May 17, 1955 R. F. MEYERS 2,708,715

CRANE CONTROL SYSTEMS

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FIG. 1

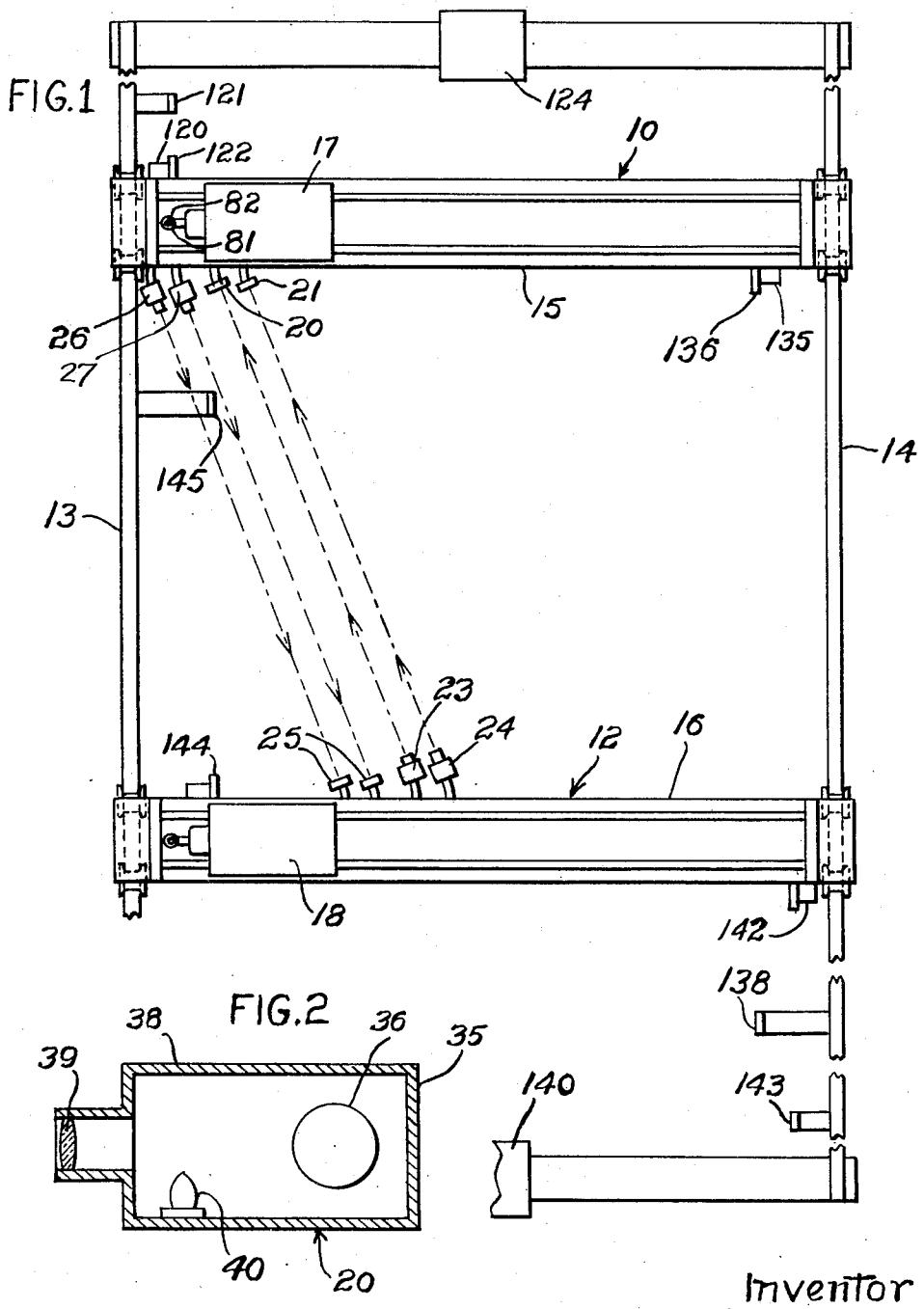


FIG. 2

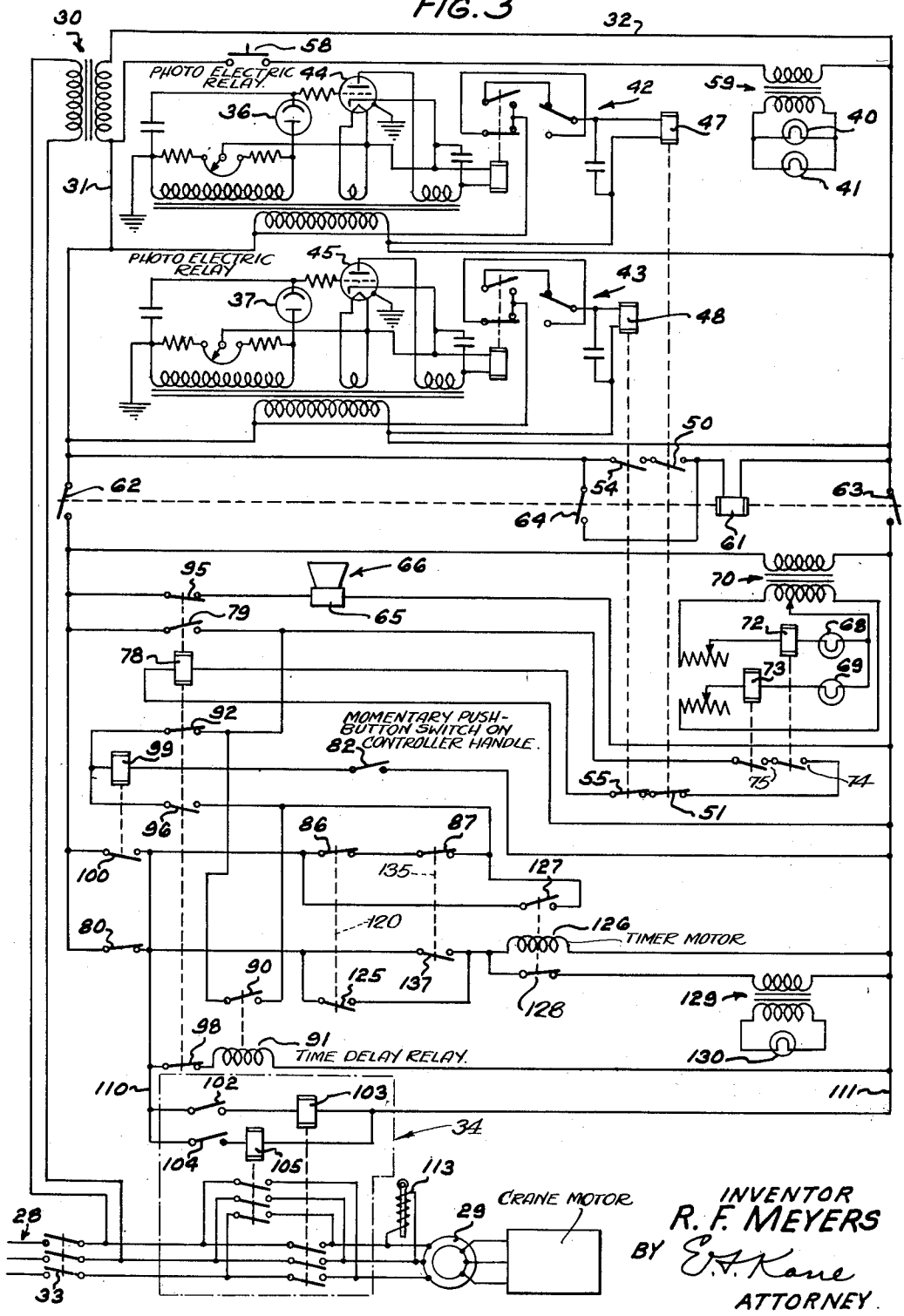
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FIG. 3



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CRANE CONTROL SYSTEMS

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8 Claims. (Cl. 246—31)

This invention relates to crane control systems, and has for an object thereof the provision of new and improved crane control systems.

