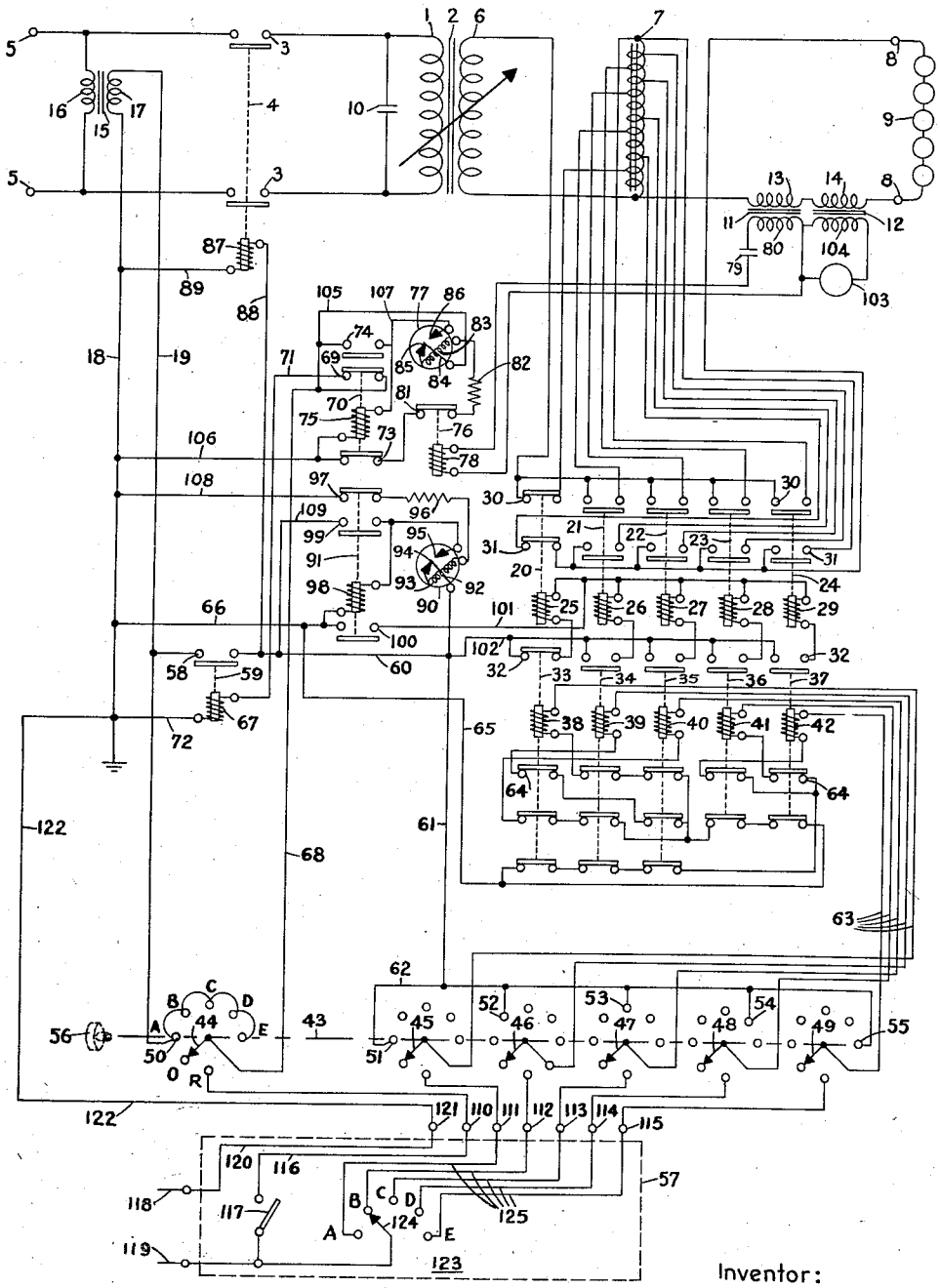
Sept. 23, 1958 A. M. SWASEY 2,853,654

LIGHTING CIRCUIT CURRENT REGULATOR

Filed Aug. 13, 1956



Inventor:
Arthur M. Swasey
by Richard E. Hosley
His Attorney

United States Patent Office 2,853,654 Patented Sept. 23, 1958

2,853,654

LIGHTING CIRCUIT CURRENT REGULATOR

Arthur M. Swasey, Hendersonville, N. C., assignor to General Electric Company, a corporation of New York

Application August 13, 1956, Serial No. 603,631

8 Claims. (Cl. 315—193)

My invention relates to lighting circuit current regulators, and more particularly to current regulators which may be operated locally or from a remote control station to supply selected levels of current to the series connected lamps of airport runway and approach lighting systems to control their brightness as required by visibility conditions at the airport.

