

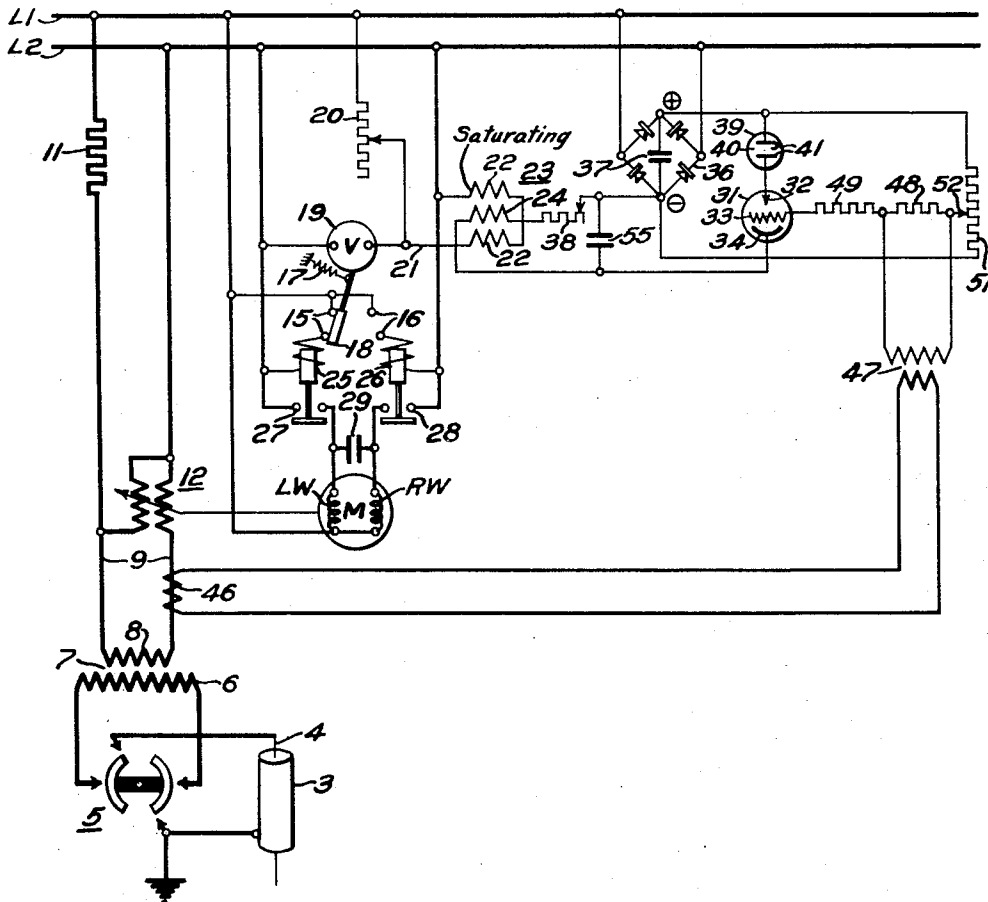
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TIME-DELAYED CONTROL-MECHANISM

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TIME-DELAYED CONTROL MECHANISM

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My invention relates to time-delayed control mechanisms in which adjustable time-delay means are provided for translating a brief electrical impulse into a definite time-controlled operation.

My invention relates more specifically, in the illustrated form of embodiment, to novel current-responsive means and novel voltage-regulating means for electrostatic smoke-precipitators or other electrical load-devices having a certain desirable operating-range in which transient flashes or current-increases occur at a certain predetermined rate at the highest safe operating-voltage which should be applied to the load-device. In this respect, my invention is an improvement over the precipitator-system described and claimed in an application of Myron J. Brown, Serial No. 362,944, filed October 26, 1940, and assigned to the Westinghouse Electric & Manufacturing Company. In this precipitator-system it was desirable to provide means for automatically varying the voltage which is applied to the precipitator so as to produce harmless momentary or transient flashings at a predetermined average rate which experience has shown to be feasible, the procedure being to keep raising and lowering the precipitator-voltage as may be necessary to maintain the rate of flashing within prescribed limits. My invention relates, in its specific application, to novel and improved means for accomplishing such a purpose, although my novel time-delay control-system is not limited to such use.