A further object of the invention is to provide new and improved photoelectric control systems for preventing collisions betwen traveling cranes.

Another object of the invention is to provide photoelectric control systems which automatically stop cranes approaching one another at points spaced a predetermined distance apart and permit deliberate operation of the cranes in closer proximity after they have been stopped as they approach one another.

A control system illustrating certain features of the invention may include a pair of cranes movable along the same track. Each of the cranes has a photoelectric control circuit carried therewith including a photoelectric tube, and also is provided with a light source mounted thereon directed at such an angle that it impinges on the photoelectric tube carried by the other crane when the cranes approach a minimum safe distance from one another. On impingement of one of the light beams with one of the photoelectric tubes, the circuit associated with that tube stops the crane on which the tube is carried. Means preferably are provided for permitting deliberate operation of the cranes closer to one another after they have been stopped by the photoelectric control circuits.

A complete understanding of the invention may be obtained from the following detailed description of a control system forming a specific embodiment thereof, when read in conjunction with the appended drawings, in which:

Fig. 1 is a diagrammatic top, plan view of the crane system including a control system forming one embodiment of the invention;

Fig. 2 is an enlarged fragmentary, horizontal section of a portion of the apparatus shown in Fig. 1 and

Fig. 3 is a schematic view of a control circuit for controlling the cranes shown in Fig. 1.

Referring now in detail to the drawings, there is shown in Fig. 3 one of two crane control circuits for stopping cranes 10 and 12 (Fig. 1) automatically when the cranes move along rails 13 and 14 to a distance from one another, which is the minimum distance the cranes may be run freely without danger of collision between the cranes. The cranes 10 and 12 include bridges 15 and 16, respectively, having carriages 17 and 18, respectively, carried by and designed to travel along the bridges. Identical photoelectric receivers 20 and 21 (Figs. 1 and 2) carried in fixed positions on the bridge 15 are designed to receive light from light beam projectors 23 and 24 carried on the bridge 16. The projectors 23 and 24 and the receivers 20 and 21 are mounted at such angles and positions on the bridges 15 and 16 that the beams impinge on the receivers 20 and 21 only when the cranes are at a minimum safe distance from one another for safely running free without danger of collision between the two cranes. Receivers 25—25 of a control circuit of the crane 16 and projectors 26—26 of the control circuit of the bridge 15 also are operative when the cranes are in such relative positions.

The crane control circuits of the cranes 10 and 12 are identical. Hence, only the crane control circuit for the crane 10 will be described in detail. This circuit (Fig. 3) includes a three-phase high voltage powerline 28 for energizing a reversible motor 29 serving to move the bridge 15 along the rails 13 and 14. A transformer 30 having its primary connected to two conductors of the powerline 28 applies a low control voltage to conductors 31 and 32 forming a control powerline. To begin operation of the crane 15, a switch 33 is closed to make power available to the conductors 31 and 32 and to the motor 29 when other switches in a reversible, acceleration and braking crane controller 34 of a well known type are closed.

The receivers 20 and 21 include identical housings, of which a housing 35 (Fig. 2) is shown, enclosing photoelectric tubes 36 and 37 (Fig. 3). The housing 35 encloses the tube 36 and a lens 39, and a test lamp 40 also is mounted in the housing 35. A test lamp 41 is similarly mounted in the housing (not shown) of the receiver 21, which also is provided with the photoelectric tube 37 and a lens (not shown). The photoelectric tubes 36 and 37 (Fig. 3) are mounted in well known photoelectric relay circuits 42 and 43 including vacuum tubes 44 and 45, respectively. These relay circuits are designed to energize relay windings 47 and 48, respectively, when light is thrown on the photoelectric tubes to cause current to flow through the tubes 44 and 45. Energization of the relay winding 47 closes a normally open contact 50 and opens a normally closed contact 51. Energization of the relay winding 48 closes a contact 54 and opens a contact 55.

