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ELECTRICAL EQUIPMENT

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Fig. 1.

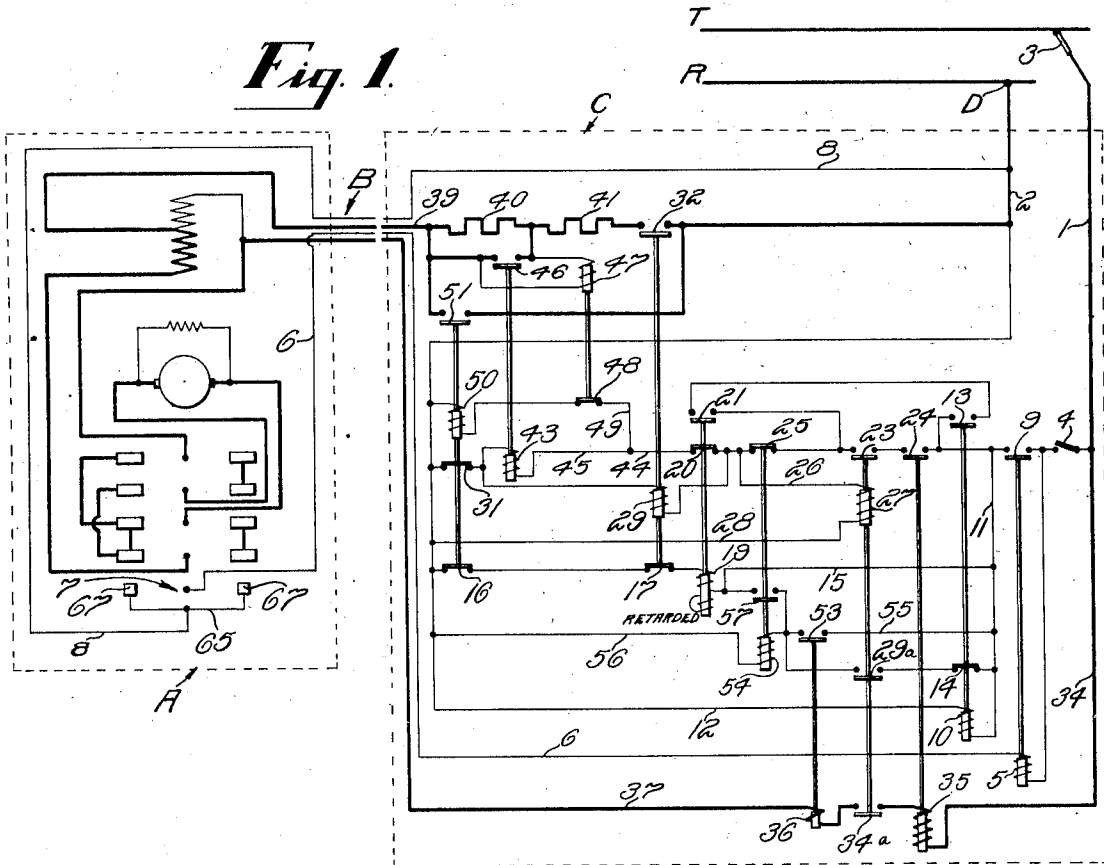
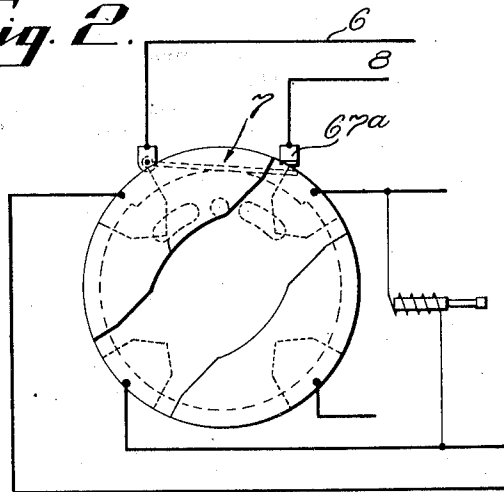


Fig. 2.



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ELECTRICAL EQUIPMENT

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11 Claims. (Cl. 172-288)

This invention relates to improved electrical control equipment and circuits, especially adapted for coal mining machines or other coal mining equipment wherein a high degree of safety is desired in addition to ease and positiveness of operation.