A more specific object of my invention is to provide a novel control-circuit for an electrical energy-translating device which is to be controlled, said control-circuit being a direct-current circuit including the main arcing path or anode-cathode space of a grid-glow tube or equivalent gas- or vapor-arc space-current arcing-device. This direct-current control-circuit, as utilized in my invention, also includes a thermally responsive glow switch which has a glow-discharge path and a pair of thermally responsive contacts. The space-current arcing-device is provided with a starting control means or grid for initiating the conductive operation of the main arcing-path, and the device has the property of maintaining the main arcing-path current, once it is started, independently of the subsequent condition of the starting control means, as long as any substantial unidirectional voltage continues to be applied to the main arcing-path. The glow switch has the property of initiating its operation by a glow discharge which heats the thermally responsive

contacts thereof and causes said contacts to close, thereby effecting a circuit-closing switching-operation in the main arcing-path of the space-current arcing-device. As soon as the thermally responsive contacts of the glow switch are closed, said contacts begin to cool, and after a predetermined delay they open again, thereby effecting a circuit-interrupting switching-operation after a time-delay which can be determined in the initial design of the glow switch which is utilized.

A still further object of my invention relates to the utilization of an alternating-current voltage-relay having its energizing winding shunted by means of the secondary windings of a saturable reactor, the primary winding of which is energized in the main arcing-path circuit of the space-current arcing-device having the glow switch serially connected therein.

With the foregoing and other objects in view, my invention consists in the apparatus, systems, combinations, methods and parts hereinafter described and claimed, and illustrated in the accompanying drawing, wherein the single figure is a diagrammatic view of the essential features of an electrostatic precipitator-equipment embodying my invention in a simple form of embodiment for illustrating the essential principles of the invention, without the distraction of numerous details which are known to the skilled workers of the art and which do not constitute any essential part of my present improvements.

My invention is illustrated as being applied to the control of an electrostatic precipitator which is diagrammatically represented as comprising a grounded conducting duct or chimney 3, through which passes one or more precipitating-wires or electrodes 4, which are energized, through a mechanical, rotating rectifier 5, from the high-voltage secondary-winding 6 of a step-up transformer 7. The primary winding 8 of the precipitator-transformer 7 is connected to a supply circuit 9 which is energized from a single-phase supply-line L1-L2 through a ballast-resistor 11 and a voltage-regulating means which is illustrated in the form of an induction-regulator 12 which is adjusted, either in a voltage-raising direction or in a voltage-lowering direction, by means of an alternating-current motor M having a raising winding RW and a lowering winding LW.

The energization of the regulator-motor M, in either the raising or lowering direction, is under the control of a timing-means having a fairly constant timing-interval which is substantially independent of the operating-condi-

tions of the precipitator, such timing-means being illustrated in the form of a slow-moving voltage-relay V such as a contact-making instrument of the induction-disc type, having back-contacts 15 and front or "make" contacts 16. The voltage-relay V has biasing-means, illustrated in the form of a spring 17, tending to return the movable contact-element 18 to its non-actuated position in engagement with the back-contacts 15, and it is also provided with an actuating-coil 19 which, when sufficiently electrically energized, so that its operating-force overpowers the pull of the biasing spring 17, causes the movable element 18 to slowly move to its actuated position in engagement with the front-contacts 16. The actuating-coil 19 of the voltage-relay V is energized from the alternating-current line L1—L2, through a variable resistor 20 by means of which the operating-speed or forward-moving speed of the voltage-relay may be adjusted.

Suitable means are provided for causing the biasing-action of the biasing spring 17 to predominate over the actuating-force of the electrically energized coil 19 at certain times, as will be subsequently described. The illustrated means for causing the biasing spring to predominate includes a short-circuiting circuit 21 around said actuating-coil 19, said short-circuiting circuit including the secondary windings 22 of a saturating reactor 23, the primary winding 24 of which is suitably energized, as will subsequently be described, for the purpose of controlling the voltage-relay V.

