

Oct. 28, 1952

R. L. ALCORN, JR

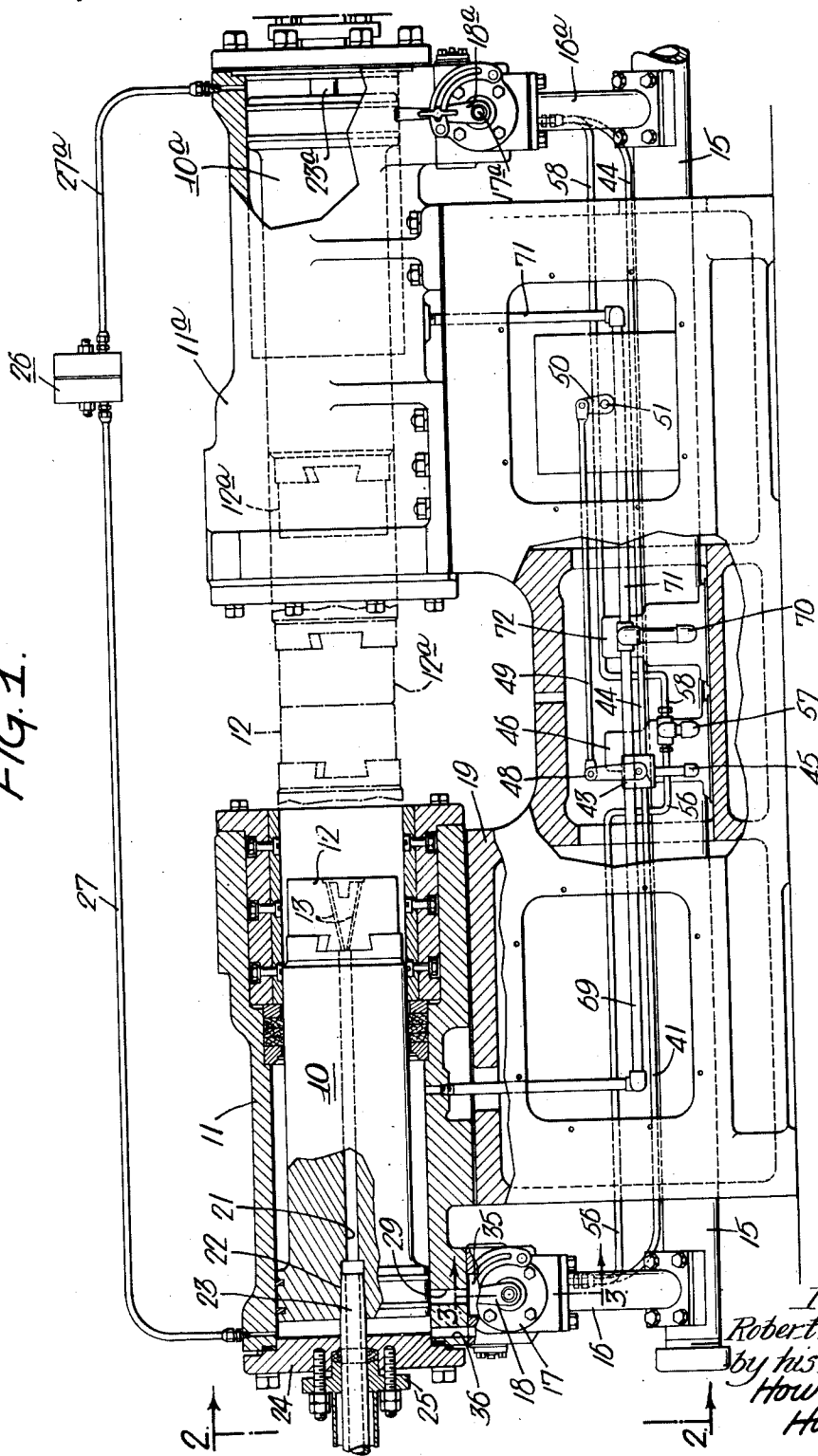
2,615,306

FORGING APPARATUS AND CONTROL THEREOF

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5 Sheets-Sheet 1

FIG. 1.



