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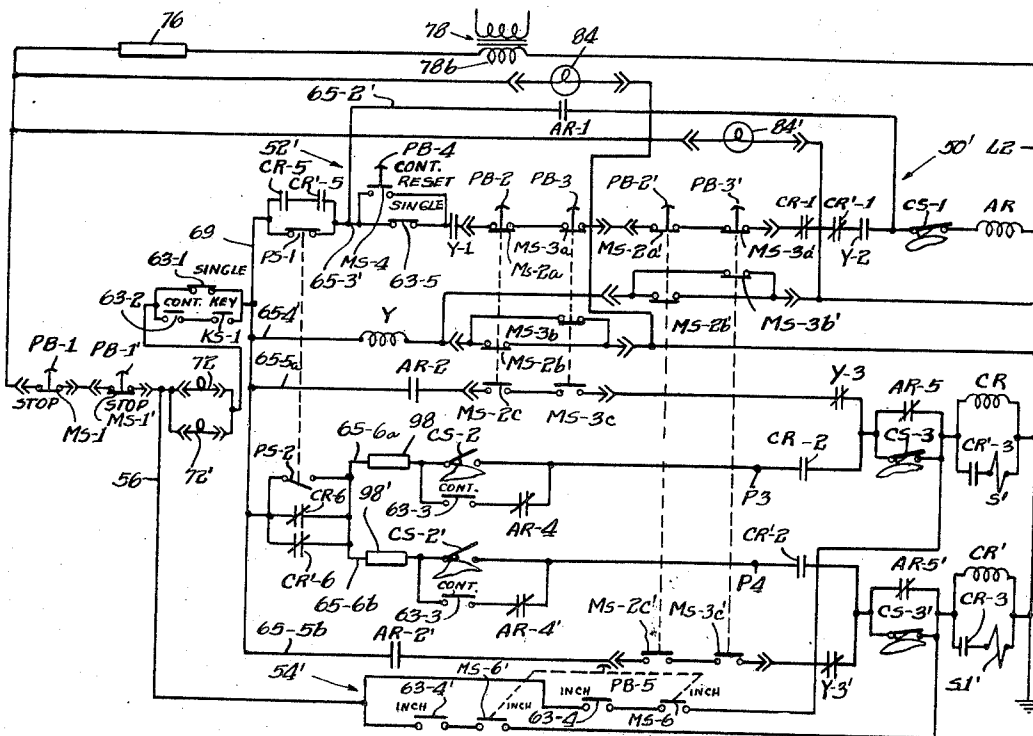
[54] **SAFETY CONTROL CIRCUIT FOR PRESSES AND THE LIKE**
44 Claims, 18 Drawing Figs.

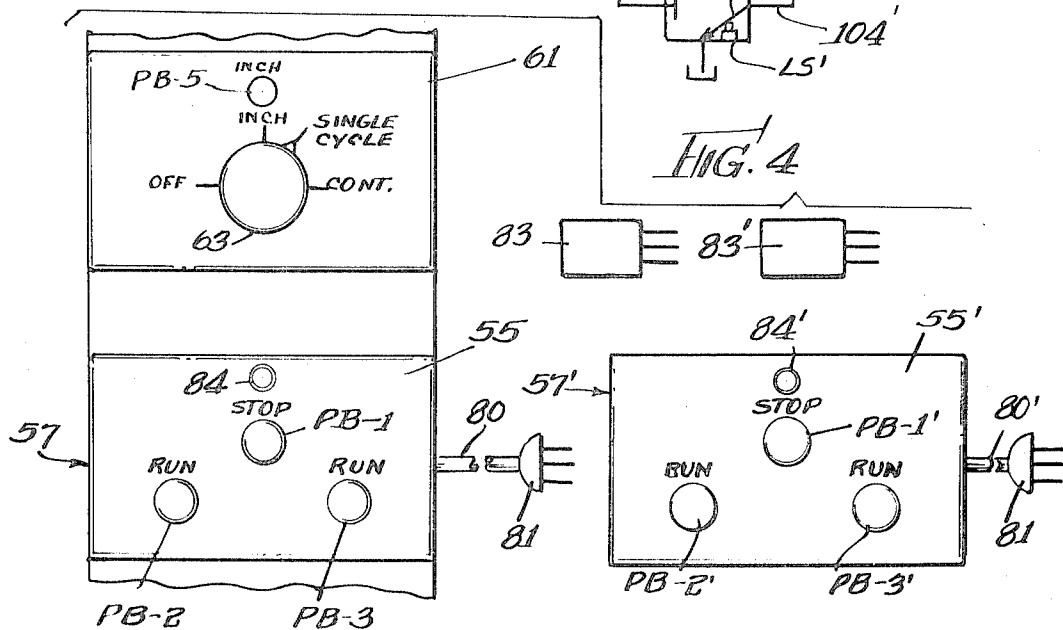
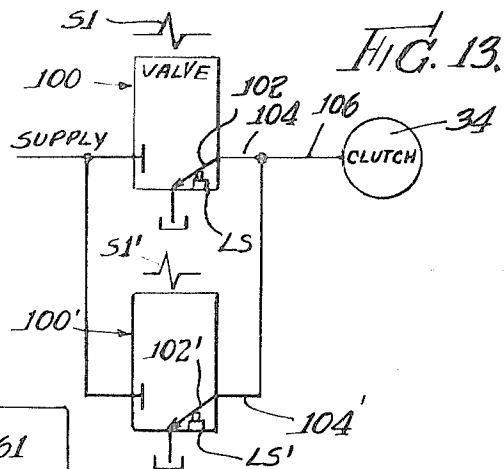
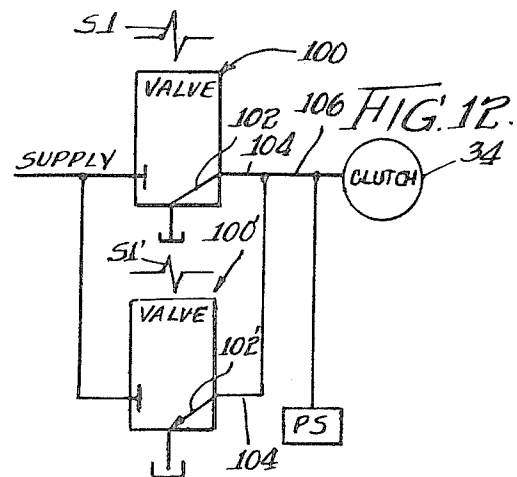
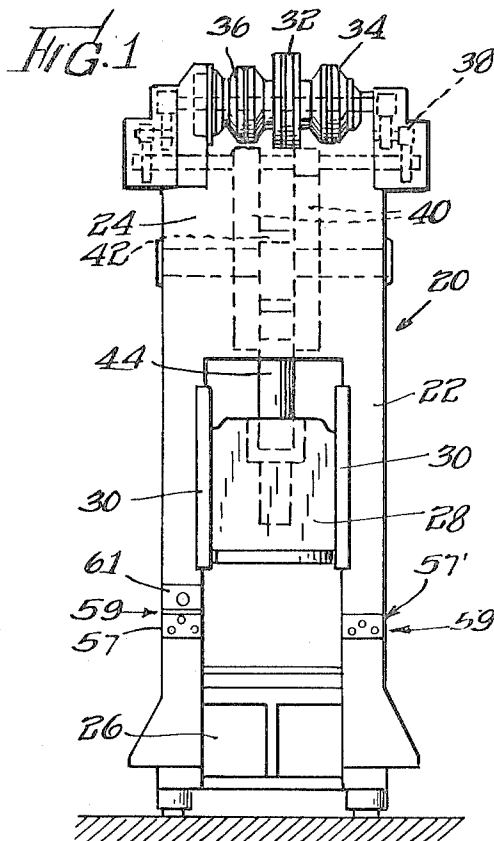
[52] U.S. Cl. 72/6,
100/53, 192/144
[51] Int. Cl. B21j 9/20
[50] Field of Search 72/6, 1, 21;
192/143, 131 R, 144, 131 H; 100/53

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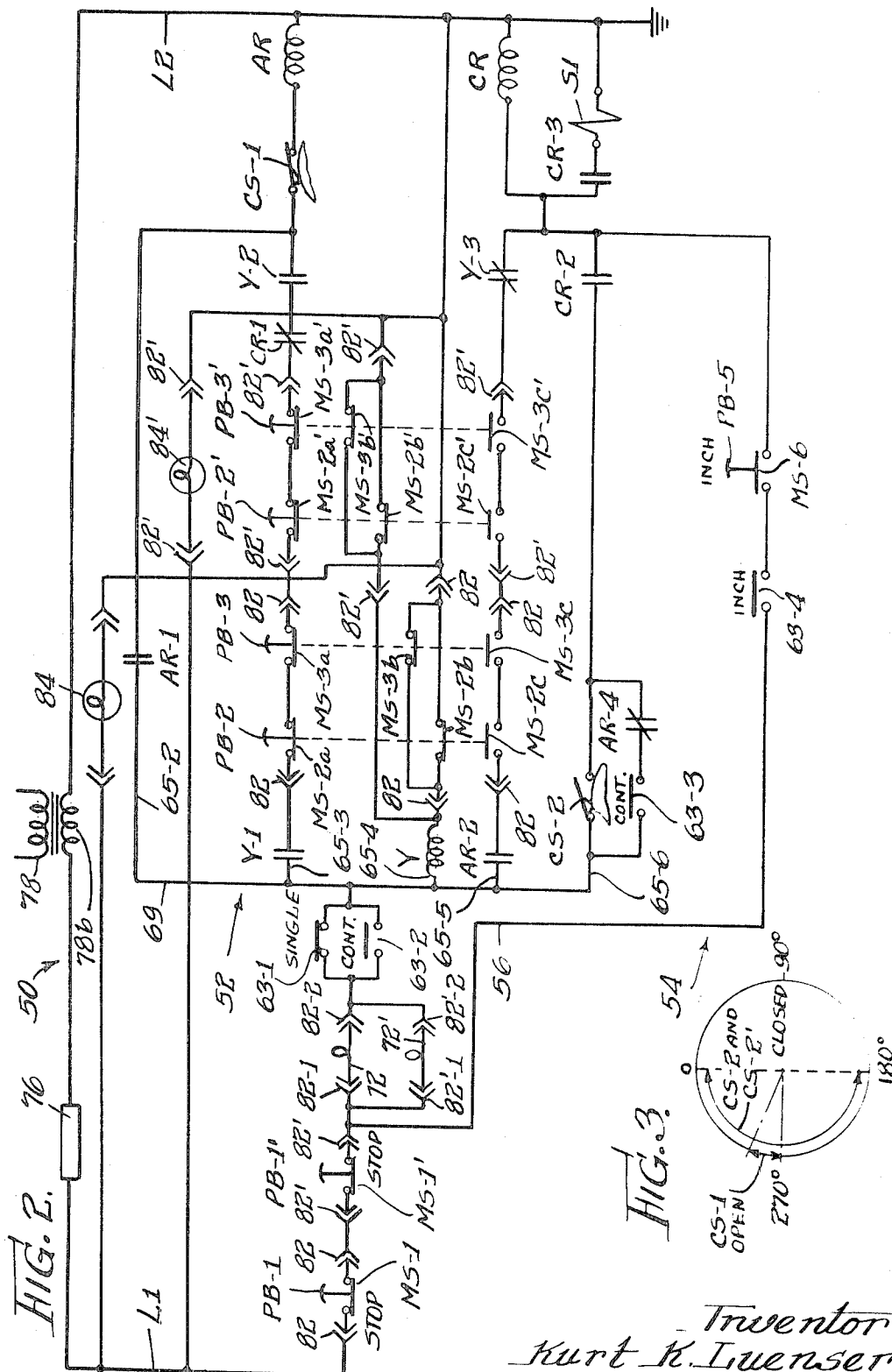
ABSTRACT: An electrical control circuit for a multicon-
trolled machine having manually operates switch means
operated by respective self-returning manually operable control
means at a number of operator stations, all of which
switch means must be operated at the same time to initiate
movement of a work producing portion of the machine. The
manually operated switch means includes normally open
switches in a drive control relay circuit and normally closed
switches connected in parallel between a manually controlled
relay and a source of power so that the manually controlled
relay cannot be deenergized until all of the normally closed
switches are opened and will not become deenergized until all
of the normally closed switches have been closed. The
manually controlled relay operates normally closed switch
means in the drive control relay circuit, and normally closed
switch means in an antirepeat relay circuit which prepares the
drive control relay circuit for energization by closure of all of
the normally open manually operated switch means.





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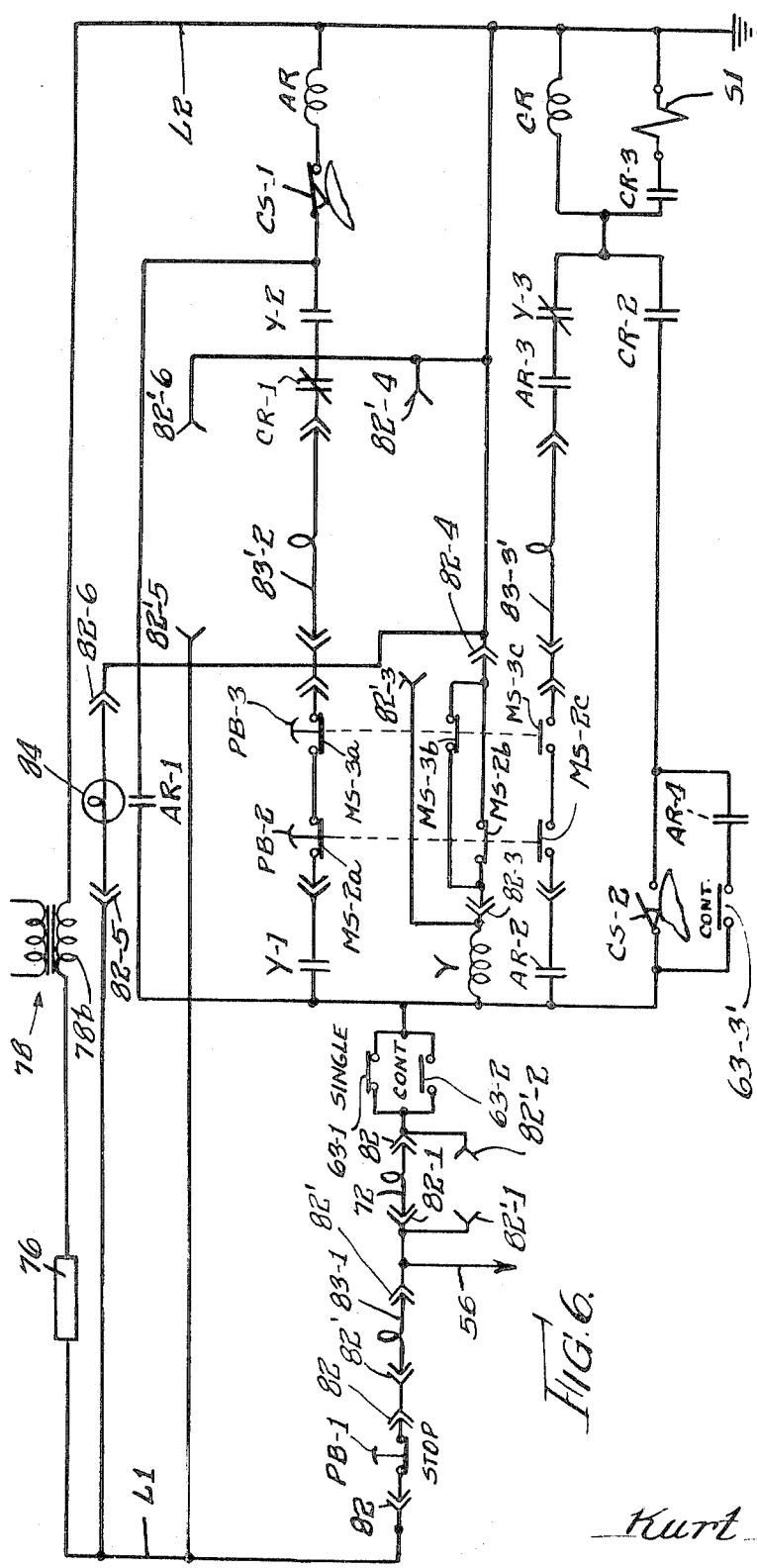


FIG. 6.

