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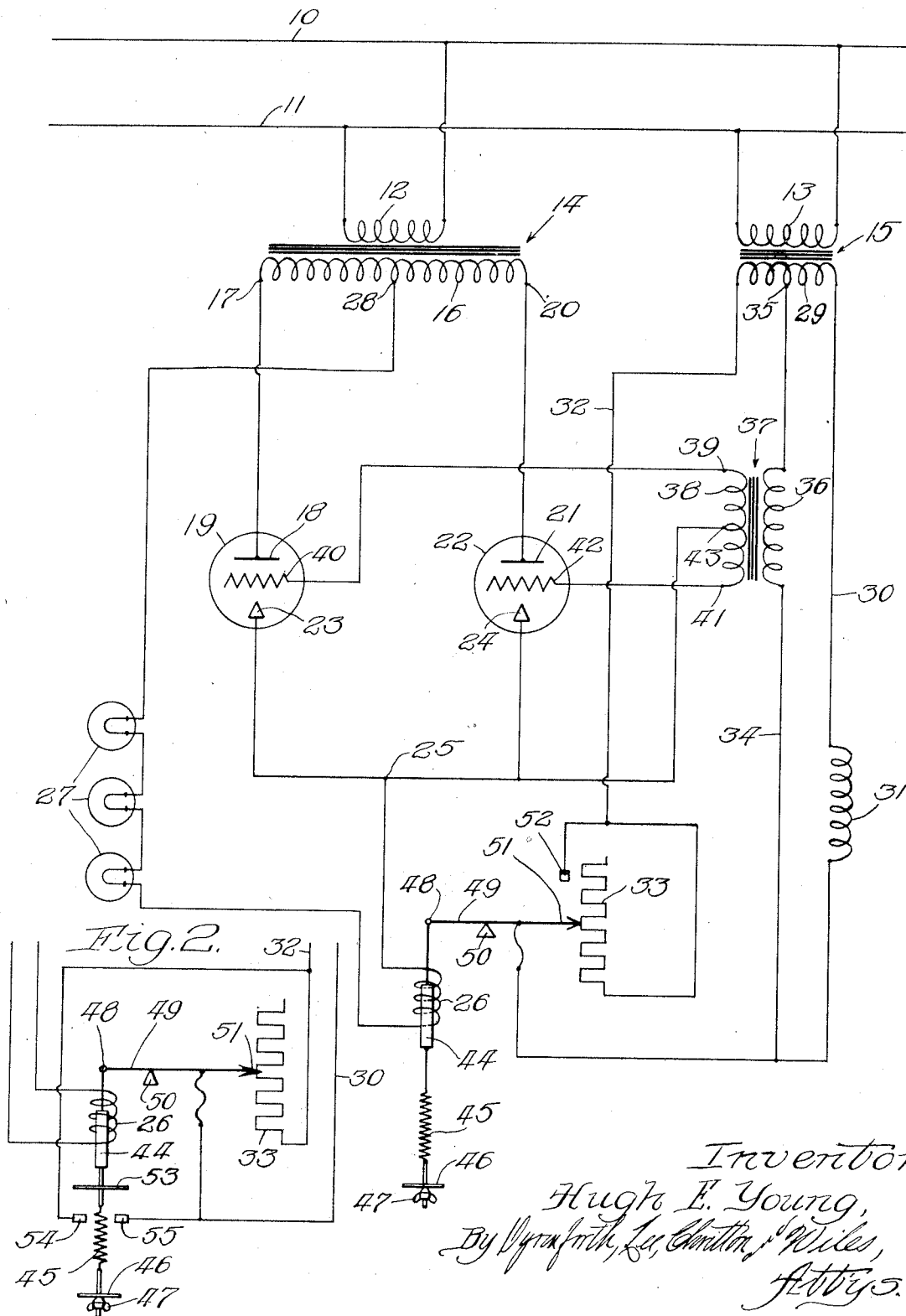
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CURRENT REGULATING SYSTEM

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Fig. 1.



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CURRENT REGULATING SYSTEM

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8 Claims. (Cl. 176-8)

This invention relates to current regulating systems, and more particularly to systems designed to maintain the current flow in a series street lighting system constant.

