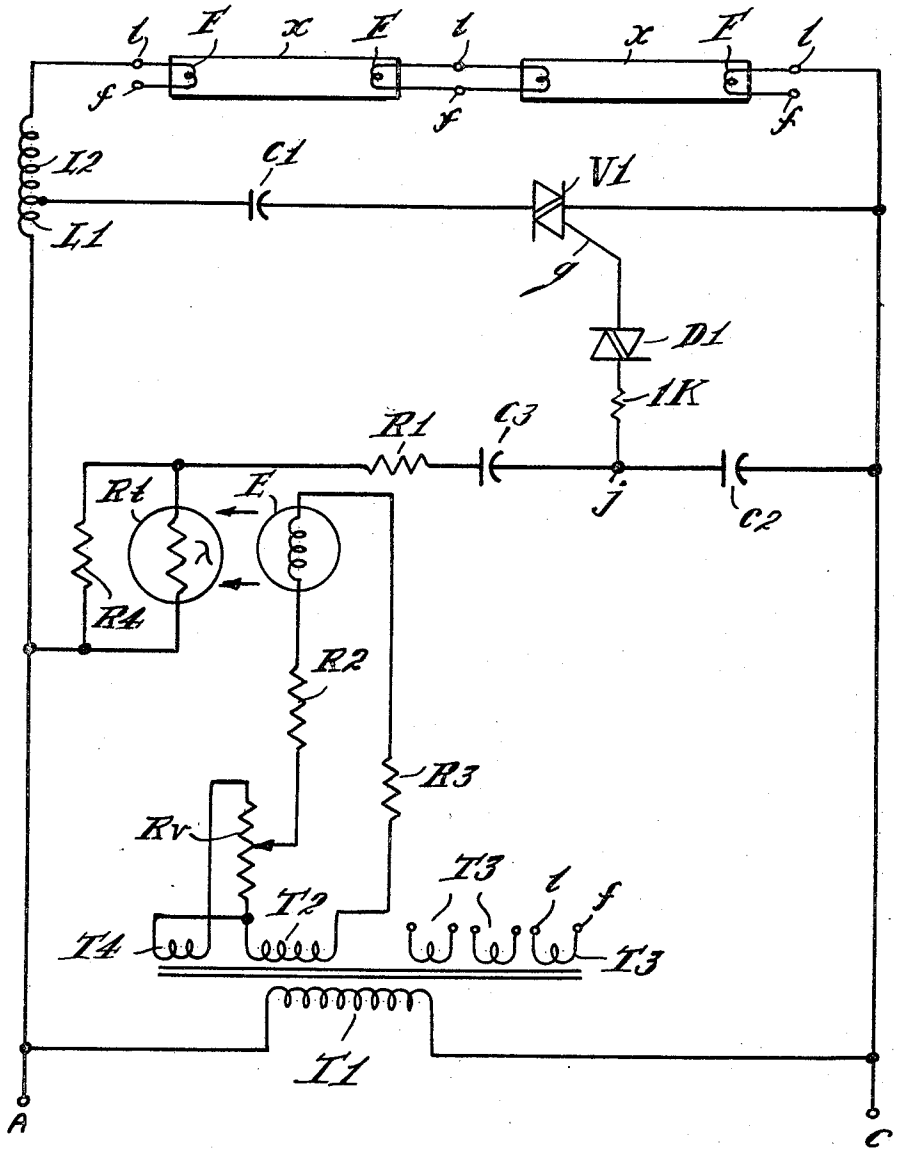
Nov. 18, 1969 F. W. PAGET ETAL 3,479,560

ARC DISCHARGE REGULATING DEVICE HAVING MEANS TO COMPENSATE FOR SUPPLY VOLTAGE VARIATIONS

Filed Dec. 29, 1967



Inventors
Frederick W. Paget
Ned Scott Van Buren
by Roberts, Cushman & Grover
Attys

