

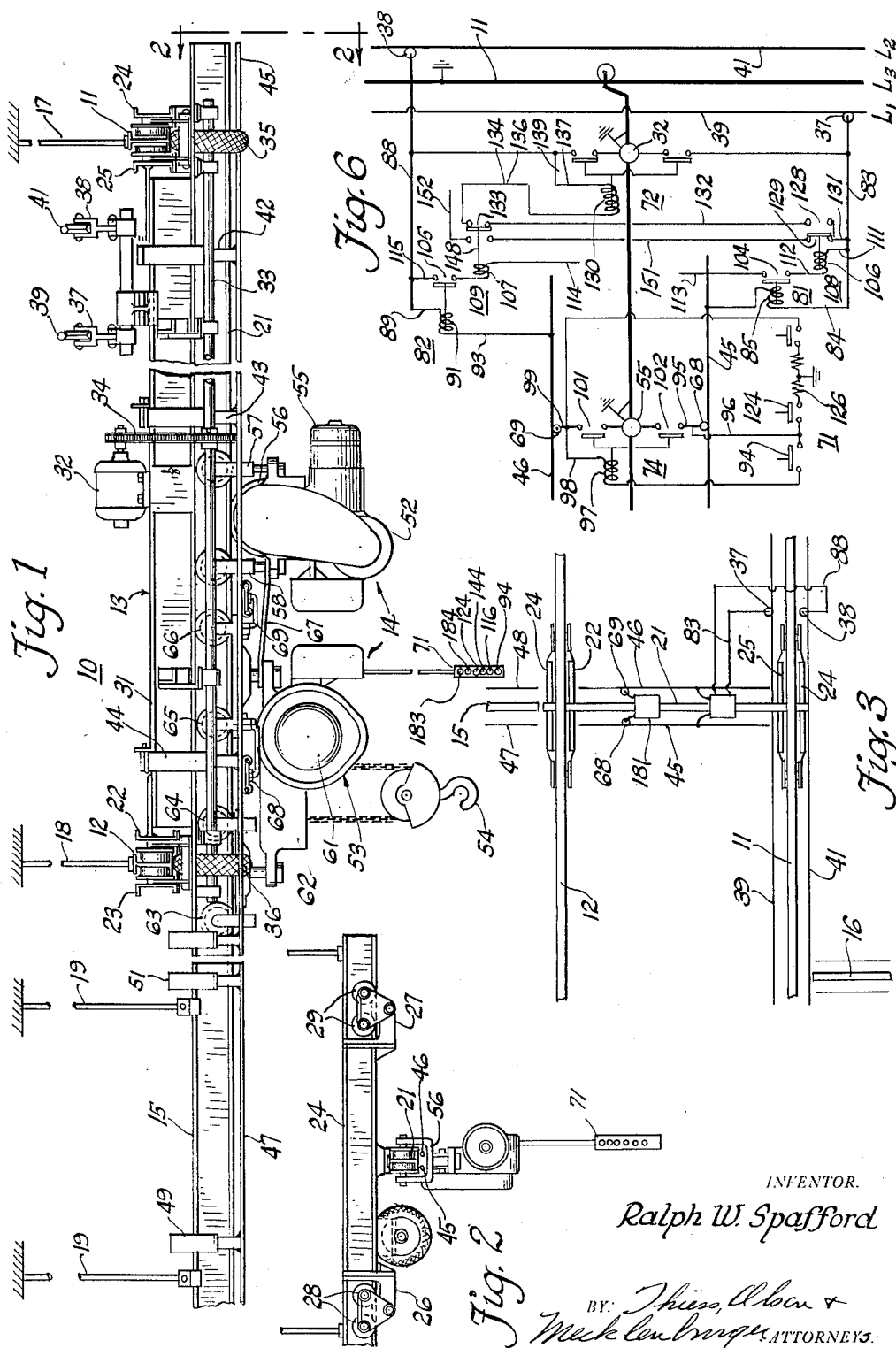
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R. W. SPAFFORD
CRANE CONTROL SYSTEM

