METHOD AND APPARATUS FOR CONTROLLING PRODUCTION MACHINES

Marvin E. Simonton and John O. Yerger, Berkeley, Calif., assignors, by mesne assignments, to Bernard R. Kat- sunk, Redwood City, Calif.

Application September 25, 1953, Serial No. 382,374

6 Claims. (Cl. 250—83.6)

This invention relates generally to methods and appara- ratus for controlling the operation of various machines. It is well known that in the operation of production machines such as metal working presses, lathes, milling machines and the like, various types of safety controls are desirable for the protection of workmen. For ex- ample, in the operation of a reciprocating punch press, control means of a photoelectric type has been employed whereby when the operator's hand is in a danger zone, the light beam to the photoelectric tube is interrupted to prevent normal operation. Another type of control which has been used employs cords which are attached to the hands of the operator, and which serve to operate control switches whereby the machine cannot be operated until the hands are withdrawn to a safe position.

Safety controls of the type described above are subject to certain inherent objectionable features. A control of the photoelectric type is subject to false opera- tion, because any interruption of the light beam, which may occur accidentally or otherwise, serves to operate the control. Safety controls of the type which attach cords to the hands of the operator serve to unduly re- strain the free movement of the operator.

In general, it is the object of the present invention to provide an improved safety control for production machines which avoids the disadvantages of previous arrangements.

Another object of the invention is to provide a safety control of the above character which is responsive only to one signal and which is not subject to false operation.

Another object of the invention is to provide a safety control of the above character which is operated by a penetrating radiation from an emitter, such as gamma and beta rays.

Another object of the invention is to provide a method of the above character in which the emitter is attached to one or both hands of the operator, and in which a movement of the emitter into a danger zone will effect the desired control of the machine, as for example, to make it inoperative.

The features and features of the invention will appear in the following description which the preferred embodiment of the invention has been set forth in detail in con- junction with the accompanying drawing.

Referring to the drawing:

Figure 1 is a circuit diagram illustrating one embodied- ment of the invention.

Figure 2 is another circuit diagram illustrating another embodiment of the invention.

Fig. 3 is a schematic view illustrating how the in- vention can be applied to a production press.

Figure 4 is a perspective view partly in section, show- ing a radiation emitter for attachment to the wrist of an operator.

In general, the present invention makes use of a sensitive indicator of radiation, such as a tube of the Geiger-Muller type. This is to be positioned in such a manner with respect to the production machine that it is responsive to emanations from an emitter placed within a specified danger zone. The Geiger tube is connected to means which produce a responsive current of sufficient magnitude for controlling the machine. By way of example, the control may be such that the machine cannot proceed with its normal operating cycle when the emitter is within the danger zone. Preferably the apparatus includes a time delay means whereby after a determined time interval following actuation of the radiation detector, the control is conditioned to prevent normal operation of the machine until such operation is initiated by again placing the emitter in the danger zone. Thus the machine cannot be used except by an operator wearing an emitter.

Referring to the circuit diagram in Fig. 1, we have shown a tube 10, preferably of the thyatron type, having its input coupled to the radiation detecting devices 11 and 12, which are assumed to be Geiger-Muller tubes. As is well known to those familiar with tubes of this type, they are provided with cylindrical and axial ele- ments 13 and 14. Although two tubes 11 and 12 are shown in Figure 1, it will be evident that in many instances a single tube will suffice. Two or more tubes can be used where it is desired to obtain a radiation response when an emitter is placed in either one of two sensitive zones.

Suitable means is provided for applying operating voltage across the terminals of the tubes 11 and 12. By way of example, we have shown a power supply transformer 16, having its primary connected to a suitable source of alternating current, such as the ordinary 60 cycle, 115 volt current supply lines. A rectifier tube 17 has the heater of its cathode connected to the termi- nal of the secondary 18. The secondary winding 19 is shown with its one terminal grounded, and its other terminal connected to the cathode of tube 17. Lead 21 connects the anode of rectifier tube 17 to one side of the tubes 11 and 12. The other terminals of tubes 11 and 12 are connected to ground through the series con- nected resistors 22 and 23. Resistor 23 is shown shunted by a condenser 24 for a purpose to be presently de- scribed. Transformer 16 is provided with another sec- ondary 25 for supplying cathode heater current to various vacuum tubes.