These multiple level current regulators have high output voltages when their load circuits are opened. Consequently, protective arrangements have been provided for de-energizing these regulators upon interruption of current flow in their load circuits in order to eliminate the hazards to personnel and equipment occasioned by the presence of these high open circuit voltages.

When the regulator comprises a constant current translating device connected to the load circuit through a transformer whose turn ratio is controlled for supplying less than full load current values, the open circuit voltages at low current values may be greater than at full load current where the voltage is limited by the output voltage of the translating device. Furthermore, when the constant current translating device is a moving coil constant current transformer, surge currents sufficient to destroy the lamps in the load circuit may be obtained until the coils of the constant current transformer can separate far enough to compensate for light load conditions.

It is an object of my invention to provide an improved multiple level current regulator for reducing open circuit voltages when supplying load currents that are less than the full load current.

It is also an object of my invention to provide an arrangement for limiting surge currents during the initial turn-on period of a multiple level current regulator embodying, as a part thereof, a moving coil constant current transformer.

It is another object of my invention to provide a multiple level current regulator having an open circuit voltage protective arrangement which requires the current selector switch to be turned to its off position for resetting it after each operation thereof so that subsequent re-energization of the regulator will occur under conditions that will protect the lamp load from destructive surge currents.

The construction and operation of regulators embodying my invention and further objects of my invention will become apparent from the following description.

When the desired lower levels of load current are obtained by controlling either the primary or secondary turns only of a transformer interposed between the constant current translating device of the regulator and the load circuit, a very high voltage is impressed on the load circuit when current flow therein is interrupted. This is a direct result of the fact that the constant current translating device is unable to force its constant current through the resulting high impedance of the transformer and consequently operates at its open circuit voltage

which is stepped-up by the ratio of winding turns in the transformer to produce a very high open circuit load voltage. In accordance with my invention, I control both the primary and secondary turns of this transformer so that, at the lower levels of load current, less than the full number of secondary turns of the transformer are used. This can be done because, at the lower lamp brightnesses obtained at reduced current levels, lower load voltages are also obtained. For example, the resistance of an incandescent lamp at one half current flow therethrough may be almost one half its resistance when full load current is supplied thereto. By reducing the secondary turns of the transformer, its output voltage is reduced; a similar reduction of the number of its primary turns to secure the desired turn ratio for the desired reduced current output also reduces the impedance of the transformer when its secondary circuit is opened and consequently more current at lower voltage flows in its primary circuit. This is productive of a greater degree of saturation in the core structure of the transformer and its voltage per winding turn approaches a constant value as saturation of its core is increased. Thus, with my arrangement, the voltage applied to the load circuit conductors on open circuit is less than that obtained by securing current level control by varying the turn ratio of the transformer by changing either its primary or secondary turns only as has been done in the past.

My improved current regulator also embodies a surge limit circuit which operates to limit the initial flow of current to the load circuit to the lowest current level of the regulator and, after a pre-determined time delay, to supply a higher current level to the load circuit if the selector switch has been set for such higher current level. An open circuit voltage protector is also provided for de-energizing the regulator if current ceases to flow in the load circuit. This protector is reset by returning the selector switch to its off position so that, after the protector has operated, the load circuit can only be re-energized under the conditions above described for preventing in load circuit surges of current which would be destructive to the lamps connected therein.

For a better understanding of my invention, reference is made to the following description of one embodiment thereof diagrammatically illustrated in the single figure of the accompanying drawing.

In the arrangement illustrated in the drawing, the primary winding 1 of a movable coil constant current transformer 2 is connected through contacts 3 of a power switch 4 to the input terminals 5 of the regulator. The secondary winding 6 of the movable coil constant current transformer is connected through an auto-transformer 7 to the output terminals 8 of the regulator. The transformer 7 is an autotransformer having primary and secondary terminals, the connection of pairs of which determine its winding ratio and the transformation of the constant current output of the constant current transformer 2 to the current output to be supplied to the load circuit.

The load 9 shown in the drawing comprises a plurality of series connected incandescent lamps of an airport runway and approach lighting system. The brightness settings of these lamps is controlled by an adjustment of the regulator to maintain desired levels of output current which will produce the brightness desired. The lamps may be connected directly in the load circuit or connected in the load circuit through isolation transformers which will insulate the lamps and their fixtures from the high voltage of the load circuit.