2,596,347

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3 Sheets-Sheet 1



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3 Sheets-Sheet 2

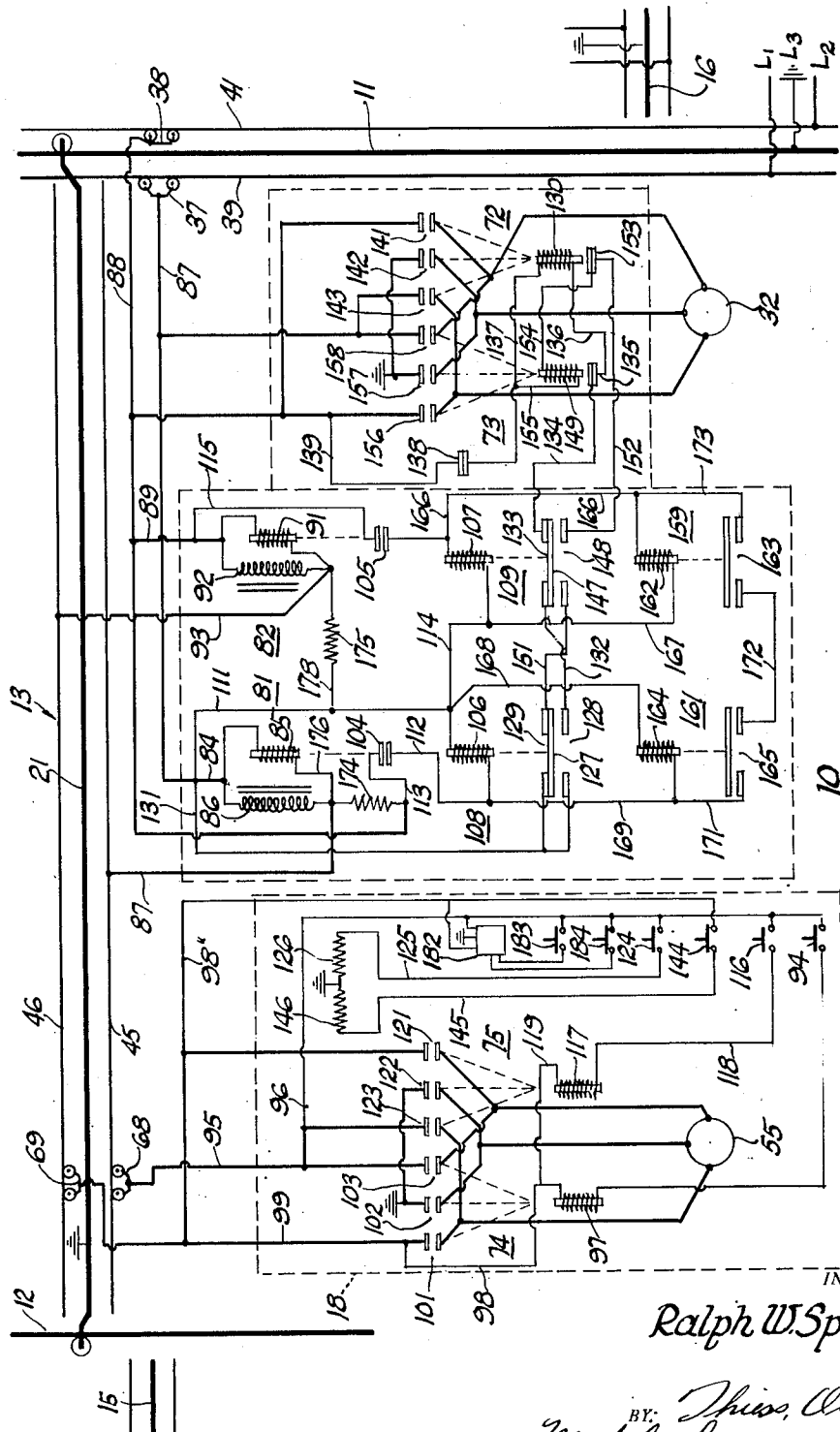


Fig. 4

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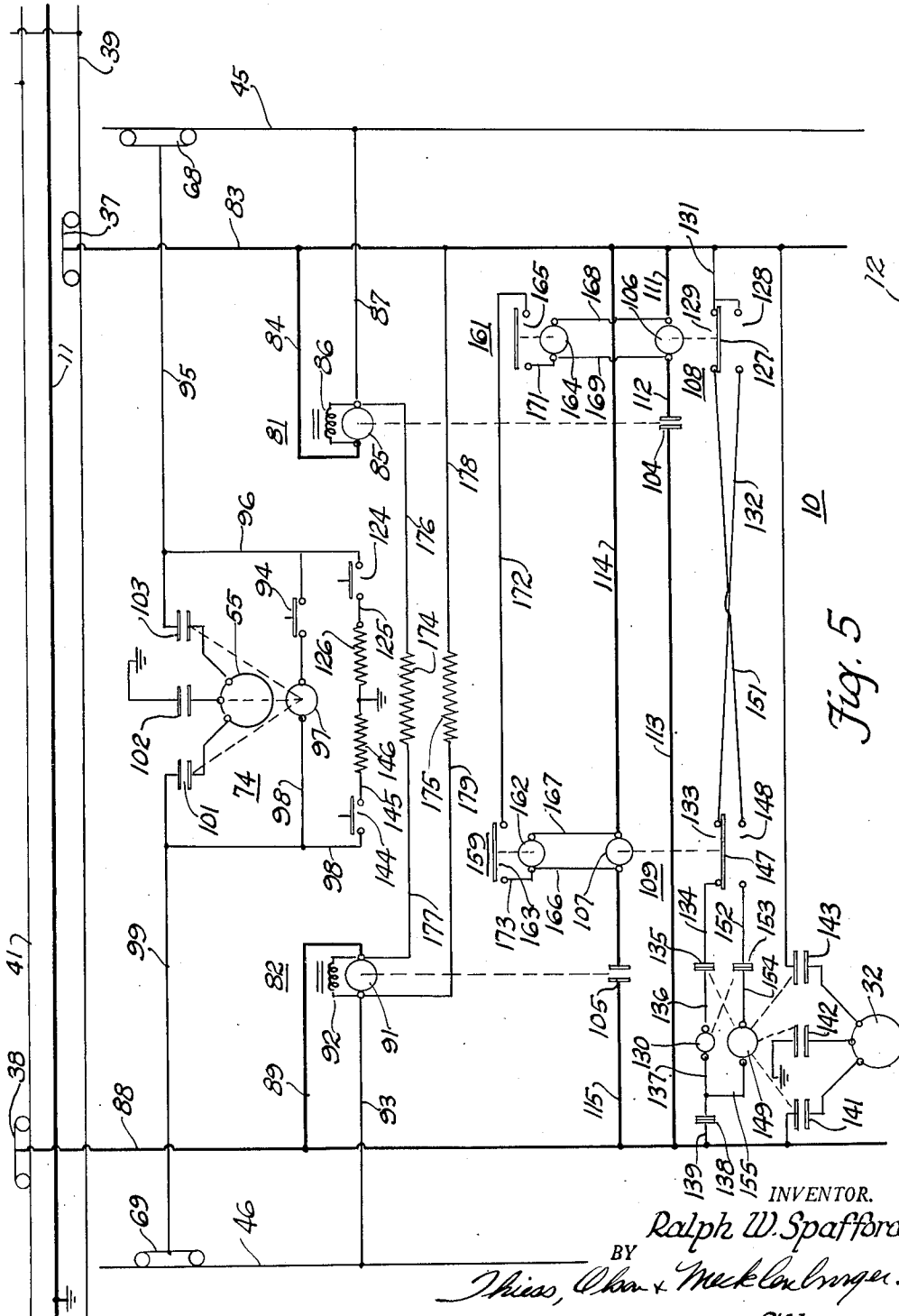
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UNITED STATES PATENT OFFICE

2,596,347

CRANE CONTROL SYSTEM

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This invention relates to crane systems and crane control apparatus, more particularly to crane systems wherein the crane may have both longitudinal to and fro movements and transverse to and fro movements on suitably provided runways, and it is an object of the invention to provide improved crane control apparatus for such systems.

