

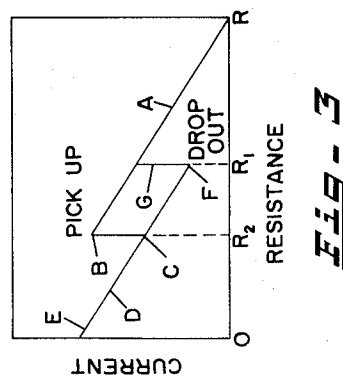
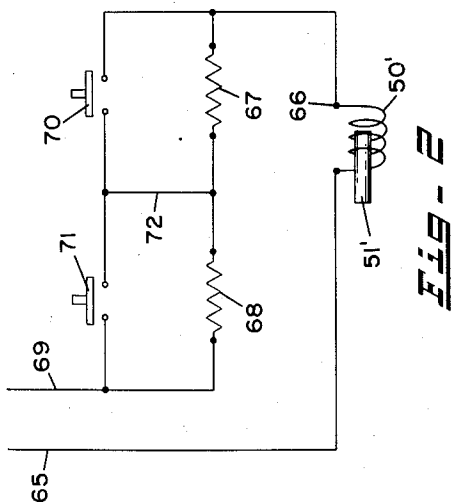
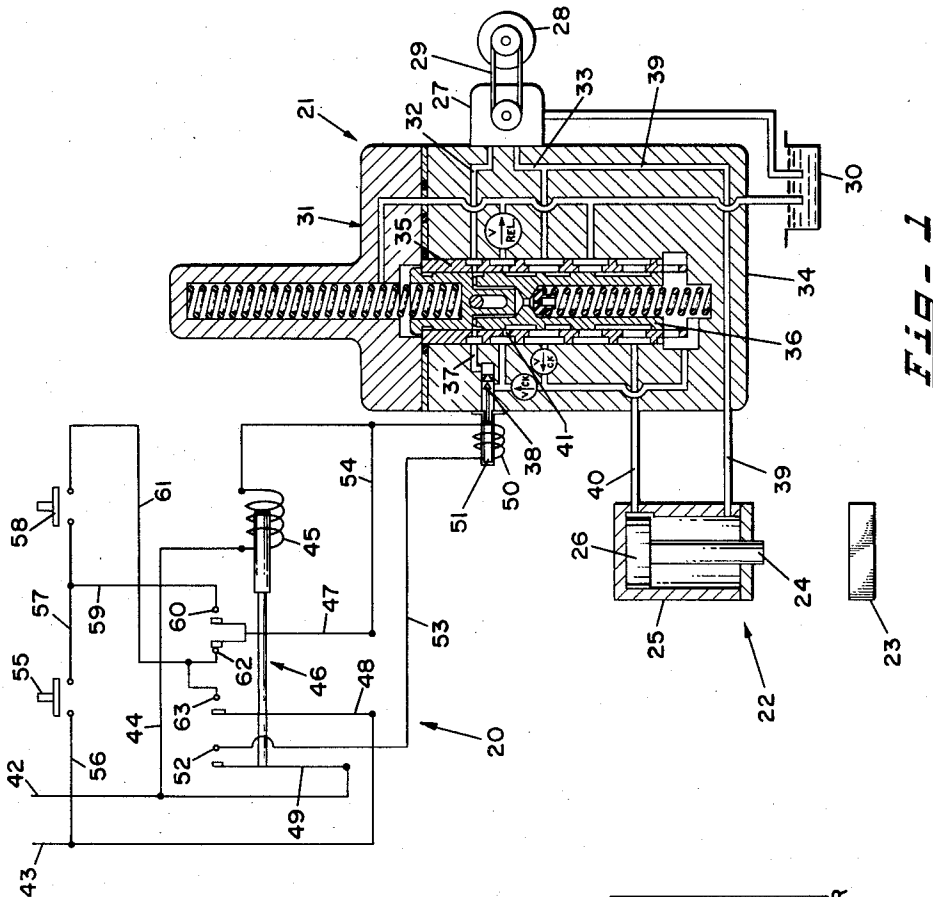
July 19, 1960

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2,945,990

ELECTRIC CONTROL CIRCUIT

Filed Feb. 23, 1956



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2,945,990

ELECTRIC CONTROL CIRCUIT

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Filed Feb. 23, 1956, Ser. No. 567,256

3 Claims. (Cl. 317-123)

This invention relates to electric apparatus and more particularly to an electric circuit or system adapted to control any solenoid actuated or operated device and which circuit or system may be employed with particular advantage, for example, for controlling the operation of a hydraulic press.