To test the photoelectric cells 36 and 37 and their circuits at the start of a period of operation of the crane 10, the operator closes a manually operable, momentary switch 58 to energize the test lamps 40 and 41 through a transformer 59. The lamps 40 and 41 throw light on the photoelectric tubes 36 and 37 so that, if both the photoelectric relay circuits 42 and 43 are operative, the relay windings 47 and 48 are energized to close the contacts 50 and 54 and open the contacts 51 and 55. Closing of both the contacts 50 and 54 causes a winding 61 to be energized to close normally open contacts 62 and 63 and close a normally open holding contact 64 in parallel with the contacts 50 and 54. Closing the holding contact 64 maintains the energization of the relay winding 61 after the contacts 50 and 54 have been opened. Closing of the contacts 62 and 63 provides power to the crane control circuit 34, and causes the winding 65 of a horn 66 to be energized so that the horn is blown. Blowing the horn indicates to the operator that both of the photoelectric relay circuits 42 and 43 are operative, inasmuch as both the contacts 50 and 54 must be closed to close the contacts 62 and 63.

When the contacts 62 and 63 are closed, lamps 68 and 69 of the projectors 23 and 24 are energized through a transformer 70. If both the lamps 68 and 69 are operative, relay windings 72 and 73 are energized to close contacts 74 and 75, which are mounted in series with the contacts 51 and 55, a relay winding 78 and a holding contact 79 controlled by the relay windings 78. Hence, assuming that the horn 66 has been sounded and the test switch 58 opened, the contacts 62 and 63 are held closed by the relay winding 61, which is energized through a holding contact 64 thereof, and the contacts 51 and 55 are closed. A time delay relay winding 91 is energized through a switch 80, which is normally closed when a controller handle 81 carrying a push button switch 82 is in neutral position, and after a delay of several seconds closes a contact 90. Closing of the contact 90 energizes the winding 78 through normally closed limit switch contacts

36 and 37 and the contact 90. Energization of the relay winding 78 opens a normally closed contact 92, closes normally open contacts 79 and 96, and opens normally closed contacts 95 and 98 in series with the horn winding 65 and the time delay relay winding 91, respectively, to silence the horn 66 and open the contact 90.

Closing of the contact 96 permits energizing a relay winding 99 whenever the switch 82 is closed, through the contacts 80, 86, 87 and 96. Energization of the winding 99 closes a contact 100 connected in parallel with the contact 80, which is closed only when the lever 81 is in neutral position. The controller 34 is operable by movement of the lever 81 from its neutral position and then has power supplied thereto through the contact 100 whenever the switch 82 is closed even though the switch 80 is opened by such movement. The controller 34 includes a forward contact 102 and relay winding 103 and reversing contact 104 and relay winding 105. The controller 34 is, per se, a conventional circuit, and whenever the power is cut off of conductors 110 and 111, as occurs when both the switch 80 and the contactor 100 are open, the relays 103 and 105 are deenergized to stop the motor 28 and a solenoid winding 113 is deenergized to actuate a brake to stop the crane 15.

A snap-type limit switch 120 mounted on the crane 15 is mounted on the crane 15 at a point at which an arm 122 of the limit switch engages an L-shaped dog 121 as the crane 15 is moved almost to a bumper 124 positioned at the upper end of the rails 13 and 14, as viewed in Fig. 1, and the dog 121 actuates the arm 122 to snap it into a position opening the contact 86 and closing a contact 125 of the limit switch 120. Opening of the contact 86 breaks the circuit to the relay winding 99 to drop out the contact 100. This stops the crane 10 before it crashes into the bumper 124. Closing of the contact 125 of the limit switch 120 permits energization of a timer motor 126 after the handle 81 has been returned to neutral to close the switch 80. After a predetermined period of time, the timer motor 126 closes a contact 127 and opens a contact 128 to deenergize a transformer 129 and extinguish a warning lamp 130. The contact 127 is in parallel with the contacts 86 and 87 so that the crane then may be run by deliberate action of the operator.

