June 7, 1932. W. R. WICKERHAM 1,861,994

CONTROL SYSTEM

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Fig. 1.

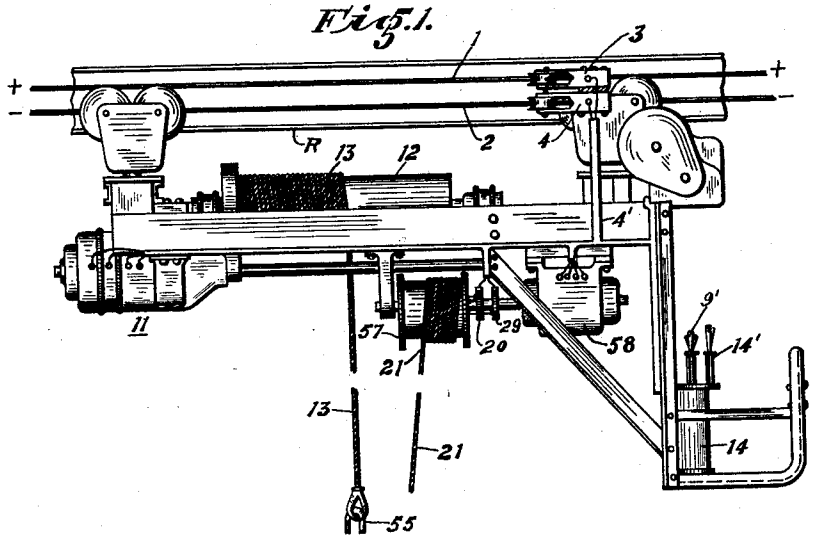


Fig. 2.

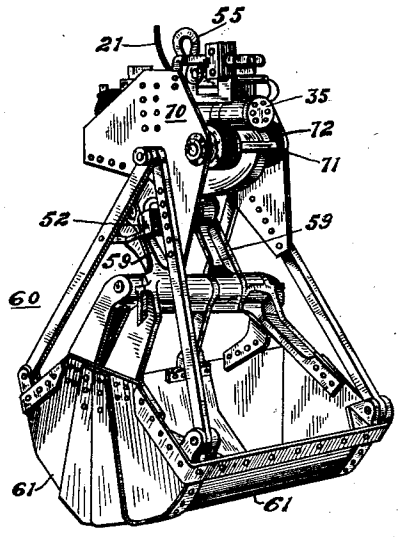
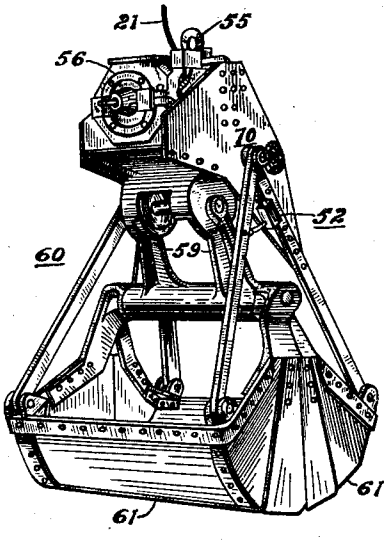


Fig. 3.