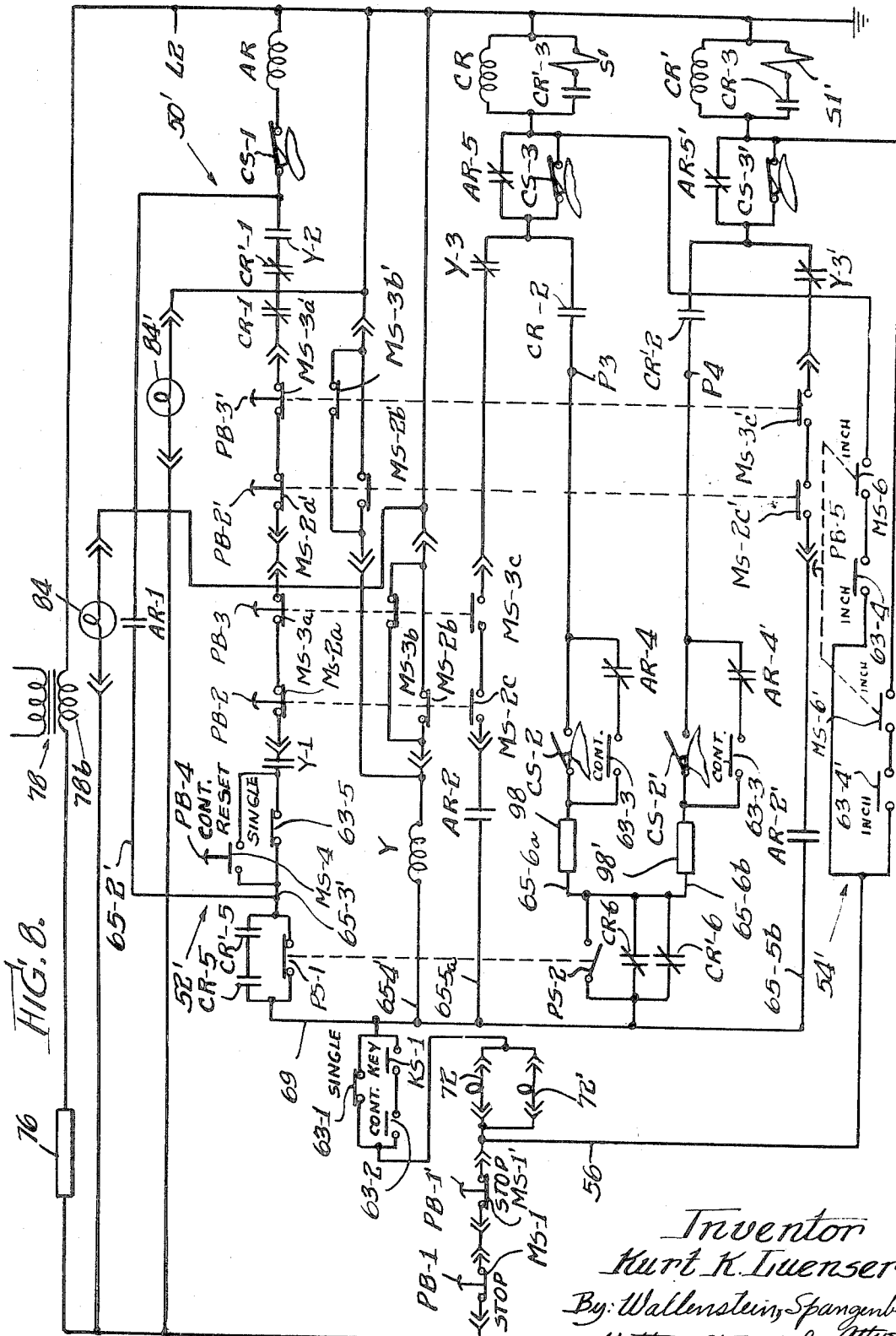
RAM POS.	RUN BUTTONS	Y	AR	CR
0°	ALL RELEASED	E	E	D
0°-180°	ALL DEPRESSED	D	E	E
180°	ALL RELEASED (CS-2 CLOSING)	E	E	E
270°	ALL RELEASED (CS-1 OPENING)	E	D	E
0°	ALL RELEASED (CS-2 OPENING)	E	E	D

NOTE: E MEANS RELAY LOCKED IN ENERGIZED STATE

FIG. 2A.

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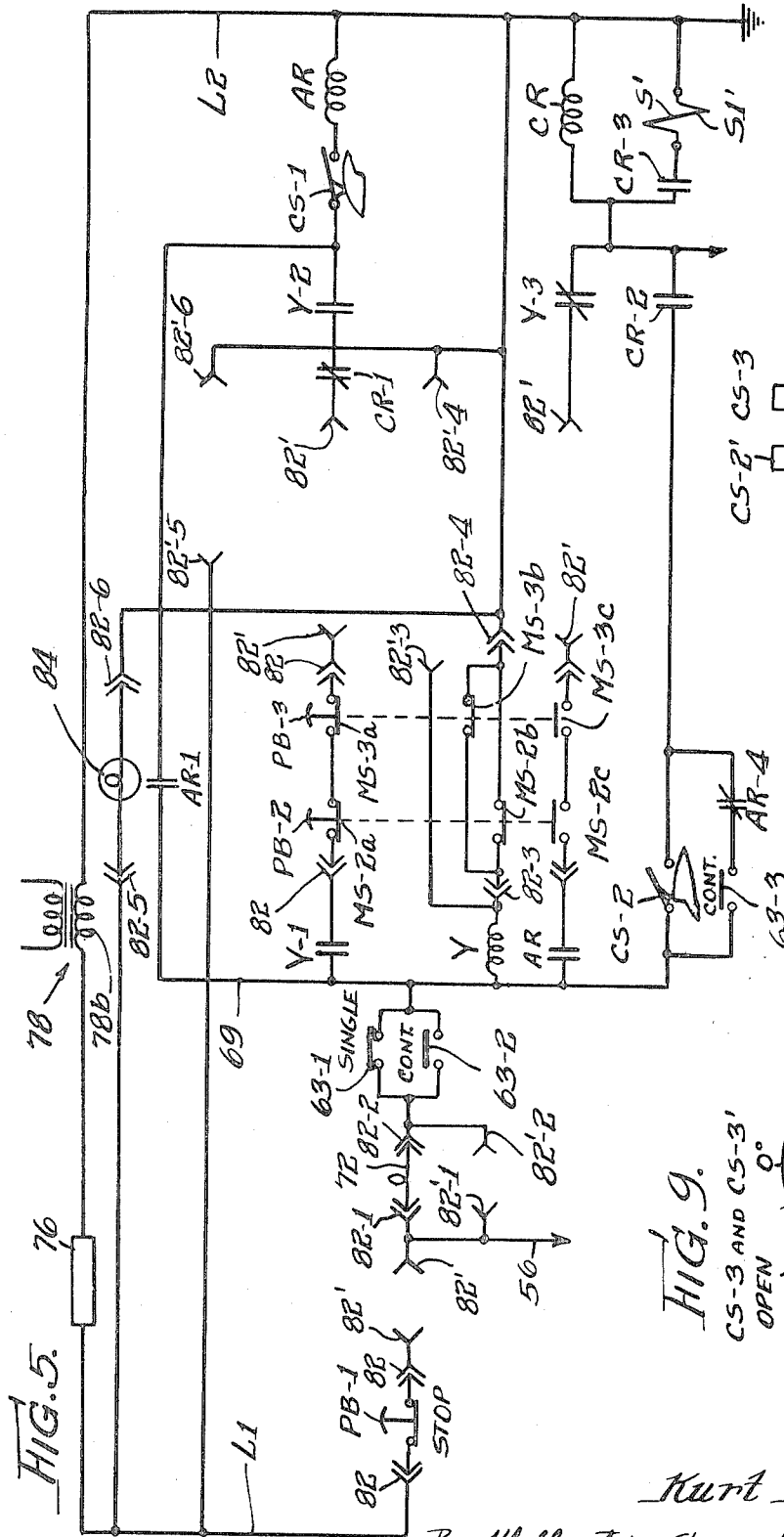
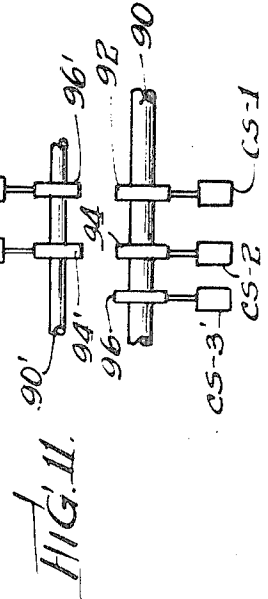
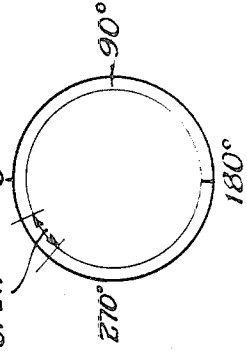


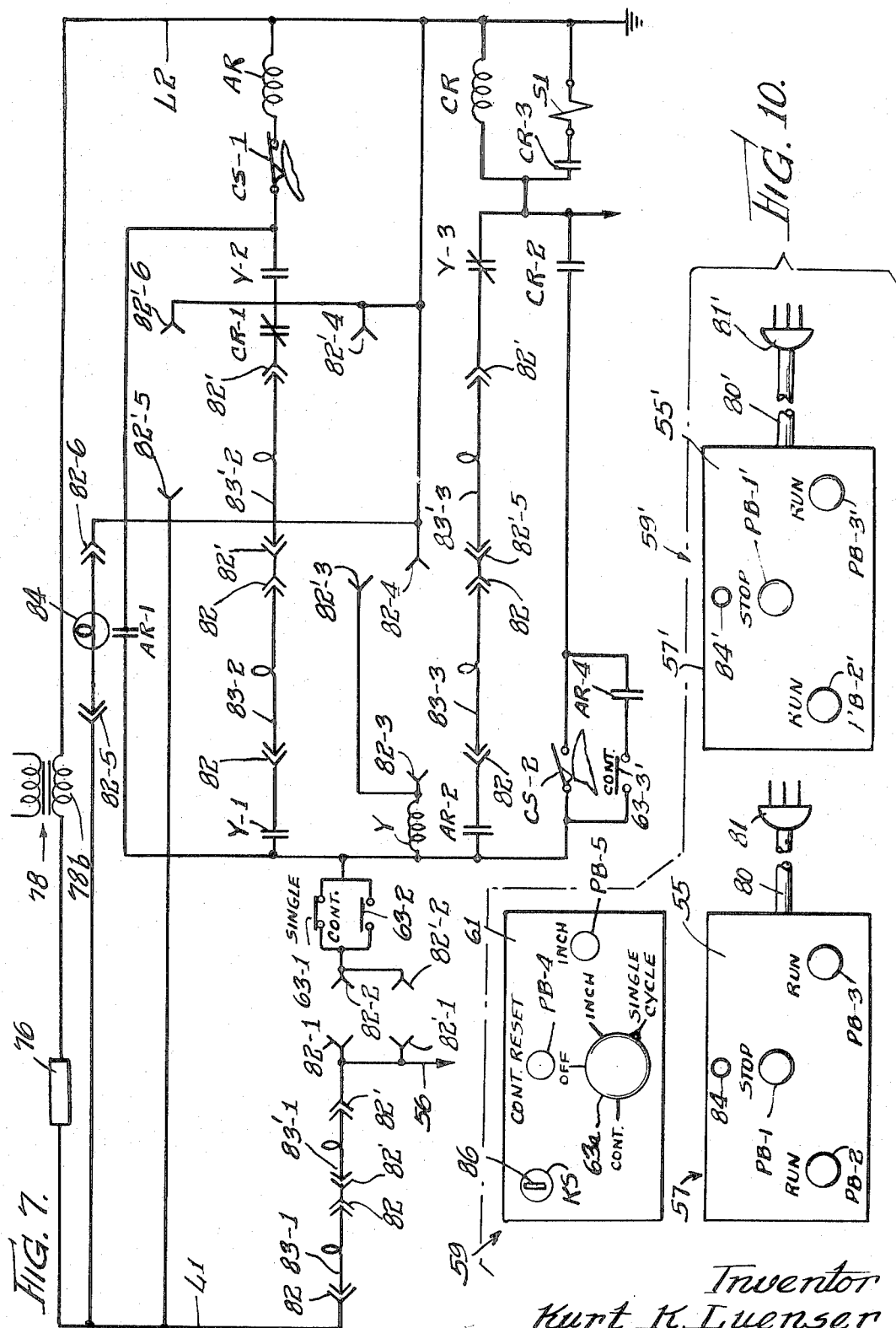
FIG. 9.

CS-3 AND CS-3' OPEN



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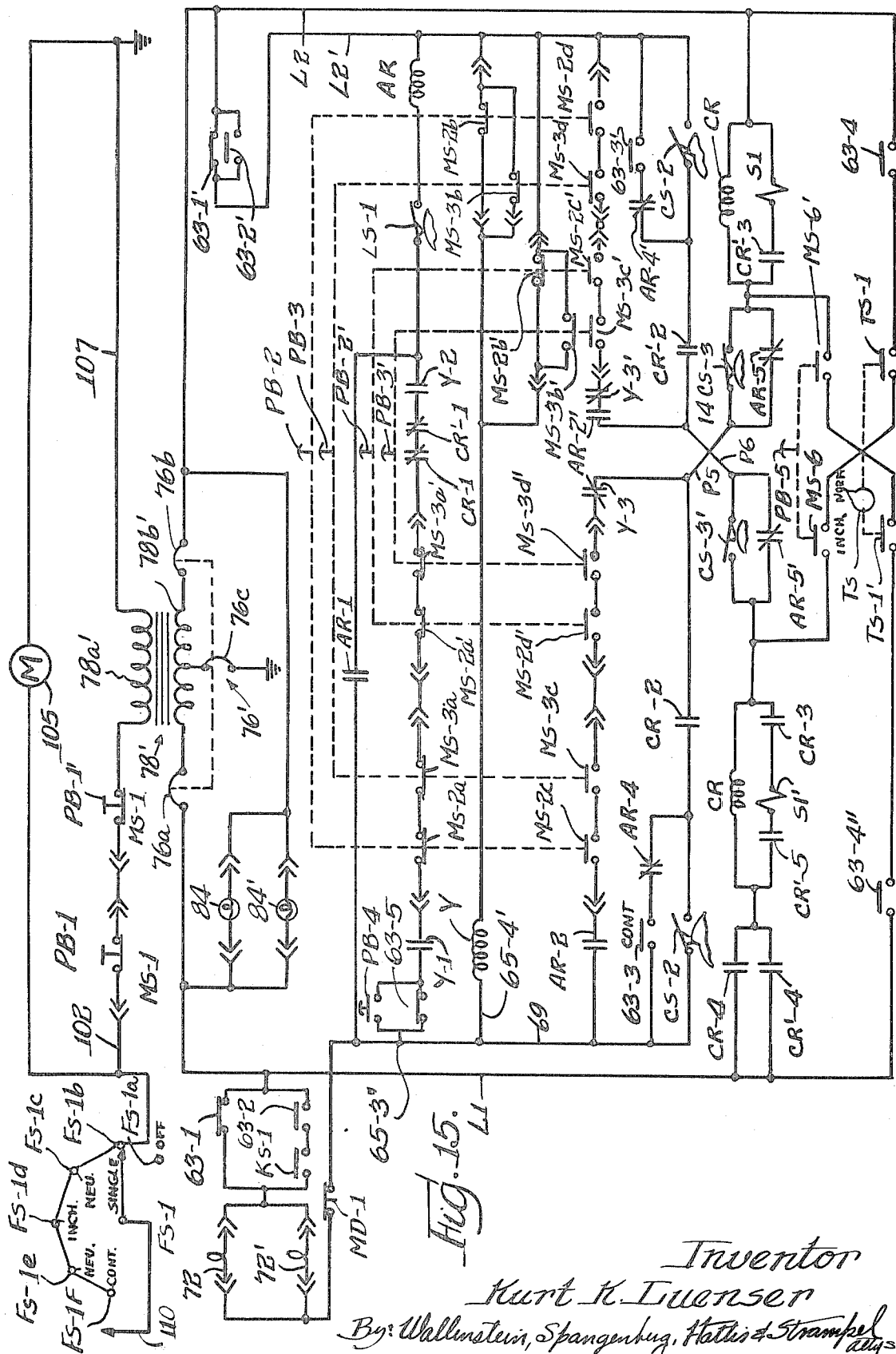


Fig. 16.