A snap-type limit switch 135 having an arm 136 includes the contact 87 and a normally open contact 137. The switch 135 is positioned on the bridge 15 so that arm 136 will engage an L-shaped dog 138 positioned on the right-hand rail 14 a distance such that the contact 87 of the switch 135 will be opened by actuation of the arm 136 by the dog 138 when the crane 12 is in a position near the bumper 140 positioned at its end of the rails 13 and 14, and the crane 10 approaches that end of the rails, thereby stopping the crane 10 to prevent collision between the two cranes. This will occur even though the lights on the crane 12 are not illuminated, as may be the case when the crane 12 is not in use. The crane 12 is provided with a limit switch 142 designed to be actuated by a dog 143 to stop the crane 12 before it crashes into the bumper 140, and also has a limit switch 144 which is operated by the dog 145 to stop the crane 12, when the crane 10 is in a position near the bumper 140 and the crane 12 is approaching the crane 10.

Operation

When an operator of the crane 10 first gets on the crane for a period of work, he presses the momentary switch 58 to set up the circuit for operation. Closing the switch 58 causes the transformer 59 to be energized, thereby lighting lamps 40 and 41. The lamps 40 and 41 illuminate the photoelectric tubes 36 and 37, and, if the circuits 42 and 43 are in proper condition, the relays 47 and 48 are energized. The relay 47 closes the contact 50 and opens the contact 51, and the relay 48 closes the contact 54 and opens the contact 55. Both the contacts 50 and 54 must be closed to energize the relay winding 61 to close contacts 62 and 63 in the control powerline formed by the conductors 30 and 31 to supply power to the control circuit, and the energization of the relay 61 also closes the holding contact 64 in parallel with the contacts 59 and 54. After the contacts 62 and 63 are closed, the horn winding 65 is energized, which indicates to the operator that the contacts 62 and 63 have been closed, and that both the photoelectric tubes 36 and 37 and their associated relay circuits 42 and 43 are in proper working order. The operator then releases the test switch 58 which opens, thereby deenergizing the transformer 59, and darkens the lamps 40 and 41 to darken the photoelectric tubes 36 and 37. This causes the relay windings 47 and 48 to be deenergized, and the contacts 50 and 54 open and the contacts 51 and 55 close. When the contacts 62 and 63 are closed, the delay relay winding 91 is energized to close the contact 90 after a predetermined period of time, the switch contact 80 being closed from the lever 81 being in neutral position, and this closes the circuit across the conductors 31 and 32 including the relay winding 78 to energize the relay winding 78. As the relay winding 78 is energized, it opens the contact 95 to stop the horn 66, opens the contact 92, closes the contact 96 and opens the contact 98, which deenergizes the relay winding 91. The relay winding 78 also closes the holding contact 79, and if both the lamp 68 and the lamp 69 are operable, relay windings 72 and 73 are energized to close the contacts 74 and 75 so that the relay winding 78 is kept energized even though the contact 90 is opened by deenergization of the winding 91. After the contact 96 has been closed, the switch 82 on the handle 81 is closed by the operator, which energizes the relay winding 99 to close the contact 100, which is in parallel with the switch 80. Hence, whenever the lever 81 is moved from its neutral position and the switch contact 82 is kept closed, the contact 100 is kept closed to supply current to the control circuit 34. The lever 81 is manipulated to actuate selectively the switches 102 and 104 in the conventional manner to operate the crane 12.

The cranes 10 and 12 are operated in the conventional manner without interference from the photoelectric control circuits thereon as long as the cranes do not approach one another sufficiently close that the light from the projectors 23 and 24 would impinge on the photoelectric tubes 36 and 37 of the crane 10 and the light from the lamps 68 and 69 of the projectors 26—26 would impinge on the photoelectric tubes of the crane 12. However, when the cranes 10 and 12 approach one another to the minimum safe operating distance therebetween, the light from the projectors 23 and 24 impinges on the photoelectric tubes 36 and 37, and the light from the projectors 26—26 impinges on the corresponding photoelectric cells in the control circuit of the crane 12. When the cells 36 and 37 have this light shown thereon, the relay windings 47 and 48 are energized to open the contacts 51 and 55, thereby deenergizing the relay winding 78. This closes the contact 95 to start the horn 66 and opens the contact 96. This deenergizes the relay winding 99 to open the contact 100 to break the powerline to the controller 34, whereby the controller circuit is deenergized to actuate the brake and deenergize the motor 128. This stops the crane 10 within less than one-half the distance that it was from the crane 12, and the crane 12, if it is running in a direction toward the crane 10, is similarly stopped within less than one-half of that distance.