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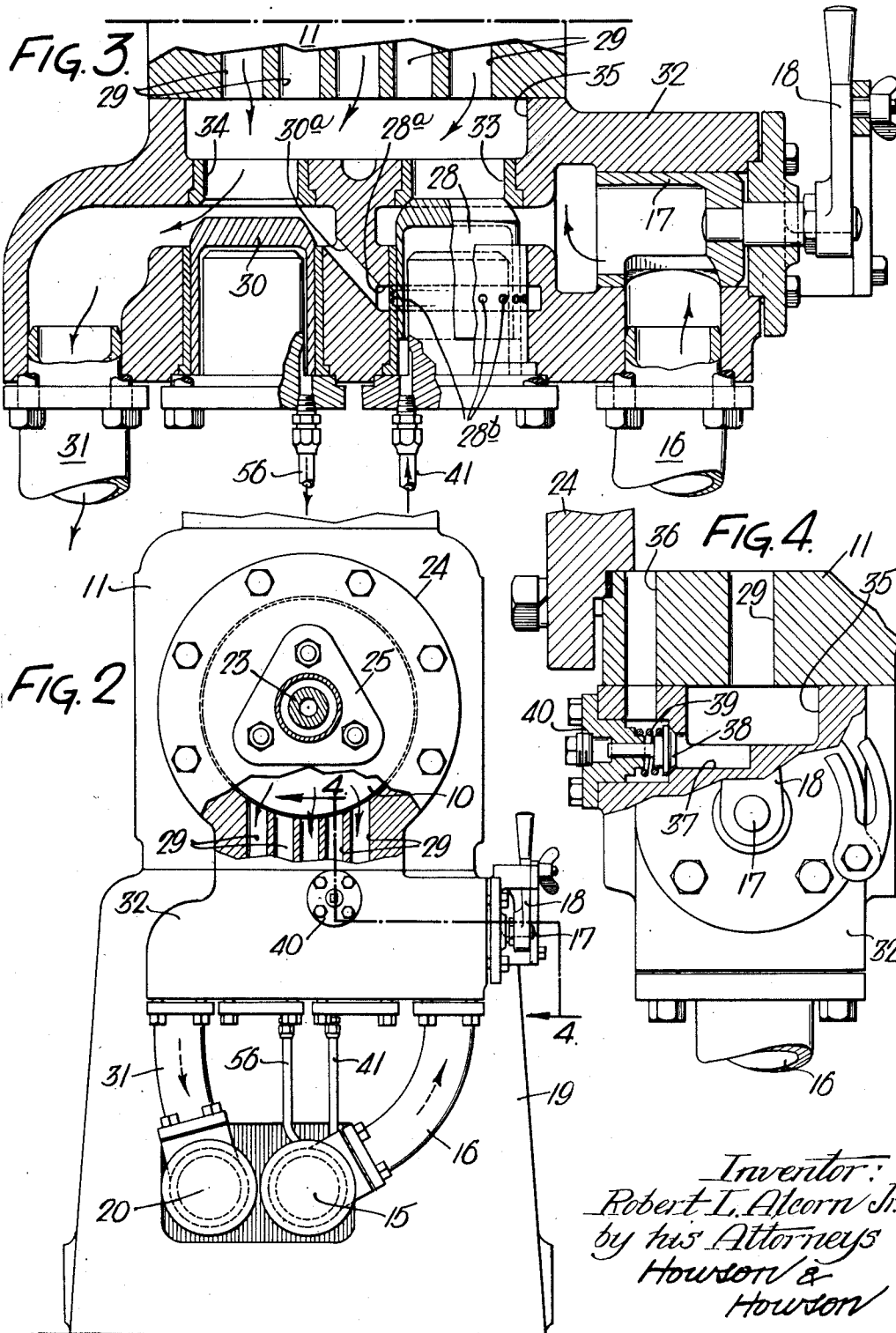
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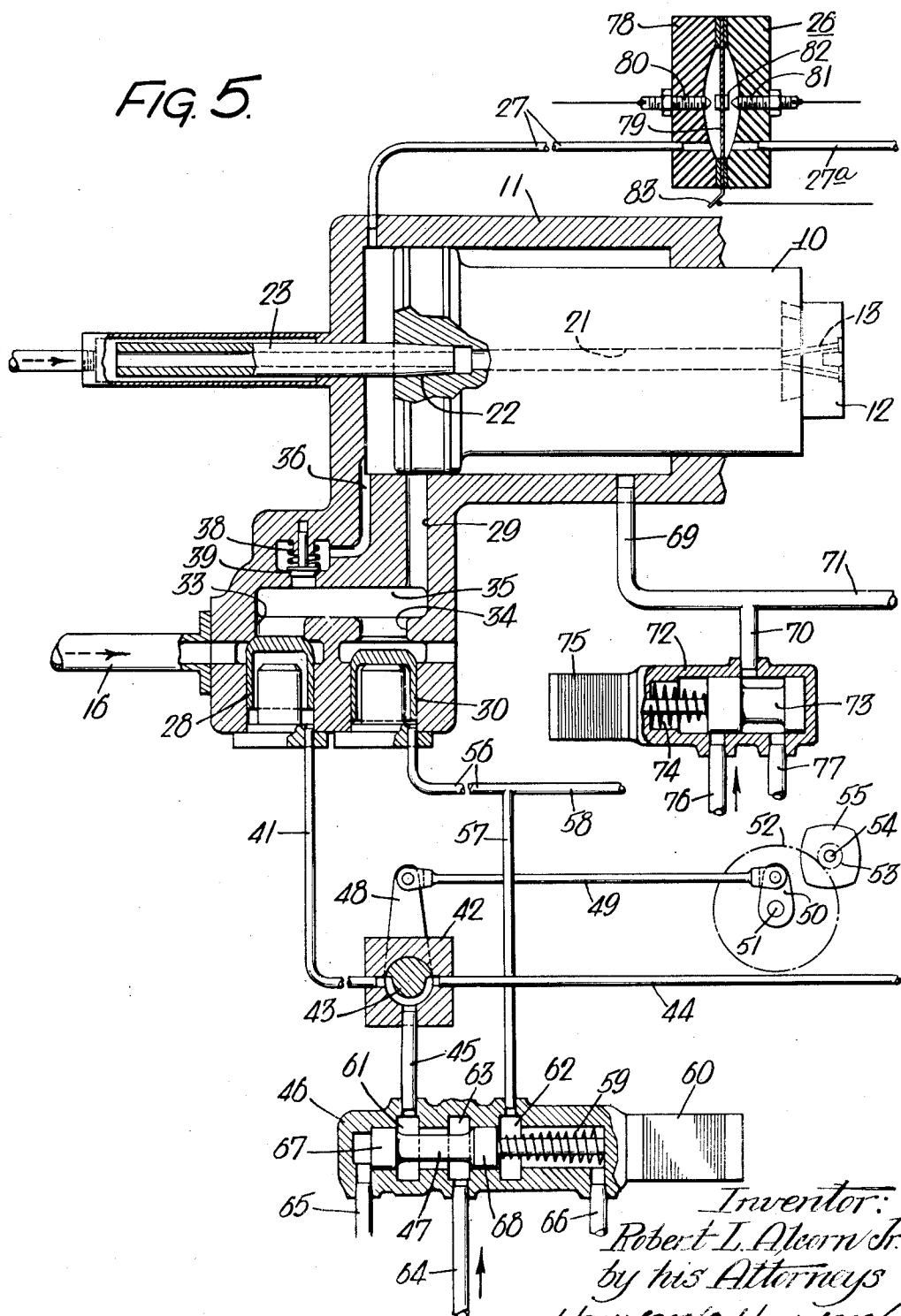
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FORGING APPARATUS AND CONTROL THEREOF