In order to avoid the necessity for utilizing voltage-relay contacts 15 and 16 which are sufficiently heavy to control the regulator-motor M, I have shown, as a matter of practical convenience, the utilization of two auxiliary relays 25 and 26 which are respectively energized from the back and front-contacts 15 and 16 of the voltage-relay V. The auxiliary relay 25 is a voltage-lowering relay having a make-contact 27 which is utilized to energize the lowering-winding LW of the regulator-motor M. The auxiliary relay 26 is a voltage-raising relay having a make contact 28 which is utilized to energize the raising-winding RW of the regulator-motor M. A capacitor 29 is connected across the terminals of the two motor-windings LW and RW so that, when the lowering-winding LW is energized as the main winding of the motor, the other winding RW will be utilized as a dephased capacitor-winding, in series with the capacitor 29, to cause the motor M to rotate in the voltage-lowering direction of the induction-regulator 12; whereas, when the raising winding RW is energized as the main winding of the motor, the other winding LW becomes the capacitor-winding and the motor rotates in the other direction.

In order to cause the voltage-relay V to reset, or to move in the backward direction under the influence of the biasing spring 17, it is necessary to provide some means for short-circuiting or by-passing the voltage-relay coil 19 and for maintaining this short-circuit or by-passing circuit for a sufficiently long time or times to permit the movable contact-element 18 of the voltage-relay to drift back from its front-contact position 16 to its back-contact position 15. I have provided a novel means for effecting this purpose, utilizing a cold-cathode grid-glow tube 31 having an anode 32, a grid 33 and a cathode 34, and a special time-delayed control-means therefor, as will be subsequently described. The grid-glow

tube 31 is typical of any gas- or vapor-filled space-current arcing-device which has the property of "breaking down" or glowing or becoming conductive, in its main arcing-path between its anode 32 and cathode 34, only when the starting control means or grid 33 is made sufficiently positive with respect to the cathode 34, for any given anode-cathode applied-voltage within the voltage-rating of the tube; and this type of tube has the further property, once it has "broken down" by the glowing of the grid, of maintaining its glowing or arcing or conducting condition, independently of the subsequent condition of said starting control means, until the applied voltage is interrupted or very materially reduced by some external or extraneous means.

In order to utilize this self-locking or current-maintaining property of the grid-glow tube 31, I provide a suitable direct-current or unidirectional-current energizing source in the anode-cathode circuit thereof, said source being illustrated in the form of a full-wave rectifier or rectifier-bridge 36 having one diagonal energized across the alternating-current supply-line L1—L2, so that the other diagonal of the bridge constitutes the direct-current terminals (+) and (—). The direct-current output-terminals (+) and (—) of the rectifier-bridge 36 are shunted by a by-passing capacitor 37 for the purpose of smoothing the direct-current voltage. The anode-cathode circuit 32—34 of the grid-glow tube 31 serially includes a regulating resistance 38 and the primary winding 24 or other electrical energy-translating device to be controlled; and it also serially includes a thermally responsive glow switch 39 which has a glow-discharge path 40 and a pair of thermally responsive contacts 41, the operation of which will be subsequently described. The anode-cathode circuit just described constitutes the main direct-current circuit of the grid-glow tube 31, and it may be traced from the positive terminal (+) through the glow switch 39, the main arcing path 32—34 of the grid-glow tube 31, the primary winding 24 of the saturating reactor 23 and the regulating resistance 38, and thence to the negative terminal (—).

