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MACHINE CONTROL DEVICE

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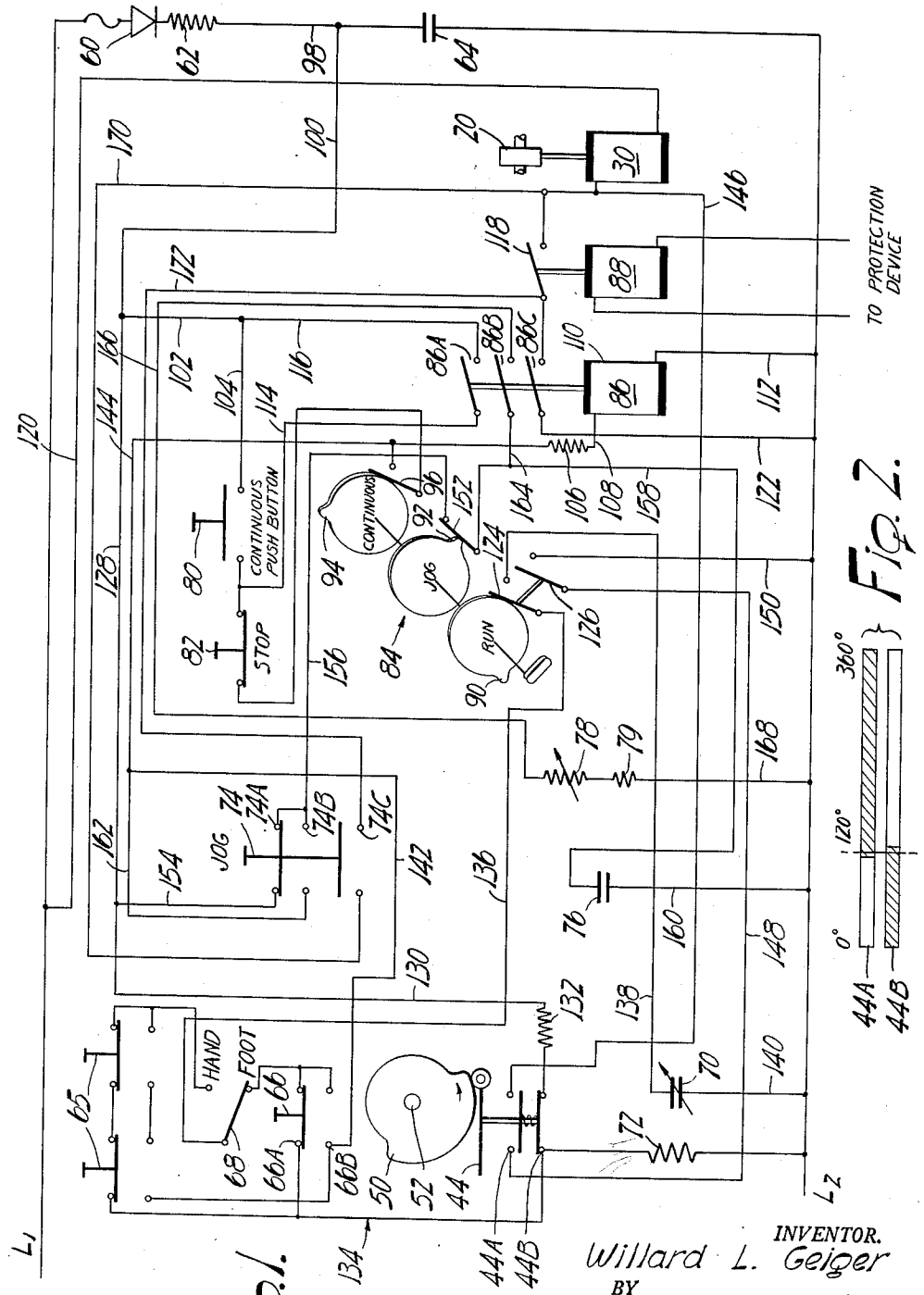


Fig. 1.

Fig. 2.

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MACHINE CONTROL DEVICE

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1

The present invention relates to electrical control systems for machinery of the class having a cycle of movements, for example, power presses in which a head reciprocates in one direction from a starting position to perform a pressing operation on work pieces and is then reciprocated back in the other direction to the starting position to complete the cycle.

