May 11, 1965 F. H. HOLLAND 3,183,377

ELECTRICAL CONTROL CIRCUITS

Filed May 3, 1961 4 Sheets-Sheet 1

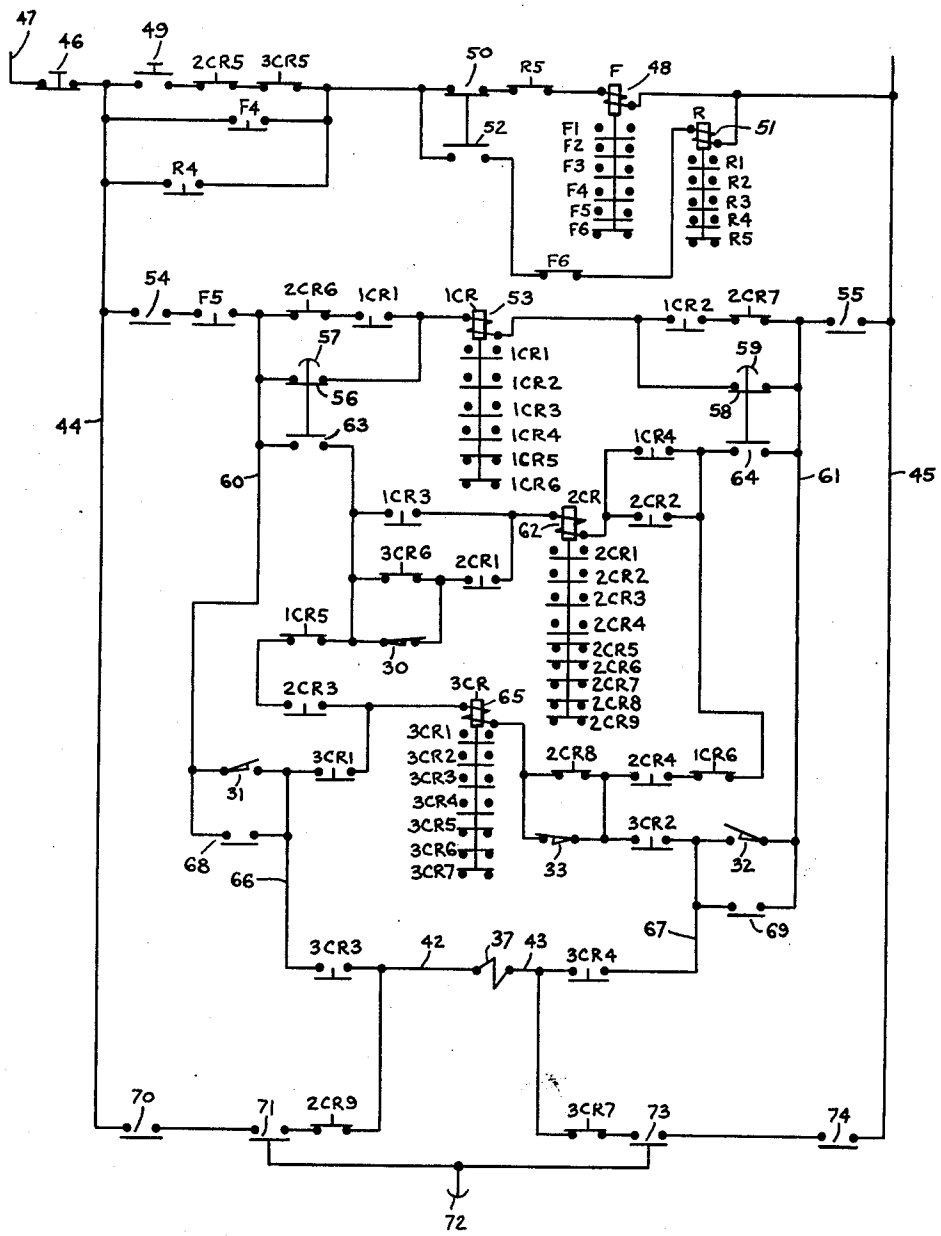


Fig. 1

INVENTOR.
FRANK H. HOLLAND
BY Charles Putnam

May 11, 1965 F. H. HOLLAND 3,183,377

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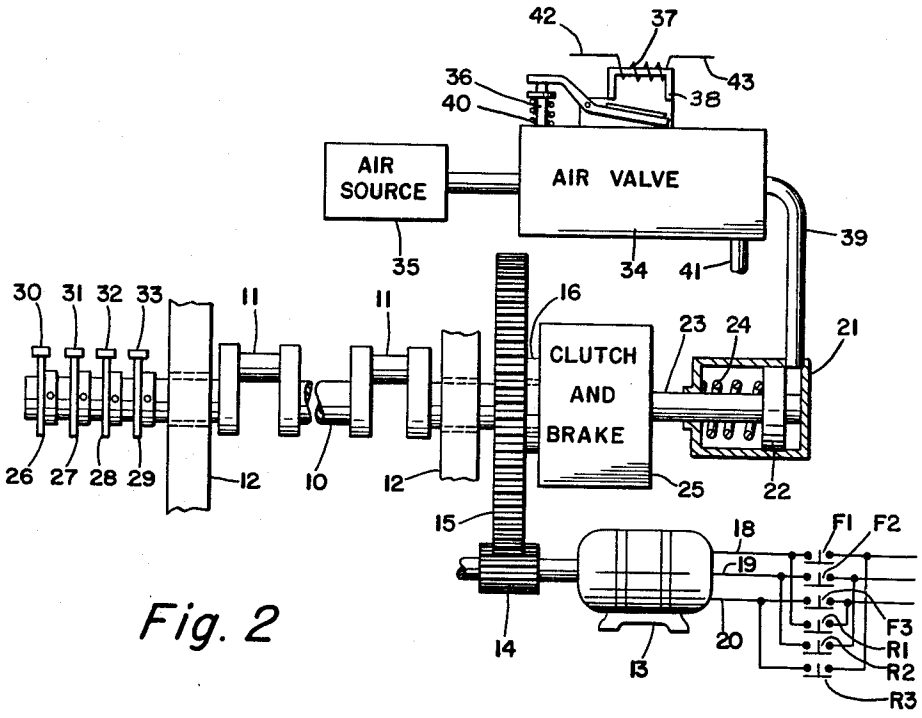


Fig. 2

OPERATION	CONTACTS					
	54	55	68	69	70	74
RUN	X	X				
CONTINUOUS	X	X	X	X		
INCH					X	X

X — DENOTES CLOSED

Fig. 3

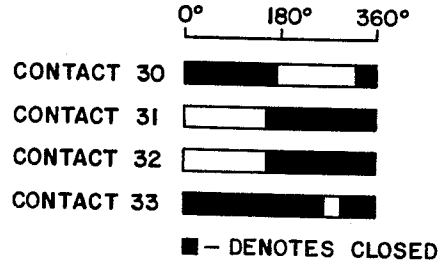


Fig. 4

INVENTOR.
FRANK H. HOLLAND
BY Charles D. Putnam

May 11, 1965 F. H. HOLLAND 3,183,377

ELECTRICAL CONTROL CIRCUITS

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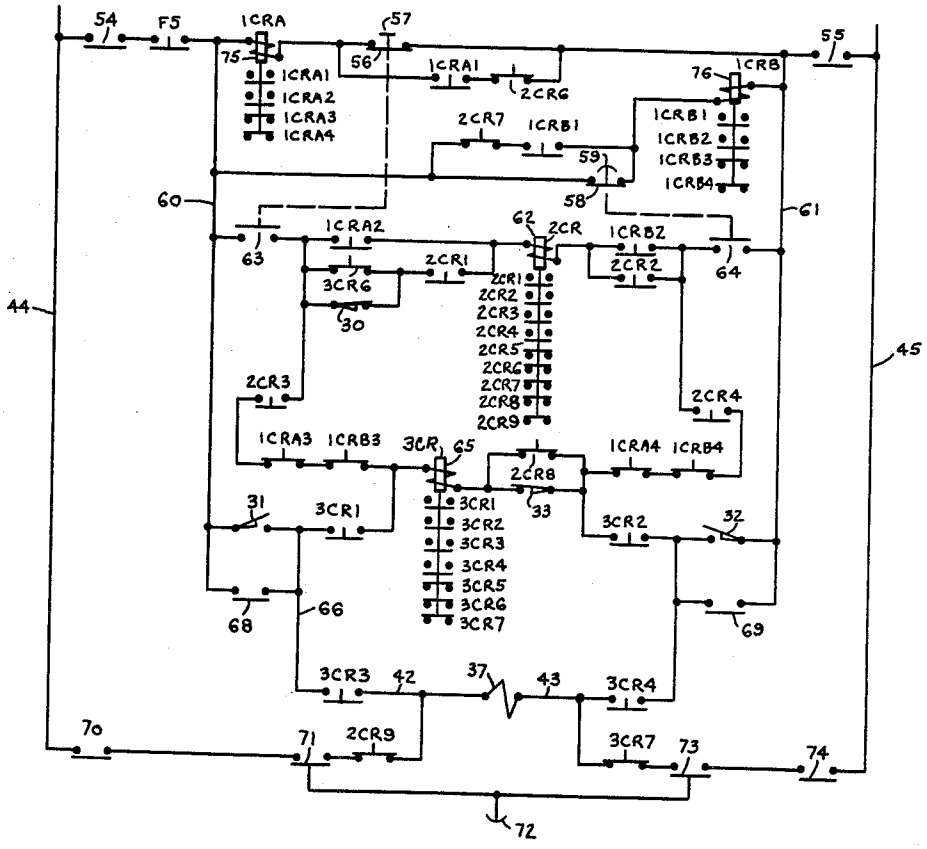


Fig. 5

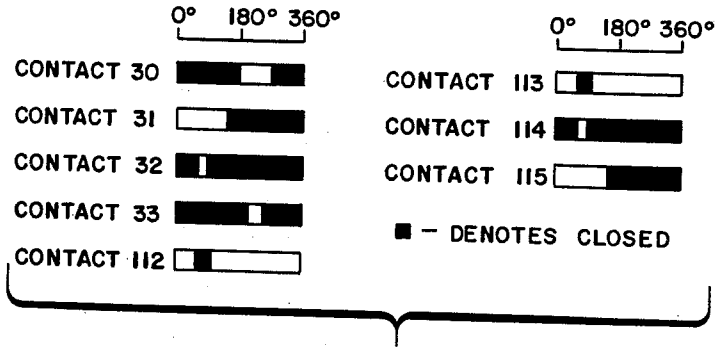


Fig. 7

INVENTOR.
FRANK H. HOLLAND
BY Charles D. Putnam

May 11, 1965 F. H. HOLLAND 3,183,377

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Filed May 3, 1961 4 Sheets-Sheet 4

