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LIFTING MAGNET CONTROLLER

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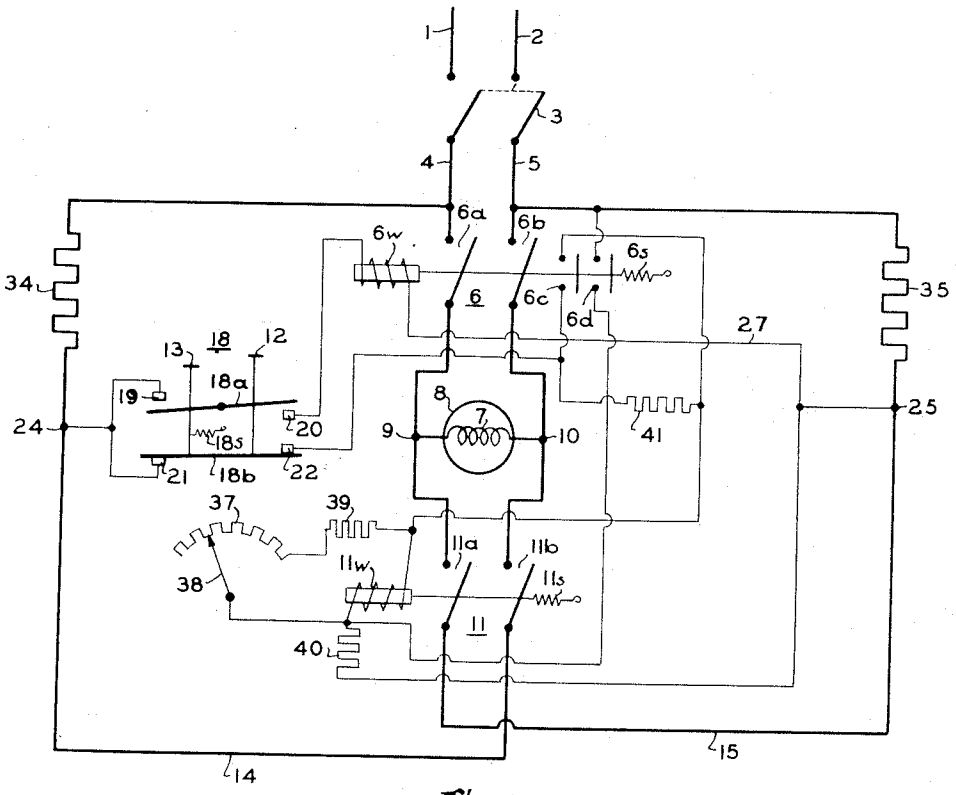


Fig. 1

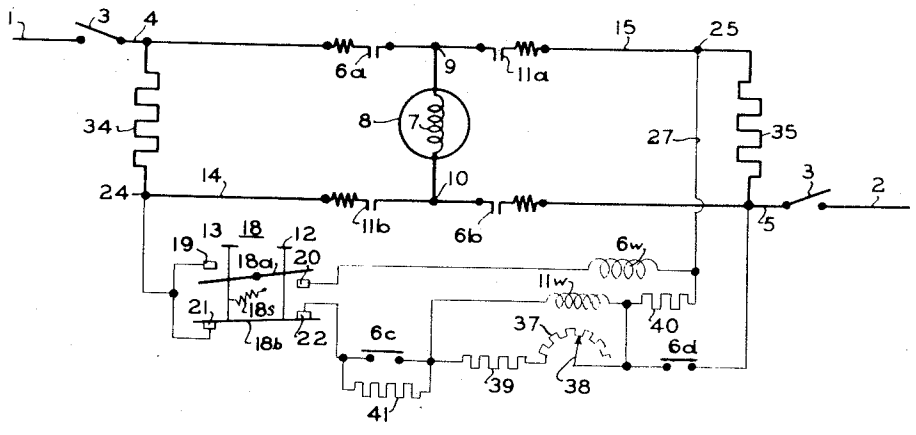


Fig. 2

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LIFTING MAGNET CONTROLLER

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8 Claims. (Cl. 175—294)

This invention relates to a control system for inductive devices, and more particularly to a protective control system for lifting magnets, power solenoids and the like.