The operator of the crane 10 then may deliberately restart the crane 10 by moving the control handle 81 back to neutral position, in which position the switch 80 is closed. After the switch 80 has been closed a predetermined period of time, the relay winding 91 closes the contact 90, and the crane 10 having coasted in stopping to a position in which the cells 36 and 37 are not struck by the light from the projectors 23 and 24 on the crane 12, the switches 51 and 55 are closed. Hence, on closure of the contact 90, the relay winding 78 is once more ener-

gized to open the contact **95** to stop the horn **66**, close the holding contact **79**, open contacts **92** and **98** and close the contact **96**. Consequently, on closing the switch **82** on the control handle **81**, the relay winding **99** is again energized, and closes the switch **100** so that power is supplied to the control circuit **34**, after the handle **81** has been moved to an operating position, thereby opening the switch **80**. However, such running and handling of the crane **10** is done with the operator fully aware that he is within a danger zone with respect to the crane **12**, and the operator proceeds cautiously. The crane **12** may be similarly operated with full warning to the operator thereof.

Should one of the lamps **68** and **69** fail, the relay winding **72** or the relay winding **73** is deenergized to open contact **74** or the contact **75**. This deenergizes the relay winding **78** to open the contacts **95**, **79** and **96**. This starts the horn **66** blowing and deenergizes the relay winding **99** to open the switch **100**, stopping the crane. The operator then may move the control handle **81** back to neutral position to close the switch **80**, and the time delay relay winding **91** after a predetermined period of time closes the contact **90**. Then, on closing the switch **82** on the control handle **81**, the relay **99** is reenergized through the contact **92** and the contact **90**. This permits the operator to run the crane **10**, but the horn **66** remains in operation and serves as a constant warning to replace the bad lamp **68** or **69** with a new lamp.

The limit switches **120**, **135**, **142** and **144** and the dogs **121**, **138**, **143** and **145** protect the cranes **10** and **12** against crashing into the bumpers **124** and **140** and also against crashes therebetween when one of the cranes is lying idle at its end of the rails.

The above-described apparatus permits the operators to run the cranes in close proximity to one another, but only by deliberate action after being completely stopped when cranes approach one another to a distance from one another which is the minimum safe operating distance therebetween for free running of the cranes. Whenever the light sources on one of the cranes fails, that crane is immediately stopped and must then, after a short delay, operate with the full blast of the horn until the lamp is replaced. Also, the photoelectric circuits **42** and **43** must be in operative condition at the start of each shift of operation of the crane **10**, in order to place the control circuits of the crane in operative condition.

It is to be understood that the above-described arrangements are simply illustrative of the application of the principles of the invention. Numerous other arrangements may be readily devised by those skilled in the art which will embody the principles of the invention and fall within the spirit and scope thereof.

What is claimed is:

1. A crane system, which comprises a track, a crane movable along the track, means for moving the crane, means for stopping the crane, a manually operable electrical control circuit adapted when supplied with power to actuate the crane-moving means for actuating the crane-stopping means when power thereto is stopped, a source of power, a control powerline connected to the power source and to the control circuit, said control circuit including a relay having a winding and a normally open contact in the powerline, a switch in the power line in parallel with the normally open contact, manually operable means movable from a neutral position to an operating position for opening the switch when moved from its neutral position, said relay winding being connected across the powerline in series with the parallelly connected switch and normally open contact when in its closed position, a timer having electrically operable means connected across the powerline in series with the switch and the contact and also having a normally open contact in series with the relay winding, a manually operable switch in series with the relay winding, photoelectric cell mounted on the crane, relay means responsive to the photoelectric cell having contact operating means, said relay means also being provided with a contact in series with said winding and the timer contact held open to prevent energization of said relay winding when the contact operating means is not actuated, said relay means also being provided with a second contact in series with said relay winding and in parallel with the last-mentioned contact and the timer contact and held closed when the contact operating means is not actuated for setting up said winding for actuation, and a third contact in series with the electrically operable means, the first switch and the contact of the first relay and held open when the contact operating means is not actuated, a second crane on the track, and means mounted on the second crane projecting a beam of light therefrom at such an angle that the beam impinges on the photoelectric cell when the cranes are a predetermined distance apart.