The main object of this invention is to provide an improved electric circuit which includes two switches both of which must be closed to initiate the operation of an operating solenoid and in which, after said operation is initiated, only one of said switches need be maintained closed to maintain said solenoid in operation.

Another object of the invention is to provide an improved electric circuit as set forth in the foregoing object which may be used with particular advantage in controlling the hydraulic apparatus, and consequently the operation, of a hydraulic press in which the press operator must use both of his hands to operate the mentioned switches to initiate operation of the press and after said operation is initiated the operator may release one of said switches and the pressing operation of the press will continue.

Further objects and advantages of the present invention will be apparent from the following description, reference being had to the accompanying drawings wherein a preferred form of embodiment of the invention is clearly shown.

In the accompanying drawings:

Fig. 1 is a diagrammatic showing of an electric control circuit including features of the invention, said circuit being shown associated with the hydraulic system of a hydraulic press which it controls;

Fig. 2 is a diagrammatic showing of a different electric circuit including the invention in a modified form, this circuit also being adapted to control the hydraulic system seen in Fig. 1, and

Fig. 3 is a graph showing current characteristics of a solenoid operating on alternating current and connected in series with a resistance.

Fig. 1 of the drawings illustrates an electric control circuit or system 20 associated with the hydraulic apparatus or system 21 of a hydraulic press which is indicated generally at 22. The hydraulic system 21 per se is the invention of Robert Smilges and is fully described and claimed in his co-pending application Serial No. 559,438, filed January 16, 1956, for "Hydraulic Press And Control Means." This system is made a part of this application for illustrating the operation and purpose of the present invention and it is described herein only in sufficient detail to set forth the operation of the apparatus herein claimed. For an understanding of the details and operation of the hydraulic system, reference should be had to the above identified application to Robert Smilges.

Referring more particularly to Fig. 1 of the drawings, the hydraulic press 22 is shown as being comprised of a bed 23 and ram 24. Ram 24 is shown as forming the piston rod of a double-acting reciprocating hydraulic motor

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which includes a cylinder 25 and a piston 26. The hydraulic system 21, in addition to the press motor, also includes a pump 27 which is driven by an electric motor 28 through sheaves and a belt 29, a reservoir or tank 30 for hydraulic liquid used in the system, a hydraulic control valve 31 and suitable conductors or pipes which are fully indicated in the drawing. The parts of the above described structure are shown in the drawings in the positions in which they occupy when the ram is held in its "up" position. Before describing the operation of the hydraulic system further, it should be pointed out that the pump 27 has two separate high pressure outlet or output ports which are connected respectively to conduits or lines 32 and 33 formed in the body 34 of valve 31 and that the volume of liquid delivered to the lines 32 and 33 are preferably, but not necessarily, different.

When the parts of the control valve 31 are in the positions shown in the drawings and the ram 34 is held in its "up" position, hydraulic liquid flows from the tank 30 to the inlet port of pump 27 in which it is divided and caused to flow to lines 32 and 33 as aforesaid. Liquid from the low volume output port of pump 27 flows through line 32 to a groove in a sleeve 35 in valve body 34 and from this groove 34 it passes to the interior of the sleeve 35 and to the upper end of a spool 36 and also to a conduit 37 in valve body 34 which is adapted to be closed by a solenoid operated valve 38. The construction of the control valve 31 is such that until the valve 38 is closed the spool 36 will remain in the position shown and the combined output volumes of the pump 27 will be directed through a conduit 39 to the bottom of the cylinder 25 and piston 26 to urge the latter to its "up" position. This liquid will be returned from the top of cylinder 25 through a conduit 40 to valve 31 and tank 30. Upon the closing of the valve 38, hydraulic pressure will increase above the spool 36 and shift it downwardly to close a valve 41 which is connected in series with the valve 38. After valve 41 is closed, if valve 38 is opened, the valve 31 will cause liquid to be delivered to the press motor to complete automatically one cycle of operation of the press, and all of the parts, after the completion of said one cycle, will return to the positions shown in the drawing. If the valve 38 is not open, the ram 24 will travel toward the bed 23, or work thereon, and will remain in an extended position until valve 38 is opened.