A power factor correcting capacitor 10 is connected across the primary winding 1 of the constant current transformer 2 and current transformers 11 and 12 have

their primaries 13 and 14 connected in series with one another in the output circuit of the regulator. A control power transformer 15 has its primary 16 connected across the input terminals 5 of the regulator and its secondary winding 17 connected to control power conductors 18 and 19.

The winding turn ratio of autotransformer 7 is controlled by a plurality of switches 20, 21, 22, 23, and 24 having operating windings 25, 26, 27, 28, and 29. Each switch is provided with contacts 30 which control the number of primary turns of the autotransformer 7 which are connected to the output circuit of the constant current transformer 2 and contacts 31 which control the number of secondary turns of the autotransformer 7 which are connected to the load circuit terminals 8 of the regulator. It will be noted that in the de-energized condition of the system, contacts 30 and 31 of relay 20 are closed and that contacts 30 and 31 of switches 21, 22, 23, and 24 are open so that upon closure of contacts 3 of the power switch 4, the regulator will automatically supply to the load circuit terminals and the load connected thereto the lowest level of current obtainable with the connections provided.

The operating windings 25—29 of switches 20—24 are respectively in circuit with the control contacts 32 of associated relays 33, 34, 35, 36, and 37 having operating windings 38, 39, 40, 41, and 42. The operation of a selected one of relays 33—37 is determined by the position of a selector switch 43 having six banks of contacts in each bank of which movable contacts 44, 45, 46, 47, 48, and 49 engage one of a circular arrangement of fixed contacts 50, 51, 52, 53, 54, and 55 depending on the position to which the selector switch has been moved by operation of a handle 56 which is attached to the shaft of the selector switch on which the movable contacts are mounted for movement into engagement with the spaced and circularly arranged fixed contacts. As has been indicated at the left-hand switch bank of the selector switch, its several operating positions have been identified by the letters R, O, A, B, C, D, and E; A, B, C, D, and E being positions for setting current levels in the load circuit; O, the off position; and R the position for connecting a remote controller 57 to the regulator for operating it from a remote location.

Current is supplied to the operating windings 38—42 of relays 33—37 to energize selected ones of these relays in positions A, B, C, D, and E of the selector switch 43. The circuits of the operating windings of these relays are completed from control conductor 19 through contacts 58 of relay 59, conductors 60, 61, one of the branch circuits of conductors 62 connected to contacts 51—55 of the selector switch, one of which is engaged by one of the movable contacts 45—49 of this selector switch, and one of the conductors 63 to one terminal of the operating windings 38—42, the other terminal of which is connected through interlocking contacts 64 of these relays and conductors 65 and 66 to the other control power conductor 18. The interlocking contacts 64 of these relays prevent operation of more than one of them at the same time and the shorting of winding sections of the autotransformer through contacts 30, 31 of two or more of switches 21—24 whose operation is controlled by operation of relays 33—37. In positions A, B, C, D, and E of the selector switch 43, its movable contact 44 engages one of the fixed contacts 50 which are connected to control power conductor 19 and completes the energizing circuit for the operating winding 67 of the control power relay 59 through conductor 68, contacts 69 of relay 70 and conductors 71 and 72 to control power conductor 18. Selector switch 43 is so constructed that its movable contacts move rapidly from one position to the next so that relay 59 is not de-energized for a sufficient length of time for it to open its contacts 58 while its movable contact 44 is passing from one position A, B, C, D, or E to the next.

Auxiliary relay 70 of the open circuit protector has, in addition to its normally closed contacts 69, normally closed contacts 73, normally open contacts 74, and an operating winding 75. The main relay 76 of the open circuit protector, in conjunction with a thermal time delay relay 77, controls the operation of relay 70. Relay 76 has an operating winding 78 which is connected in circuit with a capacitor 79 across the secondary winding 80 of the current transformer 11. Relay 76 also has normally closed contacts 81 connected in circuit with a current limiting resistor 82 to one terminal of the heater element 83 of relay 77. Relay 77 has a switch element 84 which opens its normally closed contacts 85 and closes its normally open contacts 86 after current flows through the heater element 83 for a predetermined length of time. Preferably, switch element 84 is so constructed that this transfer of circuits occurs rapidly or with a snap action. The operating time of this thermal time delay relay is from about one to two seconds. The arrangement is such that after current ceases to flow in the output circuit of the regulator, relay 76 is de-energized and completes the energization of thermal time delay relay 77 which, after a predetermined time, operates to energize relay 70 which, by opening its contacts 69, de-energizes the control power relay 59. This control power relay 59, it will be noted, also controls the energization of the operating winding 87 of power switch 4 by completing a circuit through its contacts 58 and conductors 88 and 89 to the control power conductors 18 and 19.

