

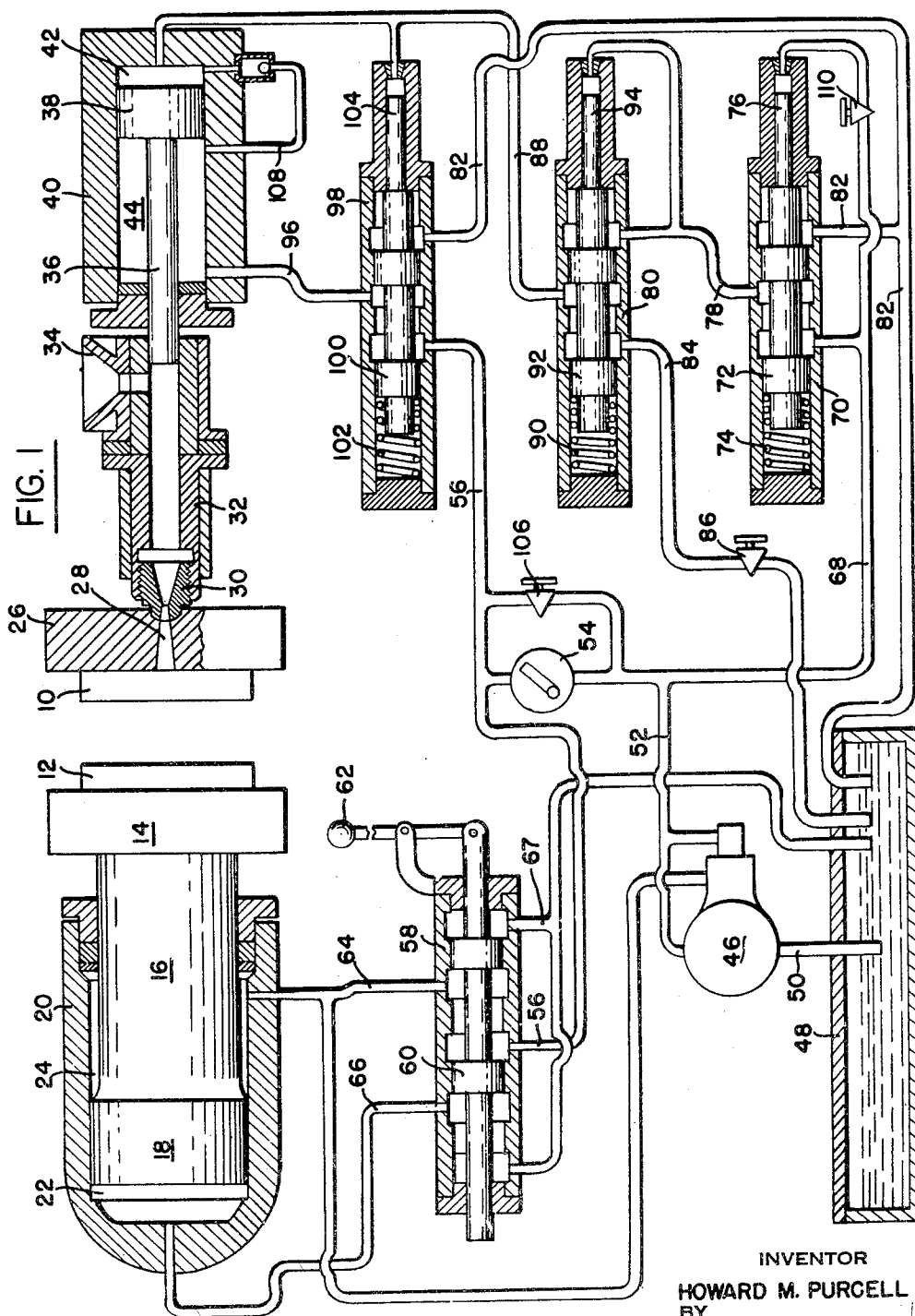
Oct. 18, 1949.

H. M. PURCELL
FLUID OPERABLE SYSTEM

2,484,907

Filed Oct. 7, 1946

4 Sheets-Sheet 1



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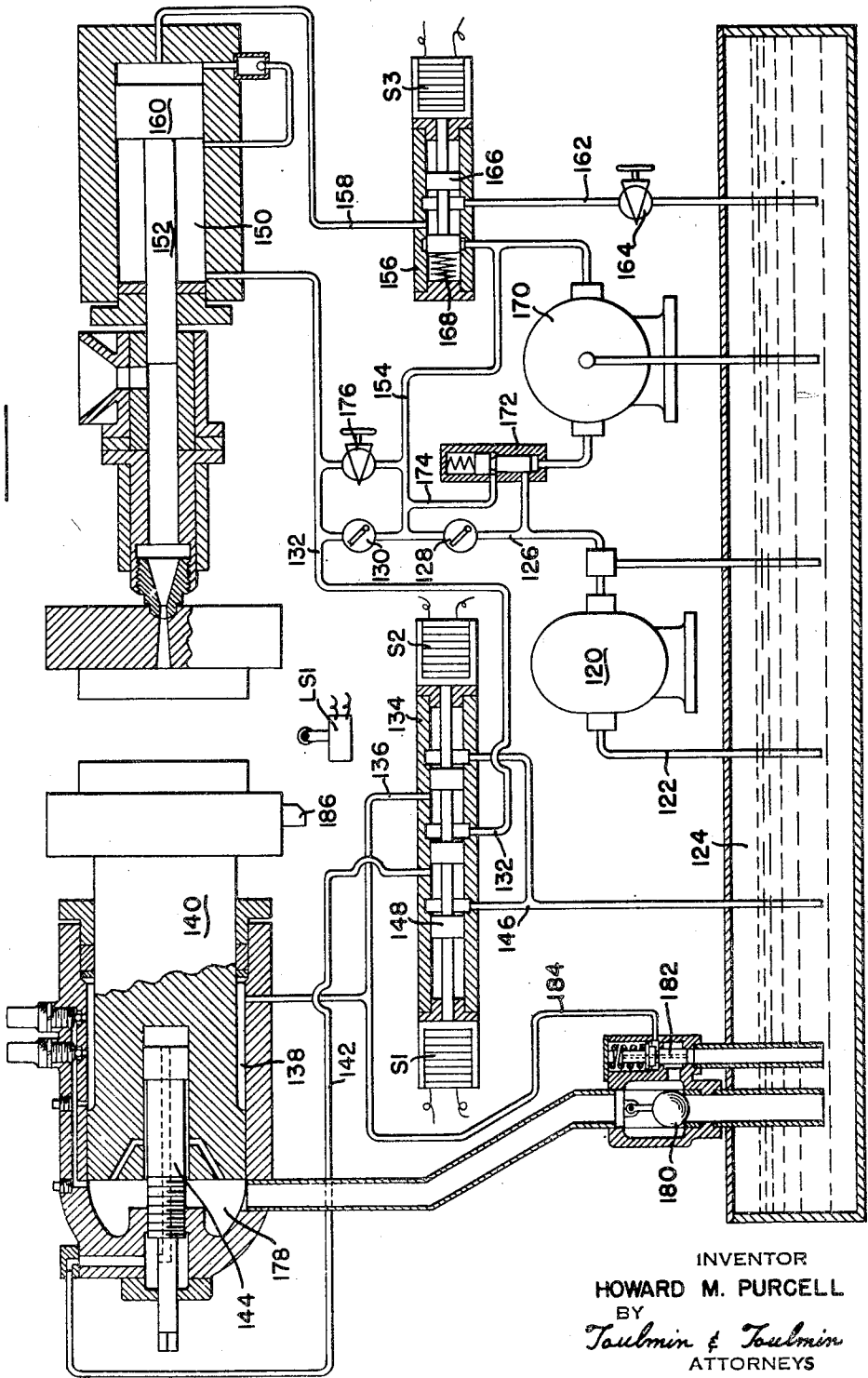
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FIG. 2