Prior systems of this class have included provision for continuous, single-cycle, and inching phases of operation. In such prior systems it has been customary to provide synchronization directly from the machine by means of a plurality of cam operated limit switches and/or relays, and the control circuit has consisted of heavy 110 volt alternating current elements. In accordance with the present invention a control for such machines is provided wherein only one cam switch and only one relay are necessary, part of the synchronization function being furnished by a time delay condenser and wherein small, light weight, quick-acting direct current elements are used in the circuits. Another important feature of the present invention resides in the provision of an inching control wherein each depression of the inching push-button results in a definite, positive operation of the machine for a pre-determined adjustable time, thereby taking the element of skill out of the inching operation and further giving superior results over that obtainable with the customary untimed inching control in the hands of even the most skilled operator. In accord with another feature of the invention, provision is made for introduction of a safety device in such a way that the safety device functions appropriately in each phase of machine operation.

The present invention has perhaps its most important application to power operated presses of the vertically reciprocatory type and will therefore be illustrated and described herein as applied to such a power press, although as will become apparent hereinafter, the invention is not limited in its application to presses but may be applied generally to machinery which has a cycle of operations.

Hence a general object of the invention is to provide an improved control system for cyclically operated machines to insure that the machines will operate safely and efficiently under all conditions of operation.

Another object of the invention is to provide in a control system for cyclically operating machines of the type employing an electro-magnetic device to control a clutch and brake for the machine, improved control means whereby only one cam operated switch and one relay are needed for synchronization and whereby light-weight, fast operating D. C. elements are used.

2

Still another object of the invention is to provide a control system for a machine of the cyclically operating type by which during single cycle operations the machine may be started only after all of the operators' push-buttons are closed and will stop unless all of the push-buttons are held closed for a predetermined part of the operating cycle of the machine and which will thereafter continue to run to the end of the cycle after the push-buttons have been released and which will automatically stop at the end of the cycle independently of whether the push-buttons have been relased and which cannot be started to begin a cycle unless all of the push-buttons have first been released at the end of the cycle.

Another important object of the invention is to provide a novel inching control wherein each depression of the inching push-button results in a positive pulse of machine operation of adjustable predetermined time length.

Another object of the invention is to provide a control means as aforesaid which incorporates both hand and foot operated switches which may be selectively employed by the machine operator to obtain any desired control effect.

Another object of the invention is to provide in a device of the character aforesaid means to connect any existing external additional safety device to the mechanism of the invention without requiring either mechanism to be rewired for operation of the protection providing unit at all times when necessary.

A still further object of the invention is to provide a protection feature wherein the protection device is effective at all times when the machine is in continuous operation and wherein the protection device is effective only during the downward stroke when the machine is in a single cycle operation and wherein the protection device is by-passed during inching operations so that each phase of operation is attended by specifically adapted protection conditions.

Other objects and advantages of the invention will appear from the specification hereinafter.

In the drawing herewith Fig. 1 is a schematic view illustrating a preferred control system for a machine embodying my invention; and

Fig. 2 is a diagrammatic view illustrating the timed sequence of operation of the contacts of the limit switch of Fig. 1.

Referring to Fig. 1, the machine to be con-

trolled by the system of the invention may be of the type, for example, in which a driving clutch and brake are alternately engaged to start and stop the press, or it may be of the type in which the brake is continuously engaged; in either case the driving clutch is usually engaged by a pneumatic or hydraulic actuator which is under the control of a solenoid valve such as is diagrammatically illustrated at **20** with its coil **30**. According to one feature of the invention, synchronization of the control with the machine is effected in part through a limit switch **44** which is operated by a cam **50** carried by the machine drive shaft **52**. The control system of my invention in the illustrated preferred form incorporates a selenium or other suitable rectifier **60** together with a current limiting resistor **62** and a filter condenser **64** to provide a direct current power supply for the system which includes a plurality of operator's "run" push-buttons **65—65** and an operator's pedal **66**, a hand-foot selector switch **68**, a "run" timing condenser **70**, a condenser bleeder resistor **72**, a "jog" push-button **74**, a "jog" condenser **76**, a "jog" condenser bleeder **78**, a "continuous" push-button **80**, a "stop" push-button **82**, a rotary selector switch **84**, and a control relay **86**, and which is subject to certain overcontrol effects of protection device **88**, as will hereinafter be more fully explained.

