Nov. 5, 1946. R. TYLER 2,410,694

MULTIPLE TABLE DRIVE

Filed July 30, 1942 7 Sheets-Sheet 1

Fig. 1.

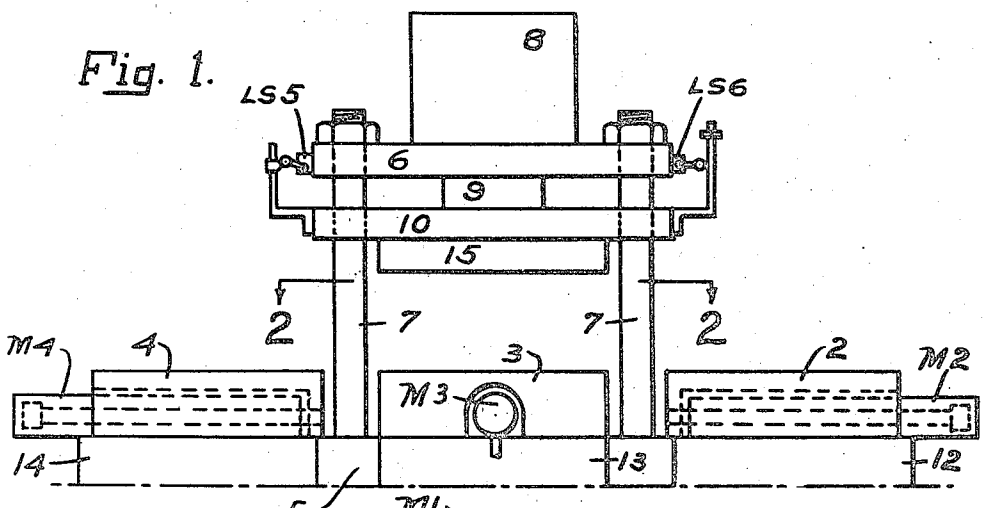
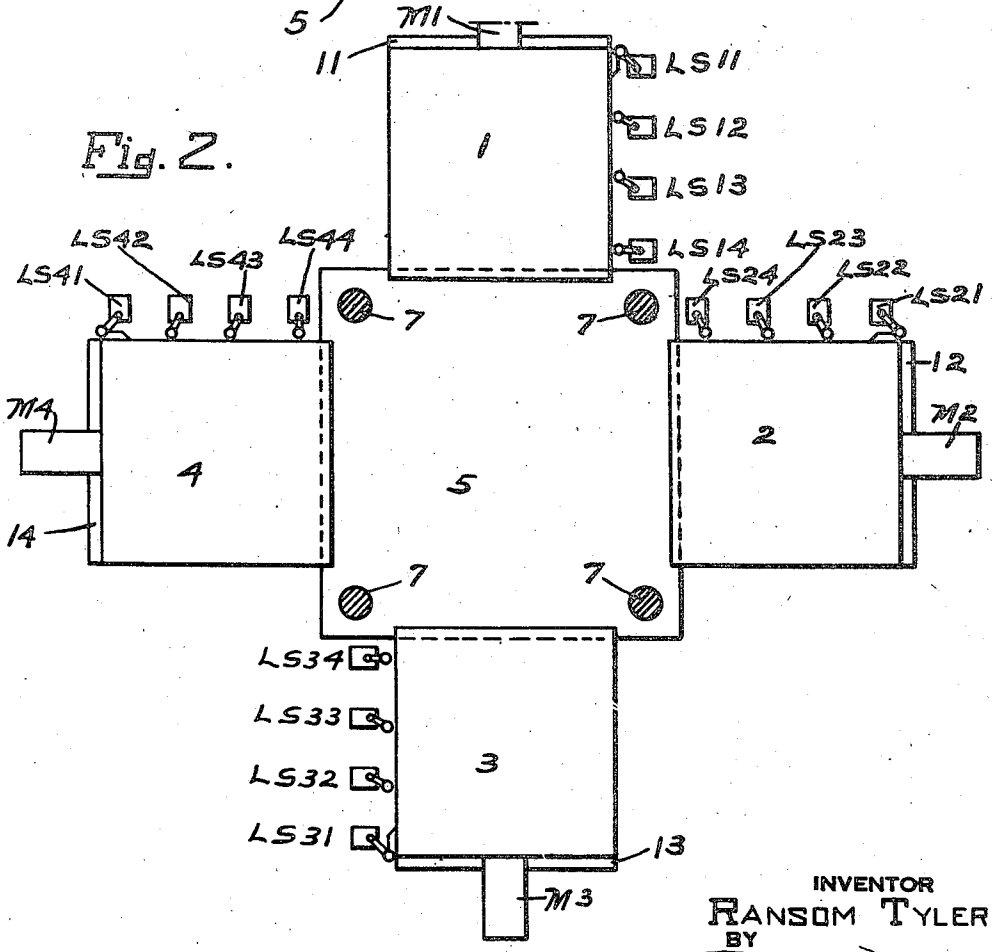


Fig. 2.



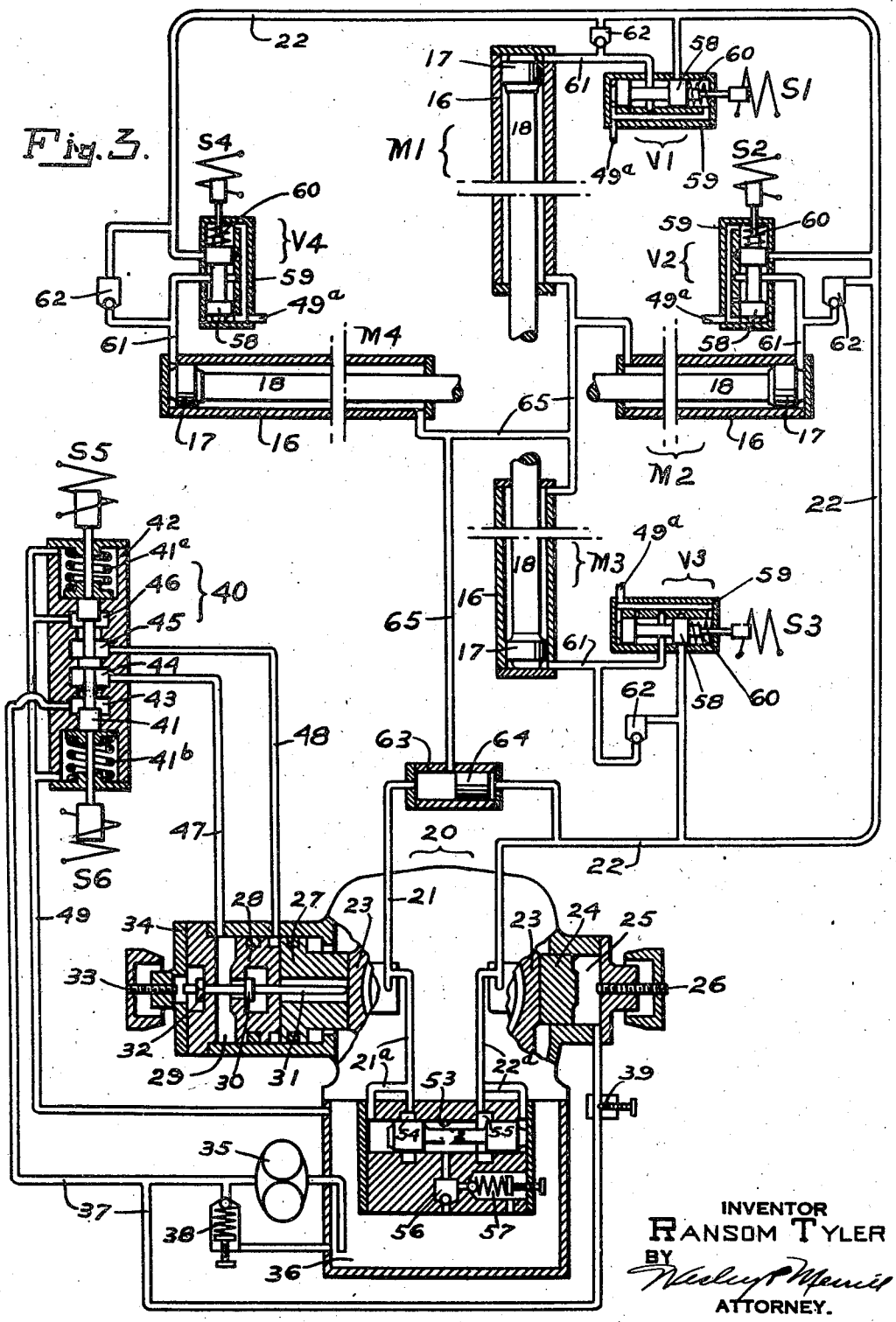
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Nov. 5, 1946. R. TYLER 2,410,694

MULTIPLE TABLE DRIVE

Filed July 30, 1942 7 Sheets-Sheet 2

Fig. 3.