United States Patent Office 3,479,560 Patented Nov. 18, 1969

3,479,560

ARC DISCHARGE REGULATING DEVICE HAVING MEANS TO COMPENSATE FOR SUPPLY VOLTAGE VARIATIONS

Fredrick W. Paget, Rockport, and Ned Scott Van Buren, Belmont, Mass., assignors to Sylvania Electric Products Inc., a corporation of Delaware

Filed Dec. 29, 1967, Ser. No. 694,653
Int. Cl. H05b 41/18
U.S. Cl. 315—105 4 Claims

ABSTRACT OF THE DISCLOSURE

A semi-conductor circuit for starting and controlling current drawn by a fluorescent lamp includes a voltage pulse discharge valve triggered by another electronic valve which breaks down once each half cycle of applied alternating current, the time of breakdown limiting the degree of ionization of the lamp by the voltage pulse and hence the current conducted each half cycle. To compensate for line current variations a photoconductor in the time constant circuit of the breakdown valve senses emission from lamp inductively coupled to the alternating current terminals by a filament transformer.

The starting and operation of arc discharge devices such as fluorescent lamps and high pressure mercury lamps presents two major problems. First, these and similar devices require a relatively high voltage to ignite an arc across the lamp as compared with the voltage needed to maintain the arc once it is ignited. Secondly, once the arc is ignited it has a negative resistance characteristic causing it to tend to draw increasingly more current until it reaches a run-away condition. Both problems have been solved by the use of an inductive ballast in series with the lamp and the line terminals supplying power to the lamp. The voltage applied across the lamp by the ballast is adequate to maintain an ignited arc. The ballast steps up or gives an inductive kick to the voltage, producing peak voltages above the line peak voltage and adequate to strike the arc. The reactance of the ballast then limits the current through the lamp to its rated value. The objections to the use of ballasts are that they are heavy and bulky by reason of the large amount of copper winding and iron core in their construction. They are expensive to make and draw substantial power not useful for lighting. They heat the environment of the lamp, and unless carefully constructed generate acoustic and electromagnetic noise.

A semi-conductor circuit lacking all the disadvantages of a reactance ballast has been developed, which circuit applies a voltage pulse to the lamp once each AC half cycle to ionize the lamp slightly less than necessary for conduction through successive half cycles, so that current through the lamp is limited by a tendency to extingish each half cycle.

It is the object of the present invention to improve such a semi-conductor system for arc discharge devices by providing automatic compensation for variations in the AC line voltage.

According to the invention an electrical system for continuously controlling operation of a negative resistance arc discharge device comprises discharge terminals for connection to each end of the device, power terminals for connection to a supply of alternating voltage less than said predetermined arc maintaining level, a power circuit connecting said power terminals to said discharge terminals, a voltage pulse generating circuit connected in parallel with said discharge terminals, said pulse generating circuit including storage means and a triggered

pulse discharge valve, a trigger circuit including a switching device connected between a power terminal and said valve and actuated by a predetermined voltage to trigger said valves and time constant means controlling the time in said alternating voltage cycle at which said predetermined voltage actuates the switching device, an ohmic radiation emitter inductively coupled to said power terminals to emit in proportion to variations in said alternating current supply, and said time constant means including a device sensitive to radiation from said emitter to change said time constant in a sense to compensate for changes in said supply current.

For the purposes of illustration a typical embodiment of the invention is shown in FIG. 1 which is a schematic diagram of a fluorescent lamp control system.

The exemplary system of FIG. 1 comprises a pair of high output fluorescent lamps X, type 48T12, having terminals *l* and *f*. The pair of lamps may be considered as one lamp having a rated starting voltage of at least 240 volts peak and an arc maintaining voltage of 60 volts RMS. Arc current is supplied to one lamp terminal *l* from one 115 volt, 60 cycle alternating current line terminal A through an autotransformer having a primary winding L1 and a secondary winding L2 with a turns ratio of 1 to 2. The other lamp terminal *l* is connected to the other line terminal C. The system, so far described, comprises the power circuit for the lamp. A filament transformer has a primary winding T1 connected across the line terminals A and C, and secondary windings T2 and T3, the latter being connected to terminals *l* and *f* for the lamp filaments F to supply heating current thereto.

