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R. A. POWERS

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PHOTOELECTRIC APPARATUS

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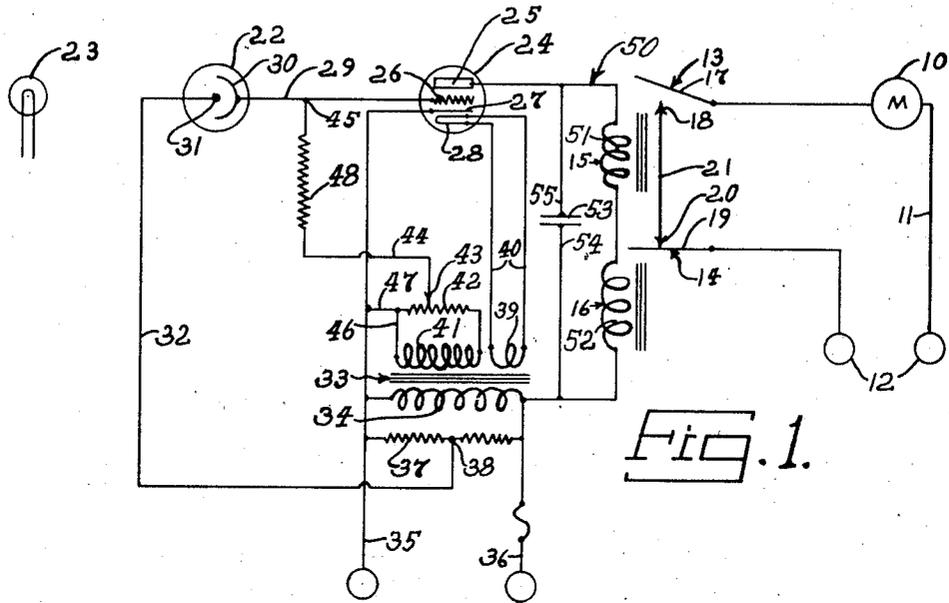


Fig. 1.

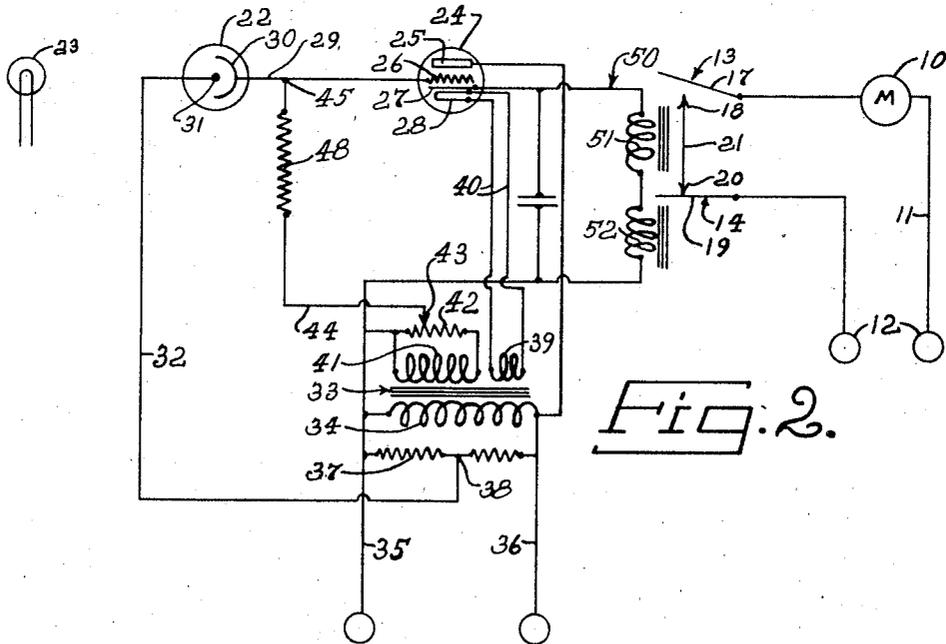


Fig. 2.

INVENTOR  
RALPH A. POWERS.  
BY *Robert C. Harris*  
ATTORNEY

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## PHOTOELECTRIC APPARATUS

Ralph A. Powers, Detroit, Mich., assignor to Electronic Control Corporation, Detroit, Mich., a corporation of Michigan

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3 Claims. (Cl. 250—41.5)

This invention relates to improvements in photo-electric apparatus.

More particularly the invention relates to the provision of an improved safe-guard in apparatus of this kind which prevents complete or partial failure of the light sensitive and other elements of the apparatus from having an effect thereon similar or equivalent to the effect on the light sensitive element of normal illumination.

The invention may be employed in numerous and diverse types of apparatus in which the uninterrupted transmission of light rays upon a photo-electric cell is relied upon to start, stop or otherwise influence the operation of portions of a machine or process. For the purpose of illustrating the invention reference will be made to a photo-electric safety control circuit such as is employed to interrupt or prevent the occurrence of the operation of a press while portions of the press operator's body or other articles are disposed in the path of the relative approaching movement of parts thereof. Such and similar apparatus depend upon the interruption of transmission of rays of light to a photo-electric cell to render the press inoperative under predetermined conditions of hazard. This is, in general, accomplished by passage of a minute current, as a result of reception of the light rays by the photo-electric cell, through an amplifier by which it is raised in value sufficiently to actuate a relay or other control apparatus by which operation of the press is governed.