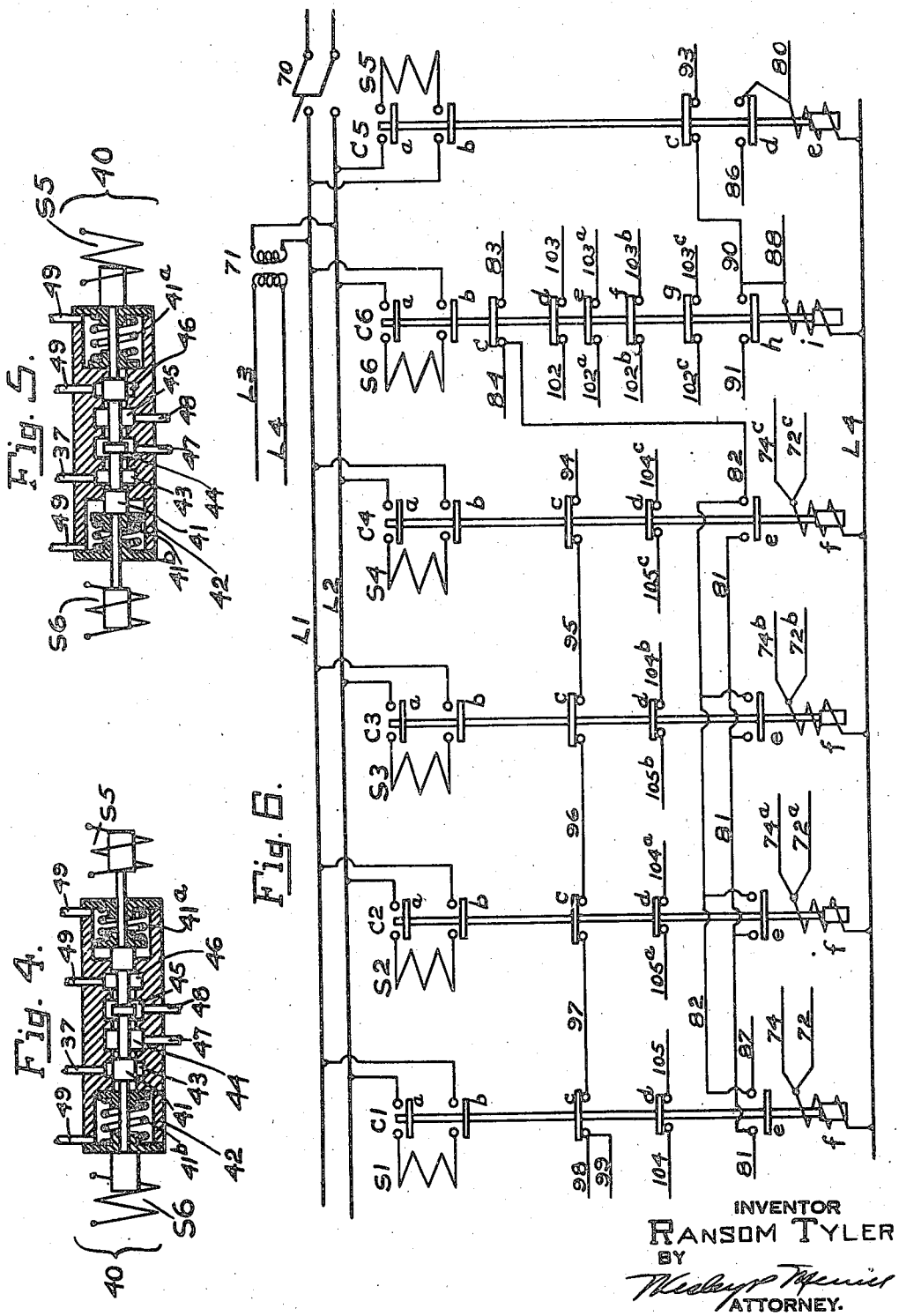


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MULTIPLE TABLE DRIVE

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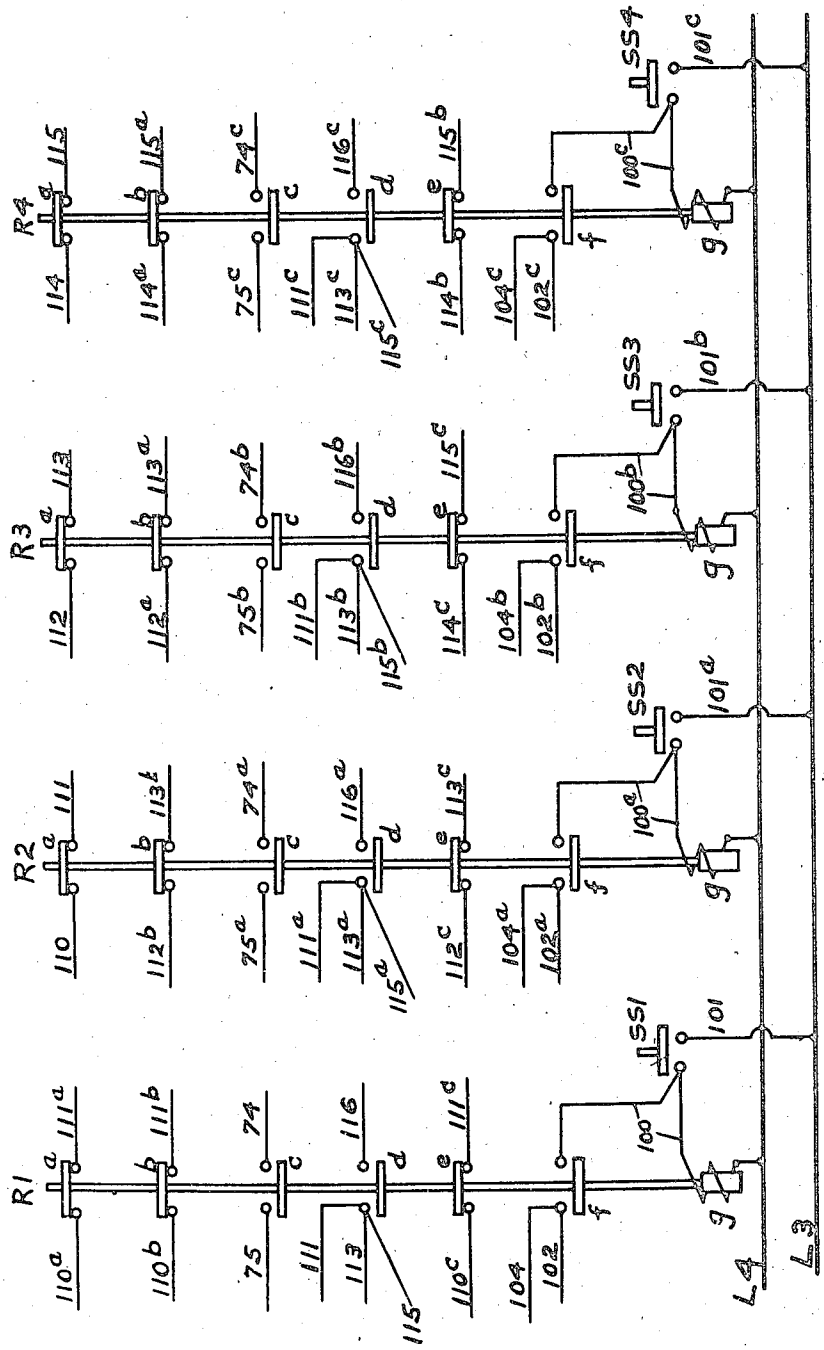


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MULTIPLE TABLE DRIVE

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Fig. 7.



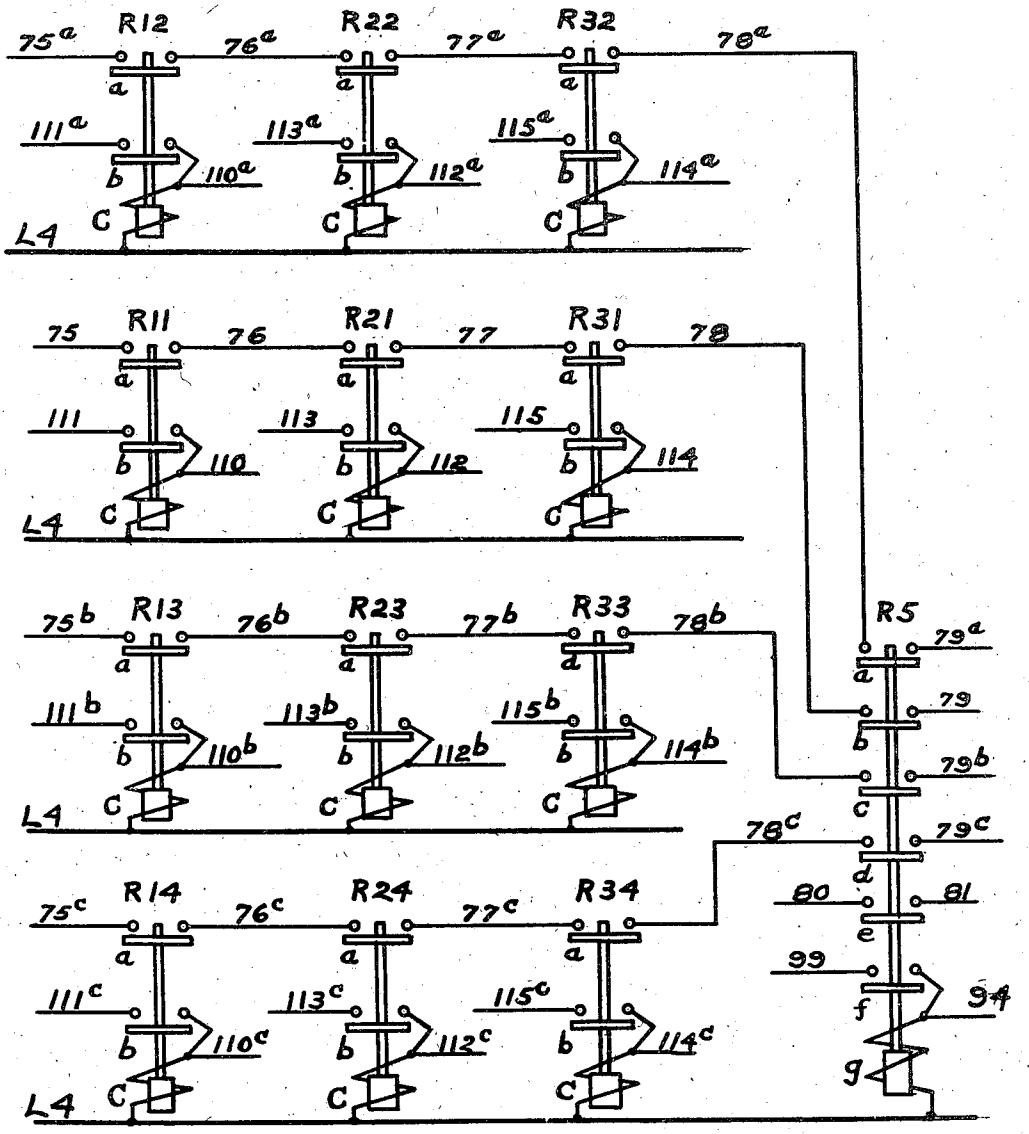
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Nov. 5, 1946. R. TYLER 2,410,694

MULTIPLE TABLE DRIVE

Filed July 30, 1942 7 Sheets-Sheet 5

Fig. 8.

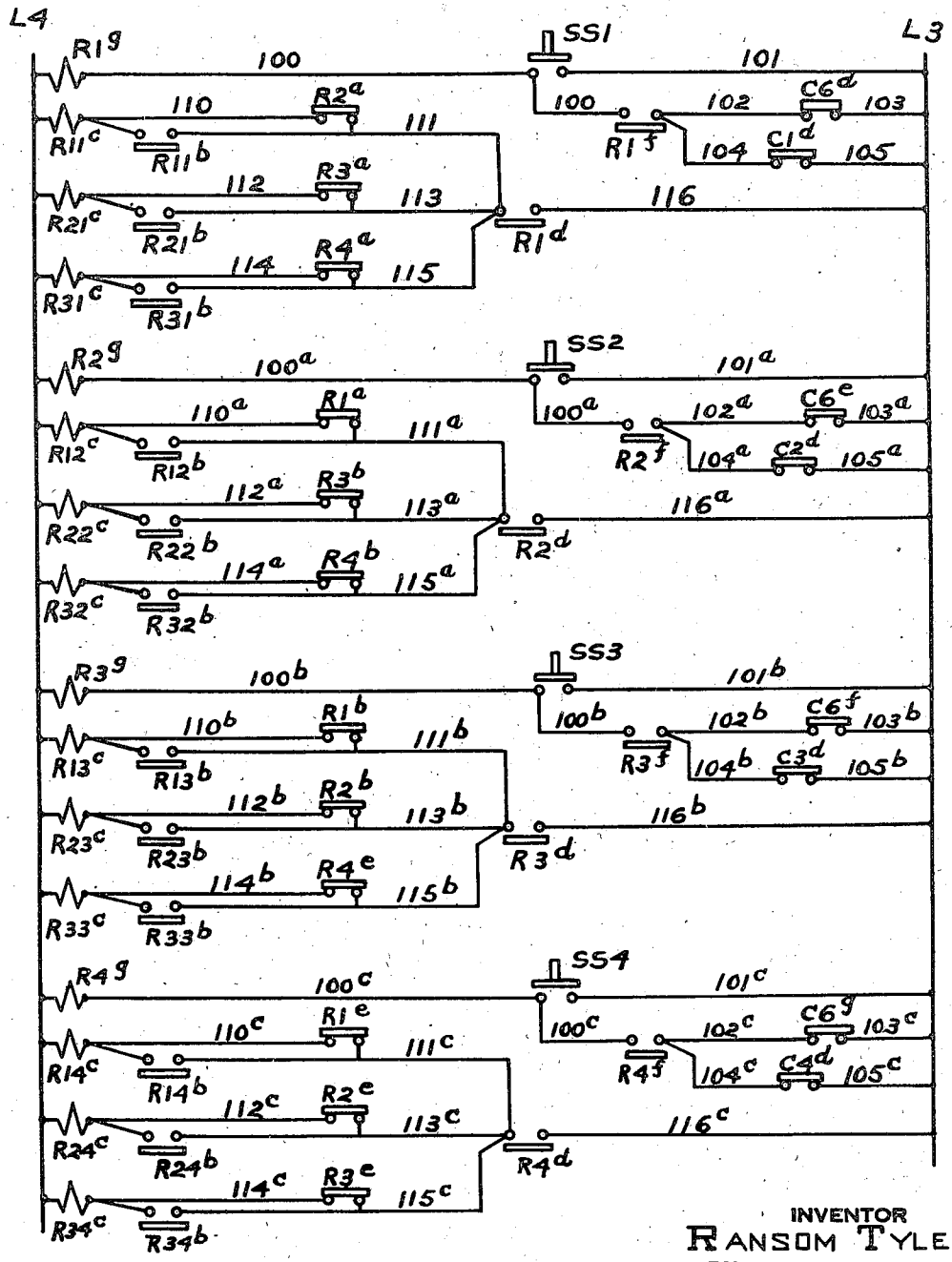


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MULTIPLE TABLE DRIVE

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Fig. 9.



