

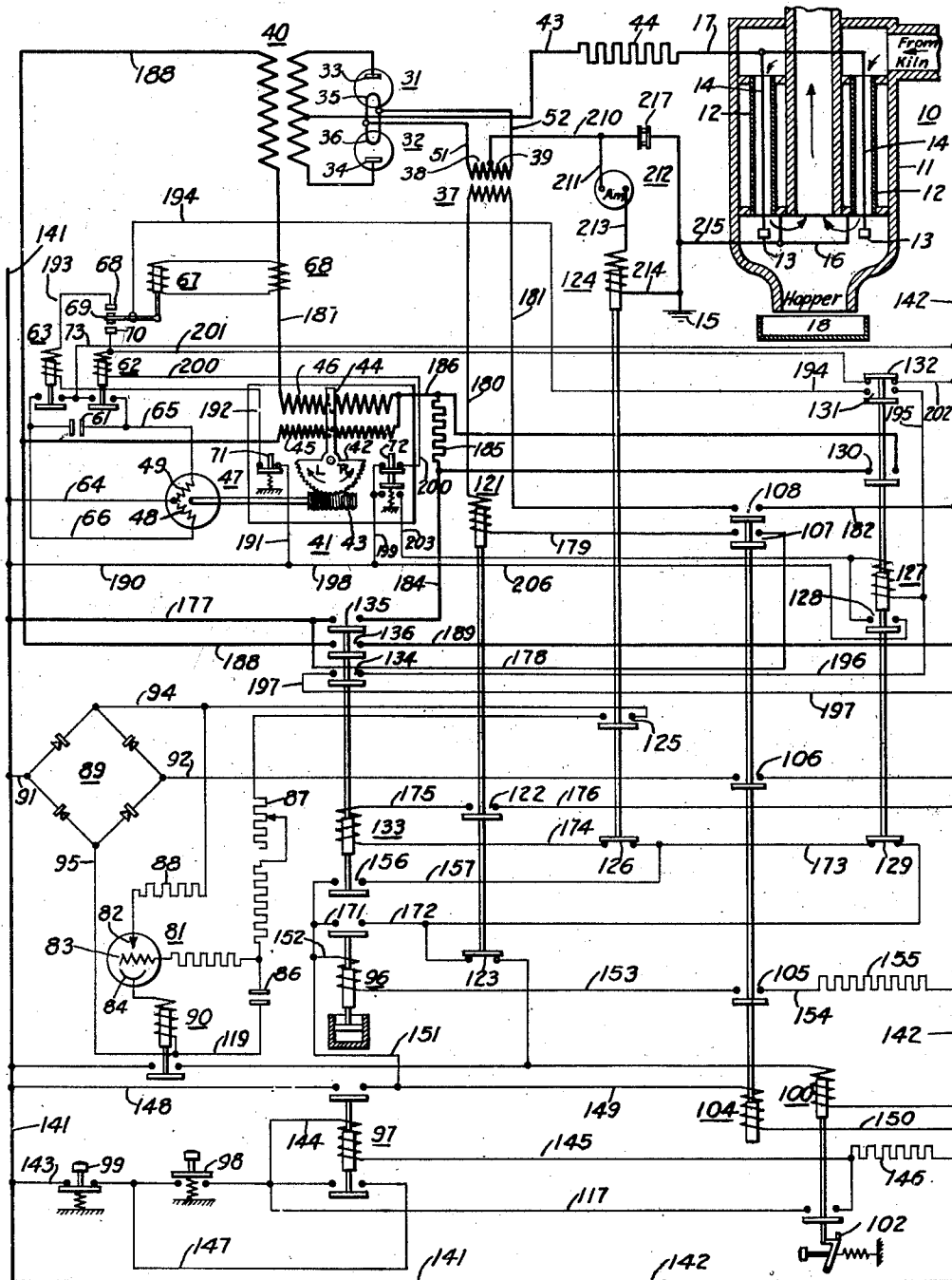
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CONTROL SYSTEM

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CONTROL SYSTEM

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My invention relates generally to control systems and more in particular to a control system that may be utilized with a precipitating device for electrically separating suspended particles from gases.

An object of my invention is to provide a control system of the class indicated that shall be simple and reliable and be readily and economically manufactured and installed.

10 Another object of my invention is to provide for supplying the discharge electrodes of an electrical precipitating device with a uni-directional current of high potential relative to said collecting electrodes of said devices.

15 It is also an object of my invention to provide for deenergizing the discharge electrodes of an electrical precipitating device when an integrated over-load condition of said electrodes attains a predetermined value.

20 A further object of my invention is to provide for intermittently deenergizing the discharge electrodes of an electrical precipitating device as long as an overload condition persists on said electrodes, and for continuously deenergizing the
25 said electrodes when an integrated overload condition of said electrodes attains a predetermined value.

A still further object of my invention is to provide for disconnecting the discharge electrodes
30 of an electrical precipitating device from the supply source when a momentary overload condition occurs on said electrodes, and for reconnecting the said electrodes to said supply source at a relatively predetermined low potential, which
35 gradually increases to a relatively high predetermined potential which represents the stabilized operating voltage condition.

