Dec. 8, 1959 T. C. RETZER 2,916,671

STARTING AND OPERATING CIRCUIT FOR GASEOUS DISCHARGE LAMPS

Filed June 6, 1958

FIG. 1.

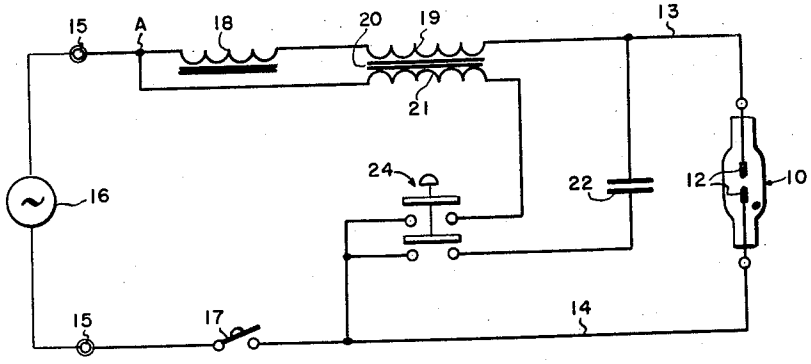
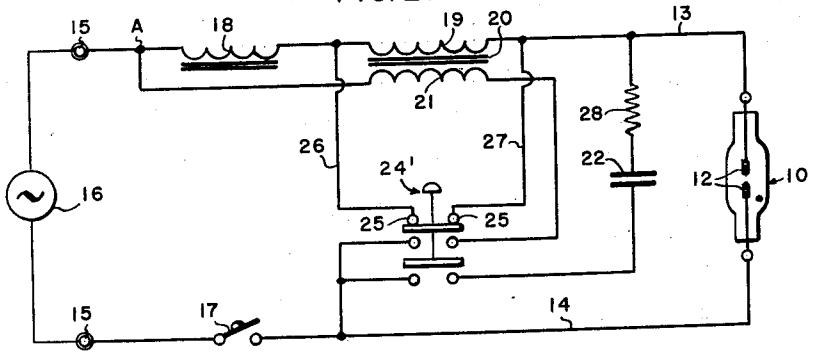


FIG. 2.



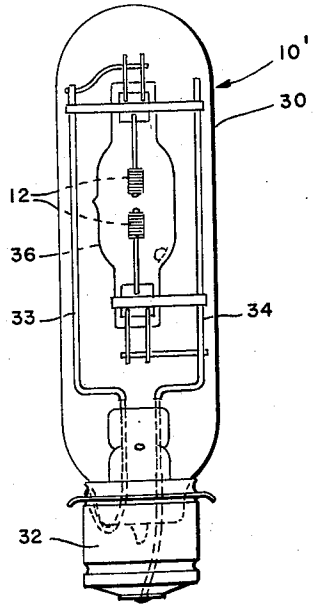


FIG. 3.

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United States Patent Office 2,916,671 Patented Dec. 8, 1959

2,916,671

STARTING AND OPERATING CIRCUIT FOR GASEOUS DISCHARGE LAMPS

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Application June 6, 1958, Serial No. 740,275

11 Claims. (Cl. 315—239)

This invention relates to an energizing system for gaseous discharge devices and, more particularly, to a circuit for starting and operating a high pressure gaseous discharge lamp of the so-called "short-arc" type.

As is well known, a higher voltage and current are required to start a short-arc vapor discharge lamp than to operate the lamp once it has been ignited and the arc stabilized or rendered self-maintaining. This is due to the fact that the voltage applied to the lamp during the starting cycle must first reach a value at least equivalent to the sparking potential of the fill gas before a gaseous discharge can be initiated between the electrodes and sufficient current must also flow through the lamp to rapidly heat the rather massive electrodes to electron-emitting temperature so that the discharge thus established can be maintained by the voltage applied to the lamp from the supply line on which the lamp is normally operated. Heretofore, lamps of this character were started by applying a series of extremely high voltage pulses to the lamp during the starting cycle from suitable auxiliary circuits, as disclosed in U.S. Patent Nos. 2,708,-251 and 2,727,188 to C. M. Rively and U.S. Patent No. 2,825,005 to L. F. Bird.