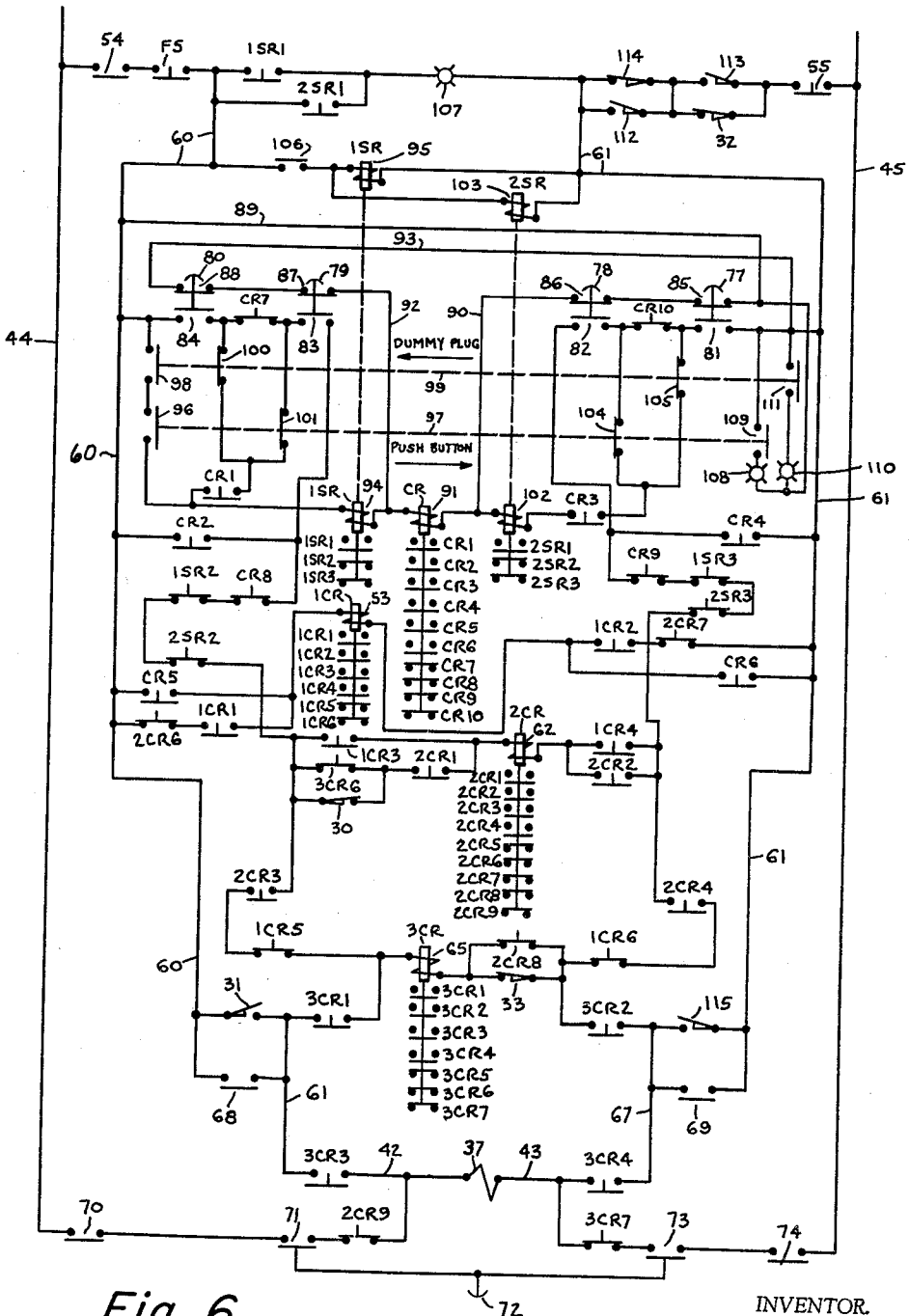


Fig. 6

INVENTOR.
FRANK H. HOLLAND
BY Charles R. Putnam

United States Patent Office 3,183,377 Patented May 11, 1965

3,183,377

ELECTRICAL CONTROL CIRCUITS

Frank H. Holland, Cleveland, Ohio, assignor to The Clark Controller Company, Cleveland, Ohio, a corporation of Ohio

Filed May 3, 1961, Ser. No. 123,603
34 Claims. (Cl. 307—113)

My invention relates to electrical control circuits and more particularly to electrical control circuits for safely controlling the operation of a punch press.

Punch presses may be of many varied sizes and types. One type utilizes a continuously running motor driving a flywheel. The flywheel is engaged with and disengaged from the press shaft by means of an air operated clutch. An air operated brake is utilized to rapidly stop and hold the press when desired. An air valve is utilized to control the flow of air from an air source to the clutch and brake, and the air valve is controlled by a winding on an electromagnet.

A second type of punch press utilizes an eddy current clutch and brake which perform the same functions as the air operated clutch and brake. The eddy current brake and clutch are controlled by an electromagnetic winding. The eddy current brake is used in stopping the press and a friction brake is used to assist in stopping and to hold the press.

Another type of punch press is a direct connected press. Here the motor is connected directly to the press ram and the operation of the press ram is controlled by the starting and stopping of the motor. The motor is controlled by a starter having an electromagnetic winding. A friction brake is also used to stop and hold the press when desired.

In the normal operation of most presses, the operating personnel are required to place their arms between the dies of the press to feed material to the press, remove the punched parts from the press, and to clean the press. It is therefore seen that presses are potentially dangerous should the control equipment malfunction causing the press to operate when not desired.

Therefore, it is the primary requirement that control for operating a punch press provide the optimum in ultimate safety to personnel, protection for the expensive equipment while still maintaining the maximum production rates.

Heretofore, press control systems have been devised whereby the operator is required to keep his hands on separate push buttons during the time that the press ram is moving downward to engage the dies. One such control system is illustrated by United States Letters Patent Number 2,299,007.

However, these systems were not capable of protecting against changes made by the operators themselves in order to increase their piece rate, nor were they capable of protecting against the mulfunction of the control components.

It is therefore the primary object of my invention to provide a press control circuit which will overcome the above mentioned difficulties and which will provide maximum safety in its operation.

It is another object of my invention to provide a press control circuit which prevents operation should any of the normally open contacts of the operator's push buttons be short circuited.

It is still another object of my invention to provide a press control circuit which will stop the operation of the press should the limit switches or their contacts not be operating properly.

A further object of my invention is to stop the press

should a control device connected in the circuit fail to operate properly when required to do so.

A still further object of my invention is to provide a press control circuit which requires that all operator's push buttons be released before the press can be restarted at any point in its operating cycle.

The present embodiment of my invention utilizes a pair of push buttons for each operator, each push button has a normally open and a normally closed contact. A first contactor is connected to be energized through the normally colsed contacts of the push buttons. Once energized, the first contactor holds itself in through its own contacts.

A second contactor is connected to be energized through the normally open contacts of the push button and normally open contacts of the first contactor. When the push buttons are depressed by the operator, the second contactor is energized through the described circuit to operate and close its contacts. The second contactor then is maintained energized through the normally open contacts of the push buttons and its own contacts. A contact of the second contactor is connected so when operated, it opens the energizing circuit of the first contactor, causing it to become de-energized.

A third contactor is connected to be energized through normally open contacts of the second contactor and normally closed contacts of the first contactor and the normally open contacts of the push buttons.

After operation of the third contactor, the device controlling the operation of the punch press, the air valve or main motor starter, as the case may be, is energized through the normally open contacts of the push button, the normally closed contacts of the first contactor and normally open contacts of the second and third contactors.

The press is then connected to operate and its ram moves downward. Should the operator remove either hand or both from the push buttons, the normally open contacts of the push button will open the circuit energizing the press controlling device and the press will stop immediately. The second and third contactors are also de-energized, and the operator must release both push buttons to re-energize the first contactor. Then, depress both push buttons to re-energize the second and third contactors before he can restart the operation of the press.

Contacts of cyclically timed switches are connected in the circuit so that after the press ram has gone beyond the point where the operator cannot injure himself, the energization of the press operating device is transferred from the normally open contacts of the push buttons to the contacts of the cyclically timed switches. These contacts open at the end of each stroke to stop the press, unless the operator has properly released and then depressed the push buttons.

Throughout the operation cycle of the press, the components of the circuit are checked by the operation of the circuit to ensure that they have operated properly. If one of the components should fail for any reason whatsoever, the press will stop when it reaches the point in the operating cycle where the failed device is checked or should have operated.

A second embodiment of my invention protects against false operation of the press should the normally open contacts of the push button become short circuited. For presses having only one operator, a single pair of push buttons is used and the first contactor is replaced by two contactors. Each contactor is connected in series with a different one of the normally closed push button contacts. Therefore, if one of the push button normally open contacts is shorted, the second contactor can-

not become energized to operate the press if only one push button is depressed.

For presses having more than one operator, a setup contactor is connected to be energized through the normally closed contacts of all the operator push buttons. When this contactor is energized, its various contacts set up a circuit for each normally open push button contact to connect one side of the source to a latch relay. If any of the normally open contacts are shorted, the latch relay operates and mechanically holds its contacts operated to prevent operation of the press. The other side of the latch relay is connected to the other side of the source through the push button normally closed contacts. Because it is desirable to have one each of the push button pairs on either side of the line, it is necessary to have two latch relays, one to check the normally open contacts on each side of the source.

A third embodiment of my invention checks the limit switch contacts from failure to operate or from the limit switch from becoming disconnected from the press. This is accomplished by having a second limit switch separately connected to the press and connected into the circuit so that it is mandatory that the limit switch contacts operate properly each cycle of press operation. If they do not, the power is removed from the circuit causing the press to stop.

Many other objects and advantages of my invention will become readily apparent to those skilled in the art when the following description is read with reference to the drawings in which:

FIGURE 1 is a schematic representation of the circuit for operating the press controlling device;

FIGURE 2 is a diagrammatic representation of a press and its operating equipment;

FIGURE 3 is a diagrammatic representation of a selector switch to illustrate the condition of its contacts in its various operated positions;

FIGURE 4 is a diagrammatic representation of the condition and operating points for the contacts of the limit switches in FIGURES 2 and 5 with respect to the press operating cycle;

FIGURE 5 is a schematic representation of a press control circuit to illustrate another embodiment of my invention;

FIGURE 6 is a schematic representation of a press control circuit illustrating a variation from FIGURE 5;

FIGURE 7 is a diagrammatic representation of the condition and the operating points for the contacts of the two limit switches of FIGURE 6 with respect to the operating cycle of the press.

Reference is first made to FIGURE 2 which illustrates part of an air clutch type press mechanism, it being understood that my invention can be used with other types of presses and that reference to this particular type of press mechanism is made only, to describe a mode of operation, as is required by law.

A main shaft 10 of the press is provided with cranks 11—11 to reciprocate the press ram, in a well known manner, and is rotatably supported in bearings on a main frame 12. Shaft 10 is driven by a motor 13 through a motor pinion 14 and a gear 15. Gear 15 has a hub 16 and is normally rotated idly on main shaft 10 like a flywheel.