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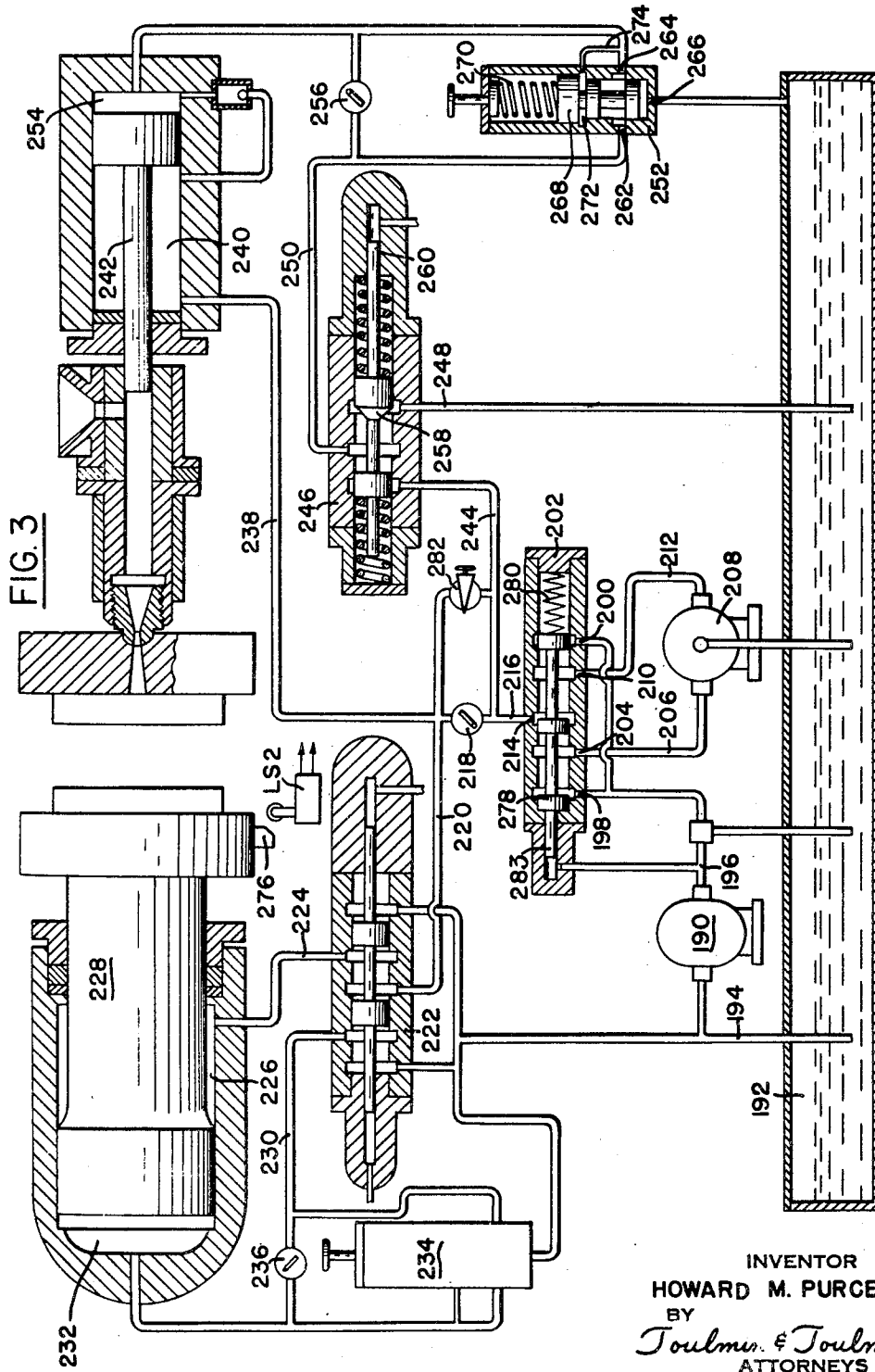
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4 Sheets-Sheet 3