In the operation of coal mining equipment of the electrically driven type, it is usual to run cables from the main line located in the entry to the mining equipment such as coal mining machines or trucks which may be disposed or traveling at a considerable distance from the main line. In my improved arrangement it is desired to effect certain automatic operations such as are disclosed in my co-pending application, Serial No. 329,928, filed Jan. 2, 1929 (now Patent No. 1,844,910), and to have the principal controls and circuits disposed near the main line with a suitable pilot circuit mounted on the mining equipment for placing the main control circuits in operation or cutting them out. It is further desirable to have the arrangement such that when the mining equipment is being transported the operator may in the usual manner simply place the trolley against one of the main lines comprising the trolley wire and when it is desired to stop, to pull the trolley off. Thus the operator may make intermittent contacts of the trolley with the trolley wire to control the rate of transportation or the distance he may wish to travel. It is also desirable to eliminate the necessity for any attention on the part of the operator other than either to close the pilot circuit or operate the trolley, and yet insure the utmost safety in the way of not allowing the motor to have full current thrown thereon when the trolley is touched to the wire while at the same time insuring that the motor will be promptly brought up to full speed when the circuits are initially closed. Other desired features include safety controls such as overload and low voltage controls.

It is an object of my invention to accomplish the above and other functions in an improved manner over that disclosed in my above mentioned co-pending application and any applications that might be incorporated therein, and also to provide improved means for breaking both lines of the motor circuit thus necessitating in actual practice the use of a double main line contactor.

Other objects and advantages will be more apparent to those skilled in the art and other modifications and arrangements will likewise be apparent to such persons from the following de-

scription of the accompanying drawing in which,

Fig. 1 is a wiring diagram showing diagrammatically the circuits and controls; and

Fig. 2 is a diagrammatic view of one portion of a preferred form of switch which is mounted upon the mining machine.

In the illustrative embodiment of the invention the electrical portions of a mining machine proper are diagrammatically illustrated at A. B represents a multi-wire flexible cable which serves to connect the mining machine with a controlling mechanism generally designated C, which is preferably arranged in a box or the like upon a truck. The mining machine A may be of a type which works when supported directly upon the mine bottom and at a distance from the truck or it may form an integral part of a "mounted" mining machine which performs its cutting operations while supported upon the wheels of the truck. In such a case the cable B will not be of great length, though when the controlling system is used for a machine of the dismountable type, the machine A may be at a substantial distance from the control apparatus C at times, so that the cable B may necessarily be of substantial length. During transport, however, the machine A may be mounted directly upon the truck and therefore in close adjacency to the control apparatus C. Irrespective of which type of mining apparatus is employed, current may be supplied to the apparatus as a whole from a trolley wire T and a track rail R, and during control of the apparatus during transport from place to place control may be conveniently effected by intermittently making contact with the trolley wire T through a trolley clip 3, it being understood that the power for effecting transport will preferably be derived from the motor forming a part of the mining machine.

It is to be understood that this improved control system is in no sense, however, limited to use with mining apparatus, though it finds a very advantageous field for employment with such mechanisms.

Referring more particularly to the drawing, two main control leads 1 and 2 are shown as connected respectively to the sides of the main line T. R, as by a trolley clip or contact 3 and any other contact device D whose form depends on the circumstances. While main control leads have been shown for simplification, it is, of course, understood that the wiring may and most likely will assume a form of lay-out such as will be suitable for the machine with which it is associated or the operating elements therefor. In

the operation, the operator first closes main control switch 4 whereupon current flows from control lead 1 through solenoid 5 and pilot wire 6 on through the machine pilot control associated with the mining machine and generally indicated at 7, and thence back to the main line as by pilot wire 8. Completion of this circuit is of course dependent upon the operator closing a pilot switch 67 in the control of the mining machine A. Energization of solenoid 5 closes switch 9 thereby energizing low voltage coil 10 by current flowing through wires 11 and 12 back to the other control lead 2, thus closing switch 13 and opening a switch 14, later described. Simultaneously with supply of current to solenoid 10, current flows through a circuit including a conductor 15, a coil 19, whose construction and characteristics will later be described, and a pair of normally closed switches 17 and 16. The coil 19 controls a pair of switches 20 and 21, of which the former is opened and the latter closed when the coil 19 is supplied with current. Closure of switch 21, since switch 13 is already closed, permits current to flow through conductor 1, switches 4, 9, 13 and 21, a normally closed switch 25, wire 26, a solenoid 27 and a further conductor 28, to the conductor 2. Energized solenoid 27 closes a contactor 34^a disposed in one of the motor leads 34 which is connected to the lead 1. It also closes a switch 29^a and a switch 23, whose functions will later appear. Simultaneously with energizing of solenoid 27, current flows through conductor 1, switches 4, 9, 13, 21 and 25 through a solenoid 29 and a normally closed switch 31 to the lead 2, thereby causing solenoid 29 to close the motor contactor 32 and at the same time to open the switch 17 previously mentioned. It may here be noted that both leads to the motor are practically simultaneously closed, one by contactor 34^a, and the other by contactor 32, and thus a circuit including the full resistance 40, 41 in series with the motor is established, this circuit including conductors 1 and 34, a solenoid 35, contactor 34^a, overload relay coil 36, conductor 37, the motor windings, conductor 39, the resistances 40, 41, contactor 32, and lead 2. Solenoid 35 closes a switch 24, which, with the switch 23 closed, establishes a current path in parallel with that controlled by the switches 13 and 21.