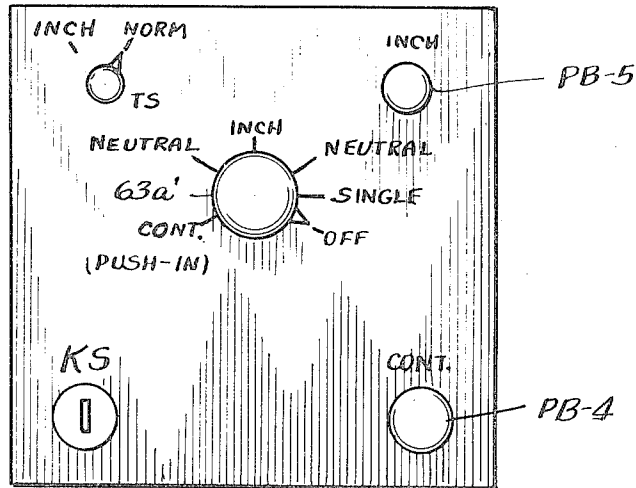
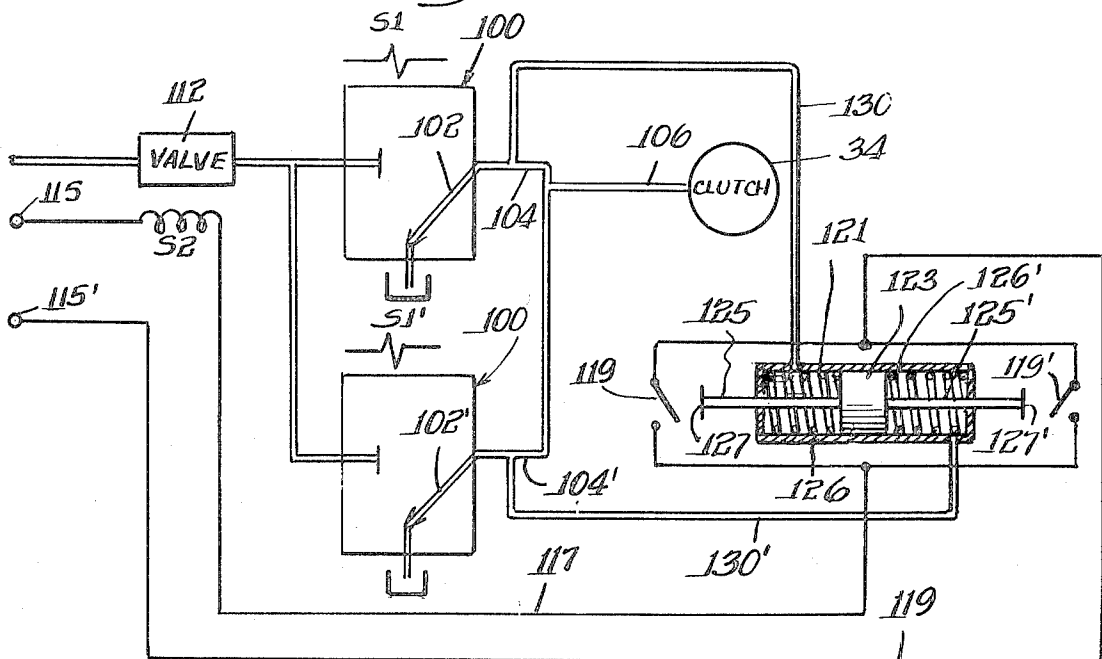


Fig. 17.



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SAFETY CONTROL CIRCUIT FOR PRESSES AND THE LIKE

This application is a continuation-in-part of application Ser. No. 824,410, filed May 14, 1969.

The present invention relates to machine controls, and more particularly to a new and improved control system having the most useful application in metal-stamping presses and the like. Although many of the features of the invention have a broader field of application, many of the various features of the invention are particularly useful in multioperator controlled presses.

It is customary in metal-stamping presses of this type to provide a continuous mode of operation where the press ram is continuously operated, a single cycle mode of operation where the press ram is under manual control only during the downstroke of the ram and the ram automatically comes to rest in the raised position thereof each cycle, and an inch mode of operation where the movement of the press ram is constantly under the control of a press operator at all times. In presses of great tonnage capacity, a number of operators are commonly stationed about the machine and for safety reasons each operator has his own operator control station with controls which together with the controls of the other stations must generally be operated to operate the press when a single cycle or inch mode of operation is desired. Generally, each operator station has a pair of "run" control pushbuttons which must be operated to initiate these modes of operation.

The press control circuits heretofore developed have left much to be desired from the standpoint of safety. For example, the "run" control pushbuttons referred to at the operator control stations are often subjected to a great deal of abuse which can cause undesired grounding or short circuits in the various contacts operated by the control pushbuttons. In such case, it is readily possible that the press ram can be operated by depression of only one or less than all of the control pushbuttons or the press ram can operate continuously when it is supposed to stop automatically after one cycle of operation, placing an operator in the path of movement of the press ram in great danger.

Additionally, the control circuit which operates the press ram frequently includes cam driven limit switches which are closed and opened at various angular positions of a crank arm operating the press ram. If the drives of these limit switches fail or short circuits occur across the limit switch contacts, the control circuit may operate the press ram continuously or when less than all the control pushbuttons are depressed. Sometimes, the grounding or short circuiting of contacts of a switch will not cause improper operation of the press until a second fault occurs in the circuit. It is important, therefore, to detect the initial difficulty when it occurs to avoid the problem caused by the second fault. The prior press control circuits frequently did not give any indication of various ground or short circuit conditions.

The press ram is frequently controlled by an air-operated clutch. Air pressure to the clutch is frequently under the control of a pair of valves operated by respective solenoids connected in parallel in the electrical control circuit involved. Both valves must be opened to develop sufficient air pressure at the air input to the clutch to initially operate the same. A serious hazard can develop if input air pressure ceases during a continuous cycle mode of operation and then becomes reestablished, or if a defect in the mechanism of one of the valves, the solenoid, or the circuit controlling the same occurs which causes one or both valves to stick or remain in an open position during a single cycle mode of operation.

Generally, press control circuits are designed to provide the continuous operating mode as a standard operating mode regardless of the intended use of the press. A very serious hazard exists if an operator inadvertently selects a continuous operating mode expecting or intending a single cycle operating mode. Presses are commonly prepared for one of the various possible modes or operation thereof, namely the continuous operating mode, the single cycle operating mode, and the inch operating mode, by manual operation of a function control

switch or by jumpering terminals. The function control switch can readily be operated mistakenly in a continuous operation position. The jumpered terminals are generally hidden from view so the addition or removal of a jumper requires the services of an electrician. A jumper permitting continuous operation may not be removed when the desirability of the continuous function no longer exists. It is apparent, therefore, that equipment which can be operated in either a continuous or noncontinuous mode of operation can involve serious hazardous conditions.

If a press control circuit is to meet the approval of many users, the control equipment must be designed so that the individual controls at a given operator control station can be deliberately bypassed. Where the aforementioned control pushbuttons at an operator station include both normally open and normally closed contacts the control pushbuttons were often designed to be locked into a position where the normally opened contacts are locked closed and the normally closed contacts remains closed. As long as one operator control station remains operative, the control circuit remains comparatively safe. However, in the event that all of the control pushbuttons are inadvertently in their locked conditions, a serious safety hazard can exist under certain conditions. The same hazard exists when the various operator control stations include plug-in units which can be replaced by dummy plugs which include jumpers which provide the necessary circuit continuity. In the event that dummy plugs are inserted in all of the stations, the same danger exists as in the case of the locked control pushbuttons. Also, where plug-in operator control units are used, it sometimes occurs that a control unit is unplugged and an operator without knowledge of this fact depresses a stop pushbutton thereat without the desired result of stopping the movement of the press ram to avoid damage or harm to a workpiece of operator in the path of the ram.

Each of the features of the invention eliminates or minimizes the danger from one or more of the various hazardous conditions just described. In the preferred form of the invention, a relatively simple and inexpensive circuit having a unique arrangement of switches therein eliminates or minimizes the danger from all of the hazardous conditions referred to.

The various features of the invention and the advantages thereof will become apparent from the following description, taken in conjunction with the claims and the accompanying drawings wherein:

FIG. 1 is an elevational view, partly schematic, of a typical press;

FIG. 2 is a diagram of an electrical control circuit incorporating many of the safety features of the present invention;

FIG. 2A is a chart indicating the conditions of the various relays shown in FIG. 2 at various angular positions of the press ram crank arm;

FIG. 3 is a timing diagram illustrating the operation of machine controlled cam switches shown in the circuit of FIG. 2 (and FIG. 8);

FIG. 4 is a front view of the operator control stations of the press of FIG. 1 and the plug-in and other control units associated therewith;

FIG. 5 shows part of the control circuit of FIG. 2 after removal of one of the operator plug-in control units of one of the operator stations;

FIG. 6 shows the control circuit of FIG. 5 when the unplugged operator control unit is replaced by a dummy plug-in unit which short circuits various terminals of the circuit of FIG. 2;

FIG. 7 shows part of the control circuit of FIG. 2 after all of the operator plug-in control units have been replaced by dummy plugs;

FIG. 8 is a diagram of a further improved control circuit of the invention which includes many additional safety features from that supplied by the circuit of FIG. 2;

FIG. 9 is a timing diagram illustrating the operation of machine controlled cam switches added to the control circuit of FIG. 8;

FIG. 10 is a front view of the operator control stations and the control units thereat used in the embodiment of the invention shown in FIG. 8;

FIG. 11 illustrates an exemplary drive system for the cam-operated switches of the circuit of FIG. 8;

FIG. 12 is a schematic diagram showing the clutch operating air control valves, solenoids operating the same and a unique pressure responsive switch means controlled by the pressure in the input to the clutch with the circuit of FIG. 8;

FIG. 13 is a schematic diagram showing the clutch operating air control valves, solenoids operating the same and a unique limit switch means controlled by the valves directly which limit switch means duplicates the function of the pressure responsive switch means of FIG. 12;

FIG. 14 is a fragmentary diagram of a part of the control circuit of FIG. 8 modified by the replacement of the pressure switch contacts of FIG. 8 by contacts operated by the limit switch means of FIG. 13;

FIG. 15 shows the most preferred control circuit of the invention;

FIG. 16 shows a master control panel with improved function controls thereon used with the circuit of FIG. 15 for minimizing the possibility of an unsafe or erroneous inadvertent operation of the controls; and

FIG. 17 is a schematic diagram showing a modified air pressure valve and solenoid control system for the clutch used with the circuit of FIG. 15.

EMBODIMENT OF FIGS. 1-7

Referring now to FIG. 1, a press 20 is shown which is of the type disclosed in the David C. Verson and Albert Clements U.S. Pat. No. 2,286,943, with certain modifications which are dictated by the present invention. The press 20 includes a frame 22 having a crown 24, a bed 26, and a reciprocable ram 28 movable in gibs 30. In the press crown is mounted a motor (now shown), a flywheel 32 driven by the motor and connected through a clutch 34, a clutch and brake assembly 36, and suitable gearing 38, to a pair of large gears 40 which drive an eccentric 42 for pitman 44 connected to the ram 28.

The clutch 34 and clutch brake assembly 36 may be of the pressure fluid-operated type (either hydraulic or pneumatic), and, in such case, the supply of fluid thereto is under the control of one or more solenoid operated valves, the solenoid or solenoids of which are incorporated in the control circuit 50 (FIG. 2) to which the present invention pertains.

Power for the control system (FIG. 2) is obtained from the lines L1 and L2 which are connected to a first section 52 of the circuit controlling the single cycle and the continuous cycle modes of operation, and a second section 54 controlling the inching cycle mode of operation of the press. The circuit 50 incorporates a pair of manually operated emergency stop switches MS-1 and MS-1' which are in series with the line L1 and the circuit sections 52 and 54. These switches are normally closed, but may be opened in an emergency to stop the press operation at any instant and for any reason. The switches MS-1 and MS-1' are operated respectively by stop pushbuttons PB-1 and PB-1' respectively mounted on front panels 55 and 55' (FIGS. 1 and 4) of operator plug-in control units 57 and 57' positioned at front and rear control stations 59-59' on the frame of the machine. (Although in the preferred form of the invention the operator control units 57 and 57' are plug-in units, it should be understood that, in accordance with the broader aspects of the invention, the operator units 57 and 57' may be permanently wired into the circuit involved.)

The operator control station 59 is a master control station at which certain controls are located not present at the other operator control station 59'. Thus, the master control station 59 includes a control panel 61 which has a manually operable function control means illustrated as a control knob 63 which is movable to a number of different stable positions identified as "off," "inch," "single cycle" and "continuous" positions. Various switch means or contacts to be described are open and closed when the control knob 63 is in its various positions

to accomplish the aforementioned inch, single cycle and continuous cycle modes of operation. The circuit section 52 is operable during the single cycle and continuous cycle operation and the circuit section 54 is operable during the inch mode of operation. When the function control knob 63 is positioned in its "single cycle" position, contacts 63-1 (FIG. 2) are closed and contacts 63-2, 63-3 and 63-4 are opened in the circuit section 52. When the function control knob 63 is moved to its "continuous" position, contacts 63-1 are opened and contacts 63-2 and 63-3 are closed. When the function control knob 63 is moved into its "inch" position, contact 63-1, 63-2 and 63-3 are opened and previously opened contacts 63-4 in the circuit section 54 are closed.

The front panel 55 of the operator plug in control unit 57 has a pair of run control pushbuttons PB-2 and PB-3 on the panel 55, and the front panel 55' of the operator plug in control unit 57' has a pair of run control pushbuttons PB-2' and PB-3'. The control pushbutton PB-2 at the operator control station 59 operates ganged normally closed contacts MS-2a and MS-2b and normally opened contacts MS-2c. (The expression "normally open" and "normally closed" indicates the condition of the relay contacts being described when the associated relay is deenergized.) The corresponding control pushbutton PB-2' at the operator control station 59' operates corresponding ganged contacts MS-2a', MS-2b' and MS-2c' which are identical to the correspondingly identified contacts of the run control pushbutton PB-2 just described. The run control button PB-3 at the operator control station 59 controls normally closed contacts MS-3a and MS-3b and normally opened contacts MS-3c. The run control pushbutton PB-3' at the operator control station 59' has contacts MS-3a', MS-3b' and MS-3c' which are identical to the correspondingly identified contacts controlled by the run control pushbutton PB-3.