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4 Sheets-Sheet 4

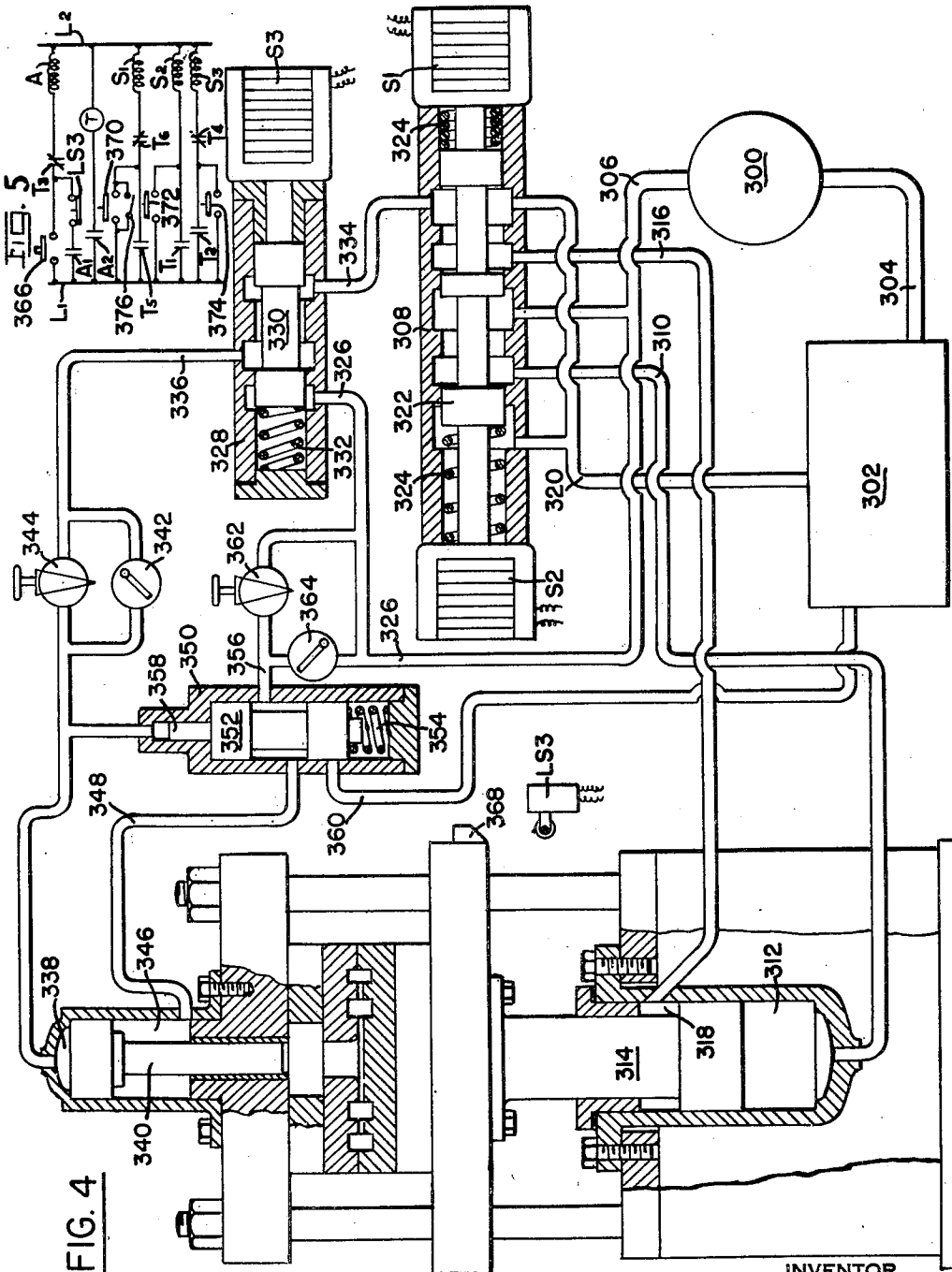


FIG. 4

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FLUID OPERABLE SYSTEM

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Application October 7, 1946, Serial No. 701,713

16 Claims. (Cl. 60—97)

1

This invention relates to fluid operable systems and to methods of operation thereof, and more particularly relates to such systems wherein there are a plurality of fluid motors.

In many instances in hydraulic circuits there are a plurality of fluid motors to be operated according to a predetermined sequence. In some instances it is required to hold pressure on one of the motors while another thereof is moving under substantially no load. Usually this is accomplished by employing separate fluid sources for the motors, or by arranging a valve in circuit with the motor operating under no load which only opens at a predetermined pressure.

When separate fluid sources are used there is the additional expense of duplicate units as well as a considerable waste of power during the time that the fluid sources are not being used. When a valve is placed in series with one of the motors to be opened in response to a predetermined pressure, there is often a loss of pressure in the circuit which can only be made up after a predetermined time delay.

A particular instance of the foregoing is a molding machine wherein there is a clamping ram for clamping together a multipart mold, and in injection ram for driving an extrusion plunger to extrude molding material into the clamped molds. A typical work cycle on a machine of this nature involves the preliminary clamping together of the mold and the subsequent extrusion of the plastic therein.

The mold must be retained tightly clamped together at all times or else the molding material will flash between the parts thereof and cause a loss of plastic material and improper or ruined workpieces. Furthermore, the clamping ram is usually of such a size that it takes a considerable period of time to develop the necessary pressure therein so that any loss of pressure in the fluid circuit would be accompanied by a delay in the building up of the necessary clamping pressure. If this loss in pressure occurred during the time that the injection ram was being actuated, then there would be greater likelihood of the mold flashing.

Accordingly, the principal object of this invention is to provide a fluid operable circuit wherein there are a plurality of motors to be operated from a single fluid source and in which the pressure can be maintained in the circuit at all times.

Another object is to provide a hydraulic circuit including a single source of pressure which is operable sequentially to actuate a plurality of fluid motors and to maintain the pressure on the actuated motors.

Still another object of this invention is the provision of an improved fluid circuit including a single pump and several motors so that the mo-

2

tors can be actuated independently and sequentially without any loss of pressure in the circuit.

A particular object of this invention is to provide an improved actuating circuit for a fluid operated molding machine having a plurality of fluid plungers.

These and other objects and advantages will become more apparent upon reference to the following description taken in connection with the accompanying drawings in which:

Figure 1 is a diagram of an actuating circuit arranged according to this invention and connected with a fluid operable molding press;

Figure 2 is a view similar to Figure 1 but shows a different arrangement of the circuit and a different means for actuating the valves therein;

Figure 3 is a still further modification and includes means for holding independent pressures on the several fluid operated motors;

Figure 4 is a modified arrangement applied to a vertical molding machine; and

Figure 5 is a wiring diagram for controlling the valves in the circuit of Figure 4.

General arrangement

According to this invention, there are a plurality of fluid motors and a single fluid source for actuating the said motors. The motors are arranged to be actuated sequentially so that one thereof is moved into working position and dwells therein under pressure while the other thereof goes through its working cycle. The second actuated motor is provided with means whereby there is a predetermined minimum pressure acting thereon even when the motor is not externally loaded, so that there is no loss of pressure at the inlet of the first actuated motor.

