

Nov. 22, 1960

R. B. RONEY ET AL

2,961,579

DIMMING CIRCUITS FOR FLUORESCENT LAMPS

Filed June 16, 1958

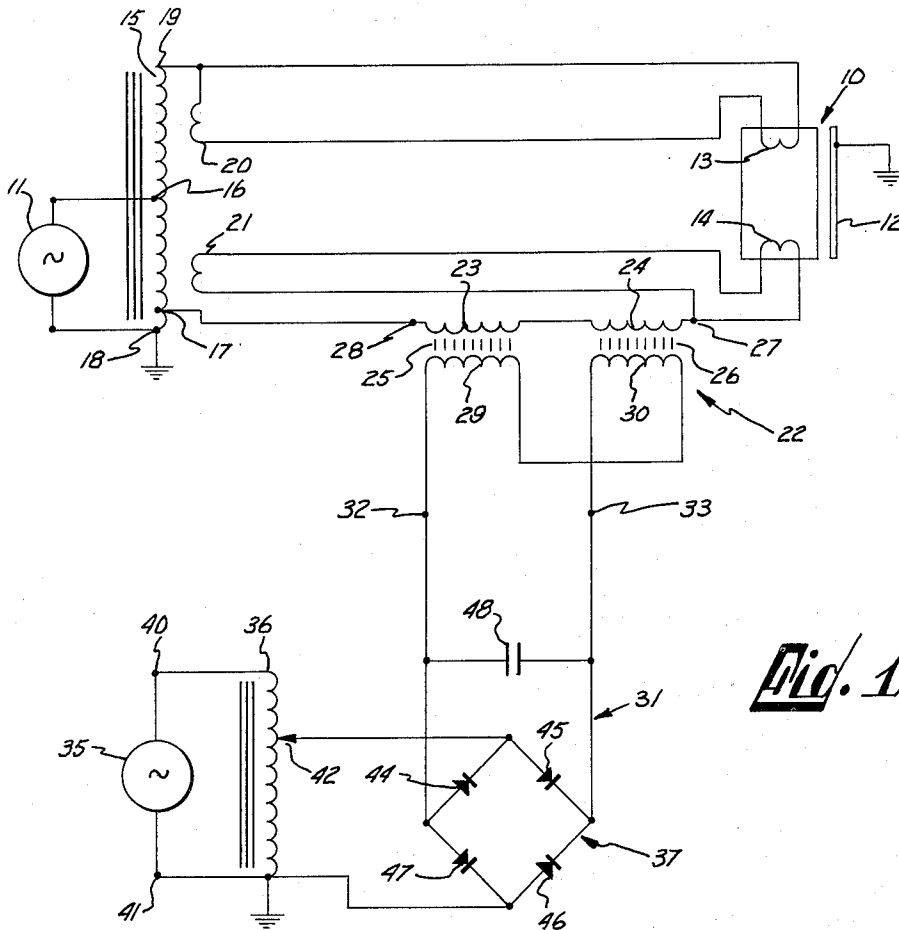
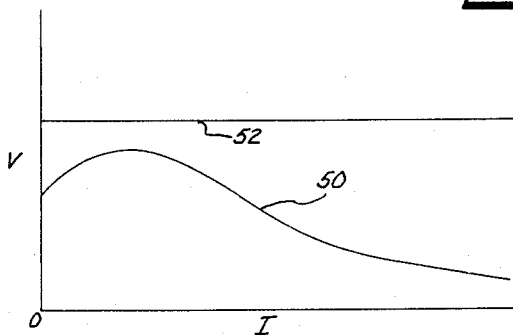


Fig. 1.

Fig. 2.



INVENTORS.
RAYMOND B. RONEY
PHILIP E. MASSIE
BY

Christie, Parker & Hale
ATTORNEYS

1

2,961,579

DIMMING CIRCUITS FOR FLUORESCENT LAMPS

Raymond B. Roney, Arcadia, and Philip E. Massie, Culver City, Calif., assignors to Day-Ray Products, Inc., South Pasadena, Calif., a corporation of California

Filed June 16, 1958, Ser. No. 742,302

5 Claims. (Cl. 315—170)

The present invention relates generally to dimming circuits and more particularly to a dimming circuit for fluorescent lamps.

In certain lighting applications such as instrument lighting for aircraft, control over the light output from one or more sources of light is a necessity. For example, a high level of light intensity must be provided within the cockpit of an aircraft during daylight flying to permit the pilot to see the instruments which are located under the windshield. Without such a high level intensity light to illuminate the instrument panel, the instruments would be obscured by the bright area of the windshield. At night the light intensity within the cockpit must be very low to provide the pilot with the greatest possible vision of the area in front of the aircraft.