Motor 13 is connected to a source of A.C. supply 17 by lines 18, 19 and 20.

A pneumatic cylinder 21, supported on main frame 12 of the press, has a piston 22 therein with a piston rod 23 projecting therefrom. Piston 22 is normally retracted by a spring 24.

Hub 16 and piston rod 23 project into a clutch and brake mechanism indicated diagrammatically at 25. The mechanism comprises elements, by which, when piston 22 is retracted by spring 24, the brake grips shaft 10 and stops the press. When piston rod 23 is projected forwardly, by fluid pressure behind piston 22, the brake is released and hub 16 is connected to shaft 10 by the clutch to cause gear 15 to drive shaft 10 and the press. The clutch is released when piston rod 23 is retracted to its rearward position by spring 24.

On the free end of shaft 10 are mouted cams 26 to 29 that rotate with shaft 10 and operate contacts 30 to 33, respectively, to open and close them. The cams are adjustable around shaft 10 to cause the contacts to operate at preselected times or points in the press cycle. In most practical applications, the cams and cam operated contacts are not an integral part of the press, but take the form of a limit switch which is mechanically connected to shaft 10.

An air valve housing 34 communicates with a source of air 35 under pressure. Within housing 34 is a main valve, not shown, controlled by a reciprocal pilot valve indicated at 36. Pilot valve 36 is reciprocated to its operated position upon energization of a winding 37 of an electromagnet 38. When winding 37 is energized, the main valve is operated by air pressure to effect communication of air pressure through a conduit 39 to cylinder 21 and moves piston 22 and rod 23 forwardly to operate clutch and brake mechanism 25, starting operation of the press.

When winding 37 is de-energized, a spring 40 restores pilot valve 36, causing the main valve to restore and cut off communication of fluid pressure to conduit 39 and open exhaust conduit 41. Cylinder spring 24 returns piston rod 23 and operates clutch and brake mechanism 25 to release the clutch and set the brake to stop the press.

Part of the energizing circuit for winding 37 is shown at 42–43.

The air valve described above, operating responsive to energization and de-energization of a winding, and shown diagrammatically in FIGURE 2, may be that constituting the subject matter of United States Letters Patent 2,902,052, issued on September 1, 1959 to which reference may be had for structural details.

In FIGURE 1, which illustrates the invention as applied to press controls, the aforesaid contacts 30 to 33, the electromagnet 38 and its winding 37 and the energizing circuit 42–43 are reproduced from FIGURE 2 with the same reference numerals.

Wires 44 and 45 are connected to a suitable source of alternating current. Wire 45 directly, and wire 44 through a normally closed "stop" push button 46 and a wire 47.

Connected across wires 44 and 45 is a contactor F having a winding 48 and normally open contacts F1 through F5 and a normally closed contact F6. The circuit consists of a "start" push button 49, contact 2CR5, contact 3CR5, contact 50 of a key operated selector switch, contact R5, winding 48.

Contact F4 is connected in parallel with "start" push button 49, contact 2CR5 and contact 3CR5. Contact R4 is connected in parallel with contact F4.

A second contactor R, having a winding 51 and normally open contacts R1 through R4 and normally closed contact R5, is connected in parallel with key operated selector switch contact 50, contact R5 and winding 48 of contactor F. This circuit consists of a second contact 52 of the key operated selector switch, contact F6 and winding 51 of contactor R.

Contacts F1 to F3 of contactor F, when closed, connect motor 13 to source 17 through wires 18, 19 and 20 to operate motor 13 in the forward direction (see FIGURE 2).

Contacts R1 to R3 of contactor R, when closed, connect motor 13 to source 17 through wires 18, 19 and 20 to operate motor 13 in the reverse direction.

A contactor 1CR, having a winding 53 and normally open contacts 1CR1 to 1CR4 and normally closed contacts 1CR5 and 1CR6, is connected across lines 44 and 45 by a circuit consisting of selector switch contact 54, contact F5, contact 2CR6, contact 1CR1, winding 53 of

contactor 1CR, contact 1CR2, contact 2CR7 and selector switch contact 55. Normally closed contact 56 of a push button 57 is connected in parallel with contact 2CR6 and contact 1CR1. Similarly, normally closed contact 58 of a push button 59 is connected in parallel with contacts 1CR2 and 2CR7.

A wire 60 is connected to this circuit between contact F5 and contact 2CR6. A second wire 61 is connected to this circuit between contact 2CR7 and selector switch contact 55.

A contactor 2CR, having a winding 62 and normally open contacts 2CR1 to 2CR4 and normally closed contacts 2CR5 to 2CR9, is connected across lines 60 and 61 by a circuit consisting of normally open contact 63 of push button 57, contact 1CR3, winding 62 of contactor 2CR, contact 1CR4, and normally open contact 64 of push button 59. Contact 3CR6 and contact 2CR1 are connected in parallel with contact 1CR3. Contact 2CR2 is connected in parallel with contact 1CR4. Contact 30 of the cyclically timed switch is connected in parallel with contact 3CR6.

Another contactor 3CR, having a winding 65 and normally open contacts 3CR1 to 3CR4 and normally closed contacts 3CR5 to 3CR7, is connected across wires 60 and 61 by a circuit consisting of contact 63 of push button 57, contact 1CR5, contact 2CR3, winding 65 of contactor 3CR, contact 2CR8, contact 2CR4, contact 1CR6 and contact 64 of push button 59. Contact 33 of the cyclically timed switch is connected in parallel with contact 2CR8.

A second circuit connects winding 65 of contactor 3CR to wires 60 and 61 and consists of contact 31 of the cyclically timed switch, contact 3CR1, winding 65, contact 2CR3, contact 3CR2 and contact 32 of the cyclically timed switch.

Connected between contact 31 and contact 3CR1 is a circuit consisting of wire 66, contact 3CR3, wire 42, winding 37 of the air valve, wire 43, contact 3CR4 and wire 67 which connects between contact 3CR2 and contact 32.

Selector switch contact 68 is connected in parallel with switch 31.

Selector switch contact 69 is connected in parallel with switch 32.

Winding 37 of the air valve may be connected directly to lines 44 and 45 by an "inching" circuit. This consists of selector switch contact 70, normally open contact 71 of an "inching" push button 72, contact 2CR9, wire 42, winding 37, wire 43, contact 3CR7, contact 73 of "inching" push button 72 and selector switch contact 74.

FIGURE 3 represents the position of the selector switch contacts 54, 55, 68, 69, 70 and 74 for the various types of press operation. Selector switches of this type are readily available. When desired to "run" the press, the selector switch is rotated to close contacts 54 and 55 leaving the remaining contacts open. When desired to operate the press "continuously," the selector switch is rotated to close contacts 54, 55, 68 and 69 leaving the remaining contacts open. When desired to "inch" the press, the selector switch is rotated to close contacts 70 and 74 and open contacts 54, 55, 68 and 69.

Operation

To begin operation, the operator must turn the key operated selector switch so contact 50 is closed and contact 52 is open. "Start" push button 49 is then depressed to energize winding 48 of contactor F through the aforedescribed circuit. Contactor F operates to close contacts F1 to F5 and open contact F6.

Contacts F1 to F3 operate to connect motor 13 to source 17 through lines 18, 19 and 20 in a manner to be operated in the forward direction.

Contact F4 closes and connects winding 48 of contactor F to line 44 so that the operator can now release "start" button 49.

Normally, a press is operated in one of three methods. One is to "inch" the press. This is to connect the press so that it will operate only as long as a push button is held depressed. By this means, the movement of the press ram can be controlled for extremely short distances and is used primarily to ensure the mating of dies when setting up a press.

Another type of operation is to "run" the press. This method of operation is used most of the time in the press productive operation. Here, the control is connected so that each operator must depress a push button with each hand to start the press operation. The press continues in its operation only if the push buttons are held depressed and will stop automatically at the end of each cycle of operation. The push buttons may be released as soon as the press ram has passed the point at which it would be dangerous to the operator's hands. During this interval, the operators may release the push buttons and use their hands to remove the finished work from the press throat and put a new piece of raw material in the dies.

The third method is the "continuous" method of operating a press. In these instances, the material is automatically fed into and retracted from the press so that it can run continuously once its initial operation is started.

Once the type of operation has been determined, the selector switch is moved to the proper position. Normally, this selector switch is of the lock type so that it cannot be operated by unauthorized individuals. FIGURE 3 is a diagrammatic representation of the selector switch and indicates which contacts are closed for the various types of operation.

When the selector switch is moved to its "run" position, contacts 54 and 55 become closed. Thus, with contact F5 closed, contactor 1CR is energized through normally closed contacts 56 and 58 of push buttons 57 and 59, respectively. Winding 53 of contactor 1CR is energized and contactor 1CR operates to close contacts 1CR1 and 1CR4 and open contacts 1CR5 and 1CR6.

After contactor 1CR becomes energized, the circuit is in the state ready for operation.

Depending upon the type and the size of the press, it may have one or more operators. While the circuit of FIGURE 1 shows only two push buttons, 57 and 59, it is noted that when more than one operator is required, an additional pair of push buttons must be added for each operator. When this is done, one of the pair is connected in series with push button 57 and the other of the pairs is connected in series with push button 59. This requires that the operators must depress all of the push buttons and maintain them depressed while the press is going through its unsafe portion of its operating cycle.

To operate, the operator must depress push buttons 57 and 59 to open contacts 56 and 58 and close contacts 63 and 64. The closing of contacts 63 and 64 connects winding 62 of contactor 2CR so it is energized through contact 63 of push button 57, contact 1CR3, contact 1CR4, and contact 64 of push button 59. Contactor 2CR operates to close contacts 2CR1 and 2CR4 and open contacts 2CR5 to 2CR9.

Even though the depression of push buttons 59 and 57 opened contacts 56 and 58, contactor 1CR remains energized through contacts 1CR1 and 1CR2. As soon as contactor 2CR becomes operated, contacts 2CR6 and 2CR7 open, to de-energize contactor 1CR and contacts 1CR1 to 1CR6 return to their unoperated position.

Contactor 2CR is now maintained energized through contacts 3CR6 and 2CR1 in parallel with contact 1CR3, and contact 2CR2 which is in parallel with contact 1CR4. It is also maintained energized by limit switch contact 30 which is in parallel with contact 3CR6.

It is seen that should the operator release either or both of the push buttons 57 and 59, the opening of either contact 63 or 64 would de-energize contactor 2CR. If only one push button was released, he would have to release the other one to re-energize contactor 1CR and

then depress both push buttons again to re-energize contactor 2CR.

The reclosing of contacts 1CR5 and 1CR6 now connect winding 65 of contactor 3CR so it is energized through contact 63 of push button 57, contact 1CR5, contact 2CR3, winding 65 of contactor 3CR, limit switch contact 33, contact 2CR4, contact 1CR6 and contact 64 of push button 58. Contactor 3CR operates to close contacts 3CR1 to 3CR4 and open contacts 3CR5 to 3CR7.