According to this invention, the predetermined pressure is maintained on the second actuated motor by throttling the discharge therefrom during at least its initial movement. Optionally, the aforementioned restriction can be removed from the discharge line of the second actuated motor in response to a predetermined pressure acting on the inlet side thereof.

According to one modification of this invention, a single operating valve controls an entire operating cycle for a pair of reciprocable plungers so that one thereof advanced to working position and dwells therein, thereafter the other thereof advances into working position and retracts, and finally the said one retracts to its original position.

According to another modification, the actuation of the fluid motors is interlocked by a suitable electric circuit and the flow of fluid to and from the motors is controlled by solenoid operated valves.

Still another modification of this invention provides for independent pressures to be held

on each of the several motors up to the maximum supplied by the pumping means in the system, and irrespective of the pressure standing in any other part of the circuit.

Arrangement of the modification illustrated in Figure 1

Referring to the drawings, Figure 1 illustrates a molding machine having a stationary mold part 10 and a movable mold part 12 which is carried on a movable platen 14. The platen 14 is mounted on the ram 16 having the piston 18 reciprocable in the cylinder 20 thereby defining the ram advancing means 22 and the ram retracting means 24.

The mold half 10 is carried on a stationary bolster member 26 which has a passage 28 there-through and through which molding material is supplied to the cavity formed by the mold halves when clamped together. Communicating with the passage 28 is the nozzle 30 of an extrusion chamber 32 which is supplied with molding material from a hopper 34 and from which the said molding material is extruded by a ram or plunger 36 which has connected therewith a piston 38 reciprocable in a cylinder 40. The piston 38 and the cylinder 40 form the ram advancing means 42 and the ram retracting means 44.

For supplying actuating fluid to the clamping and extrusion rams, there is provided a pump 46 which is connected to draw fluid from a reservoir 48 through a conduit 50. The pump 46 discharges fluid into a conduit 52 which is connected with the inlet side of a check valve 54, the discharge side of which opens into a conduit 56. The conduit 56 leads to the inlet port of a four-way valve 58 having the movable valve member 60 which can be actuated by the hand lever 62. The valve 58 includes a first service port connected by a conduit 64 with the clamping ram retracting means 24, and a second service port which is connected by the conduit 66 with the clamping ram advancing means 22.

The conduit 52 is also connected by a conduit 68 with one port of a valve 70 which has a valve member 72 therein continuously urged in one direction by a spring 74. A pilot piston 76 is also connected with the conduit 68 for moving the valve member 72 against the thrust of the spring 74 in response to a predetermined pressure. The valve 70 also has a port connected by a conduit 78 with a port in another valve 80. When the valve member is under the influence of the spring 74, the conduits 68 and 78 are connected together, and when the valve member is under the influence of the pilot piston 76 the conduit 78 is disconnected from the conduit 68 and is connected instead with the exhaust conduit 82 leading to the reservoir 48.

The valve 80 is similar to the valve 70 and includes a port which is connected by a conduit 84 through a restricting valve means 86 with the reservoir, and another port which is connected by a conduit 88 with the advancing means 42 of the extrusion ram.

A spring 90 in the valve 80 normally urges the valve member 92 thereof into position to connect the conduits 84 and 88, and a pilot plunger 94 is connected to be responsive to the pressure acting in the conduit 78 for moving the valve member 92 against the thrust of the spring to disconnect the conduit 88 from the conduit 84 and to connect it instead to the conduit 78. The retracting means of the extrusion ram is connected by a conduit 96 with one port of a valve

98 which also includes a port connected with the conduit 82 and another port connected with the conduit 56.

The valve member 100 of the valve 98 is continuously urged by a spring 102 to connect the conduits 56 and 96, and there is a pilot plunger 104 which is connected to be responsive to the pressure in the conduit 88 for moving the valve member 100 to disconnect the conduit 96 from the conduit 56 and to connect it instead with the conduit 82. For a purpose which will become more apparent hereinafter, the check valve 54 is bypassed by a flow controlling or flow restricting valve means as indicated at 106.

Operation of the embodiment of Figure 1

In explaining the operation of the embodiment shown in Figure 1 let it be assumed that the molding machine parts occupy the positions shown in the drawings. Then, to close the molds, the lever 62 is actuated to move the valve member 60 to interconnect the conduits 56 and 66, and to connect the conduit 64 with the exhaust conduit 67 of the valve 58. With the valve 58 so set, fluid from the pump 46 passes through the conduit 52, the check valve 54, the conduit 56, the valve 58 and the conduit 66 to the clamping ram advancing means 22. This moves the clamping ram rightwardly and brings the mold halves together in clamping relationship. The meeting of the mold halves causes a pressure rise in the conduit 52 which extends through the conduit 68 and the valve 70 to the conduit 78. When this pressure reaches a predetermined value the pilot plunger 94 of the valve 80 is actuated to move the valve member thereof leftwardly to interconnect the valve conduits 78 and 88, thus extending the supply of pressure fluid to the extrusion ram advancing means 42.

The supply of fluid to the extrusion ram advancing means 42 moves the said ram leftwardly to expel fluid from the retracting means 44 thereof through the conduit 96 and the valve 98. The fluid so expelled through the valve 98 enters the conduit 56 where it is connected with the said valve and then passes through the restricting means 106 to the conduit 52 where it joins with the pump discharge passing to the advancing means 42.

It will be noted that the pressure in the conduit 56 is necessarily higher than the pressure in the conduit 52 because of the flow restricting means 106. Thus, the clamping pressure standing in the clamping ram advancing means 22 is also higher than the pressure in the conduit 52. This positively insures that the pressure on the clamping ram advancing means 22 will be maintained during the initial advancing movement of the extrusion ram 36.

When the extrusion ram 36 has advanced to the point where it engages the molding material in the chamber 32 and develops a pressure thereon, this brings about an increase in pressure in the advancing means 42 which is conveyed through the conduit 88 to the pilot plunger 104 of the valve 98. When the pressure reaches a predetermined value, the valve member 100 moves leftwardly to connect the conduit 96 directly with the exhaust conduit 82. At this time, the full thrust on the piston 38 from the advancing means 42 is exerted on the extrusion ram 36. At the same time, the speed of movement of the extrusion ram slows down so that this circuit provides for a rapid advance of the clamping ram to working position.