While the pulse type starting systems described in the above-mentioned patents provide the high voltages necessary to ionize and start the higher wattage double-ended lamps, that is, those having a rating of 500 watts and above in which the electrodes are sealed in oppositely disposed stems or arms, they are rather expensive, bulky and complicated for use with lamps of lower wattages. In addition, due to the magnitude of the voltage pulses which are produced such circuits are particularly unsuited for use with the low wattage single-ended lamps recently developed and marketed because of the danger of arc-overs between the lead-in conductors or possibly within the sockets with which these single-ended lamps are used.

It is accordingly the general object of the present invention to provide an improved circuit for starting and operating gaseous discharge lamps which contain an ionizable medium and require a higher starting than operating voltage.

Another and more specific object of this invention is to provide a circuit for starting a high pressure gaseous discharge lamp which circuit is not only more compact and less complicated and expensive than the high voltage pulse starting systems generally employed heretofore but is adapted to provide a controlled starting voltage capable of igniting low-wattage short-arc discharge lamps of single-end construction without damaging the lamps or auxiliary equipment.

For a better understanding of the invention and the manner in which the aforesaid objects, and others which will become apparent to those skilled in the art to which the invention pertains as the description proceeds, reference should be had to the accompanying drawing wherein:

Fig. 1 is a schematic illustration of one type of circuit embodying this invention;

Fig. 2 is a schematic drawing of another type of circuit similar to that shown in Fig. 1 but incorporating means for limiting the capacitor discharge current through the lamp during the starting cycle and for completely disconnecting the starting circuit from the operating circuit; and

Fig. 3 is a side elevational view of a single-ended 250 watt short-arc mercury lamp which characterizes the type of low wattage lamp for which the circuit of this invention is especially adapted.

Although the principles of this invention are broadly applicable to various types of gaseous discharge devices which require a higher starting potential than that required to maintain the arc once it has been initiated, especially those devices which require a controlled starting voltage of a lower order of magnitude than that produced by a pulse type circuit, the invention is particularly adapted for use in conjunction with high pressure short-arc lamps and hence has been so illustrated and will be so described.

With specific reference to the form of the invention illustrated in Fig. 1 of the drawing, a lamp **10** of the well-known mercury short-arc type containing an ionizable medium, such as argon or the like in combination with a measured amount of mercury, and having a pair of electrodes **12**, at least one of which is thermionic-emitting, is connected to a source of alternating voltage **16** by means of terminals **15**, conductors **13** and **14**, and a line switch **17**. Connected in series with the lamp **10** is a suitable current limiting device such as an inductive ballast **18**, as here shown, or a resistor adapted to maintain the lamp current within safe limits during starting and after the lamp has been lighted and is being operated directly from the voltage source **16**. The secondary **19** of a transformer **20** is connected in series between the ballast **18** and lamp **10** thereby providing in conjunction with the voltage source **16** a series circuit for operating said lamp after it has been lighted. Alternatively, the secondary **19** may be inserted in said series operating circuit on the line side of the ballast **18**. One end of the transformer primary winding **21** is connected to the conductor **13** on either the line side of the ballast **18**, as at point A as shown in Fig. 1, or at a point between said ballast and the secondary **19**. Connection to point A as shown in the drawing is preferred since the primary **21** will then be connected directly across the voltage source **16**, as will be hereinafter described, and full line voltage will be applied to the transformer **20** at all times even when lamp current begins to flow and there is a voltage drop across the ballast **18**. However, on the lower wattage type lamps the circuit performed equally well with the primary **21** connected to point A or between the ballast **18** and the transformer secondary **19**. It should be noted that if the primary **21** is connected at point A it must be electrically isolated from the secondary **19** in order to prevent short-circuiting the ballast **18** so that in this instance the transformer **20** would be an "isolation" type transformer rather than an auto-transformer, for example. The other end of the primary **21** is connected to one side of a switch **24**, preferably a push-button switch, which is normally open and is, in turn, connected to the conductor **14** thereby providing means for connecting said primary across the voltage source **16**. The transformer **20** is connected in a manner such that the output of the secondary adds to the voltage applied to the lamp **10** from the voltage source **16** and hence may be termed a "booster" transformer. The ratio of conversion of the applied voltage by the transformer **20** is chosen so that the total voltage which appears across

the lamp 10 when the switch 24 is closed exceeds the sparking potential of the fill gas thereby initiating a gaseous discharge between the electrodes 12. Thus, if the conversion or turns ratio of the transformer 20 is 1 to 1 then the total voltage applied to the lamp 10 when the switch 24 is closed will be twice that which would be supplied by the voltage source 16 alone.