As previously indicated, one of the major sources of difficulty with press control circuits of the prior art which utilized control pushbuttons and associated switches like that just described is the undesired short circuiting or grounding of the various contacts controlled by the control pushbuttons PB-2, PB-3, PB-2' and PB-3'. One of the features of the present invention which minimizes this difficulty is in the particular arrangement of the normally closed contacts MS-2b, MS-3b, MS-2b' and MS-3b' in the circuit section 52, so that various short circuits or grounds occurring on or between these contacts will not permit movement of the press ram unless all of the run pushbuttons PB-2, PB-2', PB-3 and PB-3' are depressed.

Referring particularly to FIG. 2, circuit section 52 thereof includes the usual clutch relay CR which when energized closes its normally open contacts CR-3 in series with one or more clutch solenoids S1. As indicated, the contacts CR-3 and clutch solenoid S1 are connected in series across the clutch relay CR. The circuit section 52 also includes the usual antirepeat relay AR which has normally open contacts such as AR-2 in a circuit branch 65-5 extending between the clutch relay CR and a common bus 69. In the particular circuit described, the terminal of the clutch relay CR remote from the circuit branch 65-5 is connected to line L2 which is shown as a grounded line.

The bus 69, which is the ungrounded input to the circuit section 52, is connected to the stop switches MS-1 and MS-1' through single cycle function switch contacts 63-1 (which are closed only during the single cycle mode of operation of the press and are connected in parallel with continuous cycle function switch contacts 63-2 which are closed only during the continuous mode of operation of the press), and a pair of parallel connected jumpers 72 and 72' whose function will be explained later on in the specification. The circuit section 52 further includes a manual-controlled relay Y in a circuit branch 65-4 and having normally closed contacts Y-3 in the circuit branch 65-5 so that the clutch relay CR can be initially energized only when relay Y is deenergized, and normally open contacts Y-1 and Y-2 in a circuit branch 65-3 which

controls the initial energization of the antirepeat relay AR so that the antirepeat relay AR cannot be reset to an initially energized condition at the end of each press cycle unless the manual-controlled relay Y is energized.

In the prior circuits, it was customary to provide a relay carrying out some of the functions of the manual-controlled relay Y which relay was connected across a common bus like 69 and a powerline like L2 by a series arrangement of the contacts MS-2b, MS-3b, MS-2b' and MS-3b'. However, it was discovered that circuit reliability is greatly enhanced when the latter contacts are connected in parallel with one another and in series with the manual-controlled relay Y so that all of the run control pushbuttons PB-2, PB-2b', PB-3 and PB-3' must be depressed to deenergize the manual-controlled relay Y. In such case, most short circuits occurring between any of the run control pushbutton contacts in the circuit branch 65-4 and the pushbutton contacts in the circuit branch 65-5 will not result in the energization of the clutch relay CR unless all of the run control pushbuttons are depressed.

The circuit branch 65-3, which controls the initial energization of the antirepeat relay AR, includes a series circuit of normally open contacts Y-1 of the manual controlled relay Y, normally closed run pushbutton contacts MS-2a, MS-3a, MS-2a' and MS-3a', normally closed contacts CR-1 of the clutch relay CR and normally open contacts Y-2 of the manual-controlled relay Y. A set of normally open-holding contacts AR-1 of the antirepeat relay AR are connected between the common bus 69 and the terminal of the contacts Y-2 remote from the bus 69. The latter terminal of the contacts Y-2 is connected through a normally closed cam-controlled switch CS-1 to one terminal of the antirepeat relay AR whose opposite terminal is connected to the line L2. The cam switch CS-1, as shown in the timing diagram of FIG. 3, is opened momentarily when the arm driving the press ram in a position, such as a 270° position, where the ram is nearing the return to its initial starting position. (It is assumed that a crank arm drives the press ram between its starting and work producing positions and that, when the ram is at the top of the machine, the crank arm is in a 0° position. The crank arm rotates in a clockwise direction as viewed in FIG. 3, to first bring the press ram down to its bottommost position, which is the 180° position of the crank arm, and then rotates back to its initial starting position as it moves between the 180° and 360° positions).

For reasons to be explained, the manual-controlled relay Y has one terminal connected directly to the common bus 69 rather than to the grounded line L2 as in the case of the other relays. The parallel circuit of the run control pushbutton contact MS-2b, MS-2b', MS-3b and MS-3b' is connected between the terminal of the manual-controlled relay Y remote from the common bus 69 and the grounded line L2. It can be seen that with the connection of the manual-controlled relay Y on the side of the run pushbutton contact nearest the bus 69 and the connection of the antirepeat relay AR to the side of the run pushbutton contacts nearest line L2, any short circuits which occur between the normally closed pushbutton contacts MS-2a, MS-3a, MS-2a' and MS-3a' on the one hand, and the normally closed pushbutton contacts MS-2b, MS-3b, MS-2b' and MS-3b', on the other hand, result in a short circuit which will cause short circuit current to flow through the lines L1 and L2. A fuse 76 is provided in the connection between the line L1 and one terminal of the secondary winding 78b of a power transformer 78 whose other terminal is connected to the line L2, which fuse will blow to deenergize the control circuit and alert the operators to the fact that a short circuit may have occurred between the run pushbutton contacts referred to. The grounding of any of the normally closed pushbutton contacts MS-2a, MS-3a, MS-2a' and MS-3a' will also cause a similar short circuit to develop which blows the fuse 76.

When the manual-controlled relay Y is energized and the press ram is in its uppermost position, an energization path for the antirepeat relay AR is established through the circuit branch 65-3 whereupon the relay will lock in through a hold-

ing circuit branch including the normally open holding contacts AR-1 of the antirepeat relay, provided none of the run control pushbuttons PB-2, PB-3, PB-2' and PB-3' are depressed.

The circuit branch 65-5, which effects initial energization of the clutch relay CR, includes, in the order named, normally open contacts AR-2 of the antirepeat relay AR, the normally open run pushbutton contacts MS-2c, MS-3c, MS-2c' and MS-3c' connected in series, and normally closed contact Y-3 of the manual-controlled relay Y. It is thus apparent that upon depression of all of the run control pushbuttons PB-2, PB-3, PB-2' and PB-3' and the continued energization of the antirepeat relay AR, the manual-controlled relay is deenergized and the clutch relay CR will be energized through the circuit branch 65-5. When any of the run control pushbuttons PB-2, PB-3, PB-2' and PB-3' are released before the ram reaches its lowermost position, the clutch relay CR will become deenergized to stop the movement of the press ram. However, once the crank arm of the press ram moves into an angular position between 180° and 360° where a dangerous condition to the worker no longer exists, a machine-controlled cam switch CS-2 connected in series with the normally opened contact CR-2 of the clutch relay CR between the bus 69 and the side of the clutch relay CR remote from the ground line L2 closes to establish a holding circuit branch 65-6 which energizes the clutch relay CR independently of the position of the aforementioned run control pushbutton contacts until the cam switch CS-2 opens when the press ram returns to its uppermost position. For reasons to be explained, the cam switch CS-2 is shunted by a series circuit of the continuous function switch contacts 63-3 and normally closed contacts AR-4 of the antirepeat relay AR.

It should be noted that there are normally open contacts Y-1 and Y-2 of the manual-controlled relay Y in the circuit branch 65-3 on the opposite sides of the series circuit comprising the run control pushbutton contacts MS-2a, MS-3a, MS-2a' and MS-3a' to provide maximum protection against the hazards of a short circuit between the contacts in the circuit branches 65-3 and 65-5 which could energize the clutch relay CR. For example, such a short circuit would not result in the energization of the clutch relay CR because this would place normally open contacts Y-1 of the manual-controlled relay Y in circuit branch 65-3 in series with normally closed contacts Y-3 of the same relay in the circuit branch 65-5 which establishes a discontinuity.

It will be noted also that contacts AR-2 in the circuit branch 65-5 are placed adjacent the bus 69 to isolate short circuits between the circuit branches 65-3 and 65-5 from the line L1. Without such isolation, such a short circuit would for example, between the right-hand terminals of contacts MS-3a' and contacts MS-3c'; reenergize the antirepeat relay AR as the ram reached its uppermost position after the relay AR has been reset by opening of the cam switch CS-1 if the control pushbuttons PB-2, PB-2', PB-3 and PB-3' are depressed before the ram reaches its uppermost position. The undesired energization of the antirepeat relay as the ram reaches its uppermost position will prevent the clutch relay from being deenergized at this instant so the continued depression of the control pushbuttons would cause continued energization of the clutch relay. Thus, the aforesaid positioning of the contacts AR-2 will prevent the continued depression of the control pushbuttons from energizing the antirepeat relay if a certain short circuit exists between circuit branches 65-3 and 65-5 and causing a recycling of the machine until the control pushbuttons are released and then depressed again.

When the function control knob 63 is moved to its "continuous" position to effect a continuous cycle mode of operation of the press, to complete the initiation of a continuous cycle of operation all of the run control pushbuttons PB-2, PB-3, PB-2' and PB-3' must be continuously depressed until the ram reaches its lowermost position where the cam switch CS-2 closes to energize the holding circuit branch 65-6. The continuous cycle function switch contacts 63-3 do not

become effective to energize the clutch relay continuously until the antirepeat relay is deenergized to close the normally closed contacts AR-4 in series with the contacts 63-3. The clutch relay CR normally becomes deenergized near the end of an operating cycle when the cam switch CS-2 opens but clutch relay CR will be locked-in during "continuous" operation an energized state by closure of contacts 63-3 and AR-4 which maintains the normally closed contacts CR-1 open in the circuit branch 65-3 to keep the antirepeat relay AR continuously in its deenergized state.

When the function switch control knob 63 is in its "inching" position, function switch contacts 63-4 will close to connect line 56 extending from the stop switch MS-1' to a set of contacts MS-6 of an inching pushbutton PB-5 mounted on the master control station panel 61. The inching contacts MS-6 connect with the clutch relay CR so closure of the inching pushbutton contacts energize the clutch relay.

It will be recalled that there are occasions when it is desirable to operate the run control pushbuttons at only one of the operator control stations. In such case, it has sometimes been the practice, heretofore, to provide means to lock the normally open run pushbutton contacts closed. However, such a locking arrangement has certain hazards which can be eliminated by the use of a plug-in pushbutton unit as in the case of the operator control units 57 and 57' which can be replaced by dummy plugs like 83 and 83' (FIG. 4) having jumpers 83-1, 83-2, 83-3 (FIG. 7) and 83'-1, 83'-2, 83'-3, respectively, for jumpering various socket terminal pairs. Cables 80 and 80' extend from the operator plug-in control units 57 and 57' and terminate in plugs 81 and 81' which plug into socket terminals 82 and 82' (FIG. 2). FIG. 5 illustrates those portions of the control circuit which are disconnected by the removal of an operator plug-in control unit 57'. Removal of the other operator plug-in control unit 57 will disconnect corresponding portions of the control circuit contributed by the control unit 57. Each dummy plug is wired in such a way that when it is inserted into the socket terminal 82 or 82' left empty by the removal of an operator plug-in control unit 57' or 57 less than all of the circuits are reestablished. Thus, as shown in FIG. 7, each dummy plug 83' or 83 does not have a jumper which shorts the terminals 82'-1 and 82'-2 or 82-1 and 82-2 which are normally connected by the jumper 72' or 72 provided by the operator plug-in control unit 57' or 57. Likewise, each dummy plug 83' or 83 does not have a jumper for establishing a connection between socket terminals 82'-3 and 82'-4 or 82-3 and 82-4 across which the pushbutton contacts MS-2b' and MS-3b' or MS-2b and MS-3b were previously connected by the operator plug-in control unit 57' or 57. Similarly, each dummy plug 83' or 83 does not jumper socket terminals 82'-5 and 82'-6 or 82-5 and 82-6 in the lighting circuit branches. By providing such a circuit arrangement for the dummy plugs, where two or more such discontinuities are provided, the inadvertent placement of a dummy plug in all of the operator control stations will result in a circuit like FIG. 7 where the control circuit would be inoperative. This circuit would be inoperative even if there should be an undesired short across the socket terminals 82'-1 and 82'-2 or across socket terminals 82-1 and 82-2 because of the double discontinuity described left by the dummy plugs across socket terminals 82-3 and 82-4 and 82'-3 and 82'-4.

It sometimes occurs that a disconnected or unplugged operator plug-in control unit remains mounted in place in an operator control station. This can create a hazardous situation in an emergency when it is necessary to stop the machine as quickly as possible. In such case, an operator, who may have been unaware of or had forgotten the fact that a given operator plug-in control station was disconnected, may depress the stop pushbutton PB-1 or PB-1' thereat without effect. To minimize the possibility of such an occurrence, indicating lamps 84 and 84' are mounted on or behind openings in the panels 55 and 55' of the operator plug-in control units 57 and 57'. When the plug 81 or 81' of such an operator plug-in control unit is plugged into the socket terminals 82 or 82' which

receives the same as shown in FIG. 2, the lamp 84 or 84' is connected between the ground line L2 and the line L1 through socket terminals as indicated.

EMBODIMENT OF FIGS. 8-12

The circuit of FIG. 2, although representing a substantial improvement over the press control circuit of the prior art, suffers from the hazard of an inadvertent positioning of the function switch control knob 63 in a "continuous" position when a single cycle mode of operation is desired, or a mechanical drive failure or a cam switch failure. Refer now to FIGS. 8 through 12 which illustrates a modified press control system which minimizes these hazards.

With respect to the problem of an inadvertent positioning of the function switch knob 63 in a "continuous" position, as shown in FIG. 10 a modified function switch knob 63a and associated contacts are provided wherein the position of the knob to achieve a single cycle mode of operation is located far removed from the position thereof which effects a continuous mode of operation, so that an operator is not likely to place the knob 63a in a "continuous" position to achieve a single cycle of operation as in the case of the knob 63 of FIG. 4 where the "single cycle" position is adjacent the "continuous" position thereof. Accordingly, the switch means controlled by the function control knob 63a is designed to effect a single cycle mode of operation when it is positioned in an extreme clockwise position and to effect a continuous mode of operation when it is positioned in an extreme counterclockwise position.

The second step in reducing the hazard of an accidental continuous mode of operation is to prevent a continuous cycle mode of operation on a press when it is not intended. This is best accomplished by providing a key-operated switch which has a key-receiving member KS mounted on the outside of the panel 61' at the master control station 59. The key to operate the key switch is preferably sent by registered mail to a responsible person at the user's plant who is in a position to determine when the continuous mode of operation should or should not be used. The key-receiving member KS is rotatable from a normal "off" position to an "on" position by the insertion of a key into a key slot 86. The key-operated switch has contacts KS-1 (FIG. 8) placed in series with the previously mentioned continuous function control contacts 63-1 which close when the function control knob is in its "continuous" position. Thus, the key switch must be in its "on" position in order to couple power to the common bus 69 extending to the modified circuit section 52' shown in FIG. 8. The modified circuit section 52' is similar in many respects to the circuit section 52 of FIG. 2 and corresponding elements have been similarly identified by the same or similar reference characters.