In the past incandescent lamps have been used almost exclusively as the sources of light in aircraft because of the simplicity of operating and controlling the light output of such lamps. However, incandescent lamps are less efficient and have higher operating temperatures than fluorescent lamps which of course accounts for the increasing use of fluorescent lamps for industrial and domestic lighting. The efficiency and low operating temperature of fluorescent lamps are particularly attractive to aircraft lighting applications. The high operating temperature of incandescent lamps prohibits the placement of such lamps near the personnel in an aircraft, which may be the optimum place for light sources in a crowded cockpit. The problems involved in controlling or dimming the light output from fluorescent lamps have been largely responsible for the limited use of fluorescent lamps in the past in aircraft and other lighting applications where dimming is desirable or necessary.

Fluorescent lamps have a negative impedance characteristic in the normal or full power operating region which accounts for the use of stabilizing ballasts in series with the lamps. The negative impedance characteristic changes to a positive impedance characteristic as the power to the lamp is decreased. This results in providing an operating region in which the lamp current may have two values for one value of voltage impressed across the lamp. If the supply voltage across a fluorescent lamp and its ballast is merely decreased to dim the light output from the lamp as is common practice in dimming circuits for incandescent lamps, the fluorescent lamp will flicker as the current through the lamp changes from one value to another with a given supply voltage.

Various types of dimming circuits have heretofore been proposed for use with fluorescent lamps but none of these prior art circuits have successfully eliminated flicker over a substantial dimming range. Furthermore, many of these prior art circuits employ expensive and heavy control equipment and can be utilized to control only a single lamp. For the above reasons these prior art dimming circuits have not found wide acceptance in

2

lighting systems for aircraft and other industrial applications.

In accordance with the present invention a dimming circuit is provided which is capable of controlling the light output of any number of fluorescent lamps over a range of more than 100 to 1 without flicker and which is efficient, reliable and relatively inexpensive to manufacture.

The dimming circuit of the present invention includes a fluorescent lamp and a source of potential for energizing the lamp. A variable and controllable impedance device which may for example be a saturable reactor is provided in the circuit for controlling the light output of the lamp. The variable impedance device includes a pair of input and output terminals and is arranged to vary the impedance across the output terminals thereof in accordance with the amplitude of a control signal applied to the input terminals thereof. The output terminals of the variable impedance device and the lamp are connected in series across the source of potential. A source of control signals is coupled to the input terminals of the variable impedance device. Means for varying the amplitude of the control signals are included in the circuit to control the impedance in series with the lamp and thereby the light produced by the lamp.

The present invention is described in more detail in reference to the accompanying drawing in which:

Fig. 1 is a schematic circuit diagram of a fluorescent lamp dimming circuit employing the principles of the present invention; and

Fig. 2 is a graph illustrating the characteristic operating curve of a typical fluorescent lamp.

Referring now to the drawing and more particularly to Fig. 1 thereof, a fluorescent lamp indicated generally at 10 is suitably coupled to a first source of alternating current energizing potential 11 as will be more fully described hereinafter. The lamp 10 is of the hot cathode rapid start type and includes a pair of filaments 13 and 14 which are arranged to be continuously heated during the lamp operation. A metallic starting aid or grounded conducting plate 12 is disposed adjacent the lamp 10 to provide a small capacity between the filaments 13 and 14 and ground which aids the starting of the lamp. An auto-transformer 15 is coupled between the source 11 and the lamp 10 to provide the designed supply or operating voltage for the lamp. As may be seen in the drawing the auto-transformer 15 includes a pair of intermediate taps 16 and 17 and a pair of end terminals 18 and 19 (one of which is grounded). The source 11 is connected between the end terminal 18 and the intermediate tap 16. The end terminal 19 is connected to one end of the filament 13, the other end of which is coupled to a filament winding 20 of the transformer 15. Another filament winding 21 of the transformer 15 is connected across the filament 14. The intermediate tap 17 is connected to the filament 14 through a variable and controllable impedance device or saturable reactor indicated generally at 22. The reactor 22 includes a pair of gate windings 23 and 24 which are coupled to saturable cores 25 and 26 respectively. The cores 25 and 26 may be formed of any suitable ferro-magnetic material and are preferably made of a material having a relatively square hysteresis loop such as a high nickel alloy. The gate windings 23 and 24 are connected in series across the output circuit of the reactor 22 or between a pair of output terminals 27 and 28 which are in turn connected to the tap 17 and the filament 14, respectively. The impedance of the gate windings 23 and 24 is dependent upon the magnetization of the cores 25 and 26 respectively. The cores 25 and 26 include control windings 29 and 30 which control the level of magnetization of the cores 25 and 26 in accordance with the amplitude of

a direct current (D.-C.) signal applied thereto. The control windings 29 and 30 are connected in series across the input circuit or between a pair of input terminals 32 and 33 of the reactor 22 so that the voltage induced in the winding 29 as a result of current flow through the gate winding 23 will oppose the voltage induced in the winding 30 as a result of the current flow through the gate winding 24. Thus there is little or no voltage induced across the input terminals 32 and 33 as a result of current flow through the gate windings of the reactor 22.