5 This application is for an improvement upon my co-pending application Serial No. 618,369, filed June 20, 1932.

One feature of this invention is that it maintains the current through a series lighting system constant; another feature is that it supplies controlled D. C. current from an A. C. line; still another feature is that it is capable of manual adjustment although fully automatic in action at any given adjustment; yet another feature is that in the event of an open line at any point it automatically cuts off the voltage in the line so that there is no potential drop across the open portion of the circuit. Other features and advantages of this invention will appear from the following specification and the drawing, in which—

Fig. 1 is a schematic diagram of such a circuit; and Fig. 2 is a detailed view of another form of the automatic potential cut-off.

25 Series street lighting systems are generally operated on D. C. current, and each individual lamp has in connection therewith a short circuiting relay, not illustrated here, which operates in the case of lamp failure and prevents the circuit being opened by such a failure. Each time such a relay operates, however, the resistance of the line is necessarily lessened by the removal of a lamp filament from the circuit. Some form of constant current control is thus necessary to maintain the current through the lamps constant in spite of variations in line resistance. Voltage surges at the supply end must also be smoothed out in order to prevent overloading of the lamps. This invention provides a system which derives its power from an A. C. source, rectifies it and furnishes it to a series lighting system, maintaining the current constant at the desired level regardless of surges in the supply line or variations in resistance of the series lighting circuit.

45 Moreover, this invention provides means for cutting off the voltage in the line immediately upon an open circuit at any point. If, for example, a lamp post in a series lighting circuit is knocked down and its wires broken off, this device automatically cuts off the voltage in the line so that there is no potential drop across the exposed wires and thus no possibility of a shock to anyone coming in contact with their bare ends.

55 In the particular embodiment of this invention illustrated A. C. power from the lines 10 and

11 is supplied to the primaries 12 and 13 of the transformers 14 and 15. The secondary 16 of the transformer 14 has the end 17 thereof connected to the anode 18 of a controlled arc rectifying tube 19, and the opposite end 20 similarly connected to the anode 21 of a second controlled arc rectifying tube 22. The tubes 19 and 22 have their cathodes 23 and 24 connected together at the common point 25 from which point D. C. current passes through the solenoid 26 to the lamps 27, representing a series street lighting system, and completes the circuit by being returned to the mid point 28 of the secondary 16.

The transformer 15 has its secondary 29 in a phase splitting circuit composed of a branch 30 connected to one side of said secondary and having an inductance 31 therein, a branch 32 connected to the other end of said secondary and having a variable resistance 33 therein, and a common return circuit 34 to the mid point 35 of the secondary 29. The return circuit 34 has therein the primary 36 of a grid transformer 37 whose secondary 38 has one end 39 connected to the grid 40 in the controlled rectifying tube 19 and its other end 41 connected to the grid 42 in the tube 22. The grid return circuit is completed by a lead from the mid point 43 of the secondary 38 to the common point 25 of the two cathodes 23 and 24.

The solenoid 26 has therein a movable iron core 44 which tends to center itself in the solenoid 26 as a result of the flow of D. C. current therein. The spring 45 has one end fastened to the core 44 and the other end adjustably fastened to some fixed element 46, adjustment being secured through turning of a wing nut 47. The spring 45 supplies a straight line tension force tending to counteract the pull of the solenoid 26. The core 44 is also attached to one end 48 of a lever 49 having a fulcrum 50. The other end 51 of this lever 49 contacts the resistance 33, and motion of the lever 49 thus serves to vary the amount of resistance in the branch 32 of the phase splitting circuit. A contact 52 cooperates with the pointer 51 to provide means whereby the resistance is shorted out when the pointer swings to the extreme end of the resistance 33.

In operation the transformer 14 carries the main load current and supplies bi-phase half wave rectified D. C. to the lamps 27 through the controlled arc rectifying tubes 19 and 22. The transformer 15 carries sufficient current to energize the grids 40 and 42, which current is very small.