The third step in reducing the probabilities of an accidental continuous operation of the press is in the provision of a special operator sequence for the initiation of a continuous mode of operation. The control circuit section 52' is arranged so that a continuous mode of operation may be initiated only if the circuit is manually reset preferably by depression of a reset pushbutton PB-4 also mounted on the master operator control station panel 61'. Also, as in the case of the circuit of FIG. 2 described, it is preferable further to require the holding of the run control pushbuttons PB-2, PB-3, etc. for a sufficient period to enable the press ram to move from its initially raised to its fully lowered position.

As shown in FIG. 8, when the reset pushbutton PB-4 is depressed, contacts MS-4 are closed. The contacts MS-4 are connected in parallel with function control contacts 63-5 which are opened except when the function control knob 63a is in its "single cycle" position. The parallel arrangement of the reset control pushbutton contacts MS-4 and the function control contacts 63-5 is placed in the modified circuit branch 65-3' controlling energization of the antirepeat relay AR. Momentary depression of the reset pushbutton PB-4 will, there-

fore, energize the antirepeat relay AR which will then lock in through the holding circuit branch 65-2' including the holding contacts AR-1 as previously explained in connection with the similar circuit of FIG. 2.

With respect to the hazards due to the failure of the cam switches or the devices thereto, it should be noted that in the circuit of FIG. 2 if the cam switch CS-1 in series with the antirepeat relay failed to open, the press would continue to stroke as long as the run control pushbuttons PB-2, PB-3, PB-2' and PB-3' are depressed, and if the closed cam switch CS-2 in the holding circuit of the clutch relay CR fails to open, the press would stroke continuously regardless of the position of the run control pushbuttons PB-2, PB-3, PB-2' and PB-3'. The hazard of the failure of the cam switch CS-2 to open is obvious an extremely serious hazard. Although the prior art has made some attempt to minimize the hazard of such a cam switch failure, such prior methods have been deficient in that they checked only a mechanical failure in the drive of the cam switches and/or they were add-on devices which could easily be jumpered out of the circuit.

The improved control circuit 50' illustrated in FIG. 8 to which reference should now be made utilizes two-valve control solenoids S1 and S1' and associated clutch relays CR and CR' controlled by separate control circuit branches and wherein both solenoids must be energized in order to operate the clutch 34 involved. Also, cam switches CS-2 and CS-2' are provided in the separate control circuit branches which switches are separately driven. By separately controlling the clutch solenoids and clutch relays and separately driving the cam switches, the probabilities of individual or accumulative failures which can cause an accidental press stroke are significantly reduced. Additionally, in the control circuit 50' of FIG. 8, the antirepeat function of the antirepeat relay AR is double checked each cycle of operation of the machine to be sure that the relay can be deenergized.

The branch circuit 65-4' controlling the manual-controlled relay Y in the circuit of FIG. 8 is identical to the corresponding circuit branch 65-4 in the circuit 50 of FIG. 2 and thus further explanation of this circuit branch is not necessary. The circuit branches 65-5a and 65-5b which initially energize the clutch relays CR and CR' and solenoids S1 and S1' are each quite similar to the circuit branch 65-5 in FIG. 2. Unlike the circuit of FIG. 2, the normally open contacts MS-2c and MS-3c associated with the run control pushbuttons PB-2 and PB-3 are not connected in the same circuit branch as the normally open contacts MS-2c' and MS-3c' of the run control pushbuttons PB-2' and PB-3'. Rather, they are respectively connected in the different circuit branches 65-5a and 65-5b. Since the manual-controlled relay Y cannot become deenergized until all of these run control pushbuttons are depressed, clutch relays CR and CR' cannot be energized until all of the run control pushbuttons are depressed as in the case of the circuit of FIG. 2.

Normally closed antirepeat relay checking contacts AR-5 and AR-5' of the antirepeat relay AR respectively in parallel with normally closed cam switches CS-3 and CS-3' are positioned between the circuit branches 65-5a and 65-5b and the clutch relays CR and CR', respectively. As shown in FIG. 9, the cam switches CS-3 and CS-3' are opened for a short interval just before the ram crank arm reaches its 0° or uppermost position. At this time, the antirepeat relay AR is supposed to be in a deenergized state where the contacts AR-5 and AR-5' are closed. However, if the contacts AR-5 and AR-5' are open indicating a fault in the circuit, the opening of the cam switch contacts CS-3 or CS-3' will deenergize the associated clutch relay CR or CR' and the associated solenoid S1 and S1' which will result in the immediate stopping of the movement of the press ram. (The clutch relay CR has normally open contacts CR-3 in series with the solenoid S1' across which the clutch relay CR is not connected and the clutch relay CR' has normally open contacts CR'-3 in series with solenoid S1 across which the clutch relay CR' is not connected so the deenergization of either clutch relay and the solenoid across

which it is connected will automatically deenergize the other solenoid.) On the other hand, if the contacts AR-5 and AR-5' are closed, the opening of the cam switches CS-3 and CS-3' will have no effect on the circuit.

As previously indicated, to improve circuit reliability, the cam switch pairs CS-2 and CS-2' and CS-3 and CS-3' associated with the energizing circuits for the clutch relays CR and CR' and valve control solenoids S1 and S1' are separately driven as illustrated in FIG. 11. As shown in FIG. 11, separate cam shafts 90 and 90' which make one revolution for each revolution of the ram crank arm carry respective sets of cams 92-94-96 and 94'-96'. Follower arms extend from cam switches CS-1, CS-2 and CS-3' which respectively ride along the periphery of the cams 92-94-96 and follower arms extend from cam switches CS-2' and CS-3 respectively to ride along the periphery of the cams 94' and 96'. These cams open and close the associated cam switches CS-1, CS-2, CS-2', CS-3 and CS-3' in accordance with the cam switch operating diagrams of FIG. 3 and FIG. 9.

The holding circuit branches 65-6a and 65-6b for the clutch relays CR and CR' and solenoids S1 and S1' are each substantially identical to one another and similar to the holding circuit branch 65-6 in the circuit of FIG. 2 except for the inclusion of fuses 98 and 98' respectively in the holding circuit branches 65-6a and 65-6b and the connection of these holding circuits to the common bus 69 through parallel connected contacts PS-2 of a pressure switch PS (FIG. 12), normally closed contacts CR-6 of the clutch relay CR and normally closed contacts CR'-6 of the clutch relay CR'. The pressure switch PS to be described also has a set of normally closed contacts PS-1 connected in parallel with normally open contacts CR-5 of the clutch relay CR in series with normally open contacts CR'-5. The parallel circuit of the series connected contacts CR-5 and CR'-5 and the normally closed pressure switch contacts PS-1 connects the circuit branch 65-3' of the antirepeat relay AR to the common bus 69. The holding circuit branch 65-2' of the antirepeat relay AR connects with the terminal of the pressure switch contacts PS-1 remote from the common bus 69 so opening of the pressure switch contacts PS-1 while either of the contacts CR-5 or CR'-5 are opened will deenergize the antirepeat relay AR.

The fuses 98 and 98' prevent a hazard due to a short circuit between the holding circuit branches 65-6a and 65-6b of the clutch relays CR and CR' as, for example, between points P3 and P4, combined with a short circuit across or defect in one of the cam switches CS-2 or CS-2' which fails to open. In such case, when the other cam switch opens, the holding circuit branch associated with the shorted or defective cam switch will be connected to the powerline through a parallel circuit comprising clutch relays CR and CR' and the associated solenoids S1 and S1', which provides about double the normal current flow through the holding circuit involved. Each of the fuses 98 and 98' is designed to blow when this above-normal current flows therethrough. When the fuse blows, the clutch relays will become deenergized and the press ram will stop.

To illustrate the fault-free nature of the circuit involved under various other individual cam switch failures or failures in the drive therefor, consider the following faults: If cam switch CS-1 should fail to open, the antirepeat relay AR will not be deenergized and the press ram will stop as the antirepeat relay circuit-checking cam switches CS-3 and CS-3' open. Either cam switches CS-3 and CS-3' will be operable to check the operation of the antirepeat relay circuit. If the antirepeat relay circuit-checking cam switch CS-3 or CS-3' fails to close, the run control pushbutton PB-2, PB-3, PB-2' and PB-3' will fail to operate the circuit. If either clutch relay-holding circuit interrupting cam switches CS-2 and CS-2' fail to open, the press ram will stop at the uppermost position thereof in the normal manner. The press ram will not recycle because the clutch relay CR or CR' will remain energized keeping its associated contacts CR-1 or CR'-1 open in the initial energization circuit branch 65-3' of the antirepeat relay AR. If either or both of the cam switches CS-2 or CS-2' fail to

close, the clutch relays CR and CR' will deenergize as the run control pushbuttons are released or, if the run pushbuttons are held, the press run will stop at the top of its stroke in the normal manner during the single cycle mode of operation.

Reference should now be made to FIG. 12 which shows schematically a pair of conventional air valves 100 and 100' having movable valve parts 102 and 102' which, in the deenergized state of the associated solenoids S1 and S1', are in the valve closing positions as illustrated. The movable valve parts 102 and 102' are respectively connected to lines 104 and 104' to a common input line 106 extending to the clutch 34. When the clutch input line 106 is vented, the pressure thereat is so low that the clutch 34 cannot be engaged. When the solenoids S1 and S1' are energized, the movable parts 102 and 102' of the valves 100 and 100' are in valve opening positions where a supply line 108 is connected through both valves to the common clutch input line 106 where the pressure on the clutch input line 106 will be sufficiently high to cause the clutch 34 to operate to couple movement to the ram crank arm shaft. If, due to some defect in the system, one of the valves 100 or 100' is open while the other is closed, the pressure at the clutch input line 106 will be of a low value above atmospheric pressure which is insufficient to operate the clutch. The pressure switch PS operates to open the pressure switch contacts PS-1 and close the pressure switch contacts PS-2 when the pressure on the clutch input line 106 is at or higher than said low pressure above atmospheric pressure.

One function of the pressure switch contacts PS-1 is to prevent a hazard due to a complete loss of pressure during the middle of a cycle which is subsequently reestablished. Thus, if there should be a loss of pressure while the pressure ram is moving to its lowermost position, the ram will of course stop and the operators would release their run control pushbuttons, and will take note that a fault has occurred. If, the complete loss of pressure occurs while the press ram is returning to its uppermost position, the second set of pressure switch contacts PS-2 will open breaking the holding circuits to the clutch relay CR and CR' which will then deenergize (if the run control pushbuttons are released) so that a reestablishment of pressure will not result in the movement of the ram.

If one of the valves should be stuck open so that a partial pressure is applied to the clutch input line 106, it is important to give the operators some indication that there is a fault in the system because the subsequent sticking of the other valve will cause the ram to operate continuously. The operator is given such an indication because the pressure switch contacts PS-1 will remain open at the end of the cycle involved when normally open contacts CR-5 and CR'-5 open as the cam switches CS-2 and CS-2' open to deenergize the clutch relays CR and CR' and solenoids S1 and S1'. The open contacts PS-1 will not then permit the reenergization of the antirepeat relay AR because they are in series with the run control pushbuttons in the circuit branch 65-3' and the contacts CR-5 and CR'-5 in parallel with the contacts PS-1 cannot close until the antirepeat relay AR can be reenergized to prepare the clutch relays for energization.

Another hazard prevented by the pressure switch contacts PS-1 is one which can occur in a small press during the movement of the ram to its bottommost position. If an operator should then release one of his run control pushbuttons with one hand while holding onto the other run pushbutton with the other hand to reach into the setup area, if his shoulder or some part of his body should depress the just released control pushbutton in the absence of the contacts PS-1 the clutch relay and solenoids would be reenergized and the resultant movement of the ram could seriously injure the operator. In the circuit of FIG. 8, release of one of the run control pushbuttons prevents the reenergization of the clutch solenoids unless all of the pushbuttons are first released before the pushbuttons can be operable to energize the clutch relays and solenoids. Thus, upon release of one of the run control pushbuttons, the manual-control relay Y will become reenergized to open the contacts Y-3 and Y-3' in the energization circuits of the

clutch relays CR and CR'. Since the pressure switch contacts PS-1 take a certain period of time to reclose as pressure is then cut off, the immediate opening of the contacts CR-1 and CR-2 in parallel with the pressure switch contacts PS-1 will interrupt current in the antirepeat relay holding circuit to deenergize the antirepeat relay. In such case, the antirepeat relay AR cannot be reenergized to prepare the clutch relay circuit branches 65-5a and 65-5b for energization until all run control pushbuttons are released to once again reestablish energization of the circuit branch 65-3' which effects initial energization of the antirepeat relay AR.

The pressure switch contacts PS-2 act as a check on the proper operation of the pressure switch PS. Thus, if the pressure switch becomes inoperable because the line leading thereto becomes blocked or for other reasons, the contacts PS-2 will remain open and prevent the holding circuit branches 65-6a and 65-6b of the clutch relays CR and CR' to become operative. The contacts CR-6 and CR'-6 provide initial continuity to these holding circuit branches but the pressure switch contacts PS-2 must maintain this continuity to enable the clutch relays to remain energized when the run control pushbuttons are released.

When the press is operating in a continuous mode of operation and air pressure is lost in the supply line, the press ram would, of course, stop. It would be exceedingly dangerous if the reestablishment of the pressure would cause the press ram to resume operation. This is prevented by the pressure switch contacts PS-2 because, upon the loss of pressure, the contacts PS-2 would open breaking the holding circuit to the clutch relays CR and CR'. This prevents the restart of the press until a new continuous cycle of operation is manually initiated.

The inching circuit section 54' of FIG. 8 is similar to that of FIG. 2 except that it has separate branches with separate sets of series connected function control switch inching contacts and inching reset pushbutton contacts 63-4 and MS-6, and 63-4' and MS-6' respectively extending between bus 56 and the left-hand terminals of the clutch relays CR and CR'. Pushbutton PB-5 on control panel 61' operates both contacts MS-6 and MS-6'.

EMBODIMENT OF FIGS. 13 and 14

The pressure switch PS in FIGS. 8 and 12 may be replaced by limit switches LS and LS' (FIG. 13) and their contact pairs LS-1, LS-2, LS'-1 and LS'-2 (FIG. 14) which are operated by the movable valve parts 102 and 102' to form the modified control circuit of FIG. 14. When the movable valve parts 102 and 102' are in their normal valve closing and valve opening positions, normally closed limit switch contacts LS-1 and LS'-1 of limit switches LS and LS' are respectively in their closed and opened positions, and when the movable valve parts 102 and 102' are in their valve opening positions, normally open limit switch contacts LS-2 and LS'-2 are respectively in their opened and closed positions. The normally closed limit switch contact pairs LS-1 and LS-2 of limit switches LS and LS' connected in series replace the pressure switch contacts PS-1 and the contacts CR-5 and CR'-5 in FIG. 8 so the opening of either valve 100 or 100' will open the energization circuit to the antirepeat relay to prevent recycling of the press ram. Note that the holding circuit branch 65-2' bypasses the limit switch contacts LS-1 and LS'-1. The normally open limit switch contacts LS-2 and LS'-2 connected in series replace the normally open pressure switch contacts PS-2 in FIG. 8 so the clutch relays are immediately deenergized to instantly stop the press ram if either valve 100 or 100' becomes closed.

EMBODIMENT OF FIGS. 15-17

The embodiment of the invention shown in FIGS. 15-17 represents the most preferred form of the present invention in that it provides a much greater degree of safety than the circuit of FIG. 8 in a number of respects. Referring most particularly to the circuit diagram of FIG. 15, the circuit there shown

is similar in many respects to the circuit of FIG. 8 and to eliminate unnecessary description the circuit elements of FIG. 15 which have the same function as those shown in FIG. 8 have been identified by the same reference characters.