In crane systems of the character indicated, a pair of parallel spaced apart runways are usually provided upon which a transverse or crane bridge is adapted to run, and a crane proper is also provided for running upon the transverse bridge. The bridge moving on the runways produces longitudinal to and fro movements of the crane and may be termed runway travel, and the crane moving on the bridge produces transverse to and fro movements thereof and may be termed bridge travel. Suitable spur runways may be arranged at intervals with which the transverse bridge may come into registry so that the crane may run off of the bridge and onto a spur. The crane proper, in addition to means for producing transverse to and fro movements, may include apparatus for raising and lowering operations. The bridge runways upon which the bridge moves, and the spur runways upon which only the crane proper moves, may be suspended from a ceiling or otherwise suitably mounted in any desired and well understood manner.

Electric power, for example three-phase alternating current, 60-cycle power, advantageously may be used, one electric motor being mounted on the bridge for producing runway travel, a second motor being associated with the crane for producing transverse movements thereof or bridge travel, and a third motor being associated with the crane for producing hoisting and lowering movements.

In the operation of crane systems such as described, there is relative movement between the crane proper and the motor for driving the bridge while the crane is on the bridge, as well as when the crane is operating upon a spur runway. This may require that separate control stations be provided, one on the crane proper and movable therewith for controlling the hoist motor and the bridge travel motor, and a second one not on the crane proper and relatively stationary on the bridge for controlling the runway travel motor. Alternatively, with a single control station on the crane proper, it requires control conductors extending from the runway travel motor to the control station. Such conductors may take the form of flexible leads suspended between the crane

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proper and the control station which may interfere with the operation and necessarily limits the distance to which a crane may move off of the bridge and onto a spur runway, or they may take the form of a pair of bus bars on the bridge upon which collectors run. In the latter case, the collectors remain flapping in the air when the crane runs onto a spur runway since no control is then needed for the longitudinal runway travel and no separate bus bars need be provided.

Accordingly, it is a further object of the invention to provide improved control apparatus for a crane system wherein movements of the crane bridge along the runways (i. e. runway travel), movements of the crane on the bridge (bridge travel) and on the spur runway, and hoisting and lowering movements of the crane are controlled from a single station associated with the crane.

It is a further object of the invention to provide improved control means for a crane system of the character described wherein the same bus bars or conductors supplying power to the bridge travel motor supply power for controlling this motor, as well as for controlling the runway travel motor.

It is a further object of the invention to provide improved means for controlling a crane system of the character described that is efficient in operation, simple in character, and may be operated by one man.

In carrying out the invention in one form, crane apparatus including a pair of spaced apart runways, a crane bridge for running thereon and a crane for running on the bridge are provided together with spur runways with which the bridge may come into registry and onto which the crane may also run. A three-phase power supply is used in which two conductors or bus bars are provided, the third being a ground connection including the runways and bridge. Bus bars on the bridge are connected by collectors to the power supply bus bars through a pair of current responsive devices which control energization circuits which in turn control the runway travel motor. Power to the bridge travel motor is supplied through the bridge bus bars as is the control current therefor. When this motor is energized at a control station on the crane, both the responsive devices function and coact to prevent energization of the means controlling runway travel. The runway travel motor is supplied with power from the supply not flowing through the responsive devices, but the control therefor is such that connecting one of the bridge bus bars to ground

by the control station energizes one of the current responsive devices, which in turn effects energization of circuits controlling runway travel.

For a more complete understanding of the invention, reference should be had to the accompanying drawings in which:

Figure 1 is a front view of crane apparatus embodying the invention;

Fig. 2 is an end view taken substantially in the direction of arrows 2—2 of Fig. 1;

Fig. 3 is a schematic view of a crane system embodying the invention;

Fig. 4 is a wiring diagram somewhat schematic of the elements shown in Fig. 1;

Fig. 5 is a simplified wiring diagram corresponding to the wiring diagram of Fig. 4, and

Fig. 6 is a further simplified wiring diagram illustrating the manner of operation of the invention.

Referring to the drawings, the invention is shown embodied in a crane system 10 comprising, a pair of spaced apart runways 11 and 12, a crane bridge 13 for running thereon, a crane 14 for running on the crane bridge, and a spur runway 15 arranged to have the crane bridge come into registry therewith so that crane 14 may move off the bridge and onto the spur. In the schematic views of Figs. 3 and 4, a second spur runway 16 is shown.

Runways 11 and 12 are shown as I beams suspended from a roof or ceiling by means of rods 17 and 18, the crane bridge being adapted to run on the lower flanges of the I beams. Likewise, spur runway 15 (and other spur runways) may comprise an I beam suspended from the ceiling or roof by a series of rods 19, the crane being adapted to run on the lower flanges thereof. It will be understood that the particular construction of the runways and the manner of suspending them is exemplary and that other arrangements of runways may be used.