A still further object of my invention is to provide for decreasing the potential upon the
40 discharge electrodes when the load condition that corresponds to the said high predetermined value increases, and for increasing the said potential when the load condition that corresponds to said high predetermined value decreases.

45 Other objects of the invention will hereafter become apparent. For a fuller understanding of the object and the nature of my invention, reference may be had to the accompanying drawing which illustrates a diagrammatic view of my
50 control system shown in connection with an electrical precipitating device.

Generally, my control system comprises an electrical precipitating device 10, two high voltage rectifying tubes 31 and 32, a filament transformer
55 37, a transformer 40, an induction regulator 41, a

grid glow tube 81 with its associated potentiometer circuits, and a plurality of cooperatively associated relays.

The electrical precipitating device 10 comprises an enclosure 11 that surrounds the base portion 60 of a smoke stack for steel mills and the like. Mounted within the enclosure 11 and surrounding the smoke stack are a plurality of a nest of vertically disposed pipes 12.

As illustrated, the gases enter the upper portion 65 of the enclosure 11 from the right, and thence is forced downwardly through the vertical pipes and then upwardly through the smoke stack to the atmosphere. Disposed axially and extending through each of the vertical disposed tubes 12, is
70 a conductor 14.

For the purpose of maintaining the wires taut, weights 13 are suspended from the lower ends of each of the conductors 14. The vertically disposed tubes 12 are generally referred to as collecting tubes or electrodes, and the conductors 14, as discharge electrodes, and will hereinafter be referred to as such.

When the electrical precipitating device is in operation, the discharge electrodes 14 are charged
80 with a uni-directional current of extremely high negative potential relative to the collecting electrodes 12. In actual practice, the potential may vary from 30,000 to 75,000 volts, depending upon the design of the installation.

The removal of the particles suspended in the gas or air as it passes downwardly through the vertically disposed pipes, is accomplished by the utilization of the strong electrical field established around each of the conductors or discharge electrodes. Such a field causes ionization of the gas, which is accomplished by the familiar corona
85 discharge. When the gas is ionized, the negative electrons of the molecules are separated from the positively charged nuclei or positive ions. These
90 electrons may remain free or may unite with other neutral molecules to form negative ions.

The ions and electrons become attached to the suspended particles in the air, which thereby become negatively charged. The negatively charged particles then behave according to the law of electrostatic attraction, and, in consequence, are repelled by the negatively charged
100 discharge electrodes 14 and attracted by the positively charged collecting electrodes 12.

Just as soon as the particles are attracted to the sides of the collecting pipe, they immediately fall by means of gravity into a hopper 18, which may periodically be cleaned out by an attendant as the said particles collect in the hopper. There-
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fore, as the gas enters the bottom of the smoke stack, it is free from the particles and emitted to atmosphere as substantially pure and clean gas.

From experience, I find that uni-directional current on the discharge electrodes gives better results than alternating current, and also that best results are obtained when the discharge electrode is of negative polarity. This is because the speed of the electrons is much higher than the positive ions, so that more effective ionization by collision of electrons with suspended particles is obtained.

For the purpose of supplying uni-directional current to the discharge electrodes, I employ two high voltage rectifying tubes 31 and 32 connected in circuit to effect full wave single phase rectification. The rectifying tubes 31 and 32 are similar, the former having a plate 33 and a filament 35, and the latter having a plate 34 and a filament 36.

In a rectifying vacuum tube of this type, the container is exhausted to a high degree of vacuum, and current can only flow through the space between the plate and the filament when the filament is negative. Therefore, when one or the other of the tubes is passing current, the inoperative tube is resisting the flow of the current.

As illustrated, the filaments 35 and 36 are heated by the secondary winding of the filament transformer 37. The plates 33 and 34 are each connected to opposite terminals of the secondary of the transformer 40, having a central terminal that is connected to the discharge electrodes 14 through means of a conductor 43, a high tension protective resistor 44 and a conductor 17. The primary winding of the transformer 40 when energized with a low voltage induces an extremely high voltage for charging the discharge conductors 14.

The induction voltage regulator 41, comprises a series stator winding 46, an exciter rotor winding 45, a semi-circular worm gear wheel 42 having an extended arm 44, a complementary worm 33 driven by a single phase alternating current motor 47.

Although not shown, the exciter rotor winding 45 is actuated by the semi-circular gear wheel 42, to assume different positions relative to the series stator winding 46. In the central position, as shown, the plane of the exciter rotor winding 45 is disposed perpendicular to the plane of the series stator winding 46, with the result that the exciter winding has no effect upon the voltage across the series stator winding.

However, as the semi-circular gear wheel 42 rotates in a clockwise direction, the position of the exciter rotor winding changes relative to the series stator winding, and the effect is such that the voltage of the exciter winding opposes the voltage of the series stator winding. When the exciter rotor winding is rotated in a clockwise direction so that its plane is parallel to that of the series stator winding, a minimum output voltage is obtained. In this position, the extended arm 44 depresses the limit switch 72, which interrupts the circuit for energizing the control motor 47.