The closing of these contacts connects winding 37 so it is energized through contact 63 of push button 57, contact 1CR5, contact 2CR3, contact 3CR1, wire 66, contact 3CR3, wire 42, winding 37, wire 43, contact 3CR4, wire 67, contact 3CR2, contact 2CR4, contact 1CR6, and contact 64 of push button 59.

Winding 37 is now energized so electromagnet 38 operates to operate the air valve and air under pressure is supplied by conduit 39 to cylinder 21 behind piston 22. Piston 22 is moved forward against the bias of spring 24 and causes piston rod 23 to disengage the brake and engage the clutch. Gear 15 is connected to shaft 10 to cause the press to begin its cycle of operation.

When contactor 3CR operates to open contact 3CR6, contactor 2CR is maintained energized by parallel connected limit switch contact 30.

FIGURE 4 is a diagrammatic representation of the portion of the press cycle of operation that each of the individual limit switch contacts are opened and closed. It is noted at the beginning of the cycle that limit switch contact 30 is maintained closed until approximately 180° of the press cycle. This is the point at which the press ram has reached its maximum down stroke. It is also noted that limit switch contacts 31 and 32 become closed shortly before limit switch contact 30 opens. Further, limit switch 33 remains closed throughout the major portion of the press cycle and opens only momentarily at about the press 270° portion.

Therefore, when limit switch contacts 31 and 32 close, contactor 3CR and winding 37 are energized directly from wires 60 and 61 and, thus, push buttons 57 and 59 need no longer be held depressed by the operator. It is to be noted here that since the press ram has reached the bottom of its stroke, the operator cannot injure himself by putting his hand in the press throat.

Contactor 3CR is maintained energized by the circuit consisting of limit switch contact 31, contact 3CR1, winding 65 of contactor 3CR, limit switch contact 33, contact 3CR2 and limit switch contact 32. Likewise, winding 37 is energized through the circuit consisting of limit switch contact 31, wire 66, contact 3CR3, wire 42, winding 37, wire 43, contact 3CR4, wire 67 and limit switch contact 32.

As soon as limit switch contact 30 opens, winding 62 of contactor 2CR becomes de-energized and its contacts 2CR1 to 2CR9 return to their normal condition.

The press continues to operate as described until it reaches the 360° point of its cycle of operation at which point limit switch contacts 31 and 32 open to de-energize contactor 3CR and winding 37.

The de-energization of winding 37 allows electromagnet 38 to release pilot valve 36 and it moves up under the bias of its spring 40. The air valve becomes unoperated and shuts off the supply of air from cylinder 21 and allows the air in conduit 39 and cylinder 21 to exhaust back and out through conduit 41.

Piston 22 and piston rod 23 are moved rearward by the bias of spring 24 to disengage the clutch and set the brake to stop further movement of the press.

It is to be noted that limit switch contact 33 opened at approximately 270° of the press cycle, but that winding 65 of contactor 3CR was maintained energized through contact 2CR8, which is connected in parallel with limit switch contact 33. This operation of limit switch contact 33 checked the operation of contactor 2CR to make sure that it became de-energized properly. If it had not, the opening of limit switch contact 33 would cause contactor 3CR to become de-energized immediately to stop the press.

Had the operator maintained push buttons 57 and 59 depressed, contactor 2CR would still become de-energized and unoperated when limit switch contact 30 opened. Also, when limit switch contacts 31 and 32 opened at the end of the machine cycle, contactor 3CR and winding 37 would still become de-energized because of contacts 2CR3 and 2CR4 connected in its energizing circuit.

After the operator has released push buttons 57 and 59 and limit switch contact 30 has opened to de-energize contactor 2CR, contactor 1CR will become energized, as described, and ready for the next cycle of operation.

It is seen that should the operator release his hands from either or both push buttons 57 and 59 during the first 170° of the press cycle, either contact 63 or contact 64 or both of them open the energizing circuit to winding 37 to stop the press. This also opens the energizing circuit for contactors 2CR and 3CR and they become de-energized. However, since the energizing circuit for winding 62 of 2CR is through contacts 1CR3 and 1CR4, it is necessary that the operator release both push buttons 57 and 59, at the same time, to re-energize contactor 1CR, and then re-depress both push buttons to re-energize contactor 2CR.

In applications of this type, it is desirous to not stop the press at the end of each cycle provided the operators have had an opportunity to remove the finished material from the dies and insert the new material therein before the end of the cycle. This is referred to as "jumping the press" and is accomplished as follows.

As soon as the operators have accomplished this work, and provided it is after the press has reached the point in its cycle where limit switch contact 30 has opened and again reclosed, all the operators may put their hands back on the push buttons and depress them. This will bring in contactor 2CR in the same manner as before described and cause contactor 1CR to become de-energized. Contactor 2CR is maintained energized through its own contacts and limit switch contact 30, which again closed shortly after the point in the press cycle that limit switch contact 33 reclosed. Therefore, contactor 3CR and winding 37 are maintained energized by current through the contact 63 of push button 57 and contact 64 of push button 59 in the circuit as before described and will not become de-energized at the end of the cycle, when limit switch contacts 31 and 32 opened. "Jumping the press" is provided to facilitate production, yet allows it to be done only if all of the operators' work has been accomplished and their hands in the safe position on the push buttons.

Should it be desirous to operate the press in its continuous condition, the selector switch is turned to its continuous position where selector switch contacts 68 and 69 are closed along with contacts 54 and 55. In this type of operation, the initial starting of the press is accomplished in the same manner as aforedescribed. However, immediately after starting movement of the press, the operator can remove his hands from both push buttons and the press will continue to operate until a stop button, such as 46, is depressed. If desired, a stop button may be connected in series with selector switch contact 54 so only the press control circuit may be de-energized and not that of motor 13.

Continuous operation is accomplished as follows.

With push buttons 57 and 59 in their up position, contactor 1CR is energized to operate its contacts. The operator may then push the push buttons to close contacts 63 and 64, and open contacts 56 and 58. Contactor 2CR is energized through contacts 1CR3 and 1CR4 and maintained energized through its own contacts, 2CR1 and 2CR2, and limit switch contact 30. Contactor 1CR is

de-energized by contacts 2CR6 and 2CR7 and becomes unoperated.

Contactor 3CR is operated by current through push button contact 63, contact 1CR5, contact 2CR3, winding 64 of contactor 3CR, limit switch contact 33, contact 2CR4, contact 1CR6 and contact 64 of push button 58.

As soon as contactor 3CR becomes operated to close its contact, winding 37 becomes energized as before described. Since selector switch contacts 68 and 69 are closed for "continuous" operation, contactor 3CR is now maintained energized from wire 60 directly through selector switch contact 68, contact 3CR1, winding 65 of contactor 3CR, limit switch contact 33, contact 3CR2, and selector switch contact 69 to wire 61. Winding 37 is also maintained energized directly by the circuit consisting of selector switch contact 68, wire 66, contact 3CR3, wire 42, winding 37, wire 43, contact 3CR4, wire 67 and selector switch contact 69 to wire 61.

The operator may now release his hands from the push buttons, completely independent of the position of the press ram. Contactor 2CR then becomes de-energized to close contact 2CR8 and maintains contactor 3CR and its winding 65 energized through closed contact 2CR8, which is parallel with limit switch contact 33. The press will now continue to operate "continuously" until such time that the operator pushes a stop button to remove the power from the press control circuit.

For the other type or "inching" operation, the selector switch is turned to the inching position, at which point, selector switch contacts 70 and 74 are closed and selector switch contacts 54, 55, 68 and 69 are opened. By pushing inching push button 72, the operator can connect winding 37 directly to the source by lines 44 and 45 through the circuit consisting of selector switch contact 70, contact 71 of push button 72, normally closed contact 2CR9, wire 42, winding 37, wire 43, contact 2CR7, contact 73 of push button 72 and selector switch contact 74. In this type of operation, the press will operate when push button 72 is depressed and will continue to operate only as long as it is held depressed. This is true completely independent of the position of the ram in the press operating cycle. As before described, the use of this type of operation is primarily in the setting up and the matching of the press die.

FIGURE 5 is similar to FIGURE 1 except it has the added feature of protecting against the possible short circuiting of the push button's normally open contacts when only two push buttons are used. Therefore, like parts have been given the same reference characters, and only the portion of FIGURE 1 necessary to described the feature has been shown.

Contactor 1CRA has a winding 75 and normally open contacts 1CRA1 and 1CRA2 and normally closed contacts 1CRA3 and 1CRA4. It is connected across wires 60 and 61 by normally closed contact 56 of push button 57. Contacts 1CRA1 and 2CR6 are connected in parallel with contact 56.

Contactor 1CRB has a winding 76 and normally open contacts 1CRB1 and 1CRB2, and normally closed contacts 1CRB3 and 1CRB4. It is connected across wires 60 and 61 by normally closed contact 58 of push button 59. Contactors 1CRB1 and 2CR7 are connected in parallel with contact 58.

The remainder of the circuit for FIGURE 5 is identical with that of FIGURE 1 except that contact 1CRA2 replaces contact 1CR1, contact 1CRB2 replaces contact 1CR2, contacts 1CRA3 and 1CRB3 replace contact 1CR5, and contacts 1CRA4 and 1CRB4 replace contact 1CR6.

Therefore, the operation of the two circuits to energize winding 37 are identical except that whenever contactor 1CR operated in FIGURE 1 both contactors 1CRA and 1CRB operate in FIGURE 5. It is believed that the operation of FIGURE 5 for the normal modes of operation described for FIGURE 1 are understood, and for the sake of brevity, a complete re-description of these modes of operation will not be made.

As stated, FIGURE 5 protects against the possible short circuiting of either normally open push button contacts 63 or 64. This is as follows.

Assuming that contact 63 has become shorted due to an accident, contactor 2CR still cannot become energized because of contact 64 being open. However if only push button 64 is depressed, an unsafe condition is created since the operator's other hand is free and therefore, the press should not be allowed to operate. When this occurs, contactor 2CR operates its contacts. The opening of contact 2CR7 causes contactor 1CRB to become de-energized. Contactor 1CRA does not become de-energized since it is maintained energized through contact 56 of push button 57 which has not been depressed.

Therefore, contacts 1CRA3 and 1CRA4 in the energizing circuit for contactor 3CR remain open to prevent it from becoming energized. Thus, winding 37 cannot become energized and the press will not operate.

If both push buttons 57 and 59 are depressed when contact 63 is shorted, the press will operate in the normal manner. However, since both push buttons are depressed, an unsafe condition does not exist and operation of the press will not be harmful or dangerous.

It is to be noted that the circuit of FIGURE 5 can only be used with two push buttons or one operator. If more than one operator is required, which necessitates the use of more than two push buttons, the circuit of FIGURE 6 must be used.

Here again, FIGURE 6 is very similar to FIGURES 1 and 5, and like parts of the two figures have been given the same reference characters. Also, only that portion of FIGURE 1 necessary to describe the feature has been shown.