Suitable filter means is provided for reducing the alternating current ripple of the direct voltage applied to the tubes 11 and 12, and may consist of resistors 26 and 27, together with the grounded condensers 28 and 29. The mid point between resistors 26 and 27 is con- nected to ground through the voltage regulating tube 31, which may be of the type known by manufacturers' specifications as No. 5950.

Resistors 32 and 33 are connected in a series between the terminals of the cathode heater of tube 10, and the adjustable tap 34 on resistor 33 is connected to the cathode. This provides an adjustable bias which can be used to adjust sensitivity. The control grid of tube 10 is connected to a point between the resistors 22 and 23. The suppressor grid is grounded to maintain it at neutral potential, and the plate or anode is connected through elements which eventually connect with the tap 36 on the transformer secondary 19. Thus alternating current from the transformer is applied to the plate of the thyatron 16.

The time delay means incorporated in the circuit of Figure 1 makes use of a second tube 37 which likewise can be of the thyatron type, however, it is to be under- stood that ordinary vacuum tubes in an analogous cir- cuit can be used to accomplish a similar result. The heater terminals of tube 37 can be connected to the trans- former secondary winding 25, and one terminal lead is connected to the cathode through the peak current limit-
ing resistor 38. The suppressor grid is directly connected to the cathode. The control grid of tube 37 is connected to lead 39 as a contact 41 of A.C. relay 42. Lead 39 is also connected to ground through the resistor 43, which is shunted by condenser 44.

The winding 46 of the relay 42 is connected in series with the plate lead of the tube 10. Thus one terminal of this winding connects directly to the plate, and the other end is connected by means of a voltage dropping resistor 47 and lead 48 with the tap 36 on the transformer winding 19. A filter condenser 49 is shown shunted across the winding 46 and the resistor 47 to eliminate the chattering of contacts on relay 42. The plate of tube 37 likewise has a conductive connection with lead 48. Thus a second A.C. relay 51 has a winding 52, which has one terminal connected to the plate of tube 37, and its other terminal connected to voltage dropping resistor 53 through the lead 48. Filter condenser 54 is shunted across-the resistor 53 and relay winding 56 to eliminate chattering of the contacts on relay 51.

The relays 42 and 51 serve to control a circuit 56 which can be extended to any point desired, and which in turn serves to effect control of the production machine in the desired manner. The circuit can include a resistor 57 such as a machine means; or the like, and a source of current represented by the battery 58. The back contact 59 and movable contact 61 of relay 51 are connected in series with one side of circuit 56. Likewise, the circuit is serially connected with the front contact 62 and movable contact 63 of the relay 42. It will be evident that the contacts of both relays 51 and 42 must be closed to close circuit 56. The back contact 41 of relay 42 is open with respect to the contact 64, when the contacts 62 and 63 are closed.

Contacts 41 and 64 serve to apply voltage to the control grid of tube 37 and for charging the condenser 44, when the winding of relay 42 is de-energized. A suitable source of charging voltage is provided by resistors 66, 67 and 68, which are connected in series from the transformer secondary tap 36 to ground. Resistor 67 is in the form of a potentiometer, and its adjustable contact 69 is connected to the movable contact 64, in series with the rectifier 71. Thus rectified pulses for charging condenser 44 are applied when contacts 41 and 64 are closed.

It will be noted that contacts 63 and 64 are connected for coincident movement, and both these contacts are biased whereby contacts 41 and 64 are closed, when the winding 46 is de-energized. Relay 51 is likewise biased toward its back contact, whereby contacts 59 and 61 are closed when the winding 52 is de-energized.

Operation of the circuit shown in Figure 1 is as follows: Assuming that the circuit is in the condition shown in Figure 1, that is, that tube 10 is conducting and tube 37 is not conducting, the relay 42 will be energized because of plate current flowing from tube 10 and relay 51 will be de-energized. Thus, contacts 41 and 64 are open, 62 and 63 are closed and 59 and 61 are closed as illustrated. Let it also be assumed that the device 57 of the control circuit 56 is associated with a production machine in such a manner that when this circuit is energized, the machine will proceed with a normal predetermined cycle of operation.