Crane bridge 13 may comprise a transverse I beam 21 rigidly attached, such as by welding or clamps for example, to a pair of spaced apart and longitudinally extending channel members 22 and 23 at one end, and 24 and 25 at the other. At each end of the channel members there are brackets attached, such as by welding, upon which brackets pairs of rollers are mounted for riding upon the lower flanges of runways 11 and 12. See for example Fig. 2 wherein brackets 26 and 27 are attached to channel member 24, and pairs of rollers 28 and 29 mounted thereon respectively ride upon the lower flanges of runway 11. Mounted atop beam 21 may be a second beam 31 to provide additional rigidity and support for the crane bridge. While the crane bridge has been described as constructed of I beams and channel members, it will be understood that other shapes and forms may be used as well as other modes of construction so long as sufficient rigidity and strength are had.

Mounted upon beam 31 is an electric motor 32 which drives a shaft 33 by means of a chain 34 and sprockets, shaft 33 driving a pair of rubber tired wheels 35 and 36, which in turn engage the lower surface of runways 11 and 12 for driving the crane bridge therealong. Shaft 33 is supported by the crane bridge in bearings which may be mounted in any manner well understood in the art.

Collectors 37 and 38 may be insulatively carried by beam 21 and are adapted to engage respectively a pair of conductors 39 and 41 of a three-phase, 60 cycle power supply (L₁, L₂, L₃),

for example, the third conductor thereof (L₃) being runways 11 and 12, bridge member 21, and spur trackways 15 and 16 inasmuch as all of these members are grounded. Insulatively carried by brackets 42, 43 and 44 are conductors 45 and 46 extending along bridge member 21 for supplying power to crane 14. Similarly, a pair of conductors 47 and 48 are insulatively carried alongside runway 15 by brackets 49 and 51 for supplying power to crane 14 while on the spur runway. Other types of three-wire power sources may of course be used.

Crane 14 may comprise one part 52 including a motor 55 for towing or pushing the crane from one position to another on the spur runways and on the bridge, and a part 53 for raising and lowering the hook 54, motor 55 being adapted to drive a rubber tired member 56 which engages the lower surface of beam 21 and the lower surfaces of the various spur runways. Part 52 is suspended from beam 21 by yoke members 57 and 58 upon which are mounted rollers for riding upon the lower flange of the bridge and spur runways. Part 53 comprises a hoist motor 61 and the associated hoist gears (not shown) carried by a support 62 and pairs of rollers 63, 64, and 65, 66 adapted to run upon the lower flange of beam 21. Towing part 52 is connected to hoisting part 53 by any toggle means, such for example as a link 67. Current collectors 68 and 69 are carried by the combination for engaging conductors 45 and 46 for supplying power to motors 55 and 61. While towing part 52 and hoisting part 53 have been generally described, it will be understood that other arrangements may be used.

Runway travel motor 32, bridge and spur runway travel motor 55, as well as hoist motor 61, are controlled from a single station 71 on crane 14, which for example may be a series of push button switches. That is to say, when crane 14 is on a spur trackway, the hoisting and traveling movements are controlled from station 71, and when crane 14 is on the bridge the hoisting and bridge travel movements, as well as the runway travel movements, are controlled from this same station.

With the foregoing structure in mind, the remaining structure and circuit arrangements for producing complete crane control from a single station by one man may now be described.

Referring to Figs. 4, 5 and 6 showing the crane and control apparatus therefor schematically, runway travel motor 32 is connected to collectors 37 and 38 by either one of a pair of contactors 72 and 73, depending upon the direction of runway travel, and bridge travel motor 55 is connected to collectors 68 and 69 by either one of a pair of contactors 74 and 75 depending upon the direction of operation. The various push buttons of control station 71 are connected to collectors 68 and 69 and to ground, and thus derive their ability to control motors 32, 55 and 61 (Fig. 1) from collectors 68 and 69 which move with crane 14, even though motor 32 is connected to collectors 37 and 38 which are stationary on the bridge.

To control motor 32 from station 71, a pair of current sensitive devices or relays 81 and 82 are connected in circuit between conductors 45 and 46 and collectors 37 and 38 so that all power reaching conductors 45 and 46 must do so through relays 81 and 82. Relays 81 and 82 are energizable on small currents as well as large currents, and are adapted, when both are energized, to

prevent the operation of contactors 72 and 73, thereby preventing energization of motor 32. But when one or the other only of relays 81 and 82 is energized, a corresponding one of contactors 72 and 73 is operated to supply power to motor 32. As will be more particularly described subsequently, relays 81 and 82 in series are connectable in circuit with either one of the actuating coils of contactors 74 and 75 and collectors 68 and 69 for energizing both relays. In this situation one of contactors 74 and 75 is operated to supply power to motor 55, but contactors 72 and 73 are prevented from being energized. Similarly, relays 81 and 82 are adapted to be connected respectively in circuit between collector 37 and ground and collector 38 and ground. Thus, relays 81 and 82 may be energized one at a time, and when this is done one of contactors 72 and 73 is operated to supply power to motor 32. Consequently control of runway travel, bridge travel, and hoisting is obtained from a single station by virtue of the provision of a pair of relays, both of which are energized when bridge travel or hoisting is to take place to prevent runway travel, and when runway travel is desired only one of the two relays is energized.

The circuits for producing these functions may now be described. Power is supplied to conductors or bus bars 45 and 46 carried by the crane bridge from bus bars 39 and 41 from, respectively, collector 37 running on bus bar 39, through conductors 83 and 84, coil 85 and reactor 86 of relay 81, and conductor 87 to bus bar 45; and from collector 38 running on bus bar 41, through conductors 88 and 89, coil 91 and reactor 92 of relay 82, and conductor 93 to bus bar 46. Thus, bus bars 45 and 46 are energized at all times when bus bars 39 and 41 are energized through the coils and reactors of relays 81 and 82.