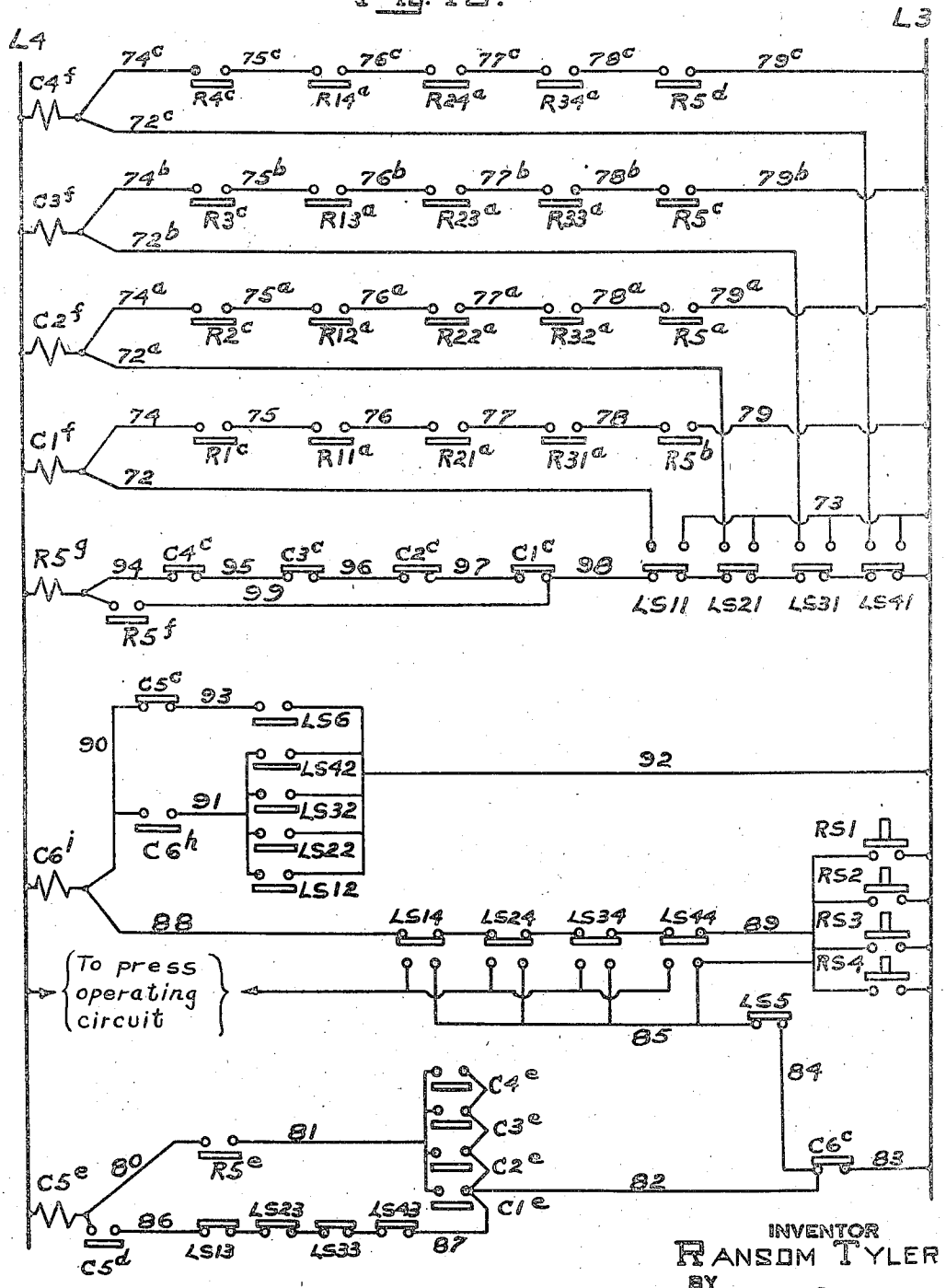
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MULTIPLE TABLE DRIVE

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Fig. 10.



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Patented Nov. 5, 1946 2,410,694

UNITED STATES PATENT OFFICE

2,410,694

MULTIPLE TABLE DRIVE

Ransom Tyler, Greenfield, Wis., assignor to The Oilgear Company, Milwaukee, Wis., a corporation of Wisconsin

Application July 30, 1942, Serial No. 452,924

20 Claims. (Cl. 113—38)

1

This invention relates to drives of the type employed for advancing and retracting a plurality of tables or slides in selective sequences.

For the purpose of illustration, the invention will be explained as employed for driving a plurality of tables associated with a hydraulic press but it is to be understood that a drive constructed according to the invention may be employed for other purposes.

Large hydraulic presses are sometimes provided with a plurality of tables or work slides which are arranged around the outside of the press and are adapted to be moved one at a time into and out of the press so that operators may load work upon the tables outside the press during the time that the press is operating upon the work on the table which has been advanced into the press.

Since the time required to arrange the work in position for pressing is ordinarily considerably longer than the time required for the pressing operation, approximately as much work can be performed upon a press having, for example, four tables as can be performed upon four single table presses.

In some instances, the tables are moved into and out of the press in a fixed sequence but, since multiple table presses are ordinarily employed for operating upon many different types of work, the time required to load one table may be only a small fraction of the time required to load another table in which case the production capacity of the press is greatly reduced if the tables are moved in a fixed sequence.

In other instances, each table is loaded by one or more operators and, as soon as it is loaded, the operator signals an operator at a control station who controls the movement of the loaded tables into and out of the press, but this arrangement requires the services of an operator in addition to the operators who load the tables.

The present invention has as an object to provide a multiple table press with a drive of such character that the operators who load the tables may control the movements of the tables into and out of the press to thereby eliminate the necessity of employing an additional operator.

Another object is to provide a drive of this character in which each operator may operate a control to initiate movement of his table into and out of the press but that table will not move until the table in the press has been fully retracted therefrom.

Another object is to provide a drive of this character in which the tables will move into and out

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of the press in the order in which the controls of the several tables are operated.

Another object is to provide a drive which will accelerate and decelerate each table at a rate slow enough to avoid displacing work arranged upon the table.

Other objects and advantages will appear from the following description of a multiple table press having a drive embodying the invention and shown schematically in the accompanying drawings in which the views are as follows:

Fig. 1 is a diagrammatic front view of a multiple table press provided with a table drive constructed according to the invention.

Fig. 2 is a sectional plan view taken on the line 2—2 of Fig. 1.

Fig. 3 is a diagram of the hydraulic circuit and shows the solenoids for operating the pilot and control valves.

Figs. 4 and 5 are views showing the pilot valve with its plunger in positions different from that shown in Fig. 3.

Fig. 6 is a diagram showing the magnetic switches for controlling the operating solenoids shown in Fig. 3.

Figs. 7 and 8 are diagrams showing relays or contactor switches for controlling the magnetic switches shown in Fig. 6.

Figs. 9 and 10 are across-the-line diagrams which together show the complete control circuit.

For the purpose of illustration, a drive embodying the invention has been shown applied to a press having four tables or work slides 1, 2, 3, and 4 but the invention may readily be applied to a press having a different number of tables.

As shown, the press includes a bed 5, a head frame 6 connected to bed 5 by four strain rods 7, a ram cylinder 8 carried by head 6 and a ram 9 fitted in cylinder 8 and connected to a platen 10 which is slidable upon and guided by rods 7. Tables 1, 2, 3 and 4 when outside the press are arranged, respectively, upon supports 11, 12, 13 and 14 which are arranged around bed 5 and have their upper surfaces flush with the upper surface of bed 5 so that they may be advanced one at a time onto bed 5 and beneath a rubber pad 15 carried by platen 10 upon the underside thereof.

At least one operator is provided for each table, dies (not shown) are arranged upon the table and work is arranged upon the dies. When any one of the tables with work thereon is advanced into the press, ram 9 will advance platen 10 and cause pad 15 to operate upon the work on that table until the pressing operation is completed

and then ram 9 will automatically retract platen 10 to and stop it in its upper position.

The press is provided with a suitable power plant for operating it and with a suitable control for causing it to operate semi-automatically as explained above but, since the press per se forms no part of the present invention, the power plant and press control have been omitted from the drawings and only so much of the press shown as is necessary for an explanation of the invention.

Tables 1, 2, 3 and 4 are operated, respectively, by reciprocating hydraulic motors M1, M2, M3 and M4 each consisting of a cylinder 16 (Fig. 3) and a piston 17 which is fitted in cylinder 16 and connected by a rod 18 to the inner end of the table as shown in dotted lines in Fig. 1, the movement of each table in each direction being limited by a positive stop, not shown.

The table motors are energized by liquid supplied thereto from a pump 20 which may be reversible to direct liquid into one and receive liquid from the other of two channels 21 and 22 or it may be of the unidirectional type and a reversing valve provided to reverse the direction of flow. For the purpose of illustration, pump 20 has been shown as being reversible and of the rolling piston type. Since this type of pump is fully illustrated and described in Patent No. 2,047,068, it is deemed sufficient to state herein that pump 20 has its pumping mechanism arranged within a displacement varying member or slide block 23 and that it will deliver liquid in a direction and at a rate dependent upon the direction and the distance slide block 23 is shifted from its central or neutral position in which position of slide block 23 the displacement of pump 20 is zero and no liquid will be delivered thereby.

Slide block 23 is at all times urged toward the left by liquid acting upon a piston 24 connected to or in engagement with slide block 23 and fitted in a stationary cylinder 25 which is carried by the casing of pump 20 and has an adjusting screw 26 threaded through its outer end to limit the movement of piston 24 and slide block 23 toward the right. Turning screw 26 will adjust the rate at which pump 20 will discharge liquid into channel 21.

Slide block 23 is adapted to be moved toward the right by liquid acting upon one or the other of two pistons 27 and 28 which are fitted in a stationary cylinder 29 carried by the pump casing. Piston 27 engages slide block 23 and piston 28 is adapted to engage the outer face of piston 27.

The movement of piston 28 toward the right is limited by a collar 30 fixed on a stop rod 31 which extends loosely through pistons 27 and 28 and through the head of cylinder 29. The inner end of rod 31 is adapted to engage slide block 23 and the outer end of rod 31 is provided with a nut 32 which, in the present instance, is adjusted to so position collar 30 that piston 28 when energized will move slide block 23 to a position just short of neutral so that pump 20 will at that time deliver liquid into channel 22 at a rate which is very limited, such as two or three percent of maximum.

The outer end of rod 31 is adapted to engage an adjusting screw 33 which is threaded through a cap 34 fixed to the head of cylinder 29. Turning screw 33 adjusts the distance rod 31 and slide block 23 may be moved toward the left to thereby determine the rate at which pump 20 will deliver liquid into channel 22.

Pistons 27 and 28 are larger than piston 24 so that slide block 23 will be moved toward the right when liquid is simultaneously supplied to both of cylinders 25 and 29 at the same pressure.

Liquid for operating pistons 24, 27 and 28 is supplied by a gear pump 35 which is ordinarily driven in unison with pump 20 and arranged in the casing thereof according to the usual practice but which, for the purpose of illustration, has been shown as being separate therefrom.