Similarly, when the plane of the exciter rotor winding is rotated in a counter-clockwise direction until it parallels the plane of the series stator winding, the maximum voltage output is obtained. In this position, the extended arm 44 depresses the limit switch 71, which interrupts the circuit for energizing the control motor 47.

In the operation of an electrical precipitating device, a quantity of dust may collect on the sides

of the collecting pipes 14 and may even build-up to such an extent as to reduce the insulation between the discharge electrodes and the said pipes and thus cause flashovers, greatly injuring the rectifying tubes 31 and 32.

For the purpose of deenergizing the control system when such a flashover or break-down occurs, I provide a grid-glow tube 81 having an associated potentiometer circuit including the condenser 86. The grid-glow tube 81 and its associated potentiometer circuit is responsive to an integrated overload condition on the discharge electrodes 14. That is to say, the grid-glow tube functions to deenergize the control system either when a continuous overload persists for a predetermined length of time, or when a series of momentary overloads occur, the combined effect of which being equal to the total effect of the continuous flashover.

The grid-glow tube 81 comprises an anode 82, a grid 83 and a cathode 84, and when the grid potential is biased towards the anode by means of the condenser 86, a glow discharge is initiated between the grid and the cathode. In other words when a flashover occurs between the discharge electrodes 14 and the conducting pipes 12, the condenser 86 is connected to a full-wave rectifier 89 through a variable resistor 87, which builds up a high voltage in the condenser 86, with the result that when sufficient voltage exists between the grid 83 and the cathode 84 a glow discharge is initiated. When a glow is established between the grid 83 and the cathode 84, it is immediately transferred to the anode 82. When a complete discharge is effected, the grid-glow tube passes current for operating the relay 90, which in co-operation with the reset relay 100 and the master relay 97, deenergizes the control system.

The action of a grid-glow tube is like the action of a very sensitive relay. That is, it passes current between the anode and cathode when a glow discharge is established, and that it prevents the flow of current therethrough when no discharge is present.

In explaining the operation of the control system, let it be assumed that the three-phase power source represented by the conductors 137, 138 and 139 are energized and that the manually operated switch 140 is closed thereby energizing the conductors 141 and 142. When the starting push button 98 is depressed, a circuit is established for energizing the master relay 97.

This circuit extends from the supply conductor 141 through a conductor 143, a stop push button 99, the contacts of the push button 98, a conductor 144, the winding of the relay 97, conductor 145 and the current limiting resistor 146 to the supply conductor 142. The lower contact of the relay 97 when closed, effects a self-energizing circuit by means of a conductor 147 for continuously energizing the said relay when the push button 98 is released.

The closure of the upper contacts of the relay 97 establishes a circuit for energizing the relay 104. This circuit may be traced from the supply conductor 141 through a conductor 148, the upper contact of the relay 97, a conductor 149, the winding of the relay 104 and a conductor 150 to the supply conductor 142. The relay 104 when energized, completes a circuit through its uppermost contacts 107 and 108 for energizing the filament transformer 37 for heating the filaments 35 and 36 of the rectifying tubes.

This circuit may be traced from the supply conductor 141 through conductors 177 and 178, con-

tacts 107, conductor 179, the winding of the relay 121, conductor 180, the primary winding of the filament transformer 37, conductor 181, the contact 108 and conductor 182 to the supply conductor 142.

In order to insure that the filaments of each of the rectifying tubes are energized, or for insuring that the filaments are energized sufficiently before the plate transformer 40 is energized, I utilize an undercurrent relay 121 which, when insufficiently energized, prevents the circuit that energizes the transformer 40 from being completed. As illustrated, the winding of the relay 121 is connected in series with the primary of the filament transformer 37, and, when only one filament is burning or if both are burning, but of insufficient voltage, the current flowing through the winding of the relay 121 becomes insufficient to operate said relay.

Furthermore, from experience, I find that it is imperative that the filaments be energized a predetermined length of time before the transformer 40 is energized. In order to accomplish this delay, I utilize a time delay relay 96 of the dashpot type, shown illustratively, by the associated piston and cylinder. The circuit for energizing the time delay relay 96 is completed by the closure of the lower contact 105 of the relay 104. The closure of the contact of the relay 96 establishes a circuit for energizing the relay 133, which, when operated, completes a circuit for energizing the plate transformer 40. The circuit for energizing the relay 133 extends from the energized conductor 151 through a conductor 171, the contact of the relay 96, a conductor 172, the lowermost contact 129 of the relay 127, a conductor 173, a contact 126 of relay 124, a conductor 174, the winding of the relay 133, a conductor 175, contact 122, which is closed when the undercurrent relay 121 is energized, a conductor 176 to the supply conductor 142. The relay 133, when energized, effects a parallel circuit for energizing the winding thereof by the closure of its lower contact 156 together with the contact 126. This parallel circuit extends from the energized conductor 151 through the contacts 156, a conductor 157, the contacts 126, a conductor 174 to the winding of the relay 133.