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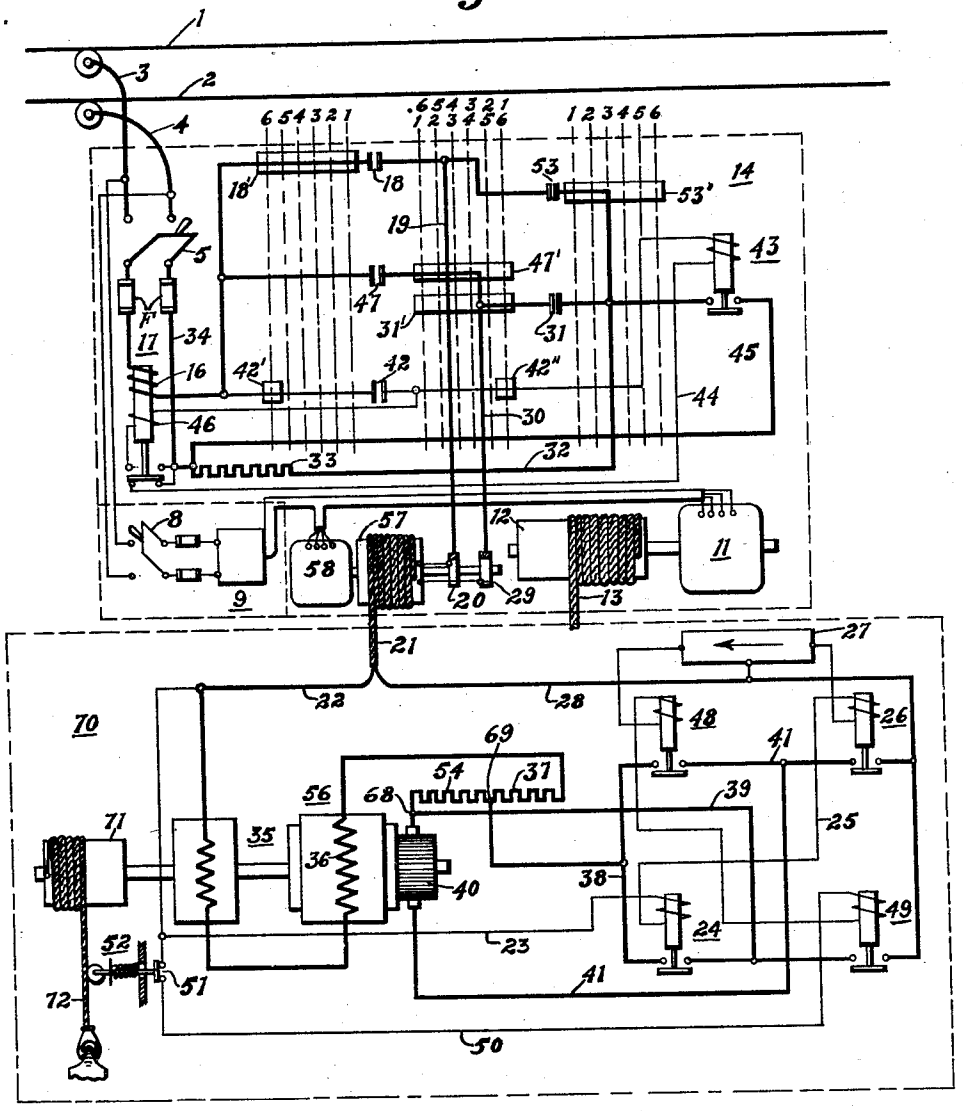
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Fig. 4.



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1,861,994

UNITED STATES PATENT OFFICE

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CONTROL SYSTEM

Application filed June 19, 1930. Serial No. 462,222.

My invention relates to hoisting machinery, and more particularly to an electrical control system for operating the motor of a hoist grab-bucket.

One of the objects of my invention is to provide for electrically controlling the closing and opening operations of the jaws of a grab-bucket by means of a simple electrical control system.

A further object of my invention is the provision of electrical means mounted on the grab-bucket to close the jaws of the bucket, and by reason of my novel control system operate the jaws to closed position by said means by a force not exceeding a predetermined value.

It is also an object of my invention to electrically limit the opening speed of the jaws of the bucket when subject to a heavy overhauling load, whereby damaging slack in the operating cables for the jaws and excessive clashing of the jaws is prevented.

Other objects and advantages will be apparent from a study of the following specification when taken in conjunction with the accompanying drawings, in which:

Figure 1 is a view in side elevation of a grab-bucket hoist.

Figs. 2 and 3 are perspective views of the grab-bucket showing the electrical equipment mounted on the bucket; and,

Fig. 4 is a diagram of the electrical control system for controlling the operation of the motor operating the jaws of the bucket.

Referring more particularly to Fig. 1 of the drawings, R designates a rail along which the frame of the grab-bucket hoist is caused to operate in a conventional manner. A pair of trolley wires 1 and 2 are disposed in parallel relation to the rail and constitute the source of direct current power for operating the electrical equipment mounted on the hoist frame and the grab-bucket.

Mounted on the frame is a motor 11 for operating the hoisting drum 12 upon which a cable or chain 13 is arranged for lowering and raising the grab-bucket 60 shown in Figs. 2 and 3. The power for operating the motor 11 and the other equipment on the hoist frame is collected from the trolley wires 1 and 2 by means of the trolley wheel-assemblage 3 and 4. A conduit 4′ carries the electric energy from the trolley wheel-assemblage to controller 14 and controller 9 located with controller 14 shown in the operator's cage (see Fig. 1). The controller 9 is disposed to control the operation of the motor 11, and the motor provided for actuating the hoist crane. The controller 9 and the electrical equipment thereby controlled constitute no part of my invention and therefore need not be described in full detail.