The rotary selector switch **84** is provided to predetermine whether the press is to run a single cycle and then stop; or whether it is to run continuously, cycle after cycle, after being once started until stopped; or whether it is to be inched ahead by small predetermined increments of movement such as are necessary when the dies on the heads of the machine are being adjusted; and the foregoing positions of the selector switch are such that the cam elements **90**, **92**, **94** thereof are correspondingly brought into operation against their respective switch elements, the selector being illustrated in the "inch" position.

Assuming that it is desired to operate the machine continuously, cycle after cycle without stopping, the rotary selector switch **84** is moved to "continuous" position whereby the cam element **94** closes its corresponding switch **96**. If the "continuous" push-button **80** is then depressed, a circuit is established from one alternating current power line L1, through the rectifier **60**, by wires **98**, **100**, **102**, and **104**, through the push-button **80** and the normally closed stop button **82**, through the closed switch **96** and the resistor **106**, by wire **108** to the coil **110** of the relay **86** and thence by wire **112** to the other AC line wire L2. This causes the relay **86** to close whereupon the contact **86A** thereof forms a maintaining circuit by wires **114** and **116** across the contacts of push-button **80**. Assuming that the protection device **88** is energized and its contactor **118** is thus closed, the closing of the relay **86** establishes another circuit from line L1, by wire **120**, through solenoid **30**, through contactors **118** and **86C**, by wire **122** to the line L2, thus energizing the coil **30** and operating the valve **20** so as to start the press. Since the control circuit has been sealed in through the contact **86A**, the press will continue to run until the circuit of the relay **86** is broken by operation of the stop button **82**, provided that the contactor **118** of the protection device **88** does not open.

If it is desired to "run" the machine by single cycles, the selector switch **84** is rotated so that the cam element **90** depresses a pair of ganged switches **124—126**. As will be seen in Fig. 2, if the machine is in position to start a cycle, the cam switch **44** will be depressed so that its contact **44A** is open and its contact **44B** is closed.

A choice of "run" operating switches is provided so that the machine may be either hand or foot controlled. For hand operation a plurality of push-buttons **65—65** are provided so as to fully occupy the hands of the operator or operators, and these push-buttons are series wired so that they must be operated concurrently to close either circuit through them. The switch **68** may be thrown to either "hand" or "foot" position, it being illustrated and described in the latter so as to put the foot pedal **66** into the circuit. Then with pedal **66** in its normal position with the contact **66A** thereof closed, a condenser charging circuit is established from line L1 through the rectifier **60** by wires **98**, **100**, **128**, and **130**, through a resistor **132**, through the closed contact **44B**, by wire **134**, through the closed contact **66A** and the hand-foot switch **68**, by wire **136**, through the switch **124**, by wire **138** to the adjustable condenser **70** which in turn is connected to the line L2 by wire **140**. This circuit quickly charges the condenser **70** to the voltage provided by the rectifier **60**. Then, if the pedal **66** is depressed so as to open the contact **66A** and to close the contact **66B** thereof, the foregoing charging circuit will be broken and a condenser discharging circuit will be established from the condenser **70** by wire **138**, through the switch **124**, by wire **136**, through the switch **68**, through the now closed contact **66B**, by wire **142** and wire **144**, through the resistor **106** and the relay coil **110**, by wire **112**, the line L2, and the wire **140** back to the condenser **70**. This will close the relay **86** so as to establish a press operating circuit through the contact **86C** thereof as before. When the press has traveled 120 degrees, the limit switch **44** will be released thereby closing its contact **44A** and opening its contact **44B**.

When the contact **44A** closes, a circuit will be established from the line L1 by wire **120** through the solenoid **30**, by wire **146**, through the contact **44A**, by wire **148**, through the switch **126**, by wire **150** to the line L2. This circuit will continue to energize the solenoid **30** so as to continue to operate the press so long as the contact **44A** is closed regardless of whether the relay **86** and the device **88** are energized. Thus, when the press is being operated under the "run" phase of control, the pedal **66** may be released at any time after the press has traveled 120 degrees without halting operation thereof. Referring to Fig. 2, it is seen that contact **44B** is closed during the first 120 degrees of press operation and that contact **44A** is closed during the remaining 240 degrees, there being a slight overlap because the limit switch **44** is of a make-before-break type. Thus, the condenser **70** can be charged through the contact **44B** only during the downward stroke of the press.