When bridge travel motor 55 is to be energized for moving the crane forward on the bridge, push button 94 is pushed to close its contacts, thereby energizing coil 97 of contactor 74 through the following circuit: From bus bar 45 through collector 68, conductors 95 and 96, push button switch 94, coil 97, conductors 98 and 99 to collector 69. Completing a circuit through coil 97 by means of push button 94 completes, at the same time, circuits through coil 85 and reactor 86, and coil 91 and reactor 92 of relays 81 and 82 through the circuits previously described for these members inasmuch as any energy on bus bars 45 and 46 must come from collectors 37 and 38 through relays 81 and 82. Energizing coil 97 causes this coil to close contacts 101, 102, and 103 of contactor 74, thereby supplying power to motor 55 from bus bars 45 and 46 through conductors 95 and 99. Contact 102 is connected to ground, as shown, for completing the motor power circuit. Motor 55 being energized, it rotates wheel 56 (Fig. 1) against the bottom of beam 21 thereby moving crane 14 forwardly or toward the right. This movement is stopped by releasing push button 94 whereupon coil 97 becomes de-energized and contacts 101, 102 and 103 open.

Inasmuch as the power current for motor 55 flows through relays 81 and 82, it is desirable that there be only a small voltage drop there-through in order that full voltage will be applied to the motor and there will be only small losses through the relays. Accordingly, coils 85 and 91 are constructed with relatively low resistance and the proper number of turns so that the coils will pick up their contacts on relatively

small currents, for example as low as one-quarter of an ampere. When current for motor 55 is flowing, a certain proportion of this current flows through coils 85 and 91. However, reactors 86 and 92 shunting, respectively, coils 85 and 91 are of the saturable character whose impedance decreases very materially when current flow becomes large. The impedance of these members decreases sufficiently so that the total current through the coils and the reactors flows without appreciable voltage drop whereby the operation of motor 55 is unimpaired. Currents as large as 50 amperes may flow through relays 81 and 82 when motor 55 is operating.

While not illustrated on the schematic Figs. 5 and 6, the crane will operate in the reverse direction upon the bridge by using push button 116 which completes a circuit for coil 117 of contactor 75 as follows (Fig. 4): From collector 68 through conductors 95 and 96, push button switch 116, conductor 118, coil 117, conductors 119, 98 and 99 to collector 69. Energizing coil 117 closes contacts 121, 122 and 123, contacts 121 and 123 being connected respectively to conductors 99 and 95, whereas contact 122 is connected to ground. These connections reverse, the two conductors leading to motor 55 thereby causing it to revolve in the reverse direction, as is well understood in three-phase circuits.

Coils 85 and 91 of relays 81 and 82 being energized by closing push button 94, contacts 104 and 105 associated therewith, respectively, are closed thereby completing circuits for energizing coils 106 and 107 respectively of relays 108 and 109 as follows: From collector 37 through conductor 83, conductor 111, coil 106, conductor 112, closed contacts 104, conductor 113, and conductor 88 to collector 38; and from collector 37 through conductor 83, conductor 114 (including conductor 111 of Fig. 4 but not of Fig. 5), coil 107, closed contacts 105 and conductor 115 to conductor 88 and collector 38. The current for energizing coils 106 and 107 comes from collectors 37 and 38 without passing through relays 81 and 82. Energizing both of coils 106 and 107 moves the contact bars of these relays such as to maintain an open circuit for contactors 72 and 73, as will be more fully explained subsequently in this specification.

Assuming that the crane is stationary on the bridge and the bridge is intended to move forwardly on the runways (i. e. runway travel), push button 124 is depressed, thereby closing its contacts and connecting bus bar 45 to ground through the following circuit: From collector 68 through conductors 95 and 96, push button 124, conductor 125, and resistor 126 to ground. Inasmuch as bus bar 45 is connected to collector 37 only through coil 85 and reactor 86 of relay 81, as already described, closing push button 124 energizes coil 85 of relay 81, thereby closing normally open contacts 104. Resistor 126 is of a sufficient value so that when push button 124 is closed, coil 85 draws the necessary current to operate its contacts but does not function as a short circuit to ground for collector 37. Closing push button 124 produces no functioning of relay 82. Closing contacts 104 completes the previously described energizing circuit for coil 106 of relay 108 thereby causing this relay to move its contact bar 127 to close the normally open contacts 128 and opening the normally closed contacts 129. Consequently, a circuit is completed for energizing coil 130 of contactor 72 as follows: From collector 37 through conductors 83 and 131, closed contacts 128, conductor 132, closed contacts 133 of

relay 109, conductor 134, normally closed contacts 135, conductor 136, coil 130, conductor 137, normally closed contacts 138, and conductor 139 to conductor 88 and collector 38. Accordingly, coil 130 is energized thereby closing contacts 141, 142 and 143 of contactor 72 for supplying power to motor 32 from conductors 88 and 83, the motor circuit being completed by a ground connection as shown. When push button 124 is released its contacts open, thereby de-energizing coil 85 of relay 81 and opening contacts 104, coil 106 becomes de-energized thereby allowing contact bar 127 to open contacts 128 and close contacts 129. This removes energization from coil 130, consequently opening contacts 141, 142 and 143 and de-energizing motor 32.