The closure of the uppermost contacts of the relay 133 establishes a circuit for energizing the primary winding of the plate transformer 40. This circuit may be traced from the supply conductor 141 to the conductor 177, the contact 135, a conductor 184, a current limiting resistor 185, a conductor 186, the series stator winding 46, a conductor 187, the primary winding of the transformer 40, conductor 188, contact 136 and conductor 189 to the supply conductor 142.

From the foregoing, it is manifest that by providing the time delay relay 96, the filaments 35 and 36 of the rectifying tube are heated preparatory to the energization of the plate transformer 40. If this delay is not obtained and full voltage is applied to the plate circuit at the same time as the filaments are energized, the full voltage is effective in speeding up electrons before the filaments have reached their normal temperature. Under such conditions, the plates generally overheat and as a result cause a breakdown or a flash-over, which may cause serious damage to the rectifying tubes.

In this connection, I provide for limiting the voltage applied to the primary winding of the plate transformer 40 when it is first energized. This is accomplished by the non-variable resistor 185

that is connected in series circuit relation with the primary winding of the plate transformer 40, together with the cooperative action of the voltage regulator 41, which is operated to minimum voltage position by a circuit that is completed through the closure of the upper contact 132 of the relay 127 for energizing the relay 62, which, when closed, causes the motor 47 to operate the voltage regulator to minimum voltage position.

Therefore, the voltage impressed across the primary winding of the plate transformer 40 is decreased by the combined action of the regulator and the non-variable resistor 185.

The circuit that controls the motor 47 which operates the induction regulator to a minimum position before power is supplied to the plate transformer 40, may be traced from the supply conductor 141, conductors 190, 198 and 199, the upper contact of the limit switch 72, conductor 200, the winding of the relay 62, conductor 201, the contact 132 and a conductor 202 to the supply conductor 142. The circuit just traced energizes the relay 62, which, when closed, permits current to flow from the supply conductor 141 through a conductor 64, the upper winding 49 of the motor 47, the contact of the relay 62 and conductor 73 to the supply conductor 142. Also by means of the condenser 61, current flows from the conductor 64, through the lower windings 48 of the motor 47, a conductor 66, the condenser 61 to the closed contact of the relay. By introducing a condenser 61 in the circuit, as shown, the phase relation of the lower winding with respect to the upper winding is shifted to produce a starting torque for the purpose of starting a single-phase alternating current induction motor.

When the motor 47 actuates the extending arm 44 in a clockwise direction to a minimum voltage position, it depresses the limit switch 72 for establishing a circuit that energizes the relay 127. The circuit for energizing said relay may be traced from the supply conductor 141 to conductors 190, 198 and 199, the lower contact of the limit switch 72, a conductor 203, the winding of the relay 127, conductor 196, contact 134 and a conductor 197 to the supply conductor 142.

The closure of the contact 128 of the relay 127 completes a self-energizing circuit for continuously energizing the said relay. This circuit parallels the lower contact of the limit switch 72 and extends from the energized conductor 198 through a conductor 206, the contact 128 and to the winding 127 of the relay.

The relay 127, by means of the opening of contact 132, excludes the relay 62 that controls the motor for actuating the induction regulator to minimum position, and, by means of the closure of the contact 131, connects the relays 62 and 63 in circuit relation with the contacts of the relay 67, so that the operation of the motor 47 is responsive to the current induced in the current transformer 68 that is connected in circuit with the primary winding of the plate transformer 40.

Therefore, when the relay 127 is closed, the induction regulator stabilizes the voltage across the primary winding of the transformer 40 in accordance with the load conditions existing in the electrical precipitating device 10.

For the purpose of permitting full voltage to be impressed across the primary winding of the transformer 40, the closure of the contact 130 of the relay 127 also excludes the non-variable resistor 185 from the primary winding of the transformer 40. Suppose, for illustration, that the

load on the electrical precipitating device decreases below the normal predetermined operating value. Under such condition, the current induced in the current transformer 68, accordingly decreases which weakens the energization of the relay 67 and thus causes the movable contact 69 to swing upwardly to engage the contact 68.

The closure of the contacts 68 and 69 completes a circuit for energizing the relay 63, which causes the motor 47 to actuate the induction voltage regulator to boost the voltage across the primary winding of the transformer 40. The circuit for energizing the relay 63 may be traced from the supply conductor 141, conductors 190 and 191, the limit switch 71, conductor 192, the winding of the relay 63, conductor 193, the contacts 68 and 69, conductor 194, contact 131, conductors 195 and 196, contact 134 and conductor 197 to the supply conductor 142. The closure of the contact of the relay 63 allows current to flow from the supply conductor 141 through a conductor 64, the lower winding 48 of the motor 47, conductor 66, the contact of the relay 63, conductor 73 to the supply conductor 142.