The electric circuit or system 20 controls the opening and closing of the solenoid operated valve 38 and this circuit or system includes a pair of main lead lines 42 and 43 which receive electric current from any suitable source.

Main lead line 42 is connected directly through a line 44 to one side of a coil or winding 45 of a solenoid which operates a switch mechanism 46. Switch mechanism 46 includes an overlapping switch having a compound contact arm 47 and two contacts 60 and 63, and two normally open switches including contact arms 48, 49 and contacts 63 and 52. Main lead line 42 may also be connected to one side of the coil or winding 50 of the solenoid 51 which operates the valve 38 through the contact arm 49 of switch 46, a contact 52 and a line 53. The other ends of the coils or windings 45 and 50 are connected through a line 54 to the compound contact arm 47 of switch 46.

Main lead line 43 is connected to the contact arm 48 of switch 46 and with one contact of a normally open push type switch 55 through a line 56. The other contact of switch 55 is connected through a line 57 with one contact of a second normally open push type switch 58 and a line 59 to a contact 60 of a normally open switch which is engaged by a contact on the compound contact arm 47 when coil 45 is energized. The other contact of switch 58 is connected through a split line 61 with a contact 62 which is engaged by a second contact on

the compound contact arm 47 when the solenoid winding 45 is de-energized and a contact 63 which is engaged by a contact on contact arm 48 when said winding 45 is energized.

The above described circuit is such that in order to energize the coils or windings 45 and 50 initially, both of the push type switches 55 and 58 must be closed, at least momentarily during the same time, and thereafter only one of said push type switches need be maintained closed to maintain the coils or windings 45 and 50 fully energized and the solenoid operated valve 38 closed.

In operation, in order to energize the coils or windings 45 and 50 initially, the press operator must close both of the push type switches 55 and 58. These switches are preferably positioned on the press whereby the operator must use both hands to close them in order that there will be no danger to his hands when the press operates. When the switches 55 and 58 are closed, current flows from main lead line 43 through line 56, switch 55, line 57, switch 58, line 61, contact 62, compound contact arm 47, line 54, coil 45 and line 44 to main lead line 42 thereby energizing coil or winding 45 and operating the solenoid of which it forms a part to close switch 46. When switch 46 is closed current for coil or winding 50 flows from main lead line 42 through arm 49 of switch 46, contact 52, line 53, coil 50, line 54, compound switch arm 47, contact 60, lines 59 and 57, switch 55 and line 56 to main lead line 43, or from line 57 through switch 58, line 61, contact 63, and arm 48 of switch to main lead line 43, depending upon which of the switches 55 or 58 is closed, to energize the coil 50. The construction of switch 46 is such that the switches including the contacts 52, 63 and 60 are closed before the switch including contact 62 is opened.

The energization and operation of the solenoids including the coils or windings 45 and 50 occurs very rapidly and after they are energized and switch 46 has closed contacts 63 and 60 and the switch including the contact 62 and contact arm 48 has opened, either of the push type switches 55 or 58 may be opened and coils or windings 45 and 50 will remain energized. Should switch 55 be opened current will travel from line 43 through contact arm 48, contact 63, line 61, switch 58, line 59, contact 60, contact arm 47 and line 54 to the coils or windings 45 and 50 and to line 42. Should switch 58 be opened current will travel from line 43 through lead 56, switch 55, lines 57 and 59, contact 60, arm 47 and line 54 to coils or windings 45 and 50 and to line 42. After both push type switches have been permitted to be open, it is, of course, necessary to close them at the same time, but not necessarily simultaneously, to initiate the operation of the system and the solenoid 51 which operates the valve 38. The function of the switch including contact 52 is to insure that the coil 50 can not be energized unless switch 52 has closed thereby preventing the operation of the press should the switch 52 or its operating solenoid fail for any reason.