The surge limit circuit of the controller embodies relays 90 and 91. Relay 90, like the time delay relay 77 of the open circuit protector, has a switch element 92, a heater element 93, normally closed contacts 94, and normally open contacts 95. A current limiting resistor 96 is connected between one terminal of heater element 93 of relay 90 and the normally closed contacts 97 of relay 91 which has an operating winding 98. Relay 91 also has normally open contacts 99 and 100. The arrangement is such that when control power relay 59 picks up, the thermal time delay relay 90 is energized and, after a predetermined time, closes its contacts 95 to energize the operating winding 98 of relay 91. Pickup of this relay completes, through its contacts 100 and conductor 101, the energizing circuit of winding 25 of switch 20 through the normally closed contacts 32 of relay 33, conductors 102 and 60, and the contacts 58 of control power relay 59. Thus, until relay 91 picks up, switch 20 operates to supply the minimum value of current to the load circuit. If the selector switch 43 is in position A, operating winding 38 of relay 33 will be energized and contacts 32 of this relay will be open so that pick-up of relay 91 will not energize winding 25 of switch 20. If, however, the selector switch has been turned to one of its positions B, C, D, or E for higher current values so that one of the relays 34, 35, 36, or 37 may be energized to close its contacts 32, the selected switch 21, 22, 23, or 24 will also be operated by pick-up of relay 91 which will complete the energizing circuit of its operating winding 26, 27, 28, or 29 at the same time as winding 25 of switch 20 is energized. Operation of switch 20 will interrupt the low current setting of the regulator and operation of the selected switch 21, 22, 23, or 24 will complete the desired current setting of the regulator after it has operated at the low current setting for the one or two seconds determined by thermal time delay relay 90. So that the operator might know the value of current being supplied to the load circuit, an ammeter 103 is connected to the secondary winding 104 of current transformer 12.

The organization of the system will be better understood by considering the operation thereof which is as follows:

In the drawing, the selector switch 43 has been illustrated in its off position and all of the relays and switches are in their de-energized positions. Positions A, B, C,

D, and E of the selector switch determine current levels at which the regulator operates to energize the lamps in the load circuit at desired brightness levels. In position A, the minimum amount of current is supplied to the load and provides the minimum brightness level and in each of the positions B, C, and D, the current level is progressively increased for operating the lamps at increased brightnesses until in position E, the lamps are operated at full brightness with the maximum current output of the regulator being supplied to them. In position E of the selector switch, the output circuit of the constant current transformer 2 is connected through contacts 30 and 31 of switch 24 to the output terminals 8 of the regulator and across the end terminals of the autotransformer 7.

If the selector switch 43 is operated to position B, to obtain a brightness level of illumination of the load circuit lamps which is the next level above the minimum brightness level, its movable contacts 44–49 will engage contacts 50–55 in the several switch banks thereof. The circuit completed between fixed contact 50 and movable contact 44 of the left-hand switch bank in position B will extend from control power conductor 19, through these contacts, conductor 68, normally closed contacts 69 of open circuit protector relay 70, conductors 71, the operating winding 67 of control power relay 59, and conductor 72 to the other control power conductor 18. Control power relay 59 will, consequently, pick-up and close its contacts 58 to energize the operating winding 87 of power switch 4 through conductors 88 and 89 from the control power conductors 18 and 19. The power switch 4 will consequently close its contacts 3 and connect the primary winding 1 of the movable coil constant current transformer 2 to its input terminals 5 which are connected to a suitable source of alternating current supply. The closed contacts 30 and 31 of switch 20 connect pairs of primary and secondary terminals of the autotransformer 7 to provide a desired winding ratio for reducing the output current of the secondary 6 of the constant current transformer 2 to the lowest level of current which it is desired to supply through autotransformer 7 to the output terminals 8 of the regulator. This current is supplied through the primaries 13 and 14 of the current transformers 11 and 12 and the amount of this current may be checked by observing the current indication on ammeter 103 which is connected to the secondary winding 104 of the current transformer 12. Current will also flow through the secondary winding 80 of current transformer 11 and thereby energize the operating winding 79 of the main relay 76 of the open circuit protector which will operate to open its contacts 81.