The initial breaking down or glowing of the grid-glow tube 31 is adjustably controlled in response to the current flowing in the alternating-current supply-circuit 9 of the precipitator. To this end, I have shown an ordinary current-transformer 46 in said supply-circuit 9, said current-transformer being utilized to energize a high-voltage or step-up transformer 47, which is loaded by means of a resistor 48 which develops a voltage-drop or potential which is proportional to the supply-circuit current. The resistor 48 is included in the grid-circuit of the grid-glow tube 31, said grid-circuit also serially including a high-resistance grid-resistor 49, and an adjustable potentiometer 51. The terminals of the potentiometer 51 are connected across the direct-current supply-circuit terminals (+) and (—), and an adjustable intermediate tap 52 of said potentiometer is included in the grid circuit. The grid-circuit may thus be traced from the grid 33 of the grid-glow tube 31 through the resistors 49 and 48 to the adjustable intermediate potentiometer-tap 52, and thence through a portion of the potentiometer 51 to the negative source-terminal (—) which is also connected to the cathode 34 of the grid-glow tube 31 through the relatively low-resistance circuit 38—24 which

has a low resistance as compared to the grid-resistor 49 and the resistor 48.

In operation, the voltage-relay V is normally energized so that said relay "picks up" and closes its front or make-contact 16, thus energizing the voltage-raising relay 26 and causing the regulator-motor M to operate in the voltage-raising direction, thus slowly raising the voltage applied to the precipitator 4. As the precipitator-voltage rises higher and higher, the frequency and the intensity of its spitting-operations increase. Whenever such spitting occurs, the supply-line current in the current-transformer 46 also increases, and when a sufficiently severe momentary or instantaneous spitting-current is obtained during a positive half-cycle, that is, during a half-cycle of the alternating-current supply during which a positive voltage-component is applied to the grid 33 by the resistor 48, this voltage-component, when added to the tapped voltage of the potentiometer 51 will exceed the critical starting-voltage of the grid-glow tube 31, causing a glow-discharge to occur between the grid 33 and the cathode 34, drawing a negligible cathode-current of the order of a fraction of a milliamperes. This grid-cathode glow-discharge immediately ionizes the tube 31, activating an anode-to-grid path 32-33 which excites the glow switch 39 with nearly the full voltage from the positive terminal (+) of the rectifier-bridge 36 to the intermediate tap 52 of the potentiometer 51. The glow switch 39 thus instantly begins to glow, drawing a current of the order of 45 milliamperes, more or less, in the circuit from (+) to 41 to 32 to 33 to 49 to 48 to 52 to (+).

After a usually brief, predetermined time, depending upon the characteristics of the glow switch, the thermally responsive or bimetallic contacts 41 are sufficiently heated, by the glow discharge of the glow switch, to close together, thereby effecting a circuit-closing operation which, in turn, applies substantially the full (+) to 52 grid-voltage to the anode-grid space 32-33 of the grid-glow tube 31, causing said grid-glow tube to glow all over, immediately breaking down the anode-cathode space 32-34, and causing this space to arc over, in a persistent arc or discharge which will thereafter maintain itself, substantially independently of the subsequent condition of energization of the grid 33, so long as any substantial direct-current voltage is applied to the plate-anode tube-space 32-34 from the (+) and (-) terminals of the direct-current source 36. The plate-anode circuit of the grid-glow tube now draws a relatively substantial plate-current which may be of the order of 15 or 20 milliamperes, more or less, and this current is utilized to energize the primary winding 24 of the saturable reactor 23 with direct current, which saturates said reactor, the degree of saturation being controllable by means of the variable resistor 38 and the design of saturating reactor.

The saturation of the saturable reactor 23 reduces the alternating-current impedance of the secondary winding 22, so that said secondary winding 22 thus bypasses the operating-coil 19 of the voltage-relay V, causing the latter to drift toward its non-actuated position, first immediately or quickly opening its front-contacts 16, thus stopping the forward or voltage-raising movement of the induction-regulator 12, after which the movable contact-member 18 of the voltage-relay slowly moves between its two limiting positions in a direction toward the voltage-lowering contact or back-contact 15.

The direct-current energization of the saturating reactor 23, which causes this backward drifting of the voltage-relay V, continues for a predetermined brief time-interval which is controlled by the design-characteristics of the glow switch 39. The rate at which the voltage-relay V is drifting backwardly, during this time-interval, is adjustable by means of the adjustable resistance 38, which controls the degree of saturation of the saturable reactor 23. By this means, it is possible to adjust the amount or distance through which the voltage-relay V drifts backwardly during the time-interval during which the glow-switch contacts 41 remain in contact, and this drifting-distance is usually chosen so that it takes more than one, or several, such time-intervals to cause the movable contact 18 of the voltage-relay V to move all the way back from its fully actuated position in contact with the make-contacts 16, to its fully retrieved position in contact with its back-contacts 15.

