

May 9, 1961

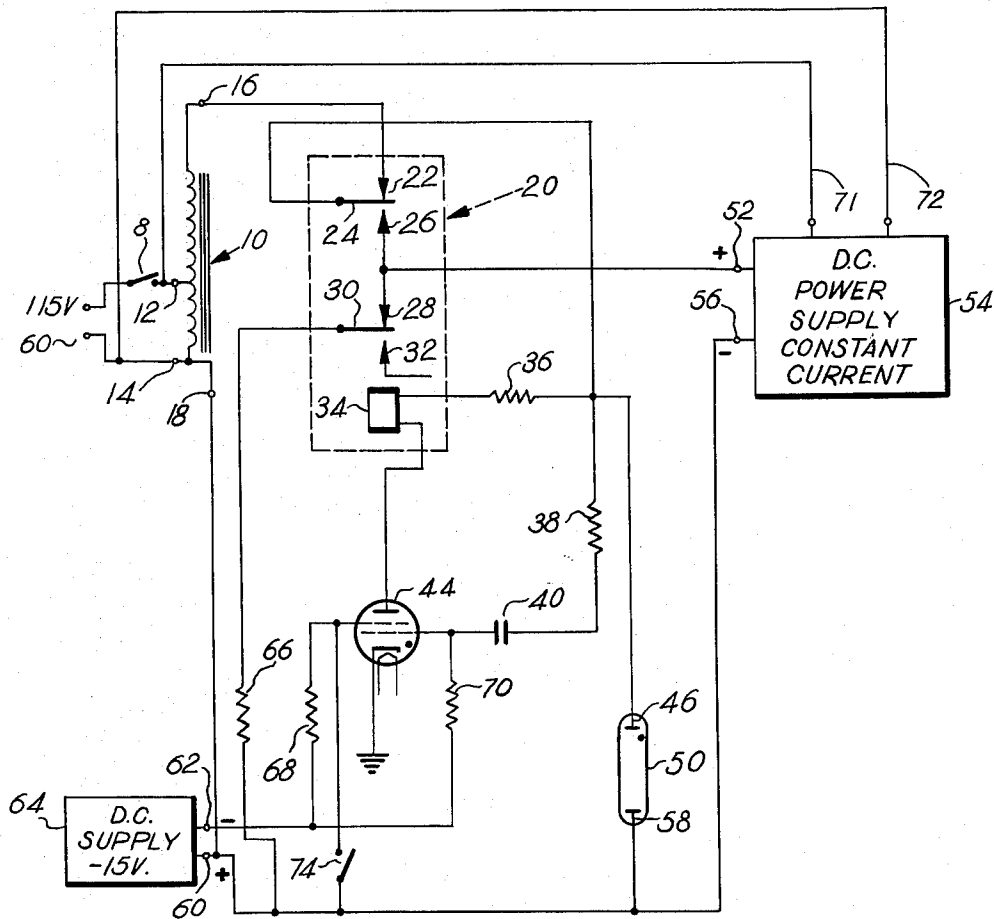
M. J. RELIS
LAMP POWER SUPPLY

2,983,848

Filed April 29, 1957

2 Sheets-Sheet 1

FIG. 1



INVENTOR.