Gear pump 35 draws liquid from a reservoir 36 and discharges it into a branched supply channel 37 at a rate in excess of requirements, the excess liquid being exhausted through a relief valve 38 which enables gear pump 35 to maintain in channel 37 a pressure equal to the resistance of relief valve 38.

One branch of supply channel 37 is connected to the outer end of cylinder 25 so that piston 24 is constantly urged toward the left by a constant force which is proportional to gear pump pressure. This branch has an adjustable choke 39 arranged therein to limit the rate of flow to and from cylinder 25 and thereby limit the rate at which pistons 24, 27 and 28 can shift slide block 23.

Another branch of supply channel 37 is connected to a pilot valve 40 which controls the flow of liquid to and from cylinder 29 and thereby controls the operation of pump 20. Pilot valve 40 has a valve member or plunger 41 fitted in a valve casing 42 to control communication between four annular grooves or ports 43, 44, 45 and 46 formed in valve casing 42.

Port 43 communicates with the branch of supply channel 37 that is connected to valve 40. Port 44 is connected by a channel 47 to cylinder 29 at or near the outer end thereof. Port 45 is connected by a channel 48 to cylinder 29 at a point between pistons 27 and 28. Port 46 is connected to a drain channel 49 which discharges into reservoir 36.

Valve member 41 is urged to and normally retained in its central or neutral position by two springs 41a and 41b which are arranged in suitable spring chambers located at opposite ends of casing 42. Valve member 41 is adapted to be shifted in one direction or the other by one or the other of two solenoids S5 and S6 the armatures of which are connected to opposite ends of valve member 41 by suitable valve stems.

Due to the displacement of each piston rod 18, the volume discharged by pump 20 will vary from the volume discharged from any one of the motors by an amount equal to the displacement of rod 18. It is therefore necessary to supply liquid from reservoir 36 to pump 20 during movement of a piston 17 in one direction and to permit the discharge of liquid into reservoir 36 during movement of a piston 17 in the opposite direction. This is accomplished by providing pump 20 with an automatic valve 52 which is arranged in a bore 53 having two annular grooves or ports 54 and 55 formed in the wall thereof. Port 54 and the left end of bore 53 are connected to channel 21 by a channel 21a, port 55 and the right end of bore 53 are connected to channel 22 by a channel 22a, and bore 53 is connected at a point intermediate ports 54 and 55 to reservoir 36 through a check valve 56 and a low pressure resistance valve 57. Check valve 56 permits pump 20 to draw liquid freely from reservoir 36 but prevents the discharge of liquid from bore 53 except through resistance valve 57.

The delivery of liquid from pump 20 to the

head ends of the four table motors M1, M2, M3 and M4 is controlled, respectively, by four normally closed control valves V1, V2, V3 and V4 each of which includes a valve member 58 arranged in a casing 59 and urged to its closed position by a spring 60. Valve member 58 controls communication between a branch of channel 22 and a channel 61 which connects casing 59 to the head end of cylinder 16.

As will presently appear, the rod ends of all four motors are supplied with pressure liquid during the time any one motor is performing a cycle of operation. Since the pressure in the end of a non-operating motor might cause liquid to leak past piston 17 of that motor and cause it to creep ahead, each valve member 58 also controls communication between a channel 61 and a drain channel 49a which connects the casings of all four control valves to reservoir 36 but which has been omitted from the drawings in order to avoid complicating the view. When a control valve is open, its valve member 58 blocks communication between channel 61 and drain channel 49a and connects channel 61 to channel 22 so that motive liquid may flow to and from cylinder 16 to effect operation of piston 17 and, when a control valve is closed, the branch of channel 22 connected thereto is blocked by valve member 58 and channel 61 is open to drain channel 49a so that liquid can escape freely from the head end of cylinder 16 and thereby enable pressure in the rod end of cylinder 16 to return piston 17 to and hold it firmly in its fully retracted position.

The four control valves are operated, respectively, by four solenoids S1, S2, S3 and S4 each of which has its armature connected to the stem of the associated control valve. A check valve 62 connected between each channel 61 and channel 22 permits liquid to be discharged freely from cylinder 16 into channel 22 but prevents the flow of liquid from channel 22 into the head end of cylinder 16 except through the associated control valve.

When a piston 17 is advanced by liquid supplied to the head end of its cylinder 16, the liquid discharged from the rod end of that cylinder 16 is directed to the head end thereof through a differential valve which includes a casing 63 and a piston 64 fitted therein. Casing 63 has channels 21 and 22 connected to opposite ends thereof and it is connected intermediate its ends by a branched channel 65 to the rod ends of all four cylinders 16.

As shown in Fig. 2, each of tables 1, 2, 3 and 4 in its inward and outward movements operates four limit switches which have been indicated, respectively, by placing the digits 1, 2, 3 and 4 after the table reference numerals which are preceded by the letters LS. That is, table 1 operates limit switches LS11, LS12, LS13 and LS14, table 2 operates limit switches LS21, LS22, LS23 and LS24, table 3 operates limit switches LS31, LS32, LS33 and LS34, and table 4 operates limit switches LS41, LS42, LS43 and LS44.

Limit switches LS11, LS21, LS31 and LS41 are operated at the outer limits of table movement, switches LS12, LS22, LS32 and LS42 are operated during outward table movement, switches LS13, LS23, LS33 and LS43 are operated during inward table movement, and switches LS14, LS24, LS34 and LS44 are operated at the inner limits of table movement. A limit switch LS5 is operated at or near the upper limit of platen 10 and another limit switch LS6 is operated during upward movement of platen 10 as shown in Fig. 1.

The actual mechanisms for operating the limit switches, the mountings therefor and the exact locations thereof have not been illustrated since they form no part of the invention and since the limit switches are necessarily shown on a much larger scale than the press structure. For example, the tables have been shown as relatively short and as having short strokes while in practice the table stroke is sometimes more than six feet.

Solenoid S5 and a control valve solenoid S1, S2, S3 or S4 are energized simultaneously as will presently be explained. Energizing a control valve solenoid causes it to open its control valve V1, V2, V3 and V4. Energizing solenoid S5 causes it to shift plunger 41 of pilot valve 40 to the position shown in Fig. 4 to connect channels 47 and 48 to drain channel 49 so that gear pump liquid can flow through channel 37 to cylinder 25 and cause piston 24 to move slide block 23 slowly toward the left at the rate determined by choke 39.

Moving slide block 23 toward the left will cause pump 20 to discharge liquid into channel 22 and this liquid will tend to flow through channel 22a to reservoir 36 but, due to the resistance of valve 57, pressure will rise, extend to the right end of bore 53 and shift automatic valve 52 to the left to uncover port 54 and to block port 55 so that pump 20 can draw liquid from reservoir 36 through check valve 56 but cannot discharge liquid into reservoir 36.

The liquid delivered by pump 20 will then flow through channel 22 and the open control valve to the head end of the table motor M1, M2, M3 or M4 associated with the open valve, thereby causing pump pressure to increase and shift differential valve piston 64 toward the left so that pump pressure can extend through channel 65 to the rod ends of all four motors. If the pistons 17 of the other motors have crept forward, the pressure in the rod ends of those motors will return those pistons to their fully retracted positions for the reason that the head ends of those motors are open to drain through the closed control valves.

The liquid delivered by pump 20 to the head end of the motor M1, M2, M3 or M4 will cause its piston 17 to advance the table 1, 2, 3 or 4 connected thereto, and the liquid expelled by piston 17 from cylinder 16 will flow through channel 65 and differential valve casing 63 into channel 22 so that pump 20 need supply only a volume of liquid proportional to the area of rod 18, the area of the rod ordinarily being nearly one half that of the piston so that the table is moved at nearly the same speed in both directions.

Due to the action of choke 39, slide block 23 moves slowly toward the left and gradually increases the displacement and volumetric delivery of pump 20 so that the table motor starts the table at a very slow speed and gradually accelerates it to full speed. The table will continue to move inward at full speed until it operates limit switch LS13, LS23, LS33 or LS43 which will cause solenoid S5 to be deenergized as will presently be explained.

Deenergizing solenoid S5 permits spring 41a to shift plunger 41 of pilot valve 40 to its neutral position and then gear pump liquid will flow through the channel 47 to cylinder 25 and cause piston 24 to move slide block 23 nearly to its neutral position. Due to the action of choke 39, slide block 23 will move slowly and thereby slow-

ly decrease the displacement and volumetric delivery of pump 20 so that the speed of the inward moving table is gradually reduced until it reaches its inner limit and engages a positive stop (not shown) at which time pump delivery will have been reduced to the very limited rate previously mentioned and then pump 20 will discharge through the relief valve (not shown) which is always provided in pumps of this character. The pressure created by pump 20 at this time will hold the advanced table against its inner stop and the retracted tables against their outer stops (not shown).

Just as or before the advancing table reaches its inner limit, it operates limit switch LS14, LS24, LS34 or LS44 to render the press control mechanism effective which will cause ram 9 to move platen 10 downward until the pressing operation is completed and to then retract platen 10. As platen 10 approaches its upper limit, limit switch LS5 is operated to energize solenoid S6 which will shift plunger 41 of pilot valve 40 to the position shown in Fig. 5 and then gear pump liquid will flow through channel 48 and cause piston 27 to shift slide block 23 toward the right from its neutral position which will cause pump 20 to discharge liquid into channel 21.

Resistance valve 57 will prevent pump 20 from discharging into reservoir 36 except at a low pressure and this pressure will extend through channel 21^a to the left end of bore 53 and shift valve 52 toward the right to the position shown to uncover port 55 and to block port 54 so that pump 20 can draw liquid freely from reservoir 36 through channel 22^a but cannot discharge liquid into reservoir 36 through channel 21^a.

The liquid discharged by pump 20 will then flow through channel 21 to differential valve casing 63, shift piston 64 toward the right to the position shown and then flow through channel 65 to the rod end of the table motor and cause its piston 17 to retract the table that is in the press. The liquid expelled from the head end of cylinder 16 by piston 17 is considerably in excess of the liquid required to supply pump 20, and the excess liquid is discharged through channel 22^a, port 55, bore 53 and resistance valve 57 into reservoir 36.

Due to the action of choke 39, slide block 23 will move slowly and thereby cause the table to be started slowly and gradually accelerated to full speed as previously explained. The table will continue to move at full speed until it operates limit switch LS12, LS22, LS32 or LS42 to cause solenoid S6 to be deenergized and thereby permit spring 41^b to shift plunger 41 of pilot valve 40 to its neutral position to connect pipe 48 to drain so that gear pump liquid may flow to cylinder 25 and cause piston 24 to move slide block 23 toward the left until it is stopped by piston 27 engaging piston 28 at which time slide block 23 is nearly in its neutral position and the delivery of pump 20 is reduced to the very limited rate previously mentioned, choke 39 limiting the speed of slide block 23 and thereby causing the table to be gradually decelerated as previously explained.

As shown in Fig. 6, solenoids S1, S2, S3 and S4 are controlled, respectively, by magnetic switches or contactors C1, C2, C3 and C4 each of which includes five mechanically connected switches *a*, *b*, *c*, *d*, and *e* and a magnet *f* for operating those switches. Solenoid S5 is controlled by a magnetic switch or contactor C5 which includes four mechanically connected switches *a*, *b*, *c*, and *d* and a magnet *e* for operating those switches. Solenoid S6 is controlled by a magnetic switch or contactor C6 which includesh eight mechanically connected switches *a*, *b*, *c*, *d*, *e*, *f*, *g* and *h* and a magnet *i* for operating those switches.

Magnet *i* of contactor C6 may be energized to effect reversal of a table by closing a manually operable reversing switch four of which are provided and associated, respectively, with tables 1, 2, 3 and 4 but all of these reversing switches are rendered inoperative by any one of limit switches LS14, LS24, LS34 and LS44 being closed by a table reaching its inner position.