At the termination of the delayed-action current-responsive impulse which is provided by the combined action of the grid-glow tube 31 and the glow switch 39, as has been described, the short-circuit is removed from around the operating-coil 19 of the voltage-relay V, so that the movable element 18 of said voltage-relay starts drifting forward again, toward its front or make-contact 16. This forward-drifting speed is controllable by the adjustable resistor 20, and is preferably adjusted so that it is of the same order of magnitude as the backward-drifting or resetting speed previously referred to.

If a second current-impulse of sufficient magnitude and polarity does not occur before the voltage-relay V closes its front-contacts 16, the regulator-motor M will start moving again in the voltage-raising direction, thus again slowly raising the voltage applied to the precipitator-wire 4. If, however, another current-impulse occurs, so as to check the forward drifting of the voltage-relay V before it closes its front-contacts 16 again, said voltage-relay will start drifting backward again, through another short time-period under the control of the short-time thermally responsive electronic relay or glow switch 39, and on this occasion the voltage-relay will drift back still further, closer to its back-contact 15, because it started to drift backwardly from an intermediate position between the two limiting contacts 15 and 16.

When such current-responsive impulses occur at a sufficiently fast rate, the movable element 18 of the voltage-relay V will drift all the way back to its back-contact 15, thereby energizing the voltage-lowering winding LW of the induction-regulator motor M, thus quickly reducing the voltage which is applied to the precipitator. At the termination of the last current-responsive delayed-action or short-time impulse which caused a reduction of the precipitator-voltage, the voltage-relay V will again start to drift forward, opening its back-contact 15; and if the frequency of recurrence of the precipitator-flashings has now been sufficiently reduced, as a result of the reduction in the precipitator-voltage, the voltage-relay V will finally drift to its full-actuated position 16, starting all over again to slowly move the regulator-motor M in the voltage-raising direction.

While I have described my invention in connection with certain relative time-intervals and drifting-times, and while I have referred to the current-response as a series of discrete responses to transient current-impulses, I wish it to be

understood that the operation of my device is not altogether limited in these respects, nor is it by any means limited to the time-delayed impulse-control of a precipitator voltage-regulator, as it is of general application to any electrical energy-translating device which is to be controlled by means of discrete, timed impulses. It is to be noted, in particular, that I have provided means whereby a wide range of adjustment is readily possible, in regard to the choice of the various timing-intervals and drifting-speeds or periods. As an example, but not by way of limitation, it may be noted that my invention can be utilized in a precipitating system under such operating conditions as to obtain from 6 to 20 snaps or flashings per minute, utilizing a voltage-relay V having a drifting-time of some 20 seconds, or between 10 seconds and 60 seconds, for a full swinging-movement of the movable contact-element 18 in either direction of movement and utilizing a novel timing-means 31—39 which has a relatively brief pickup time, but which holds its make-contacts 41 closed for a time interval which may be adjusted from 1 second to 10 or 15 seconds, or more. These various time-intervals are indicated only by way of illustration; as my invention, in its broader aspects, is not limited thereto.

Considering, in more detail, the current-interrupting operation of the glow switch 39, when the thermally responsive contacts 41 thereof reopen as a result of their cooling operation, a glow-discharge or arc will not restrike at said contacts, provided that the breakdown-voltage of the glow switch 39 is higher than the impressed voltage, which is substantially the full direct-current voltage from (+) to (—). Thus, the opening of the contacts 41 extinguishes the glow-discharge or arc in the anode-cathode space 32—34 of the grid-glow tube 31, provided that the critical-voltage characteristics of the glow switch 39 are properly chosen. The design of the glow switch 39 can be made much less critical, in the way of avoiding danger of restriking of the arc or glow discharge in said switch when the contacts 41 thereof reopen, by connecting a capacitor 55 around the load-device comprising the primary winding 24 and the variable resistor 38. When said capacitor 55 is utilized, the capacitor retains its charge for a short time, so that it operates as a source of back-voltage which is effective at the instant of reopening of the contacts 41, thus reducing the restriking voltage applied to the glow switch 39 to a very small value commensurate with the almost negligible voltage-drop in the rest of the circuit, including said glow switch when the contacts 41 were closed, and also including the voltage-drop in the grid glow tube 31 when the latter was in its current-conducting state.

