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ELECTRIC CONTROLLERS FOR MACHINES

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Fig. 1

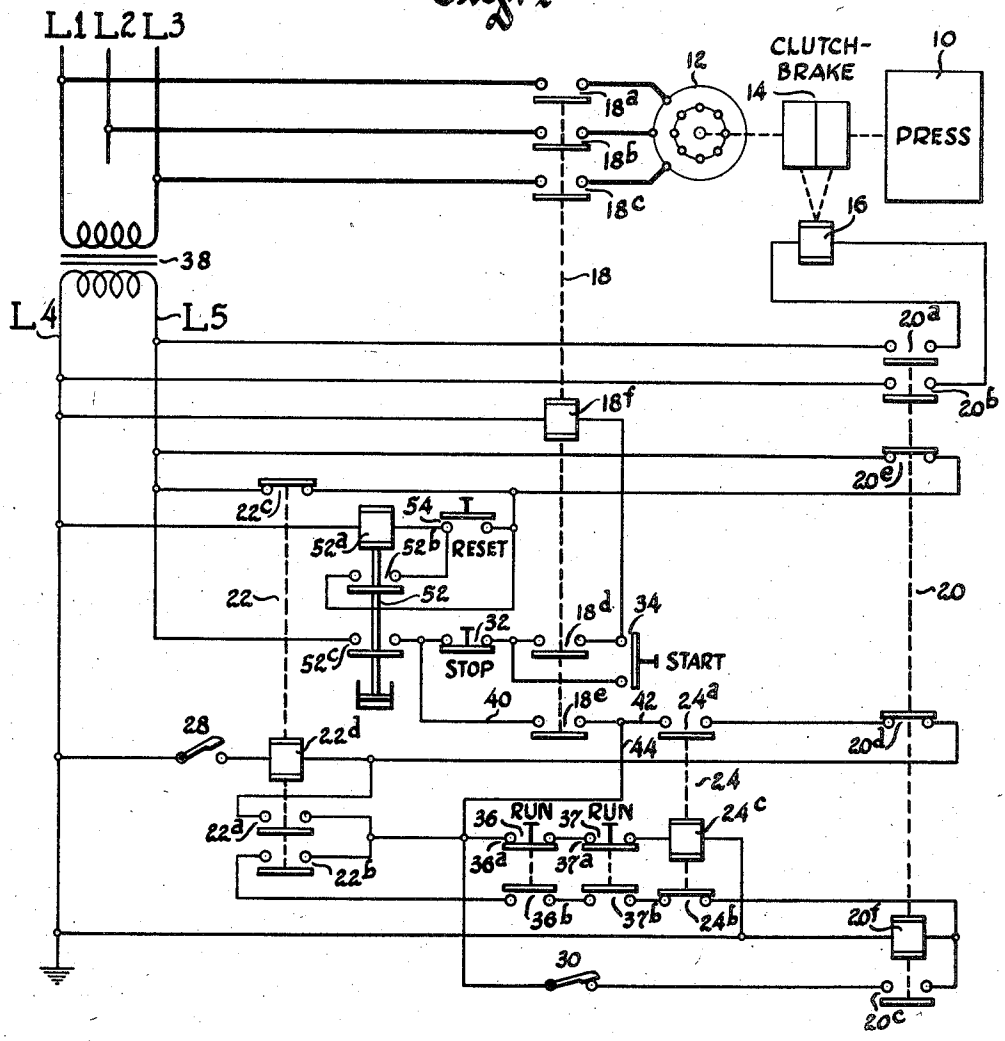
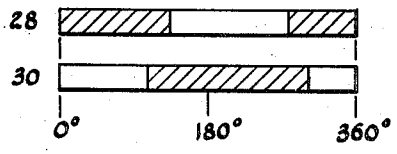


Fig. 2



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ELECTRIC CONTROLLERS FOR MACHINES

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4 Claims. (Cl. 192—144)

This invention relates to improvements in electric controllers for effecting "single-cycle" operation of machines.

An object of the invention is to provide an electric controller of the character described in which is incorporated improved safety means.

In their efforts to provide machine controllers which will protect machine operators against their own carelessness and willingness to take dangerous risks, control engineers have tried to anticipate all of the dangerous actions possible to be taken by the operator and to design control equipment which will prevent personal injury caused by the taking of such actions. For example, it is common, in controllers for forming presses and certain other machine tools, to provide two spaced Run buttons for each operator. The buttons must be held, one with each hand, until the punch and die have closed so that a hand may not be inserted between them. To insure that the operator cannot defeat the purpose of the Run buttons by fastening them down, the controller is arranged so that all of the Run buttons must be released and then reclosed before another cycle of press operation can be initiated.