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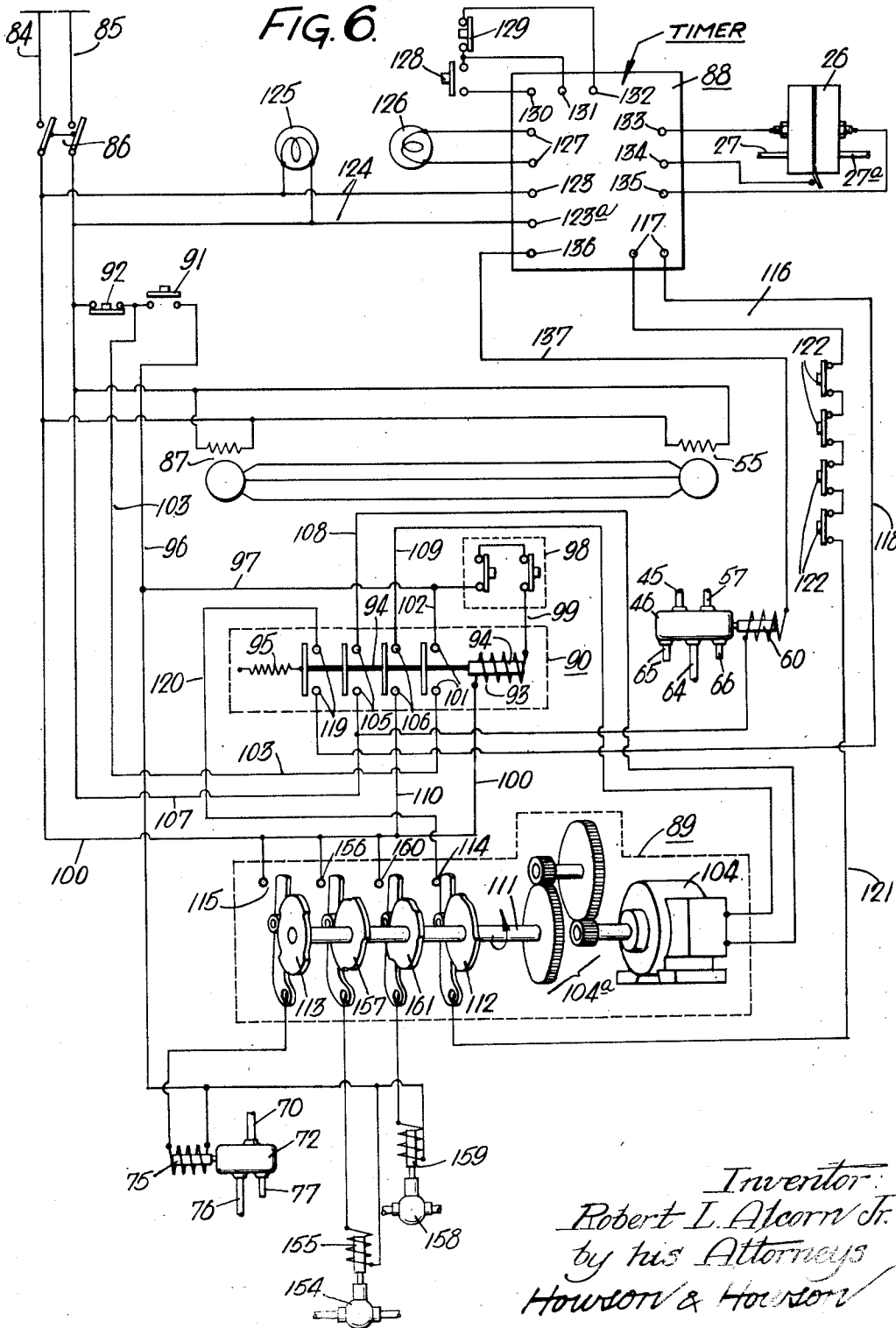
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FORGING APPARATUS AND CONTROL THEREOF

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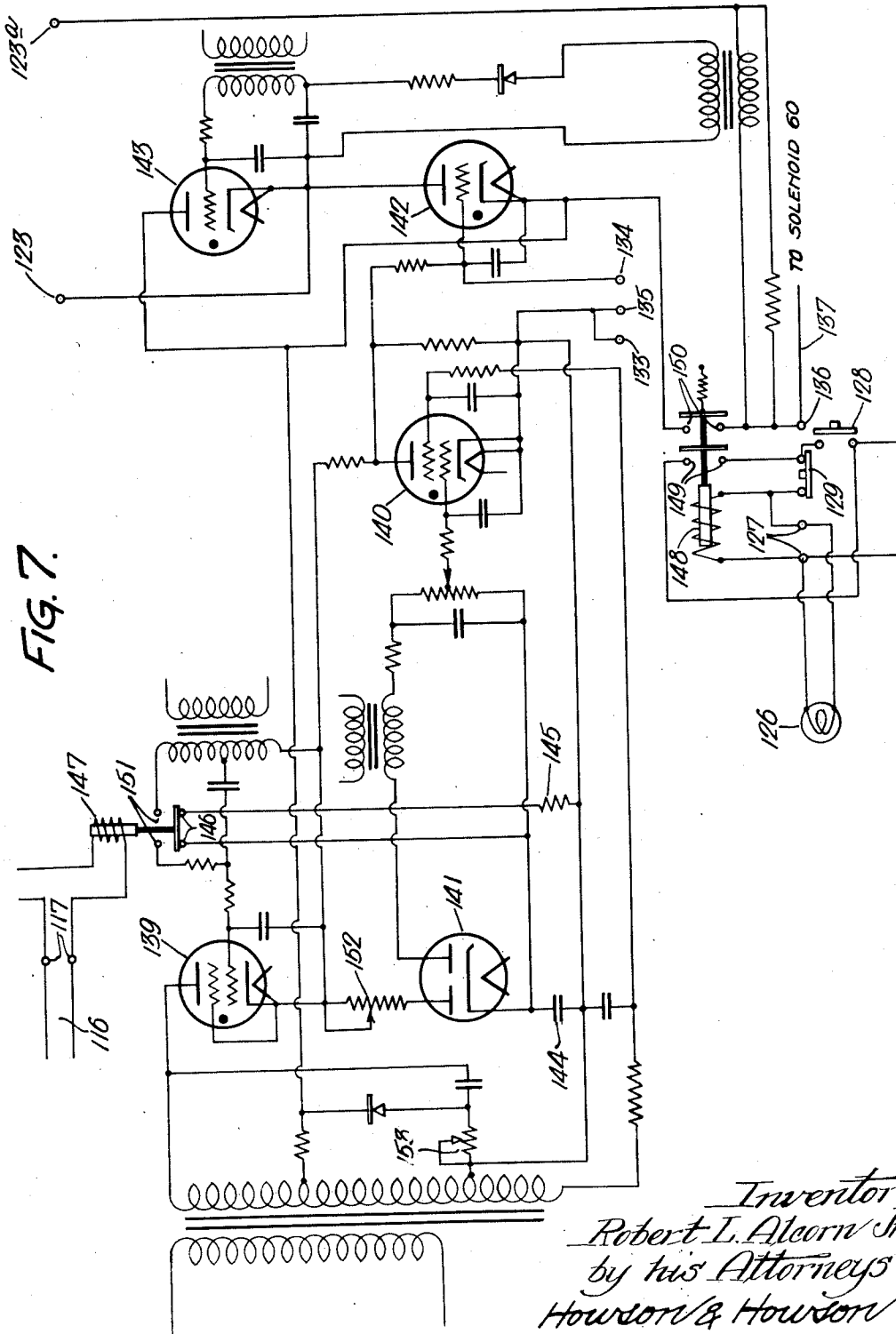
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FORGING APPARATUS AND CONTROL THEREOF

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5 Sheets-Sheet 5

FIG. 7.