While I have described and illustrated my invention in a single preferred form of embodiment, and while I have exemplified my description of the operation with numerical figures or values, I desire it to be understood that my invention, in its broadest aspects, is not limited to these details, and I desire therefore, that the appended claims shall be accorded the broadest construction consistent with their language.

I claim as my invention:

1. Time-delayed control-mechanism comprising, in combination; an electrical energy-translating device to be controlled; a main direct-current circuit therefor; a gas or vapor-arc space-current arcing-device of a type having a

main arcing-path which is normally substantially non-conducting; starting control means for initiating the conductive operation of said main arcing-path; said space-current arcing-device being of a type in which the main arcing-path current, once started, will remain flowing, independently of the subsequent condition of said starting control means, as long as any substantial uni-directional voltage is applied to said main arcing-path; said main arcing-path being serially included in said main direct-current circuit; a thermally responsive glow switch also serially included in said main direct-current circuit, said glow switch having a glow-discharge path and a pair of thermally responsive contacts; and control-circuit means for, at times, operatively energizing said starting control means; whereby the glow switch thereupon discharges, heating itself and after a predetermined delay closing the thermally responsive contacts therein; thereby effectively energizing said main direct-current circuit including said controlled energy-translating device, including also the main arcing-path of said space-current arcing-device, and including also the thermally closed contacts of said glow switch; whereupon the glow-switch contacts begin to cool and after a predetermined delay open again, thereby interrupting the current-flow in said main direct-current circuit; the duration of the effective energization of said starting control means by said control-circuit means being, at least at times, shorter than the time for said glow-switch contacts to reopen.

2. Time-delayed control-mechanism comprising, in combination; a source of unidirectional potential; an electrical energy-translating device to be controlled; a capacitor; a gas or vapor-arc space-current arcing-device of a type having a main arcing-path which is normally substantially non-conducting; starting control means for initiating the conductive operation of said main arcing-path; said space-current arcing-device being of a type in which the main arcing-path current, once started, will remain flowing, independently of the subsequent condition of said starting control means, as long as any substantial unidirectional voltage is applied to said main arcing-path; a thermally responsive glow switch having a glow-discharge path and a pair of thermally responsive contacts; circuit-connection means for establishing a main direct-current circuit serially including said source, said controlled energy-translating device, the main arcing path of said space-current arcing-device, and said glow switch; circuit-connection means for connecting said capacitor in shunt across a portion of said main direct-current circuit, said portion including said controlled energy-translating device; and control-circuit means for, at times, operatively energizing said starting control means; whereby the glow switch thereupon discharges, heating itself and after a predetermined delay closing the thermally responsive contacts therein; thereby effectively energizing said main direct current circuit; whereupon the glow-switch contacts begin to cool and after a predetermined delay open again; thereby interrupting the current-flow in said main direct-current circuit; the duration of the effective energization of said starting control means by said control-circuit means being, at least at times, shorter than the time for said glow-switch contacts to reopen.