Unless a voltage limiting protective device is used, the inherent self-inductance of a highly inductive winding will cause a high voltage to be induced consequent upon disconnection of the winding from the source of supply. This large induced voltage results in destructive arcing at the switching contacts and also causes a high voltage strain on the insulation of the winding itself and the conductors connected thereto.

In some applications of inductive windings it is common practice to connect a resistance across the terminals of the winding at the time of interruption. The use of such a resistance limits the discharge voltage and prevents destructive arcing or high voltage strains. However, the use of a resistance in this manner results in a slow decay of magnetic flux which is very undesirable in lifting magnet operation because of the resultant delayed dropping of the load.

To reduce the flux quickly and still prevent damaging induced voltages, it has been found expedient to apply reverse voltage to the winding after it has been disconnected from the source of supply. Even if this is done, it is also necessary in order to prevent the induction of destructive voltages, to provide a discharge circuit at the instant of the removal of the energization voltage. A further improvement in the control of such inductive devices is disclosed in United States Reissue Patent No. 20,274, issued on May 10, 1938, to D. C. Wright, wherein is described a control system providing for the connection of a lifting magnet to a reverse power source prior to the removal of energizing power connections and which permits the magnet to discharge into the supply source through protective resistance, which resistance also serves to prevent a short circuit across the supply circuit during the switching operation.

Among various prior control systems with which the present invention may be used is one such as described in the Wright patent which operates very satisfactorily and has eliminated nearly all of the defects of the earlier prior art devices. But one of the most common troubles experienced in the use of any lifting magnet controller has not been eliminated. This trouble is the failure of the discharge resistors and resultant open-circuit condition. One of the reasons for prevalence of this trouble is that the discharge resistors are subjected to sudden impulses of very high currents which heat them to high temperatures so that they have to be placed in an exposed position in order to permit cooling. Furthermore, they are usually mounted upon the crane which is handling the magnet and are thus subjected to very severe vibrations. This alternate heating and cooling, exposure to the elements, and vibration make it impossible to design practical resistors which will not break after a certain length of time. Another common reason for the failure of discharge resistors to limit the discharge voltage is that the conductors required to connect the controller itself to the resistors, which must be mounted in an exposed place, are often necessarily long and thus exposed to mechanical damage.

Heretofore, if a discharge resistor became open-circuited for any reason whatsoever, it was possible to continue using the magnet, with consequent deleterious arcing and possibility of damage to the magnet itself. In such cases, if the operator would refrain from reporting the damage because it would tend to delay him in completing his task, or for other reasons, or if the contactors were enclosed in a cabinet preventing the trouble from being quickly detected, the contacts on the switch supplying power to the magnet would be badly damaged or destroyed, or the insulation of the magnet would be punctured and the windings short-circuited. Although signal lights or alarm bells could be used to inform those in authority that such a break had occurred, the impracticability and additional expense of such complications in the crowded cabs of cranes using lifting magnets is readily apparent.

It is therefore an object of this invention to provide a lifting magnet control system employing resistors and wherein energization of the magnet is impossible when a discharge resistor is open-circuited.

It is a further object of this invention to provide an improved protective lifting magnet control system of this character which requires no extra equipment to render impossible the energization of the magnet as long as a discharge resistor is open-circuited.

A more specific object is to provide such a system which employs switching means for closing the circuit to the magnet and which means are so series connected with the resistors that the switching means are rendered inoperative to close the circuit when the resistors are open-circuited.

Other objects and advantages will become ap-

parent from the following specification, wherein reference is made to the drawing, in which:

Fig. 1 is a full diagrammatic diagram of a lifting magnet controller in accordance with this invention; and

Fig. 2 is a simplified wiring diagram of the same controller.

In the drawing, a source of supply is illustrated at 1 and 2 and a double-pole knife switch 3 has been provided to connect the source of supply 1 and 2 to conductors 4 and 5 which lead to an electromagnetic switch 6. The switch 6 has an operating coil 6w, normally-open main contacts 6a and 6b, normally-open auxiliary contacts 6c and 6d, and a biasing spring 6s.