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UNITED STATES PATENT OFFICE

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FORGING APPARATUS AND CONTROL THEREOF

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Application July 21, 1949, Serial No. 106,045

16 Claims. (Cl. 60—97)

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This invention relates to forging apparatus and the control thereof, and more particularly to the control of an apparatus of the type wherein two horizontally aligned rams, operated by pressurized fluid, serve to forge by impact work pieces interposed between them.

The principal object of the invention is to provide an improved apparatus for accurately controlling the forging operation.

In an apparatus of this character, precise timing of the forging blow is very important. It is necessary to apply pressurized fluid to the rams during a very short time interval which may be a small fraction of a second. Moreover, it is highly desirable to provide for rapid successive operation of the apparatus in order that work pieces may be forged in rapid succession.

A further object of the present invention is to provide an apparatus which enables such precise timing and rapid cyclic operation. The apparatus is novelly characterized in that it comprises a cycling mechanism and an electronic timer under control of said mechanism.

It is also desirable in such an apparatus to be able to control with great accuracy the intensity of the forging blow, and it is a further object of this invention to provide such control. This is achieved by means of the electronic timer which is adjustable to control the intensity of the forging blow.

Still another object of the invention is to provide means for differentially controlling the supply of pressurized fluid to the rams to establish the exact plane of impact of the rams.

A further object of the invention is to provide means for preventing or interrupting a forging operation in the event that a dangerous unbalance of pressure should develop.

Other objects and features of the invention will be apparent hereinafter.

The invention may be fully understood from the following detailed description with reference to the accompanying drawings, wherein

Fig. 1 is a view, partly in longitudinal section and partly in elevation, of a forging apparatus embodying the present invention;

Fig. 2 is an end elevational view taken along line 2—2 of Fig. 1, with a portion of the apparatus broken away for the sake of illustration;

Fig. 3 is a sectional view taken along line 3—3 of Fig. 1;

Fig. 4 is a sectional view taken along line 4—4 of Fig. 2;

Fig. 5 is a schematic illustration of the controlling arrangement employed in conjunction with the impact rams;

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Fig. 6 is a diagrammatic illustration of the electrical system which serves to control the operation; and

Fig. 7 is a diagrammatic illustration of the electronic timer which is employed in the electrical system.

Referring first to Fig. 1, there are shown two horizontally aligned rams 10 and 10a which are movable within fluid cylinders 11 and 11a, the rams moving toward and away from each other during a complete cycle of operation. Removably attached to the rams are dies 12 and 12a which engage a work piece (not shown) to forge the same.

The rams are actuated during the work stroke by pressurized fluid supplied to the cylinders from a common fluid line 15 through intake conduits 16 and 16a. Preferably, the rams are actuated by means of compressed air, the line 15 being connected to a suitable source of compressed air. The air is supplied to the cylinders through manually-adjustable valves 17 and 17a having adjustable levers 18 and 18a which may be set in any desired position.

As shown in Fig. 1, the ram-containing cylinders are mounted on a supporting framework 19 which may also serve to support certain controlling valves as hereinafter described. The supply conduit 15 extends longitudinally through the supporting framework, as does also a common exhaust conduit 20 (see Fig. 2) through which the air is exhausted from the cylinders during the return stroke.

Referring still to Fig. 1, provision is made for supplying pressurized fluid through an axial passage in each ram to the associated die, the purpose of which is to cool the die block and to facilitate removal of the forged work pieces and also to facilitate scale removal. Since both rams are alike, only the left-hand ram in Fig. 1 is illustrated in detail. An axial passage 21 is provided in the ram, and the pressure end of the ram has a recess 22 to accommodate a fluid supply conduit 23. The conduit 23 is attached firmly to the ram by a tapered fit in recess 22 and reciprocates with ram 10 through packing gland 25 which allows the introduction of fluid through passage 21 without danger of mixing with the main operating fluid. The passage 21 communicates with passages 13 in the die block.

As also shown in Fig. 1, a pressure-responsive device 26 is connected by means of conduits 27 and 27a to the pressure ends of the respective cylinders. The device 26 quickly responds to a difference in pressure between the cylinders and, as hereinafter described, it serves to interrupt

the operation in the event that a pressure unbalance develops in excess of a safe maximum.

Referring now to Figs. 2 to 4, these figures illustrate the controlling valves associated with the ram 10 and its cylinder 11, it being understood that similar valves are provided in association with the ram 10a and its cylinder 11a. A fluid-operable valve 28 controls the air input from conduit 16 to the ports 29 which extend to the interior of the cylinder at the pressure end thereof. A second fluid-operable valve 30 controls the air exhaust to conduit 31 which extends to the exhaust line 20. The valves 28 and 30 are arranged in a common valve casing designated generally by reference character 32 which also contains the manually-operable valve 17. In the illustration of Fig. 3, the valve 28 is closed and the valve 30 is open, this being the condition for exhaust. When the valve 30 is closed and the valve 28 is open, air is admitted to the cylinder from conduit 16 at a rate dependent upon the setting of valve 17.

In order to positively prevent mixture of the valve operating fluid and the main operating fluid, a passage 30a is provided which serves to by-pass leakage of either fluid to the exhaust conduit 31. The passage 30a extends to an annular recess 28a and holes 28b in the guide around valve 28.

As may be seen in Fig. 3, the ports 29 are in communication with the valve ports 33 and 34 through a common chamber or space 35. As shown in Fig. 4, the ports 29 are spaced from the cylinder head 24, and a by-pass port 36 is disposed immediately adjacent the cylinder head 24 and is adapted to be placed in communication with a transverse port 37 leading to the chamber or space 35. A spring-biased check valve 38 normally closes the port 37 under the influence of its spring 39. This valve is supported by a plug 40 bolted to the valve casing. The purpose of the check valve and the by-pass controlled thereby will be explained presently.