At the same time, the closure of the contact of the relay 63 permits current to flow from the conductor 64 through the upper winding 49 of the motor 47, the conductor 65, and the capacitor 61 to the contact of the relay 63. As previously explained, the phase relation of the current flowing through the upper winding, in this case, is shifted relative to that of the lower winding, by means of the capacitor 61. The shifting of said phase relation provides a starting torque for starting the single phase induction motor 47.

The induction motor 47 continues to actuate the induction regulator for gradually boosting the voltage across the primary winding of the transformer 40, which eventually reaches a predetermined normal operating value, with the result that the energization of the relay 67 increases to balance the movable contact 69 substantially mid-way between the two oppositely disposed stationary contacts 68 and 70.

Suppose, however, for the purpose of explanation, that the load on the precipitating device increases beyond its normal operating predetermined load as a result of the increased voltage across the primary winding of the transformer. Under this condition, the energization of the relay 67 increases and swings the movable contact 69 downwardly to engage the lower contact 70. The closure of contacts 69 and 70 completes a circuit for energizing the relay 62, which when closed energizes the motor 47.

As previously explained, the energization of the motor 47, by the closure of relay 62, causes the motor to actuate the induction regulator in a clockwise direction towards the minimum voltage position. The motor 47 continues to operate until the load on the precipitating device has decreased to its predetermined normal operating value. Therefore, the cooperative action of the relays 62 and 63, together with the motor 47 and the induction regulator 41, provides for stabilizing the voltage on the transformer 40, so as to maintain the load on the electrical precipitating device substantially constant.

When a voltage is impressed upon the primary winding of the transformer 40, a current of extremely high potential is induced in the secondary windings of the transformer, which is rectified by means of the two tubes 31 and 32 and transmitted to the discharge electrodes 14 of the precipitating device. Let it be assumed that, for any particular

instant, the potential of the upper-terminal of the secondary of the transformer relative to the mid-terminal is positive, and that the potential of the mid-terminal relative to the lower-terminal is positive. Under this assumption, since the tubes only operate when the filaments are negative and the plates are positive, current flows from the upper-terminal of the secondary of the transformer through the tube 31, the conductors 51 and 52 in parallel, the split windings 38 and 39 of the filament transformer, conductors 210 and 211, a milliammeter 212, conductor 213, the winding of the overload relay 124, conductors 214 and 215 to the collecting tubes 12, which are connected by means of a conductor 16 to the ground 15. At the same time, it is noted that the discharge electrodes 14 are connected to the mid-terminal of the secondary of the transformer which provides for negatively energizing said electrodes.

A high tension protective resistor 44 is inserted between the mid-terminal of the secondary of the transformer 42 and the discharge electrodes 14 for stabilizing the operating conditions of the electrical precipitating device.

Suppose that the alternating current has changed so that the lower-terminal is positive with respect to the mid-terminal, and that the mid-terminal is positive with respect to the upper-terminal. Under this supposition, since the tubes only rectify when the filaments are negative and the plates are positive, current flows from the lower terminal of the secondary winding of the transformer through the rectifying tube 32, the conductors 51 and 52 in parallel, the split windings 38 and 39 of the filament transformer 37, and thence to the collecting electrodes 12 and the ground 15, as previously explained. At the same time, it will be noted that the polarity of the discharge electrodes 14 is always maintained negatively.

For the purpose of protecting the milliammeter 212 and the overload relay 124, I utilize a film cut-out 217 in parallel with said milliammeter and relay, so that when a flashover occurs, current is by-passed through the film cutout.

As a result of the dust collecting on the inside of the collecting tubes, flashovers or breakdowns frequently occur, which if not controlled, greatly injure the rectifying tubes 31 and 32.

The flashovers give rise to surges in the rectifying circuit, because of the inductance of the transformer. These surges subject the tubes to potentials of from 30,000 to 75,000 volts, the full potential of the secondary winding of the transformer, whereas in normal operation, when the rectifying tubes are passing current, only a few hundred volts drop persists between the electrodes of the said tubes. Again, the flashovers create a heavy demand on the tubes for current which, of course, the tubes cannot supply, because their emission is limited to the saturation current corresponding to the temperature of the filaments.

As a result, the potential across the filament and plate increases very rapidly at the time when the current emission is a maximum, thus causing the tubes to absorb the energy of the flashover until the circuit is opened. This condition sometimes, if not fully controlled, as a result of the high temperature caused by the current flowing during a flashover condition, melts or damages the filament and the plate.

In order to provide the proper control when a flashover or a heavy overload condition persists, the overload relay 124 that is connected in cir-

cuit with the output of the rectifying tubes by means of its lower contact 126, operates to immediately deenergize the relay 133. Deenergization of the relay 133 immediately interrupts the circuit for energizing the primary winding of the plate transformer 40, which immediately removes the overload condition. Also, the relay 133, when deenergized, interrupts the circuit for energizing relay 127 through the opening of contact 134. The opening of the contact 130 of the relay 127, inserts the unvariable resistor 185 in circuit with the primary winding of the transformer 40 for limiting the voltage of the said primary winding when the relay 133 recloses.

