and 28 are in their closed position, as the mechanism hereinbefore described will actuate the toggle 40 to lock the dies in their closed position before the molten metal reaches the level 164.

The holding furnace 148 for the molten die cast metal is disposed below the bed 22 which, as shown in FIG. 3, is supported on girders 166. This arrangement separates the casting and trimming operations from those involved in charging the furnace pot 146.

An ejector plate 170 is associated with the movable die 28 and is suitably connected to an ejector piston 172 of a hydraulic ejector cylinder 174. As is common in the art, knockout pins 176 are associated with the plate 170 and arranged to be moved thereby for displacing the casting from the cavity of the die 28 after the latter is moved to its open position. The ejector plate 170 is connected to the piston 172 so as to move therewith.

A fluid pressure line (not shown) is connected to the port 178 of the cylinder 174 for supplying hydraulic fluid under pressure to the cylinder for moving the piston 172 so as to actuate the ejector plate 170. The piston 172 is retracted by hydraulic fluid under pressure supplied to the cylinder on the other side of the head of the piston 172 through the port 180, and the hydraulic pump 182 for supplying hydraulic fluid under pressure to the cylinder 174 may be mounted on the lower slide 26 and driven by the motor 184.

As illustrated in FIGS. 10A and 10B, power for the machine is supplied by the lines L1, L2 and L3, which lead to the controller or relay CR90 and through it to the three phase induction motor 90, and to the controller or relay CR116 and through the latter to the induction motor 116. Motor 90 is mounted on the frame and drives the upper slide 30, while motor 116 is mounted on the upper slide 30 and operates the toggle 40.

Lines 201 and 202 lead from L1 and L3, to the brake controlling coil B1 for the motor 90, and similar lines 203 and 204 lead from lines L1 and L3 to the brake controlling coil B2 for motor 116. Thus when a motor is running, its brake is released, but when the circuit for such motor opens, it is braked to an immediate stop.

Other branch lines L1*a* and L2*a* lead to the primary of the transformer TR.

From the secondary of the transformer TR lines L4 and L5 form the main lines to the control. L4 has a branch L4*a* which passes through stop switch S and relay switch CR8*c* to form an auxiliary lead for all subsequent actions. Likewise, L5 passes through switch CR8*b* and all subsequent circuits are connected to L4*a* and L5 at points beyond relay CR8.

Relay CR1 is energized by pressing pushbutton PB1, momentarily. This forms a circuit from L4 to L5 via wires 205, switch PB1, wires 206, 207, 208, coil CR8 and wire 209 to energize relay CR8, which holds itself in via circuit formed by wire L4*a*, stop button S, the continuation of wire L4*a*, wire 210, relay switch CR8*a*, wire 211, relay switch CRAH*a* (described later), wires 212 and 208, coil CR8, and wire 209.

The energizing of CR8 closes switches CR8*b* and CR8*c* to energize the lead wires L4*a* and L5 leading to the remainder of the control. CR8 will be de-energized by opening stop button S momentarily. Thus no control circuit can be made unless CR8 is energized, and all control circuits become inactive when CR8 is de-energized by opening stop button S, since de-energizing CR8 opens switches CR8*b* and CR8*c*.

Push button PB1 has a second set of contacts. When closed, PB1 sets up a circuit through relay CR1 via wire 213, PB1, wire 214, coil CR1, and wire 215. CR1 is now energized, closing switch CR1*a*, opening switches CR1*b* and CR1*c*. Opening of switch CR1*b* breaks a circuit (described later) previously established through relay CR4. Opening of switch CR1*c* breaks a previousy established circuit through CR3 (described later). Hence CR1*b* and CR1*c* clear all circuits established at the end of the previous cycle. CR1 relay does not hold itself in. PB1 must be held slightly more than momentarily to prevent re-establishing of the circuit through CR4 relay, since at this time cam C1*b* is holding limit switch LS2 closed and the relay CR4 can be re-established, until such time as the cam C1*b* has released switch LS2.

Switch CR1*a* establishes a circuit to start motor 90 via wire 225, switch CRAH*b*, wires 216, 217, 218, 219, switch CR1*a*, wires 220 221, 222, switch CR4*b*, wires 223 and 224, relay coil CR90 and wire 226. The energizing of relay coil CR90 closes switches CR90*a*, CR90*b*, CR90*c* and CR90*d*, while opening switch CR90*e*. Closing of switch CR90*a* causes CR90 to hold itself in via wire 225, switch CRAH*b*, wires 216, 217, 218, 228, 229, switch CR90*a*, wires 227, 221, 222, switch CR4*b*, wires 223, 224, coil CR90, and wire 226.