Connected in parallel with the lamp is a voltage pulse generating circuit comprising a primary voltage pulse storage capacitor C1 (8 microfarads) and a bilateral controlled electron valve V1, known as a triac (G.E., type SC45B). A triac is triggered into avalanche conduction in either direction between its primary electrodes *f* when a voltage of either polarity is applied to its gate electrode *g*. An equivalent network is two silicon controlled rectifiers connected in parallel in opposite polarity. Other bidirection electron valves triggered externally or internally may be substituted. The triac is triggered by a diac D1 (G.E., type ST2), similar to the triac but lacking a gate electrode. A diac breaks down to avalanche conduction when the voltage across it exceeds a predetermined value. A diac may be replaced by two avalanche diodes connected in parallel. The diac D1 is connected between the triac gate *g* and the junction *j* in a time constant network connected between the power terminals A and C in parallel with the lamps X.

The time constant network comprises, in series, storage capacitors C2 (0.1 microfarad) and C3 (0.07 microfarad), fixed resistors R1 (2.4 kilohms) and R4 (27 kilohms), and a photo-conductor R*t* (Sylvania PL 466E) in parallel with resistor R4. During each half cycle of alternating current at the power terminals A and C capacitors C2 and C3 charge at a rate dependent on the RC values in the time constant network until the voltage at the junction *j* reaches the breakdown value of the diac D1. Typically breakdown occurs at about 70 volts or at about 25° of the half cycle. Breakdown of the diac applies a voltage to the gate electrode *g* of the triac which abruptly is triggered into avalanche conduction, allowing the primary capacitor C1, charged from a previous cycle, to discharge and reverse its charge to the instantaneous line voltage through the triac. The capacitor thereby discharges a voltage pulse or oscillatory pulse train through the autotransformer primary L1. This discharge voltage is stepped up in the transformer secondary L2 of the lamp X, and the stepped up voltage

pulse or train is applied to the lamp terminals *l*. At this instant a limited number of ions are established in the lamp depending on the amplitude and duration of the pulse. Shortly thereafter the lamp fully ignites and conducts line current for part or all of the remaining half cycle. At a time either before or shortly after the half cycle when the line voltage again passes through zero, the arc almost extinguishes since the limited ionization cannot maintain the arc until the line voltage rises in the subsequent half cycle to arc maintaining voltage level.

With a conventional ballast, once the arc is ignited by one or more initial inductive kicks and the lamp attains its negative resistance condition, the excess ionization provided by the ballasts allows the line voltage to carry the lamp through successive half cycles of conduction without applying higher arc starting voltage. In fact the ballast is necessary to prevent run-away conduction. In contrast the present pulse generating circuit injects an ionizing voltage pulse each half cycle. Failure of the pulse generating circuit to re-ionize the lamp each half cycle would immediately or quickly result in extinction of the arc. Thus, with rare exceptions, the generating circuit applies an arc starting voltage to the lamp once each half cycle of line voltage. On the other hand, the values of the generating circuit components are selected to limit the degree of ionization to that just necessary to support about one half cycle of conduction at line voltage. By thus limiting the amount of ions available to conduct current at the lower line voltage the lamp tends to, and almost does, extinguish each half cycle as the alternating line voltage passes through zero. With this ionization control the lamp is prevented from progressing to run-away conduction condition. The pulse generating circuit thus eliminates the conventional heavy ballast, but with a new mode of operation provides the arc starting and current limiting functions of such a ballast. The prior heavy ballast (e.g. ten pounds) is replaced by a significantly lighter autotransformer (e.g. three pounds) whose much lower inductance draws a small fraction of the power drawn by a conventional ballast.