The modified electric circuit or system shown in Fig. 2 of the drawings is also adapted to control the operation of the hydraulic system seen in Fig. 1 and this circuit is shown as including a solenoid 51' having a winding 50' for operating the valve 38 of said hydraulic system 21. In the embodiment of the invention shown in Fig. 2, one side of the solenoid coil or winding 50' receives electric current directly from the main lead line 65 and the other side 66 of coil or winding 50' is connected through a pair of resistors 67 and 68 in series to the other main lead line 69. Resistors 67 and 68 are such that when they are connected in series, as above described, insufficient current will flow through them to energize the solenoid coil 50' sufficiently to move the solenoid armature or core to its operated position, that is, insufficient current will flow through the coil 50' to operate solenoid 51'. The end 66 of coil or winding 50' may also be connected directly to lead line 69 through a pair of normally open push type switches 70 and 71 connected in series or

through either of resistors 67 and 68 and one of switches 70 and 71 and a bypass conductor or line 72 connected from between the switches 70 and 71 to between the resistors 67 and 68.

In the operation of the circuit or system seen in Fig. 2, in order to energize the solenoid 50' to operate it initially, it is necessary to close both push type switches 70 and 71 at the same time, but not necessarily simultaneously, in order to bypass both of the resistors 67 and 68 and to permit the full line current from lines 65 and 69 to flow to the coil or winding 50'. After the solenoid 51' has been energized initially by said flow of current either of the push type switches 70 or 71 may be opened and the solenoid 50' will remain in operation. Stated another way, when the circuit is employed in connection with the hydraulic system 21 it is necessary to close both push type switches 70 and 71 to close valve 38 and after said valve 38 is closed only one of said switches 70 or 71 need be maintained closed to hold the valve 38 closed.

It will be seen that after the initial operation of solenoid 51' that if switch 70 is permitted to open that the flow of current to coil 50' from lead line 69 will be through closed switch 71, bypass connector 72 and resistor 67 to side 66 of the coil 50'. It will also be seen that if switch 71 is opened that the flow of current to coil 50' from lead line 69 will be through resistor 68, bypass connector 72 and switch 70 to side 66 of coil 50'. Thus when both switches 70 and 71 are closed, both resistors 67 and 68 will be bypassed. When switch 70 is opened and switch 71 is closed, resistor 68 will be bypassed and when switch 71 is opened and switch 70 is closed resistor 67 will be bypassed.

Fig. 3 is a graph showing current characteristics of a solenoid operating on alternating current which are taken advantage of in the circuit seen in Fig. 2 of the drawings. In this graph, current flowing through the coil or winding of the solenoid is represented as a function of a resistance connected in series with the solenoid.

Referring more particularly to the graph shown in Fig. 3, R represents a resistance which will permit no current to flow through a solenoid coil and as R is decreased progressively (moved toward point O) the current which flows through the solenoid coil will increase, as indicated by the line A, up to the point B where the solenoid "picks up" and operates by shifting its core. When the current flowing in the solenoid coil increases to the "pick up" point B and the solenoid operates, the current flowing through the solenoid coil drops immediately to the point C due to the increase in impedance of the solenoid and as the resistance R is further decreased the current flowing through the solenoid coil will increase along line D up to the point E of maximum current applied to it.

When the resistance R is increased from the point O of no resistance, the current flowing through the solenoid coil decreases along line D to a "drop out" point F at which the magnetic field created by the coil of the solenoid is insufficient to maintain the solenoid in operation. Upon shifting of the solenoid core at the "drop out" point F, current flowing through the coil will rise immediately along the line G to line A due to the decrease in impedance of the solenoid and will then continue to decrease along line A as the resistance is increased.