Switches CR90*b*, CR90*c*, and CR90*d* connect L1, L2 and L3 to motor 90. Action of motor 90 turns cam C1*b* releasing limit switch LS2 and hence permitting operator to release PB1.

As the motor 90 rotates the crankshaft 32, cam C1*a* rotates due to the crankshaft 32 turning. Cam C1*a* is adjustable on the shaft 32, so that its function of starting motor 116 to drive the lower slide 26 may be timed for the most efficient functioning of the toggle drive for the lower slide, with reference to the crank drive for the upper slide via motor 90.

When cam C1*a* contacts and closes limit switch LS1 a circuit is established via wire 225, switch CRAH*b*, wires 216, 230, 231, switch LS1, wires 232, 233, 234, switch CR5*b*, wires 235, 236, coil CR116 and wire 237. Coil CR116 is thus energized. Switches CR116*a*, CR116*b*, CR116*c*, CR116*d*, and CR116*e* are closed. Coil CR116 now holds itself in via the circuit wire 225, switch CRAH*b*, wires 216, 217, 238, 239, switch CR116*a*, wires 240, 234, switch CR5*b*, wires 235, 236, coil CR116, and wire 237.

Motor 116 starts, since switches CR116*b*, CR116*c* and CR116*d* connect it to the lines L1, L2 and L3. Switch CR116*e* is used to close the circuit (not described here) which initiates the shot cycle.

As motor 90 turns the crankshaft 32 approximately 180°, cam C1*c* (which is adjustable on crankshaft 32 for most efficient timing and operation) closes limit switch LS2*a* creating a circuit through wires 247, switch CR1*b*, wire 241, switch T*a*, wires 242, 248, 253, limit switch LS2*a*, wires 254, 245, 251, relay coil CR4, and wire 246.

Relay coil CR4 is now energized closing switch CR4*a*, opening switch CR4*b*, and closing switch CR4*c*. Switch CR4*a* permits coil CR4 to hold itself in via the circuit through wire **247**, switch CR1*b*, wire **241**, switch T*a*, wires **242**, **248**, **249**, **250**, switch CR4*a*, wires **252** and **251**, coil CR4 and wire **246**.

The opening of switch CR4*b* by energizing coil CR4, breaks the circuit through the motor control CR**90**, causing motor **90** to stop with the idle stroke in its closed position with its brake B**1** applied. Cam C1*c* has been adjusted on crankshaft **32** so that this stopping position brings the yoke **135** of the "beaver tail" into a position where cam C3 on the yoke **135** closes limit switch LS4 on a circuit to be described later.

Similarly, as motor **116** turns shaft **106** through approximately 180°, cam C2*b* on shaft **106** closes limit switch LS3*a* creating a circuit via wire **247**, switch CR1*b*, wire **241**, switch T*a*, wires **242**, **248**, **249**, **255**, **266**, **267**, limit switch LS3*a*, wires **268**, **269**, **270**, switch CR**90***e*, wire **271**, relay coil CR5, wire **256**. Coil CR5 is now energized, closing switch CR5*a*, opening switch CR5*b*, and closing switch CR5*c*. This last is in a circuit to be described later.

Closing of switch CR5*a* allows coil CR5 to hold itself in via wire **247**, switch CR1*b*, wire **241**, switch T*a*, wires **242**, **248**, **249**, **255**, **266**, **257**, switch CR5*a*, wires **258**, **270**, switch CR**90***e* (whose purpose will be described later), wire **271**, relay coil CR5, and wire **256**.

The opening of switch CR5*b*, by energizing coil CR5, breaks the circuit through motor control CR**116**, causing motor **116** to stop with the power stroke in its locked-up position with the brake B**2** being applied. Cam C2*b* has been adjusted on crankshaft **106** so that this stopping position brings the yoke **124** into a position where cam **127** engages the operating arm of limit switch LS5 to close the same.

Both motors are now stopped with their respective drives in their locked positions and relays CR4 and CR5 are energized. A circuit is now completed to energize the timer T as follows: wire **225**, switch CRAH*b*, wires **216**, **230**, **259**, **260**, limit switch LS4, wire **261**, limit switch LS5, wire **262**, switch CR3*d*, wire **263**, switch CR4*c*, wire **264**, switch CR5*c*, wires **265**, **272**, timer T, wire **273**. A branch on this circuit wire **274** leads to the shot cycle portion of the circuit (not shown).