In order to increase the current flowing through the lamp 10 during the starting cycle and thus facilitate the heating of the electrodes 12 and, in turn, decrease the time required for the arc to become self-maintaining, one terminal of a capacitor 22 is connected to the conductor 13 at a point on the aforesaid series operating circuit between the secondary 19 and lamp 10 and the other terminal of said capacitor is connected to a second set of contacts provided in the switch 24 previously referred to thereby enabling said capacitor to be connected by means of said switch directly across the lamp. Thus, when the switch 24 is closed the primary 21 is connected across the voltage source 16 and the capacitor 22 across the lamp 10 whereupon the output of the secondary 19 is applied along with the voltage from said source to both said capacitor and lamp. Since the capacitor 22 alone shunts the lamp 10 it immediately charges to the voltage appearing across said lamp. Hence, when the applied alternating voltage reaches a value sufficient to break down the gas between the electrodes 12 and an arc is struck therebetween rendering the lamp 10 conductive, the capacitor 22 discharges through said lamp to a voltage equal to the arc voltage at which time the current through the lamp will decrease to a value determined solely by the applied voltage and ballast 18. The capacitor 22 is chosen such that the increase in the current through the lamp 10 incident with the discharge of said capacitor is sufficient to substantially increase the temperature of the electrodes 12. If the current does not continue to flow thru the lamp 10, the capacitor 22 will, so long as the switch 24 is held closed, repeatedly recharge and then discharge through the lamp until current flows continuously, at which time the electrodes 12 will be at thermionic emitting temperature and the arc voltage decreased sufficiently to permit the lamp to be operated directly from the voltage source 16. The capacitor 22 and ballast 18 are generally selected to provide a starting current of from about one and a half to two times the normal operating current so that the electrodes 12 reach thermionic-emitting temperature and the lamp starts within a predetermined period of time (a matter of seconds) after the starting switch 24 is actuated, otherwise excess metal will be sputtered off and the electrodes which may cause early blackening of the lamp and prematurely shorten its useful life.

After the lamp 10 has started the switch 24 is released and allowed to return to its normally open position thereby disconnecting the primary 21 and capacitor 22 from the series operating circuit and allowing the lamp 10 to operate directly from the voltage source 16 through the ballast 18 and the secondary 19. Since the secondary 19 in this embodiment of the invention remains in the operating circuit it is necessary that the transformer 20 be designed to carry the current which flows through the lamp 10 when it is operating normally.

In order to simplify the design and reduce the cost of the transformer 20, the secondary 19 may be connected in such a manner that it is also disconnected from the series operating circuit along with the primary 21 and capacitor 22 after the lamp 10 has been lighted. This alternative embodiment is shown in Fig. 2 wherein a switch 24' having an additional set of contacts 25 is provided which contacts are shorted when the switch is in its normally open position. Said contacts 25 are connected by means of jumper leads 26 and 27 to the conductor 13 on either side of the secondary 19, and the primary 21 is connected to the aforesaid conductor at either point A or between the ballast 18 and the transformer secondary 19, as above-described, thus providing means for disconnecting both said primary and secondary from the series operating circuit when the switch 24' is released. The switch 24' is preferably a push-button or single-action type switch so that when it is closed it not only temporarily and simultaneously connects the primary 21 across the voltage source 16, and the capacitor 22 across the lamp 10, as described above, but also inserts the secondary 19 in the series operating circuit, preferably in series between the ballast 18 and the point on said series operating circuit at which the capacitor 22 shunts the lamp.