The controller 14 provided with a controller lever 14′, controls the operation of the electrical equipment mounted intermediate the supporting members 70 on the grab-bucket 60 (see Figs. 2 and 3). Mounted on the grab-bucket between the members 70 is a series magnetic brake 35 for holding the jaws 61 of the grab-bucket either in fully closed or fully opened positions. A motor 56, a jamming resistor 37, an armature shunt resistor 54, a winding drum 71, magnetically operated directional contactors 24, 26, 48 and 49 and a rugged copper ozide rectifier for selectively controlling the operation of the magnetically operated directional contactors, are all mounted on the grab-bucket. A limit switch 52 is also mounted on the grab-bucket and is operably associated with the cable 72 (see Fig. 4) for operating the levers 59 to close the jaws 61 of the grab-bucket.

The function of the limit switch 52 is to interrupt the circuit for the motor 56 and to cause the locking of the brake mounted on the grab-bucket. The limit switch is actuated either when the jaws have completely opened and a slack occurs in the cable 72 or when a slack occurs in the cable 72 because of the fact that the jaws have engaged an obstruction and thus cannot open.

Motor 58 is a torque motor which operates the winding drum 57 for paying out the electrical cable 21 and is so designed that it holds the cable 21 taut at all times, thereby preventing unnecessary wear on the cable and also possible rupture of the cable due to unusual operating conditions. It is of course understood that winding drum 57 may be operated by a spring mounted within the

drum 57 and disposed to operate on the principle of a window shade roller. For smaller and less expensive grab-buckets a spring operated drum 57 would be preferable. This is especially true with my invention where the cable 21 never contains more than two conductors and in consequence is a very light cable.

In the devices heretofore known the cable 21 usually contained from four to five conductors, and it is one of the novel characteristics of my control system, that the cable for conducting the electrical energy to the electrical equipment on the grab-bucket contains but two conductors. In consequence the drum 57 and the operating mechanisms associated with it may be relatively light and inexpensive.

A more detailed understanding of my invention may be had from a discussion of Fig. 4. In Fig. 4 the controllers 9 and 14 and the supporting structure 70 are shown schematically in dotted lines. The elements 11, 12, 57, 58, 56, 71, etc. refer to the elements heretofore discussed in connection to Figs. 1, 2 and 3.

The operation of my control system to actuate the grab-bucket 60 is as follows: Assuming that trolley wires 1 and 2 are supplied with direct current voltage of a predetermined value, then upon the closing of the safety switch 8 the controller 9 is energized and when the control lever 9′ is actuated the hoist frame may be caused to move along the rail R and the motor 11 may be caused to operate. Motor 58, since it operates on the principle of a torque motor is supplied with energy under constant conditions and is thus not subject to any special control.

When the safety switch 5 is closed and the segments of the controller 14 are actuated to the right, to any position other than position 6, a circuit is established which may be traced from the positive trolley wire 1 through trolley wheel 3, safety switch 5, overload circuit breaker F, actuating coil 16 of the torque limiting relay 17, contact fingers 18 bridged by the controller segment 18′, conductor 19, slip ring 20, cable 21, conductors 22 and 23, the actuating coils of the directional contactors 24 and 26, the copper oxide rectifier 27, conductor 28, cable 21, slip ring 29, conductor 30, contact fingers 31 bridged by the controller segment 31′, conductor 32, starting resistor 33, conductor 34, overload circuit breaker F, safety switch 5 and trolley wheel 4 to the negatively energized trolley wire 2.

The copper oxide rectifier 27 operates as an electric valve, permitting current to flow only in the direction indicated by the arrow. Furthermore this rectifier is well known in the trade and is of very rugged design, capable of withstanding severe shocks and other abuses in service over long periods of time without undergoing any material changes in operating characteristics.

Immediately upon operation of directional contactors 24 and 26 a circuit is established which extends from the positively energized conductor 22 through the coil of the magnetic brake 35, the series field windings 36 of the motor 56, jamming resistor 37, conductor 38, the contact members of the directional contactor 24, conductor 39, the armature 40 of the motor 56, conductor 41, the contact members of the directional contactor 26 to the negatively energized conductor 28. It will be noted that during the closing operation of the jaws 61 of the grab-bucket 60, the armature shunt resistor 54, is not connected in shunt relation to the armature 40, but is connected in shunt relation to the circuit extending from the junction 69 through the contacts of the directional contactor 24 to the junction 68. Since this last traced circuit is of low resistance value, the effect of resistor 54 is unimportant.