Upon closure of switch 32 it will be noted that current flows through a coil 47, in parallel with resistance 40, thereby opening a switch 48, later mentioned in more detail. Closure of switch 32 is accompanied by opening of switch 17, as previously noted, thereby causing deenergizing of solenoid 19 and closing of switch 20 and opening of switch 21. However, the action of solenoid 19 upon being deenergized, with the consequent opening of switch 21, is sufficiently delayed so that series relay 35 has closed switch 24 before switch 21 opens, so that the main control circuit through the solenoid 29 is maintained by current flowing through the main control lead 1, switches 4, 9, 24 and 23, switch 25, coil 29, switch 31, and back to the control lead 2. The element described as solenoid 19 may advantageously take the form of a copper jacketed core, electromagnet, so constructed that on breaking of the circuit through the winding the magneto motive force will be maintained for a definite interval before the parts controlled thereby will move.

To cut out the motor circuit resistance in steps and thereby suitably increase current flow to the motor, upon deenergization of solenoid 19 and

consequent closure of switch 20, a solenoid 43 is energized as by current flowing from the conductor 1 through switches 4, 9, 24, 23, 25, 20, wires 44, 45, and switch 31 to the other control lead 2. Energization of solenoid 43 closes switch 46 thereby shunting resistance 40 and permitting increased current flow to the motor. It will be noted that upon closure of switch 46 solenoid 47, which was energized when current initially flowed through wire 39, is deenergized, being short-circuited, to permit the closure of its switch 48, whereupon current flows between the control leads 1 and 2 as by way of switches 4, 9, 24, 23, 25 and 20, wires 44 and 49, switch 48, a solenoid 50, and back to the control lead 2, whereupon energization of the solenoid 50 causes closure of a switch 51, thereby entirely cutting out resistances 40 and 41. Closure of switch 51, however, is accompanied by opening of switches 31 and 16, whereby even though solenoid 29 deenergizes, and permits reclosure of switch 17, still solenoid 19 will not be reenergized to open switch 20 so as to disturb the energization of solenoid 50, because switch 16 by being open prevents reenergization of solenoid 19. The making of the element designated solenoid 47 of a relatively high self-inductance insures a suitable delay between the closure of switches 46 and 51.

Upon occurrence of a predetermined overload current, solenoid 36 will be sufficiently energized to close the overload switch 53, thereby energizing solenoid 54 by current flowing through a wire 55, switch 53, solenoid 54, a wire 56 and thence to control lead 2. Energization of solenoid 54 closes a holding circuit switch 57 and opens switch 25, thereby causing opening of main motor switch 51, and maintaining of the same open due to solenoid 54 being maintained energized by current flowing from wires 11 and 15 through switch 57 and solenoid 54 to wires 56 and 2, the latter being not affected by opening of switch 25. Thus the motor circuit cannot be automatically reestablished until the overload condition is eliminated. To attempt automatic reestablishment of the motor circuit it is first necessary to break the holding circuit for solenoid 54 and this involves opening of the pilot switch on the machine A to deenergize solenoid 5 and open switch 9, or the panel switch 4 may be opened likewise to deenergize solenoid 5. In either case, opening of switch 9 breaks the holding circuit through wires 11 and 15 and switch 57, to thus deenergize solenoid 54 and permit reclosure of switch 25. Hence upon manually reclosing either panel switch 4 or the pilot switch 67, solenoid 5 will be reenergized and the sequence of starting operations automatically initiated. However, if the overload conditions still prevail the overload coil 36 will be reenergized when the motor current reaches the predetermined amount, thus again effecting opening of switch 25 and breaking the motor circuit. The operator can of course intermittently break or close the pilot switch 67 of the panel switch 4 until the overload condition is eliminated, it being noted that throughout any of these operations the machine or equipment is not endangered, for the various switches and resistances 40 and 41 are automatically controlled and each time the motor circuit is broken both power connections are broken as by switches 34^a and 51. This adds considerably to the safety of operation. When the overload condition is finally corrected, the equipment will continue to function and the motor starting resistance will

finally be automatically cut out entirely, thus requiring not only a minimum amount of attention on the part of the operator as far as the electrical controls are concerned, but also providing a high degree of safety and effectiveness of operation.