5

When the mold cavity has been filled with molding material, the extrusion ram comes to a halt, and the discharge pressure increases. This increased pressure extends through the conduits 52 and 68 to the pilot plunger 76 of the valve 70. When the pressure reaches a predetermined amount, the valve member 72 moves leftwardly and connects the conduit 78 with the conduit 82 while simultaneously interrupting the communication between the conduits 78 and 88. When the conduit 78 is connected with exhaust, the pressure acting on the plunger 94 drops to exhaust pressure and the spring 90 returns the valve member 92 to the position shown in the drawings. The valve member 92 now interconnects the conduits 84 and 88 so that the advancing means 42 of the extrusion ram is connected with the reservoir through the flow restricting means 86.

The connecting of the advancing means 42 with the reservoir brings about a lowering of the pressure therein which permits the spring 102 of the valve 98 to move the valve member 100 back to the position shown in the drawings. The valve member 100 now connects the conduits 56 and 96 to supply actuating fluid to the extrusion ram retracting means 44 for retracting the said ram.

As the ram retracts, the fluid expelled from the advancing means 42 thereof passes through the restricting means 86 so that a high pressure is maintained in the retracting means 44 and the conduits 96 and 56. This insures that the pressure in the clamping ram advancing means 22 will remain high enough to maintain the mold halves clamped together. After the extrusion ram completes its retraction stroke, the discharge from the pump 46 may be bypassed through the checked bypass connection 108, the advancing means 42, the conduits 88 and 84 and the restricting means 86 to the reservoir.

After the mold halves have remained clamped a sufficiently long time for the material which has been extruded into the cavities thereof to set or cure, the lever 62 may be actuated to return the valve member 60 to the position shown in the drawings. This retracts the clamping ram 16 to the position shown in the drawings and the machine is ready for a new cycle of operations.

It will be noted that the clamping ram 16 is directly under the control of the valve 60, while the extrusion ram goes through a complete cycle of operations for one position of the clamping ram.

In the event that it is desired for the extrusion plunger to dwell against the material to hold a pressure within the cavity of the clamp mold halves, the actuation of the valve 70 may be somewhat delayed, as by the choke valve 110 which is connected in series with the pilot plunger 76.

Arrangement of the modification illustrated in Figure 2

In Figure 2 there is shown an arrangement similar to that shown in Figure 1 wherein there is a pump 120 which draws fluid through a conduit 122 from a reservoir 124, and discharges the said fluid through a conduit 126 and the serially arranged check valves 128 and 130 to the conduit 132. The conduit 132 connects with the inlet port of a four-way valve 134 which includes a first service port connected by a conduit 136 with the retracting means 138 of the clamping ram 140.

The valve 134 also has a second service port which is connected by a conduit 142 with the

6

working areas of a booster ram 144. There is also connected with the valve 134 an exhaust conduit means 136, and reciprocable in the valve is a valve member 148 movable to interconnect the pressure conduit 132 with either of the service ports while connecting the other of the service ports with the exhaust conduit. The solenoids S1 and S2 at the opposite ends of the valve are selectively energizable for shifting the valve member therein.

The conduit 132 also connects directly with the retracting means 150 of the extrusion ram 152. From between the check valves 128 and 130 there is a branch conduit 154 which leads to one port of a valve 156 which also comprises a port connected by the conduit 158 with the extrusion ram advancing means 160, and a port which is connected by a conduit 162 through the flow restricting means 164 with the reservoir 124. The valve member 166 of the valve 156 is normally urged by a spring 168 to interconnect the conduits 158 and 162, and by the energization of the solenoid S3 to interconnect the conduits 154 and 158.

For supplying intensified fluid pressure to the rams, there may be included in the circuit a fluid intensifier as indicated at 170 which has its discharge port connected with the conduit 154 and its inlet port connected with the discharge port of a normally closed pilot operated valve 172. The inlet port of the valve 172 is connected with the discharge side of the pump 120 and the valve is adapted for being piloted into open position by fluid conducted thereto from between the check valves 128 and 130 by a conduit 174.

As in the case of the modification shown in Figure 1, there is provided the flow restricting means as at 176 for passing the discharge from the extrusion ram retracting means during the advancing stroke of the said ram. This valve 176 bypasses the check valve 130.

For supplying fluid to the advancing means 178 of the clamping ram during its rapid approach toward clamping position, there is provided a check valve 180 opening from the reservoir 124 into the said advancing means. A pilot operated unloading valve as at 182 is actuated by pressure fluid conducted thereto from the retracting means 138 by a conduit 184 for bypassing the check valve during the retracting stroke of the clamping ram.

In order to commence the actuation of the extrusion ram at the proper instant, there may be provided the limit switch LS1 which is positioned to be engaged by the cam 186 carried by the clamping ram which is prior to the clamping together of the mold halves. This serves the purpose of checking the speed of the clamping ram by diverting a portion of the pump discharge to the extrusion plunger, and also shortens the cycling time of the machine.

Operation of the embodiment of Figure 2

In the operation of the circuit shown in Figure 2, the clamping ram 140 is moved in its clamping direction by energizing the solenoid S1 which shifts the valve member 148 to direct pressure fluid from the conduit 132 through the conduit 142 to the booster ram 144. When the clamping ram has moved to a point where the cam 186 engages and closes the limit switch LS1 the solenoid S3 is energized and shifts the valve member 166 to connect the conduits 154 and 158. This last mentioned connection directs a portion of the pump discharge to the extrusion ram advancing means 160. As the extrusion ram advances the fluid expelled from the retracting means 150

thereof is passed through the flow restricting means 176 so as to maintain at least as high a pressure in the clamping ram advancing means as there is at the discharge side of the pump 120.

Following the extrusion of material into the clamped mold halves, the extrusion plunger may be retracted by de-energizing the solenoid S3 whereupon the pressure standing in the retracting means 150 drives the said ram in its retracting direction. The fluid expelled from the advancing means 160 at this time is passed through the restricting means 164 so that a substantial pressure is maintained in the fluid circuit to maintain the mold halves clamped together.

After a predetermined dwell of the mold halves together, the solenoid S1 is de-energized and the solenoid S2 is energized to return the clamping ram 140 to the position shown in the drawings.

It will be apparent that any time the discharge pressure to the pump reaches the value necessary to open the valve 172, the intensifier 170 will commence operating to supply fluid at increased pressure to the fluid circuit.