As indicated by the graph, less resistance is required to cause the solenoid to "pick up" or operate to shift its core than is required to permit the solenoid to "drop out." Stated another way, it requires more current flowing through the solenoid coil to energize the solenoid sufficiently to cause it to operate than it requires to keep it in operation once it has been initially energized and operated.

In the electric circuit or system of Fig. 2, each of the resistances 67 and 68 is such as to offer resistance to current (which could be shown on the graph as lying at a point between R-1 and R-2) so that when either of the resistances is connected in series with the coil or winding

50' of solenoid 51' sufficient current will be applied to the coil 50' to maintain the solenoid 51' in operation once it has been initially energized by closing both push type switches 70 and 71 and so that when the resistors 67 or 68 are connected in series, as when both switches 70 and 71 are opened, the combined resistance of the resistors 67 and 68 will be such as to cause the current applied to the coil 50' to be insufficient to maintain the solenoid in operation (the combined resistances of resistors 67 and 68 would fall upon the graph somewhere between the point R-1 and R).

The hydraulic press 22 including the hydraulic apparatus or system 21 performs each cycle of operation very rapidly, that is, when valve 38 is closed the ram 28 travels toward the bed, or work on the bed, or returns to its "up" position rapidly and at such a rate of speed that an operator has not time to release any of the push type switches 55 and 58 or 70 and 71 and get either of his hands caught under the ram. He may, however, release or permit all or any one of these switches to open while the ram is traveling toward the press bed 23 or work thereon and should he permit only one of said switches to open the ram will travel only to its extended position and "dwell" at a maximum pressing pressure upon work on the bed 23.

For the reasons set forth, it will be seen that the operator can not "cheat" the system in operating the press as by blocking one of the push type switches in a closed position since in both described embodiments of the invention both of said switches 55 and 58 or 70 and 71 must be opened to cause the ram to return from its "dwell" position to its "up" position.

While the form of embodiment of the present invention as herein disclosed constitutes a preferred form, it is to be understood that other forms might be adopted, all coming within the scope of the claims which follow.

I claim:

1. An electrically operated control means including an armature; a coil for moving said armature; circuit means through which said coil is energized, said circuit means including two switch means operated by said armature, one of said switch means including normally closed and normally open contacts and operating to close its normally open contacts prior to opening its normally closed contacts, and the other of said switches having normally open contacts; a pair of switches connectible in series through said normally closed contacts to one side of said coil when the latter is unenergized and connectible individually through said normally open contacts and the contacts of said other switch with said one side of said coil when the latter is energized whereby said pair of switches must be closed at the same time to energize said coil initially and after which one only of said pair of

switches need be maintained closed to maintain said coil energized.

2. An electrically operated control means including an armature; a coil for moving said armature, a pair of supply conductors, one of which is connected to one side of said coil; circuit means for connecting the other of said supply conductors to the other side of said coil, said circuit means including two switch means operated by said armature, one of said switch means including normally closed and normally open contacts and operating to close its normally open contacts prior to opening its normally closed contacts, the other of said switch means being normally open; a pair of switches; conductor means for connecting the other of said supply conductors, said normally closed contacts, said pair of switches and the other side of said coil in series when the latter is unenergized; and conductor means connecting said other supply conductor through said normally open switch, one switch of said pair of switches, and said normally open contacts with said other side of said coil when the latter is energized whereby said pair of switches must be closed at the same time to energize said coil initially and after which one only of said pair of switches need be maintained closed to maintain said coil energized.

3. An electric circuit including a control solenoid having a coil; a control circuit for said solenoid coil including relay switch means having a first pair of normally open contacts, a second pair of normally open contacts, a pair of normally closed contacts, and an operating coil, said relay operating to close said second pair of normally open contacts prior to opening said normally closed contacts; a pair of switches connectible in series between a supply conductor through said normally closed contacts to one side of said coil when the latter is unenergized, and conductor means connecting one switch of said pair of switches, said first pair of normally open contacts and the second pair of normally open contacts in series with said one side of said coil when the latter is energized, one contact of said first pair of normally open contacts also being connected to said supply conductor whereby both of said switches must be closed at the same time to energize said relay coil initially and after which one only of said switches need be maintained closed to maintain said relay coil energized.

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