Conventional photo-electric cell circuits are inherently adapted to "fail safe" in the event of certain types of failures such as loss of cell emission, failure of light source, and burning out of the heater or filament of the amplifying tubes, but numerous other failures and occurrences, which are not infrequent, have the effect upon the circuit of normal light ray reception by the photo-electric cell and thus result in faulty and deceptive operation of the circuit. An inter-electrode short within the amplifying tube of such a control circuit, as for example, a short between the cathode and grid continues to pass sufficient plate current to hold the relay closed even while the transmission of light rays to the photo-electric cell is discontinued. If the grid leak of the circuit becomes open due to faulty solder connections or corrosion, the tube becomes locked and continues to pass current, thus keeping the relay energized although the photo-electric cell is in complete darkness. An inter-electrode short circuit within the photo-electric cell causes the passage of positive voltage to the grid of the am-

plifying tube and energizing of the relay independently of light reception by the photo-electric cell. This same effect would be produced by a short circuit between two operating prongs in the base of the photo-electric tube.

It is one of the main objects of this invention to provide in a light sensitive apparatus of this character improved means which will cause such apparatus to fail safe under all of the foregoing condition.

A further object of the invention is the provision in the amplified current circuit of apparatus of this character of a pair of relays which are so connected in series in the load circuit controlled by the apparatus that the latter circuit is opened by actuation of one relay when the current of the amplified current circuit falls below a predetermined value and opened by actuation of the other relay when the amount of the amplified current circuit exceeds a slightly higher predetermined value.

Another object of the invention is the provision of a pair of relays in the above mentioned load circuit of which one is normally open but is adapted to be closed by current of a predetermined intensity, such as that resulting from a predetermined amplification of current emitted by a photo-electric cell under normal illumination, the other relay being normally closed but adapted to be opened by the supply of current thereto resulting from any one or more of the faulty operating conditions enumerated or any other faulty operation of the system.

A still further object of the invention is the provision of an inexpensive means for causing light sensitive devices of the above character to fail safe and which can be conveniently, accurately and economically predetermined with a high degree of precision to function at selected current values of very little difference.

An illustrative embodiment of the invention is shown in the accompanying drawing, in which:

Fig. 1 is a diagrammatic illustration showing a light sensitive apparatus embodying the invention and disclosing the wire diagrams of the various circuits thereof.

Fig. 2 is a view similar to Fig. 1 but illustrating a modified form of the invention.

In Fig. 1 is illustrated an embodiment of the invention in safety guard apparatus of the type which is suitable for guarding a press. Apparatus of this type includes a motor diagrammatically shown at 10 in a circuit 11 having a source of power 12 by which control mechanism, such as a valve, clutch, brake or other portion of the

press (not shown), can be automatically actuated to start and stop operation of the press.

The motor control circuit 11 includes a pair of switches, generally designated 13 and 14, which constitute parts of relays 15 and 16, respectively. The switch 13 has a contact 17 normally biased to open position with respect to its fixed contact 13, and the switch 14 has a movable contact 19 normally biased to closed position with respect to its fixed contact 20. The contact elements 13 and 20 are electrically connected by a conductor 21 and the switches 13 and 14 are thus so connected in the circuit 11 in series relationship that when either switch is open operation of the motor 10 is discontinued.

The switches 13 and 14 of the relays 15 and 16 are controlled by an initially minute, but subsequently amplified, current which flows through a photo-electric cell 22 when light rays are received by the latter. The cell 22 is so positioned with respect to a source of light 23 as to receive rays of light therefrom when, for example, the passage of light rays to the cell is not obstructed by portions of the body of the operator of the press or by other articles. The cell 22 is electrically connected in an amplifying circuit of conventional construction which includes a vacuum tube 24 having a plate 25, a grid 26, a cathode 27, and a filament 28. The grid 26 is electrically connected by a conductor 29 to a cathode 30 of the photo-electric cell 22 and the anode 31 of the cell is electrically connected by a conductor 32 to a source of current supply.

The amplifier is energized preferably from a 110 volt circuit through a transformer 33. The latter has a primary coil 34 electrically connected by conductors 35 and 36 with the source of 110 volt A. C. current. Shunted across the conductors 35 and 36 is a voltage divider 37 to an intermediate point of which is connected at 38 the conductor 32 leading from the anode 31 of the photo-electric cell. The transformer 33 has a secondary winding 39 of relatively few turns which is connected by conductors 40 with the filament 28 of the amplifying tube. This transformer has another secondary coil 41 of a greater number of turns. A resistance bias adjustment 42 is shunted across the terminals of the secondary coil section 41 and is provided with an adjustable contact 43 which is electrically connected by a conductor 44 to the conductor 29 at a point 45 intermediate the cathode 30 and the grid 26. The left hand terminal 46 of the secondary coil 41, as viewed in Fig. 1, is electrically connected by conductor 47 to the conductor 35 leading from the 110 volt A. C. circuit to the cathode 27. A grid leak resistance 48 is connected in series in the conductor 44.