Arrangement of the modification illustrated in Figure 3

In Figure 3 there is shown a fluid circuit wherein a pump 190 draws fluid from a reservoir 192 through a conduit 194, and discharges the said fluid through a conduit 196 to the ports 198 and 200 and a valve 202. The valve 202 also comprises a port 204 connected by a conduit 206 with one port of a fluid pressure converter 208, and a port 210 which is connected by a conduit 212 with the other port of the said converter. The converter 208 is adapted for passing fluid from the conduit 212 to the conduit 206 and to increase the pressure thereof while reducing the volume, or to pass fluid from the conduit 206 to the conduit 212 reducing the pressure thereon while increasing the volume.

A converter of this type forms no part of the present invention except the particular use to which it is being put and is illustrated and described in the co-pending application Serial No. 594,413, filed May 18, 1945, in the name of Warren R. Tucker and assigned to the same assignee as the instant application.

The valve 202 also includes a discharge port 214 which is connected with a conduit 216. The conduit 216 is connected through a check valve 218 with a conduit 220 which leads to the inlet of a four-way reversing valve 222 which has one service port connected by a conduit 224 with a retracting means 226 of the clamping ram 228, and a second service port connected by a conduit 230 with the advancing means 232 of the said clamping ram. Preferably, there is inserted in the conduit 230 a pressure reducing valve 234 of a type to be described hereinafter which is by-passed by a check valve 236 opening away from the said advancing means. The conduit 220 has a branch 238 which is connected directly with the retracting means 240 of the extrusion ram 242.

Branching off from the conduit 216 is a conduit 244 that leads to one port of a valve 246 which includes another port connected with the reservoir 192 by a conduit 248, and another port connected by a conduit 250 through the pressure reducing valve 252 with the advancing means 254 of the extrusion ram. Preferably, the valve 252 is bypassed by a check valve 256 opening away from the said retracting means.

The valve 246 has therein a valve member 258

which is normally positioned to interrupt communication between the conduit 244 and 250 while providing a restricted communication between the conduits 250 and 248, and movable by fluid pressure on the pilot plunger 260 to interconnect the conduits 244 and 250.

The valves 234 and 252, as best seen in connection with the latter, each comprise an inlet port 262, an outlet port 264, and an exhaust port 266. A valve member 268 is normally urged by a spring 270 to connect the ports 262 and 264 freely. An actuating area 272 is connected by a channel 274 with the discharge port 264 and, in response to a predetermined fluid pressure therein urges the valve member 268 upwardly to interrupt communication between the inlet port 262 and the outlet port 264. Should this pressure be increased the valve member 268 will move still farther to connect the port 264 with the port 266 to permit fluid to be exhausted from the said discharge port.

The effect of the valve is to maintain the discharge pressure substantially constant within very close limits up to the pressure supplied at the inlet port thereof. As in the case of the modification shown in Figure 2, there may be a limit switch LS2 adapted for being engaged by a cam 276 shortly prior to the meeting of the mold halves so that the valve 246 can be actuated to commence the extrusion stroke as soon as possible.

Operation of the embodiment of Figure 3

In the operation of the circuit of Figure 3, the movable valve number 278 of the valve 202 is positioned in its left-hand position as shown by the spring 280 when the discharge pressure of the pump 190 is low. This connects the pump through the conduit 196, the ports 198 and 204 and the conduit 206 with the converter 208 so that fluid at reduced pressure and increased volume is discharged through the conduit 212 and ports 210 and 214 to the conduit 216. The clamping ram may be moved in its clamping direction by shifting the movable valve member of the valve 222 to connect the conduit 220 with the conduit 230. When the clamping ram moves far enough to bring the cam 276 against the switch LS2 the valve member 258 of the valve 246 is actuated leftwardly to interconnect the conduits 244 and 250. This brings about a supply of fluid from the conduit 216 through the valve 252 to the extrusion ram advancing means 254. As the extrusion ram advances, the fluid displaced from the retracting means 240 thereof is passed through the flow restricting means 282 which bypasses the check valve 218. As in the case of the other modifications of this invention, this maintains a relatively high pressure in the portion of the fluid circuit leading to the clamping ram.

After the extrusion cycle is completed, the extrusion ram 242 is retracted by again shifting the valve member 258 to the position shown in the drawings. This permits the throttled discharge from the advancing means 254 and the retracting movement of the extrusion ram takes place by the supply of fluid to the retracting means 240 from the conduit 238.

The clamping ram may be returned by the shifting of the valve 222 to supply actuating fluid to the retracting means 226.

It will be apparent that whenever the discharge pressure of the pump rises to a predetermined value, the pilot plunger 283, which is connected with the discharge side of the pump, will move

the valve member 278 rightwardly against the spring 280 in order to reverse the flow of fluid through the converter 208 whereby a reduced supply of fluid at intensified pressures is passed to the conduit 216.

It will also be apparent that the arrangement of Figure 3 provides for separate and independently adjustable pressures for the clamping and extrusion rams whereby the machine can readily be accommodated to different mold arrangements and different types of molding materials and work cycles.

Arrangement of the modification illustrated in Figure 4

In Figure 4 there is a pump 300 which draws fluid from a reservoir 302 through a conduit 304 and discharges the fluid at increased pressure into a conduit 306. The conduit 306 leads to the inlet port of a valve 308 which includes a first service port connected by a conduit 310 with the advancing means 312 of the mold clamping ram 314, and a second service port which is connected by a conduit 316 with the retracting means 318 of the said clamping ram. The valve also includes an exhaust connection represented by the conduit 320 and a valve member 322 movable to connect the pressure port with either of the service ports while connecting the other with exhaust.

The valve member is normally centered by the springs 324 and when centered provides a bypass directly to exhaust for the pump discharge. Energization of the solenoid S1 moves the valve member to direct actuating fluid to the retracting means 318 and energization of the solenoid S2 moves the valve member to direct actuating fluid to the advancing means 312.

The conduit 306 has a branch 326 extending therefrom which leads to one port of a valve 328 having a valve member 330 movable into a first position by a spring 332 to interconnect the conduit 336 with an exhaust conduit 334, and by the energization of a solenoid S3 to move into position to connect the conduit 326 with the conduit 336. The conduit 336 extends to the advancing means 338 of the extrusion ram 340 and includes a check valve 342 opening toward the said advancing means and a choke valve 344 which bypasses the said check valve.