MATTHEW J. RELIS

BY

Eli Weiss

ATTORNEY

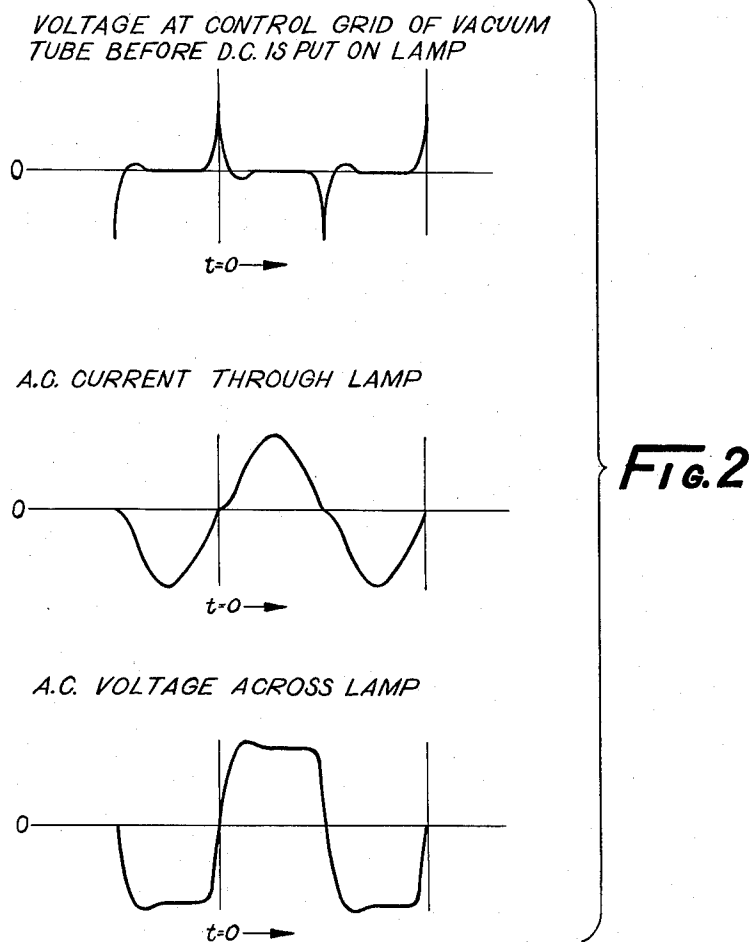
May 9, 1961

M. J. RELIS
LAMP POWER SUPPLY

2,983,848

Filed April 29, 1957

2 Sheets-Sheet 2



INVENTOR.
MATTHEW J. RELIS
BY *Eli Weiss*
ATTORNEY

1

2,983,848

LAMP POWER SUPPLY

Matthew J. Relis, Bayside, N.Y., assignor to Burroughs Corporation, Detroit, Mich., a corporation of Michigan

Filed Apr. 29, 1957, Ser. No. 655,615

5 Claims. (Cl. 315—175)

This invention relates in general to an arc lamp power supply and more particularly to a power supply that can economically initiate and maintain a constant intensity source of light.

Gas discharge tubes which are also referred to as arc lamps exhibit particular starting and operating characteristics which must be considered carefully when selecting a power supply to initiate and maintain operation of the lamp.

For example, a typical mercury arc lamp, when cold, requires a minimum peak potential of approximately four hundred volts to initiate an arc. Immediately after the lamp starts to conduct the potential across the lamp drops to approximately 30 volts R.M.S. Continued operation of the lamp results in the dissipation of energy in the form of heat, which increases the pressure of the gas in the lamp gradually. Due to this gradual increase in gas pressure within the lamp, the voltage required to maintain the arc lamp operating increases gradually until a state of equilibrium is reached at which time the arc drop across the lamp is approximately two hundred and fifty volts R.M.S. The time differential between the initiating of an arc in the lamp and the attaining of steady state conditions is approximately three minutes.

The magnitude of the current that flows through the lamp is determined by the magnitude of the lamp arc drop and by the impedance of the power supply. Initially the arc drop is low and therefore the current is relatively high. If, however, the electrical power that is supplied to the lamp exceeds the power that is dissipated by the lamp in the form of heat and light, then the magnitude of the arc drop will increase gradually as already indicated and the current through the lamp will diminish slowly until a balance of power is established. For proper operation of the lamp the power supply must be designed to deliver rated power to the lamp when steady state operating conditions prevail.

The simplest form of power supply for utilization with an arc type of lamp is a source of constant current that has a high internal impedance. Immediately before an arc lamp starts to conduct the high internal potential of the source of constant current will appear across the lamp. This potential must be of sufficient magnitude to initiate an arc in the lamp. The source of constant current should be designed to feed rated power to the lamp after steady state operating conditions prevail. Thus the design of the power supply is determined by the magnitude of the potential required to initiate the operation of the lamp, and by the magnitude of the current fed to the lamp during steady state operation.

An auto transformer will satisfy these conditions. If a step-up autotransformer is wound to present a high secondary winding leakage reactance it will approximate a source of constant current and will satisfy the conditions for starting and operating an arc lamp. The low voltage input winding of the autotransformer is connected to a standard one hundred and fifteen volt sixty

2

cycle power line and the high voltage output winding is connected to the arc lamp.