3. Time-delayed control-mechanism comprising, in combination; an alternating-current energy-translating device to be controlled; an alternating-current circuit therefor; a saturable reactor having a primary winding and a secondary winding; circuit-connection means for connecting said secondary winding in controlling relation to said alternating-current energy-translating device; a source of unidirectional potential; a gas or vapor-arc space-current arcing-device of a type having a main arcing-path which is normally substantially non-conducting; starting control means for initiating the conductive operation of said main arcing-path; said space-current arcing-device being of a type in which the main arcing-path current, once started, will remain flowing, independently of the subsequent condition of said starting control means, as long as any substantial unidirectional voltage is applied to said main arcing-path; a thermally responsive glow switch having a glow-discharge path and a pair of thermally responsive contacts; circuit-connection means for establishing a main direct-current circuit serially including said source, the primary winding of said saturable reactor, the main arcing path of said space-current arcing-device, and said glow switch; and control-circuit means for, at times, operatively energizing said starting control means; whereby the glow switch thereupon discharges, heating itself and after a predetermined delay closing the thermally responsive contacts therein; thereby effectively energizing said main direct-current circuit; whereupon the glow-switch contacts begin to cool and after a predetermined delay open again, thereby interrupting the current-flow in said main direct-current circuit; the duration of the effective energization of said starting control means by said control-circuit means being, at least at times, shorter than the time for said glow-switch contacts to reopen.

4. Voltage-regulating equipment for an electrical load-device subject to transient current-increases randomly recurring at a rate and with an intensity dependent upon the voltage, comprising, in combination; a supply-circuit for supplying energy to said load-device; voltage-regulating means associated with said supply-circuit; a source of unidirectional potential; a space-current arcing-device of a type having an anode-cathode arcing-space which is normally substantially non-conducting, starting control means for initiating the conductive operation of said anode-cathode arcing-space, said space-current arcing-device being of a type in which the anode-cathode current, once started, will remain flowing, independently of the subsequent condition of said starting control means, as long as any substantial unidirectional voltage is applied to said anode-cathode arcing-space; a thermally responsive glow switch having a glow-discharge path and a pair of thermally responsive contacts; circuit-connection means for establishing a main direct-current circuit serially including said unidirectional-potential source, the anode-cathode circuit of said space-current arcing-device, and said glow switch; means responsive to the load-current of the load-device for causing said starting control means to be operatively energized upon the attainment of an instantaneous current-magnitude of a predetermined value in said load-device, whereby the glow switch thereupon discharges, heating itself and after a predetermined delay closing the thermally responsive

contacts therein, thereby effectively energizing said main direct-current circuit, whereupon the glow-switch contacts begin to cool and after a predetermined delay open again, thereby interrupting the current-flow in said main direct-current circuit; the duration of the effective energization of said starting control means by said control-circuit means being, at least at times, shorter than the time for said glow-switch contacts to reopen; a timing-device having two different operational conditions; means for normally developing a first actuating-effect tending to change said timing device from a first one of its operational conditions to its second operational condition; current-responsive means including a response to the anode-cathode circuit of said space-current arcing-device for at times counter-acting said first actuating-effect and developing a second actuating-effect tending to change said timing-device in the opposite direction at a speed which is so slow, at times, as to require a plurality of transient current-increases to occur before the timing device is completely changed from its second operational condition to its first operational condition; means for making a lowering adjustment of said voltage-regulating means when said timing-device reaches its first operational condition; and means for making a raising adjustment of said voltage-regulating means when said timing-device reaches its second operational condition.

5. Voltage-regulating equipment for an electrical load-device having a desirable operating-range in which a predetermined rate of occurrence of predetermined, randomly recurrent, transient, voltage-responsive increases in the magnitude of the load-current is maintained between predetermined limits, comprising, in combination; an alternating-current supply-circuit for said load-device; voltage-regulating means associated with said alternating-current supply-circuit; a voltage-relay having an energizing-winding energized from said alternating-current supply-circuit; an impedance device in series with the energizing-winding of said voltage-relay; a saturable reactor having a primary winding and a secondary winding, said secondary winding being in shunt to the energizing-winding of said voltage-relay; a source of unidirectional potential; a space-current arcing-device of a type having an anode-cathode arcing-space which is normally substantially non-conducting, starting control means for initiating the conductive operation of said anode-cathode arcing-space, said space-current arcing-device being of a type in which the anode-cathode current, once started, will remain flowing, independently of the subsequent condition of said starting control means, as long as any substantial unidirectional voltage is applied to said anode-cathode arcing-space; a thermally responsive glow switch having a glow-discharge path and a pair of thermally responsive contacts; circuit-connection means for establishing a main direct-current circuit serially including said unidirectional-potential source, the primary winding of said saturable reactor, the anode-cathode circuit of said space-current arcing-device, and said glow switch; means responsive to the load-current of the load-device for causing said starting control means to be operatively energized upon the attainment of an instantaneous current-magnitude of a predetermined value in said load-device, whereby the glow switch thereupon discharges, heating itself and after a predetermined delay closing the ther-