Referring generally to Figs. 1 to 5, and particularly to the schematic illustration of Fig. 5, the inlet valve 28 for the ram 10 and its associated cylinder 11 is controlled by pressurized fluid, preferably compressed air, through a conduit 41 extending to casing 42 of a differential controlling valve 43. In like manner, the input valve for the other ram and its associated cylinder is controlled through the fluid conduit 44 which extends from said valve to the other side of the controlling valve 43. The conduits 41 and 44 communicate, through valve casing 42, with a common fluid conduit 45 which extends from the valve casing 42 to the casing 46 of a valve 47. The purpose of the differential controlling valve 43 is to control differentially the supply of fluid to the input valves for the two rams, thereby to control the relative timing of the operation of the input valves and thus establish the exact plane of impact of the rams. The valve 43 has a crank arm 48 which is connected through link 49 to a crank arm 50 on a shaft 51. This shaft is connected through reducing gears 52 and 53 to the shaft 54 of a Selsyn receiver 55. The purpose of this is to provide for remote control of the valve 43 as hereinafter described.

The exhaust valve 30 for the ram 10 and its associated cylinder 11 is controlled through branch 56 of a T conduit 57. The other branch arm 58 of the T conduit extends to the exhaust valve for the other ram and its associated cyl-

inder. The leg of conduit 57 extends to the casing 46 of the valve 47.

The valve 47 is spring biased to the position shown by means of spring 59, and it is actuated against the action of the spring by a solenoid 60. The casing of this valve has spaced annular recesses 61 and 62 to which are respectively connected the conduits 45 and 57. Between these annular recesses is an annular recess 63 to which a compressed air conduit 64 extends. This conduit may be connected to the main air supply conduit 15 hereinbefore mentioned. Exhaust conduits 65 and 66 extends into the ends of valve casing 46, and these conduits may be connected to the main exhaust line 20 hereinbefore mentioned. The valve member 47 has spaced portions 67 and 68 which control the valve ports.

When the solenoid 60 is deenergized as shown, the input valve 28 is in communication with the air supply conduit 64 and the valve is held closed. At the same time, the exhaust valve 30 is in communication with exhaust conduit 66 and that valve is open. When the solenoid 60 is energized, the valve member 47 moves to the right, and the exhaust valve 30 is placed in communication with the air supply conduit 64 and is cut off from the exhaust conduits. At the same time, the input valve 28 is cut off from the air supply conduit 64 and is placed in communication with the exhaust conduit 65. At such time, therefore, the exhaust valve 30 is closed and the input valve 28 is opened.

After the impacting stroke of ram 10, the ram is returned by air pressure supplied to the cylinder 11 through branch 69 of a T conduit 70 whose other branch arm 71 extends to the cylinder of the other ram. The leg of the T conduit 70 extends to the casing 72 of a valve 73 which is biased by spring 74 and is operable by a solenoid 75. An air supply conduit 76 and an exhaust conduit 77 also extend to the valve casing 72. These conduits may be connected respectively to the main air line 15 and the main exhaust line 20 hereinbefore mentioned. Normally, the valve 73 is in the position shown, and the conduit 70 is in communication with the exhaust conduit 77. However, when solenoid 75 is energized, the conduit 70 is placed in communication with the air conduit 76 and is cut off from the exhaust conduit 77. At such time, air is supplied to the cylinder 11 to move the ram 10 back to its initial position.

From the description thus far, it will be seen that the operation of the rams is controlled by means of the solenoids 60 and 75. These solenoids are controlled by the electrical control system presently to be described.

The purpose of the check valve 38 may now be understood. Referring still to Fig. 5, the disposition of the ports 29, with reference to the end of the cylinder 11, provides an air cushioning action when the ram 10 is returned. During the return of the ram, the head thereof closes the ports 29 and air is trapped at the end of the cylinder, providing an air cushion which prevents the ram from striking the cylinder head. This becomes particularly important if the ram should rebound due to the impact.

With the ram stopped in the position shown in Fig. 5, the cylinder is closed against intake of air through the ports 29. However, the check valve 38 and the by-pass 36 permits air to enter the cylinder from the chamber or space 35, and such air moves the ram until the ports 29 are cleared. It should be noted that the check valve

does not interfere with the above-mentioned air cushioning action, since it will not permit air to leave the cylinder by way of the by-pass.

Mention was made above of the unbalanced pressure-responsive device 26, and it may now be noted from Fig. 5 that this device comprises a two-part casing 78 containing a pressure-responsive diaphragm 79 which is subject to the air pressure transmitted through conduits 27 and 27a. The casing carries contacts 80 and 81 whose inner ends are in spaced relation to one another, and the diaphragm carries a contact 82 which is normally out of engagement with the stationary contacts but may engage either of those contacts when there is sufficient unbalance of the pressures in conduits 27 and 27a. The diaphragm 79 is formed of conductive material and it is provided with a terminal 83. The casing parts are formed of insulating material. The screw contacts 80 and 81 and the terminal 83 are connected to the electrical system as hereinafter described.

Referring now to Fig. 6, an A. C. supply line 84, 85, e. g. a 60 cycle supply line, serves as a common source of electrical supply for the various elements through the manual switch 86. It will be recalled that the differential control valve 43, shown in Fig. 5, is actuated by a Selsyn receiver 55. Fig. 6 shows the complete Selsyn system for actuating the valve 43, which system is of conventional form and comprises the receiver 55 and a transmitter 87 connected to each other and to the line conductors 84 and 85. Thus the valve 43 is remotely controllable from the Selsyn transmitter 87.

It will also be recalled that the operation of the rams is controlled by means of the solenoids 60 and 75. The energization of solenoid 60 is effected by means of a timer 88 under control of a motor-driven switch mechanism 89. The energization of solenoid 75 is effected by the switch mechanism 89. The manner in which the two solenoids are controlled will be described presently.

The electrical control system is conditioned for operation, after closure of switch 86, by a contactor 90 which is under control of start and stop switches 91 and 92. The contactor 90 comprises a solenoid 93, an armature 94, and a biasing spring 95 which tends to maintain the armature in the position shown. When the start switch 91 is momentarily closed, the solenoid 93 is energized through a circuit which includes conductor 96, conductor 97, the closed contacts of a safety device 98, conductor 99 and conductor 100. The contactor locks itself in through contacts 101 which close a branch circuit in shunt with the start switch 91 and including conductors 102 and 103.