The instantaneous intensity of light generated by an arc lamp is determined by the magnitude of the instantaneous power fed to the lamp. Thus, an arc lamp operated from a supply of alternating current will produce light that varies in intensity with the variations in the instantaneous magnitude of the applied input power.

In many applications such as photography or photo-electric scanning the intensity of the light produced by an arc lamp must remain absolutely constant. Since the intensity of the light from an arc lamp is determined by the magnitude of the power fed to the lamp, then a constant intensity source of light can only be obtained from an arc lamp fed by a lamp power supply that produces a direct current potential that is free of ripple.

A direct current power supply that can be utilized to generate a relatively constant intensity source of light consists of a high voltage rectifier coupled to the arc lamp through a series resistor. The rectifier must be capable of supplying the necessary open circuit potential required to initiate operation of the lamp. The series resistor provides the internal impedance required to limit the current fed to the lamp to its rated value. This type of direct current power supply is expensive to build and inefficient to operate. The maximum volt-amperes supplied by the power supply is determined by multiplying the magnitude of the open-circuit potential by the initial current drawn by the lamp. With reference to the Hanovia AH-8 mercury arc lamp, a typical arc lamp, the open circuit potential required for positive activation of the lamp is in the order of six hundred volts, while the initial current drawn by the lamp is approximately eight-tenths of an ampere. The initial power drawn is 480 watts. Approximately three minutes after the arc is initiated, the lamp reaches its steady state operating conditions. At this time approximately eighty watts is required to operate the lamp and an additional one hundred and twenty watts is dissipated in the series current limiting resistor. Thus, the power supply must be capable of supplying four hundred and eighty watts to initiate the operation of the arc lamp although only eighty watts is required by the lamp during the major portion of its operating cycle, and then an additional one hundred and twenty watts is wasted in the current limiting resistor.

It is a primary object of this invention to provide an improved power supply for an arc lamp to generate a constant intensity light free of ripple or fluctuations.

It is another object of this invention to provide an improved power supply for an arc lamp that is economical to produce and to operate.

It is an additional object of this invention to provide an improved power supply for an arc lamp that is reliable in operation regardless of lamp variations or power line potential fluctuations.

Other objects and many of the attendant advantages of this invention will be readily appreciated as the apparatus becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings wherein:

Fig. 1 illustrates the invention in block and schematic form; and

Fig. 2 illustrates the voltage and current wave forms that appear across the arc lamp during the warm up period.

Briefly, a source of alternating current is coupled to an arc lamp through a substitution switching means to initiate and maintain operation of an arc lamp until steady state conditions of operation prevail. After the lamp stabilizes the substitution switching means is activated to transfer the arc lamp from the source of alter-

nating current to a source of direct current without interrupting the operation of the arc lamp. The switching procedure is synchronized to occur after the lamp reaches steady state operating conditions and during the occurrence of the positive portion of the output signal from the source of alternating current to prevent interruption of the operation of the lamp. The light generated by the arc lamp is not utilized until after the source of direct current has been substituted for the source of alternating current. The source of alternating current is utilized to initiate the operation of the lamp, and the source of direct current is utilized to economically operate the arc lamp as a source of constant intensity light.

Referring to Fig. 1, an autotransformer 10 that exhibits a high leakage reactance is utilized as a source of alternating current to initiate the action of an arc lamp 50. Two input terminals 12 and 14 of the autotransformer 10 are coupled through an on-off switch 8 to a standard 115 volt 60 cycle power line. The output terminals 16 and 18 of the autotransformer 10 are coupled respectively to a stationary contact 22 of a relay 20, and to the positive output terminal 60 of a direct current bias supply 64. The movable contact 24 of the substitution switching means or relay 20 is coupled to a terminal 46 of an arc lamp 50, to the control grid of a thyatron tube 44 through a resistor 38 and a capacitor 40, and to the anode of the thyatron tube 44 through a resistor 36 and the relay coil 34. The shield grid of the thyatron tube 44 is coupled to the positive output terminal 60 of the bias supply 64 through an on-off switch 74, and to the negative output terminal 62 of the bias supply 64 through a resistor 68. The stationary contacts 26 and 28 of the relay 20 are connected together and to the positive output terminal 52 of a source of regulated constant current power. The negative output terminal 56 of the source of regulated constant current power 54 is connected to the terminal 58 of the arc lamp 50, and to the positive output terminal of the direct current bias supply 64.