One of the important changes made in the circuit of FIG. 15 is the provision of a transformer 78' having a grounded center-tapped secondary winding 78b'. Short circuit current-responsive switch means 76c is connected between the center tap point of the secondary winding 78b' and ground. Similar short circuit current-responsive switch means 76a and 76b are positioned respectively in the connections between the ends of the secondary winding 78b' and the powerlines L1 and L2. The short circuit current-responsive switch means 76a, 76b and 76c are designed so that when any of these switch means receives a short circuit current or a current above a given desired limit, that switch means and all the other short circuit current-responsive switch means will automatically open. (Such a ganged relationship of switch means is well known in the art and thus a description of the construction of same will not here be given.) The ground connection applied to the line L2 in the embodiment of the invention shown in FIG. 8 has been removed from the line L2 in the embodiment of FIG. 15, so that the presence of any ground connection within the various circuit branches of FIG. 15 results in the flow of short circuit current in either the left or right half of the secondary winding 78b', resulting in the complete decoupling of the powerlines L1 and L2 from ground or any source of voltage.

The switches MS-1 and MS-1' controlled by the stop push-buttons PB-1 and PB-1' have been relocated in the circuit of FIG. 15 so as to be positioned between one of the ends of the primary winding 78a' and a main power input line 110. A section or level FS of the function switch is added which includes a wiper FS-1 connected to the main power input line 110 and adapted to make selected engagement with stationary contacts FS-1a, FS-1b, FS-1c, FS-1d, FS-1e and FS-1f identified as "off," "single," "inch," "neutral" and "cont." contacts corresponding to the positions of a function switch control knob 63a' (FIG. 16) to be described which moves the wiper FS-1. Wiper FS-1 is connected to a common shaft (not shown) operated by the function switch control knob 63a'. The function switch control knob 63a' in FIG. 16 has opposite extreme stable positions identified as "off" and "cont." positions. As the function switch control knob is moved between these positions, it passes into various stable switch positions identified as "single," "neutral," "inch," and "neutral" positions in the order named. The function switch control knob 63a' thus differs in its mode of operation from control knob 63a in the embodiment of the invention shown in FIG. 8 in that a "neutral" position is provided between the "single" and "inch" positions and between the "inch" and the "cont." positions. The "neutral" positions are positions which are inoperative positions where the control circuit being described is deenergized. This arrangement minimizes the possibility of inadvertent movement of the control knob into an undesired operating position from another operating position when the control knob is moved one position from the operative "single," "inch" or "cont." positions. Thus, for example, if the control knob 63a' were in its "single" position, inadvertent movement of the control switch one position counterclockwise rather than one position clockwise to the "off" position would not result in the system being adjusted for an "inch" mode of operation as would be the case if the control knob 63a in the embodiment of FIG. 8 were to be moved clockwise from the "inch" position rather than counterclockwise to the "off" position shown therein.

The control knob 63a' is supported for movement in a manner to prevent inadvertent operation of the control knob 63a' into its "cont." position. Thus, in order to move the control knob 63a' into its "cont." position, it is necessary not only to rotate the control knob into its fully counterclockwise position as viewed in FIG. 16, but, unlike the operation of the control knob into its other positions, it is also necessary to depress the control knob in this position to effect closure of the con-

tacts to be closed during the continuous mode of operation. Such a construction of a switch which requires the depression of the control knob in one position is known in environments other than that of the present invention and thus a detailed description thereof is unnecessary. (Needless to say, it is apparent how such a switch construction can be obtained as by positioning the contacts to be closed in the "cont." position of the control knob 63a' only when the shaft carrying the control knob has a given degree of axial inward movement against the force of a spring or the like. In the other positions of the shaft to which the control knob is attached, a stop shoulder or the like engaged by a projection on the shaft prevents the inward movement of the shaft.)

As the control knob 63a' is moved respectively between its "off," "single" neutral, "inch," "neutral" and "cont." positions shown in FIG. 16, the movable wiper FS-1 will respectively engage the stationary contacts FS-1a, FS-1b, FS-1c, FS-1d, FS-1e and FS-1f. All these stationary contacts but the contact FS-1a are connected to a conductor 103 extending to the switches MS-1 and MS-1' connected to the secondary winding 78a' of the transformer 78' so the primary winding 78a' of the transformer 78 will be energized in all positions of the control knob 63a' except the "off" position thereof since the right end of the secondary winding 78a' is connected by conductor 107 to ground. A motor 105 which drives the input shaft of the clutch which controls the movement of the press ram (and any other device to be energized continuously) are connected between the conductor 103 and ground so that the motor 105 and such other devices will be energized at all times except when the control knob 63a' is in its "off" position.

In FIG. 15, the line L2 instead of being connected directly to the various circuit branches of the control circuit associated with the antirepeat relay AR and manual-controlled relay Y are connected thereto through parallel connected normally opened contacts 63-1' and 63-2' which are counterparts of the contacts 63-1 and 63-2 associated with line L1 and are thus respectively closed only when the function control switch knob 63a' is in its "single" and "cont." positions. Thus, whenever the control knob 63a' is positioned in any position other than its "single" and "cont." positions, the circuit branches associated with the antirepeat relay AR and manual-controlled relay Y will be completely disconnected from any voltage sources. The contacts 63-1' and 63-2' are connected respectively to a common bus L2' leading to the aforementioned relay control circuit branches.

In the circuit branch including the function switch contact 63-1, 63-2, KS-1 and the jumpers 72 and 72', there is incorporated in series therewith motor direction sensing contacts MD-1 which are closed whenever the motor 105 driving the input shaft to the ram control clutch is rotating in the direction for normal operation of the press. In many circumstances, it is desirable for the operator to be able to operate the motor 105 in one direction or the other so that the ram can be operated in its normal way or reversed in its direction for various adjustment and work setup purposes. However, since the functions controlled by the antirepeat relay are and the manual-controlled relay Y are utilized only when the ram is operated in the normal manner, it is desirable to deenergize the bus 69 leading to the circuit branches of the various relays referred to when the motor 105 is to be operated in a reverse direction. In such reverse operation of the press ram, the clutch relays CR and CR' and the associated clutch solenoids S1 and S1' are placed under control of the various inch controls and contacts to be described. For this purpose also, the branch circuits controlling the clutch relays CR and CR' and the associated clutch solenoids S1 and S1' are located in modified branch circuits which extend directly to the left-hand line L1 rather than to the bus 69 so they bypass the motor direction responsive contacts MD-1. (The branch circuits which control the clutch relays CR and CR' and the clutch solenoids S1 and S1' are modified also in other respects to be described for increased safety.) Accordingly, the clutch relay CR and the clutch solenoid S1 are connected directly to the line L2 rather

than being connected thereto through the aforesaid contacts 63-1' and 63-2' which are closed only during single cycle and continuous cycle modes of operation. For the inch mode of operation, the clutch relay CR and the clutch solenoid S1 are energized through a branch extending between the side of the clutch relay CR remote from the line L2 and through normally open contacts MS-6' closed by the pushbutton PB-5, normally open contacts TS-1' which are normally spring urged to their open position and closed by the movement of a control knob TS to an "inch" position, and normally opened contacts 63-4' connected to the line L1. The contact 63-4' is closed only when the function control knob 63a' is in its "inch" position.

Unlike the clutch relay CR and the solenoid S1', the clutch relay CR' and the associated solenoid S1' are connected on the side of the various run pushbutton contacts MS-2c', MS-3c' etc. nearest the line L1 so that any short circuit occurring between the branches including the clutch relays CR and CR' and the run button contacts during energization of these branches will effect a short circuit between the lines L1 and L2 to cause interruption of power to the control circuit. The clutch relay CR' is connected to the line L1 through parallel connected contacts CR-4 and CR'-4 of the clutch relays CR and CR', respectively. A set of normally opened contacts CR'-5 of the clutch relay CR' are connected between one end of the solenoid S1' and the left-hand terminal of the clutch relay CR'. The contacts CR'-5 in association with the contacts CR-4 and CR'-4 are for the purpose of preventing the connection of the clutch relay CR' and CR and the associated solenoids in series with one another if a short circuit should develop between for example points P5 and P6 shown in FIG. 15 when the circuit branches are deenergized so the short circuit protection referred to would not be operative. Thus, when the clutch relay CR and CR' are in their deenergized state, a short circuit occurring between the points P5 and P6 would be isolated from the line L1 because of the opened condition of the contacts CR-4, CR'-4, CR'-5 and CR-3. If one of the clutch relays CR should be energized while the clutch relay CR' is deenergized during the occurrence of the short circuit between points P5 and P6, the contacts CR'-5 will be opened to prevent the energization of the solenoid S1' and the consequent movement of the press ram requiring the simultaneous energization of the solenoids S1 and S1'. The deenergization of clutch relay CR while clutch relay CR is deenergized will not result in the energization of solenoid S1' because of the opened condition of contacts CR-3.

The side of the clutch relay CR' remote from the line L1 is connected to the line L2 during the inch mode of operation by a branch including normally open contacts MS-6 which are closed by the pushbutton PB-5, normally open contacts TS-1 which are closed when the control knob TS is turned to its "inch" position, and the contacts 63-4 which are closed only when the function switch control knob 63a' is in the "inch" position. Similarly, the side of the clutch relay CR remote from the L2 is connected to the Line L1 through a branch including normally open contacts MS-6' which are closed by depression of the pushbutton PB-5, normally open contacts TS-1' which are closed when the control knob TS is turned to its "inch" position and contacts 63-4' which are closed when the control knob 63a' is in its "inch" position.

Thus, an inching operation can be obtained independently of whether the motor 105 is rotated in a forward or reverse direction simply by moving the function control knob 63a' to the "inch" position thereof and simultaneously depressing the pushbutton PB-5 and turning the control knob TS to the "inch" position. The purpose of the control knob TS and the associated contacts TS-1', TS-2 is to prevent the inadvertent operation of the press ram when the function switch control knob is in its "inch" position if somebody should inadvertently, without knowing it, lean against the "inch" pushbutton PB-5.

One of the important unique features in the circuit of FIG. 15 is the addition of another set of normally open contacts operated by each of the run pushbuttons PB-2, PB-3, PB1-2', and PB-3'. It will be recalled in the embodiment of FIG. 8 that the pushbuttons PB-2 and PB-3 or PB-3' and PB-3' operated at any given operator control station operate contacts which are only in an energizing branch circuit associated with either the clutch relay CR' or the clutch relay CR. If the operator control station containing either one of the pairs of pushbuttons referred to were replaced by a dummy plug-in unit, the contacts controlled by the pushbuttons PB-2 and PB-3 at the sole remaining operator control station would not have any contacts in the branch circuit which controls the clutch relay CR'. The feature of being able to operate the machine from only one station when desired can be made more safe if each of the run pushbuttons involved has contacts in the energization circuits of both of the clutch relays. Accordingly, pushbuttons PB-2 and PB-3 respectively have additional sets of normally opened contacts MS-2d and MS-3d respectively in series with the contacts MS-2c' and MS-3c' in the branch circuit controlling the initial energization of the clutch relay CR', and run pushbuttons PB-2' and PB-3' respectively have additional sets of normally opened contacts MS-2d' and MS-3d' connected in series with the contacts MS-2c and MS-3c in the branch circuit controlling the initial energization of the clutch relay CR.

In the construction of pushbutton switch controls which have normally opened and normally closed contact sections, it is customary to utilize a single movable bridging contact for both sections of the switch and which, in the normal condition of the switch, bridges a pair of stationary contacts constituting the normally closed section of the switch and, upon depression of the pushbutton, moves to bridge a pair of stationary contacts constituting the normally open section of the switch. In such an arrangement, to prevent undesired arcing between the closely spaced stationary and movable contacts, it is considered unsafe to have the stationary contacts associate respectively with the normally opened and normally closed sections of the switch to be connected to lines of opposite polarity. With the reverse arrangement of the energizing circuits for the clutch relays CR and CR', the additional sets of normally opened contacts MS-2d, MS-3d, MS-2d' and MS-3d' can safely share common bridging contacts with the associated respective normally closed contacts MS-2b, MS-3b, MS-2a' and MS-3a' which are connected to the same power busses 69 or L2'.

It should be noted that the circuit of FIG. 15 is devoid completely of any pressure responsive switches. Such pressure switches are omitted to simplify the circuit, and most of the functions thereof are effected in the manner shown in FIG. 17, to which reference is now made. In FIG. 16, a master control valve 112 is connected between the input supply line and the input to the air valves 100 and 100'. The master control valve 112 is under control of a solenoid S2 having one terminal connected to a voltage input terminal 115 and another terminal connected by conductor 117 to a pair of parallel connected normally open contacts 119 and 119', the parallel connected contacts 119 and 119', in turn, connected by a conductor 119 to a voltage input terminal 115'. The voltage terminals 115 and 115' connect to a suitable source of energizing voltage which will energize the solenoid S2 if either of the contacts 119 or 119' are closed.

An air cylinder identified by reference numeral 121 is provided having a movable plunger 123 therein which is normally in a centered position within the cylinder 121 through the use of centering springs 126-126. A pair of control rods 125-125' extend axially from the opposite faces of the plunger 123 which rods carry on the ends thereof switch-operating extensions 127 and 127'. When the plunger 123 is moved to the left end of the cylinder 121, switch-operating extension 127 will close the contacts 119. When the plunger 123 is moved to the right-hand end of the cylinder 121, the switch-operating extension 127' will close the contacts 119'. The left-hand por-

tion of the cylinder 121 is connected by an air line 130 to the output side of the air valve 100, and the right-hand portion of the cylinder 121 is connected by an air line 130' to the outlet side of the air valve 100'. It can thus be seen that when there is air pressure at the output of valves 100 and 100', or no air pressure at the outputs of air valves 100 and 100', the piston 123 will be in a centered position. If the pressure at the outputs of the air valves 100 and 100' are different, the plunger 123 will be at the left-hand or right-hand end of the cylinder 121 to close either the contacts 119 and 119' and energize the solenoid S2. Energization of the solenoid S2 will close the valve 112 and thereby prevent the movement of the clutch 34 whenever a substantial difference in pressure exists at the output of the air valves 100 and 100'.

The various aspects of the present invention has thus provided an exceedingly safe press control system with a control circuit of minimum complexity and maximum reliability.

It should be understood that numerous modifications may be made in the most preferred forms of the invention described above without deviating from the broader aspects thereof.

I claim:

1. In a multioperator controlled machine which has a work producing portion movable by an operating drive means from a remote starting position, where an operator is relatively safe, to a work producing position where it can injure an operator in the vicinity thereof and then back to said starting position, at least two operator control stations each having self-returning manually operable control means thereat movable from a normal stable inoperative position to an unstable run position when it is desired to operate the drive means, each of said manually operable control means controlling normally open switch means and normally closed switch means which are respectively opened and closed when the manually operable control means is in its normal position and are respectively closed and opened when said control means is in its run position, electrically operated drive control means which when connected across a pair of powerlines operates said drive means, the improvement in a control circuit for controlling the connection of said drive control means across said powerlines, the control circuit comprising: manual-controlled relay means connected across said powerlines separately through each of said normally closed switch means of said manually operable control means, the manual-controlled relay means remaining energized as long as any of said normally closed switch means of said manually operable control means remains closed, means connecting said normally open switch means of the manually operable control means of said operator control stations and said drive control means across said powerlines so the drive control means is energized only when all of the latter switch means are closed unless flow of current therethrough is otherwise prevented, and switch means controlled by said manual-controlled relay means for preventing the flow of said current through said drive control means while the manual-controlled relay means is energized.