Energization of the contactor closes an energizing circuit for the motor 104 of the device 89 through closure of contacts 105 and 106. This circuit includes conductors 107, 108, 109, and 110. The motor 104 drives, through reduction gearing 104a, a shaft 111 on which are mounted cams 112 and 113. These cams actuate switches 114 and 115, respectively, in sequential and timed relation. The movable arms of the switches are biased toward the cams, as by means of springs (not shown).

The operation of timer 88 is initiated through an initiating circuit 116 connected to terminals 117 of the timer. The initiating circuit extends by way of conductor 118 through contacts 119 of the contactor 90, through conductor 120 to

switch 114, and back to the timer by way of conductor 121. A number of safety switches 122 are shown serially included in the initiating circuit, to which reference will be made later. Switch 115 of device 89 is included in an energizing circuit for solenoid 75, which circuit is in shunt with the solenoid 93 of contactor 90.

The impulse timer 88 has energy input terminals 123 and 123a which are connected to supply line 84, 85 via conductors 124. A lamp 125 is connected across the latter conductors to indicate closure of switch 86. This lamp preferably gives off green light. A second lamp 126, which preferably gives off red light, is connected to terminals 127 of the timer, this lamp indicating that the timer is conditioned for operation. Start and stop switches 128 and 129 are connected to terminals 130, 131 and 132 of the timer in the manner shown and serve to control the conditioning of the timer for operation as hereinafter described.

The pressure-responsive device 26, hereinbefore described, is connected to terminals 133, 134 and 135 of the impulse timer.

The impact-controlling solenoid 60 is connected between terminal 136 on the impulse timer and one of the supply line conductors through connections 137 and 138.

The impulse timer 88 functions to supply an impulse of accurately timed short duration to the solenoid 60. While this timer may be of any suitable type, a preferred form thereof is shown in Fig. 7. The impulse timer shown is a modified Westinghouse type SP-19 timer which provides a precisely timed output impulse. So far as its general structure and operation are concerned, this timer is a known device and it need only be described here sufficiently to enable a complete understanding of the present invention.

As may be seen in Fig. 7, the timer comprises a start tube 139, a stop tube 140, a bias-providing tube 141 and a pair of controlled power tubes 142 and 143. All of the tubes are thyratrons with the exception of tube 141 which is a double diode rectifier. The tubes 142 and 143 constitute a lead and follow combination, tube 142 being the lead tube and tube 143 being the follow tube. Condenser 144 is a timing condenser, the charging of which determines the time duration of the output impulse.

Relays 147 and 148 are provided to control the timer as hereinafter described. These relays and the several transformers shown with their primary windings unconnected are energized from the power supply line by way of terminals 123 and 123a. The connections are omitted for simplicity of illustration.

In the inoperative state of the timer, all of the thyratrons are non-conducting due to the potentials applied to their control grids. The condenser 144 is fully discharged through a resistor 145 which is connected across the condenser through normally closed contacts 146 of a relay 147.

As hereinbefore mentioned, the timer is conditioned for operation by closing the start switch 128 which energizes relay 148. This relay locks itself in through contacts 149. Its contacts 150 are included in the output circuit of the timer, but the solenoid 60 remains deenergized because of the non-conductive condition of the tubes 142 and 143. The lamp 126 indicates that the relay 148 has been energized and that the timer is in condition for operation.

When the initiating circuit 116 (see Fig. 6) is

closed by closure of switch 114, relay 147 is energized. This relay opens the discharge circuit for condenser 144, and its contacts 151 close and cause a variation of the potential on the control grid of tube 139, thus causing that tube to fire. Conduction of tube 139 initiates charging of condenser 144 through one side of the rectifier tube 141, and it also causes tube 142 to fire. The latter in turn furnishes a firing impulse for tube 143. When tubes 142 and 143 become conductive, the output circuit is closed and furnishes current to the solenoid 60. In the meantime, tube 140 has remained non-conductive by virtue of the D. C. bias on its control grid.

When the voltage on condenser 144 rises to a value approximately equal to the D. C. bias on tube 140, this tube fires and renders tubes 142 and 143 non-conductive. At this time, the solenoid 60 is deenergized. When the switch 114 opens, relay 147 is deenergized and the timer is restored to its inoperative condition and is ready for the next operation when switch 114 closes.

The charging rate of condenser 144 is controllable by means of potentiometer 152. Since the rate of charge of the condenser determines the time during which operating fluid is supplied to the rams, the adjustment of the potentiometer 152 sets the intensity of the forging blow with great accuracy.

A second potentiometer 153 constitutes a power factor adjustment, the purpose of which will be described later.

It should now be noted that the pressure unbalance responsive device 26 will interrupt the operation of the timer if contact is made in said device due to an undesirable unbalance of the pressures in the ram cylinders. Upon such contact being made, the grid of tube 142 is driven to a potential considerably negative with respect to its cathode, and current flow to the solenoid 60 is cut off in less than the time of one cycle of the A. C. supply current. This prevents the completion of the forging blow in the event that seriously unbalanced pressures are driving the rams.

Considering the operation of the apparatus as a whole, and referring particularly to Fig. 6, the operator first closes the line switch 85 and then presses the push button start switch 91, whereupon the contactor 90 is energized and locks itself in as hereinbefore described. The contactor 90 remains energized until such time as the operator presses the push button stop switch 92 which is connected in the holding circuit of contactor 90. The energization of contactor 90 starts the motor 104 which runs continuously until the contactor is deenergized. Consequently, the switches 114 and 115 are cyclically operated by their motor driven cams 112 and 113. The cam 112 is so designed that the switch 114 is held closed during a time interval within which the timer 88 may effect timed energization of the solenoid 60 as hereinbefore described. The cam 113 is so designed that it closes switch 115 after switch 114 has opened.

With the apparatus conditioned for operation by energization of contactor 90, the operator may start the operation at any time by pushing the push button start switch 128 for the timer 88. This causes energization of relay 148 (see Fig. 7) which locks itself in. The timer will then operate cyclically under control of switch 114 until such time as the operator pushes the push button stop switch 129.