2. A crane control system which comprises a track, a crane movable along the track, electromotive means for moving the crane along the track, means for braking the crane, an electric controller selectively operable to a neutral condition actuating the braking means and an operating condition actuating the crane moving means, said controller serving to actuate the braking means when power is cut off therefrom, a source of electrical power, a powerline extending between the source of power and the electric controller, an operating relay having a winding connected across the powerline and a normally open contact in the powerline in series with the controller and the winding, a neutral switch in the powerline in series with the controller and in parallel with the operating relay contact, said neutral switch being closed when the controller is in its neutral condition actuating the crane-braking means and being opened when the controller is in its operating condition actuating the crane-moving means, a time delay relay having a winding across the powerline between the controller and the neutral switch in series with the operating relay contact and being provided with a normally open contact in series with the operating relay winding, an electrically operable indicator connected across the powerline between the source of power on the one hand and the neutral switch and the operating relay contact on the other hand, an indicator relay having a winding across the powerline between the source of power on the one hand and the neutral switch and the operating relay contact on the other hand and also connected in series with the time delay relay contact and the operating relay contact and the neutral switch, said indicator relay also being provided with a normally closed contact in series with the indicator for actuating the indicator when the indicator relay is deenergized and having a normally open holding contact in series with the indicator relay winding and in parallel with the time delay relay contact, the operating relay contact and the neutral switch for locking in the indicator relay winding, said indicator relay having a normally closed contact in series with the time delay relay winding for deenergizing the time delay relay winding when the indicator relay winding is energized and also having a normally open contact in series with the operating relay winding and in parallel with the time delay relay contact for actuating the operating relay winding when closed and a normally closed contact in series with the time delay contact and the operating relay winding for setting up an actuating circuit to the operating relay winding, a photoelectric cell mounted on the crane, a relay responsive to the photoelectric cell having a normally closed contact in series with the indicator relay winding between both the holding contact thereof and the time delay relay contact, a beam projector having a lamp connected across the powerline and a projector relay having a winding in series with the lamp and a normally open contact in series with the indicator relay winding.

3. A crane control system, which comprises a trackway, a crane movable along the trackway, a second crane

movable along the trackway, a photoelectric cell carried by the first crane, a projector carried by the second crane for impinging a beam of light on the photoelectric cell when the cranes are a predetermined distance apart, a controller for controlling the operation of the first crane, a test light source operable momentarily on the start of operation of the first crane for illuminating the photoelectric cell, means operable by initial illumination of the photoelectric cell for rendering the controller operative, and means operable on a second illumination of the photoelectric cell for stopping the first crane.

4. A crane control system, which comprises a track, a crane movable along the track, an electric motor for moving the crane along the track, a power source, a switch for actuating the driving motor, a switch arm movable from a neutral position to an actuating position for actuating the switch, a second switch in series with the power source and the first switch and openable by the switch arm when it is moved from said neutral position to said actuating position and closeable by the switch arm when it is moved to its neutral position, a photoelectric cell carried by the crane, amplifying means responsive to illumination of the photoelectric cell, and relay means responsive to the amplifier means and having a contact in series with the power source, the first switch and in parallel with the second switch and maintained closed when the photoelectric cell is not illuminated and opened by illumination of the photoelectric cell so that whenever the photoelectric cell is illuminated and the switch arm is in its actuating position, both the second switch and the contact of the relay means are opened so that the drive motor is not actuated.