The removal of the overload condition on the discharge electrodes 14 causes deenergization of the overload relay 124, which through its contact 126, together with the contact 129 of the relay 127, completes a circuit for immediately energizing the relay 133.

However, the relay 127 remains deenergized until the motor 47 actuates the induction regulator 41 to its minimum voltage position. The circuit for energizing the relay 62 that causes the motor 47 to actuate the induction regulator to minimum voltage position is completed by the closing of contact 132 of the relay 127. The motor continues to operate until the induction regulator is operated to a minimum voltage position at which time the extended arm 44 depresses the limit switch 72 and energizes the relay 127 through its lower contact.

Energization of the relay 127, as hereinbefore explained, by means of the opening of the contact 132, interrupts the circuit that energizes the relay 62, and, by means of the closing of the contact 131, connects the relay 67 in circuit again to cause the induction regulator to operate in accordance with the current induced in the current transformer 68. This means that the voltage impressed on the precipitating device is again stabilized by means of the induction regulator and operation will continue as such unless a second flashover occurs. Should more flashovers occur, the circuit will operate as just explained.

However, after a predetermined number of flashovers, for example three, I provide for deenergizing the control system by means of the grid-glow tube 81 and its associated relay 90, which operates the reset relay 100 which, when operated, continuously deenergizes the control system until it is reset by the operator. Each time that a flashover occurs, it has been noted that the overload relay 124 operates to intermittently interrupt the primary of the transformer 40, and at the same time the relay 124, by means of its contact 125, connects the condenser 86 in circuit with the unidirectional output conductors 94 and 95 of the full-wave rectifier 89.

This circuit may be traced from the upper terminal of the rectifier 89 through a conductor 94, the contact 125, the variable resistor 87, the condenser 86, conductors 119 and 95 to the lower terminal of the rectifier 89. At the same time, it will be observed that the rectifiers 89 are energized by alternating current through a circuit that extends from the supply conductor 141 through a conductor 91, the rectifier 89, conductor 92, contact 106 and conductor 93 to the supply conductor 142.

Therefore, each time that the overload relay 124 operates a certain amount of uni-directional current is delivered to the condenser 86 so that

when the said relay operates a predetermined number of times the said condenser becomes sufficiently charged to initiate a glow discharge between the grid 83 and the cathode 84. However, at this point, it is readily manifest that by changing the value of the variable resistor 87, the number of interruptions that is necessary to charge the condenser to provide sufficient voltage for initiating a glow discharge, may be varied.

It should be noted in the case of a single momentary short circuit on the discharge electrodes of the precipitating device, the relay 124 operates to connect the capacitor 86 for a predetermined length of time in circuit with the unidirectional supply conductors 94 and 95. This predetermined length of time is insufficient to cause the grid-glow tube 81 to function. The charge that is delivered to the capacitor 86 during a single momentary short circuit is gradually dissipated, so that after a predetermined length of time, if a second short circuit occurs, the capacitor is in its normal discharge condition. Therefore, when the momentary short circuits are at wide intervals, the time required to charge the condenser is also the same for initiating a low discharge, which means that the relay 124 always operates a predetermined number of times for deenergizing the transformer 40.

When a discharge is initiated, the grid-glow tube 81 becomes conducting, acting like a relay when in closed position, allows current to flow from the uni-directional energized conductor 94 through a non-variable resistor 88 through the grid-glow tube 81, the winding of the relay 90 and the conductor 95 to the lower terminal of the rectifier 89.

The closure of the relay 90 completes the circuit for energizing the relay 100 which when energized, establishes a circuit for excluding the winding of the relay 97. At the same time that the armature of the relay 100 is raised, a spring biased latch 102 swings counter-clockwise to hold the said relay in closed position. The closure of the contact of the relay 100, since it excludes the winding of the relay 97 through the conductor 117, deenergizes the relay 97 which accordingly deenergizes the entire control system, except the two supply conductors 141 and 142.

Since the relay 100 is of the hand reset type, it is necessary for the operator to reset the said relay before the control system is in position for reenergization by the closing of the push button 98. Also provision is made for the operator to completely deenergize the entire control system by depressing the push button 99, which likewise deenergizes the relay 97.

Therefore, I have shown and described a control system that provides for intermittently deenergizing an electrical precipitating device when an overload condition occurs and for continuously deenergizing said precipitating device when the integrated overload condition attains a predetermined value.

Since certain changes in my invention may be made without departing from the spirit and scope thereof, it is intended that all matters contained in the foregoing description and shown in the accompanying drawing shall be interpreted as illustrative and not in a limiting sense.

I claim as my invention:

1. A control system comprising, in combination, a load circuit, means for supplying said load circuit with a uni-directional current of high potential, means including an electric discharge device for interrupting the supply means,

responsive to the integrated overload condition on said load circuit for operating the said interrupting means, and means responsive to a predetermined number of interruptions of the supply means for locking out said supply means.