Timer T is now energized. At this time plunger **42** advances and the shot is made and the casting chilled. When the timer T times out, it actuates the switches T*a*, opening it, and T*b*, closing it. Opening of the switch T*a* breaks the circuits through relays CR4 and CR5, which controlled the stopping of the motors **90** and **116**. This also opens the switches CR4*c* and CR5*c* in the timer circuit, but not before the closing of switch T*b* has formed a circuit through relay coil CR3 as follows: wire **225**, switch CRAH*b*, wires **216**, **230**, **259**, **275**, **276**, switch T*b*, wire **277**, switch CR1*c*, wires **278**, **279**, relay coil CR3, and wire **280**.

The energizing of control relay CR3 which results closes switches CR3*a*, CR3*b* and CR3*c* and opens switch CR3*d* and closes switch CR3*e*. Closing switch CR3*a* causes coil CR3 to hold itself in via the circuit through wire **225**, switch CRAH*b*, wires **216**, **230**, **259**, **275**, **281**, switch CR3*a*, wires **282** and **279**, coil CR3, and wire **280**.

Closing switch CR3*b* restarts motor **90** via the circuit consisting of wire **225**, switch CRAH*b*, wires **216**, **217**, **218**, **228**, **283**, switch CR3*b* (now closed), wires **284**, **222**, switch CR4*b*, wires **223**, **224**, relay coil CR**90**, and wire **226**. The brake B**1** now releases, the motor **90** starts to open the dies, and coil CR**90** holds itself in, all as described above.

Simultaneously, a circuit for starting motor **116** is made through switch CR3*c* as follows: wire **225**, switch CRAH*b*, wires **216**, **217**, **238**, **285**, switch CR3*c*, wires **286**, **233**, **234**, switch CR5*b*, wires **235**, **236**, relay coil CR**116**, wire **237**. Thus the brake B**2** is released, motor **116** starts opening the toggle **40**, and coil CR**116** holds itself in, all as previously described.

At this time the cams C1*b* and C1*c* are in the reverse position from that shown in FIG. 10B since the machine is locked up, while the diagram shows the cams in the open position. Likewise, cams C2*a* and C2*b* are reversed from the positions shown for the same reason.

As the motor **90** drives crankshaft **32** through approximately 180°, cam C1*b* will close limit switch LS2 to form a circuit through CR4 as follows: wire **247**, switch CR1*b*, wire **241**, switch T*a*, wires **242**, **243**, limit switch LS2, wires **244**, **245**, **251**, relay CR4 and wire **246**. Coil CR4 is now energized, switch CR4*b* opens, the motor **90** stops, brake B**1** is applied, as before described, and the idle drive has returned to its open position.

Similarly, as motor **116** turns crank **104** through approximately 180°, cam C2*a* closes LS3, energizing relay coil CR5 by forming a circuit through wire **247**, switch CR1*b*, wire **241**, switch T*a*, wires **242**, **248**, **249**, **255**, **287**, limit switch LS3, wires **288**, **269**, **270**, switch CR**90***e* (whose purpose is described later), wire **271**, relay coil CR5, and wire **256**. Coil CR5 is now energized, switch CR5*b* opens, the motor **116** stops, brake B**2** is applied, as before described, and the power drive stops in its open position.

At this time cams C3 and **127** on the yokes **135** and **124** close limit switches LS4 and LS5 respectively. When this occurred in the lock-up position of the machine, a circuit was made through T to start the timer. Now, however, switch CR3*d* is open, because relay coil CR3 is still energized (as are coils CR4 and CR5) with the machine open. Therefore no circuit is made through T, and hence timing only starts in the locked-up position. The opening of switch CR3*d* has also reset the timer.

Reference should be made to the switches CR4*c* and CR5*c* in the circuit through the timer. In some designs the cams C3 and **127** may close limit switches LS4 and LS5 two or more times during the movement of crankshafts **32** and **104** through 180°, and these closures may occur simultaneously. Since relay coils CR4 and CR5 are not energized until the crankshafts have traveled approximately 180°, the closing of limit switches LS4 and LS5 does not complete a circuit except when the crankshafts reach their locked-up positions with switches CR4*c* and CR5*c* remaining open during earlier closures of limit switches LS4 and LS5.