To control the D.-C. current flow through the control windings 29 and 30 and thereby the level of magnetization of the cores 25 and 26 and the current flow through the output circuit of the reactor 22 and the lamp 10, a suitable source of variable amplitude direct current control signals indicated generally at 31 is coupled to the input terminals 32 and 33. The control signal source includes a second source of energizing potential 35 which may conveniently be an alternating current source, an adjustable auto-transformer 36, a bridge rectifier 37 and a capacitor 48. As is shown in the drawing, the auto-transformer 36 includes a pair of input terminals 40 and 41 which are connected directly across the source of potential 35. The terminal 41 may be grounded as shown. The auto-transformer 36 also includes a movable intermediate tap 42 which may be positioned at any point between the input terminals 40 and 41 to thereby provide a large or small amplitude voltage between the tap 42 and ground. The bridge rectifier 37 includes an input circuit which is connected between the tap 42 and ground, and an output circuit which is connected between the terminals 32 and 33. The bridge rectifier 37 comprises four rectifiers 44 through 47 which are connected in a bridge arrangement as is well known in the art to provide full wave rectification. The isolation capacitor 48 is connected across the output circuit of the rectifier 37 to isolate the input circuit of the rectifier 37 from any unbalanced voltages induced across the control windings 29 and 30 as a result of current flow through the gate windings 23 and 24.

In operation the lamp in the circuit of Fig. 1 is started by connecting the energizing source 11 to the auto-transformer 15. The lamp starts as soon as the filament temperature is such that thermionic emission takes place and forms an ionized cloud near the filaments 13 and 14. The conducting plate 12 causes a high voltage gradient to appear at this point which results in moving the ions out of the ionized cloud. The voltage between the filaments moves the free ions across the lamp causing the lamp to fire. The current drawn by the lamp 10 and the light produced by the lamp is dependent upon the impedance of the gate windings 23 and 24. As has been mentioned previously, the impedance of the gate windings is changed by merely supplying more or less direct current to the control windings 29 and 30. The maximum impedance across the gate windings 23 and 24 and consequently the minimum current flow through the lamp is attained when the direct current flow through the control windings 29 and 30 is at a minimum or when the movable tap 42 is adjacent the input terminal 41 of the auto-transformer 26. As the movable tap 42 is raised towards the input terminal 40 of the transformer 36 the direct current flow through the windings 29 and 30 increases which in turn raises the level of magnetization of the cores 25 and 26 and thereby lowers the impedance of the gate windings 23 and 24. When the tap 42 is extended to its open position or adjacent the input terminal 40 the maximum direct current is fed to the control windings 29 and 30 which results in establishing a minimum impedance across the gate windings 23 and 24. The lamp 10 may be started at any given light output level as determined by the position of the tap 42.

While only one lamp 10 is illustrated as being controlled by the control signal source 31 it is to be understood that any number of lamps may be controlled by

the source 31. It is only necessary to provide each of the lamps with a separate saturable reactor and connect the control windings of each of the reactors in parallel to the output circuit of the rectifier 37. The diodes 44—47, the voltage source 35 and the auto-transformer 36 must be designed to carry the load anticipated.

The amount of magnetic core material used in the cores 25 and 26 and the number of turns of the gate and control windings thereon are not critical and may be varied according to the impedance range that is required for the desired light output range of any given fluorescent lamp and the range of control voltages available. The supply voltage between the taps 17 and 19 or the voltage for the lamp is, however, somewhat critical. When this voltage becomes too low the voltage drop across the gate windings 23 and 24 is not sufficient to prevent flicker of the lamp in the lower current range. This condition is illustrated in Fig. 2 wherein the curve 50 represents the characteristic curve of a typical fluorescent lamp and the line 52 represents the supply voltage therefor which in the circuit of Fig. 1 would be the average amplitude of the alternating current voltage between the intermediate tap 17 and the end terminal 19 of the transformer 15. The amplitude of the supply voltage 52 must be greater than the peak voltage impressed across the lamp 52 by a predetermined amount to insure that the lamp will not flicker when operating in its lower current range or near its peak voltage. This minimum supply voltage may best be determined by experiment by adjusting the impedance of the gate windings 23 and 24 to limit the current drawn by the lamp so that the lamp is operating near the peak voltage portion of its characteristic curve and varying the supply voltage until it is just high enough to prevent lamp flicker. In practice, of course, the supply voltage should be considerably higher than this minimum voltage to eliminate any chance of flicker when different lamps of the same type are used in the circuit of Fig. 1.