A magnet winding 7 of an electromagnet 8 has terminals 9 and 10 which are connected to the conductors 4 and 5 respectively when the switch 6 is in a closed position. An electro-magnetic switch 11 having an operating coil 11w, normally-open contacts 11a and 11b, and a biasing spring 11s, is arranged to provide reverse voltage connections for the magnet winding 7 by connecting terminals 9 and 10 to conductors 5 and 4, respectively, through conductors 15 and 14 and resistors 35 and 34, respectively.

A master switch 18 controls the operation of the switches 6 and 11. The master switch 18 is preferably of the snap action type and is shown as having a toggle action spring 18s, having one end connected to a movable part of the switch 18 and the other end stationary so that when the switch 18 is moved past a dead center position, the spring 18s will cause the switch to rapidly move to one of its closed positions. The switch 18 has a lift button 12, a drop button 13, and stationary contacts 19, 20, 21 and 22. When the drop button 13 is operated, a connector 18b electrically connects the contacts 21 and 22, and when the lift button 12 is operated, a connector 18a electrically connects the contacts 19 and 20, and the connector 18b is removed from the contacts 21 and 22. The connectors 18a and 18b move simultaneously so that only one of them is completing a circuit when the master switch 18 is in one of its closed positions.

The contacts 19 and 21 are connected to the conductor 14 at a point 24, and the contact 20 is connected to one terminal of the coil 6w of the electromagnetic switch 6. A conductor 27 leads from the other terminal of the coil 6w to the conductor 15 at a point 25.

The contact 22 is connected through the contacts 6c of the switch 6 to a terminal of the coil 11w; the other terminal of the coil 11w is connected through the contacts 6d of the switch 6 to the conductor 5. Another connection from the terminal of coil 11w which is connected to the contacts 6d is through a resistor 40 to the conductor 15 at the point 25. A resistor 41 shunts the contacts 6c and completes a circuit from the contact 22 to the terminal of the coil 11w which is connected to the contacts 6c. The purpose of the resistors 40 and 41 is to reduce to a safe value the voltage applied to the coil 11w when the magnet 8 is discharging.

To provide an adjustment of the operating characteristics of the switch 11, an adjustable resistor 37 having an adjustable connector 38 is connected in parallel with the coil 11w. A fixed resistor 39 is connected in series with the adjustable resistor 37.

The control system operates as follows:

If the knife switch 3 is closed so as to apply power from the source 1 and 2 to the conductors 4 and 5, and if the lift button 12 is operated to connect contacts 19 and 20 through the connector 18a, an operative circuit is set up for the coil 6w from the conductor 4 through the resistor 34 to the point 24 on the conductor 14, through the master switch 18 by means of connector 18a to the coil 6w, and by means of the conductor 27 to the point 25 on the conductor 15, and thence through the resistor 35 to the conductor 5. Energization of the coil 6w operates the switch 6 to its closed position and power is supplied to the magnet winding 7 through a circuit which extends from conductor 4, the contact 6a, the terminal 9, the winding 7, the terminal 10, and the contact 6b to the conductor 5.

When it is desired to deenergize the magnet winding 7, the drop button 13 is operated to connect contacts 21 and 22 by means of connector 18b, and simultaneously connector 18a is removed from the contacts 19 and 20. The coil 11w of the switch 11 is then energized through a circuit which extends from the conductor 4, through the resistor 34 to the point 24 on the conductor 14, the connector 18b, through the now closed contacts 6c of switch 6, the coil 11w and through the now closed contacts 6d to conductor 5.