5. A crane control system, which comprises a track, a first crane movable along the track, a second crane movable along the track, means for driving the first crane, means for driving the second crane, means carried by the first crane for projecting a light angularly across the track generally toward the second crane, means carried by the second crane for projecting a light beam angularly across the track generally toward the first crane, a photoelectric beam carried by the first crane in a position such that it is actuated by the light beam of the second beam when the cranes approach one another to within a predetermined distance apart, photoelectric means carried by the second crane in a position such that it is actuated by the light beam from the first crane when the cranes are a predetermined distance apart, means responsive to the first-mentioned photoelectric beams for stopping the first crane when actuated, means responsive to the second photoelectric means for stopping the second crane when actuated, means carried by the first crane responsive to failure of the first beam projecting means for stopping the first crane, and means carried by the second crane responsive to failure of the second beam projecting means for stopping the second crane.

6. A crane system, which comprises a track, a crane mounted on the track, means for moving the crane along the track, a second crane mounted on the track, means for moving the second crane along the track, a light beam projector carried on the first crane designed to project a light beam generally toward the second crane and at a predetermined angle across the track, a control circuit operable to actuating the second crane-moving means when power is supplied thereto and to stop the second crane when power is cut off therefrom, a powerline leading to the control circuit, said control circuit including a first relay having a normally open contact in the powerline and a winding and a holding contact connected in series across the powerline, an electrically operable warning indicator, a second relay having a winding and also being provided with a normally closed contact in series with the indicator for actuating the indicator and a holding contact in series with the second relay winding for maintaining the second relay winding energized, said second relay also having a normally open contact, a photoelectric cell, photoelectric relay means having a normally open contact in series with the first relay winding and in parallel with the holding contact thereof for actuating the first relay and also including a normally closed contact in series with the second relay winding and the holding contact of the second relay for deenergizing the second relay winding when the photoelectric cell is illuminated, test means for illuminating the cell to energize the first relay winding and deenergize the second relay winding, and a third relay including a winding connected across the powerline by said normally open contact of the second relay, whereby said normally open contact of the second relay controls the energization of the third relay winding, said third relay also having a normally open contact between the powerline and the control circuit for controlling the supply of power to the control circuit.

7. A crane control system which comprises a track, means directing a light beam across the track, a crane movable along the track, electromotive means for moving the crane along the track, means for braking the crane, an electric controller having an element selectively operable to a neutral position actuating the crane-braking means and to operating positions actuating the crane-moving means, said controller also serving to actuate the crane-braking means when the power is cut off therefrom, a source of electrical power, a powerline extending between the source of power and the electric controller, an operating relay having a winding connected across the powerline and a normally open contact in the powerline in series with the controller for supplying power to the controller when said normally open contact is closed, a neutral switch in the powerline in series with the controller and in parallel with the operating relay contact for supplying power to the controller when closed, said neutral switch being closed when said element of the controller is in its neutral position actuating the crane-braking means and being opened when said element of the controller is in its operating positions actuating the crane-moving means, an electrically operable indicator connected across the powerline, an indicator relay having a winding connected across the powerline in series with the neutral switch and the operating relay contact and also being provided with a normally closed contact in series with the indicator for actuating the indicator when closed and also having a normally open holding contact in series with the indicator relay winding across the powerline and the operating relay contact and the neutral switch for locking in the indicator relay winding, said indicator relay also having a normally open contact in series with the operating relay winding for actuating the operating relay, a photoelectric cell mounted on the crane illuminable by the beam-directing means when the crane is in a predetermined position relative to the beam-directing means, and relay means actuatable by the photoelectric cell and having a normally closed contact in series with the indicator relay winding for deenergizing the indicator relay winding when the cell is illuminated.

8. A crane control system which comprises a track, a crane movable along the track, electromotive means for moving the crane along the track, means for braking the crane, an electric controller selectively operable for actuating the crane-moving means when power is supplied thereto and for actuating the crane-braking means when power is cut off therefrom, a source of electrical power, a powerline extending between the source of power and the electric controller, relay means having a winding and also having a holding contact operable when closed to connect the winding across the powerline and also being provided with a normally open contact in the powerline between the source of power and the controller and operable when closed to supply power to the controller, a photoelectric cell carried by the crane, relay means actuatable by illumination of the photoelectric cell and operable when actuated to cut off power from the controller to actuate the crane-braking means, and test illuminating means for lighting the photoelectric cell to actuate said

relay means to close said contact thereof, whereby the winding is energized to close the holding contact.

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