Such "single-cycle" machine operation can be accomplished with a source of supply power, an operator's switch having normally open and normally closed contacts, first and second machine operated switches, a "non-repeat" electromagnetic contactor having two normally open contacts and electro-responsive means to start and stop machine operation. The first machine operated switch is connected across the supply source in series with the coil of the contactor and a parallel circuit the branches of which contain, respectively, a contact of the contactor and the normally closed contact of the operator's switch. The electro-responsive means is connected across the source in series with a parallel circuit having the second machine operated switch in one branch and the other contact of the contactor and the normally open contact of the operator's switch in series in the other branch. Of course, many variations of this "single-cycle" circuit are possible.

A specific object of this invention is to provide in a "single-cycle" circuit, means to insure safe operation of the controlled machine if the "non-repeat" elements should fail.

The safety and control functions of the controller are so closely related that a change in components or circuitry to provide one function may effect the performance of the controller in respect of other functions. The problem is to provide all of the desired functions in such a way as to preclude dangerous malfunctioning of the controller and the machine in the event that one component or circuit should fail.

Accordingly, a broader object of the invention is to provide a control scheme which will provide the safety and machine control features which are commonly provided and which in addition will "fail-safe" so that upon failure of any component the press or machine will come to rest immediately or at the end of its stroke.

Another object of the invention is to provide a controller in which the foregoing safety features are extended to include control of the drive motor for the machine as well as for the machine itself.

Other objects and advantages of the invention will hereinafter appear.

The accompanying drawings illustrate one embodiment of the invention, it being understood that various modifications may be made in the embodiment illustrated and that other embodiments are possible to be made without departing from the spirit of the invention and the scope of the appended claims.

In the drawing,

Figure 1 is a diagrammatic illustration of an electric controller embodying the invention; and

Fig. 2 is a chart illustrating the operation of the controller of Fig. 1.

Referring to the drawing, there is shown a mechanical press, or other machine having a cyclically driven element 10 which is driven by a three phase electric motor 12 through the medium of a Clutch-Brake combination 14 when a solenoid 16 is energized. Power for the motor 12 is supplied from a suitable three phase alternating power source such as lines L1, L2 and L3.

The function of the remainder of the system is to control energization of motor 12 and solenoid 16. Only so much of the control system is illustrated as is necessary to "single-cycle" or "non-repeat" operation of the machine or press 10. In this mode of operation it is intended that the motor 12 be run continuously. Each cycle of press operation is to require operation of a push-button; and, the pushbutton must be released before another cycle of machine operation can be initiated.

The control circuit comprises: a main electromagnetic contactor 18 having normally open contacts 18^a, 18^b, 18^c, 18^d and 18^e and an energizing coil 18^f; a control contactor 20 having normally open contacts 20^a, 20^b and 20^c, normally closed contacts 20^d and 20^e and an operating coil 20^f; a first "non-repeat" contactor 22 having normally open contacts 22^a and 22^b, normally closed contact 22^c and an energizing coil 22^d; a second "non-repeat" contactor 24 having normally open contact 24^a, normally closed contact 24^b and an energizing coil 24^c; limit switches 28 and 30 which are operative at selected positions of the movable element of the machine; a normally closed Stop switch 32; a normally open Start switch 34; Run buttons 36 and 37 having normally closed contacts 36^a and 37^a and normally open contacts 36^b and 37^b; a Reset button 54; and a timing relay 52 having an energizing coil 52^a and normally open contacts 52^b and 52^c which close rapidly but are opened at a selected time following de-energization of coil 52^a.

Power for the control circuits is supplied by lines L4 and L5 from lines L1 and L3 through an isolating transformer 38. When more than one operator is required to operate the press additional pushbuttons are provided. The limit switches 28 and 30 may be mechanically connected to the machine directly or indirectly and may be mechanically or electrically operated.

Fig. 2 illustrates the operation of limit switches 28 and 30, the darkened areas indicate a closed limit switch contact and the un-darkened areas indicate an open limit switch contact. The left- and right-hand side of Fig. 2, marked 0 degrees and 360 degrees respectively, indicate the upper extreme position of the ram of press 10. The 180 degree position in Fig. 2 indicates the lower extreme position of the ram of press 10.

The brake portion of the Clutch-Brake combination 14 is arranged to stop the press 10 with its ram at its uppermost or zero position. When the ram is in this position, limit switches 28 and 30 are closed and open, respectively.