The negative output terminal 62 of the bias supply 64 is coupled to the control grid of the thyatron tube 44 through a resistor 70. The movable contact 30 of the relay 20 is coupled to the positive output terminal 60 of the bias supply 64 through a resistor 66. The source of regulated constant current 54 is energized by the standard 115 volt 60 cycle power line through the on-off switch 8 and the conductors 71 and 72.

In the operation of this invention, the autotransformer 10 is the source of alternating current that initiates the action of the arc lamp 50. This transformer has a high leakage reactance which limits the current that is initially drawn by the lamp.

When the on-off switch 8 is closed, the potential that appears across the output terminals 16 and 18 of the transformer 10 is fed through normally closed contacts 22 and 24 of the relay 20 to the arc lamp 50. Initially, when the source of alternating current is being utilized to initiate the operation of the lamp, the thyatron tube 44 is not conducting, the relay coil 34 is deenergized, and the contacts of the relay 20 are in the position shown in Fig. 1. Immediately after the lamp starts to conduct, the magnitude of the R.M.S. potential present across the lamp 50 starts to increase while the magnitude of the R.M.S. current through the lamp 50 starts to decrease. This condition exists because the arc drop of the lamp increases as the lamp approaches its steady state operating conditions.

Since the arc lamp 50 functions as a non-linear resistor, the wave form of the voltage that appears across the arc lamp during the initial transient period represents a wave that is flattened on top and approximates a square wave.

Referring in particular to the Hanovia AH-8 type of mercury arc lamp, immediately after the lamp starts to conduct the potential that appears across the lamp slowly increases to a steady state value of approximately two hundred and eighty volts R.M.S. while the current through

the lamp falls to a steady state value of approximately three hundred and fifty milliamperes.

At any instant after the arc lamp has reached its steady state operating condition, the point of minimum demand by the arc lamp upon the direct current source has been reached, and the source of regulated constant current can be substituted for the source of alternating current.

Referring further to Fig. 1, the resistors 38 and 70 function as a voltage divider to pass a small portion of the potential that appears across the arc lamp 50 to the control grid of the thyatron tube 44. The capacitor 40, in combination with the resistors 38 and 70 differentiates the signal that is fed to the control grid of the thyatron tube 44. The direct current bias supply 64 maintains the control grid and shield grid of the thyatron tube 44 at a negative potential to prevent the tube from firing when positive half cycles of the alternating potential are passed through the resistor 36 and the relay coil 34 to the plate of the tube.

When the arc lamp is initially activated the source of regulated constant current power 54 must be maintained in its normal operating condition.

This is accomplished by connecting a loading resistor 66 across the output terminal of the source 54 by means of the relay contacts 28 and 30. The loading resistor maintains the source of regulated constant current power in its normal operating mode immediately prior to the switching operations. If the loading resistor were not present, then the source of regulated constant current power 54 would not be supplying current immediately prior to the switching operation and, therefore, the supply 54 would not be operating as a constant current power supply. The loading resistor prevents the sudden demand for current which occurs during the switching operation from producing an extreme transient condition in the source of regulated constant current and the possible interruption of the operation of the lamp. The loading resistor is preset to the largest value that will insure proper switching to minimize the power drawn by it. Approximately three minutes after the on-off switch 8 is closed, the potential across the lamp and the current through the lamp stabilize and the lamp is in condition to be transferred from the source of alternating current to the source of regulated direct current. To accomplish this the bias is removed from the shield grid of the thyatron 44 by closing the switch 74, and the thyatron tube fires when the instantaneous magnitude of the positive potential pulses fed to the control grid is sufficient to overcome the negative bias on the control grid. The actuation of the switch 74 can be either manual or automatic.

The activation of the thyatron tube 44 energizes the relay coil 34 and the movable contacts 24 and 30 move in a downward direction to transfer the arc lamp 50 from the source of alternating current to the source of regulated constant current without interrupting the operation of the arc lamp. Thus, the thyatron tube functions as an energizing means for the relay. The action of the relay removes the load resistor 66 from the output terminals of the source of regulated constant current.