In addition to the foregoing arrangement for completely disconnecting the starting circuit from the series operating circuit after the lamp 10 has been started, a second current limiting means such as a resistor 28 may be connected in series with the capacitor 22, as shown in Fig. 2, to provide a resistor-capacitor combination for shunting the lamp 10 during the starting cycle. The resistor 28 not only limits the current through the lamp 10 to a safe value when the latter is rendered conductive and said capacitor is discharged therethrough, but since the voltage drop across the combination will be the vector sum of the drops across each component, the use of a resistor boosts the voltage developed across said lamp during starting to a value greater that that which would be developed if only a capacitor were used.

As will be obvious, by properly designing the ballast 18 and selecting the conversion factor of the transformer 20 as well as the values of the capacitor 22 and resistor 28, when the latter is used, the starting voltage and current may be varied over a considerable range from slightly above the line voltage and normal operating current to several times these values. As a specific example of one application of the relatively low range of controlled starting voltages which can readily be obtained in accordance with the principles of this invention, the circuits above-described have been found to be especially suited for use in conjunction with single-ended low-wattage gaseous discharge lamps such as the 250 watt short-arc lamp 10' shown in Fig. 3. As illustrated, the lamp 10' comprises generally a well-known inner arc tube 36 of quartz or other high temperature radiation-transmissive material which contains two electrodes 12, at least one of which is thermionic-emissive, a low pressure fill of an ionizable medium such as argon or the like, and a measured amount of mercury. In order to rigidly support the arc tube and connect it with a source of power said arc tube is longitudinally mounted within a tubular outer envelope 30 by means of spaced lead-in conductors 33 and 34 which are sealed through the same end of said envelope by means of a conventional reentrant stem assembly. Proper positioning of the lamp 10' is facilitated by means of a pre-focus type base 32 secured to the sealed end of the outer envelope 30 thus providing a lamp unit similar in appearance and size to a standard incandescent type projector lamp. The space between the arc tube 36 and outer envelope 30 may be evacuated or filled with an inert gas such as dry nitrogen. In either case, it has been found desirable to limit the starting voltage applied to lamps of this construction and size to about 400 volts maximum otherwise destructive arcs may occur between the lead-in support members 33 and 34 or within the base 32 on the socket fixture.

As a specific example of the size of the various components required for a particular case, it has been found that when a booster transformer having a conversion ratio of approximately 1 to 1, an 85 microfarad capacitor, a 20 ohm resistor, and an inductive ballast suitably designed to limit the normal operating current to approximately 8 amperes are combined in the manner shown in Fig. 2, a starting voltage of approximately 256 volts will be developed across the socket terminals when the

circuit is connected to a 110 volt 60-cycle supply line which starting voltage will start the illustrated 250 watt short-arc lamp **10'** in less than 3 seconds without any damage whatsoever to the lamp or socket fixture or deleterious blackening effect. The normal operating current and voltage of this particular lamp are approximately 8 amperes and 37 volts, respectively. If a 20 microfarad condenser is used, the resistor **28** may be eliminated, as shown in Fig. 1, since the increase in the lamp current during starting produced by the discharge of the condenser in this case will not be sufficient to damage the delicate seal construction of the arc tube **36** but will still be great enough to effect the desired heating of the electrodes **12**.

As is well known, a considerably higher voltage is required to restart a hot lamp than to start the same lamp when it is cold, that is, at room temperature. Hence, the voltage applied to the single-ended lamp **10'** by circuits having the aforementioned values will only start such a lamp when it is cold. This limitation in the instant case is, however, a distinct advantage insofar as it affords a built-in safeguard against inadvertently applying a higher starting voltage to lamps of this type in an attempt to restart a lamp while it is hot and thereby creating a situation where the lamp or socket could be seriously damaged or destroyed by flash-overs between the internal lead-in supports or within the base or socket.