When it is desired to operate the crane bridge along runways 11 and 12 in the reverse direction, push button 144 is closed thereby connecting bus bar 46 to ground through the circuit including collector 69, conductors 99 and 98', push button switch 144, conductor 145 and resistor 146 to ground. Since bus bar 46 is continually energized through relay 82, closing push button 144 connects coil 91 and reactor 92 of relay 82 into circuit between collector 38 and ground, resistor 46 having sufficient value of resistance that coil 91 will be energized without placing a short circuit on the system. Energizing coil 91 by closing push button 144 does not energize coil 85, but closes normally open contacts 105 thereby energizing coil 107 through a circuit previously described. Energizing coil 107 causes contact bar 147 to move from a position closing contacts 133 to a position closing contacts 148. This completes a circuit for a coil 149 as follows: From collector 37 through conductors 83 and 131, closed contacts 129, conductor 151, closed contacts 148, conductor 152, closed contacts 153, conductor 154, coil 149, conductors 155 and 137, normally closed contacts 138, and conductors 139 and 88 to collector 38. Energizing coil 149 closes contacts 156, 157 and 158 (Fig. 4) to energize motor 32 to run in the reverse direction.

Normally closed contacts 153 are opened when coil 130 is energized, and normally closed contacts 135 are opened when coil 149 is energized. Hence, when motor 32 is operating in either direction, the contactor for causing it to operate in the reverse direction cannot be energized. Short circuiting of the power system is thereby prevented.

From the description of the structure thus far, it will be apparent that to cause the crane to travel along the crane bridge, push buttons 94 and 116 are used, depending upon the direction, this causing both relays 81 and 82 to be energized, which in turn causes relays 108 and 109 to be energized, these latter relays maintaining the energizing circuits for the contactors 72 and 73 open so that the crane does not move along the runways. But when either push button 124 or 144 is used, a corresponding single one of relays 81 and 82 is energized thereby causing one or the other of relays 108 and 109 to operate, whereby an energizing circuit for one of contactors 72 and 73 is completed.

Referring particularly to Figs. 5 and 6, it will be noted that the circuit for coil 130, for example, includes the normally open contacts 128 and the normally closed contacts 133 so that when both relays 107 and 108 operate, the circuit to coil 130 remains open, but when relay 108 alone operates a complete circuit for coil 130 is made. Likewise for coil 149 the energizing circuit in-

cludes normally closed contacts 129 and normally open contacts 148 so that when both relays 107 and 108 operate, the energizing circuit for coil 149 remains open. However, when relay coil 107 alone is energized, contacts 148 are closed and a complete energizing circuit for coil 149 is made.

When both relays 108 and 109 are energized, as when the crane is traveling along the bridge, both coils 85 and 91 are energized since these coils control contacts 104 and 105. Then, when push button switch 94, for example, is opened to de-energize coils 85 and 91, these coils do not always permit contacts 104 and 105 to open simultaneously, this being due to residual magnetism in the iron circuits of coils 85 and 91 and other ordinary differences between relays 81 and 82. If contacts 104 and 105 do not open simultaneously, the one remaining closed, for example 104, will permit relay coil 106 to remain energized thereby maintaining contacts 128 closed and consequently completing a circuit for coil 130, as already described. This, of course, energizes motor 32 so that the crane starts to travel along the runways. As soon as relay 106 de-energizes, however, this movement stops. The result is that the crane may give a jerk in one direction or the other along the runway when the crane traveling on the bridge is stopped or when the hoist motor is stopped.

This phenomenon is prevented by the provision of relays 159 and 161 (Figs. 4 and 5). Relay 159 includes a coil 162 and normally open contacts 163, coil 162 being connected in parallel with coil 107 and consequently being energized whenever coil 107 is energized to close contacts 163. Similarly, relay 161 includes a coil 164 and normally open contacts 165, coil 164 being connected in parallel with coil 106 and consequently being energized at the same time that coil 106 is energized to close its normally open contacts 165. Whenever both coils 162 and 164 are energized (that is, when both relays 81 and 82 are energized), contacts 163 and 165 complete additional energizing circuits for coils 106 and 107. Consequently, should either of contacts 104 and 105 open before the other, the additional energizing circuits maintain coils 106 and 107 energized until the second of the contacts 104 and 105 open. Referring particularly to Fig. 5, the circuits for energizing coils 162 and 164 may be traced as follows: From conductor 88 through conductor 115, contacts 105, conductor 166, coil 162, conductors 167 and 114 to conductor 83. From conductor 88 through conductor 113, contacts 104, conductor 112, conductor 169, coil 164, and conductors 68 and 111 to conductor 83.

When both contacts 104 and 105 are closed (coils 162 and 164 are energized to close contacts 163 and 165), the additional circuits for energizing coils 106 and 107 may be traced as follows: From conductor 83 through conductor 111, coil 106, conductors 169 and 171, closed contacts 165, conductor 172, closed contacts 163, conductors 173 and 166, closed contacts 105, and conductor 115 to conductor 88. From conductor 83 through conductor 114, coil 107, conductors 166 and 173, closed contacts 163, conductor 172, closed contacts 165, conductors 171, 169 and 112, closed contacts 104, and conductor 113 to conductor 88. It will be observed from the circuits just traced that when contacts 104 are open, as when relay 81 opens prior to relay 82 (contacts 105 remaining closed), there is a completed circuit for coils 106 and 107 which accordingly remain energized. However, under this condition when contacts 105

open, as when relay 82 becomes de-energized, the additional circuit traced out for coil 106 as well as the regular circuit for coil 107 open, and consequently both relays 106 and 107 become de-energized simultaneously. The reverse situation occurs of course when contacts 105 open first. In other words, when both relays 81 and 82 are energized, the coil 106 and 107 become de-energized only when the second of relays 81 and 82 opens its contacts. Consequently, there can be no transfer of control from the bridge travel motor 55 to runway travel motor 32, and consequently jerking is prevented.