mally responsive contacts therein, thereby effectively energizing said main direct-current circuit, whereupon the glow-switch contacts begin to cool and after a predetermined delay open again, thereby interrupting the current-flow in said main direct-current circuit; the duration of the effective energization of said starting control means by said control-circuit means being, at least at times, shorter than the time for said glow-switch contacts to reopen; means for making a lowering adjustment of said voltage-regulating means when said voltage-relay reaches its fully deenergized position; and means for making a raising adjustment of said voltage-regulating means when said timing-device reaches its fully energized position.

6. Means for translating a brief electrical impulse into a definite time-controlled operation, comprising the combination; with a controlling-means for providing a brief electrical impulse; of a space-current arcing-device of a type having an anode-cathode arcing-space which is normally substantially non-conducting; starting control means for initiating the conductive operation of said anode-cathode arcing-space; said space-current arcing-device being of a type in which the anode-cathode current, once started, will remain flowing, independently of the subsequent condition of said starting control means, as long as any substantial unidirectional voltage is applied to said anode-cathode arcing-space; direct-current energizing-means for the anode-cathode circuit of said space-current arcing-device; an electrical energy-translating load-device serially included in said anode-cathode circuit; means responsive to said impulse for causing said starting control means to be operatively energized; and a thermally responsive glow switch serially included in said anode-cathode circuit, said glow switch having a glow-discharge path and a pair of thermally responsive contacts.

7. Voltage-regulating equipment for an electrical load-device subject to transient current-increases randomly recurring at a rate and with an intensity dependent upon the voltage, comprising, in combination, a supply-circuit for said load-device; voltage-regulating means associated with said supply-circuit; a space-current arcing-device of a type having an anode-cathode arcing-space which is normally substantially non-conducting; starting control means for initiating the conductive operation of said anode-cathode arcing-space; said space-current arcing-device being of a type in which the anode-cathode current,

once started, will remain flowing, independently of the subsequent condition of said starting control means, as long as any substantial unidirectional voltage is applied to said anode-cathode arcing-space; direct-current energizing means for the anode-cathode circuit of said space-current arcing-device; means responsive to load-device current-increases of a predetermined intensity for causing said starting control means to be operatively energized; a thermally responsive glow switch serially included in said anode-cathode circuit, said glow switch having a glow-discharge path and a pair of thermally responsive contacts; and means responsive to the anode-cathode current of said space-current arcing-device for producing a lowering adjustment of said voltage-regulating means.

8. Voltage-regulating equipment for an alternating-current electrical load-device subject to transient current-increases randomly recurring at a rate and with an intensity dependent upon the voltage, comprising, in combination; an alternating-current supply-circuit for said load-device; voltage-regulating means associated with said supply-circuit; an alternating-current voltage-relay having an energizing-winding and a biasing-means opposing the actuating-force produced by said energizing-winding; means for electrically energizing said energizing-winding from across said supply circuit with an amount of energization which normally causes the actuating-force of the energizing-winding to predominate in such manner as to tend to cause the timing-relay to move, in a first direction, from a non-actuated position to an actuated position; an impedance device in series with the energizing-winding of said voltage-relay; a saturable reactor having a primary winding and a secondary winding, said secondary winding being in shunt to the energizing-winding of said voltage-relay; means for translating those transient load-device current-increases which are of a predetermined magnitude into discrete time-controlled unidirectional current impulses of a predetermined magnitude and for utilizing said impulses to temporarily excite said primary winding in such degree as to cause the biasing-force to predominate in said timing-relay so as to tend to cause the timing-relay to move, in the opposite direction, toward its non-actuated position; and means responsive to the non-actuated position of said timing-relay for producing a lowering adjustment of said voltage-regulating means.

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