Movement of the controller segment 42′ to bridge the contact fingers 42, that is movement of the controller drum 14 to position 6 establishes a circuit which extends from the right hand terminal of the energized coil 16 through the contact fingers 42 bridged by the controller segment 42′, the actuating coil of the accelerating relay 43, conductor 44, back contacts of torque-limit relay 17 to the negatively energized conductor 34. Operation of the accelerating relay 43 establishes a shunt circuit for the starting resistor 33.

If during the closing of the jaws an obstruction is encountered by the jaws, it is very desirable that the jaws be not urged to closed position by an excessive force, first, because of the danger to the electrical equipment resulting from the heavy current thus taken from the line and second, because it is usually desirable not to crush the object intermediate the jaws. In the devices of the prior art, a friction clutch was generally provided which, during the conditions just specified, would slip and thus permit continued rotation of the motor. It is thus obvious that mal-adjustment of the friction clutch may nevertheless cause damage to the motor and at the same time crush the object intermediate the jaws. Further, if the friction clutch be adjusted too loosely the object intermediate the jaws may drop after having been hoisted to a considerable height with consequent danger to attendants and workmen in the vicinity of the hoist.

To eliminate the undesirable characteristics just outlined, I have provided the torque limiting relay 17. If, during a closing operation of the jaws, an obstruction is encountered and an excessive current is taken by the motor then the actuating coil 16 operates to open the back contact members of the

torque limiting relay and to close the main or upper contact members of the relay. Interruption of the circuit at the back contact members of the relay 17 removes the shunt circuit from the starting resistor 33, and the motor is supplied with energy through resistor 33 and the jamming resistor 37. The motor will thus stall and operate on the principle of torque motor to resiliently hold the object intermediate the edges of the jaws without crushing the object and without drawing an excessive current from the line. Closing of the upper contact members of the torque-limit relay 17 merely establishes a holding circuit for the relay 17 through the coil 46, thereby preventing chattering of the relay.

During the stalling of the motor, as just explained, the voltage impressed on the coils of the closing directional contactors decreases, but since these coils are connected in parallel circuit relation with the coil of the magnetic brake 35, the series field windings 36 and the jamming resistor 37 connected in series, the voltage impressed on the coils of the closing directional contactors is sufficient to maintain the motor circuit.

During the opening operation of the grab-bucket 60 the controller 14 is moved to the left thereby causing the bridging of contact fingers 53 and 47 by controller segments 53′ and 47′. A circuit is thus established which may be traced from the positively energized right hand terminal of the actuating coil 16 through contact fingers 47 bridged by the controller segment 47′ conductor 30, slip ring 29, cable 21, conductor 28, rectifier 27, the actuating coils of the opening directional contactor 48 and 49, conductor 50, contact members 51 of the limit switch 52, conductor 22, cable 21, slip ring 20, contact fingers 53 bridged by the controller segment 53′, conductor 32, starting resistor 33 to the negatively energized conductor 34.

Immediately upon operation of the directional contactors 48 and 49 a circuit is established which extends from the positively energized conductor 28 through the contact members of directional contactor 49, conductor 39, armature 40, conductor 41, the contact members of directional contactor 48, the jamming resistor 37, series field winding 36 and the releasing coil of the magnetic brake 35 to the negatively energized conductor 22. It will be noted that the resistor 54 is connected in parallel circuit relation with the armature 40 and in consequence the speed of the motor during the opening operation, especially if the load is overhauling, is limited to a safe value.

When the jaws 61 of the bucket 60 have opened completely and also when the opening of the jaws is prevented by an obstruction, a slack occurs in cable 72 whereby the limit switch 52 is permitted to operate to open the circuit for the directional contactors 48 and 49, which in turn causes an interruption of the energy supplied to the motor 56 and locking of the magnetic brake 35.

The motor 56 is accelerated in the opening direction in the same manner as it is accelerated in the closing direction, since movement of the controller segment 42″ to bridge contact fingers 42 energizes the accelerating relay 43 which in turn establishes a shunt circuit for the starting resistor 33.

While the foregoing disclosure sets forth with particularity the circuit connection inherent in my invention and discloses the combination of these connections with the grab-bucket and the means for operating the grab-bucket, I do not wish to be limited to the specific details disclosed but wish to be limited only by the appended claims.

I claim as my invention:

1. A motor control system for an electrically operated grasping device, a grasping device, electrical devices mounted on the grasping device and including a motor for operating the grasping device, a contactor for connecting the motor to cause opening of the grasping device, a limit switch for causing the interruption of the connections established by the contactor when the grasping device fails to open in response to the normal torque of the motor and a magnetic brake for holding the operated parts of the grasping device in the position to which they were moved by the motor at the instant of the operation of the limit switch.