The controlled arc rectifying tubes 19 and 22 do

not begin to pass current immediately upon their anodes becoming positive, but instead pass current only after the voltage on their grids has become more positive than the critical grid voltage of the particular tubes employed. Since the phase of the current on the grids may be shifted as much as 180° with relation to that on the anodes the tubes may pass current during a full cycle, as when the grid voltages are in phase with the anode voltages, or only during a half cycle, as when the grid voltages are 90° out of phase with the anode voltages, or not at all, since when the grid voltages have been shifted 180° out of phase with the anode voltages the tubes will not start at all.

At any given instant the voltage drop in the return circuit 34 of the phase splitting circuit is the resultant of the two components provided by the voltage drop across the variable resistance 33 and the inductance 31. Assuming that the resistance 33 has been reduced to zero the voltage drop in branch 32 will be negligible, and this branch will furnish practically the entire voltage across the return circuit 34. In the event that the resistance 33 is entirely in circuit, and is of a rather high value, the voltage drop in the branch 32 will be so great that the voltage across the return circuit 34 will be in phase with that supplied by the branch 30. The phase of the voltage applied to the grids may thus be shifted from a position in phase with the anode voltages to a position 180° out of phase, through any desired intermediate positions, by the action of the variable resistance 33. In place of varying the resistance 33, of course, the inductance 31 can be varied while the resistance branch is fixed, without in any way changing the action of the circuit.

Assuming that the spring 45 has been adjusted to provide a tension which just balances the pull on the solenoid 26 on the core 44 when a current of six amperes is flowing through the solenoid, the current control device and phase splitting circuit will cooperate to automatically maintain the current at six amperes regardless of changes in the series lighting line. In the event that the current tends to rise to seven amperes for any reason, the increased current will result in an increased solenoid pull, which will move the core 44 further into the solenoid and act to shift the point 51 of the lever 49 to include less of the resistance 33 in the branch 32. This will shift the voltages on the grids further out of phase with respect to those on the anodes and thus permit the tubes to operate only during a smaller portion of the cycle, thus maintaining the average D. C. current at six amperes. Should the current in the coil start to drop the attraction of the solenoid will not be sufficient to neutralize the pull of the spring and the core 44 will tend to move out of the solenoid, acting through the lever 49 to increase the amount of resistance in the branch 32 of the phase splitting circuit and thus shifting the grid voltages more nearly into phase with the anode voltages, resulting in tube operation during a larger portion of each cycle and thus maintaining the D. C. current at the desired value of six amperes. Since the device is capable of a 180° phase shift, all or none of the lamps, or any part thereof, may be in circuit, and the current through the lamps will always be automatically maintained at the desired predetermined value.

This current regulating system is of great value where it is desired to use different forms of lamps on the same system, or where vapor lamps are employed rather than those of the filament type.

It has heretofore been impossible, for example, to operate a set of sodium vapor lamps in series, or with a set of filament lamps, without complicated multiple wire systems, due to the falling resistance characteristic of a sodium vapor lamp as the arc is set up therein. With a regulating device of this kind, however, the relatively large resistance changes as a sodium vapor lamp comes into action in no way detrimentally affects the system since the current is always maintained at the desired amperage regardless of the internal resistance changes in the sodium vapor lamps.

The safety features of the automatic voltage cut-off are very important. In the event of a broken lamp-standard, it quite frequently happens that two exposed ends of wire are within the reach of children, or of inexperienced adults. In the usual series lighting circuit the complete potential is developed across an open point of this kind, and since this potential may run in the neighborhood of 2300 volts, it is clearly dangerous. The operation of the automatic voltage cut-off in Figure 1 is as follows. If there is a breakage at any point in the line the series resistance of a line rises greatly, and the current drops to a substantially negligible value. Since there is now practically no current through the solenoid 26, there is no force tending to counteract the pull of the spring 45, and the pointer 51 swings up until it touches the contact 52. A circuit is thus provided which shorts out the resistance 33, and thus throws the voltage supplied to the grids 180° out of phase with that supplied to the anodes of the tubes. This causes the tube to completely block the current, and all of the potential supplied by the transformer 14 is developed across the tube, rather than across the open point in the line.