In actual operation of this invention, intermittent closure or chatter of the relay contacts does not occur as an arc is maintained across the relay contacts 22 and 24 during the entire switching procedure. The arc permits a flow of current that is sufficient to sustain operation of the lamp 50. The normally opened contacts 24 and 26, and the source of regulated constant current hold the relay in its energized condition. The operating time of the relay should not be greater than one-quarter of the period of the supply voltage frequency otherwise it will not operate before the internal E.M.F. of the autotransformer drops below the magnitude of the lamp potential, which occurs at full conduction, and the lamp will be extinguished during the switching operation.

To effectively switch the lamp from the source of

alternating current to the source of regulated constant current, the switching operation must occur when the alternating current potential across the lamp is substantially at its maximum value.

During switching, as the movable contact arm 24 moves downward, an arc occurs between the movable contact 24 and the stationary contact 22. As the arm continues to move downward, it makes contact with the stationary contact 26, however, the arc between the movable contact 24 and the stationary contact 22 is still present. Thus, immediately after the movable arm moves downward, a conductive path exists between the source of alternating current and the source of regulated constant current through the arc across the open contacts and the closed contacts of the relay. At the same time the arc drop across the lamp reaches its maximum positive value, the lamp is not fully conducting (Fig. 2), and the differential between the instantaneous arc drop of the lamp and the instantaneous internal E.M.F. of the autotransformer is relatively small. However, the internal E.M.F. of the source of regulated constant current is considerably greater. Therefore, if the movable contact arm 24 contacts the stationary contact 26 at this instant then the source of regulated constant current will assume a substantial portion of the load required by the lamp.

The arc across the contacts 22 and 24 persists as long as the internal E.M.F. of the autotransformer exceeds the arc drop of the lamp by an amount equal to the potential drop due to the arc that appears across the contacts. As the internal E.M.F. in the transformer decreases, the arc across the contacts is extinguished and the lamp becomes fully disconnected from the autotransformer, and the constant current supply assumes the full load.

The operation of switching the lamp from the source of alternating current to the source of regulated constant current produces a transient condition in the output signal from the source of regulated constant current. Sufficient time must be allotted for this transient condition to pass before the autotransformer is disconnected from the switching operation, otherwise the lamp may not remain in a conductive state. The source of regulated constant current should be adjusted to maintain the same steady state conditions in the lamp after the switching operation as existed in the lamp prior to the switching operation.

The switching operation can not be effected during the negative portion of the lamp wave form. If this were attempted the positive potential currents supplied by the source of regulated constant current would nullify the negative current supplied by the transformer to reduce the current flowing through the lamp to a value below the value needed to sustain operation.

Immediately after the switch 74 is closed, a positive potential pulse signal appears on the control grid of the thyatron 44 when the lamp potential begins to go positive. However, due to the delay of the operation of the relay, the relay 20 does not begin to operate until shortly after the lamp potential passes its positive peak. The circuit described above insures the occurrence of switching at the proper point in the A.C. supply voltage cycle.

Obviously many modifications and variations of the present invention are possible in the light of the above teachings. It is therefore to be understood that within the scope of the appended claims the invention may be practiced otherwise than as specifically described.

What is claimed is:

1. A lamp power supply to initiate and produce a source of constant intensity light in an arc lamp comprising a source of continuous low frequency alternating current; a high leakage reactance autotransformer fed by said source of continuous low frequency alternating current to activate said arc lamp until steady state conditions prevail; a source of regulated constant

current to activate uniformly said arc lamp, a relay to couple said high leakage reactance autotransformer to said arc lamp, then couple said source of regulated constant current to said arc lamp, and then decouple said high leakage reactance autotransformer from said arc lamp; a load impedance coupled to maintain said source of regulated constant current operative during the operation of said arc lamp by said high leakage reactance autotransformer; a thyatron tube coupled to energize said relay to effect the transference of the arc lamp from the high leakage reactance autotransformer to the source of regulated constant current; and a differentiator network interposed between said thyatron tube and said high leakage reactance autotransformer to initiate energization of said thyatron tube when the magnitude of the signal from the high leakage reactance autotransformer is at a maximum value to insure continuous operation of said arc lamp.