Energization of the motor 12 and the control circuit

is initiated by pressing Reset button 54 to complete a circuit from line L4 through coil 52^a of relay 52, the Reset button, and through normally closed contact 20^e, and through normally closed contact 22^c to line L5. Contact 52^b closes to establish a maintaining circuit for coil 52^a around the Reset button 54. Contact 52^c of relay 52 closes to complete a circuit from line L5 to a conductor 40 and through Stop switch 32 to the Start switch 34. Upon closure of Start switch 34, the latter circuit is continued through coil 18^f of relay 18 to line L4. Upon energization of coil 18^f, contacts 18^a, 18^b and 18^c are closed to energize and effect operation of motor 12. Contact 18^d closes to complete a maintaining circuit for coil 18^f. Contact 18^e is closed to complete a circuit from conductor 40 to conductors 42 and 44.

The energizing coil 24^c of contactor 24 is then energized through a circuit which may be traced from conductor 44 through normally closed contacts 36^a and 37^a of Run buttons 36 and 37 and coil 24^c to line L4. Contactor 24 picks up to open its contact 24^b and to close its contact 24^a. Closure of the latter contact completes a circuit from conductor 42 through contact 24^a, normally closed contact 20^d, energizing coil 22^d of contactor 22 and limit switch 28 to line L4. Energization of coil 22^d results in the opening of contact 22^c and closure of contacts 22^a and 22^b.

Closure of contact 22^a completes a maintaining circuit for coil 22^d around contacts 24^a and 20^d. Closure of contact 22^b completes a circuit from conductor 44 through contact 22^d to one terminal of normally open contacts 36^b of Run button 36.

To effect energization of solenoid 16 to release the brake and connect the clutch of Clutch-Brake 14 for operation of the press 10 by motor 12, the press operator must depress the Run buttons 36 and 37 to open contacts 36^a and 37^a and close contacts 36^b and 37^b. By this action coil 24^c is de-energized and contact 24^a is opened. Coil 22^d remains energized by virtue of the maintaining connection through its contact 22^a.

Contact 22^b remains closed and current flows from conductor 44 through contact 22^b, through the now closed contacts 36^b and 37^b of Run buttons 36 and 37 and the now closed contact 24^b of contactor 24, and through energizing windings 20^f of contactor 20 to line L4. Contactor 20 is actuated to close contact 20^a and 20^b to complete a circuit from line L5 through solenoid 16 to line L4. The Clutch-Brake combination 14 interconnects press 10 and motor 12 and the press begins to move. At the same time, contact 20^c closes and contacts 20^d and 20^e open.

Upon opening of contact 20^e, the energizing circuit for coil 52^a is interrupted to begin a timing operation after which contacts 52^b and 52^c will open unless contact 22^c is reclosed first.

Energization of coil 22^d is maintained through its contact 22^a. Although contact 24^a is closed, coil 22^d is not energized from conductor 42 because contact 20^d is open.

After the press parts have moved to a position in which the operator cannot get hurt, limit switch 30 closes to complete a maintaining circuit for coil 20^f from conductor 44, through limit switch 30, through the now closed contact 20^c and through coil 20^f to line L4. The operator may, and normally does, release the Run button 36 at this time. Upon release of the Run button, contacts 36^a and 37^a are closed and coil 24^c is re-energized to close its contact 24^a preparatory to re-establishment of the main energizing circuit for coil 22^d. Coil 24^c having been re-energized, contact 24^b opens. A short time later in the cycle of press operation, limit switch 28 opens to de-energize coil 22^d. Contact 22^a is opened to open the maintaining circuit for coil 22^d. Contact 22^b is opened to open the main energizing circuit for coil 20^f. Contact 22^c closes to re-establish the maintaining circuit for coil 52^a before contacts 52^b can open.

Somewhat later in the cycle of press operation limit switch 28 re-closes. Coil 22^d is not energized because its maintaining contact 22^a is open and its main energizing circuit is open at contact 20^d. Near the end of the cycle of press operation, limit switch 30 opens to interrupt the maintaining circuit for coil 20^f. Coil 20^f is de-energized to open contacts 20^c, 20^a and 20^b and to de-energize solenoid 16 and operate the Clutch-Brake combination 14 to stop the press 10 when the ram reaches the top of its stroke. The control circuit has now been returned to its original condition following closure of Start switch 34. A new cycle of press operation may be initiated by operation of Run buttons 36 and 37.

Contact 20^e is connected in parallel with contact 22^c so that the motor 12 can continue to run during periods when the press is stopped. The press stops with its ram in the uppermost position. Contact 22^c is open so that the main energizing circuit for the coil 52^a of the timing relay is interrupted. But contact 20^e is closed, when the press is stopped, to establish an auxiliary energizing circuit for coil 52^a.