FIGURE 6 has four push buttons 77, 78, 79 and 80. Each push button has a normally open contact 81, 82, 83 and 84, and a normally closed contact 85, 86, 87 and 88, respectively.

The normally closed contacts are connected from wire 60 by a wire 89, contact 85, contact 86, a wire 90, winding 91 of a contactor CR, a wire 92, contact 87, contact 88 and a wire 93 to wire 61.

Contactor 90 has normally open contacts CR1 to CR6 and normally closed contacts CR7 to CR10.

A first latch relay 1SR having a latching winding 94 is connected by three possible separate circuits between wires 92 and 60. Latch relay also has a trip winding 95 and a normally open contact 1SR1 and normally closed contacts 1SR2 and 1SR3.

The first of the possible circuits is through a normally open contact 96 of a first selector switch 97 and a normally open contact 98 of a second selector switch 99 to wire 60. The purpose of selector switches 97 and 99 will be described in more detail hereinafter.

The second circuit is through contact CR1, a normally closed contact 100 of selector switch 99, contact 84 of push button 80 to wire 60.

The third circuit is through contact CR1, a normally closed contact 101 of selector switch 97, contact 83 of push button 79, and contact CR2 to wire 60.

A second latch relay 2CR having a latching winding 102 is connectable by two possible separate circuits between wire 90 and wire 61. Latch relay 2SR also has a trip winding 103 and a normally open contact 2SR1 and normally closed contacts 2SR2 and 2SR3.

The first possible circuit is through contact CR3, a normally closed contact 104 of selector switch 97, contact 82 of push button 78 and contact CR4 to wire 61.

The second circuit is through contact CR3, a normally closed contact 105 of selector switch 99, and contact 81 of push button 77 to wire 61.

Trip windings 95 and 103 are connected in parallel with each other and in series with a normally open contact 106 across wires 60 and 61.

Contacts 1SR1 and 2SR1 are connected in parallel with each other and in series with an indicating lamp 107 across wires 60 and 61.

The normally open contact of the push buttons are connected from wire 60, contact 84, contact CR7, contact 83, contact CR8, contact 1SR2, contact 2SR2, contact 1CR3, winding 62 of contactor 2CR, contact 1CR4, contact 2SR3, contact 1SR3, contact CR9, contact 82, contact CR10, and contact 81 to wire 61.

Contactor 1CR is connected across wires 60 and 61 by contact CR5, winding 53 of contactor 1CR and contact CR6. Contacts 2CR6 and 1CR1 are connected in series with each other and in parallel with contact CR5. Contacts 1CR2 and 2CR7 are connected in series with each other and in parallel with contact CR6.

A second indicating lamp 108 is connected across wires 60 and 61 by a circuit from wire 60 consisting of wire 89, indicating lamp 108, normally open contact 109 of selector switch 97 to wire 61.

A third indicating lamp 110 is connected across wires 60 and 61 by a circuit from wire 60 consisting of wire 89, indicating lamp 110, normally open contact 111 of selector switch 99 to wire 61.

This circuit operates as follows.

When all of the push buttons are released, contactor CR is energized by the circuit from wire 60 through wire 89, contacts 85 and 86, wire 90, winding 91 of contactor CR, wire 92, contacts 87 and 88, and wire 93 to wire 61. Contactor CR operates to close contacts CR1 to CR6 and open contacts CR7 to CR10.

Should any of the normally open contacts of the push buttons be shorted, this fault is automatically indicated at this time and operation of the press is prevented since an unsafe condition may possibly exist.

If the short exists across contacts 83, latch relay 1SR is energized by the circuit from wire 60 through contact CR2, shorted contact 83, contact 101, contact CR1, latch winding 94 of latch relay 1SR, wire 92, contacts 87 and 88, and wire 93 to wire 61.

If the short exists across contacts 84, latch relay 1SR is energized by the circuit from wire 60 through shorted contact 84, contact 100, contact CR1, latch winding 94 of latch relay 1SR, wire 92, contacts 87 and 88, and wire 93 to wire 61.

When latch winding 94 of latch relay 1SR is energized, it operates to close contact 1SR1 and open contacts 1SR2 and 1SR3. The closing of contact 1SR1 connects indicating lamp 107 across wires 60 and 61 to illuminate it, giving a visual indication that a short exists. The opening of contacts 1SR2 and 1SR3 opens the energizing circuit for contactor 2CR so it cannot be operated, thereby preventing the energization of contactor 3CR and winding 37, and operation of the press.

If a short exists across contacts 81, latch relay 2SR is energized by the circuit from wire 60 through wire 89, contacts 85 and 86, wire 90, latch winding 102 of latch relay 2SR, contact CR3, contact 105, and shorted contact 81 to wire 61.

If a short exists across contact 82, latch relay 2SR is energized by the circuit from wire 60 through wire 89, contacts 85 and 86, wire 90, latch winding 102 of latch relay 2SR, contact CR3, contact 104, shorted contact 82, and contact CR4 to wire 61.

When latch winding 102 of latch relay 2SR is energized, it operates to close contact 2SR1 and open contacts 2SR2 and 2SR3. The closing of contact 2SR1 connects indicating lamp 107 across wires 60 and 61 to illuminate it, giving a visual indication that a short exists. The opening of contacts 2SR2 and 2SR3 opens the energizing circuit for contactor 2CR so it cannot be energized, thereby preventing the energization of contactor 3CR and winding 37, and operation of the press.

Latch relays 1SR and 2SR are of the well known type where the contacts are operated by energization of the latch winding, and once operated, the contacts are maintained operated by a mechanical latch independent of the energization of the latch winding. Subsequent energization of the trip winding after deenergization of the latch winding releases the contacts so they can return to their unoperated condition.

Therefore, indicating lamp 107 remains illuminated and the energizing circuit for contactor 2CR remains open even though the push buttons may later be depressed.

After the shorted contact of the push button has been repaired, the circuit energizing the latch winding becomes open. To reset the circuit so the press can be operated, contact 106, which may be a contact of a push button or other suitable device, is closed. This energizes trip windings 95 and 103 of latch relays 1SR and 2SR, respectively, to, as described, release the latch mechanism and allow their contacts to become unoperated.

The press may now be operated as follows.

Contactor CR is operated as described when all the push buttons are released.

Winding 53 of contactor 1CR is now energized by the circuit from wire 60 through contact CR5, winding 53, and contact CR6 to wire 61. Contactor 1CR operates to close contacts 1CR1 to 1CR4 and open contacts 1CR5 and 1CR6.

Push buttons 77, 78, 79 and 80 can now be depressed to open their contacts 85, 86, 87 and 88. This de-energizes winding 91 of contactor CR, causing its contacts to become unoperated.

Contactor 1CR remains operated by the circuit through contacts 2CR6 and 1CR1 connected in series with each other and in parallel with contact CR5, and contacts 1CR2 and 2CR7 which are connected in series with each other and in parallel with contact CR6.

The depression of the push buttons also close contacts 81, 82, 83 and 84 to operate contactor 2CR. Its winding 62 is energized by the circuit from wire 60 through contacts 84, CR7, 83, CR8, 1SR2, 2SR2 and 1CR3 to winding 62, and thence through contacts 1CR4, 2SR3, 1SR3, CR9, 82, CR10 and 81 to wire 61. Contactor 2CR operates to close contacts 2CR1 to 2CR4 and open contacts 2CR5 to 2CR9.

Contactor 1CR is caused to become unoperated by the opening of contacts 2CR6 and 2CR7, after which contactor 3CR is energized through the circuits consisting of contacts 84, CR7, 83, CR8, 1SR2, 2SR2, 2CR3 and 1CR5 to winding 65, and thence through contacts 33, 1CR6, 2CR4, 2SR3, 1SR3, CR9, 82, CR10 and 81. Winding 37 is energized through contacts 3CR1, 3CR3, 3CR4 and 3CR2 in addition to the above described circuit except for winding 65 and contact 33. The details of operation for this circuit are the same as described for FIGURE 1, which for the sake of brevity will not be repeated.

While I have described this feature connected in a circuit that utilizes four push buttons, it is understood that the feature is operable in a circuit having any number of push buttons. This is accomplished by making a separate circuit available for each normally open contact of each of the push buttons through which one of the latch windings of latch relays 1SR or 2SR can be energized.

Selector switches 97 and 99 have been included in the circuit to permit the use of "dummy plugs." Their use is well known in the art of press control and they are used to close both the normally open and closed contacts of the push buttons. The purpose is to reduce the number of push buttons required, when a fewer number of operators are needed to operate the press.

To replace an operator in FIGURE 6, a "dummy plug" may be inserted for push buttons 78 and 79. This closes contacts 82, 83, 86 and 87, and if no changes are made in the circuit, latch relays 1SR and 2SR would operate to indicate that contacts 82 and 83 were shorted. Also, the operation of latch relays 1SR and 2SR would, as described, prevent energization of winding 37 and operation of the press.

The operation of latch relays 1SR and 2SR is prevented

by turning selector switch 97 to close contacts 96 and 109, and open contacts 101 and 104. The opening of contact 101 prevents latch relay 1SR from being energized through the now closed contact 83. The opening of contact 104 prevents latch relay 2SR from being energized through the now closed contact 82. The closing of contact 109 connects indicating lamp 108 to wire 61 and by wire 89 to wire 60 so it is illuminated to indicate that one set of "dummy plugs" have been inserted for push buttons 78 and 79.

It is seen that if all the push buttons are replaced by the "dummy plugs" the press will not operate because of the operation of contactor CR, but it still would create an undesirable and potentially unsafe condition. Therefore, it is further protected against, since if both selector switches 97 and 99 are not turned to the "dummy plug" position, latch relays 1SR and/or 2SR will operate. If both selector switches are turned to the "dummy plug" position, contacts 96 and 98 will be closed to energize latch winding 94 of latch relay 1SR from wire 60 through contacts 96 and 98, winding 94, wire 92, contacts 87 and 88, and wire 93 to wire 61. Latch relay 1SR thus operates to prevent operation of the circuit and indicate by lamp 107 that something is wrong, as has been previously described.

It is to be noted that one selector switch is required for each pair of push buttons or for each operator.

FIGURE 6 also illustrates another safety feature which may be incorporated with the circuits of FIGURES 1 and 5 if desired. This safety feature is to provide protection against the faulty operation of the limit switch contacts or the disconnection of the limit switch from the press. To achieve this safety feature, a fifth cam and a contact 112 operated thereby must be added to the limit switch in FIGURE 2 and a second limit switch having three cams and cam operated contacts 113, 114, and 115 must be connected directly to shaft 10 of the press (not shown).

These contacts are connected to operate in the circuit of FIGURE 6 as follows.

Contact 115 of the second limit switch is connected in FIGURE 6 in the same manner that contact 32 is connected in FIGURES 1 and 5. That is, between contact 3CR2 and wire 61. Contact 32 is connected in series with contact 114 between wire 61 and selector switch contact 55. Contact 113 is connected in parallel with contact 32 and contact 112 is connected in parallel with contact 114. The contacts of the cam operated limit switches of FIGURE 6 operate in the sequence shown by the diagrammatic representation of FIGURE 7.