Magnets *f* of contactors C1, C2, C3 and C4 are controlled in part by magnetic switches or relays R1, R2, R3 and R4 respectively. As shown in Fig. 7, each of these relays include six mechanically connected switches *a*, *b*, *c*, *d*, *e* and *f* and a magnet *g* for operating those switches. Magnet *g* of the relays are initially energized, respectively, by means of manually operable starting switches SS1, SS2, SS3 and SS4. A fifth relay R5 (Fig. 8) also includes six mechanically connected switches *a*, *b*, *c*, *d*, *e* and *f* and a magnet *g* for operating those switches. The circuit also includes four groups of interlocking switches or relays R11, R21 and R31, R12, R22 and R32, R13, R23 and R33 and R14, R24 and R34. Each of these relays includes two mechanically connected switches *a* and *b* and *a* magnet *c* for operating those switches as shown in Fig. 8.

The magnets and individual switches of the several contactors and relays have been indicated in Figs. 9 and 10 and will be hereinafter referred to by reference characters produced by adding the reference letters of the magnets and switches as exponents to the reference characters of the contactors and relays. For example, the switches and magnets of relay R34 are designated $R34^a$, $R34^b$ and $R34^c$ respectively.

As shown in Fig. 6, current for energizing the several solenoids is supplied from power lines L1 and L2 which are connected to a source of power through a line switch 70, and current for energizing the magnets of the several contactors and relays is supplied from power lines L3 and L4 which are connected to lines L1 and L2 through a transformer 71. Solenoids S1, S2, S3, S4, S5 and S6 have the opposite ends of their windings connected to lines L1 and L2 through the switches *a* and *b* of contactors C1, C2, C3, C4, C5 and C6 respectively.

Magnet $C1^f$ (Figs. 6 and 10) has one end of its winding connected to line L4 and the second end of its winding connectable through a wire 72, the upper pair of contacts of limit switch LS11 and a wire 73 to line L3. The second end of the winding is also connectable through a wire 74, switch $R1^c$, a wire 75, switch $R11^a$, a wire 76, switch $R21^a$, a wire 77, switch $R31^a$, a wire 78, switch $R5^b$ and a wire 79 to line L3.

Magnet $C2^f$ has one end of its winding connected to line L4 and the second end of its winding connectable through a wire 72^a, the upper pair of contacts of limit switch LS21 and a wire 73 to line L3. The second end of the winding is also connectable through a wire 74^a, switch $R2^c$, a wire 75^a, switch $R12^a$, a wire 76^a, swith $R22^a$, a wire 77^a, switch $R32^a$, a wire 78^a, switch $R5^a$ and a wire 79^a to line L3.

Magnet $C3^f$ has one end of its winding connected to line L4 and the second end of its winding connectable through a wire 72^b, the upper pair of contacts of limit switch LS31 and wire 73 to line

L3. The second end of the winding is also connectable through a wire 74b, switch R3c, a wire 75b, switch R13a, a wire 76b, switch R23a, a wire 77b, switch R33a, a wire 78b, switch R5c and a wire 79b to line L3.

Magnet C4f has one end of its winding connected to line L4 and the second end of its winding connectable through a wire 72c, the upper pair of contacts of limit switch LS41 and wire 73 to line L3. The second end of the winding is also connectable through a wire 74c, switch R4c, a wire 75c, switch R14a, a wire 76c, switch R24a, a wire 77c, switch R34a, a wire 78c, switch R5d and a wire 79c to line L3.

Magnet C5e has one end of its winding connected to line L4 and the second end thereof connectable through a wire 80, switch R5e, a wire 81 any one of switches C1e, C2e, C3e and C4e, a wire 82, switch C6e and a wire 83 to line L3. Wire 82 is also connectable through a wire 84, limit switch LS5, a wire 85 and any one of limit switches LS14, LS24, LS34 and LS44 to the operating circuit of the press. The second end of the winding of magnet C5e is also connectable through switch C5d, a wire 86, limit switches LS13, LS23, LS33 and LS43 which are in series, and a wire 87 to wire 82 and thence through switch C6c and wire 83 to line L3.

Magnet C6f has one end of its winding connected to line L4 and a second end thereof connectable through a wire 88, limit switches LS14, LS24, LS34 and LS44 which are in series, wire 89 and any one of reversing switches RS1, RS2, RS3 and RS4 to line L3. The second end of the winding of magnet C6f is also connected by a wire 90 to one terminal of switches C6h and C5c. The second terminal of switch C6h is connectable through a wire 91, any one of limit switches LS12, LS22, LS32 and LS42 and a wire 92 to line L3, and the second terminal of switch C5c is connectable through a wire 93, limit switch LS6 and a wire 92 to line L3.

Magnet R5g (Figs. 8 and 10) has one end of its winding connected to line L4 and the other end thereof connectable through a wire 94, switch C4c, a wire 95, switch C3c, a wire 96, switch C2c, a wire 97, switch C1c, a wire 98 and limit switches LS11, LS21, LS31 and LS41 to line L3. The second end of the winding is also connectable through switch R5f and a wire 99 to wire 98.

Magnet R1g (Figs. 7 and 9) has one end of its winding connected to line L4 and the other end thereof connected through a wire 100 to one terminal of switch R1f and to one terminal of starting switch SS1 the other terminal of which is connected by a wire 101 to line L3. The other terminal of switch R1f is connectable through a wire 102, switch C6d and a wire 103 to line L3 and through a wire 104, switch C1d and a wire 105 to line L3.

Magnet R2g has one end of its winding connected to line L4 and the other end thereof connected through a wire 100a to one terminal of switch R2f and to one terminal of starting switch SS2 the other terminal of which is connected by a wire 101a to line L3. The other terminal of switch R2f is connectable through a wire 102a, switch C6e and a wire 103a to line L3 and through a wire 104a, switch C2d and a wire 105a to line L3.

Magnet R3g has one end of its winding connected to line L4 and the other end thereof connected through a wire 100b to one terminal of switch R3f and to one terminal of starting switch SS3 the other terminal of which is connected by a wire 101b to line L3. The other terminal of switch R3f is connectable through a wire 102b, switch C6f and a wire 103b to line L3 and through a wire 104b, switch C3d and wire 105b to line L3.

Magnet R4g has one end of its winding connected to line L4 and the other end thereof connected through a wire 100c to one terminal of switch R4f and to one terminal of starting switch SS4 the other terminal of which is connected by a wire 101c to line L3. The other terminal of switch R4f is connectable through a wire 102c, switch C6g and a wire 103c to line L3, and through a wire 104c, switch C4d and a wire 105c to line L3.

Magnet R11c (Figs. 8 and 9) has one end of its winding connected to line L4 and the other end thereof connected to one terminal of switch R11b and connected through a wire 110 to one terminal of switch R2a. The other terminals of switches R11b and R2a are both connected by a wire 111 to one terminal of switch R1d.

Magnet R21c has one end of its winding connected to line L4 and the other end thereof connected to one terminal of switch R21b and connected through a wire 112 to one terminal of switch R3a. The other terminals of switches R21b and R3a are both connected by a wire 113 to the terminal of switch R1d to which wire 111 is connected.

Magnet R31c has one end of its winding connected to line L4 and the other end thereof connected to one terminal of switch R31b and connected through a wire 114 to one terminal of switch R4a. The other terminals of switches R31b and R4a are both connected by a wire 115 to the terminal of switch R1d to which wires 111 and 113 are connected. The other terminal of switch R1d is connected by wire 116 to line L3.

Magnet R12c has one end of its winding connected to line L4 and the other end thereof connected to one terminal of switch R12b and connected through a wire 110a to one terminal of switch R1a. The other terminals of switches R12b and R1a are both connected by a wire 111a to one terminal of switch R2d. Magnet R22c has one end of its winding connected to line L4 and the other end thereof connected to one terminal of switch R22b and connected through a wire 112a to one terminal of switch R3b. The other terminals of switches R22b and R3b are both connected by a wire 113a to the terminal of switch R2d to which wire 111a is connected.

Magnet R32c has one end of its winding connected to line L4 and the other end thereof connected to one terminal of switch R32b and connected through a wire 114a to one terminal of switch R4b. The other terminals of switches R32b and R4b are both connected by a wire 115a to the terminal of switch R2d to which wires 111a and 113a are connected. The other terminal of switch R2d is connected by a wire 116a to line L3.

Magnet R13c has one end of its winding connected to line L4 and the other end thereof connected to one terminal of switch R13b and connected through a wire 110b to one terminal of switch R1b. The other terminals of switches R13b and R1b are both connected by a wire 111b to one terminal of switch R3d. Magnet R23c has one end of its winding connected to line L4 and the other end thereof connected to one terminal of switch R23b and connected through a wire 112b to one terminal of switch R2b. The other terminals of switches R23b and R2b are both connected by wire 113b to the terminal of switch R3d to which wire 111b is connected.

Magnet R33c has one end of its winding connected to line L4 and the other end thereof connected to one terminal of switch R33b and connected through a wire 114b to one terminal of switch R4e. The other terminals of switches R33b and R4e are both connected by a wire 115b to the terminal of switch R3d to which wires 111b and 113b are connected. The other terminal of switch R3d is connected by a wire 116b to line L3.

Magnet R14c has one end of its winding connected to line L4 and the other end thereof connected to one terminal of switch R14b and connected through a wire 110c to one terminal of switch R1e. The other terminals of switches R14b and R1e are both connected by a wire 111c to one terminal of switch R4d.

Magnet R24c has one end of its winding connected to line L4 and the other end thereof connected to one terminal of switch R24b and connected through a wire 112c to one terminal of switch R2e. The other terminals of switches R24b and R2e are both connected by a wire 113c to the terminal of switch R4d to which wire 111c is connected.

Magnet R34c has one end of its winding connected to line L4 and the other end thereof connected to one terminal of switch R34b and connected through a wire 114c to one terminal of switch R3e. The other terminals of switches R34b and R3e are both connected by a wire 115c to the terminal of switch R4d to which wires 111c and 113c are connected. The other terminal of switch R4d is connected by a wire 116c to line L3.

Operation

Assuming that the several parts are in the positions shown and that pumps 20 and 35 are running, the drive will operate as follows:

Line switch 70 (Fig. 6) is first closed to connect lines L1 and L2 directly to the source of power and to connect lines L3 and L4 to the source of power through transformer 71. This establishes, as shown in Fig. 10, a circuit (L4—R5g—94—C4c—95—C3c—96—C2c—97—C1c—98—LS11—LS21—LS31—LS41—L4) to energize magnet R5g which will raise relay R5 (Fig. 8) to close the switches *a*, *b*, *c*, *d*, *e* and *f* thereof. Closing switch R5f establishes a circuit (L4—R5g—R5f—99—98—LS11—LS21—LS31—LS41—L3) to keep magnet R5g energized when any one of switches C1c, C2c, C3c or C4c open.

Let it now be assumed that table 2 has been loaded, that starting switch SS2 has been closed and that tables 4, 1 and 3 were loaded and starting switches SS4, SS1 and SS3 were successively closed after switch SS2 was closed.

As shown in Fig. 9, closing switch SS2 establishes a circuit (L4—R2g—100a—SS2—101a—L3) to energize magnet R2g which will operate relay R2 (Fig. 7) to close switches *c*, *d* and *f* thereof and to open switches *a*, *b* and *e* thereof. Closing switch R2f establishes a circuit (L4—R2g—100a—R2f—102a—C6e—103a—L3) and a circuit (L4—R2g—100a—R2f—104a—C2d—105a—L3) to keep magnet R2g energized.

Closing switch R2d establishes three circuits (L4—R12c—110a—R1a—111a—R2d—116a—L3), (L4—R22c—112a—R3b—113a—R2d—116a—L3) and (L4—R32c—114a—R4b—115a—R2d—116a—L3) to energize magnets R12c, R22c and R32c which will operate relays R12, R22 and R32 to close the switches *a* and *b* thereof. Closing switches R12b, R22b and R32b connects magnets R12c, R22c and R32c to wires 111a, 113a and 115a respectively to keep magnets R12c, R22c and R32c energized should switches R1a, R3b and R4b open.