Relays 81 and 82 operating on low currents as well as high currents are sensitive in their operation to the amount of residual magnetism remaining in the coils whenever the relay circuits are broken. When the coils are drawing high amperage the residual magnetism may delay or prevent the relays from dropping out. This may be envisioned as when the current is interrupted at the peak of the alternating current wave. To prevent this from occurring, resistors 174 and 175 are connected in circuit respectively with coils 85 and 91. Thus (Fig. 5) a circuit may be traced from conductor 83 through conductor 84, coil 85, conductor 176, resistor 174, and conductors 177 and 89 to conductor 88. Since conductors 83 and 88 are continually energized, it will be apparent that coil 85 is continually receiving alternating current energization, resistor 174 being sufficiently large so that this current is not sufficient to cause relay 81 to pick up. The small amount of current which flows, however, does effectively reduce residual magnetism. Likewise, (Fig. 5) a circuit may be traced from conductor 83 through conductor 178, resistor 175, conductor 179, coil 91, and conductor 89 to conductor 88. Thus, it is seen that coil 91 has a circuit whereby a small amount of current is always flowing therethrough to reduce the residual magnetism.

In comparing Figs. 4, 5 and 6, all conductors are not always shown in each figure since Figs. 5 and 6 are simplified so that each circuit may be seen individually.

From the foregoing description it will be seen that the bus bars or conductors 45 and 46, together with bridge member 21, supply current to bridge travel motor 55, and at the same time supply the circuits for controlling the energization not only of bridge travel motor 55, but of runway travel motor 32. Accordingly, the need for supplying additional bus bars for control purpose has been obviated. Likewise, the need for separate conductors from control box for motor 32 to control station 71 has been obviated. In some prior constructions these flexible conductors hung in a loop between the control box of motor 32 and control station 71. In such constructions, of course, the crane could not move from the bridge onto the spur runway 15, for example, except up to the length of such conductors.

With the structure as described, the crane can move off of bridge member 21 and onto any spur runway, for example spur runway 15, inasmuch as the conductors 47 and 48 may line up directly with conductors 45 and 46 so that power for motor 55, as well as for control, is continually available to the crane. Bus bars or conductors 47 and 48 are of course separated from bus bars 45 and 46 by an air gap and do not receive energization through bus bars 45 and 46. Consequently, runway travel motor 32 may not be energized when crane 14 is run off the bridge and onto the spur runway. This is as desired

in virtually all instances inasmuch as the crane will usually return from spur runway and onto the bridge.

To insure that runway travel motor 55 may not be energized while there is no crane on the bridge, normally closed contacts 133, in series with both coils 130 and 149, is provided (coils 130 and 149 controlling energization of motor 32). Whenever the crane moves off of the bridge and onto a spur runway, the normally closed contacts 133 are opened, the contacts being in the form of a limit switch, for example. With contacts 133 open, runway travel motor 32 may not be energized. When the crane returns onto the bridge, contacts 133 are closed and thereafter motor 32 may be energized by manipulating the push button at control station 71.

When the crane is on a spur runway and its collectors 68 and 69 are running on bus bars 47 and 48, the various circuits traced out for motor 55, as well as the control circuits for contactors 74 and 75, are completely operative inasmuch as bus bars 47 and 48 are energized. This may be visualized from Fig. 4 by noting that the structure within the rectangle 181 embodies all of the control equipment for and including motor 55.

The control for hoisting motor 61 has not been shown in detail inasmuch as it is a duplicate for that of motor 55. Accordingly, motor 61 and its control apparatus is shown schematically as embodied in the rectangle 182 of Fig. 4, push buttons 183 and 184 being provided at control station 71 for controlling lowering and raising of hook 54 by motor 61. Push buttons 183 and 184 control motor 61 through a circuit arrangement extending from collectors 68 and 69 in identical fashion to motor 55.

While particular embodiments of the invention have been shown, it will be understood, of course, that the invention is not limited thereto since many modifications may be made, and it is, therefore, contemplated by the appended claims to cover any such modifications as fall within the true spirit and scope of the invention.

Having thus described the invention, what is claimed and desired to be secured by Letters Patent is:

1. A three-conductor control system comprising, a pair of responsive means connected to one pair of said conductors, first energizing means, means connecting said pair of responsive means in circuit with said first energizing means whereby said first energizing means performs one control function, second energizing means, means connecting one of said pair of responsive means to a second pair of said conductors for effecting energization of said second energizing means to perform a second control function, and means actuated by the other of said pair of responsive means when energized for preventing energization of said second energizing means.

2. A three-phase, three-conductor control system comprising, a pair of responsive means connected to one pair of said conductors, first energizing means, means connecting said pair of responsive means in circuit with said first energizing means whereby said first energizing means performs one control function, second energizing means, means connecting one of said pair of responsive means to a second pair of said conductors for effecting energization of said second energizing means to perform a second control function, and means actuated by the other of said pair of responsive means when energized

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for preventing energization of said second energizing means.

3. A three-conductor control system comprising, a pair of responsive means connected to one pair of said conductors, first energizable means, means connecting said pair of responsive means in circuit with said first energizable means whereby said first energizable means performs one control function, second energizable means, a circuit having normally open and normally closed contact means serially arranged connecting said second energizable means to a pair of said conductors, said normally open contact means being caused to move to closed position by one of said pair of responsive means, said normally closed contact means being caused to move to open position by the other of said responsive means, and means for connecting said one of said pair of responsive means to another of said pair of conductors for effecting closure of said normally open contact means.

4. A three-conductor control system comprising, a first energizable means for performing a control function, a pair of energizable means respectively for effecting connection to and disconnection from a pair of said conductors of said first energizable means, a second energizable means for performing a control function connected in open circuit to a pair of said conductors through both of said energizable means, means for closing said open circuit, and means for connecting said connection of one of said pair of energizable means to another pair of said conductors.