In the mode of operation described above the average current drawn by the lamp each half cycle depends on the amount of ionization injected in the lamp by the primary storage capacitor C1. This in turn depends on the amplitude to which the line voltage has risen at the time the valve V1 is triggered by breakdown of the switch device D1. The earlier the breakdown and triggering, the lower the instantaneous line voltage, and the less the ionization and average current in the lamp. In the circuit of FIG. 1 the number of ions, and the line voltage, control the average current through the lamp. These factors can be chosen to represent the proper lamp circuit. However, current drawn by the lamp, and hence its light emission, exhibit undesired variations as the alternating current supply voltage changes.

According to the present invention supply voltage changes are compensated by varying the charging time of the time constant circuit. For this purpose a 6 volt incandescent lamp E, such as Sylvania type 8760, is connected in series with an additional secondary 10 volt winding T2 of the filament transformer, whose primary is winding T1. A further 3 volt winding T4 produces an opposing voltage producing a voltage available across a 0 to 100 ohm potentiometer Rv in the range of 7 to 10 volts. Protective resistors R2 (120 ohms) and R3 (130 ohms) are also in series with the additional secondary T2. These values of resistance, voltage and lamp type are not critical inasmuch as the function of the lamp is to emit light radiation to a *CdSe* or *CdS* photoconductor Rt such as Sylvania type PL 466E. The resistance of the photoconductor Rt, being in the time constant network, controls the charging time of the network and hence the

firing time of the diac D1. For example, as the peak supply voltage rises from normal amplitude the light emission of the lamp E increases causing a reduction in the resistance of the photoconductor Rt and of the charging time of the time constant network. Consequently the diac breakdown voltage at junction *j* is reached earlier in the AC half cycle thereby compensating for the higher supply voltage. Conversely a line voltage drop will result in later triggering of triac V1 at a time in the AC half cycle when the voltage has reached the desired level for starting pulse discharge.

While one desirable embodiment of the invention has herein been disclosed by way of example, it is to be understood that the invention is broadly inclusive of any and all modifications falling within the terms of the appended claims.

We claim:

1. An electrical system for continuously controlling operation of a negative resistance ionized arc discharge device comprising,
   - discharge terminals for connection to each end of the device,
   - power terminals for connection to a supply of alternating voltage less than a predetermined arc maintaining level,
   - a power circuit connecting said power terminals to said discharge terminals,
   - a voltage pulse generating circuit connected in parallel with said discharge terminals,
   - said pulse generating circuit including storage means and a triggered pulse discharge valve,
   - a trigger circuit including a switching device connected between a power terminal and said valve and actuated by a predetermined voltage to trigger said valves and time constant means controlling the time in said alternating voltage cycle at which said predetermined voltage actuates the switching device,
   - an ohmic radiation emitter inductively coupled to said power terminals to emit in proportion to variations in said alternating current supply,
   - and said time constant means including a device sensitive to radiation from said emitter to change said time constant in a sense to compensate for changes in said supply current.

2. A system according to claim 1 wherein said discharge device comprises a lamp with filaments for connection to filament terminals, and characterized by a filament transformer having primaries connected between said power terminals and secondaries connected to said filament terminals, and an additional secondary connected in series with said radiation emitter.

3. A system according to claim 2 characterized by a variable resistance in series with said additional secondary and said radiation emitter.

4. A system according to claim 1 wherein said radiation emitter is an incandescent lamp and said sensitive device is a photoconductor exposed to said lamp.

References Cited

UNITED STATES PATENTS

3,307,070	2/1967	Hutson	315—101
3,310,687	3/1967	Howell	315—207 X
3,344,311	9/1967	Nuckolls	315—158 X
3,358,217	12/1967	Deelman	323—21

JAMES W. LAWRENCE, Primary Examiner

E. R. LA ROCHE, Assistant Examiner

U.S. Cl. X.R.

307—246; 315—159, 199, 260