It is a well-known fact that the contacts of an electromagnetic switch close more quickly upon energization of its operating coil than the contacts of a similar switch open upon deenergization of its operating coil. Thus the switch 11 closes before the switch 6 opens and a discharge circuit is then provided through the power lines before the magnet is disconnected therefrom. If the natural time of opening of the switch 6 is not longer than the natural closing time of the switch 11, any of several well-known arrangements may be used either to speed up the closing of the switch 11 or to slow down the opening of switch 6, or both. For instance, a short-circuited winding may surround the core of the switch 6 to delay its demagnetization, or the coil 11w might be designed to provide an extremely large closing force. The discharge circuit extends from the terminal 10 of the magnet winding 7, through the contacts 11b, the conductor 14, the resistor 34, the conductor 4, the knife switch 3, the supply source 1 and 2, the knife switch 3, the conductor 5, the resistor 35, the conductor 15, and the contacts 11a to the terminal 9 of the winding 7. When the switch 6 opens, the discharge voltage of the magnet is opposed to the supply line voltage and when the discharge voltage, which may be twice or three times as much as the supply voltage at the beginning of the discharge, has reduced to a value equal and opposed to the applied voltage, the current in the magnet winding 7 is zero. Current now begins to flow in the reverse direction through the magnet winding 7, over a circuit which extends from the conductor 4, the resistor 34, the conductor 14, the contacts 11b, the terminal 10, the winding 7, the terminal 9, the contacts 11a, the conductor 15, and the resistor 35 to the conductor 5. The current now begins to build up in the reverse direction in the magnet winding 7 and tends to cause the remaining flux in the magnet to decrease to a zero value.

The original circuit to the coil 11w through the contacts 6c and 6d of switch 6 was interrupted when the switch 6 was opened, but the coil 11w remained energized due to the discharge voltage of the magnet over a circuit which extends from the terminal 9, the contacts 11a, the

conductor 15, the point 25, the resistor 40, the coil 11w, the resistor 41, the connector 18b, the point 24, the conductor 14, and the contacts 11b, to the terminal 10. When the discharge voltage reaches a predetermined value due to the reverse current, the operating coil 11w will be sufficiently deenergized to permit the switch 11 to open, thereby cutting off the current at the moment the magnet 8 is de-magnetized to the required degree.

The adjustable resistance 37 is provided in the circuit of the coil 11w to permit control of the value of reverse current which will allow operation of the switch 11 to its open position. By use of the adjustable resistance 37 the reverse current can be set to give the best drop on any material which the magnet 8 might be lifting and can also be adjusted for changes in line voltage. The purpose of the fixed resistance 39 is to prevent too great a current inrush through th auxiliary contacts 6c and 6d of the switch 6 upon the closure of the switch 11 in case the adjustable resistance 37 should be all removed from the circuit by means of the adjustable connector 38.

When the magnet 8 is discharged and the drop button 13 of the master switch 18 closed, a current from the source 1 and 2 flows through the coil 11w over a circuit which extends from the conductor 4, through the resistor 34 to the point 24 on the conductor 14, the connector 18b, the resistor 41, the coil 11w, the resistor 40, the point 25 on the conductor 15, and the resistor 35 to the conductor 5. The current in this circuit is not sufficient to close the switch 11, due to the high ohmic value of the resistors 40 and 41 in relation to the voltage of the source 1 and 2. Due to the fact that the resistors 40 and 41 are also included in the operative circuit previously traced for the coil 11w when the magnet 8 is discharging, it is obvious that an open circuit in either of the resistors 40 or 41 would prevent proper operation of the switch 11 and consequent destructive arcing or other damage, as is true of prior art controllers which employ resistors for a similar purpose. However, it is to be noted that no current flows through the resistors 40 and 41 when the switch 6 is closed, thus greatly reducing the heating thereof and rendering them less likely to break and cause an open circuit.

If the lift switch 6 was permitted to close, as was the case heretofore, even though the discharge resistor 34 or 35 might be burned out, the magnet winding 7 would be energized. In such case, the closing of the drop switch 11 would be of no effect, and upon the opening of the lift switch 6 a voltage of some ten times the line voltage would be induced in the winding 7 to cause a high voltage strain on the insulation and a destructive arc to be formed at the contacts of the switch 6.

By virtue of the connection of the operating coil 6w of the switch 6 to the conductor 14 at the point 24, and to the conductor 15 at the point 25, no current can flow through the coil 6w from the source 1 and 2, and the switch 6 cannot be operated to energize the magnet winding 7, unless both resistors 34 and 35 are in good condition. In event that either or both of these resistors should burn out or become disconnected for any reason, no current can be supplied to the operating coil 6w and consequently no power can be applied to the magnet winding 7. Thus it is impossible for the operator of the magnet to use the magnet unless the discharge resistors which limit the discharge current to a safe value are in condition to perform their proper function.