The capacity of the condenser **70** is adjusted relative to the current drain of the coil **110** of the relay **86** so that the condenser will furnish sufficient power to continue to energize the relay **86** during the entire 120 degrees downward stroke of the press during which the press is dependent upon the contact **86C** for its operation, but the capacity of the condenser **70** is adjusted to be less than the amount which would be necessary to energize the relay **86** for the remaining 240 degrees of operation. The condenser **70** may be rendered adjustable in any suitable manner, as for example it may be made up of a number of

condensers in parallel with provision to disconnect one or more from the circuit to decrease the total capacity. Thus, if the pedal 66 is depressed and held, the press will start to operate as a result of the closing of the relay 86, and there will be a sufficient charge in the condenser 70 so that before it is depleted to the point where the relay 86 will drop out the press will have traveled 120 degrees and the contact 44A will have closed so as to continue the cycle to completion. During the first 120 degrees the press may be started and stopped at will by operation of the pedal 66, each release thereof re-establishing a full charge on the condenser 70. However, even if the condenser 70 is recharged just before the press reaches 120 degrees, continued holding of the pedal 66 will not cause the press to repeat because the charge on the condenser 70 will have been fully dissipated in the remaining 240 degrees of operation. If the pedal 66 were released during the return portion of the cycle while a substantial charge still remained in condenser 70, it might be possible to redepress pedal 66 just before the end of the cycle and cause the press to repeat were it not for the resistor 72 which is adjusted to bleed the condenser 70 during the return stroke of the press even though the push-button or foot pedal is released. Thus the condenser 70 will be bled of its charge during the return portion of the run cycle in any event so that a new cycle cannot be initiated until the condenser 70 is recharged through contacts 44B and 86A. It will be observed that in the "run" phase of control the protective device 88 is effective only during the downward stroke of the press, it being by-passed through the contact 44A during the upward stroke for reasons which will appear hereinafter.

If it is desired to inch or "jog" the press by small increments, as, for example, when setting up dies or jigs, the selector switch 84 is rotated so that the cam element 92 thereof depresses the corresponding switch 152. A "jog" condenser charging circuit is then established from the line L1 through the rectifier 60, by wires 98, 100, and 154, through the normally closed contact 74A of the "jog" push-button 74, by wire 156, through the closed switch 152, by wire 158 to the "jog" timing condenser 76 and thence by wire 160 to the other line L2. If the jog push-button 74 is then depressed, the foregoing charging circuit will be broken by the opening of the contact 74A and a discharging circuit will be established from the condenser 76, by wire 158, through the switch 152, by wire 156, through the now closed contact 74B, by wires 162 and 144, through resistor 106, by wire 108, through the coil 110 of the relay 86 and by wires 112, L2, and 160, back to the other side of the condenser 76, thus quickly picking up relay 86 by the full power of the condenser 76 so as to close the contact 86C and initiate operation of the press. When the relay 86 has completely closed the contact 86B establishes a condenser bleeder circuit across the condenser 76 by wires 158 and 164, through the contactor 86B, by wire 166, through adjustable resistor 78 and the fixed resistor 79 and by wires 168, L2, and 160. This bleeder circuit immediately starts to drain the charge from the condenser 76, and the rate of drain may be predetermined by adjustment of resistor 78 so that the voltage across the condenser 76 will reach the drop out value of the relay 86 within any desired interval after the closing of the relay 86 so as to terminate the "jog" power impulse. It is a special feature and advantage of this invention that the "jog" interval is limited to an adjustably predetermined maximum so that all the operator need do is adjust the resistor 78 for the desired jog increment and then press the jog push-button 74 and continue to hold it depressed until the jog impulse has been completed, so that no skill or attention on the part of the operator is necessary to prevent unwanted excess in the jog movement. It is another important feature of the invention that the relay 86 is positively picked up with the full power of the condenser 76 regardless of how short a jog increment is desired, inasmuch as the variable jog terminating function is not brought into the circuit until the relay 86 actually closes. Inasmuch as no protection is needed or desired during the jogging operation, the jog push-button 74 is provided with a third, normally open contact 74C which shunts the contact 118 of protection device 88 through wires 170 and 172 whenever the push-button is depressed.