In the case of higher wattage or double-ended lamps where the danger of arc-overs is not present and higher starting voltages are required, voltages of the desired magnitude may be obtained by properly matching the inductive ballast **18** and capacitor **22** so that they have the same order of reactance when they are both connected to the voltage source **16** thereby providing a series resonant circuit when the starter switch **24** or **24'** shown in Figs. 1 and 2, respectively, is actuated. The values of these reactive components may, of course, be selected to achieve either total or partial resonance so that the desired voltage will be developed across the capacitor **22**, or serially arranged capacitor **22** and resistor **28** combination as the case may be, and thus applied to the lamp **10** during the starting cycle, care being taken to provide a resistor or other current limiting means of sufficient rating and size to limit the starting current to a safe value. In this type circuit the transformer **20** is preferably so designed that it has a low reactance so as not to complicate the proper balancing of the capacitive and inductive reactances, and for all practical purposes may be permanently disconnected and eliminated from the circuit.

As will be obvious to those skilled in the art, the invention may also be employed to start lamps which are normally operated from a D.C. power supply by either incorporating in the starting circuit means to temporarily convert the D.C. to A.C. voltage, such as a vibrator for example, or by providing a separate A.C. voltage source for energizing the starting circuit.

It will be apparent from the foregoing that the objects of the invention have been achieved insofar as a simple, more compact and inexpensive circuit has been provided for starting and operating lamps containing an ionizable medium and having thermionic-emitting type electrodes whereby a higher voltage is required to start than to operate the lamp. In addition, by combining the desirable features of a series resonant circuit with a voltage boosting-capacitor discharge arrangement an exceptionally versatile starting circuit is provided which can supply a wide range of precisely controlled starting voltages thereby permitting the same basic circuit to be used with the various types and sizes of discharge lamps now being marketed.

While several specific embodiments of the invention have been described in detail by way of illustration and example for the purposes of clarity and understanding in accordance with the patent statutes, it is understood that various changes and modifications may be made without departing from the spirit and scope of the invention.

I claim:

1. A circuit for starting a lamp containing an ionizable medium and requiring a higher starting than operating voltage, said circuit comprising conductor means for connecting said lamp to an alternating voltage source, a transformer having a primary and a secondary, a capacitor, and means including a switch for temporarily connecting said primary across the input side of said conductor means and said capacitor across said lamp, and applying the output of said secondary to said capacitor and lamp.

2. A circuit for starting and operating a lamp containing an ionizable medium and requiring a higher starting than operating voltage, said circuit comprising conductor means for connecting said lamp to an alternating voltage source, current limiting means connected to said lamp through said conductor means, a transformer having a primary and a secondary, said secondary being connected in series with said lamp and current limiting means and in conjunction with said current limiting means and conductor means constituting a series circuit for operating said lamp after it has been lighted, a capacitor, and switch means for connecting said capacitor across said lamp, and said primary across the input side of said conductor means.

3. A circuit for starting and operating a lamp containing an ionizable medium and requiring a higher starting than operating voltage, said circuit comprising conductor means for connecting said lamp to an alternating voltage source, current limiting means connected to said lamp through said conductor means and adapted in conjunction therewith to operate said lamp after it has been lighted, a transformer having a primary and a secondary, a capacitor, and means for connecting said capacitor across said lamp, said primary across the input side of said conductor means, and said secondary in series with said current limiting means and lamp.

4. A circuit for starting and operating a lamp containing an ionizable medium and requiring a higher starting than operating voltage, said circuit comprising conductor means for conducting said lamp to an alternating voltage source, current limiting means connected to said lamp through said conductor means, a transformer having a primary and a secondary which are electrically isolated from each other, said secondary being connected in series between said lamp and current limiting means through said conductor means thereby to provide a series circuit for operating said lamp after it has been lighted, a capacitor, and means including a switch for connecting said capacitor across said lamp, and said primary across said conductor means at a point on the series operating circuit closer to the input terminals thereof than said current limiting means.

5. A circuit for starting and operating a lamp containing an ionizable medium and requiring a higher starting than operating voltage, said circuit comprising conductor means for connecting said lamp to an alternating voltage source, an inductive ballast connected in series with said lamp through said conductor means, a low reactance transformer having a primary and a secondary which are electrically isolated from each other, said secondary being connected in series between said lamp and ballast through said conductor means thereby to provide a series circuit for operating said lamp after it has been lighted, a capacitor and means including a switch for temporarily and simultaneously connecting said capacitor across said lamp, and said primary across the input side of said conductor means.