Having thus described my invention, I claim:

1. In a control system for a lifting magnet, a source of power, switching means for connecting the winding of the lifting magnet directly to the source of power, resistance means, reverse switching means for connecting the winding to said source through said resistance means for applying reverse power to said winding, electromagnetic operating means for said first mentioned switching means, said electromagnetic operating means being connected to the source of power in series with said resistance means, whereby said electromagnetic means is rendered inoperative when said resistance means is open-circuited.

2. In a control system for a lifting magnet to be connected to and disconnected from a source of power, said system including discharge protective means for preventing the occurrence of high induced voltages upon deenergization of the magnet resulting from disconnection of the magnet from the source of power, electromagnetic switching means selectively operable to connect and disconnect the magnet to and from the source of power, means connecting said discharge protective means to the magnet, magnetic operating means energizable from the source of power for operating the switching means to connect the magnet to the source of power and being connected to the source of power through said discharge protective means, whereby the magnetic operating means cannot operate the switching means to connect the magnet to the source of power when said discharge protective means is open-circuited.

3. In a control system for a lifting magnet having an operating coil to be connected to and disconnected from a source of power, a pair of contacts connected to two opposite terminals of the coil, respectively, and to said source in series with the coil, a resistor connected to one of said terminals of the coil and forming a parallel circuit with the coil and with the one of said contacts which is connected to the other of the said two terminals of the coil, the parallel circuit being in series with the other contact of said pair across the source of power, another resistor connected to said other of said terminals of the coil and forming a parallel circuit with the coil and with the contact which is connected to the said one of said terminals of the coil, the second parallel circuit being in series with the said one of said contacts across the source of power, switching means for opening both of said contacts concurrently, whereby, when the contacts are open, the coil remains connected to said source of power in series with said resistors, thereby reversing the power applied to the coil, and electrically operated means operable when energized for closing said contacts and holding said contacts in closed position and operable when unenergized for opening said contacts, and said electrically operated means being connected to the source of power in series with both of said resistors, whereby the switching means are rendered inoperative for closing the contacts when either one, or both, of said resistors are open-circuited.

4. In a control system for a lifting magnet, switching means for closing a circuit through said magnet from a current supply source, electromagnetic operating means for closing said switch-

ing means, means for dissipating the inductive discharge of the magnetic field while the magnet is being deenergized, said dissipating means being connected to said source, and a discharge circuit connecting the magnet to said discharge dissipating means, said electromagnetic operating means being connected to said source through a point on said discharge circuit between said discharge dissipating means and said magnet, whereby said switching means cannot be operated if said discharge circuit is open-circuited between said point of connection and said source.

5. In a control system for a lifting magnet, resistance means, switching means to complete a circuit for said magnet exclusive of said resistance means, switching means to complete a circuit for said magnet inclusive of said resistance means, said second-named switching means being in said second-named circuit between the magnet and said resistance means, and electromagnetic operating means for the first-named switching means, said operating means being connected for energization to a point on said second-named circuit between said second-named switching means and said resistance means.

6. In a control system for a lifting magnet, switching means for closing a circuit through said magnet from a current supply source, electromagnetic operating means for closing said switching means, means for dissipating the inductive discharge of the magnetic field while the magnet is being deenergized, said dissipating means being connected to said source, and a discharge circuit connecting the magnet to said discharge dissipating means, said electromagnetic operating means being connected for energization only in response to currents flowing in a circuit completed by said discharge dissipating means, whereby said switching means cannot be operated if said discharge dissipating means is open-circuited.

7. The combination with a control system for a lifting magnet and a source of power therefor, including switching means normally operable to connect the lifting magnet to the source of power and a discharge circuit connected to the magnet and including a discharge resistor, of means to constrain said switching means from said normal operation when said discharge resistor is open-circuited.

8. The combination with a control system for a lifting magnet to be connected to a source of power, said system including switching means normally operable to connect the magnet to the source of power, means to disconnect said magnet from the source of power, and resistance means connected to the magnet to limit the discharge voltage of the magnet, of means operative to render said switching means inoperative to connect the magnet to the source of power when said resistance means is open-circuited.

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