Thus, the invention provides a control wherein the various elements are brought into cooperative relationships such as to individually satisfy the requirements of each phase of machine operation—continuous, run, and jog. For example, the relay 86 is utilized in all phases of operation, but it is supplied with unique control circuits for each phase and is by-passed by the contact 44A during part of the run cycle. Further, the protection device is particularly adapted to each phase of operation; for example, it is effective to stop the machine at all times during continuous cycling so that in addition to preventing injury during the down stroke, it will also detect material fouling or the like on the up stroke. On the other hand, during single cycle run operations the machine is always attended so that the danger of material fouling on the up stroke is not present; on the contrary, it is desirable that the operators be free to serve the press during the non-dangerous part of the cycle without the inconvenience resulting from stopping the press due to tripping of the protection device. Thus, when the machine is being operated under run conditions the protection device is effective during only the first 120 degrees of the cycle, it being shunted by the contact 44A during the remainder thereof. Finally, during jog operations there is no danger, and, as a matter of fact, it is necessary that the operator be free to enter between the jaws of the press so that he can adjust the dies, etc.; therefore, the additional contact 74C is provided on the jog push-button 74 to shunt protection device so that the latter will not prevent inching of the machine.

From the foregoing it will be apparent that the invention provides an extraordinarily foolproof, light, and compact control for cyclically operated machines while employing a minimum of moving elements and providing for a maximum of safety and efficiency of operation. Although only one form of the invention has been illustrated and described in detail, it will be understood that the invention is not so limited but may be otherwise embodied within the scope of the appended claims.

What is claimed is:

1. In a control for a cyclicly operated machine, an operator's push-button having a normally closed contact and a normally open contact, a limit switch with a first contact and a second contact closable substantially alternately, a cam adapted to be operable by the machine to close said first contact during a predetermined first portion of the cycle of the machine and to

close said second contact during the remainder of the cycle, a source of electric energy, a condenser, a resistor, a relay having a normally open contact, a condenser charging circuit including said source and said first contact of said limit switch and said normally closed contact of said push-button and said condenser in series, a condenser discharging circuit including said condenser and said normally open contact of said push-button and the input of said relay in series, a condenser bleeder circuit including said condenser and said normally closed contact of said push-button and said resistor in series, and a machine actuating circuit including said contact of said relay in parallel with said second contact of said limit switch.

2. In a control for a cyclicly operated machine, an operator's push-button having a first contact and a second contact, a limit switch with a first contact and a second contact, a cam adapted to be operable by the machine to actuate the contacts of said limit switch, a condenser, a resistor, a relay, a condenser charging circuit including said first contact of said limit switch and said first contact of said push-button and said condenser adapted to be under series control of said first contacts, a condenser discharging circuit including said condenser and said second contact of said push-button and said relay adapted to operate said relay under series control of said second contact of said push button and the discharge current of said condenser, and a condenser bleeder circuit including said condenser and said first contact of said push-button and said resistor adapted to be under series control of said first contact of said push button, a machine actuating circuit including a contact of said relay, and a second machine actuating circuit including said second contact of said limit switch.

3. In a control for a cyclicly operated machine, an operator's push-button having a normally closed contact and a normally open contact, a limit switch with a first contact and a second contact arranged to be closable substantially alternately, a cam adapted to be operable by the machine to close said first contact during a first portion of the cycle of the machine and to close said second contact during the remainder of the cycle, a condenser, a relay having a normally open contact, a source of electric energy, a condenser charging circuit including said source and said first contact of said limit switch and said normally closed contact of said push-button and said condenser in series, a condenser discharging circuit including said condenser and said normally open contact of said push-button and the input of said relay in series, and a machine actuating circuit including said contact of said relay in parallel with said second contact of said limit switch.