6. A circuit for starting and operating a lamp containing an ionizable medium and requiring a higher starting than operating voltage, said circuit comprising conductor means for connecting said lamp to an alternating voltage source, an inductive ballast connected in series

with said lamp through said conductor means and in conjunction therewith providing a series circuit to operate said lamp after it has been lighted, a low reactance transformer having a primary and a secondary, a capacitor, and means including a switch for connecting said capacitor across said lamp, said primary across the input side of said conductor means, and said secondary in series between said ballast and lamp and closer to said ballast than the point on said series operating circuit at which the capacitor shunts the lamp.

7. A circuit for starting and operating a lamp containing an ionizable medium and requiring a higher starting than operating voltage, said circuit comprising conductor means for connecting said lamp to an alternating voltage source, a first current limiting means connected in series with said lamp through said conductor means and operable in conjunction therewith to operate said lamp after it has been lighted, a transformer having a primary and a secondary, a capacitor, a second current limiting means connected in series with said capacitor, and means operable to connect said serially arranged capacitor and second current limiting means across said lamp and said primary across the input side of said conductor means, and to apply the output of said secondary to said serially arranged capacitor and second current limiting means and to said lamp.

8. A circuit for starting and operating a lamp containing an ionizable medium and requiring a higher starting than operating voltage, said circuit comprising conductor means for connecting said lamp to an alternating voltage source, an inductive ballast connected in series with said lamp through said conductor means and operable in conjunction therewith to provide a series circuit for operating said lamp after it has been lighted, a low reactance transformer having a primary and a secondary, a capacitor having a resistor connected in series therewith, and means including a single-action multiple-contact switch for temporarily and simultaneously connecting said capacitor-resistor combination across said lamp at a point on the series operating circuit closer to said lamp than said ballast, said primary across the input side of said series operating circuit, and said secondary in said series operating circuit in series with said ballast and lamp between said ballast and the point on said series operating circuit at which the capacitor-resistor combination shunts the lamp.

9. In an energizing circuit for a lamp containing an ionizable medium and requiring a higher starting than operating voltage, a starting circuit comprising conductor means for connecting with a source of alternating voltage, voltage-converting means, a capacitor, and means

including a switch for temporarily connecting said voltage-converting means across the input side of said conductor means and said capacitor across said lamp, and for applying the output of said voltage-converting means to said capacitor and lamp, said voltage-converting means being adapted and electrically oriented to increase the voltage normally applied to said lamp by the energizing circuit to a value sufficient to initiate a gaseous discharge in said lamp within a predetermined time limit after said switch is closed.

10. In an A.C. energizing circuit for a lamp containing an ionizable medium and having at least one thermionic-emitting electrode, a starting circuit comprising a transformer having a primary and secondary, a capacitor, and means including a switch for connecting said primary across the line side of said energizing circuit, said capacitor across said lamp, and applying the output of said secondary to said capacitor and lamp thereby to increase the voltage applied to said lamp to a predetermined value such that said lamp is rendered conductive and said capacitor is discharged therethrough, said capacitor being of such value that the increase in current flowing through the lamp incident with the discharge of said capacitor substantially increases the temperature of the thermionic electrode without damaging said lamp.

11. In an inductively ballasted A.C. energizing circuit for a lamp containing an ionizable medium and having at least one thermionic-emitting electrode, a starting circuit comprising a low reactance transformer having a primary and secondary, a capacitor having a current limiting means in series therewith, and means including a switch for temporarily connecting said primary across the line side of said energizing circuit, said capacitor and current limiting combination across said lamp at a point on said energizing circuit closer to said lamp than the inductive ballast, and applying the output of said secondary to said capacitor-current limiting combination and to said lamp, said capacitor being chosen to have the same order of reactance as the ballast when said switch is closed and the capacitor is in the circuit, and said current limiting means having a value such that the increase in current through the lamp incident with the discharge of said capacitor substantially increases the temperature of the thermionic electrode without damaging said lamp.

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