During each cycle of operation, the switch 114

starts the timer 88 and the latter effects energization of solenoid 60 during an accurately timed interval, as hereinbefore described. The energization of solenoid 60 causes operation of the rams through their work stroke to forge the work piece by impact. After the timed energization of solenoid 60, the solenoid 75 is energized by closure of switch 115, and the rams are returned preparatory to the next work stroke. This cycle of operation is repeated automatically until such time as the operator presses the push button stop switches 129 and 92. In the illustrated embodiment, a cycle of operation takes place during one-half revolution of the shaft 111, and the cams are designed accordingly.

It will be apparent that the work pieces must be fed to the impacter apparatus and this may be done automatically by the provision of suitable automatic feeding means. Since the present invention is not concerned with the feed mechanism, it suffices to note that such mechanism could be pneumatically operated and could be controlled by a valve 154 (see Fig. 6) operable by a solenoid 155 under control of a switch 156 which may be cyclically operated by a cam 157 on the motor driven shaft of the switch mechanism 89.

The cycling switch mechanism 89 may also be used to control other functions. For example, a valve 158, operated by solenoid 159, may control the air supply to the axial passages of the rams, and the solenoid may be controlled by a switch 160 and an actuating cam 161 on the switch mechanism 89.

Referring still to Fig. 6, mention was made above of the safety device 98 and the safety switches 122. These are desirable optional devices. The device 98 prevents or interrupts energization of contactor 90 in the event that the pressure of the operating fluid rises above a predetermined maximum or falls below a predetermined minimum. This device may comprise two switches as indicated arranged for response to pressure of the fluid. The safety switches 122 may be controlled by various conditions so as to prevent operation of the timer 88 in the event that some undesired condition exists. For example, one of these switches may be arranged so as to be closed only if the work pieces are properly positioned. Another of these switches may be responsive to temperature produced by the means for heating the work pieces prior to forging. Still another of these switches may be arranged so as to open if certain guards for the operator's safety are removed. As many of these switches may be provided as are necessary to assure proper and safe operation.

The complete apparatus and its operation having now been described, it is deemed desirable to recapitulate and emphasize the salient features and advantages.

The predominant feature of the apparatus is the control of the forging operation by the electronic timer and the cyclic operation of the timer by the cycling switch mechanism. Such control of the forging operation provides a number of important advantages as set forth below.

The electronic timer provides an extremely short timing interval which may be as short as the time required for two cycles of the 60-cycle current. Furthermore, the electronic timer makes it possible to adjust the occurrence of the timing interval according to the natural power factor of the solenoid 60. Due to the inductive nature of the solenoid, the duration of its energization

is affected by the point on the voltage wave at which the circuit is made and broken with respect to the current. It will be understood, of course, that the voltage and current waves do not coincide but are displaced according to the power factor of the solenoid. The potentiometer 153 (Fig. 7) enables adjustment of lag of the application of voltage to suit the power factor of the solenoid.

A further advantage of the system is that the intensity of the forging blow can be set with great accuracy by adjustment of potentiometer 152. A light blow may be struck by setting the potentiometer so that the charging of condenser 144 occupies the time of three cycles; or a heavy blow may be struck by a setting such that the charging of the condenser occupies the time of eight cycles. This enables pre-selection of the blow without disturbing the air supply pressure.

A further advantage of the system is that the operation of the timer is interrupted by unbalanced pressures through the medium of the pressure responsive device 26.

Another feature of the apparatus is the differential control of the input valves for the rams to establish the exact plane of impact.

It will be apparent from the foregoing description that the invention provides a novel apparatus which embodies various desirable features and which has important advantages. While a particular embodiment of the apparatus has been illustrated and described, it is to be understood that the invention is not limited thereto but is capable of various modifications and further embodiments.

I claim:

1. In an apparatus of the class described, fluid-operated means, means for supplying pressurized fluid to said first means, means including a valve for controlling the supply of fluid to said first means, a solenoid for actuating said valve, a source of electric current, cyclically-operable timing means for supplying current from said source to said solenoid during an accurately timed interval, and power-driven cycling switch means for controlling the operation of said timing means.

2. In an apparatus of the class described, a pair of horizontally opposed pistons, a pair of fluid cylinders for the respective pistons, means for supplying pressurized fluid to said cylinders so as to drive said pistons toward each other, means including a valve for controlling the supply of fluid to said cylinders, a solenoid for actuating said valve, means including a second control valve for supplying pressurized fluid to said cylinders so as to return said pistons, a second solenoid for actuating said second valve, energizing circuits for said solenoids, cyclically-operable timing means for effecting energization of said first solenoid during an accurately timed interval, and power-driven cycling switch means for initiating operation of said timing means and for controlling the energization of said second solenoid.

3. In an apparatus of the class described, a pair of horizontally opposed pistons, a pair of fluid cylinders for the respective pistons, input and exhaust valves operatively connected to one end of each cylinder, fluid supply and exhaust means under control of said valves, means including a solenoid for actuating said valves, means including another valve and an operating solenoid therefor for supplying pressurized fluid to said cylinders at the other end thereof so as to

return the pistons, energizing circuits for said solenoids, cyclically-operable timing means for effecting energization of said first solenoid during an accurately timed interval, and power-driven cycling switch means for initiating operation of said timing means and for controlling the energization of said second solenoid.

4. In an apparatus of the class described, a pair of horizontally opposed pistons, a pair of fluid cylinders for the respective pistons, means for supplying pressurized fluid to said cylinders so as to drive said pistons toward each other, means including a valve for controlling the supply of fluid to said cylinders, a solenoid for actuating said valve, means including a second control valve for supplying pressurized fluid to said cylinders so as to return said pistons, a second solenoid for actuating said second valve, energizing circuits for said solenoids, cyclically-operable timing means for effecting energization of said first solenoid during an accurately timed interval, means for adjusting said timing means to set precisely the desired timed interval, and power-driven cycling switch means for initiating operation of said timing means and for controlling the energization of said second solenoid.

5. In an apparatus of the class described, a pair of horizontally opposed pistons, a pair of fluid cylinders for the respective pistons, input and exhaust valves operatively connected to one end of each cylinder, fluid supply and exhaust means under control of said valves, means including a solenoid for actuating said valves, means including another valve and an operating solenoid therefor for supplying pressurized fluid to said cylinders at the other end thereof so as to return the pistons, energizing circuits for said solenoids, cyclically-operable timing means for effecting energization of said first solenoid during an accurately timed interval, means for adjusting said timing means to set precisely the desired timed interval, and power-driven cycling switch means for initiating operation of said timing means and for controlling the energization of said second solenoid.