In position B of the selector switch 43, a circuit is also completed for operating relay 34 which will prepare the energizing circuit of the operating winding 26 of switch 21 which circuit will be completed upon operation of relay 91 of the surge limit circuit and the closure of its contacts 100. The operating circuit for relay 34 extends from the control power conductor 19, through contacts 58 of control power relay 59, conductors 60, 61, and 62, contacts 52, 46 of the selector switch, one of the conductors 63, the operating winding 39 of relay 34, the interlocks of relays 38, 40, 41, and 42, and conductors 65 and 66, to the other control power conductor 18. Relay 34 will thus close its control contacts 32 and open its interlock contacts so that none of the other relay windings 38, 40, 41, or 42 can become energized. The closure of control contacts 32 of relay 34 only prepares the energizing circuit for operating winding 26 of switch 21 since this circuit is open at contacts 100 of relay 91. This circuit extends from control power conductor 19, through contacts 58 of control power relay 59, conductors 60 and 102, control contacts 32 of relay 34, the operating winding 26 of switch 21, conductor 101, the contacts 100 of relay 91, and conductor 66, to the other

control power conductor 18. Until relay 91 operates, switch 21 will remain in its open position so that current is supplied through the minimum current connection of the autotransformer 7 which is established by the closed contacts 30 and 31 of switch 20. If in passing to the B position, the selector switch 43 remains for any appreciable time in position A, relay 33 will operate to open its control contacts 32 but this will have no effect since the operating winding 25 of switch 21 is already de-energized by the open circuit at contacts 100 of relay 91. In position B of the selector switch 43, relay 33 will be de-energized and its control contacts 32 will be closed so that switch 21 will operate at the same time as switch 20 when the energizing circuits of windings 25 and 26 of these switches are completed by the closure of contacts 100 of relay 91. The energizing circuit for winding 25 of switch 20 extends from control power conductor 19, through contacts 58 of control power relay 59, conductors 60 and 102, control contacts 32 of relay 33, the operating winding 25 of switch 20, conductor 101, contacts 100 of relay 91, and conductor 66, to the other control power conductor 18. The energizing circuit for the winding 26 of switch 21 has been described above.

If, for any reason, current does not flow in the output circuit of the regulator so that relay 76 is not operated to open its contacts 81, a control circuit of the open circuit protector will be completed from control conductor 19, through contacts 50, 44 of the left-hand switch bank of the selector switch 43, conductors 68 and 105, switch element 84 of thermal time delay relay 77, normally closed contacts 85 of this relay and its heater element 84, current limiting resistor 82, the normally closed contacts 81 of relay 76, the normally closed contacts 73 of the auxiliary open circuit protector relay 70, and conductor 106 to the other control power conductor 18. If this interruption in current flow persists for the operating time of thermal time delay relay 77, which is from one to two seconds, this relay will operate to open its contacts 85 and close its contacts 86. Closure of its contacts 86 will complete a circuit from control power conductor 19, through contacts 50, 44 of the left-hand switch bank of the selector switch 43, conductors 68 and 105, switch element 84 and contacts 86 of relay 77, conductor 107, operating winding 75 of relay 70, and conductor 106 to the other control power conductor 18. Relay 70 will thus pick-up opening its contacts 69 and 73 and closing its contacts 74. The opening of its contacts 69 will de-energize the control power relay 59 which will open its contacts 58 and thereby de-energize the operating winding 87 of the power switch 4 which will then open its contacts to de-energize the primary winding of the constant current transformer 2. Closure of contact 74 of relay 70 completes a holding circuit for the operating winding 75 of this relay from control power conductor 19 through contacts 50, 44 of the left-hand switch bank of selector switch 43, conductors 68 and 105, contacts 74 of relay 70, conductor 107, operating winding 75 of relay 70, and conductor 106 to the other control power conductor 18. Consequently, the open circuit protector cannot be reset unless the selector switch is placed in its off position in order to interrupt this holding circuit of relay 70. The opening of contact 73 of relay 70 de-energizes the operating circuit of thermal time delay relay 77 which will consequently reset closing its contacts 85, so as to be in condition for timing another time delay period when the regulator is again energized and output current flow does not result from such energization with the result that relay 76 maintains its contacts 81 closed.