2. A control system comprising, in combination, an electrical load, means for supplying said electrical load with a uni-directional current of high potential, means for interrupting the supply means and means including an electric discharge device and a capacitor for operating said interrupting means, said means being responsive to the duration of the overload condition on said electrical load, and means operable in response to a predetermined number of successive operations of the interrupting means to preclude a further energization of the electrical load.

3. A control system for an electrical precipitator comprising, means for supplying said precipitator with a uni-directional current of high potential relative to said collecting electrode, and means for interrupting the supply means in response to an overload condition on the precipitator, said means including means operable in response to a predetermined number of successive interruptions of the supply means to preclude further energization of the precipitator.

4. A control system for an electrical load comprising, means for charging said electrical load with a uni-directional current of high potential, supply means for energizing said charging means, means responsive to a predetermined overload condition on the electrical load for intermittently deenergizing said charging means as long as the said overload condition persists, and means for interrupting the supply means when the integrated overload condition on the said electrical load attains a predetermined value.

5. A control system comprising, in combination, an electrical load, means for charging said electrical load with a uni-directional current of high potential, supply means for energizing said charging means, means responsive to a predetermined overload condition on the electrical load for intermittently deenergizing said charging means as long as said overload condition persists and means for reducing the potential of said electrical load to a relatively low predetermined value subsequent to each occurrence that said charging means is intermittently deenergized.

6. A control system comprising, in combination, an electrical load, means for charging said electrical load with a uni-directional current of high potential, supply means for energizing said charging means, means responsive to a predetermined overload condition on the electrical load for intermittently deenergizing said charging means as long as said overload condition persists, means for reducing the potential of said electrical load to a relatively low predetermined value subsequent to each occurrence that said charging means is intermittently deenergized, and means for increasing the potential on said electrical load from said predetermined low value to a relatively high predetermined value.

7. A control system comprising, in combination, an electrical load, means for charging said electrical load with a uni-directional current of high potential, supply means for energizing said charging means, means responsive to a predetermined overload condition on the electrical load for intermittently deenergizing said charging means as long as said overload condition persists, means for reducing the potential of said electrical load

to a relatively low predetermined value subsequent to each occurrence that said electrical load is intermittently deenergized, means for increasing the potential on said electrical load from said predetermined low value to a relatively high predetermined value, and means for decreasing the said potential when the load condition that corresponds to said predetermined high value increases and for increasing the said potential when the load condition that corresponds to said high predetermined value decreases.

8. A control system for an electrical precipitator comprising, means for charging said precipitator with a uni-directional current of high potential, supply means for energizing said charging means, an electric discharge device having a capacitor associated therewith, a relay responsive to the overload condition on said precipitator for intermittently deenergizing said charging means as long as said overload condition persists, means for decreasing the potential of said charging means subsequent to each of said interruptions for the purpose of removing said overload condition, means for gradually increasing said potential to a predetermined high operating value, means for charging said capacitor with a uni-directional current to cause said electric discharge device to function when the said relay intermittently deenergizes said charging means a predetermined number of times and means for interrupting said supply means when said discharge device functions.

9. A control system for an electrical precipitator comprising, means for charging said precipitator with a uni-directional current of high potential, supply means for energizing said charging means, an electric discharge device having a capacitor associated therewith, a relay responsive to the overload condition on said precipitator for intermittently deenergizing said charging means as long as said overload condition persists, means for charging said capacitor with a uni-directional current to cause said electric discharge device to function when the said relay intermittently deenergizes said charging means a predetermined number of times and means for interrupting said supply means when said discharge device functions.

10. A control system comprising, in combination, an electrical load, means for charging said electrical load with a uni-directional current of high potential, supply means for energizing said charging means, an electric discharge device having a capacitor associated therewith, means responsive to the overload condition of said electrical load for charging said capacitor with a uni-directional current to cause said electric discharge device to function and means for interrupting said supply means when said discharge device functions.

11. A control system comprising, in combination, an electrical load, means for charging said electrical load with a uni-directional current of high potential, an electric discharge device having a capacitor associated therewith, means responsive to the overload condition of said discharge electrode for intermittently interrupting said charging means for the purpose of removing said overload condition, means for changing the condition of the capacitor each time that the charging means is intermittently interrupted, means for causing the electric discharge device to function when the condition of the capacitor is sufficient to initiate a glow discharge therein and means for

interrupting said supply means when said discharge device functions.

12. A control system for a precipitating device having a collecting electrode, a discharge electrode disposed in spaced relation with said collecting electrode, and means for passing gases through the region of said electrodes comprising, in combination, means for charging said precipitating device with a uni-directional current of high potential, supply means for energizing said charging means, an electric discharge device, means responsive to the overload condition of said precipitating device for intermittently interrupting said charging means for the purpose of removing said overload condition, means for causing the electric discharge device to function when the said interrupting means operates a predetermined number of times and means for interrupting said supply means when said discharge device functions.