The function of switch CR**90***e* will now be described. At the start of a cycle cam C2*a* is holding limit switch LS3 closed, permitting relay coil CR5 to be energized, thus keeping switch CR5*b* open and preventing starting of motor **116** via CR**116** when the limit switch LS1 is closed. The opening of switch CR1*b* does break the circuit through CR5 (as well as CR4). Push button PB1 is held depressed until motor **90** has moved cam C1*b* to permit limit switch LS2 to open keeping the circuit through coil CR4 open. However, the release of push button PB1 will allow switch CR1*b* to close and the circuit through coil CR5 will be re-established. At this time motor **90** is operating and relay coil CR**90** is energized. Therefore, switch CR**90***e* is open preventing a circuit through coil CR5, thus closing switch CR5*b* and permitting the circuit to relay coil CR**116** to be made when cam C1*a* closes limit switch LS1. Note that on the closing stroke of the machine, the motor **90** always stops before motor **116**. Therefore switch CR**90***e* is closed in time for the proper functioning of relay CR5.

On the return or opening stroke of the die caster, both motors start simultaneously, but it is uncertain which crankshaft **32** or **106** will reach its open position first. If crankshaft **106** reaches its open position first, it will overtravel as switch CR**90***e* is open, and hence no circuit can be made through coil CR5 to stop motor **116**. To prevent this, switch CR3*e* is provided. This will now be closed since relay coil CR3 is energized. This closed switch CR3*e* bridges over the now open switch CR**90***e*

via wires 289 and 290, so that the circuit through coil CR5 may be made at the proper time to stop motor 116 with crank 104 in the proper position.

As stated above, coils CR3, CR4 and CR5 are energized at the end of a cycle. These coils are all de-energized or reset when push button PB1 is depressed, energizing coil CR1. Switch CR1*b* then opens to break circuits through coils CR4 and CR5 while switch CR1*c* breaks the circuit through coil CR3.

The construction described has shown two cams C1*b* and C1*c* operating two limit switches LS2 and LS2*a*. Likewise two cams C2*a* and C2*b* are shown actuating two limit switches LS3 and LS3*a*. This has been done for clarity. One limit switch with one cam having two nodes may be used in each case.

For die setting and other purposes, it is convenient to "inch" the motors 90 and 116 independently. At such times all automatic sequences must be eliminated. To accomplish this the hand operated switch Y is provided. During the automatic sequence described above, this switch Y was open. For "inching" operation it is closed, energizing relay coil CRAH. This opens switches CRAH*a* and CRAH*b*, and closes switch CRAH*c*. Opening of switch CRAH*a* interrupts the holding circuit on relay coil CR8, so that this relay coil cannot hold itself in and, as described later, is only energized as long as push button PB2 or push button PB3 is held depressed. Hence, no self-sustaining circuit may be obtained.

Switch CRAH*b*, now opened, interrupts circuits to motors 90 and 116 through the contacts used when on automatic cycle. It also interrupts the circuit to the timer T and to the shot cycle portion of the circuit.

Switch CRAH*c*, now closed, connects line L4*a* to the push buttons PB2 and PB3 via wires 290, 291 and 292. PB2 and PB3 are double contact switches. Their second contacts are connected to L4 by wires 293 and 294 respectively.

In order to energize any subsequent circuit, it is necessary to energize the relay CR8, to close switches CR8*b* and CR8*c* on lines L5 and L4*a* respectively. When push button PB2 is depressed, coil CR8 is energized via a circuit through wire 293, push button PB2, wires 300, 296, 207, 208, coil CR8, and wire 209. Likewise, when push button PB3 is depressed, coil CR8 is energized through a circuit via wire 294, push button PB3, wires 295, 296, 207, 208, coil CR8, and wire 209. Since the circuit through holding switch CR8*a* is now interrupted by switch CRAH*a* being opened, coil CR8 is de-energized as soon as a given push button PB2 or PB3 is released, since coil CR8 no longer holds itself in.

Push button PB2, when depressed, operates motor 90 via relay CR90 by a circuit through wire 290, switch CRAH*c*, wires 291, 297, push button PB2, wires 298, 224, coil CR90, and wire 226. Since CR8 coil is energized at the same time, motor 90 operates as long as push button PB2 is held depressed.

Likewise, push button PB3, when depressed, operates motor 116, via relay CR116 by a circuit through wire 290, switch CRAH*c*, wires 291, 292, push button switch PB3, wires 299, 236, relay coil CR116, and wire 237. Since CR8 coil is also energized when push button PB3 is depressed, motor 116 operates as long as push button PB3 is held depressed.

"Inching" of either motor is obtained by momentarily depressing its respective push button. No other actions are involved since switches CRAH*a* and CRAH*b* are open, breaking all other circuits which control movements of the machine.