If in position B of the selector switch current flows to the load circuit, relay 76 will operate to open its normally closed contacts 81 and the open circuit protector will not operate to disconnect the source of supply from the primary winding of the constant current transformer. In this case, as previously stated, the lowest level of cur-

rent flow is supplied to the load circuit by reason of the fact that contacts 30 and 31 of switch 20 are closed. These contacts 30 and 31 of switch 20 will remain closed and the corresponding contacts 30 and 31 of switch 21 will remain open until the operating windings 25 and 26 of these switches are energized by the closure of contacts 100 of relay 91 in the surge limiting circuit. Relay 91 operates in response to the closure of contacts 58 of control power relay 59 after a time delay of one or two seconds determined by relay 90 during which time the windings of the constant current transformer 2 and 6 will assume their operating position for the adjusted current output of this constant current transformer.

At the time control power relay 59 closed its contacts 58, it completed an energizing circuit for thermal time delay relay 90 from control power conductor 19 through contacts 58 of control power relay 59, conductors 60 and 61, switch element 92 of thermal time delay relay 90, its contacts 94 and heater element 93, current limiting resistor 96, the normally closed contacts 97 of relay 91, and conductor 108 to control power conductor 18. After the time delay period of relay 90, it will open its contacts 94 and close its contacts 95 to complete the energization of the operating winding 98 of relay 91 from control power conductor 19, through contacts 58 of control power relay 59, conductors 60 and 61, switch element 92 and contacts 95 of relay 90, the operating winding 98 of relay 91, and conductors 66 to the other control power conductor 18. Relay 91 will, consequently, pick-up opening its contacts 97 and closing its contacts 99 and 100. The opening of contacts 97 of this relay permits the thermal time delay relay 90 to reset and the closure of its normal open contacts 99 complete a holding circuit for this relay from control power conductor 19, through contacts 58 of control power relay 59, conductor 109, contacts 99 of the relay, its operating winding 98 and conductor 66 to the other control power conductor 18. The closure of its contacts 100 completes the energizing circuit previously referred to for the operating windings 25 and 26 of switches 20 and 21 which respectively open and close their contacts 30 and 31 in order to provide a turn ratio in autotransformer 7 which will supply the desired level of current to load circuit 9 which was determined by operation of the selector switch 43 to its B position.

If, in position B, current ceases to flow to the load circuit, the open circuit protector will again operate to deenergize the regulator in the manner above described and the selector switch will have to be placed in its off position to rest the open circuit protector and then again be moved to position B, if it is desired to continue to operate the lamp load at this previously selected brightness level.

It will be noted that the brightness levels determined by positions B, C, D, and E of the selector switch may be changed directly without operating switch 20 in order to provide an initial current flow at the minimum current value. Once the constant current transformer 2 has been operated at one current level, the regulator may be set to a different current level without producing destructive surge currents in the load circuit.

In view of the above description of the operation of the system with the selector switch in position B, the operation of the system is believed to be quite obvious when the selector switch is moved to another of the positions C, D, or E since in each of these positions, the turn ratio of the autotransformer 7 is progressively altered so as to provide progressively higher or lower levels of current of the load circuit depending on the operation of switches 22, 23, or 24 in response to the operating of relays 35, 36, or 37. The operating windings 40, 41, or 42 of these relays are energized through circuits similar to the ones previously traced except that the connection is completed through contacts 53, 47; 54, 48; or 55, 49 of the selector switch instead of the contacts previously described in describing the operation of relays 33 and 34 and the consequent operation of switches 20 and 21.

The current regulator may be operated from a remote location by placing the selector switch 43 in its R position and using remote controller 57 or its equivalent. In this position of the selector switch, its movable contacts 44—49 engage contacts 50—55 of the several switch banks thereof to complete connections to the terminals 110, 111, 112, 113, 114, and 115 of the remote controller 57. Terminal 110 of this controller is connected through a conductor 116 and a switch 117 to one conductor of a control power source 118 corresponding to control power conductor 19 of the controller. The other control power conductor 119 for this remote controller is connected through conductor 120, terminal 121 and conductor 122 to the control power conductor 18 of the controller, which is illustrated in the drawing as grounded. The remote controller preferably has a snap actuated switch 123 whose movable contact 124 engages in positions A, B, C, D, and E contacts which are respectively connected through conductors 125 to terminals 110—115 of this remote controller. It is thus seen that with the selector switch 43 in its remote position R, the snap switch 123 may be operated to any one of its positions A, B, C, D, or E in which its movable contact 124 will energize the controller in the same manner that the controller was energized by operation of the local selector switch 43 forming a part thereof.