Contacts 30, 31 and 33 of FIGURE 6 operate in the same manner described for them in FIGURE 1 and contact 115 operates the same as described for contact 32 in FIGURE 1. That is, contact 30 opens at approximately the 180° point to de-energize winding 62 of contactor 2CR and reclose at approximately the 270° point to permit "jumping the press" as described. Contacts 31 and 115 close at approximately the 170° point to allow the operators to release the push buttons without stopping the press and reopen at the end of the press cycle. Contact 33 opens at approximately the 200° point and then recloses at the 250° point to insure that contact 2CR has operated properly, and if not to stop the press. The details of operation for these contacts in the circuit is set forth in the description for FIGURE 1 and for the sake of brevity will not be repeated here.

At the beginning of the press cycle, contacts 32 and 114 are closed and contacts 112 and 113 are open. Therefore, the circuit from wire 61 to wire 45 is completed through contacts 32 and 114 and contact 55.

At approximately the 60° point in the press cycle, contacts 112 and 113 close and at about the 70° point contacts 32 and 114 open. Now the circuit from wire 61 to wire 45 is completed through contacts 112 and 113.

Contacts 32 and 114 reclose at about the 90° point and contacts 112 and 113 re-open at about the 100° point to transfer the circuit back through contacts 32 and 114.

If either of the limit switches had become broken or disconnected from shaft 10 at a point in the press operating cycle when either contact 112 or 113 was open, then when the above described transfer of the circuit took place to contacts 112 and 113, the press would stop immediately because the open contact disconnects the source of power from the circuit.

Had the limit switch broken or become disconnected with either of the contacts 112 or 113 were closed, an unsafe condition would not occur. It is seen that when contacts 112 and 113 are closed, contacts 31 and 115 are open.

Therefore, when the press reached the point for closing contacts 31 and 115 only one would do so and the other would remain open to prevent the energization of contactor 3CR and winding 37 from being transferred from the normally closed contacts of the push buttons. Thus, as soon as the operator released his hands from the push buttons, the press would stop regardless of its position. This gives the indication that something is wrong which should be corrected and makes the condition safe by compelling the operator's hands to be on the push buttons.

Although I have described my invention with a certain degree of particularity, it is understood that the above disclosure has been made only by way of example as required by law and that many changes in the details of circuitry may be resorted to by those skilled in the art without departing from the spirit and the scope of my invention as hereinafter claimed.

I claim:

1. A circuit for controlling energization of a work device comprising a first, second, and third contactor; each contactor having a plurality of normally open closed contacts; a source of electrical power; an operator push button having a normally open and a normally closed contact; said first contactor energized through the normally closed contact of the push button and sustained energized through a normally closed contact of the second contactor and a normally open contact of the first contactor; upon depression of the operator push button, the second contactor is energized through the normally open contacts of the push button and a normally open contact of the first contactor means, and sustained energized by a normally open contact of the second contactor; and the third contactor is energized through the normally open contacts of the push button and a normally closed contact of the first contactor and a normally open contact of the second contactor; and the device is energized through the push button normally open contact, a normally closed contact of the first contactor, a normally open contact of the second and third contactors.

2. A circuit for controlling energization of a work device comprising a first, second, and third contactor; each contactor having a plurality of normally open and normally closed contacts; a source of electrical power; an operator push button having a normally open and a normally closed contactor; said first contactor energized from the source through the normally closed contact of the push button and sustained energized through a normally closed contact of the second contactor and a normally open contact of the first contactor; upon depression of the push button, the second contactor is energized from the source through the normally open contact of the push button and a normally open contact of the first contactor and sustained energized by a first and device operated switch and a normally open contact of the second contactor; and the third contactor is energized through the normally open contact of the push button, a normally closed contact of the first contactor and a normally open contact of the second contactor; and the device is energized through the push button normally open contact, a normally closed contact of the first con-

tactor, and a normally open contact of the second and third contactors.

3. A circuit for controlling energization of a work device comprising a first, second, and third contactor; each contactor having a plurality of normally open and normally closed contacts; a source of electrical power; an operator push button having a normally open and a normally closed contactor; said first contactor energized from the source through the normally closed contact of the push button and sustained energized through a normally closed contact of the second contactor and a normally open contact of the first contactor; upon depression of the push button, the second contactor is energized from the source through the normally open contacts of the push button and a normally open contact of the first contactor and sustained energized by a first device operated switch connected in parallel with a normally closed contact of the third contactor, and both connected in series with a normally open contact of the second contactor; and the third contactor is energized through the normally open contact of the push button, a normally closed contact of the first contactor and a normally open contact of the second contactor; and the device is energized through the push button normally open contacts, normally closed contacts of the first contactor, and a normally open contact of the second and third contactors.

4. A circuit for controlling energization of a work device comprising a first, second, and a third contactor each contactor having a plurality of normally open and normally closed contacts; a source of electrical power; an operator push button having a normally open and a normally closed contact; said first contactor energized from the source through the normally closed contact of the push button and sustained energized through a normally closed contact of the second contactor and a normally open contact of said first contactor; upon depression of the push button, the second contactor is energized from the source through the push button normally open contact and a normally open contact of the first contactor and sustained energized through a normally open contact of the second contactor; and operation of the second contactor causes its normally closed contact in the sustaining circuit of the first contactor to de-energize the first contactor; and the third contactor is energized through the normally open contact of the push button, a normally closed contact of the first contactor, and a normally open contact of the second contactor; and the work device is energized through the normally open contact of the push button, a normally closed contact of the first contactor, and a normally open contact of the second and third contactor.

5. A latching circuit comprising a first and second contactor; each contactor having a plurality of normally open and normally closed contacts; a source of electrical power; an operator push button having a normally open and a normally closed contact connected in the circuit; said first contactor energized through the normally closed contact of the push button and sustained energized through a normally closed contact of the second contactor and a normally open contact of the first contactor; and upon depression of the push button, said second contactor is energized through the normally open contact of the push button and a normally open contact of the first contactor and sustained energized by a normally open contact of the second contactor, and said first contactor remains energized until said second contactor is operated to open its normally closed contact in the sustaining circuit of the first contactor.

6. A circuit for energizing a work device to control a cyclically operating machine comprising a first, second, and third contactor; each contactor having a plurality of normally open and normally closed contacts; a source of electrical power; an operator push button having a normally open and a normally closed contact; said first contactor energized from the source through the normally closed contact of the push button and sustained energized through a normally closed contact of the second contactor and a normally open contact of said first contactor; upon depression of the push button, the second contactor is energized through the normally open contact of the push button and a normally open contact of the first contactor and sustained energized through a normally open contact of the second contactor; and the third contactor is energized through the normally open contact of the push button, normally closed contacts of the first contactor and a normally open contact of the second contactor; and the device is energized through the normally open contact of the push button, a normally closed contact of the first contactor and a normally open contact of the second and third contactors, and a first normally open machine operated switch is set to close at a safe point in the machines cycle of operation to connect the source to energize the third contactor and the work device directly through a normally open contact of the third contactor.

7. A circuit for energizing a work device to operate a cyclically operating machine as described in claim 6 wherein a normally closed second machine operated switch is connected in the sustaining circuit of the second contactor and set to open at a point in the machine cycle after the closing of the first machine operated switch to thereby de-energize said second contactor.

8. A circuit for energizing a work device for operating a cyclically operating machine as set forth in claim 7 wherein a normally closed third machine operated switch is connected in the energizing circuit of the third contactor and has a normally closed contact of the second contactor connected in parallel with said third machine operated switch, and whereby said third machine operated switch is arranged to be opened momentarily after opening of said second machine operated switch to insure that said second contactor means has become unoperated.

9. A circuit for energizing a work device to control a cyclically operating machine comprising, a first, second, and third contactor; each contactor having a plurality of normally open and normally closed contacts, a source of electrical power; an operator push button having a normally open and a normally closed contact; said first contactor energized from the source through the normally closed contact of the push button and sustained energized through a normally closed contact of the second contactor and a normally open contact of said first contactor; upon depression of the push button, the second contactor is energized through the normally open contact of the push button and a normally open contact of the first contactor and sustained energized through a normally closed first machine operated switch connected in parallel with a normally closed contact of the third contactor and both in series with a normally open contact of the second contactor; and after the second contactor is energized, the first contactor is de-energized by the opening of the normally closed contact in its sustaining circuit; and the third contactor is energized through the normally open contact of the push button, normally closed contacts of the first contactor and a normally open contact of the second contactor; and the device is energized through the normally open contact of the push button, a normally closed contact of the first contactor, a normally open contact of the second and third contactor.

10. A circuit for energizing a work device for controlling a cyclically operating machine comprising a first, second and third contactor; each contactor having a plurality of normally open and normally closed contacts; a source of electrical power; an operator push button having a normally open and a normally closed contact; said first contactor energized from the source through the normally closed contact of the push button and sustained energized through a normally closed contact of the second contactor and normally open contact of said first contactor; upon

depression of the push button, the second contactor is energized through the normally open contact of the push button and normally open contact of the first contactor and sustained energized by a normally closed first machine operated switch and a normally open contact of the second contactor; whereby operating of the second contactor opens the sustaining circuit to the first contactor causing it to become unoperated; and the third contactor is energized through the normally open contact of the push button, normally closed contacts of the first contactor, normally closed contacts of the second contactor, and a normally closed second machine operated switch; a normally closed contact of the second contactor is connected in parallel with said normally closed second machine operated switch; whereby the device is energized through the normally open contact of the push button, normally closed contacts of the first contactor, normally open contacts of the second contactor and normally open contacts of the third contactor to start operation of the cyclically operating machine and after its unsafe portion of operation, a normally open third machine operated switch closes to connect the third contactor to the source through its own normally open contact and said parallel connected second machine operated switch and normally closed contact of the second contactor, and also connects the work device to the source through normally open contacts of the third contactor thereby allowing release of said push buttons, and said first machine operated switch is set to open to de-energize the second contactor, and thereafter said second machine operated switch opens momentarily to insure said second contactor has become unoperated and at the end of said machines operating cycle, said third machine operated switch opens to de-energize the third contactor and the work device to stop the machine.

11. A circuit for controlling a cyclically operating machine as set forth in claim 10 wherein a normally closed contact of the third contactor is connected in parallel with the normally closed first machine operated switch to prevent it opening from de-energizing the second contactor until after the third contactor has been energized.

12. A latching circuit comprising a first, second, and third contactor; each contactor having a plurality of normally open and normally closed contacts; a source of electrical power; a pair of operating push buttons, each having a normally open and a normally closed contact; said first contactor energized from the source through the normally closed contact of one of said push buttons and having a sustaining circuit of one of its normally open contacts and a normally closed contact of said third contactor; said second contactor energized from the source through the normally closed contacts of the other push button and having a sustaining circuit containing one of its normally open contacts and a normally closed contact of said third contactor; and upon depression of said push buttons said third contactor is energized through the push buttons normally opened contacts and a normally open contact of said first and second contactor, said third contactor having a sustaining circuit through the normally open contacts of the push buttons and its normally open contacts, whereby said first and second contactors become unoperated due to the opening of said normally closed third contactor contacts in their sustaining circuit.