The operator cannot cause the press to run continuously by keeping the Run buttons depressed throughout the entire operating cycle of the press. If he attempts to do so, contact 24^a will remain open. After relay 22 is de-energized by the opening of limit switch 28 and after contact 22^b opens, an energizing circuit cannot be established for coil 20^f even though contacts 36^b, 37^b and 24^b are all closed. The control circuit "checks" itself on each stroke of the press. If a failure should occur, the circuit will "fail safe" and prevent commencement of the next press stroke.

Upon failure of supply power, contactor 18 drops out and the motor and press both stop. The Reset and Start buttons must be operated to restart the motor.

If relay 22 fails to pick up, coil 20^f cannot be energized. If contactor 22 fails to drop out, contacts 52^b of relay 52^a will open to interrupt the energizing circuit for coil 52^a and contacts 52^c will open to de-energize coil 18^f and conductor 40. The motor and the control circuit will be de-energized and the motor and press will stop. These results are obtained even if the operator fails to release the Run button during a press stroke.

If contactor 24 fails to pick up, contactor 22 cannot be energized and the press will stop at the end of its stroke. If contactor 24 fails to drop out, contactor 20 cannot be energized and a new cycle of press operation cannot be initiated.

If "dummy" plugs are inserted in the Run button stations, contactor 24 will continue to be energized so that contactor 20 cannot be energized. Thus a new cycle of press operation cannot be initiated.

If contactor 20 fails to pick up, the solenoid 16 cannot be energized and the press cannot be started. If contactor 20 fails to drop out, its normally closed contact 20^d will be open so that the energizing circuit to coil 22^d will be open. Therefore, contact 22^d will be opened and it will be impossible to re-energize coil 20^f even though the Run button is operated properly.

We claim:

1. In an electric controller for a cyclically operable machine driven by an electric motor through a clutch, said controller being of a type having electro-responsive means sensitive to energization and deenergization to operate the clutch to engage and disengage the machine and motor, a main electromagnetic contactor to control energization of the motor and an energizing circuit for the main contactor and a control circuit for effecting cyclic operation of the machine through the medium of the clutch, said control circuit comprising an operator's switch having normally open and normally closed contacts, a limit switch operated by the machine to open its contacts during a portion of the operating cycle of the machine, a second electromagnetic contactor in series with the limit switch and being dependent for initial energization on closure of the normally closed contacts of the

operator's switch, and an energizing circuit for said electro-responsive means comprising in series the normally open contacts of the operator's switch and a normally open contact which is closed in response to energization of said second contactor, the improvement which comprises, an electromagnetic timing relay having a safety contact in series with the energizing circuit of the main contactor and the second contactor and the electro-responsive means, and an energizing circuit for the timing relay comprising in series with the relay parallel branches one containing a normally closed contact operated in response to energization of the second contactor and the other containing a normally closed contact which is operated in response to energization of the electro-responsive means, the timing relay acting when energized to close its contact and to open said contact after a time interval longer than the duration of said portion of the cyclic operation of the machine following de-energization of said timing relay unless the latter is re-energized sooner.

2. In an electrical controller for an electric motor driven cyclically operable machine having means including electro-responsive means to complete and interrupt the driving connections to the machine, in combination, a first electromagnetic contactor energizable to complete an energizing circuit for the electro-responsive means, a second electromagnetic contactor, an electromagnetic relay having means affording it time delay drop out, means including means under the control of said second contactor for completing a first energizing circuit for said relay whenever said second contactor is deenergized and further including means under the control of said first contactor for completing a second energizing circuit for said relay whenever said first contactor is deenergized, a manual switch, a second switch operable to close circuit during a selected portion of the cycle of the machine,

means for completing an energizing circuit for said second contactor whenever said manual switch is in a first position and said second switch closes circuit, and means including means under the control of said relay for completing an energizing circuit for said first contactor whenever said relay is energized and said manual switch is operated to a second position, said means affording time delay drop out of said relay providing maintenance of energizing connections for said first contactor for a predetermined period in which completion of the selected portion of the cycle of the machine drop out of said second contactor and recompletion of said first energizing circuit for said relay normally occurs.

3. The combination according to claim 2 wherein said relay has an operating winding and normally open contacts, wherein the means under the control of said first and second contactors respectively comprise normally closed contacts which when closed complete said second and first energizing circuits respectively for the operating winding of said relay and wherein the normally open contacts of said relay are in said energizing circuit for said first contactor to afford drop out of the latter in the event said second contactor fails to drop out upon expiration of said predetermined period.

4. The combination according to claim 2 together with a fourth electromagnetic contactor and means for completing an energizing circuit for said fourth contactor which is interruptible by drop out of said relay.

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