In the controller above described, it will be noted that for each of the current output levels which is less than full load, the secondary turns of the autotransformer are smaller in number than the total number of secondary turns and that in selecting the current levels that both the primary and secondary turns of the transformer are varied in order to secure the desired current reduction in the autotransformer. Less than the total number of secondary turns with a desired turn ratio of primary and secondary windings for the desired lower current levels may be used since at the lower lamp brightnesses obtained at reduced current levels, lower load voltages are obtained and, in accordance with my invention, I make use of this characteristic of the load. Insofar as this feature of my invention is concerned, it is quite obvious that other forms of constant current translating devices may be substituted for the movable coil constant current transformer above described as forming part of the illustrated embodiment thereof. For example, various resonant circuits, such as the monocyclic square, may be substituted for the moving coil constant current transformer.

It is also obvious that various features of the above described embodiment of my invention may be changed without departing from the spirit and scope thereof. Thus, instead of using the selector switch and switch operating relays above described, some equivalent form of switch mechanism could be used such as a manually or motor operated drum switch. If a motor-operated drum switch were employed, suitably interlocked circuits could be employed for operating the driving motor until the drum switch was in a desired position as determined by an auxiliary selector switch. Furthermore, a two-winding transformer with primary and secondary winding taps may be substituted for autotransformer 7. Different forms of open circuit protectors and surge current controllers may be substituted for the described arrangements. These and other modifications of my invention will occur to those skilled in the art and I intend to cover in the appended claims all such modifications as fall within the true spirit and scope of my invention.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. Apparatus for supplying selected current values to

a series connected incandescent lamp lighting circuit comprising: a constant current translating device having input terminals for connection to a source of alternating potential and output terminals for supplying a substantially constant current; a transformer having a first series of connections determining the number of windings in its primary circuit and a second series of connections determining the number of windings in its secondary circuit; load circuit terminals for connection to said lighting circut; and selective switching means for simultaneously connecting predetermined pairs of said first series of connections in the primary circuit of said transformer across the output terminals of said translating device and predetermined pairs of said second series of connections in the secondary circuit of said transformer across said load circuit terminals; the number of winding turns of said transformer connected by said switching means across said load circuit terminals at each current level less than full load current being less than the total number of secondary circuit winding turns, and the number of winding turns of said transformer connected by said switching means across said output terminals of said translating device at each current level less than full load current being less than the total number of said primary circuit winding turns.

2. A current level regulator for a load circuit having series connected incandescent lamps therein comprising: a moving coil constant current transformer having input terminals and output terminals; a current ratio transformer having primary and secondary terminals selected pairs of which determine its winding ratio for reducing its current output relative to its current input; load circuit terminals; selective switching means connecting said output terminals of said constant current transformer to said load circuit terminals through selected pairs of primary and secondary terminals of said current ratio transformer to control the magnitude of current flow to said load circuit terminals; a selector switch having a plurality of operating positions; means including said selector switch for operating said switching means to provide in one operating position of said selector switch a minimum value of current to said load circuit terminals and in the other operating positions of said selector switch selected values of current greater than said minimum value of current; and surge current limiting means conditioning said switching means to establish said minimum value of current to said load circuit terminals for a predetermined interval of time following movement of said selector switch to said other operating positions prior to establishing a selected value of current greater than said minimum value.

3. A brightness control for series connected incandescent lamps comprising: a moving coil constant current transformer having input terminals for connection to a source of alternating potential and output terminals for supplying a substantially constant current; a current ratio transformer having primary and secondary terminals, selected pairs of which determine the turn ratio of said transformer; load circuit terminals for connection to said series connected incandescent lamps; selected switching means connected to complete the connection of said output terminals of said constant current transformer to the end terminals of said current ratio transformer and to said load circuit terminals for operating said lamps at full brightness and connected to complete the connection of said output terminals of said constant current transformer to said load circuit terminals through less than the total number of primary and secondary winding turns of said current ratio transformer by respectively connecting selected pairs of its said primary and secondary terminals to said output terminals of said constant current transformer and to said load circuit terminals for operating said lamps at reduced brightness, the number of secondary winding turns of said current ratio transformer between said selected pair of secondary terminals being less than the total number of said secondary winding turns and in accordance with the lower voltage requirements of the load at reduced brightness and the ratio of primary to secondary turns of said current ratio transformer between said selected pairs of primary and secondary terminals being that required for reducing the output current of said constant current transformer to a predetermined value for operating said lamps at reduced brightness; a current level selector switch having a plurality of operating positions; and surge current limiting means including said selector switch in one of its operating positions for operating said switching means to provide a minimum value of current to said load circuit terminals and including said selector switch in its other operating positions for operating said switching means to provide selected values of current greater than said minimum value of current after minimum current to said load circuit terminals has been established for a predetermined interval of time.