2. The control circuit of claim 1 wherein: each of said manually operable control means at each operator station includes second normally closed switch means which is closed when the associated manually operable control means is in its normal position and is opened when the same is in its run position, and there are provided machine driven switch means which is closed except when said work producing portion of the machine is nearing a return to said starting position, antirepeat relay means connected across said powerlines through said machine driven switch means and the second normally closed switch means of said manually operable control means connected in series, switch means controlled by said manual-controlled relay means permitting the connection of said antirepeat relay means across said powerlines through said second normally closed switch means of said manually operable control means when the manual-controlled relay means is energized and preventing such connection when the manual-controlled relay means is deenergized by the simul-

taneous opening of all of the first mentioned normally closed switch means of said manually operable control means, switch means controlled by said antirepeat relay means for preventing the flow of current to said drive control means when the antirepeat relay means is deenergized and permitting such flow when said antirepeat relay means is energized, and switch means controlled by said antirepeat relay means which establishes a holding circuit in series with said machine driven means and bypassing said second normally closed switch means of said manually operable control means and said switch means controlled by said manual-controlled relay means.

3. The control circuit of claim 2 wherein said normally open switch means and said second normally closed switch means of said manually operable control means are connected between the same powerline and the associated respective drive control means and antirepeat relay means, and said current flow preventing switch means controlled by said antirepeat relay means includes a normally open switch located on the side of said normally opened switch means of the manually operable control means remote from said drive control means.

4. The control circuit of claim 2 wherein the said switch means controlled by said manual-controlled relay means includes a normally open switch located on one side of said second normally closed switch means of said manually operable control means, and there is further provided a normally closed switch controlled by said manual-controlled relay means which switch is connected in series between the normally open switch means of said manually operable control means and said drive control means so a short circuit occurring between said second normally closed switch means and said normally open switch means of said manually operable control means will not cause energization of said drive control means.

5. The control circuit of claim 2 wherein the first mentioned normally closed switch means of said manually operable control means at the operator stations are connected between one of said powerlines and said manual-controlled relay means and the second normally closed switch means of the manually operable control means at the operator stations are connected between the other powerline and said antirepeat relay means.

6. The control circuit of claim 1 wherein said drive control means include at least two separate drive control devices connected in separate branch circuits across said powerlines, both of which drive control devices must be energized to operate said drive means, and each of which devices is connected across said powerlines through different normally open switch means controlled by said manually operable control means.

7. In a machine which has a work producing portion movable by an operating drive means from a remote starting position, where an operator is relatively safe, to a work producing position where it can injure an operator in the vicinity thereof and then back to said starting position, at least one operator control station having manually operable control means thereat operable from a normal inoperative condition to a run condition when it is desired to operate the drive means, the manually operable control means of each operator control station controlling normally open switch means and first and second normally closed switch means which are respectively opened and closed when the manually operable control means is in its normal condition and are respectively closed and opened when said control means is in its run condition, electrically operated drive control means which when connected across a pair of powerlines operates said drive means, the improvement in a control circuit for controlling the connection of said drive control means across said powerlines, the control circuit comprising: manual-controlled relay means connected across said powerlines through the first normally closed switch means of said manually operable control means of each operation control station, the manual-controlled relay means remaining energized as long as the normally closed switch means of said manually operable control means remains closed, means connecting said normally open switch means of

the manually operable control means of each operator control station and said drive control means across said powerlines so the drive control means is initially energized only when the latter switch means are closed unless flow of current therethrough is otherwise prevented, switch means controlled by said manual-controlled relay means for preventing the flow of said current through said drive control means while the manual-controlled relay means is energized, machine driven switch means which is closed except when said work producing portion of the machine is nearing a return to said starting position, antirepeat relay means connected across said powerlines through said machine driven switch means and the second normally closed switch means of said manually operable control means, switch means controlled by said manual-controlled relay means permitting the connection of said antirepeat relay means across said powerlines through said second normally closed switch means of said manually operable control means when the manual-controlled relay means is energized and preventing such connection when the manual-controlled relay means is deenergized by the opening of the first mentioned normally closed switch means of said manually operable control means, switch means controlled by said antirepeat relay means for preventing the flow of current to said drive control means when the antirepeat relay means is deenergized and permitting such flow when said antirepeat relay means is energized, switch means controlled by said antirepeat relay means which establishes a holding circuit in series with said machine driven means and bypasses said second normally closed switch means of said manually operable control means and said switch means controlled by said manual-controlled relay means, and said normally open switch means and said second normally closed switch means of said manually operable control means of each operator control station being respectively connected between the same powerline and the associated drive control means and antirepeat relay means, and said current flow preventing switch means controlled by said antirepeat relay means includes a normally open switch located on the side of said normally open switch means of the manually operable control means remote from said drive control means.

8. In a machine which has a work producing portion movable by an operating drive means from a remote starting position, where an operator is relatively safe, to a work producing position where it can injure an operator in the vicinity thereof and then back to said starting position, at least one operator control station having manually operable control means thereat operable from a normal inoperative condition to a run condition when it is desired to operate the drive means, the manually operable control means of each operation control station controlling normally open switch means and first and second normally closed switch means which are respectively opened and closed when the manually operable control means is in its normal condition and are respectively closed and opened when said control means is in its run condition, electrically operated drive control means which when connected across a pair of powerlines operates said drive means, the improvement in a control circuit for controlling the connection of said drive control means across said powerlines, the control circuit comprising: manual-controlled relay means connected across said powerlines through the first normally closed switch means of said manually operable control means of each operator control station, the manual-controlled relay means remaining energized as long as the normally closed switch means of said manually operable control means remains closed, means connecting said normally open switch means of the manually operable control means of each operator control station and said drive control means across said powerlines so the drive control means is initially energized only when the latter switch means are closed unless flow of current therethrough is otherwise prevented, switch means controlled by said manual-controlled relay means for preventing the flow of said current through said drive control means while the manual-controlled relay means is energized, machine driven switch means which

is closed except when said work producing portion of the machine is nearing a return to said starting position, antirepeat relay means connected across said powerlines through said machine driven switch means and the second normally closed switch means of said manually operable control means, switch means controlled by said manual-controlled relay means permitting the connection of said antirepeat relay means across said powerlines through said second normally closed switch means of said manually operable control means when the manual-controlled relay means is energized and preventing such connection when the manual-controlled relay means is deenergized by the opening of the first mentioned normally closed switch means of said manually operable control means, switch means controlled by said antirepeat relay means for preventing the flow of current to said drive control means when the antirepeat relay means is deenergized and permitting such flow when said antirepeat relay means is energized, switch means controlled by said antirepeat relay means which establishes a holding circuit in series with said machine driven means and bypassing said second normally closed switch means of said manually operable control means and said switch means controlled by said manual-controlled relay means, said manual-controlled relay means including normally open switch means located on one side of said second normally closed switch means of said manually operable control means and normally closed switch means connected in series between the normally open switch means of said manually operable control means and said drive control means so a short circuit occurring between said second normally closed switch means and said normally open switch means of said manually operable control means will not cause energization of said drive control means.

9. In a machine which has a work producing portion movable by an operating drive means from a remote starting position, where an operator is relatively safe, to a work producing position where it can injure an operator in the vicinity thereof and then back to said starting position, at least one operator control station having a pair of manually engageable control members to be respectively operated by the two hands of an operator and each separately operable from a normal inoperative condition to a run condition when it is desired to operate the drive means, each of said manually engageable control members directly controlling normally open switch means and first and second normally closed switch means which are respectively opened and closed when the control member is in its normal condition and are respectively closed and opened when said control member is in its run condition, electrically operated drive control means which when connected across a pair of powerlines operates said drive means, the improvement in a control circuit for controlling the connection of said drive control means across said powerlines, the control circuit comprising: manual-controlled relay means connected across said powerlines through the first normally closed switch means of said manually engageable control members, the manual-controlled relay means remaining energized as long as the normally closed switch means of said manually engageable control members remains closed, means connecting said normally open switch means of each of the manually engageable control members of each operator control station and said drive control means in series across said powerlines so the drive control means is energized only when the latter switch means are closed unless flow of current therethrough is otherwise prevented, switch means controlled by said manual-controlled relay means for preventing the flow of said current through said drive control means while the manual-controlled relay means is energized, machine driven switch means which is closed except when said work producing portion of the machine is nearing a return to said starting position, antirepeat relay means connected across said powerlines through said machine driven switch means and the second normally closed switch means of said manually engageable control members connected in series, switch means controlled by said manual-controlled relay means permitting the connection of said an-

tirepeat relay means across said powerlines through said second normally closed switch means of said manually engageable control members when the manual-controlled relay means is energized and preventing such connection when the manual-controlled relay means is deenergized by the opening of all of the first mentioned normally closed switch means of said manually engageable control members, switch means controlled by said antirepeat relay means for preventing the flow of current to said drive control means when the antirepeat relay means is deenergized and permitting such flow when said antirepeat relay means is energized, switch means controlled by said antirepeat relay means which establishes a holding circuit in series with said machine driven means and bypassing said second normally closed switch means of said manually engageable control members and said switch means controlled by said manual-controlled relay means, the first mentioned normally closed switch means of said manually engageable control members of each operator control station being connected between one of said powerlines and said manual-controlled relay means, and the second normally closed switch means of the manually engageable control members of each operator control station being connected between the other powerline and said antirepeat relay means, and short circuit current responsive means for deenergizing said control circuit when short circuit current flows due to a short circuit between said first and second normally closed switches of said manually engageable control members.

10. In a machine which has a work producing portion movably by an operating drive means from a remote starting position, where an operator is relatively safe, to a work producing position where it can injure an operator in the vicinity thereof and then back to said starting position, a pair of manually engageable control members to be respectively operated by different hands of one operator or the hands of separate operators and each operable from a normal inoperative condition to a run condition when it is desired to operate the drive means, each manually engageable control member directly controlling normally open switch means and normally closed switch means which are respectively opened and closed when the manually engageable control member is in its normal condition and are respectively closed and opened when said control member is in its run condition, and a pair of electrical power input terminals, the improvement comprising a control system for said machine including at least two separate drive control devices connected in separate branches across said power input terminals both of which drive control devices must be energized to operate said drive means, said normally open switch means controlled by said pair of manually engageable control members being respectively in said branches to effect energization thereof when closed, manual-controlled relay means connected across said power input terminals through said normally closed switch means of said manually engageable control members, the manual-controlled relay means remaining energized as long as said normally closed switch means of said manually engageable control member remains closed, and switch means in said respective branches controlled by said manual-controlled relay means for preventing the flow of current through said drive control devices while the manual-controlled relay means is energized.

11. The system of claim 10 wherein said normally closed switch means of said manually engageable control members are connected in parallel between said manual-controlled relay means at said power input terminals, wherein the manual-control relay means remains energized as long as any of said normally closed switch means remains closed.

12. The control system of claim 10 wherein said pair of manually engageable control members are located at one operator control station, and each of said manually engageable control members has additional normally open switch means operating similarly to the just mentioned normally open switch means thereof and located in the other of said branches in series with the normally open switch means of the other of said manually engageable control members so each branch

has similarly operating normally open switch means of both manually engageable control members connected in series circuit relation.

13. The control circuit of claim 12 wherein there are two operator control stations each of which has a pair of said manually engageable control members wherein each control member has said normally open switch means located in both of said branches and connected in series with the normally open switch means of all of the other manually engageable control members.

14. An electrical control system to be energized from a pair of electrical power input terminals and including a pair of manually engageable control members to be respectively operated by different hands of one operator or the hands of separate operators operable from a normal inoperative condition to an operative condition when it is desired to effect a given operation, each of said manually engageable control members directly controlling normally open switch means which open and close when the control member is in its normal condition and are respectively closed and opened when the control member is in its operative condition, the improvement comprising: at least two separate operation producing devices connected in separate branches across said power input terminals, both of which operation producing devices must be energized to effect the desired operation, said normally open switch means of said pair of manually engageable control members being respectively in said branches to energize the same in their closed condition, said operation producing devices in one of said branches being connected between one of said power input terminals and the normally open switch means controlled by one of said manually engageable control members and the other of said operation producing devices is connected between the other power input terminal and the normally open switch means controlled by the other manually engageable control member, and short circuit current responsive means responsive to the flow of short circuit current resulting from a short circuit between said branches for deenergizing the branches.

15. In a machine which has a work producing portion movable by an operating drive means from a remote starting position, where an operator is relatively safe, to a work producing position where it can injure an operator in the vicinity thereof and then back to said starting position, a pair of manually engageable self-returning control members to be respectively operated by different hands of one operator or the hands of different operators and each movable from a normal inoperative position to a run position when it is desired to operate the drive means, each of said manually engageable control members controlling at least one switch means operated in a given run position as long as the operator applies operating force to the associated control member, and a pair of electrical power input terminals the improvement in a control system for operating said drive means, said control system comprising: at least two electrically operated drive control devices which, when both are simultaneously connected across said power input terminals, operate said drive means, separate branch circuits coupled across said power input terminals in parallel and each including a different one of said electrically operated drive control devices and a different one of said switch means controlled by said manually engageable control members, said switch means energizing the associated drive control device when the associated manually engageable control member is held in the run position thereof, and said branch circuits including drive control relays and said drive control devices are solenoids which control said drive means and each solenoid is connected in parallel with one of said drive control relays through normally open switch means of the other drive control relay so the deenergization of one of said drive control relays will result in the deenergization of both solenoids.

16. The control system of claim 15 wherein each of said drive control devices are drive control relays and there is provided a relay holding branch circuit associated with each of said drive control relays each of which holding branch circuits

includes machine operated switch means for maintaining the energization of the associated drive control relay when said manually engageable control members are released as said work producing portion of the machine returns to said starting position from said work producing position.

17. The control system of claim 16 wherein said drive control relays are connected between the respective holding branch circuits and the same power input terminals, and there is provided fuse means in each relay holding branch circuit on the same side of the associated drive control relays as said machine driven switch means which fuse means blows upon current flow therethrough only exceeding a given level occurring upon a short circuit between said relay holding branch circuits at a point between said drive control relays and said machine driven switch means and the opening in one of the relay holding branch circuits of said machine driven switch means which opens once each cycle of operation of the machine while the corresponding switch means in the other relay holding branch circuit remains closed when it is supposed to open, so the fuse means in the latter relay holding branch circuit carries all the current which normally flows in both relay holding branch circuits.

18. The control system of claim 15 wherein said drive means is a pressure responsive drive means which is rendered operable when the pressure applied thereto exceed a given level and which cannot normally be rendered operable below such level, and there is provided a pair of pressure control valves respectively controlled by said drive control devices and connected in parallel between a pressure supply line and an input line to said pressure responsive drive means, each of said valves being opened to connect said supply line to said input line when the associated drive control device is energized and being closed when the associated drive control device is deenergized, the pressure on said input line being a maximum when both of said valves are opened and a minimum when both of said valves are closed and valve responsive means responsive to the continued opening of one of said valves and the continued closing of another of said valves for effecting the continued deenergization of both drive control devices at least by the time the work producing portion of the machine returns to said starting position and independently of the operation of said switch means of said manually engageable control members.

19. The control system of claim 18 wherein there is provided additional switch means controlled by each of said manually engageable control members and relay means controlled by said additional switch means, said drive means is a gas pressure responsive drive means, said pressure on said input line being intermediate said minimum and maximum value when one of said valves is open and one of said valves is closed, said additional switch means of each manually engageable control member includes a normally closed switch which is opened when the control member is held in its run position, said valve responsive means is a pressure responsive switch including a normally closed switch which opens when the pressure of said input line reaches or exceeds said intermediate value, and the normally closed switch of each manually engageable control member is connected in series circuit with said normally closed switch of said pressure switch and said relay means across said powerlines, said relay means when energized preparing both of said drive control devices for energization by the first mentioned switch means controlled by said manually engageable control members when the latter are all operated at the beginning of a machine cycle.