5. A three-conductor control system comprising, a first energizable means for performing a control function, second energizable means for performing a second control function, a pair of means both of which are responsive when said second energizable means is energized respectively for effecting connection to and disconnection from a pair of said conductors of said first energizable means, and means for connecting said connection of one of said pair of means to another pair of said conductors.

6. A control system for a crane system including runways, a crane bridge for traveling on said runways, and a crane for traveling on said crane bridge comprising, one pair of conductors spaced along said runways, a second pair of conductors spaced along said crane bridge, said runways and said bridge forming a third conductor, a pair of responsive devices in circuit respectively with said second and said first pairs of conductors, one energizable means on said crane bridge for controlling to and fro movements thereof on said runways, second energizable means on said crane for controlling to and fro movements thereof on said bridge, means on said crane for connecting said second energizable means to said second pair of conductors, a circuit having normally open and normally closed contact means operated in response to energization of respective ones of said pair of responsive devices connecting said one energizable means to said first pair of conductors, and means on said crane for connecting each one of said second pair of conductors individually to said third conductor.

7. A control system for a crane system including runways, a crane bridge for traveling on said runways, and a crane for traveling on said crane bridge comprising, one pair of conductors spaced along said runways, a second pair of conductors spaced along said crane bridge, said runways and said bridge forming a third conductor, collectors on said bridge engaging said first pair of con-

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ductors, a pair of responsive devices in circuit between respective ones of said second pair of conductors and said collectors, one energizable means on said crane bridge for controlling to and fro movements thereof on said runways, second energizable means on said crane for controlling to and fro movements thereof on said bridge, means on said crane for connecting said second energizable means to said second pair of conductors, a circuit having normally open and normally closed contact means operated in response to energization of respective ones of said pair of responsive devices connecting said one energizable means to said collectors ahead of said responsive devices, and means on said crane for connecting each one of said second pair of conductors individually to said third conductor.

8. A crane system including runways, a crane bridge for traveling on said runways, and a crane for traveling on said crane bridge comprising, one motor on said crane bridge for driving said crane bridge to and fro on said runways, a second motor on said crane for driving said crane to and fro on said crane bridge, one pair of conductors spaced along said runways, a second pair of conductors spaced along said crane bridge, said runways and said bridge forming a third conductor, collectors on said crane bridge engaging said first pair of conductors, a pair of responsive means in circuit between respective ones of said second pair of conductors and said collectors, one energizable means on said crane bridge for connecting said one motor to said collectors ahead of said responsive devices, second energizable means on said crane for connecting said second motor to said second pair of conductors, means on said crane for connecting said second energizable means to said second pair of conductors, a circuit having normally open and normally closed contact means operated in response to energization of respective ones of said pair of responsive devices connecting said one energizable means to said collectors ahead of said responsive devices, and means on said crane for connecting each one of said second pair of conductors individually to said third conductor.

9. A crane system including runways, a crane bridge for traveling on said runways, and a crane for traveling on said crane bridge comprising, one motor on said crane bridge for driving said crane bridge to and fro on said runways, a second motor on said crane for operation thereof, one pair of conductors spaced along said runways, a second pair of conductors spaced along said crane bridge, said runways and said bridge forming a third conductor, collectors on said crane bridge engaging said first pair of conductors, a pair of responsive means in circuit between respective ones of said second pair of conductors and said collectors, one energizable means on said crane bridge for connecting said one motor to said collectors ahead of said responsive devices, second energizable means on said crane for connecting said second motor to said second conductors, means on said crane for connecting said second energizable means to said second conductors, a circuit having normally open and normally closed contact means operated in response to energization of respective ones of said pair of responsive devices connecting said one energizable means to said collectors ahead of said responsive devices, and means on said crane for connecting each one of said second pair of conductors individually to said third conductor.

10. A crane control system including runways,

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a crane bridge for traveling on said runways, and a crane for traveling on said crane bridge comprising, one pair of conductors spaced along said runways, a second pair of conductors spaced along said crane bridge, said runways and said bridge forming a third conductor, a pair of responsive devices on said bridge in circuit respectively with said second and said first pairs of conductors, one energizable means on said crane bridge for controlling to and fro movements thereof on said runways, second energizable means on said crane for controlling thereof on said bridge, means on said crane for connecting said second energizable means to said second pair of conductors, thereby to energize both said responsive means, a circuit having normally open and normally closed contact means connecting said one energizable means to said first pair of conductors, a pair of operating means for said normally open and closed contact means controlled by energization of respective ones of said pair of energizable means, means on said crane for connecting each one of said second pair of conductors individually to said third conductor, and means associated with said pair of operating means for assuring simultaneous operation thereof when both said pair of energizable means become de-energized.

11. A crane control system including runways, a crane bridge for traveling on said runways, a spur runway adapted to come into registry with said crane bridge, and a crane for traveling on said crane bridge and said spur runway comprising, a pair of conductors spaced along said runways, a second pair of conductors spaced along said crane bridge, a third pair of conductors spaced along said spur runway, said runways and said bridge forming a third conductor, a pair of responsive devices on said bridge in circuit respectively with said second and said first pairs of

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conductors, one energizable means on said crane bridge for controlling to and fro movements thereof on said runways, collectors on said crane for engaging said second and said third pairs of conductors, second energizable means on said crane for controlling thereof on said bridge and said spur runway, means on said crane for connecting said second energizable means to said collectors, thereby to energize both said responsive means, a circuit having normally open and normally closed contact means connecting said one energizable means to said first pair of conductors, a pair of operating means for said normally open and closed contact means controlled by energization of respective ones of said pair of energizable means, means on said crane for connecting each one of said second pair of conductors individually to said third conductor, and means associated with said pair of operating means for assuring simultaneous operation thereof when both said pairs of energizable means become de-energized.

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