While it is understood that the circuits specification of the lamp dimming circuit of the present invention may vary according to the desired design for any particular lamp, the following circuit specifications for the circuit of Fig. 1 to provide a dimming range of approximately 700 to 1 for a T5 fluorescent lamp are included by way of example only:

Voltage sources 11 and 35—115 volts, 400 cycles.
Auto-transformer 15—Arranged to provide approximately 190 volts between the end terminal 19 and ground and 150 volts between the intermediate tap 17 and the end terminal 19.
Lamp 10—T5—Rapid start fluorescent lamp 20½" in length.
Saturable reactor 22—Arranged to provide a maximum impedance of 100,000 ohms for each gate winding 23 and 24 with the tap 42 adjacent the terminal 41 and a minimum impedance of 330 ohms across each gate winding with the tap 42 adjacent the terminal 40 to provide a direct current flow of 30 milliamperes in each of the control windings 29 and 30.

There has thus been disclosed a dimming circuit which is capable of controlling the light output of any number of fluorescent lamps over a large range without flicker and which is efficient, reliable, and relatively inexpensive to manufacture.

We claim:

1. A dimming circuit for a fluorescent lamp comprising a fluorescent lamp having a peak voltage characteristic defined by a positive and negative impedance characteristic whereby at least a plurality of lamp current values for the same lamp voltage drop is possible in the absence of a large control impedance thereby rendering the lamp unstable within said impedance range, a first source of alternating current connected to said lamp, said first source being a constant voltage source having a minimum voltage value a predetermined amount

5

above the peak voltage characteristic of the lamp, and a variable and controllable ballast impedance connected in series circuit relationship with said first source of voltage and the lamp and being proportioned relative to said series elements to maintain a stable current flow through said lamp including through the unstable portion by changing the impedance thereof and thereby the current flow in the lamp to provide flicker free dimming, said ballast impedance comprising a saturable reactor including first and second magnetic cores having a square loop hysteresis characteristic, a gate winding and a control winding wound on each of the magnetic cores, means connecting the gate windings in series between said lamp and the first source of energizing potential, a second source of alternating current energizing potential, an auto-transformer including a movable intermediate tap connected to the second source of energizing potential, a full wave bridge rectifier having an input and an output circuit, the input circuit of the rectifier is connected between the movable tap and one end of the auto-transformer, a capacitor connected across the output circuit of the rectifier, and means for connecting the control windings in series across the output circuit of the rectifier.

2. In a lamp dimming circuit, the combination which comprises at least one fluorescent lamp, a reactor having an input and output circuit and being arranged to control current through the output circuit in accordance with the amplitude of a control signal applied to the input circuit thereof, a source of control signals, means for coupling the source of control signals to the input terminals of the reactor, the lamp and the output circuit of the reactor being directly connected in series between a pair of

6

terminals, means for applying a substantially constant voltage across the pair of terminals whereby the voltage across the series connected lamp and output circuit of the reactor is maintained substantially constant, and means for varying the amplitude of the control signals to thereby control the current through the lamp whereby the light produced by the lamp may be varied over a wide range without flicker.

3. A lamp dimming circuit as defined in claim 2, wherein the last named means is arranged to vary the amplitude of the control signals independently of the current through the lamp.

4. A lamp dimming circuit as defined in claim 3, wherein the reactor is a direct current controlled saturable reactor including a pair of gate windings connected in series across the output circuit of the reactor, at least one control winding connected across the input circuit of the reactor, and at least one core of ferro-magnetic material having a square hysteresis characteristic coupled between the gate windings and the control winding.

5. A lamp dimming circuit as defined in claim 3 wherein a single fluorescent is connected in series with the output circuit of the reactor between the pair of terminals.

References Cited in the file of this patent

UNITED STATES PATENTS

2,665,394	Arvidsson et al.	Jan. 5, 1954
2,683,241	Passmore	July 6, 1954
2,829,314	Vradenburgh	Apr. 1, 1958
2,830,232	Carpenter et al.	Apr. 8, 1958
2,864,035	Davis	Dec. 9, 1958