Relays R2 and R5 having been raised as explained above, raising relays R12, R22 and R32 establishes, as shown in Fig. 10, a circuit (L4—C2f—74a—R2c—75a—R12a—76a—R22a—77a—R32a—78a—R5a—79a—L3) to energize magnet C2f which will raise contactor C2 (Fig. 6) to close switches *a*, *b* and *e* thereof and to open switches *c* and *d* thereof. Closing switches C2a and C2b causes solenoid S2 to be energized and open valve V2 (Fig. 3). Closing switch C2e establishes, as shown in Fig. 10, a circuit (L4—C5c—80—R5e—81—C2e—82—C6c—83—L3) to energize magnet C5e which will raise contactor C5 (Fig. 6) to open switch *c* thereof and to close switches *a*, *b*, and *d* thereof.

Opening switch C5c prevents magnet C6f from being energized if and when limit switch LS6 closes during the down stroke of platen 10. Closing switch C5d establishes a circuit (L4—C5e—C5d—86—LS13—LS23—LS33—LS43—87—82—C6c—83—L3) to keep magnet C5e energized. Closing switches C5a and C5b causes solenoid S5 (Fig. 6) to be energized and operate pilot valve 40 (Fig. 3) to cause slide block 23 of pump 20 to be shifted toward the left from its neutral position and liquid from pump 20 to flow through channel 22, valve V2 and channel 61 to the head end of motor M2 and cause it to advance table 2, the speed of slide block being limited by choke 39 so that the displacement of pump 20 is gradually increased from zero with the result that table 2 is started slowly and gradually accelerated to full speed as previously explained.

It has been assumed that starting switches SS4, SS1 and SS3 were successively closed shortly after starting switch SS2 was closed. Closing switch SS4 establishes, as shown in Fig. 9, a circuit (L4—R4g—100c—SS4—101c—L3) to energize magnet R4g which will raise relay R4 (Fig. 7) to open switches *a*, *b* and *e* thereof and to close switches *c*, *d* and *f* thereof.

Opening switches R4a and R4e prevent, respectively, magnets R31c and R33c from being energized. Opening switch R4b has no effect as the circuit through magnet R32c is maintained through switch R32b. Closing switch R4f establishes two circuits (L4—R4g—100c—R4f—102c—C6g—103c—L3) and (L4—R4g—100c—R4f—104c—C4d—105c—L3) to keep magnet R4g energized when switch SS4 opens.

Closing switch R4d establishes, as shown in Fig. 9, two circuits (L4—R14c—110c—R1e—111c—R4d—116c—L3) and (L4—R34c—114c—R3e—115c—R4d—116c—L3) to energize magnets R14c and R34c which will operate relays R14 and R34 to close the switches *a* and *b* thereof. Closing switches R14b and R34b connects magnets R14c and R34c to wires 111c and 115c, respectively, to keep those magnets energized. Closing switch R4d will not cause magnet R24c to be energized for the reason that switch R2e is open and, consequently, relay R24 will not be raised and contactor magnet C4f will not be energized as the circuit therethrough is broken at switch R24a as shown in Fig. 10. Since magnet C4f cannot be energized and operate contactor C4, solenoid S4 will not be energized and table 4 cannot be advanced.

Closing starting switch SS1 will establish, as shown in Fig. 9, a circuit (L4—R1g—100—SS1—101—L3) to energize magnet R1g which will raise relay R1 (Fig. 7) to open switches *a*, *b* and *e* thereof and to close switches *c*, *d* and *f* thereof.

Opening switches R1a and R1e has no effect as the circuits through magnets R12c and R14c are maintained by switches R12b and R14b respectively. Opening switch R1b prevents magnet R13c from being energized.

Closing switch R1f establishes two circuits (L4—R1g—100—R1f—102—C8d—103—L3) and (L4—R1g—100—R1f—104—C1d—105—L3) to keep magnet R1g energized. Closing switch R1d establishes, as shown in Fig. 9, a circuit (L4—R21c—112—R3a—113—R1d—116—L3) to energize magnet R21c which will raise relay R21 to close the switches *a* and *b* thereof. Closing switch R21b keeps magnet R21c energized by connecting it to wire 113.

However, closing switch R1d will not cause magnets R11c and R31c to be energized as the circuits therethrough are broken at switches R2a and R4a and, consequently, relays R11 and R31 will not be raised and contactor magnet C1f will not be energized as the circuit therethrough is broken at switches R11a and R31a. Since magnet C1f cannot be energized and operate contactor C1, solenoid S1 will not be energized and table 1 cannot be advanced.

Closing starting switch SS3 will establish, as shown in Fig. 9, a circuit (L4—R3g—100b—SS3—101b—L3) to energize magnet R3g which will raise relay R3 to open switches *a*, *b* and *e* thereof and to close switches *c*, *d* and *f* thereof. Opening switches R3a, R3b and R3e has no effect as the circuits through magnets R21c, R22c and R34c are maintained by switches R21b, R22b and R34b respectively.

Closing switch R3f establishes two circuits (R3g—100b—R3f—102b—C8f—103b—L3) and (R3g—100b—R3f—104b—C3d—105b—L3) to keep magnet R3g energized. Closing switch R3d will have no effect for the reason that switches R1b, R2b and R4e are open and, consequently, solenoid S3 cannot be energized to cause table 3 to advance.

It is therefore obvious that, after one starting switch has been closed to initiate a circuit to effect an advance movement of the table controlled by that switch, advance movement of any of the other tables is prevented.

As table 2 starts to advance, limit switch LS21 operates to break the circuit through magnet R5g and to connect wire 72a to wire 73 to establish a new circuit through magnet C2f. Breaking the circuit through magnet R5g causes relay R5 to drop and break the previously established circuit through magnet C2f but limit switch LS21 has overlapping contacts and establishes the new circuit before the previous circuit is broken so that magnet C2f remains energized. Dropping relay R5 also breaks one of the circuits through magnet C5e but the magnet is kept energized by the holding circuit extending through switch C5d.

As table 2 moves forward, it will close limit switch LS22, which will have no effect at this time, and table 2 will continue forward at high speed until it opens limit switch LS23 to break the circuit through magnet C5e which will cause contactor C5 to drop and deenergize solenoid S5 so that plunger 41 of pilot valve 40 is returned to its neutral position to cause the displacement of pump 20 to be gradually reduced and cause table 2 to be gradually decelerated as previously explained.

As table 2 reaches its forward limit, it operates limit switch LS24 to establish a circuit (Fig. 10) from line L3 through wire 83, switch C8c, wire 84, limit switch LS5, wire 85, limit switch LS24, the starting solenoid (not shown) of the press operating circuit to line L4, thereby causing platen 10 to descend, perform a pressing operation upon the work on table 2 and then return to and stop in its initial position.

As platen 10 starts downward, limit switch LS5 opens and cuts the starting solenoid out of the table control circuit so that it may be controlled by the press operating circuit. Limit switch LS6 is not operated electrically during the down stroke of platen 10 but it is closed momentarily during the up stroke thereof.

Closing limit switch LS6 establishes a circuit (L4—C6i—90—C5c—93—LS6—92—L3) to energize magnet C6i which will raise contactor C6 to open switches *c*, *d*, *e*, *f* and *g* thereof and to close switches *a*, *b* and *h* thereof.

Opening switch C6c has no effect as the circuit therethrough was broken when limit switches LS23 and LS24 opened. Opening switches C6d, C6f and C6g has no effect as the circuits through magnets R1g, R3g and R4g are maintained by switches C1d, C3d and C4d respectively. Opening switch C6e breaks the circuit through magnet R2g which permits relay R2 to drop and close switches *a*, *b* and *e* thereof and to open switches *c*, *d* and *f* thereof.

Opening switches R2c and R2f has no effect as the circuits therethrough were previously broken. Opening switch R2d breaks the circuits through magnets R12c, R22c and R32c to deenergize them and permit relays R12, R22 and R32 to drop which has no effect as the circuit controlled thereby was broken when relay R5 dropped.

Closing switches R2a and R2b establishes two circuits (L4—R11c—110—R2a—111—R1d—116—L3) and (L4—R23c—112b—R2b—116b—113b—R2d—L3) to energize magnets R11c and R23c which will raise relays R11 and R23 and establish holding circuits through these magnets but raising relays R11 and R23 has no effect at this time as relays R31, R13 and R33 have not been raised.

Closing switch R2e establishes a circuit (L4—R24c—112c—R2e—113c—R4d—116c—L3) to energize magnet R24c which will raise relay R24 and establish a holding circuit through magnet R24c but raising relay R24 will have no effect until relay R5 is raised.

It has previously been stated that raising contactor C6 closed switches *a*, *b* and *h* thereof. Closing switch C6h establishes a circuit (L4—C6i—90——C6h—91—LS22—92—L3) to keep magnet C6i energized when limit switch LS6 opens as it is closed only momentarily. Closing switches C6a and C6b causes solenoid S6 (Fig. 6) to be energized and operate pilot valve 40 (Fig. 3) to cause slide block 23 of pump 20 to be shifted toward the right from its near neutral position and liquid from pump 20 to flow through channel 21, differential valve 63 and channel 65 to the rod end of motor M2 and cause it to retract table 2, the speed of slide block 23 being limited by choke 39 so that the displacement of pump 20 is gradually increased with the result that table 2 is started slowly and gradually accelerated to full speed as previously explained.

As table 2 moves outward, it will permit limit switch LS24 to return to its initial position, then it will operate limit switch LS23 to its initial position and it will continue to move outward at high speed until it opens limit switch LS22 to break the circuit through magnet C6i which will permit contactor C6 to drop and deenergize solenoid S6 to permit plunger 41 of pilot valve 40 to

be returned to its neutral position to cause the displacement of pump 20 to be gradually reduced and thereby cause table 2 to be gradually decelerated as previously explained.

When table 2 reaches its outer limit, it operates limit switch LS2I to its initial position, thereby breaking the circuit through magnet $C2^f$ which will permit contactor C2 to drop and open its switches *a*, *b* and *e* and close its switches *c* and *d*.

Opening switch $C2^e$ has no effect but opening switches $C2^a$ and $C2^b$ deenergizes solenoid S2 which permits control valve V2 to close. Closing switch $C2^d$ has no effect but the closing of switch $C2^c$ and the return of switch LS2I to its initial position re-establishes, as shown in Fig. 10, the circuit (L4—$R5^g$—94—$C4^c$—95—$C3^c$—96—$C2^c$—97—$C1^c$—98—LS1I—LS2I—LS3I—LS4I—L3) to energize magnet $R5^g$ which raises relay R5.

If none of the other starting switches had been closed, the drive would now come to rest and remain idle until a starting switch was closed but it has been assumed that starting switches SS4, SSI and SS3 were closed in succession after switch SS2 was closed, and the closing of switches SS4, SSI and SS3 caused certain circuits to be set up as explained above.

Therefore, since relays R4, RI4, R24 and R34 have been raised due to the establishing of circuits as a result of closing switch SS4, raising relay R5 will establish, as shown in Fig. 10, a circuit (L4—$C4^f$—74^c—$R4^c$—75^c—$RI4^a$—76^c—$R24^a$—77^c—$R34^a$—78^c—$R5^d$—79^c—L3) to energize magnet $C4^f$ which will raise contactor C4 to energize solenoid S4 and to deenergize magnet $R5^g$, thereby causing table 4 to be advanced and retracted in the same manner that table 2 was advanced and retracted and causing relay R5 to drop.

The electric circuits for controlling the four tables function in the same manner and are substantially identical, contactors C5 and C6 and relay R5 being common to all four circuits.