An alternate form for this cut-off is shown in Figure 2. In this form of the device a bar 53 is provided, adapted to bridge the two contact points 54 and 55. In this form an excess of current through the solenoid 26 allows the spring 45 to pull the bar 53 downwards and thus bridge the two contacts. When these two contacts are thus connected, the resistance 33 is shorted out of the phase splitting circuit, and the voltage drop is across the tube rather than across the line, as discussed in the previous paragraph. This form of the device can be used with any phase-splitting circuit of this general type, whether operation of the phase-splitting circuit is being achieved through variation of the resistance, of the inductance, or in some other way. The form illustrated in Figure 1 obviously can only be used where the resistance is being varied.

While I have shown and described certain embodiments of my invention, it is to be understood that it is capable of many modifications. Changes, therefore, in the construction and arrangement may be made without departing from the spirit and scope of the invention as disclosed in the appended claims, in which it is my intention to claim all novelty inherent in my invention as broadly as possible in view of the prior art.

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

1. Apparatus of the character described, including; an A. C. supply; a controlled arc-rectifying tube; a load circuit in series with said tube the resistance of said load circuit varying between maximum value and substantially short circuit value; a phase-splitting circuit; a regulator for maintaining current constant in said

load circuit, said regulator having a coil in series with said load circuit, and having a control element for shifting the phase of voltage of said phase splitting circuit; means whereby the voltage in said phase-splitting circuit is impressed on the control means in said tube; and said regulator having means whereby an open circuit condition in said load-circuit automatically alters one of the constants of said phase-splitting circuit to render said tube inoperative.

2. Apparatus of the character described, including; an A. C. supply; a controlled arc rectifying tube; a load circuit in series with said tube; a phase-splitting circuit having a resistance branch therein; means whereby the voltage in said phase-splitting circuit is impressed on the control means in said tube; means whereby current variations in said load circuit are translated into mechanical motion; and means whereby a drop of the current in said load-circuit to a substantially negligible value causes said mechanical motion producing means to complete a short circuit for said resistance to render said tube inoperative.

3. Apparatus of the character described, including; an A. C. supply; a controlled arc rectifying tube; a solenoid and a D. C. load in series with said tube; a phase-splitting circuit having a resistance branch; a reactance branch, and a common return circuit for said branches; means whereby the voltages in said return circuit are impressed on the control means in said tube; a movable core in said solenoid; and means associated with said movable core whereby substantially negligible current in said solenoid effects the completion of a short circuit for the resistance branch of said phase-splitting circuit.

4. Apparatus of the character described, including; an A. C. supply; a controlled arc rectifying tube; a load-circuit in series with said tube; a second circuit associated with the control means of said tube; and means responsive to current variations in said load circuit whereby negligible current in said load circuit effects a change in said second circuit to render said tube inoperative.

5. In a system of the class described, an alternating current supply circuit, a load circuit the resistance of which varies between maximum value and substantially short circuit value, a rec-

tifying tube between said circuits, means for firing the tube during a selected portion of each cycle impressed upon the tube, a regulator sensitive to the current flow in said load circuit for regulating the action of said firing means to maintain the flow of current through said load circuit substantially constant for all variations of resistance therein between the aforesaid values, said regulator tending to increase the voltage on said load circuit as the current flow decreases until a predetermined low value of current is reached, and means actuated by said regulator when said predetermined low value of current flow in the load circuit is reached for rendering said firing means ineffective, whereby the load circuit is freed of potential.

6. In a system of the class described, an alternating current supply line, a series lamp circuit providing a variable lamp load, a tube between said line and said circuit, firing means for the tube, a regulator controlled by the current in the circuit to control the action of said firing means to keep the current constant for all variations of resistance of the lamp load, and a device controlled by the regulator for preventing operation of said firing means when the series lamp circuit is open circuited.

7. In a system of the class described, an alternating supply line, a load circuit having a load therein the resistance of which varies between substantially short circuit value and a predetermined maximum value, means for transferring electrical energy from said supply line to said load circuit, and a regulator controlled by current flow in said load circuit for regulating said energy transferring means to keep the current in the load circuit constant, said regulator having means to render the energy transferring means inactive upon a rise of resistance in said load circuit above said predetermined maximum value.

8. In a system, a constant current series lamp circuit, means for supplying electrical energy thereto, a regulator for increasing the voltage of the supply means as the resistance of the lamp circuit increases to keep the current constant, and means for reducing the voltage to zero upon the occurrence of a break in the lamp circuit.

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