13. A control system for a precipitating device having a collecting electrode, a discharge electrode disposed in spaced relation with said collecting electrode, and means for passing gases through the region of said electrodes comprising, in combination, means for charging said precipitating device with a uni-directional current of high potential, supply means for energizing said charging means, an electric discharge device, means responsive to the overload condition of said precipitating device for intermittently interrupting said charging means for the purpose of removing said overload condition, means for causing the electric discharge device to function when the said interrupting means operates a predetermined number of times, means for selecting one or more predetermined number of times, and means for interrupting said supply means when said discharge device functions.

14. A control system for supplying a uni-directional current of relatively high potential to a load, comprising in combination, means for converting alternating current to uni-directional current, said means including two electrodes between which the current passes in one direction but not the other, a load that is disposed to operate on uni-directional current, a source of alternating current, means for connecting said current converting means between said source and said load, means for energizing one of the said electrodes a predetermined length of time before the said converting means is connected between said source and said load, means responsive to an overload condition of the load for disconnecting the current-converting means from the source, and means responsive to a predetermined number of successive operations of the overload responsive means for rendering said means inoperative to effect further energization of the load.

15. A control system for supplying a uni-directional current of relatively high potential to a load, comprising, in combination, a source of alternating current, a load circuit that is disposed to operate on a uni-directional current, means connected between said source and said load circuit for converting alternating current to uni-directional current, means responsive to an overload condition of said load circuit for intermittently disconnecting said load circuit and said converting means from said source for the purpose of removing said overload condition and means for continuously disconnecting said load circuit and said converting means from said source when the intermittently interrupting means operates a predetermined number of times.

16. A control system for supplying a uni-

directional current of relatively high potential to a load, comprising, in combination, a source of alternating current, a load circuit that is disposed to operate on a uni-directional current, means connected between said source and said load circuit for converting alternating current to uni-directional current, means responsive to an overload condition of said load circuit for intermittently disconnecting said load circuit and said converting means from said source for the purpose of removing said overload condition, means for lowering and gradually increasing the potential on said load circuit subsequent to each intermittent interruption, and means for continuously disconnecting said load circuit and said converting means from said source when the intermittently interrupting means operates a predetermined number of times.

17. A control system for supplying a uni-directional current of relatively high potential to a load, comprising, in combination, a source of alternating current, a load circuit that is disposed to operate on a uni-directional current, means including two electrodes connected between said source and said load circuit for converting alternating current to uni-directional current, means responsive to an overload condition of said load circuit for intermittently disconnecting said load circuit and said converting means from said source for the purpose of removing said overload condition, means for lowering and gradually increasing the potential on said load circuit subsequent to each intermittent interruption, and means for continuously disconnecting said load circuit and said converting means from said source when the intermittently interrupting means operates a predetermined number of times, and means for energizing one of the said electrodes before said converting means is connected between said source and said load circuit for the purpose of preventing injury to said converting means.

18. A control system for a precipitating device having a collecting electrode, a discharge electrode disposed in spaced relation with said collecting electrode, and means for passing gases through the region of said electrodes comprising, in combination, a transformer having a primary and a secondary winding, a plurality of tubes having a filament and a plate for rectifying alternating current into uni-directional current, means for connecting the tubes in circuit with the secondary of the transformer and the precipitating device, the connection being such that uni-directional current is delivered to said device, a supply of alternating current for energizing the primary of said transformer, a voltage regulator connected in circuit with the primary of said transformer for stabilizing the load on precipitating device, an overload relay responsive to the overload condition on the precipitating device for intermittently deenergizing the said transformer as long as the overload condition persists, means for actuating the regulator to decrease the voltage impressed on the transformer to a minimum subsequent to each time that the transformer is intermittently deenergized, an electric discharge device associated with a capacitor, means for charging said condenser with uni-directional current each time that the transformer is intermittently deenergized, means for causing the electric discharge device to function when the capacitor is charged to a predetermined potential and means for interrupting the alternating current supply when said discharge device functions.

19. A control system for a precipitating device having a collecting electrode, a discharge electrode disposed in spaced relation with said collecting electrode, and means for passing gases through the region of said electrodes comprising, in combination, a transformer having a primary and a secondary winding, a plurality of tubes having a filament and a plate for rectifying alternating current into uni-directional current, means for connecting the tubes in circuit with the secondary of the transformer and the precipitating device, the connection being such that uni-directional current is delivered to said device, a supply of alternating current for energizing the primary of said transformer, a voltage regulator connected in circuit with the primary of said transformer for stabilizing the load on said precipitating device, an overload relay responsive to the overload condition on the precipitating device for intermittently deenergizing the said transformer as long as the overload condition persists, means for actuating the regulator to decrease the voltage impressed on the transformer to a minimum subsequent to each time that the transformer is intermittently deenergized, an electric discharge device associated with a capacitor, means for charging said condenser with uni-directional current each time that the transformer is intermittently deenergized, means for causing the electric discharge device to function when the capacitor is charged to a predetermined potential and means for interrupting the alternating current supply when said discharge device functions, and means for energizing the filament of said rectifying tubes a predetermined length of time before the transformer is energized.	80
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