When the cathode 30 of the photo-electric cell is subjected to a normal predetermined illumination from the light source 23 a minute positive voltage is supplied to the grid 26 which results in the flow of an amplified current through the amplifying current circuit, generally designated by the numeral 50, which is connected at one end to the plate 25 of the amplifying tube and at its other end to the primary coil 34 of the transformer. The relays 15 and 16 are provided with coils 51 and 52, respectively, which are connected in series in the amplified current circuit 50. A condenser 53 is connected by conductors 54 and 55 across the portion of the amplified circuit 50 in which the coils 51 and 52 are included.

The coil 51 of the relay 15 and the amplitude

of the bias by which the switch 13 thereof is urged to an open position are so predetermined that when the coil 51 is excited by an amplified current corresponding to the minute current resulting from normal illumination of the photo-electric cell, the switch 13 will be closed. If the switch 14 is normally closed under these conditions the motor circuit 11 will be closed and the motor 10 will be operated. The bias by which the movable contact 19 of the switch 14 is urged to closed position and the coil 52 of the relay 16 are so predetermined that when the amplified current in the circuit 50 exceeds by only a slight amount that current which is produced therein by amplification of the current normally produced by illumination of the photo-electric cell, the switch 14 will be opened so as to prevent operation of the motor 10. These values can be so accurately predetermined that the switch 13 will be closed when the circuit 50 carries 25 milli-amperes and the switch 14 will be opened when this circuit carries 26 milli-amperes. Because of the extreme sensitivity of this apparatus it is possible to safeguard a safety system so that it will "fail safe" under all of the previously mentioned conditions of failure.

In the form of the invention illustrated in Fig. 2 the apparatus by which the control system is caused to "fail safe" is substantially identical in structure to that disclosed in Fig. 1 and identical parts of the structure and diagram are designated by the same numerals. In this form of the invention, however, the field relay coils 51 and 52 are connected in that branch of the amplified current circuit 50 which includes the conductors 35 leading from one terminal of the 110 volt circuit to the cathode of the amplifying tube 24. As pointed out in the description of Fig. 1, the coils 51 and 52 are included in that branch of the amplified current circuit 50 which leads from the plate 25 to the opposite terminal of the 110 volt circuit.

Although but several embodiments of the invention are herein shown and described it will be understood that various changes, including the size, shape and arrangement of parts, may be made without departing from the spirit of the invention, and it is not my intention to limit the latter other than by the terms of the appended claims.

What I claim is:

1. In light sensitive control apparatus for a load circuit including a photo-electric cell having a source of current connected therewith, means for amplifying the current flowing through said cell when light rays are received by it comprising a circuit having a source of electrical power for said amplifying means and an amplified current circuit; mechanism for causing said light sensitive control apparatus to fail safe under a plurality of diverse faulty conditions comprising a normally open switch means and a normally closed switch means in series relation in said load circuit, and a pair of relay coils in series relation in said amplified current circuit each operatively associated with one of said switch means respectively, the relay coil associated with said normally open switch means being so constructed and arranged as to close the latter when excited by current in excess of a predetermined value and the relay coil of said normally closed switch means being so constructed and arranged as to open the latter only when excited by a current in excess of a

predetermined amount higher than said predetermined value.

2. In light sensitive control apparatus for a load circuit including a source of light, a photo-electric cell spaced from said light source and adapted to receive light rays therefrom when the space between said cell and said source is unobstructed and means for amplifying current flowing through said cell in response to illumination thereof by said source including an amplified current circuit; mechanism for causing said light sensitive control apparatus to fail-safe under a plurality of diverse faulty conditions comprising normally open and normally closed relays having normally open and normally closed switch elements respectively in series relation in said load circuit, said relays having coils connected in series in said amplified current circuit, said normally open relay being so constructed and arranged as to close said load circuit when the coil thereof is excited by normal amplified cell-passed current and said normally closed relay being so constructed and arranged as to break said load circuit when the coil thereof is excited by current of a higher value.

3. In light sensitive control apparatus for a load circuit including a photo-electric cell having a circuit connected with the latter for supplying current thereto, means for amplifying the current passed by said cell when light rays are received by it including a vacuum tube amplifier having plate and cathode circuits respectively, mechanism for causing said light sensitive control apparatus to fail-safe under a plurality of diverse faulty conditions, a pair of relays each having a coil connected in series in one of said tube circuits and each having a switch element connected in series in said load circuit, the switch element of one of said relays being normally biased to open position and the switch element of the other relay being normally biased to closed position, the normally open relay being so constructed and arranged as to close said load circuit when the coil thereof is excited by a predetermined low current and the other relay being so constructed and arranged as to open said load circuit when its coil is excited by a current in excess of slight amount higher than that at which said normally open relay is closed.

RALPH A. POWERS.