When contactor C6 is raised in response to operation of limit switch LS6 during upward movement of platen 10 as explained above, it causes relays R4, RI4, R24 and R34 to drop for the same reason that relays R2, RI2, R22 and R32 dropped during operation of table 2.

Dropping relay R4 establishes, as shown in Fig. 9, two circuits (L4—$R3I^c$—114—$R4^a$—115—RI^d—116—L3) and (L4—$R33^c$—114^b—$R4^e$—115^b—$R3^d$—116^b—L3) to energize magnets $R3I^c$ and $R33^c$ which will raise relays R3I and R33 and establish holding circuits through these magnets but raising relays R3I and R33 has no effect at this time as relay R5 has not been raised.

When table 4 reaches its outer limit, it operates limit switch LS4I to cause contactor C4 to drop and establish, as shown in Fig. 10, a circuit (L4—$R5^g$—94—$C4^c$—95—$C3^c$—96—$C2^c$—97—$C1^2$—98—LS1I—LS2I—LS3I—LS4I—L3) to energize magnet $R5^g$ which will raise relay R5 and establish through switch $R5^f$ a holding circuit for magnet $R5^g$.

If none of the starting switches had been closed after switch SS4 was closed, the drive would now come to rest and would remain idle until a starting switch was closed but it has been assumed that switches SSI and SS3 were closed in succession after switch SS4 was closed, and the closing of switches SSI and SS3 caused certain circuits to be set up as explained above.

Therefore, since relays RII, R2I and R3I have been raised due to the establishing of circuits as the result of closing switch SSI, raising relay R5 will establish, as shown in Fig. 10, a circuit (L4—

$C1^f$—74—$R1^c$—75—RII^a—76—$R2I^a$—77—$R3I^a$—78—$R5^b$—79—L3) to energize magnet $C1^f$ which will raise contactor C1 to energize solenoid SI and to deenergize magnet $R5^g$, thereby causing table 1 to be advanced and retracted in the same manner that tables 2 and 4 were advanced and retracted and causing relay R5 to drop.

When contactor C6 is raised in response to operation of switch LS6 during upward movement of platen 10, it causes relays RI, RII, R2I and R3I to drop for the same reason that relays R2, RI2, R22 and R32 dropped during operation of table 2.

Dropping relay RI establishes, as shown in Fig. 9, a circuit (L4—$RI3^c$—110^b—RI^b—111^b—$R3^d$—116^b—L3) to energize magnet $RI3^c$ which will raise relay RI3 and establish a holding circuit through that magnet but raising relay RI3 will have no effect until relay R5 is raised.

When table 1 reaches its outer limit, it operates switch LSII to cause contactor CI to drop and establish, as shown in Fig. 10, a circuit (L4—$R5^g$—94—$C4^c$—95—$C3^c$—96—$C2^c$—97—$C1^c$—98—LSII—LS2I—LS3I—LS4I—L3) to energize magnet $R5^g$ which will raise relay R5 and establish through switch $R5^f$ a holding circuit in magnet $R5^g$.

Since starting switch SS3 was closed after switch SSI was closed and since relays R3, RI3, R23 and R33 have been raised as explained above, raising relay R5 will establish, as shown in Fig. 10, a circuit (L4—$C3^f$—74^b—$R3^c$—75^b—$RI3^a$—76^b—$R23^a$—77^b—$R33^a$—78^b—$R5^c$—79^b—L3) to energize magnet $C3^f$ which will raise contactor C3 to energize solenoid S3 and to deenergize magnet $R5^g$, thereby causing table 3 to be advanced and retracted in the same manner that tables 2, 4 and 1 were advanced and retracted and causing relay R5 to drop.

When contactor C6 is raised in response to operation of switch LS6 during upward movement of platen 10, it causes relays R3, RI3, R23 and R33 to drop for the same reason that relays R2, RI2, R22 and R32 dropped during operation of table 2.

When table 3 reaches its outer limit, it operates limit switch LS3I to re-establish the circuit through magnet $R5^g$ which will raise relay R5 and establish through switch $R5^f$ a holding circuit for magnet $R5^g$.

If none of the starting switches were closed after switch SS3 was closed, the drive will now come to rest and will remain idle until any one of the starting switches is closed but, if one of the starting switches has been closed, raising relay R5 will cause the table controlled by that starting switch to perform a cycle of operation as explained above.

If it is desired to retract a table after it has started to advance, it is simply necessary to close the reversing switch RS1, RS2, RS3 or RS4 associated with that table to establish a circuit from line L3 through the reversing switch, wire 89, limit switches LS44, LS34, LS24 and LS14, wire 88 and magnet $C6^1$ to line L4 to energize magnet $C6^1$ which will raise contactor C6 to effect reversal of pump 20 and consequently retraction of the table but, if the reversing switch is closed after the table is fully advanced and has opened limit switch LS14, LS24, LS34 or LS44, the table will not be retracted for the reason that the circuit through magnet $C6^1$ is broken by the open limit switch.

From the foregoing, it will be obvious that the tables will be operated in the order in which the starting switches are closed, that any table may

be operated a plurality of times before another table is operated and that the number of tables or other elements may be varied by simply varying the number of circuits.

The drive shown and described herein is susceptible of various modifications and adaptations without departing from the scope of the invention which is hereby claimed as follows:

1. In a machine having a plurality of tables, the combination of a hydraulic motor connected to each table to advance and retract the same, a pump, fluid channels connecting said motors to said pump and forming therewith a hydraulic circuit, valve means for controlling the flow in said circuit and the operation of each of said motors, a starting means associated with each motor and operable to effect operation of said valve means to cause the motor associated with that starting means to advance the table connected thereto, the several starting means being operable in any desired sequence, means responsive to any table being fully advanced for effecting operation of said valve means to reverse the flow in said circuit and thereby cause the motor connected to that table to retract the same, and means responsive to any table being fully retracted for effecting operation of said valve means to cause an advance movement of the table connected to the motor the starting means of which was next operated in said sequence.

2. In a machine having a plurality of tables, the combination of a hydraulic motor connected to each table to advance and retract the same, a pump, fluid channels connecting said motors to said pump and forming therewith a hydraulic circuit, valve means for controlling the flow in said circuit and the operation of each of said motors, a starting means associated with each motor and operable to effect operation of said valve means to cause the motor associated with that starting means to advance the table connected thereto, the several starting means being operable in any desired sequence, means for causing the speed of the advancing table to be gradually increased from zero to maximum, means responsive to a table being advanced to a given point for causing said table to be gradually decelerated, means responsive to any table being fully advanced for effecting operation of said valve means to reverse the flow in said circuit and thereby cause the motor connected to that table to retract the same, and means responsive to any table being fully retracted for effecting operation of said valve means to cause an advance movement of the table connected to the motor the starting means of which was next operated in said sequence.

3. In a machine having a plurality of tables, the combination of a hydraulic motor connected to each table to advance and retract the same, a pump, fluid channels connecting said motors to said pump and forming therewith a hydraulic circuit, valve means for controlling the flow in said circuit and the operation of each of said motors, a starting means associated with each motor and operable to effect operation of said valve means to cause the motor associated with that starting means to advance the table connected thereto, the several starting means being operable in any desired sequence, means for causing the speed of the advancing table to be gradually increased from zero to maximum, means responsive to a table being advanced to a given point for causing said table to be gradually decelerated, means responsive to any table being fully advanced for effecting operation of said valve means to reverse the flow in said circuit and thereby cause the motor connected to that table to retract the same, means for causing the speed of the retracting table to be gradually increased from zero to maximum, means responsive to a table being retracted to a given point for causing said table to be gradually decelerated, and means responsive to any table being fully retracted for effecting operation of said valve means to cause an advance movement of the table connected to the motor the starting means of which was next operated in said sequence.

4. In a machine having a plurality of tables, the combination of a hydraulic motor connected to each table to advance and retract the same, a pump, fluid channels connecting said motors to said pump and forming therewith a hydraulic circuit, valve means for controlling the flow in said circuit and the operation of each of said motors, a starting means associated with each motor and operable to effect operation of said valve means to cause the motor associated with that starting means to advance the table connected thereto, the several starting means being operable in any desired sequence, means responsive to any one table starting to advance for preventing any other table from advancing until after said one table has been fully retracted, means responsive to any table being fully advanced for effecting operation of said valve means to reverse the flow in said circuit and thereby cause the motor connected to that table to retract the same, and means responsive to any table being fully retracted for effecting operation of said valve means to cause an advance movement of the table connected to the motor the starting means of which was next operated in said sequence.

5. In a machine having a plurality of tables, the combination of a hydraulic motor connected to each table to advance and retract the same, a pump, fluid channels connecting said motors to said pump and forming therewith a hydraulic circuit, valve means for controlling the flow in said circuit and the operation of each of said motors, a starting means associated with each motor and operable to effect operation of said valve means to cause the motor associated with that starting means to advance the table connected thereto, the several starting means being operable in any desired sequence, means responsive to any one table starting to advance for preventing any other table from advancing until after said one table has been fully retracted, means for causing the speed of the advancing table to be gradually increased from zero to maximum, means responsive to a table being advanced to a given point for causing said table to be gradually decelerated, means responsive to any table being fully advanced for effecting operation of said valve means to reverse the flow in said circuit and thereby cause the motor connected to that table to retract the same, means for causing the speed of the retracting table to be gradually increased from zero to maximum, means responsive to a table being retracted to a given point for causing said table to be gradually decelerated, and means responsive to any table being fully retracted for effecting operation of said valve means to cause an advance movement of the table connected to the motor the starting means of which was next operated in said sequence.

6. In a machine having a plurality of tables,

the combination of a hydraulic motor connected to each table to advance and retract the same, a pump, fluid channels connecting said motors to said pump and forming therewith a hydraulic circuit, flow control means for controlling the flow in said circuit, valve means for controlling each of said motors, and a control for controlling said control means and including a starting means for each motor operation of which effects operation of said flow control means and the valve means for controlling the same motor to cause said motor to advance the table connected thereto, the several starting means being operable in any desired sequence, means responsive to any table being fully advanced for effecting operation of said flow control means to reverse the flow in said circuit and thereby cause the motor connected to that table to retract the same, and means responsive to any table being fully retracted for effecting operation of said flow control means and the valve means for controlling the motor the starting means of which was next operated in said sequence to thereby cause that motor to advance the table connected thereto.

7. In a machine having a plurality of tables, the combination of a hydraulic motor connected to each table to advance and retract the same, a pump, fluid channels connecting said motors to said pump and forming therewith a hydraulic circuit, flow control means for controlling the flow in said circuit, valve means for controlling each of said motors, and a control for controlling said control means and including a starting means for each motor operation of which effects operation of said flow control means and the valve means for controlling the same motor to cause said motor to advance the table connected thereto, the several starting means being operable in any desired sequence, means responsive to any one table starting to advance for preventing any other table from advancing until after said one table has been fully retracted, means responsive to any table being fully advanced for effecting operation of said flow control means to reverse the flow in said circuit and thereby cause the motor connected to that table to retract the same, and means responsive to any table being fully retracted for effecting operation of said flow control means and the valve means for controlling the motor the starting means of which was next operated in said sequence to thereby cause that motor to advance the table connected thereto.

8. In a machine having a plurality of tables, the combination of a hydraulic motor connected to each table to advance and retract the same, a pump, fluid channels connecting said motors to said pump and forming therewith a hydraulic circuit, flow control means for controlling the flow in said circuit, valve means for controlling each of said motors, and a control for controlling said control means and including a starting means for each motor operation of which effects operation of said flow control means and the valve means for controlling the same motor to cause said motor to advance the table connected thereto, the several starting means being operable in any desired sequence, means for causing the speed of the advancing table to be gradually increased from zero to maximum, means responsive to a table being advanced to a given point for causing said table to be gradually decelerated, means responsive to any table being fully advanced for effecting operation of said flow control means to reverse the flow in said circuit and thereby cause the motor connected to that table to retract the same, and means responsive to any table being fully retracted for effecting operation of said flow control means and the valve means for controlling the motor the starting means of which was next operated in said sequence to thereby cause that motor to advance the table connected thereto.