4. Apparatus for supplying selected current values to a series connected incandescent lamp lighting circuit comprising: a constant current translating device having input terminals for connection to a source of alternating potential and output terminals for supplying a substantially constant current; load circuit terminals for connection to said lighting circuit; a variable turn-ratio transformer arranged to transfer electrical energy from the output terminals of said constant current translating device to said load circuit terminals, said transformer having a first series of connections determining the number of windings in its primary circuit and a second series of connections determining the number of windings in its secondary circuits; selective switching means cooperating with said first and second series of terminals and operatively connected to alter simultaneously the number of turns connected in the primary and secondary circuits of said variable turn-ratio transformer, the number of turns connected in both said primary and secondary circuits being respectively fewer at progressively lower preselected lighting circuit current levels.

5. A current level regulator for a load circuit having series connected incandescent lamps therein comprising: a constant current translating device having input terminals for connection to a source of alternating potential and output terminals for supplying a substantially constant current; terminals for connection to said load circuit; a variable turn-ratio transformer having primary and secondary circuit connections arranged to transfer electrical energy from the output terminals of said constant current translating device to said load circuit terminals; selective switching means operatively connected to alter the number of turns connected in the primary circuit of said transformer and simultaneously therewith to alter the number of turns connected in the secondary circuit of said transformer, the number of turns connected in both said primary and secondary circuits being respectively fewer at progressively lower preselected load circuit current levels.

6. Apparatus for supplying preselected current levels to a series connected lighting circuit for filamentary lamps comprising: a constant current translating device having input terminals for connection to a source of alternating potential and output terminals for supplying a substantially constant current; load terminals for connection to said lighting circuit; a variable turn-ratio transformer having a series of input connections and a series of output connections for determining the turn ratio of windings in its primary and secondary circuits; a series of relays, each having an operating winding and a pair of electrical switches simultaneously operated thereby, one of each pair of switches being connected to make and to break circuit connections between said output terminals of said constant current translating device and respective input connections of said transformer, the other of each of said pair of switches being connected to make and to

break circuit connections between said load terminals and repective output connections of said transformer; means for selectively energizing the operating winding of each of said relays to establish preselected turn ratios between the windings in the primary and secondary circuits of said variable turn-ratio transformer, thereby providing preselected current levels in said load circuit, the number of turns connected by said switches in the primary and secondary circuits of said variable turn ratio transformer being respectively fewer at progressively lower preselected current levels in said load circuit.

7. A current level regulator for a load circuit having series connected incandescent lamps therein comprising: a constant current moving coil transformer having input terminals for connection to a source of operating potential and output terminals for supplying a constant current; load terminals for connection to said load circuit; a variable turn ratio transformer having primary and secondary circuit connections arranged to transfer electrical energy from the output terminals of said constant current transformer to said load circuit terminals; and means for establishing preselected current levels in said load circuit including switching means cooperating with the primary and secondary circuit connections of said variable turn ratio transformer to alter the number of windings in said primary circuit and simultaneously therewith to alter the number of windings in said secondary circuit, the number of winding turns connected in both said primary and secondary circuits being respectively fewer at progressively lower preselected load circuit current levels.

8. A current level regulator for a load circuit having series connected incandescent lamps therein comprising:

a constant current moving coil transformer having input terminals for connection to a source of operating potential and output terminals for supplying a constant current; load terminals for connection to said load circuit; a variable turn ratio transformer having primary and secondary circuit connections arranged to transfer electrical energy from the output terminals of said constant current transformer to said load circuit terminals; and means for establishing preselected current levels in said load circuit including switching means cooperating with the primary and secondary circuit connections of said variable turn ratio transformer to alter the number of windings in said primary circuit and simultaneously therewith to alter the number of windings in said secondary circuit, the number of winding turns connected in both said primary and secondary circuits being respectively fewer at progressively lower preselected load circuit current levels, selective actuating means effective on actuation to control said switching means to provide a preselected current level in said load circuit, and surge current limiting means conditioning said switching means to establish a minimum current level in said load circuit for a predetermined interval of time following actuation of said actuating means prior to establishing a higher preselected current level.

References Cited in the file of this patent

UNITED STATES PATENTS

2,085,060	Young	June 29, 1937
2,138,335	Brackensey	Nov. 29, 1938
2,351,486	Constable	June 13, 1944
2,602,150	Hauck	July 1, 1952