20. The control system of claim 16 wherein said machine operated switch means in said holding branch circuit open when said work producing portion of the machine returns to said starting position and close when said work producing portion of the machine reaches said work producing position.

21. The control system of claim 19 wherein said drive means is pressure operated by separate valves controlled respectively by said drive control devices, each valve being normally open when the associated drive control device is

energized and being closed when the associated drive control device is deenergized, said drive means being normally operable only when both of said valves are opened, and means responsive to the closure of both of said valves for opening both of said holding branch circuits.

22. The control system of claim 15 wherein there is provided means for deenergizing said drive control devices once each cycle of operation of the machine, said drive means is a pressure responsive drive means which is rendered operable when the pressure applied thereto exceeds a given level and which cannot normally be rendered operable below such level, and there is provided a pair of pressure control valves respectively controlled by said drive control devices and connected in parallel between a pressure supply line and an input line to said pressure responsive drive means, each of said valves being opened to connect said supply line to said input line when the associated drive control device is energized and being closed when the associated drive control device is deenergized, the pressure on said input line being a maximum when both of said valves are opened, a minimum when both of said valves are closed and means responsive to the continued opening of one of said valves and the continued closing of another of said valves and the deenergization of at least one of said drive control devices for effecting the continued deenergization of both control devices at least by the time the work producing portion of the machine returns to said starting position and independently of the operation of said switch means of said manually engageable control members.

23. The control system of claim 15 wherein said pair of manually engageable control members are located at one operator control station and each of said manually engageable control members has additional switch means operating similarly to the first mentioned switch means thereof and located in the other of said branches so each branch has similarly operating switch means of both manually engageable control members.

24. An electrical control system comprising a power input source comprising a transformer having a primary winding to be connected to a source of alternating current and a center-tapped secondary winding, the center tap of which is grounded and the opposite ends of which form voltage input terminals for a control circuit, a control circuit comprising a pair of powerlines coupled to said voltage input terminals, a pair of manually engageable control members, at least two circuit branches coupled directly across said powerlines and each including an operation producing device which effects a desired operation when energized and a different control switch means in series therewith operated directly by a different one of said pair of manually engageable control members for normally controlling the energization and deenergization of said operation producing devices, said control switch means in one of said circuit branches being coupled only between one of said powerlines and the associated operation producing device and the control switch means in the other circuit branch being coupled only between the other powerline and the associated operation producing device whereby any short circuit between said control switch means of said circuit branches or the grounding of any portion of either circuit branch will cause a short circuit current to flow in one or both portions of the secondary winding of said transformer, and short circuit current responsive means for sensing the flow of any of said short circuit currents for disconnecting power to said powerlines.

25. The electrical control system of claim 24 wherein each of said pair of manually engageable control members has additional control switch means operating similarly to the first mentioned switch means thereof and located in the other of said branches so each branch has similarly operating switch means of both pair of manually engageable control members, and each of said pair of manually engageable control members and the associated control switch means forming a switch unit wherein the control switch means can be short circuited if the switch unit is damaged.

26. The electrical control system of claim 25 wherein said operation producing devices in said circuit branches cooperate to produce the same given operation if both are energized and fail to perform said operation if only one or neither of same are energized.

27. A machine which has a work producing portion movable by an operating drive means from a remote starting position, where an operator is relatively safe, to a work producing position where it can injure an operator in the vicinity thereof and then back to said starting position, said drive means being a gas pressure responsive drive means which is rendered operable when the pressure applied thereto exceeds a given level and which cannot normally be rendered operable below such level, a pair of pressure control valves, drive control devices controlling said valves, said control valves being connected in parallel between a pressure supply line and an input line to said pressure responsive drive means, each of said valves being opened to connect said supply line to said input line when the associated drive control device is in a valve opening condition and being closed when the associated drive control device is in a valve closing condition, the pressure on said input line being a maximum when both of said valves are opened, a minimum when both of said valves are closed and an intermediate valve when one of said valves is opened and one of the valves is closed, a control system for operating said valve operating drive control devices, said control system including means responsive to the opening of one of said valves and the closing of the other of same for operating both of said drive control devices to a valve closing condition if not already in such a condition and pressure responsive means responsive to the presence of said intermediate pressure in said input line at a time in the machine cycle when the pressure thereat should be zero for operating both of said drive control devices to their valve closing conditions.

28. In combination, an operator controlled machine which has a work producing portion movable by the operation of pressure responsive drive means from a remote starting position, where an operator is relatively safe, to a work producing position, where it can injure an operator in the vicinity thereof, and then back to said starting position; operator control station means with manually operable control means, said drive means being rendered operable when the pressure applied thereto exceeds a given level and is normally inoperative at input pressures below such level; a pair of pressure control valves having movable valve opening and closing parts and being connected in parallel between a pressure supply line and an input line to said pressure responsive drive means, the pressure on said input line being a maximum when both of said valves are opened to operate said pressure responsive drive means and less than said maximum value where said pressure responsive drive means is inoperative when both or one of the valves is closed; drive control devices for controlling said valves; and a drive control system for operating said drive control devices, said control system including first means responsive to operation of said manually operable control means for operating said drive control devices from a normal valve closing condition to a valve opening condition, second means responsive to the movement of said work producing portion of said machine between said work producing position to said starting position for continuing the operation of said drive control devices in said valve opening condition independently of the operation of said manually operable control means until said work producing portion of the machine at least returns to said starting position; third means responsive to either one of said valves being in an open position for preventing the operation of said drive control devices by said manually operable control means, and fourth means responsive to either one of both of said valves being in a closed position for terminating the operation of said drive control devices upon release of said manually operable control means.

29. The combination of claim 28 wherein said third and fourth means includes means controlled directly by the movement of said movable valve parts.

30. The combination of claim 28 wherein said third and fourth means includes means controlled directly by the pressure in said input line.

31. The combination of claim 28 wherein said drive control devices are solenoids which open said valves when energized; said control system includes antirepeat relay means which when energized locks into such energized state and prepares said drive control devices for energization by said manually operable control means, first machine drive means which breaks the locked-in condition of said antirepeat relay means as said work producing portion of said machine is returned to said starting position, means including machine driven means which lockin said solenoids into their energized condition when said work producing portion of the machine moves between said work producing position and said starting position, and said third and fourth means includes normally closed switches in series with said antirepeat relay means to prevent initial energization of same when open and normally open switches in holding circuit branches of said solenoids to break the holding circuit branches when open.

32. A machine which has a work producing portion movable by an operating drive means from a remote starting position, when an operator is relatively safe, to a work producing position where it can injure an operator in the vicinity thereof and then back to said starting position, operator control station means each having self-returning manually operable control means thereat movable from a normal inoperative position to a single cycle run position when it is desired to operate the drive means, said manually operable control means controlling normally open switch means and normally closed switch means which are respectively opened and closed when the manually operable control means is in its normal position and are respectively closed and opened when said control means is in its run position, first machine driven switch means which is closed except when said work producing portion of the machine is nearing a return to said starting position and antirepeat relay means connected across said powerlines through said machine driven switch means and the normally closed switch means of said manually operable control means connected in series, two separate electrically operable drive control relays connected in separate branch circuits across said powerlines, both of which drive control relays must be energized to operate said drive means and each of which relays is connected across said powerlines through a different normally open switch means controlled by said manually operable control means, holding branch circuits between said drive control relays and one of said powerlines and including switch means controlled by said drive control relays to hold the same in an energized state independently of the opened or closed condition of said normally open switch means of said manually operable control means, second machine driven switch means which interrupts said holding circuits of said drive control relays when said work producing portion of the machine returns to said starting position, switch means controlled by said antirepeat relay means for preventing a renewed energization of the drive control relays if the antirepeat relay remains deenergized after said holding circuits are opened by said second machine driven switch means and permitting such energization when said antirepeat relay means is energized, and antirepeat relay circuit check means comprising first and second normally closed switch means controlled by said antirepeat relay means so as to be closed and opened respectively during the deenergization and energization thereof and connected in series respectively with said separate drive control devices, and third and fourth separately machine driven normally closed switch means connected across said first and second normally closed switch means of said antirepeat relay means, said third and fourth separately machine driven normally closed switch means being opened momentarily during the return of said work producing portion of the machine driven switch means is opened to break the holding circuits of the associated drive control relays and terminate operation of said drive means if the antirepeat relay means did

not become deenergized by proper operation of said first machine driven switch means.

33. In combination, a machine having a work producing portion movable by an operating drive means from a starting remote position, where an operator is relatively safe, to a work producing position where it can injure an operator in the vicinity thereof and then back to said starting position; manually operable self-returning control means movable from an inoperative position to a run position when it is desired to operate said drive means; manually operable function control means having stable off, single cycle operation and continuous operation positions; key operable control means having stable continuous-off and continuous-on positions; means responsive to the simultaneous positioning of said manually operable function control means to its single cycle operation position and said manually operable self-returning control means to its run position for operating said drive means for a single cycle which moves said work producing portion of the machine from said starting position to said work producing position and back to said starting position; and means responsive to the simultaneous positioning of said key-operated control means to its continuous on position, said manually operable function control means to said continuous operation position and said manually operable self-returning control means to the run position for continuously operating said drive means, continuously to move said work producing portion of the machine repeatedly between said starting and work producing positions.

34. The combination of claim 33 wherein said manually operable self-returning control means includes a first self-returning control which must be continuously operated in its run position to effect a continuous cycle of operation for a period wherein said work producing portion of the machine moves from its starting to its work producing position.

35. The combination of claim 34 wherein said manually operable self-returning control means further includes a second self-returning manually operable control which must be momentarily operated prior to said first self-returning control means to effect the initiation of the continuous cycle of operation by operation of said key operable control means to its continuous on position and the operation of said first self-returning manually operable control continuously during the interval when said work producing portion of the machine is moving between said starting and work producing positions.

36. In combination, a machine having a work producing portion movable by an operating drive means from a starting remote position, where an operator is relatively safe, to a work producing position where it can injure an operator in the vicinity thereof and then back to said starting position; manually operable self-returning control means movable from an inoperative position to a run position when it is desired to operate said drive means; manually operable function control means having a movable handle which is movable generally in a given plane to first and second positions in said plane respectively, to move said control means into positions for obtaining a stable off and single cycle operation positions, and said manually movable handle being movable into a third position in said plane where the handle is then movable in a direction transverse to said plane into a second plane where said control means is in a continuous operating position; key operable control means having stable continuous-off and continuous-on positions; means responsive to the simultaneous positioning of said manually operable function control means to its single cycle operation position and said manually operable self-returning control means to the run position for operating said drive means for a single cycle which moves said work producing portion of the machine from said starting position to said work producing position and back to said starting position; and means responsive to the simultaneous positioning of said key-operated control means to its continuous on position, said manually operable function control means to said continuous operation position and said manually operable self-returning control means to the run position for continuously operating said drive means continuously to move said work producing

portion of the machine between said starting and work producing positions.

37. In combination, a machine having a work producing portion movable by an operating drive means from a starting remote position, where an operator is relatively safe, to a work producing position where it can injure an operator in the vicinity thereof and then back to said starting position; at least one manually operable self-returning control means movable from a stable inoperative position to an unstable operative position when it is desired to operate said drive means; and manually operable function control means having a handle coupled thereto for moving the same between discrete stable off, single cycle, inch and continuous operating positions, said inch operating position being located between said single cycle and continuous operation positions so the function control means cannot readily be moved inadvertently from the single cycle operation position to said continuous operation position; means responsive to the simultaneous position of said manually operable function control means to its single cycle operation position and all manually operable self-returning control means to the operative position thereof for operating said drive means for a single cycle which moves said work producing portion of the machine from said starting position to said work producing position while said self-returning control means is held in said operative position and then back to said starting position even when said self-returning control means is released; means responsive to the simultaneous positioning of said manually operable function control means to said continuous operation position and all manually operable self-returning control means to the operative position thereof for obtaining the operation of said drive means continuously to move said work producing portion of the machine repeatedly between said starting and work producing positions; and means responsive to the simultaneous positioning of said manually operable function control means to said inch operation position and said manually operable self-returning control means to the operative position thereof for obtaining the operation of said drive means only as long as the latter self-returning control means is held in said operative position.

38. The combination of claim 37 wherein said continuous operation position of said manually operable function control means is the position furthest removed from the off position thereof.

39. The combination of claim 37 wherein said manually operable function control means has a neutral or inoperative stable position between the single cycle and inch positions, and between said inch and continuous operation positions, at which neutral or inoperative positions said drive means is inoperative.

40. The combination of claim 37 wherein there is provided key operable control means having stable off and on positions, said means which is responsive to the simultaneous positioning of said manually operable function control means and the continuous operation position of said manually operable self-returning control means also requiring the simultaneous positioning of said key operable control means in the stable on position thereof to effect the continuous operation of said drive means.

41. A machine having a work producing portion movable by an operating drive means from a starting remote position, where an operator is relatively safe, to a work producing position where it can injure an operator in the vicinity thereof, at least one depressible self-returning control means movable by application of manual force from a stable inoperative extended position to an unstable depressed operative position when it is desired to operate said drive means, a second initially nondepressible self-returning control means movable by manual force from a stable inoperative position to an unstable operative position when it is desired to operate said drive means, and control means responsive to said depressible and nondepressible self-returning control means for inhibiting the operation of said drive means when either of said manually operable self-returning control means are in their stable in-

operative positions and for operating said drive means when said depressible and nondepressible self-returning control means are simultaneously manually held in their unstable operative positions.

42. In combination, a multioperator controlled machine which has a work producing portion movable by an operating drive means from a remote starting position, where an operator is relatively safe, to a work producing position where it can injure an operator in the vicinity thereof and then back to said starting position; at least two operator control stations, each operator control station having self-returning manually operable control means thereat movable from a normal inoperative position to a run position when it is desired to operate the drive means, each of said manually operable control means controlling switch means, each manually operable control means and the associated switch means being part of an operator unit having contact terminals removably engageable with complementary contact terminals at the associated operator control station; electrically operated drive control means which when connected across a pair of powerlines operates said drive means; a control circuit for controlling the connection of said drive control means across said powerlines, the control circuit comprising circuit-forming means interconnecting said powerlines, drive control means, switch means and at least some of said complementary contact terminals for normally energizing said drive control means when said manually operable control means of all the operator control means of all the operator control stations are simultaneously operated to their run positions; each of said operator units having a jumper connected by some of said complementary contact terminals at a point of said control circuit in series with said powerlines so the absence of jumpers will render the control circuit inoperative; and dummy units each of which can be substituted for one of said operator units and has con-

tact terminals removably engageable with at least some of the complementary contact terminals of the operator control stations of the operator unit it is to replace, each of said dummy units having jumpers which interconnect some of said complementary contact terminals but not said complementary contact terminals which connect said operator unit jumpers.

43. The combination of claim 42 where each of said dummy units leave additional portions of said control circuit un-jumpered so an undesired short circuit across one of the un-jumpered portions of the circuit when all of the operator units are replaced by dummy unit will still leave the control circuit inoperative.

44. In combination, a multioperator controlled machine which has a work producing portion movable by an operating drive means from a remote starting position, where an operator is relatively safe, to a work producing position where it can injure an operator in the vicinity thereof and then back to said starting position, at least two operator control stations, each operator control station having self-returning manually operable control means thereat movable from a normal inoperative position to a runs position when it is desired to operate the drive means, said operable control means at each operator control station being part of an electrical operator unit having contact terminals removably engageable with complementary contact terminals at the associated operator control station; each of said operator units having a machine stopping control thereon for rendering said drive means inoperable to stop the machine at any point in an operating cycle, and each of said operator units further having an indicating light which becomes automatically energized to indicate that the unit is operable when the unit contact terminals engage with said complementary contact terminals at the operator control station involved.

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