If low voltage occurs, solenoid 10 is deenergized thereby opening switch 13 and closing switch 14. Current thus flows from control lead 1 through wire 11 and switches 14 and 29^a to energize solenoid 54 and thus open switch 25 and close holding circuit switch 57. The motor circuit switch 51 is thereby opened in the same manner as previously described for the overload condition. Before the motor circuit can be reestablished normal voltage must be restored, whereupon low voltage solenoid 10 is reenergized to open switch 14 and close switch 13, thereby permitting the sequence of starting operations.

Due to breaking both lines 34 and 39 of the motor circuit, it is necessary to provide a return pilot wire 8 and connect the same to the wire 2 on the line side of switch 51 so as to permit current to be supplied to the solenoid 5 when the pilot switch on the mining machine A is closed. Inasmuch as the controller, mounted on the mining machine, and its circuits have been described in detail in Patent No. 1,844,910, it is not necessary to describe the same again. It may be said, however, as to Fig. 1 which diagrammatically shows two pilot contacts 67, that the two contacts may be connected by a conductor 65 and by the latter to return pilot wire 8; while as actually used in a preferred construction, a pivoted type pilot switch element is movable to connect conductor 6 with return pilot wire 8 upon engagement with a stationary contact 67^a.

Another important improvement presented by my improved controlling mechanism resides in the fact that a system particularly useful in trolleying about a mine is provided. It will be noted that by breaking the circuit, as by removing the trolley clip 3 from contact with the trolley wire, the entire motor control system will immediately be returned to "off" condition and upon reapplication of the trolley clip to the trolley wire, the entire sequence of operations including the initial making of a circuit through all the resistance and the step by step cutting out of the resistance will automatically take place, there being no possibility of injuring the motor by the passing of full line current directly through the motor windings when the latter is stationary or barely turning over because by reason of the relationship of the various control elements, initial establishment of any circuit through the motor necessarily includes all the resistance.

From the foregoing it is seen that I have provided an improved control, having all of the desired characteristics which are conducive to safety and effectiveness of operation, including for instance the breaking of each motor line as by switches 34^a and 51 without interfering with operation of the pilot circuit, thus permitting the operator to remain at the machine and effect any desired control over the various circuits.

While there is in this application specifically described one form which the invention may assume in practice, it will be understood that this form of the same is shown for purposes of illustration and that the invention may be modified and embodied in various other forms without departing from its spirit or the scope of the appended claims.

What I claim as new and desire to secure by Letters Patent is:

1. In combination, an electric motor having a plurality of terminal leads, a starting resistance, and means for connecting said motor leads to the opposite sides of a power line including switch devices for simultaneously connecting one of said leads with one side of said power line and the other of said leads through said starting resistance with the other of said power lines, and means for automatically thereafter cutting out said resistance and connecting said second lead directly to said second mentioned side of said power line including controlling devices one of which is associated with and moves with each of said switch devices.

2. In combination, an electric motor having a plurality of leads, a starting resistance, and means for connecting said motor leads to the opposite sides of a power line including switch devices for simultaneously connecting one of said leads with one side of said power line and the other of said leads through said starting resistance with the other of said power lines, and electro-magnetic means for automatically thereafter cutting out said resistance in a plurality of steps and connecting said second lead directly to said second mentioned side of said power line, said electromagnetic means having a controlling circuit containing switches one of which is governed by movement of one of said switch devices and another of which is governed by movement of another of said switch devices.

3. In an electric motor control-system, a motor having terminal power leads, main power lines, a resistance, a plurality of switches, including switches for respectively connecting the different leads of said motor with the power lines, arranged first to connect the motor to the lines through the resistance and then in suitably timed relation to cut out the resistance, electro-magnetic means arranged to be energized to effect closing of each of said switches, control circuits for supplying current to said electro-magnetic means to effect operation of said switches in predetermined order including switches one moved by each of the electro-magnetic operating means for the switches which respectively connect the different motor leads with the power lines, and an operator controllable switch governing said control circuits.

4. In an electric motor control system, a motor having terminal power leads, main power lines, a starting resistance, a plurality of switches including a switch for connecting one motor lead through the resistance to one power line, a switch for connecting the same motor lead to the same power line independently of said resistance, and a switch for connecting another motor lead to another power line independently of the resistance, electro-magnetic means for operating said switches, control circuits for supplying current to said electro-magnetic means to effect a closing of said first and third switches together and subsequent closure of said second switch including switches moved by the electro-magnetic operating means of each of said three switches, and an operator controlled switch governing said control circuits.