Assuming that a radiation emitter 72 such as one emitting gamma and beta rays, is placed within effective range of either one of the tubes 11 and 12, the result of voltage response charges the condenser 24 negatively through current limiting resistor 22 to thereby bias the control grid of the tube 10 negatively, which stops the tube 10 from conducting the next time the A.C. voltage on the plate of the tube 10 passes through zero. The cessation of plate current from tube 10 de-energizes the winding 46 of relay 42 with the result that contacts 62 and 63 are opened to open the control circuit 56. Assuming that the emitter 72 is attached to the hands of an employee, the device 46 and 56 in a sensitive or danger zone such as may be necessary for placing work in a machine or removing work, then under such conditions and because of the opening of the circuit 56, the production machine is temporarily rendered inoperative to proceed with its normal cycle of operation.

The relay 42 and the condenser 24 act as an integrating circuit whereby the tube 10 is not affected by random voltage responses because the resistor 23 at all times tends to discharge any charge on the condenser 24. Thus, in order to bias the tube 10 to stop it from conducting, it is necessary that a series of voltage responses be received in rather rapid succession in order that a charge on condenser 24 can be built up before it is dissipated through resistor 23. Thus, as long as a continuous succession of voltage responses are received from the tubes 11 and 12 the tube 10 will remain biased negatively. However, when the back contact 64 is opened, the danger or sensitive zone, the tubes 11 and 12 will stop giving voltage responses whereby the condenser 24 will be discharged across resistor 23 and the grid of tube 10 will swing toward positive allowing the tube to become conducting again. As a result the winding of relay 42 is again closed, and the machine circuit disconnects again closed to energize the circuit 56. Now the control circuit has been reconditioned whereby the production machine may proceed with its normal operation.

In some instances a considerable loss of time may occur following positioning the emitter in the danger zone. Under such circumstances the timing means is utilized to interrupt the control circuit 56. In other words, the arrangement is such that if not operated at regular intervals by the emitter being positioned in operative position with the Geiger tubes, the control circuit 56 will be automatically opened and cannot be closed until an operator places an emitter in the danger zone. This feature prevents unauthorized use of the machine by persons not wearing an emitter. As previously mentioned the tube 37 is normally non-conducting, whereby contacts 59 and 61 remain closed. However, it is maintained non-conducting by the negative bias normally on the control grid. This negative bias is normally maintained because the condenser 44 will be charged negatively by the recurrent opening and closing of contacts 41 and 64. This charging takes place almost instantaneously and thus a negative bias is maintained on the grid until the charge from the condenser 44 drains off across resistor 43 before the condenser 44 is recharged. In such a case the control grid will swing toward positive and the tube 37 will start conducting to energize the winding of relay 51 to open the contacts 59 and 61. The discharging of the condenser 44 across the resistor 43 takes a predetermined amount of time, for example 15 seconds, which can be varied by changing the circuit constants involved. It will be evident that contacts 41 and 64 remain open for a period beyond this predetermined interval, the tube 37 will start conducting. When subsequently an emitter is again placed in the danger zone to operate the tubes 11 and 12, the closing of contacts 41 and 64 serves to recharge the condenser negatively whereby the grid of tube 37 will regain control the next time the A.C. voltage of the plate of tube 37 goes through zero thereby rendering tube 37 non-conducting.

In the modification of Figure 2, timing means of the electric motor type has been used in place of the electronic timing means of Figure 1. The timing device 76 has the winding of its motor connected to an energizing circuit 77, which includes the relay contacts 78 and 79, and a source of current provided by the A.C. supply lines. The motor drives the cam 81, which in turn operates the contacts 82 and 83. Motor timing devices of this kind generally use a motor of the
induction disc type, or a self-starting synchronous motor, which serves to rotate its shaft and cam 81 at a predetermined speed, when current is applied to the motor. The cam commences its movement from a stop position, and within a predetermined period of time serves to open the contacts 82 and 83. Upon interrupting the current to the motor, the cam is returned to its initial start position.