4. In a control for a cyclicly operated machine, a machine control solenoid, an electro-magnetic contactor having a first normally open contact, an overcontrol protection device relay having a normally open load contact and an operating coil, said coil having energizing leads arranged for connection to an external protection device as the sole control of said coil, a source of electric energy, a first machine actuating circuit comprising said first normally open contact and said normally open load contact and said control solenoid in series across said source, continuous and single cycle and inching control circuit means for corresponding types of machine operation, each said control circuit means being adapted to control said electromagnetic contactor, a selector switch for selectively bringing said control circuit means into control relation with said electro-magnetic contactor, said inching control circuit means comprising means for limiting the extent of the movement of the machine to a small increment during each operation thereof, said inching control circuit means comprising a shunt contact arranged to be closed by and during operation thereof, and a second machine actuating circuit comprising said shunt contact in series with said solenoid and in series with said first normally open contact and in parallel with said normally open load contact across said source, whereby said machine may be actuated by said solenoid subject to energization of said protection device relay and may be actuated by said solenoid independently of said protection device relay but subject to closure of said shunt contact, according to the position of said selector switch.

5. In a control for a cyclicly operated machine, a machine control solenoid, an electro-magnetic contactor having a first normally open contact, an overcontrol protection device relay device having a normally open load circuit means and an input, said input having control leads arranged for connection to an external protection device as the sole control of said input, a source of electric energy, a first machine actuating circuit comprising said first normally open contact and said load circuit means and said control solenoid in series across said source, a plurality of control circuit means for different types of machine operation each adapted to control said electro-magnetic contactor, a selector switch for selectively bringing said control circuit means into control relation with said electro-magnetic contactor, at least one of said control circuit means comprising a shunt contact arranged to be closed by and during operation of said machine by said one control circuit means, and a second machine actuating circuit comprising said shunt contact in series with said solenoid and in parallel with said load circuit means across said source whereby said machine may be actuated by said solenoid subject to energization of said protection device relay device and may be actuated by said solenoid independently of said protection device relay device but subject to closure of said shunt contact, according to the position of said selector switch.

6. In a control for a cyclicly operated machine, an operator's control device having a first switch means and a second switch means, a limit switch device with a first switch means and a second switch means, said limit switch device being adapted and arranged to be operable by the cyclic movement of the machine to actuate the switch means of said limit switch device, a condenser, a resistor, a relay having an input and an output, a source of electric energy, a condenser charging circuit including said source and said first switch means of said limit switch device and said first switch means of said control device and said condenser adapted to be under series control of both said first switch means, a condenser discharging circuit including said condenser and said second switch means of said control device and said input of said relay adapted to operate said relay under series control of said second switch means of said control device and the discharge current of said condenser, and a condenser bleeder circuit including said condenser and said first switch means of said control device and said resistor adapted to be under series control of said first switch means of said control device, a machine actuating circuit

including said output of said relay, and a second machine actuating circuit including said second switch means of said limit switch device.

7. In a control for a cyclicly operated machine, an operator's control device having a first switch means and a second switch means, a limit switch device with a first switch means and a second switch means, said limit switch device being adapted and arranged to be operable by the cyclic movement of the machine to actuate the switch means of said limit switch device, a condenser, a relay having an input and an output, a source of electric energy, a condenser charging circuit including said source and said first switch means of said limit switch device and said first switch means of said control device and said condenser adapted to be under series control of both said first switch means, a condenser discharging circuit including said condenser and said second switch means of said control device and said input of said relay adapted to operate said relay under series control of said second switch means of said control device and the discharge current of said condenser, a machine actuating circuit including said output of said relay, and a second machine actuating circuit including said second switch means of said limit switch device.

8. In a control for a cyclicly operated machine, an operator's control device having a first switch means and a second switch means, a limit switch device with a switch means, said limit switch device being adapted and arranged to be operable by the cyclic movement of the machine to actuate the switch means of said limit switch device, a condenser, a relay having an input and an output, a source of electric energy, a condenser charging circuit including said source and said switch means of said limit switch device and said first switch means of said control device and said condenser adapted to be under series control of said first switch means and said switch means of said limit switch device, a condenser discharging circuit including said condenser and said second switch means of said control device and said input of said relay adapted to operate said relay under series control of said second switch means of said control device and the discharge current of said condenser, and a machine actuating circuit including said output of said relay.

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