6. In an apparatus of the class described, a pair of fluid cylinders, means for supplying pressurized fluid to said cylinders, means for detecting an unbalanced pressure rise in said cylinders, and means responsive to detection of such condition for interrupting the supply of fluid to said cylinders.

7. In an apparatus of the class described, a pair of horizontally opposed pistons, a pair of fluid cylinders for the respective pistons, means for supplying pressurized fluid to said cylinders, means for detecting an unbalanced pressure rise in said cylinders, and means responsive to detection of such condition for interrupting the supply of fluid to said cylinders.

8. In an apparatus of the class described, a pair of opposed pistons, a pair of fluid cylinders for the respective pistons, means for supplying pressurized fluid to said cylinders, means including a valve for controlling the supply of fluid to said cylinders, a solenoid for actuating said valve, a source of electric current, timing means for supplying current from said source to said solenoid during an accurately timed interval, and means responsive to an unbalanced pressure rise in said cylinders for interrupting the operation of said timing means so as to interrupt the current flow to said solenoid.

9. In an apparatus of the class described, a pair of horizontally opposed pistons, a pair of

fluid cylinders for the respective pistons, means for supplying pressurized fluid to said cylinders so as to drive said pistons toward each other, means including a valve for controlling the supply of fluid to said cylinders, a solenoid for actuating said valve, means including a second control valve for supplying pressurized fluid to said cylinders so as to return said piston, a second solenoid for actuating said second valve, energizing circuits for said solenoids, cyclically-operable timing means for effecting energization of said first solenoid during an accurately timed interval, power-driven cycling switch means for initiating operation of said timing means and for controlling the energization of said second solenoid, and means responsive to an unbalanced pressure rise in said cylinders for interrupting the operation of said timing means so as to interrupt the energization of said first solenoid.

10. In an apparatus of the class described, a pair of horizontally opposed pistons, a pair of fluid cylinders for the respective pistons, input and exhaust valves operatively connected to each cylinder, fluid supply and exhaust means under control of said valves, means including a solenoid for actuating said valves, means including another valve and an operating solenoid therefor for supplying pressurized fluid to said cylinders so as to return the pistons, energizing circuits for said solenoids, cyclically operable timing means for effecting energization of said first solenoid during an accurately timed interval, power-driven cycling switch means for initiating operation of said timing means and for controlling the energization of said second solenoid, and means responsive to an unbalanced pressure rise in said cylinders for interrupting the operation of said timing means so as to interrupt the energization of said first solenoid.

11. In combination, fluid pressure-actuated means operable through a work stroke and a return stroke, means for supplying pressurized fluid to said first-mentioned means so as to operate the same through the work stroke, means including a first valve for controlling the supply of fluid to said first-mentioned means, a first solenoid for actuating said valve, means including a second control valve for supplying pressurized fluid to said first-mentioned means so as to operate the same through the return stroke, a second solenoid for actuating said second valve, a pair of cyclically-operable switches, actuating means for said switches, cyclically-operable timing means under control of one of said switches and adapted to operate through a timing cycle each time the switch closes, an energizing circuit for said first solenoid controlled by said timing means, and an energizing circuit for said second solenoid controlled by the other of said switches.

12. In combination, fluid pressure-actuated means operable through a work stroke and a return stroke, means for supplying pressurized fluid to said first-mentioned means so as to operate the same through the work stroke, means including a first valve for controlling the supply of fluid to said first-mentioned means, a first solenoid for actuating said valve, means including a second control valve for supplying pressurized fluid to said first-mentioned means so as to operate the same through the return stroke, a second solenoid for actuating said second valve, a pair of cam-actuated cyclically-operable switches, an electric motor arranged to drive the actuating cams of

said switches, cyclically-operable timing means under control of one of said switches and adapted to operate through a timing cycle each time the switch closes, an energizing circuit for said first solenoid controlled by said timing means, and an energizing circuit for said second solenoid controlled by the other of said switches.

13. In an apparatus of the class described, a pair of opposed pistons, a pair of fluid cylinders for the respective pistons, means for supplying pressurized fluid to said cylinders so as to drive said pistons toward each other, means including a first valve for controlling the supply of fluid to said cylinders, a first solenoid for actuating said valve, means including a second control valve for supplying pressurized fluid to said cylinders so as to return said pistons, a second solenoid for actuating said second valve, a pair of cyclically-operable switches, actuating means for said switches, cyclically-operable timing means under control of one of said switches and adapted to operate through a timing cycle each time the switch closes, an energizing circuit for said first solenoid controlled by said timing means, and an energizing circuit for said second solenoid controlled by the other of said switches.

14. In an apparatus of the class described, a pair of opposed pistons, a pair of fluid cylinders for the respective pistons, means for supplying pressurized fluid to said cylinders so as to drive said pistons toward each other, means including a first valve for controlling the supply of fluid to said cylinders, a first solenoid for actuating said valve, means including a second control valve for supplying pressurized fluid to said cylinders so as to return said pistons, a second solenoid for actuating said second valve, a pair of cam-actuated cyclically-operable switches, an electric motor arranged to drive the actuating cams of said switches, cyclically-operable timing means under control of one of said switches and adapted to operate through a timing cycle each time the switch closes, an energizing circuit for said first solenoid controlled by said timing means, and an energizing circuit for said second solenoid controlled by the other of said switches.

15. Apparatus according to claim 13, including means for differentially controlling the fluid supplied to said cylinders through said first valve.

16. Apparatus according to claim 13, including means for detecting an unbalanced pressure rise in said cylinders, and means responsive to detection of such condition for interrupting the supply of fluid to said cylinders.

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REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
232,792	Whitcomb	Sept. 28, 1880
776,159	Whiteside	Nov. 29, 1904
1,012,334	Davis	Dec. 19, 1911
1,375,562	Cartzdafner	Apr. 19, 1921
1,785,998	Brooke	Dec. 23, 1930
1,985,589	Meer	Dec. 25, 1934
1,999,834	Ernst	Apr. 30, 1935
2,019,766	Peterson	Nov. 5, 1935
2,354,860	Hartsock	Aug. 1, 1944
2,443,964	Sanders	June 22, 1948
2,467,576	Zimmermann	Apr. 19, 1949