I claim:

1. A vertical die casting machine of the cold chamber type having a frame including a stationary horizontal bed supporting a stationary die, a vertically reciprocable head above said bed operable to move and position a die in locked position for cooperation with said stationary die to define the mold cavity for a die cast part, said frame including a crown and tie rods interconnecting said crown and bed, power actuated positive mechanical linkage means reacting on said crown and head and operable for vertically moving said head to its locked position thereby to positively lock said dies together, a shot cylinder extending vertically through said bed and disposed so as to communicate at its upper end with a gate in said stationary die, a furnace pot for molten die cast metal below said bed, and means communicating with the lower end of said shot cylinder below said bed and with said pot for supplying a measured shot of molten die cast metal under pressure to the mold cavity from said pot through said vertical shot cylinder, said power actuated linkage means comprising a vertically reciprocable slide, a toggle operatively disposed between and arranged to react on said head and slide, a motor mounted on said slide and connected to said toggle for opening and closing said toggle, a pitman connected to said slide for advancing and retracting the same, a crankshaft having a crank to which said pitman is connected, a motor and gearing driven thereby connected to said crankshaft for turning the same, and control means for said crankshaft motor for stopping the same with said crank substantially on dead center when said slide is in its advanced position.

2. A die casting machine having a frame including a stationary bed forming a support for a stationary die, a head reciprocably mounted on said frame and operable to move and support a movable die in a locked position for cooperation with said stationary die to define the mold cavity for a die cast part, a power actuated slide reciprocably mounted on said frame for movement under no-load conditions from its open to its closed position, said head being positioned between said slide and said bed and being movable therewith as the slide moves to its closed position, a toggle arranged to react on said slide and head and being open as said slide moves to its closed position, power means connected to said toggle and operable when said slide is in its closed position for closing said toggle and thereby moving said head to its locked position and positively locking said dies together, power actuated means of low mechanical advantage relative to said toggle and including a crank and pitman reacting on said frame and said power actuated slide for advancing said slide to its closed position upon movement of said crank to its dead center position, said power means for closing said toggle including a motor, gearing driven by said motor, a crank driven by said gearing, a pitman interconnecting said last-mentioned crank and toggle for opening and closing the latter upon rotation of said last-mentioned crank, and a stop mechanism associated with said gearing for stopping said toggle alternately in its closed and in its open positions.

3. A die casting machine having a frame, a stationary bed for supporting a stationary die, a head reciprocably mounted on said frame and in its locked position supporting a movable die for cooperation with said stationary die to define the mold cavity for a die cast part, a slide reciprocably mounted on said frame for movement between closed and open positions, a crankshaft, a pitman connected to the crank of said shaft, an adjusting screw interconnecting said pitman and slide, power means for turning said shaft to effect the movement of said slide under no-load conditions between its open and closed positions and so that said slide is in its closed position when said crank is on dead center, said head being positioned between said slide and said bed and connected to said slide so as to move therewith during such movement of said slide to its closed position, a toggle between said slide and head operable when said slide is in its closed position and upon closing of said toggle for moving said head to its locked position thereby to lock said dies together, and a motor mounted on said slide and connected to said toggle for opening and closing the same.

4. A vertical die casting machine having a frame, a horizontal bed for supporting a stationary die, a head

reciprocably mounted on said frame above said bed and adapted in its locked position to support a movable die for cooperation with said stationary die to define the mold cavity for a die cast part, a slide reciprocably mounted on said frame above said head for movement between closed and open positions, a crankshaft, a pitman connected to the crank of said shaft and said slide, power means for turning said shaft to effect the movement of said slide under no-load conditions between its open and closed positions, a stop mechanism associated with said power means for stopping said crankshaft on dead center when said slide is in its closed position, said head being positioned between said slide and said bed and connected to said slide so as to move therewith during such movement of said slide to its closed position, a toggle between said slide and head operable when said slide is in its closed position for moving said head to its locked position thereby to lock said dies together, an electric motor mounted on said slide and connected to said toggle for opening and closing the same, and a stop mechanism associated with said toggle motor for stopping said toggle in its open and closed positions.

5. A vertical die casting machine having a frame, a horizontal bed adapted to support a stationary die, a head reciprocably mounted on said frame above said bed and adapted in its locked position to support a movable die for cooperation with said stationary die to define the mold cavity for a die cast part, a slide reciprocably mounted on said frame above said head for movement between closed and open positions, a crankshaft, a pitman connected to the crank of said shaft and said slide, power means for turning said shaft to effect the movement of said slide to its closed position upon movement of the crank of said crankshaft to its dead center position, said head being positioned between said slide and said bed and connected to said slide so as to move therewith during such movement of said slide to its closed position, a toggle between said slide and head operable when said slide is in its closed position for moving said head to its locked position thereby to lock said dies together, a motor connected to said toggle for opening and closing the same, and means counterbalancing the weight of said head and the die carried thereby.

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