The retracting means 346 of the extrusion ram is connected by a conduit 348 with one port of a valve 350 which includes a valve member 352 which is normally positioned by a spring 354 to connect the conduit 348 with a conduit 356. A pilot piston 358 is responsive to pressure from the advancing means 338 for moving the valve member into position to connect the conduit 348 with the exhaust conduit 360 which leads directly to the reservoir 302. The conduit 356 is connected with the conduit 326 through a choke valve 362 and a check valve 364 which bypasses the said choke valve and opens toward the valve 350.

Figure 5 illustrates an electrical circuit adapted for controlling the solenoids S1, S2 and S3 of Figure 4. In Figure 5 there are the power lines L1 and L2 and connected therebetween is a contactor coil A which is in series with the normally closed blades T3 of a timer motor T and a normally open push button indicated at 366. Closure of the push button 366 energizes A which brings about the closure of the blades A1 to provide a holding circuit for A, and the closure of the blades A2 to energize the timer motor T. Energization of the timer motor T immediately closes the blades T1 thereof which are connected in

series with the solenoid S2. Energization of S2 brings about the clamping together of the mold halves of the press for a molding cycle.

After a predetermined time, the blades T2 of the timer close and energize the solenoid S3. Energization of the solenoid S3 brings about the advancing movement of the extrusion plunger 340. After a predetermined greater time, the blades T4 open to de-energize the solenoid S3 to bring about the retracting movement of the extrusion plunger. Thereafter, after the material has set within the mold, the blades T1 open and the blades T5 close to energize S1 to bring about a retracting movement of the clamping ram. After the ram has fully retracted, the cam 368 on the platen may strike the limit switch LS3 which brings about the deenergization of A, and therethrough the de-energization of T which clears the entire circuit and de-energizes all of the solenoids. Optionally, the cycle may be halted by the timing out of the timer T whereupon the blades T3 and T6 open in order to clear the circuit.

For actuating the ram 314 independently of the extrusion ram, there may be provided the push buttons 370 and 372, as shown. These may be selectively closed for shifting the valve to reciprocate the ram 314. When the injection ram is to be reciprocated independently of the clamping ram, there is provided the push button 374 and in addition thereto the selector switch 376 which bypasses the push button 370 so that the valve 308 can be shifted away from its bypassing center position in order to provide a supply of pressure fluid for actuating the extrusion ram.

Operation of the embodiment of Figure 4

In operation, the embodiment illustrated in Figure 4 is similar to that of the modification in Figures 1, 2 and 3. The valve member 322 is first shifted to the right to supply pressure fluid to the clamping ram advancing means 312 to move the molds into clamped position. Thereafter, the valve member 330 is moved leftwardly to connect the discharge side of the pump directly with the extrusion ram advancing means 338. This brings about an extrusion stroke and the fluid expelled from the extrusion ram retracting means is passed through the choke valve 362 to augment the supply of actuating fluid for the advancing means 338. When the extrusion ram 340 encounters resistance, the pressure in the advancing means 338 increases and actuates the valve member 352 to connect the retracting means 346 directly with exhaust. This provides for the full thrust of the advancing means to be employed in the extrusion of the molding material.

The extrusion ram is retracted by returning the valve member 330 to its Figure 4 position whereupon the valve member 352 also returns to its Figure 4 position and the retracting means 346 is supplied with pressure while the advancing means is exhausted.

During the retraction of the extrusion ram, the choke valve 344 maintains pressure in the circuit for holding the molds clamped together. After a predetermined dwell, the clamping ram is retracted by shifting the valve member 322 into its left end position, and following the retraction of the clamping ram, the valve member 322 is again moved to its center position.

It will be apparent from the foregoing that the fluid circuits constructed according to this invention provide a means whereby a plurality of rams can be operated according to a predetermined

11

sequence while fluid pressure is maintained at all times for holding any of the rams under pressure while others thereof are cycling. This is accomplished by a single fluid source and with little or no loss of useful power.

It will be evident that this invention is particularly useful in connection with molding machines as illustrated because it utilizes the fluid source to the fullest extent and eliminates the idle bypassing of pressure fluid and the necessity for auxiliary pumps for maintaining the molds clamped under pressure.

It will be understood that this invention is susceptible to modification in order to adapt it to different usages and conditions and, accordingly, it is desired to comprehend such modifications within this invention as may fall within the scope of the appended claims.

I claim:

1. In a fluid operable system; a plurality of independently operable fluid motors at least one of which is double acting; a single fluid source; a valve movable to direct fluid from said source to one of said motors other than said double acting motor; another valve movable for thereafter directing fluid said source to one side of said double acting motor; and means for restricting the discharge from the other side of said double acting motor whereby a predetermined minimum pressure is maintained by said source.

2. In a fluid operable system; a plurality of fluid motors having inlets and outlets; a single fluid source for supplying actuating fluid to said motor means; means of connecting said source with the inlet of one of said motor means for actuating the same; means of thereafter connecting said source with the inlet of another motor means; and means operable to maintain a predetermined pressure at the outlet port of the last mentioned motor for maintaining a predetermined minimum pressure in the system for maintaining the first mentioned motor energized.

3. In a fluid operable system; first and second fluid motors having inlets and outlets; a single fluid source for supplying said motors; means to connect said source with the inlet of one of said motors for energizing the same; means of thereafter connecting said source with the inlet of the other of said motors; and means of restricting the discharge from the said other motor for maintaining a predetermined minimum pressure in the system for maintaining both of said motors energized.

4. In a fluid operable system; first and second motor means; a fluid source; means of connecting said source with the first of said motor means; means responsive to a predetermined pressure acting on said first motor means for connecting said source with said second motor means; means operable automatically for maintaining a predetermined minimum pressure in said system; and means responsive to a predetermined pressure acting on said second motor means for disconnecting it from said source while maintaining the connection between said source and said first motor means.

5. In a fluid operable system; first and second motor means having inlets and outlets; a fluid source; means to connect said source with the inlet of the first of said motors; means responsive to a predetermined pressure thereon for thereafter connecting said source with the inlet of said second motor; means resisting the discharge of fluid from the outlet of said second motor for maintaining a predetermined minimum actuating

12

pressure in said system; and means responsive to a predetermined pressure at the inlet of said second motor for making the said means for resisting ineffective whereby said second motor develops its full operating thrust.