2. A lamp power supply to initiate and produce a source of constant intensity light in an arc lamp comprising a source of continuous low frequency alternating current; a high leakage reactance transformer fed by said source of continuous low frequency alternating current to activate said arc lamp until steady state conditions prevail; a source of regulated constant current to activate uniformly said arc lamp; a relay to couple said high leakage reactance transformer to said arc lamp, then couple said source of regulated constant current to said arc lamp, and then decouple said high leakage reactance transformer from said arc lamp; a load impedance coupled to maintain said source of regulated constant current operative during the operation of said arc lamp by said high leakage reactance transformer; a thyatron tube coupled to energize said relay to effect the transference of the arc lamp from the high leakage reactance transformer to the source of regulated constant current; a source of direct current coupled to said thyatron tube to inhibit conduction of said thyatron tube; a differentiator network interposed between said thyatron tube and said high leakage reactance transformer, and switch means interposed between said source of direct current and said thyatron tube to disconnect said source of direct current from said thyatron tube to permit the thyatron tube to conduct during the occurrence of the maximum positive portion of the signal from the high leakage reactance transformer to insure continuous operation of said arc lamp.

3. Means to initiate and produce a source of constant intensity light in an arc lamp comprising: a starting power supply including a source of continuous low frequency alternating current; a steady state power supply including a source of regulated constant current to activate uniformly said arc lamp; first switching means coupling said source of alternating current to said arc lamp, said first switching means being operative, when actuated, to couple said source of regulated constant current to said arc lamp and to decouple said source of alternating current from said arc lamp; second switching means operative, when actuated, to actuate said first switching means to effect the transference of the arc lamp from the source of alternating current to the source of regulated constant current; and means controlling the actuation of said second switching means so that it is initiated at a positive alternation of the alternating current to prevent interruption of operation of said arc lamp at the time of said transference.

4. Means to initiate and produce a source of constant intensity light in an arc lamp comprising: a starting power supply including a source of continuous low frequency alternating current; a steady state power supply including a source of regulated constant current to activate uniformly said arc lamp; switching means to couple said source of alternating current to said arc lamp, then couple said source of regulated constant current to said arc lamp, and then decouple said source of al-

7

ternating current from said arc lamp; a load impedance coupled across said steady state power supply to maintain said source of regulated constant current operative during the operation of said arc lamp by said starting power supply, said load impedance being decoupled by said switching means from said source of regulated constant current when said starting power supply is decoupled from said arc lamp; a gas tube coupled to energize said switching means to effect the transference of the arc lamp from the low frequency alternating current to the source of regulated constant current; and means coupled to said gas tube and to said arc lamp to initiate energization of said gas tube at a positive alternation of the alternating current to prevent interruption of operation of said arc lamp.

5. Means to initiate and produce a source of constant intensity light in an arc lamp comprising: a starting power supply including a source of continuous low frequency alternating current and a high leakage reactance transformer fed by said source of continuous low frequency alternating current to activate said arc lamp until steady state conditions prevail; a steady state power supply including a source of regulated constant current to activate uniformly said arc lamp; a relay to couple said high leakage reactance transformer to said arc

8

lamp, then couple said source of regulated constant current to said arc lamp, and then decouple said high leakage reactance transformer from said arc lamp; a load impedance coupled across said source of regulated constant current to maintain said source of regulated constant current operative during the operation of said arc lamp by said transformer, said load impedance being decoupled from said source of regulated constant current when said reactance transformer is decoupled from said arc lamp; a gas tube coupled to energize said relay to effect the transference of the arc lamp from the high leakage reactance transformer to the source of regulated constant current; and means coupled to said gas tube and to said arc lamp to initiate energization of said gas tube at a positive alternation of the high leakage reactance transformer to prevent interruption of operation of said arc lamp.

References Cited in the file of this patent

UNITED STATES PATENTS

1,492,691	Leich	May 6, 1924
2,593,952	Willoughby	Apr. 22, 1952
2,607,023	Coughlin	Aug. 12, 1952
2,651,742	French	Sept. 8, 1953