9. In a machine having a plurality of tables, the combination of a hydraulic motor connected to each table to advance and retract the same, a pump, fluid channels connecting said motors to said pump and forming therewith a hydraulic circuit, flow control means for controlling the flow in said circuit, valve means for controlling each of said motors, and a control for controlling said control means and including a starting means for each motor operation of which effects operation of said flow control means and the valve means for controlling the same motor to cause said motor to advance the table connected thereto, the several starting means being operable in any desired sequence, means responsive to any one table starting to advance for preventing any other table from advancing until after said one table has been fully retracted, means for causing the speed of the advancing table to be gradually increased from zero to maximum, means responsive to a table being advanced to a given point for causing said table to be gradually decelerated, means responsive to any table being fully advanced for effecting operation of said flow control means to reverse the flow in said circuit and thereby cause the motor connected to that table to retract the same, means for causing the speed of the retracting table to be gradually increased from zero to maximum, means responsive to a table being retracted to a given point for causing said table to be gradually decelerated and means responsive to any table being fully retracted for effecting operation of said flow control means and the valve means for controlling the motor the starting means of which was next operated in said sequence to thereby cause that motor to advance the table connected thereto.

10. In a press having a platen, power means for reciprocating said platen, a control adapted when actuated to cause said power means to advance and retract said plates, and a plurality of tables each of which is adapted to be advanced into and retracted from the path of said platen, the combination of a hydraulic motor connected to each table to advance and retract the same, a pump, fluid channels connecting said motors to said pump and forming therewith a hydraulic circuit, valve means for controlling the flow in said circuit and the operation of each of said motors, a starting means associated with each motor and operable to effect operation of said valve means to cause the motor associated with that starting means to advance the table connected thereto, the several starting means being operable in any desired sequence, means responsive to any one table being fully advanced for actuating said press control to thereby cause said platen to be advanced and retracted, means responsive to said platen being retracted for effecting operation of said valve means to reverse the flow in said circuit and thereby cause the motor connected to said one table to retract the same, and means responsive to any table being fully retracted for effecting operation of said valve means to cause an advance movement of the table connected to the motor

the starting means of which was next operated in said sequence.

11. In a press having a platen, power means for reciprocating said platen, a control adapted when actuated to cause said power means to advance and retract said platen, and a plurality of tables each of which is adapted to be advanced into and retracted from the path of said platen, the combination of a hydraulic motor connected to each table to advance and retract the same, a pump, fluid channels connecting said motors to said pump and forming therewith a hydraulic circuit, valve means for controlling the flow in said circuit and the operation of each of said motors, a starting means associated with each motor and operable to effect operation of said valve means to cause the motor associated with that starting means to advance the table connected thereto, the several starting means being operable in any desired sequence, means responsive to any one table starting to advance for preventing any other table from advancing until after said one table has been fully retracted, means responsive to any one table being fully advanced for actuating said press control to thereby cause said platen to be advanced and retracted, means responsive to said platen being retracted for effecting operation of said valve means to reverse the flow in said circuit and thereby cause the motor connected to said one table to retract the same, and means responsive to any table being fully retracted for effecting operation of said valve means to cause an advance movement of the table connected to the motor the starting means of which was next operated in said sequence.

12. In a press having a platen, power means for reciprocating said platen, a control adapted when actuated to cause said power means to advance and retract said platen, and a plurality of tables each of which is adapted to be advanced into and retracted from the path of said platen, the combination of a hydraulic motor connected to each table to advance and retract the same, a pump, fluid channels connecting said motors to said pump and forming therewith a hydraulic circuit, valve means for controlling the flow in said circuit and the operation of each of said motors, a starting means associated with each motor and operable to effect operation of said valve means to cause the motor associated with that starting means to advance the table connected thereto, the several starting means being operable in any desired sequence, means responsive to any one table starting to advance for preventing any other table from advancing until after said one table has been fully retracted, means for causing the speed of the advancing table to be gradually increased from zero to maximum, means responsive to a table being advanced to a given point for causing said table to be gradually decelerated, means responsive to any one table being fully advanced for actuating said press control to thereby cause said platen to be advanced and retracted, means responsive to said platen being retracted for effecting operation of said valve means to reverse the flow in said circuit and thereby cause the motor connected to said one table to retract the same, means for causing the speed of the retracting table to be gradually increased from zero to maximum, means responsive to a table being retracted to a given point for causing said table to be gradually decelerated, and means responsive to any table being fully retracted for effecting operation of said valve means to cause an advance movement of the table connected to the motor the starting means of which was next operated in said sequence.

13. In a press having a platen, power means for reciprocating said platen, a control adapted when actuated to cause said power means to advance and retract said platen, and a plurality of tables each of which is adapted to be advanced into and retracted from the path of said platen, the combination of a hydraulic motor connected to each table to advance and retract the same, a reversible variable delivery pump, fluid channels connecting said motors to said pump and forming therewith a hydraulic circuit, a pump control for causing said pump to deliver liquid into either side of said circuit and for varying pump delivery between zero and a maximum, valve means for controlling each of said motors, a starting means for each motor operation of which effects operation of said pump control and the valve means for controlling the same motor to cause said pump to deliver liquid to that motor and enable it to advance the table connected thereto, the several starting means being operable in any desired sequence, means responsive to any one table being advanced for effecting operation of said pump control to cause pump delivery to be reduced approximately to zero, means responsive to any one table being fully advanced for actuating said press control to thereby cause said platen to be advanced and retracted, means responsive to said platen being retracted for effecting operation of said pump control to reverse the flow in said circuit and thereby cause the motor connected to said one table to retract the same, and means responsive to any table being fully retracted for effecting operation of said pump control and said valve means to cause an advance movement of the table connected to the motor the starting means of which was next operated in said sequence.

14. In a press having a platen, power means for reciprocating said platen, a control adapted when actuated to cause said power means to advance and retract said platen, and a plurality of tables each of which is adapted to be advanced into and retracted from the path of said platen, the combination of a hydraulic motor connected to each table to advance and retract the same, a reversible variable delivery pump, fluid channels connecting said motors to said pump and forming therewith a hydraulic circuit, a pump control for causing said pump to deliver liquid into either side of said circuit and for varying pump delivery between zero and a maximum, valve means for controlling each of said motors, a starting means for each motor operation of which effects operation of said pump control and the valve means for controlling the same motor to cause said pump to deliver liquid to that motor and enable it to advance the table connected thereto, the several starting means being operable in any desired sequence, means responsive to any one table starting to advance for preventing any other table from advancing until after said one table has been fully retracted, means responsive to any one table being advanced for effecting operation of said pump control to cause pump delivery to be reduced approximately to zero, means responsive to any one table being fully advanced for actuating said press control to thereby cause said platen to be advanced and retracted, means responsive to said platen being retracted for effecting operation of said pump control to reverse

the flow in said circuit and thereby cause the motor connected to said one table to retract the same, and means responsive to any table being fully retracted for effecting operation of said pump control and said valve means to cause an advance movement of the table connected to the motor the starting means of which was next operated in said sequence.

15. In a system having a plurality of elements, the combination of a plurality of motors each of which is connected to one of said elements and adapted when energized to drive it in opposite directions, a power source for energizing said motors, means for controlling the delivery of energy to said motors including a separate controller for each motor, and an electric circuit having instrumentalities for operating said control means and including a starting switch for each element and adapted when operated to initiate a circuit to effect operation of said control means to cause movement in one direction of the element with which that switch is associated, a plurality of switch means each of which is operable by one of said elements at a given point in the movement thereof in said direction and adapted when operated to initiate a circuit for operating said control means to effect movement of that element in the opposite direction, a plurality of limit switches each of which is operable by one of said elements at the end of its movement in said opposite direction, means responsive to the initial movement of any one element for preventing the subsequent operation of any other starting switch from causing movement of any other element until after said one element has reached the end of its movement in said opposite direction, and means responsive to operation of any one of said limit switches for establishing a circuit to effect operation of any one of the other elements whose starting switch was operated next after the element operating said one limit switch had started to move.

16. A hydraulic drive, comprising a plurality of hydraulic motors, a source of motive liquid, fluid channels connecting said motors to said source in parallel with each other and forming therewith a hydraulic circuit, flow control means for directing liquid from said source into either or neither side of said circuit, valve means for controlling each of said motors, and an electric circuit having instrumentalities for operating said means and including a plurality of sub-circuits, a plurality of starting switches each of which is associated with one of said motors and adapted when operated to initiate energization of a sub-circuit to effect operation of said flow control means and the valve means for controlling the motor with which the operated starting switch is associated to thereby cause that motor to operate in one direction, a plurality of switch means each of which is operable by one of said motors during operation thereof in said direction and which when operated is adapted to initiate energization of a sub-circuit to effect operation of said flow control means to thereby cause that motor to operate in the opposite direction, a plurality of limit switches each of which is operable by one of said motors at the completion of its operation in said opposite direction, means responsive to initiating operation of any one motor for preventing the subsequent operation of any other starting switch from causing operation of any other motor until after said one motor has completed its operation in said opposite direction, and means responsive to operation of any one of said limit switches for energizing a sub-circuit to effect operation of any one of the other motors whose starting switch was operated next after the motor operating said one limit switch had started to operate.

17. In a system having a plurality of individually movable elements, the combination of a plurality of motors each of which is connected to one of said elements and adapted when energized to operate the same, means for energizing said motors, control means for said motors including a separate controller for each motor, a starting means associated with each motor and operable to effect operation of said control means to cause the associated motor to operate the element connected thereto, the several starting means being operable in any desired sequence, means responsive to one element starting to operate for preventing any other element from being operated, and means responsive to an element completing its operation for effecting operation of another of said motors the starting means of which was next operated in said sequence.

18. In a system having a plurality of individually movable elements, the combination of a plurality of motors each of which is connected to one of said elements and adapted when energized to operate the same, means for energizing said motors, control means for said motors including a separate controller for each motor, a starting means associated with each motor and operable to effect operation of said control means to cause the associated motor to operate the element connected thereto, the several starting means being operable in any desired sequence, means responsive to one element starting to operate for preventing any other element from being operated, means for gradually accelerating and decelerating each of said motors, and means responsive to an element completing its operation for effecting operation of another of said motors the starting means of which was next operated in said sequence.

19. In a system having a plurality of individually movable elements, the combination of a plurality of hydraulic motors each of which is connected to one of said elements and adapted when energized to operate the same, means for supplying motive liquid to said motors to energize the same, control means for said motors including a separate control valve for each motor, and an electric circuit including magnetic means for operating said control means, a starting switch associated with each motor and operable to effect operation of said control means to cause the associated motor to operate the element connected thereto, the several starting switches being operable in any desired sequence, means responsive to one element starting to operate for preventing any other element from being operated, and means responsive to an element completing its operation for effecting operation of another of said motors the starting switch of which was next operated in said sequence.

20. In a machine having a plurality of individually movable elements, a plurality of motors each of which is connected to one of said elements and adapted when energized to move it through a given cycle, and means for energizing said motors, the combination of means for controlling the delivery of energy to said motors including a separate controller for each motor, and interlocking electric circuits having devices for operating said control means and including a start-

ing switch associated with each element and adapted when operated to establish a circuit to effect operation of said control means to initiate movement of the element with which that switch is associated, a plurality of limit switches each of which is operable by one of said elements at the end of its cycle of movement, means responsive to the initial movement of any one element for preventing the subsequent operation of a starting switch from causing movement of any other

element until after said one element has reached the end of its cycle of movement, and means responsive to operation of any one of said limit switches for establishing a circuit to effect movement of any other element whose starting switch was operated next after the switch associated with the element operating said one limit switch was operated.

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