6. In a fluid operable system; first and second motor means having inlets and outlets; a fluid source; valve means movable to connect said source with the inlet of said first motor; means responsive to a predetermined pressure at the inlet of said first motor for connecting said source with the inlet of said second motor; means restricting the discharge of fluid from the outlet of said second motor to maintain a predetermined minimum actuating pressure in the system; and means responsive to a predetermined pressure at the inlet of said second motor for disconnecting the said inlet from said source and for connecting said source instead with the outlet of said second motor.

7. In a fluid operable system; first and second motor means having inlets and outlets; a fluid source; valve means movable to connect said source with the inlet of said first motor; means responsive to a predetermined pressure at the inlet of said first motor for connecting said source with the inlet of said second motor; means restricting the discharge of fluid from the outlet of said second motor to maintain a predetermined minimum actuating pressure in the system; means responsive to a predetermined pressure at the inlet of said second motor for disconnecting the said inlet from said source and for connecting said source instead with the outlet of said second motor; and means restricting the subsequent discharge of fluid from the inlet of said second motor to maintain the actuating pressure in said system.

8. In a fluid operable system; first and second motors having advancing and retracting means; a fluid source continuously connected with the retracting means of said second motor; means to connect said source with the advancing means of said first motor; means responsive to a predetermined pressure acting on the said advancing means for connecting said source with the advancing means of said second motor; means responsive to a predetermined pressure acting on the advancing means of said second motor for disconnecting the retracting means thereof from said source and for connecting it instead with the exhaust; and means responsive to a still higher pressure acting on the advancing means of said second motor for again connecting the retracting means thereof with said source while connecting the said advancing means with exhaust.

9. In a fluid operable system; a fluid motor having advancing means and a smaller retracting means; a fluid source connected with said retracting means; first means responsive to a predetermined discharge pressure of said source for connecting said advancing means with said source; means responsive to a higher pressure acting on said advancing means for disconnecting said retracting means from said source and connecting it with exhaust; and means responsive to a still higher pressure at said source for disconnecting said advancing means therefrom and for connecting the advancing means with exhaust, said means also being operable at the same time to again connect said retracting means with said source.

10. In a molding machine having a mold clamping ram and a material extruding ram; a single fluid source; first valve means movable to con-

13

nect said source with the advancing or the retracting side of said clamping ram; means normally connecting said source with the retracting side of said extrusion ram; means to connect said source with the advancing side of the said extrusion ram; and means responsive to a predetermined pressure developed by said source for disconnecting said extrusion ram retracting means therefrom and for connecting the said means with exhaust whereby the said extrusion ram advances rapidly to working position and thereafter develops full thrust.

11. In a molding machine having a mold clamping ram and a material extruding ram; a single fluid source for actuating said rams; means to connect said source with the advancing or the retracting means of said clamping ram; means normally connecting said source with the retracting means of said extrusion ram for free flow toward the said retracting means and restricted flow therefrom; means responsive to a predetermined pressure developed by said source for connecting the same with the advancing means of said extrusion ram; and means responsive to a predetermined higher pressure developed by said source for disconnecting said retracting means therefrom and for connecting the said means instead with exhaust.

12. In a molding machine having a mold clamping ram and a material extruding ram; a single fluid source for actuating said rams; means to connect said source with the advancing or the retracting means of said clamping ram; means normally connecting said source with the retracting means of said extrusion ram for free flow toward the said retracting means and restricted flow therefrom; means responsive to a predetermined pressure developed by said source for connecting the same with the advancing means of said extrusion ram; means responsive to a predetermined higher pressure developed by said source for disconnecting said retracting means therefrom and for connecting the said means instead with exhaust; and means responsive to a still higher pressure for again connecting said source with said retracting means of said extrusion plunger while connecting the advancing means thereof with exhaust.

13. In a molding machine having a clamping ram and an extrusion ram; a single fluid source for supplying actuating fluid to said rams; means to direct the delivery of said source to the advancing or retracting side of said clamping ram; means normally connecting said source with the retracting side of said extrusion ram; means responsive to a predetermined movement of said clamping ram in the advancing direction for connecting said source with the advancing side of said extrusion ram; and means restricting the discharge of fluid from the retracting side of said extrusion ram for maintaining a predetermined minimum actuating pressure on the advancing sides of both of said rams.

14. In a molding machine; clamping and extrusion rams each having larger advancing areas and smaller retracting areas; a single fluid source for supplying said areas and normally connected with the retracting area of said extrusion ram; valve means selectively operable to connect said source with the advancing or

14

retracting area of said clamping ram; means responsive to a predetermined movement of said clamping ram in the advancing direction for connecting said source with the advancing area of said extrusion ram; means controlling the discharge of fluid from the retracting area of said extrusion ram to maintain a predetermined minimum actuating pressure in the circuit; and means responsive to a predetermined pressure acting on the advancing area of said extrusion ram for disconnecting the retracting area thereof from said source and for connecting it instead with exhaust whereby said extrusion ram advances rapidly and thereafter develops full thrust.

15. In a molding machine; clamping and extrusion rams each having larger advancing areas and smaller retracting areas; a single fluid source for supplying said areas and normally connected with the retracting area of said extrusion ram; valve means selectively operable to connect said source with the advancing or retracting area of said clamping ram; means responsive to a predetermined movement of said clamping ram in the advancing direction for connecting said source with the advancing area of said extrusion ram; means controlling the discharge of fluid from the retracting area of said extrusion ram to maintain a predetermined minimum actuating pressure in the circuit; means responsive to a predetermined pressure acting on the advancing area of said extrusion ram for disconnecting the retracting area thereof from said source and for connecting it instead with exhaust; and means of again connecting said source with the retracting area of said extrusion ram while controllably exhausting the advancing side thereof to retract said extrusion ram while maintaining said clamping ram energized.

16. In a molding machine having a clamping ram and a double acting extrusion ram; a single fluid source for supplying said rams; means of connecting said source with said clamping ram for clamping a mold; means of thereafter connecting said source with the advancing side of said extrusion ram for bringing about an extrusion of material into said mold; a valve between the retracting side of said extrusion ram and exhaust for restricting the discharge of fluid therefrom to maintain a predetermined minimum pressure in the actuating circuit during the advancing movement of said extrusion ram; and a valve between said source and each of said rams operable to maintain independent pressures on said clamping ram and the advancing side of said extrusion ram for controlling the thrusts thereof.

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