13. A circuit for controlling energization of a work device comprising a first, second, third, and fourth contactor; each contactor having a plurality of normally open and normally closed contacts; a source of electrical power; a pair of operator push buttons, each having a normally open and a normally closed contact; said first contactor energized through a normally closed contact of one of said push buttons and sustained energized through one of its normally open contacts and a normally closed contact of said third contactor; said second contactor energized through the normally closed contact of the other push button and sustained energized through one of its normally open contacts and a normally closed contact of said third contactor; said third contactor energized through the normally open contact of said push buttons and a normally open contact of said first and second contactors and sustained energized through the normally open contacts of said push buttons and one of its normally open contacts; said fourth contactor energized from the source through the normally open contact of said push buttons and a normally closed contact of said first and second contactors and a normally open contact of said third contactor; and said work device energized through said normally open contact of both push buttons, said normally closed contacts of said first and second contactors, normally open contacts of said third contactor, and normally open contacts of said fourth contactor.

14. A circuit for energizing a work device to control a cyclically operating machine comprising a first, second, third, and fourth contactor; each contactor having a plurality of normally open and normally closed contacts; a source of electrical power; a pair of operator push buttons, each having a normally open and a normally closed contact; said first contactor energized through a normally closed contact of one of said push buttons and sustained energized through one of its normally open contacts and a normally closed contact of said third contactor; said second contactor energized through the normally closed contact of the other push button and sustained energized through one of its normally open contacts and a normally closed contact of said third contactor; said third contactor energized through the normally open contact of said push buttons and a normally open contact of said first and second contactors and sustained energized through the normally open contacts of said push buttons and one of its normally open contacts; and after the third contactor is energized, the first and second contactors are de-energized by the opening of said normally closed third contactor contacts in their sustaining circuit; said fourth contactor is energized from the source through the normally open contact of said push buttons and a normally closed contact of said first and second contactors and a normally open contact of said third contactor; and said work device energized through said normally open contact of both push buttons, said normally closed contacts of said first and second contactors, normally open contacts of said third contactor, and normally open contacts of said fourth contactor to operate the machine, and a first normally open machine operated switch set to close at a safe point in the machine cycle of operation to connect the source through normally open contacts of the fourth contactor and maintain the fourth contactor and the work device energized and the machine operating.

15. A circuit for energizing a work device to operate a cyclically operating machine as described in claim 14 wherein a normally closed second machine operated switch is connected in the sustaining circuit of the third contactor and set to open at a point in the machine cycle after the closing of the first machine operated switch to thereby de-energize said third contactor.

16. A circuit for energizing a work device to operate a cyclically operating machine as described in claim 15 wherein a normally closed contact of the fourth contactor is connected in parallel with the second machine operated switch to thereby insure that the fourth contactor is energized before the third contactor can be de-energized by opening of the second machine operated switch.

17. A circuit for energizing a work device to operate a cyclically operating machine as described in claim 16 wherein a normally closed third machine operated switch is connected in the energizing circuit of the fourth contactor and has a normally closed contact of the third contactor connected in parallel with said third machine operated switch, and whereby said third machine operated switch is arranged to be opened momentarily after opening of said second machine operated switch to insure that said third contactor has become unoperated.

18. A circuit for detecting a shorted condition of nor-

mally open contacts of an operable push button which are connected to energize an operating circuit from a source of electrical power comprising; normally closed contacts on said push button; a first contactor having a normally open contact and an operating means connected to be energized from the source through the normally closed push button contacts to close said normally open control of said first contactor; indicating means connected in series with the source, the normally closed push button contacts, the normally open contact of the first contactor, and the normally open push button contacts whereby if the said normally open push button contacts are in a shorted condition when the push button is in its normal position said indicating means is energized.

19. A detecting circuit as set forth in claim 18 wherein the indicating means is a second contactor having normally closed contacts connected in the operating circuit whereby if said normally open push button contact is shorted said second contactor is energized to open its contacts and de-energize the operating circuit.

20. A detecting circuit as set forth in claim 18 wherein the indicating means is a latch relay having normally closed contacts connected in the operating circuit whereby if said normally open push button contact is shorted said latch relay is energized to open its contacts to make and maintain the operating circuit until the latch relay is reset.

21. A circuit for detecting a shorted condition of normally open contacts connected in series to energize an operating circuit from a source of electrical power comprising; a plurality of push buttons, each having a said normally open contact and a normally closed contact; a first contactor having normally open and normally closed contacts, and connected to be energized from the source through the normally closed push button contacts; a second contactor connected to be energized from the source through the normally closed push button contacts and a plurality of isolated circuits, each circuit having a normally open push button contact and at least one normally open contact of said first contactor and said circuits made isolated by the normally closed contacts of the first contactor, whereby if one of the normally open push button contacts is shorted, the second contactor is energized.

22. A circuit for detecting a short circuit condition as described in claim 21 wherein the second contactor has normally closed contacts connected in the operating circuit whereby when said second contactor is energized, it opens its contacts to de-energize the operating circuit.

23. A circuit for controlling energization of a work device comprising a first, second, third, and fourth contactor; each contactor having a plurality of normally open and normally closed contacts; a fifth contactor having a normally closed contact; a source of electrical power for energizing the contactors and work device; an operators push button having a normally open and a normally closed contact; the first contactor connected to be energized through the normally closed push button contact; the fifth contactor connected to be energized through the normally closed push button contact and through a separate circuit containing the normally open push button contact and at least one normally open contacts of said first contactor, said separate circuit established by a normally closed contacts of said first contactor; said second contactor energized through a normally open contact of the first contactor and maintained energized through one of its normally open contacts and a normally closed contact of said third contactor; said third contactor energized through the normally closed contact of the push button, a normally closed contact of the first and fifth contactor and a normally open contact of the second contactor, and sustained energized through one of its normally open contacts; said fourth contactor energized through a normally closed contact of first and second and fifth contactor, and a normally open contact of said third contactor; said work device energized through a normally closed contact of the first and second and fifth contactor, and a normally open contact of the third and fourth contactor.

24. A circuit for controlling energization of a work device comprising a first, second, third, and fourth contactor; each contactor having a plurality of normally open and normally closed contacts; a fifth contactor having a normally closed contact; a source of electrical power for energizing the contactors and work device; a plurality of operators push buttons, each having a normally open and a normally closed contact; the first contactor connected to be energized through the normally closed push button contacts; the fifth contactor connected to be energized through the normally closed push button contacts and a plurality of separate circuits; each separate circuit containing one of the normally open push button contacts and at least one normally open contacts of said first contactor and established by normally closed contacts of said first contactor; said second contactor through normally open contacts of the first contactor and maintained energized through one of its normally open contacts and a normally closed contact of said third contactor; said third contactor energized through the normally closed contacts of the push buttons, a normally closed contact of the first and fifth contactor and a normally open contact of the second contactor, and sustained energized through one of its normally open contacts; said fourth contactor energized through a normally closed contact of first and second and fifth contactor, and normally open contacts of said third contactor; said work device energized through a normally closed contact of the first and second and fifth contactor, and a normally open contact of the third and fourth contactor.

25. A circuit for energizing a work device to control a cyclically operating machine comprising a first, second, third, and fourth contactor; each contactor having a plurality of normally open and normally closed contacts; a fifth contactor having a normally closed contact; a source of electrical power for energizing said contactor and work device; and operators push button having a normally open and normally closed contact; said first contactor connected to be energized through the normally closed push button contact; said fifth contactor connected to be energized through the normally closed push button contact, a normally open push button contact and normally open contact of the first contactor; said second contactor energized through a normally open contact of the first contactor and sustained energized through one of its normally open contacts and a normally closed contact of the third contactor; and upon depression of said push button said first contactor is de-energized and said third contactor is energized through the normally open contact of the push button, a normally closed contact of said first and fifth contactor and a normally open contact of said second contactor, and sustained energized through one of its normally open contacts; said second contactor becoming de-energized by the opening of the normally closed contact of the third contactor in its energizing circuit; said fourth contactor energized through the normally open contact of the push button, a normally closed contact of said first and second and fifth contactors, and a normally open contact of said third contactor; said work device energized through the normally open contact of the push button, a normally closed contact of said first and second and fifth contactors, and a normally open contact of said third and fourth contactors to operate the machine, and a first normally open machine operated switch set to close at a safe point in the machines operating cycle whereby the fourth contactor and the work device are maintained energized through said switch and a normally open contact of the fourth contactor to keep the machine operating.

26. A circuit for energizing a work device to control a cyclically operating machine comprising a first, second,

third, and fourth contactor; each contactor having a plurality of normally open and normally closed contacts; a fifth contactor having a normally closed contact; a source of electrical power for energizing said contactor and work device; a plurality of operators push buttons, each having a normally open and normally closed contact; said first contactor connected to be energized from the source through the normally closed push buttons contacts; said fifth contactor connected to be energized through the normally closed push buttons contacts and a plurality of separate circuits, each separate circuit containing one of the normally open push button contacts and at least one normally open contact of said first contactor and established by normally closed contacts of said first contactor; said second contactor energized through normally open contacts of the first contactor and sustained energized through one of its normally open contacts and a normally closed contact of the third contactor; and upon depression of said push button said first contactor is de-energized and said third contactor is energized through the normally closed contacts of the push button, a normally closed contact of said first and fifth contactor and a normally open contact of said second contactor, and sustained energized through one of its normally open contacts; said second contactor becoming de-energized by the opening of the normally closed contact of the third contactor in its energizing circuit; said fourth contactor energized through the normally open contacts of the push buttons, a normally closed contacts of said first and second and fifth contactors and a normally open contact of said third contactor; said work device energized through the normally open contacts of the push buttons, a normally closed contact of said first and second and fifth contactors, and a normally open contact of said third and fourth contactors to operate the machine, and a first normally open machine operated switch set to close at a safe point in the machines operating cycle whereby the fourth contactor and the work device are maintained energized through said switch and a normally open contact of the fourth contactor to keep the machine operating.