Instead of timing means of the electric motor type, it may be desirable to use a dash pot relay to accomplish the same result. With the arrangement of Figure 2, it will be evident that when winding relay 42 is energized, the control circuit 84 to the control device is closed. Likewise, contacts 78 and 79 are closed to cause operation of the timing device 76. If a predetermined time interval passes before relay 42 is de-energized, by excitation of the Geiger tubes, then contacts 82 and 83 are opened to open the circuit 84.

Figure 3 schematically illustrates a representative installation of our apparatus on a metal working press. The two die parts 86 and 87 are carried respectively by the press head and bed, and it is assumed that the press is provided with a cycling clutch which is tripped as by means of a foot treadle. Assuming that one Geiger tube 11 is used, it is enclosed within a box housing 88, which is mounted in a proper position whereby it is sensitive to radiation within the zone 89. This zone is arranged to correspond to a zone in which one or both hands of the operator must be placed in order to introduce or remove work from the machine. In other words it corresponds generally to what may be termed a danger zone, in that when the hands of the operator are within this zone, it is desirable to render the machine inoperative to perform its usual operations. The radiation emitter 72 is shown strapped to the wrist of the operator's hand 91. A shaded zone 92 is shown in front of the zone 89, and may be referred to as an uncertain area through which the emitter passes when the operator advances or withdraws his hands from the machine. In effect this is a transition zone between a safe region for the hands, and a danger zone. Cable 93 is shown connecting the Geiger tube to the assembly 94, which includes the thyratron tubes and associated parts. An electrical cable 96 extends from the unit 97, which may by means of the solenoid type for rendering the treadle operated trip means for the clutch, inoperative. Cable 98 is for power supply. It will be evident that with the installation of Figure 3, the machine is controlled in the desired manner by the radiations from the emitter. The radiations are effective through objects such as the work piece or the hands or other parts of the body, thus insuring proper operation.

Figure 4 shows a suitable emitter which can be strapped to the wrist. It includes the wrist strap 73, and the mounting 74 for the radiation emitting material 72. Suitable materials for this purpose are the radio-isotopes of cobalt 60, radium 226, and strontium 89. Such material may be contained in a capsule or incorporated in a suitable nonradioactive medium. The mounting can include a radiation shield 75 of suitable material such as lead.

In the foregoing we have described our machine as applied to a production machine in which means such as a treadle is employed to trip the cycling clutch of the machine, for performing a cycle of operation. Many methods for controlling the cycle of operation and stopping the machine can be employed. Device 57 may be a solenoid operated switch or relay which serves to control such a start circuit, whereby the machine cannot be cycled by pressing the start button, if the hands are in the danger zone. Device 57 may be a motor means for operating the stop circuit can be controlled whereby the machine is stopped if the hands are placed in the danger zone.
7: detecting the radiation emitted from the source in the danger zone, rendering the machine inoperative to perform its prescribed function in accordance with the response thus obtained, rendering the machine inoperative in the event the time lapse following withdrawal of the source from the danger zone, without reinsertion, is beyond a predetermined period that is longer than the period of a normal operating cycle of the machine, and rendering the machine operative by reinsertion of the source in the danger zone.

5: In a safety control apparatus for controlling a machine of the type having a predetermined normal work cycle; a radioactive emitter, said radioactive emitter being adapted to be carried by the operator, detecting means responsive to the radiation from said emitter when said emitter is within a predetermined zone, said detecting means serving to provide an electrical response, and control means for preventing a normal work cycle of the machine, said control means being conditioned by said electrical response to prevent a normal work cycle until said emitter has been removed from said predetermined zone.

6: Safety control apparatus as in claim 5 together with additional means serving to condition the apparatus for preventing a normal work cycle of the machine, said additional means including time delay means and serving to prevent a normal work cycle after a predetermined time lapse has occurred following a preceding actuation of said control means, said predetermined time lapse being greater than the normal work cycle of the machine, and means actuated by said emitter effectively re-establishing said time delay means at zero each time said emitter is disposed in operative proximity to said detecting means.

References Cited in the file of this patent

UNITED STATES PATENTS

2,082,210 McMaster June 1, 1937
2,309,329 Powers June 26, 1943
2,320,346 Broekhuysen June 1, 1943
2,331,023 Gayring Oct. 5, 1943
2,499,889 Teichmann Mar. 7, 1950