2. In a control system for a motor mounted on a grab-bucket having jaws, means responsive to a predetermined overload on the motor during the closing of the jaws, caused either by the fact that the jaws have completely closed or by the fact that the jaws have encountered an obstruction during closing, for reducing the armature current of the motor to cause operation of the motor on the principle of a torque motor to hold the jaws against the obstruction or in closed position.

3. In a motor control system for an electrically operated grab-bucket, in combination, a grab-bucket, electrical devices mounted on the bucket and including a motor for opening and closing the bucket, closing contactors, opening contactors, a limit switch in series with the opening contactor and responsive to abnormal opening conditions of the bucket and a magnetic brake in series with the motor, a pair of conductors leading to the electrical devices, supply lines for supplying electric energy and a controller disposed for operation to selectively connect the supply lines to the pair of conductors.

4. In a motor control system for an electrically operated grab-bucket, in combination, a grab-bucket, electrical devices mounted on the grab-bucket and including a motor

for opening and closing the bucket and closing contactors for connecting the motor to cause closing of the grab-bucket, a pair of conductors leading from the electrical devices, supply lines for supplying electric energy and a controller disposed for operation to selectively connect the supply lines to the conductors, said controller including a starting resistor, and means responsive to a predetermined excessive load on the motor during closing to decrease the armature current whereby the motor is stalled and operates on the principle of a torque motor.

5. A motor control system for an electrically operated grab-bucket having jaws, comprising, in combination, a motor mounted on the grab-bucket for opening and closing the grab-bucket, a pair of conductors leading from the motor, supply lines for supplying electric energy, a controller remote from the motor for selectively connecting the supply lines to the conductors thereby causing opening or closing of the grab-bucket depending on the connection selected by the controller, said controller including a starting resistor, means responsive to a predetermined overload on the motor during the closing of the jaws caused by an obstruction encountered by the jaws or by the fact that the jaws have completely closed, for connecting the starting resistor in series with the motor thereby causing the jaws to be held in closed position against the action of the motor operating on the principle of a torque motor.

6. In a control system for an electrically operated grab-bucket, electrical devices mounted on the grab-bucket and including a motor for operating the grab-bucket, a reversing contactor unit, a resistor connected in series circuit relation with the motor, said reversing contactor unit being connected in parallel with the motor, whereby the reversing contactor unit is maintained energized regardless of changes in counter-electromotive force of the motor, a magnetic brake and an electric valve for selectively controlling the reversing contactor unit, a source of power, two conductors leading from the source of power and a double throw controller for selectively connecting the two conductors to the source of power, said controller including a resistor, means for shunting the resistor and means responsive to a predetermined overload on the motor for deenergizing the resistor shunting means.

7. In a control system for an electrically operated grab-bucket having jaws, and having mounted thereon a motor for opening and closing the jaws, a magnetic brake, and a resistor connected in series circuit relation with the motor, opening directional contactors and closing directional contactors in parallel with the motor, brake and resistor, the resistance drop across the resistor when subject to normal operating voltage being sufficient to prevent the opening of the directional contactor when in closed position, a speed control resistor arranged to be connected in parallel with the motor armature when the motor is operating to open the jaws of the grab-bucket thereby preventing excessive speeds in the opening direction.

8. In a control system for an electrically operated bucket having a movable jaw, electrical devices mounted on the bucket and including, a motor for operating the jaw, a contactor having contact members for connecting the motor to operate the jaw and a resistor connected in series circuit relation with the motor, said contactor being connected to be responsive to the resistance drop across the resistor to prevent the actuation of the contact members to their open position, a controller, conductors connecting electrical devices to the controller, means responsive to overload on the motor for limiting the current drawn by the motor whereupon the jaw is actuated by the motor operating on the principle of a torque motor.

9. In a control system for an electrically operated bucket, electrical devices mounted on the bucket and including a motor, a magnetic brake, current limiting means for limiting the motor current when the motor is operating in one direction, means for limiting the speed of the motor when operating in the opposite direction, a reversing contactor unit and an electric valve for selectively controlling the energization of the reversing contactor unit, two conductors connected to the electrical devices, a reel for the conductors to maintain them taut, a source of power and a controller for connecting the source of power to the conductors, current limiting means mounted on the controller operating jointly and additively with the current limiting device on the bucket.

In testimony whereof, I have hereunto subscribed my name this 17th day of June, 1930.

WILLIAM R. WICKERHAM.