27. A circuit for energizing a work device to control a cyclically operating machine comprising a first, second, and third contactor; each contactor having a plurality of normally open and normally closed contacts; a first and second limit switch operated by the machine, each switch having a plurality of contacts set to operate at various preselected points in the machines operating cycle; a source of electrical power for energizing the contactor and work device and connected to the circuit through a normally closed first contact of each limit switch; a normally open second contact of each limit switch connected in parallel with its respective normally closed contact; an operator push button having a normally open and a normally closed contact; said first contactor energized through the normally closed contact of the push button and sustained energized through one of its normally open contacts and a normally closed contact of the second contactor; upon depression of the push button, the second contactor is energized through the normally open contact of the push button and a normally open contact of the first contactor and sustained energized through one of its normally open contacts, and after the second contactor is energized, the first contactor is de-energized by the opening of the normally closed contact in its sustaining circuit; the third contactor is energized through the normally open contact of the push button, a normally closed contact of the first contactor and a normally open contact of the second contactor; and the device is energized through the normally open contact of the push button, a normally closed contact of the first contactor, a normally open contact of the second contactor and a normally open contact of the third contactor to operate the machine and said second contacts of both limit switches are set to close and immediately thereafter said first contacts of both limit switches open momentarily and then reclose, after which said second contacts of both limit switches reopen to thereby check the operation of both limit switches and if one should not be operating to disconnect the source of power from the circuit.

28. A circuit for energizing a work device to control a cyclically operating machine comprising a first, second, and third contactor; each contactor having a plurality of normally open and normally closed contacts; a first and second limit switch operated by the machine, each switch having a plurality of contacts set to operate at various preselected points in the machines operating cycle; a source of electric power for energizing the contactors and work device and connected to the circuit through a normally closed first contact of each limit switch; a normally open second contact of each limit switch connected in parallel with its respective normally closed contact; an operator push button having a normally open and a normally closed contact; said first contactor energized through the normally closed contact of the push button and sustained energized through one of its normally open contacts and a normally closed contact of the second contactor; upon depression of the push button, the second contactor is energized through the normally open contact of the push button and a normally open contact of the first contactor and sustained energized through one of its normally open contacts and a normally closed contact of the third contactor, and after the second contactor is energized, the first contactor is de-energized by the opening of the normally closed contact in its sustaining circuit; a normally closed third contact of the first limit switch connected in parallel with the normally closed contact of the third contactor; and the third contactor is energized through the normally open contact of the push button, a normally closed contact of the first contactor and a normally open contact of the second contactor and the second contactor remains energized through its normally open contact and the third contact of the first limit switch; and the device is energized through the normally open contact of the push button, a normally closed contact of the first contactor, a normally open contacts of the second contactor and a normally open contact of the third contactor to operate the machine, said second contacts of both limit switches arranged to close and said first contacts of both limit switches arranged to momentarily open and then reclose their contacts after which said second contacts reopen in the unsafe portion of the machines cycle, and after said unsafe portion a normally open fourth contact of the first limit switch and a normally open third contact of the second limit switch are arranged to close to maintain the third contactor and work device energized through said third and fourth contacts and normally open contacts of the third contactor to keep the machine operating.

29. A circuit for energizing a work device to operate a cyclically operating machine as described in claim 28 wherein a normally closed fifth contact of the first limit switch is connected in the energizing circuit of the third contactor and having a normally closed contact of the second contactor connected in parallel therewith, and whereby said fifth limit switch contact is arranged to be opened momentarily after said third contact of the first limit switch opens to insure that said second contactor has become unoperated, and if not, to de-energize the third contactor and the work device to stop the machine.

30. A circuit for energizing a work device to control a cyclically operating machine comprising a first, second, third, and fourth contactor; each contactor having a plurality of normally open and normally closed contacts; a first and second machine operated limit switch,

each limit switch having contacts operated at various preselected positions in the machines cycle of operation; a source of electrical power for energizing the contactors and the work device and connected to the circuit through a normally closed first contact of each limit switch, a normally open second contact of the respective limit switches connected in parallel with the normally closed first contact; a pair of operator push buttons, each having a normally open and a normally closed contact; said first contactor energized through a normally closed contact of one of said push buttons and sustained energized through one of its normally open contacts and a normally closed contact of said third contactor; said second contactor energized through the normally closed contacts of the other push button and sustained energized through one of its normally open contacts and a normally closed contact of said third contactor; said third contactor energized through the normally open contact of said push buttons and a normally open contact of said first and second contactors, and sustained energized through the normally open contacts of said push buttons and one of its normally open contacts; and after the third contactor is energized, the first and second contactors are de-energized by the opening of said normally closed third contactor contacts in their sustaining circuits; said fourth contactor energized through the normally open contacts of the push buttons, a normally closed contact of said first and second contactors and a normally open contact of said third contactor; and said work device energized through said normally open contact of the push buttons, a normally closed contact of said first and second contactors and a normally open contact of said third contactor and said fourth contactor to operate the machine, and said second contacts of both limit switches are set to close and immediately thereafter said first contacts of both limit switches open and then reclose, and said second contacts of both limit switches repoen to thereby disconnect the source from the circuit should either of said limit switches not be operating properly.

31. A circuit for energizing a work device to control a cyclically operating machine comprising a first, second, third, and fourth contactor; each contactor having a plurality of normally open and normally closed contacts; a first and second machine operated limit switch, each limit switch having contacts operated at various preselected positions in the machines cycle of operation; a source of electrical power for energizing the contactors and the work device, and connected to the circuit through a normally closed first contact of each limit switch, a normally open second contact of the respective limit switches connected in parallel with the normally closed first contact; a pair of operator push buttons, each having a normally open and a normally closed contact; said first contactor energized through a normally closed contact of one of said push buttons and sustained energized through one of its normally open contacts and a normally closed contact of said third contactor; said second contactor energized through the normally closed contacts of the other push button and sustained energized through one of its normally open contacts and a normally closed contact of said third contactor; said third contactor energized through the normally open contact or said push buttons and a normally open contact of said first and second contactors, and sustained energized through the normally open contacts of said push buttons and one of its normally open contacts and a parallel connected normally closed contact of the fourth contactor and a third contact of the first limit switch respectively; and after the third contactor is energized, the first and second contactors are de-energized by the opening of said normally closed third contactor contacts in their sustaining circuits; said fourth contactor energized through the normally open contacts of the push buttons and a normally closed contact of said first and second contactors; and a normally open contact of said third contactor; and said third contactor remains energized through its normally open contact and the third contact of the first limit switch; and said work device is energized through said normally open contact of the push buttons, a normally closed contact of said first and second contactors and a normally open contact of said third contactor and said fourth contactor to operate the machine, said second contacts of both limit switches arranged to close and said first contacts of both limit switches arranged to open and then reclose after which said second contacts reopen in the unsafe portion of the machines cycle, and after said unsafe portion of the cycle a normally open fourth contact of the first limit switch and a normally open third contact of the second limit switch are arranged to close to maintain the fourth contactor and the work device energized through said third and fourth contact and normally open contacts of the fourth contactor to keep the machine operating.

32. A circuit for energizing a work device to operate a cyclically operating machine as described in claim 31 wherein a normally closed fifth contact of the first limit switch is connected in the energizing circuit of the fourth contactor and having a normally closed contact of the third contactor connected in parallel therewith, and whereby said fifth contact is arranged to be opened momentarily after said third contact of the first limit switch opens to insure that said third contactor has become unoperated, and if not, to de-energize the third contactor and the work device to stop the machine.

33. A circuit for energizing a work device to control a cyclically operating machine comprising a first, second, third, and fourth contactor; each contactor having a plurality of normally open and normally closed contacts; a fifth contactor having normally closed contacts; a first and second machine operated limit switch, each limit switch having contacts set to operate at various preselected points in the machines operating cycle; a source of electrical power for energizing the contactor and the work device, and connected to the circuit through normally closed first contacts of both limit switches, each normally closed contact having a normally open contact of its respective limit switch connected in parallel therewith; an operator push button having a normally open and a normally closed contact; said first contactor to be connected to energize through the normally closed contact of the push button; said fifth contactor connected to be energized through the normally closed contact of the push button, a normally open contact of the first contactor and normally open contact of the push button; said second contactor energized through a normally open contact of said first contactor and sustained energized through one of its own normally open contacts and a normally closed contacts of said third contactor; and upon depression of said push button said first contactor is de-energized and said third contactor is energized through the normally open contact of the push button, a normally closed contact of said first and fifth contactors, and a normally open contact of said second contactor, and sustained energized through one of its normally open contacts; and after the third contactor is energized, the second contactor is de-energized by the opening of said normally closed third contactor contact in its sustaining circuit; said fourth contactor is energized through the normally open contact of the push button, a normally closed contact of the first and second and fifth contactors, and a normally open contact of the third contactor; and said work device is energized through the normally open contact of said push button, a normally closed contact of said first and second and fifth contactors, and a normally open contact of said third and fourth contactors to operate the machine whereby said second contacts of the limit switches are operated to close and immediately thereafter said first contacts of the limit switches are op-

erated to open and reclose, and said second contacts are operated to reopen to thereby de-energize the circuit and stop the machine should either of the limit switches not be operating properly.

34. A circuit for energizing a work device to control a cyclically operating machine comprising a first, second, third, and fourth contactor; each contactor having a plurality of normally open and normally closed contacts; a fifth contactor having normally closed contacts; a first and second machine operated limit switch, each limit switch having contacts set to operate at various preselected points in the machines operating cycle; a source of electrical power for energizing the contactors and the work device, and connected to the circuit through normally closed first contacts of both limit switches, each normally closed contact having a normally open contact of its respective limit switch connected in parallel therewith; a plurality of operators push buttons, each having a normally open and a normally closed contact; said first contactor connected to be energized through the normally closed contact of the push buttons; said fifth contactor connected to be energized through the normally closed contact of the push buttons and a plurality of separate circuits, each separate circuit containing one of the normally open push button contacts and at least one normally open contact of said first contactor and established by normally closed contacts of said first contactor; said second contactor energized through a normally open contact of said first contactor and sustained energized through one of its own normally open contacts and a normally closed contact of said third contactor; and upon depression of said push buttons said first contactor is de-energized and said third contactor is energized through the normally open contact of said push buttons, a normally closed contact of said first and fifth contactors, and a normally open contact of said second contactor, and sustained energized through one of its normally open contacts; and after the third contactor is energized, the second contactor is de-energized by the opening of said normally closed third contactor contact in its sustaining circuit; said fourth contactor is energized through the normally open contact of the push buttons, normally closed contact of the first and second and fifth contactors, and a normally open contact of the third contactor; and said work device is energized through the normally open contact of said push buttons, a normally closed contact of said first and second and fifth contactors, and a normally open contact of said third and fourth contactors to operate the machine whereby said second contacts of the limit switches are operated to close and immediately thereafter said first contacts of the limit switches are operated to open and reclose, and said second contacts are operated to reopen to thereby de-energize the circuit and stop the machine should either of the limit switches not be operating properly.

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LLOYD McCOLLUM, *Primary Examiner.*

MILTON O. HIRSHFIELD, *Examiner.*

UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,183,377 May 11, 1965

Frank H. Holland

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 2, line 11, for "colsed" read -- closed --; column 14, line 35, after "open" insert -- and normally --; column 19, line 8, for "control" read -- contact --.

Signed and sealed this 23rd day of November 1965.

(SEAL)
Attest:

ERNEST W. SWIDER
Attesting Officer

EDWARD J. BRENNER
Commissioner of Patents