5. In an electric motor control system, a motor having power leads, main power lines, a starting resistance, a plurality of switches including a switch for connecting one motor lead through the resistance to a power line, a switch for connecting the same motor lead to the same power line independently of the resistance, and a switch

- for connecting another motor lead to another power line independently of said resistance, electro-magnetic means for operating each of said switches, a control circuit for supplying current to said electro-magnetic means to effect operation of said switches in predetermined sequence, and means for automatically breaking the circuit through the electro-magnetic means for operating the switch for connecting the motor lead through the resistance to a power line, on closing of the second mentioned switch, and an operator controllable switch in said control circuit.
6. In an electric motor control system, a motor having power leads, main power lines, a starting resistance, a switch for connecting one of said motor leads to a power line independently of the resistance, switches for connecting another motor lead to a different power line through said resistance and for progressively cutting out said resistance in a predetermined manner including a switch for connecting the last mentioned power lead to the last mentioned power line independently of the resistance, electro-magnetic means for operating each of said switches, a control circuit for supplying current to said electro-magnetic means to effect operation of said switches in predetermined sequence, and mechanical means for automatically breaking the circuit through all of said electro-magnetic means except the ones for operating the last switch and the first mentioned switch on the closing of the last switch, and an operator controllable switch in said control circuit.
7. In combination, an electric motor having power leads, power lines constituting the sole source of current supplied to the motor windings, and automatic controlling apparatus for said motor including a starting resistance, electro-magnetically actuated contactor devices for simultaneously connecting each of the motor leads with the lines, with the starting resistance in series with the motor, and thereafter automatically cutting out the resistance, controlling means for said contactor devices including a pilot circuit and automatically controlled circuits for effecting serial operation of said contactor devices, certain of said automatically controlled circuits including a relay responsive to low voltage and automatically operative to effect reinsertion of the resistance in the motor circuit, but inoperative to maintain the motor disconnected from the line, on a substantial drop in line voltage.
8. In combination, an electric motor having a plurality of power leads, a resistance, a power line, automatic controlling apparatus for connecting said motor to the line initially through the resistance and operative gradually to cut out said resistance and place the motor directly on the line, said automatic controlling apparatus including contactors controlling each of the motor leads, and having a common pilot control circuit, and means operative upon a predetermined reduction in line voltage for automatically resetting said controlling apparatus so as to connect the motor to the power line through the resistance, and on return of the normal power supply, gradually to cut out said resistance and place the motor directly on the line after a predetermined time interval.
9. In combination, a source of power, a motor, said motor having a plurality of power leads, a resistance, primary circuit making and resistance short-circuiting contactors operating in sequence for connecting the motor to a source of power through said resistance and gradually cutting out said resistance, said primary circuit including contactors controlling each of the motor power leads, and means including a relay operative on a predetermined drop in line voltage to effect opening of all closed resistance controlling contactors and to connect the motor through all said resistance to the power line through said primary circuit making contactors whereby said controlling apparatus must again function to cut out the resistance on return of the normal power supply.
10. In combination, an electric motor having leads, a power line constituting the sole source of current supply to the motor windings, automatic controlling apparatus including an adjustable resistance, a plurality of resistance controlling contactors and a plurality of motor lead controlling contactors, for controlling supply of power to the motor initially at reduced voltage and finally at full line voltage, a control circuit for controlling each of said contactors, and means including a low voltage relay operative in response to a substantial voltage drop in the power supply to interrupt the control circuit for the final contactor and on recurrence of normal voltage to establish a circuit through the initial contactor to permit starting of the motor through said resistance.
11. In combination, a motor, a reverse switch, conductors associated therewith including a pair of leads constituting terminal connections for the motor and reverse switch irrespective of the connections effected by the latter, a resistance, power lines, contactors respectively operable to connect one of said terminal connections with one of said power lines independently of said resistance and to connect the other of said terminal connections with the other of said power lines through said resistance, resistance short-circuiting contactors for respectively shunting a part of said resistance and shunting the whole of said resistance and also the second mentioned one of said first mentioned contactors, and electro-magnetic operating means for said several contactors including circuits for effecting closure of said first mentioned contactors substantially simultaneously, subsequent closure of said contactor for shunting part of said resistance, and finally closure of said second mentioned resistance short-circuiting contactor, said circuits including means for causing opening of all of the closed contactors except the first mentioned contactor on closure of said second mentioned resistance short-circuiting contactor.

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