Oct. 29, 1935. K. F. J. KIRSTEN 2,018,856

GAS ARC LAMP

Filed June 6, 1933 3 Sheets-Sheet 1

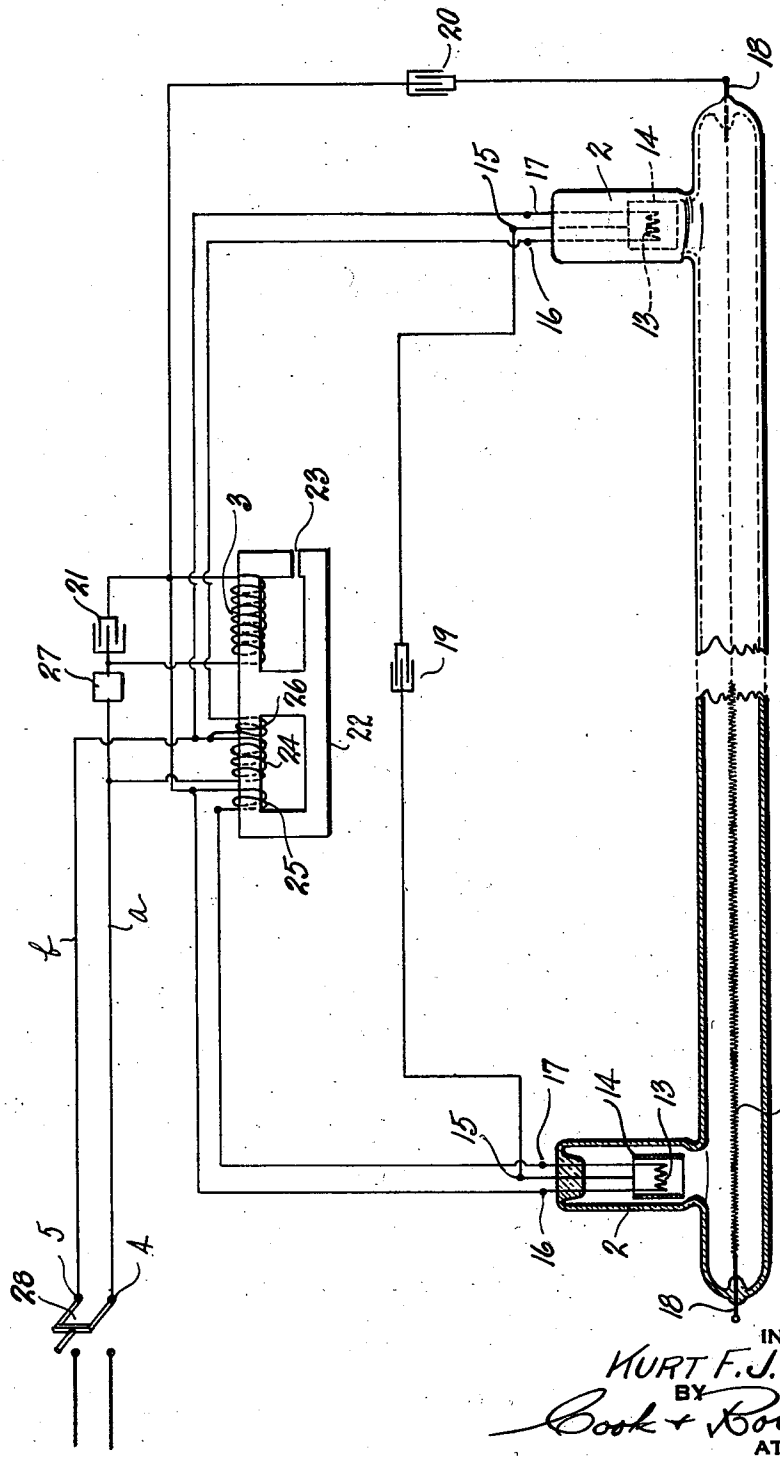

Fig. 1

INVENTOR
KURT F. J. KIRSTEN
BY
Cook & Robinson
ATTORNEY

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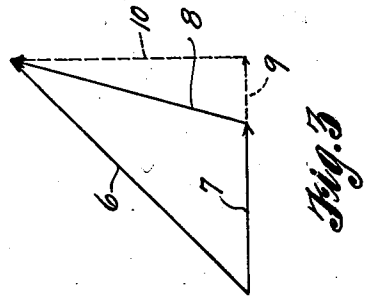

Fig. 3

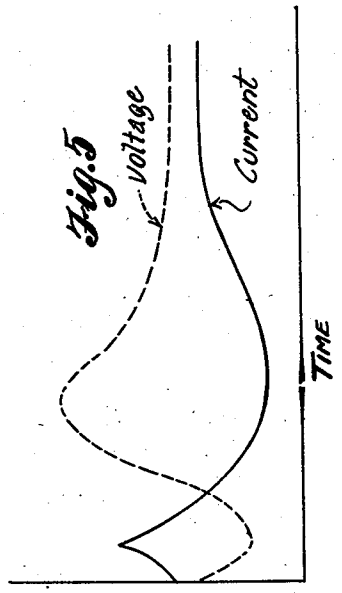

Fig. 5

Voltage and Current

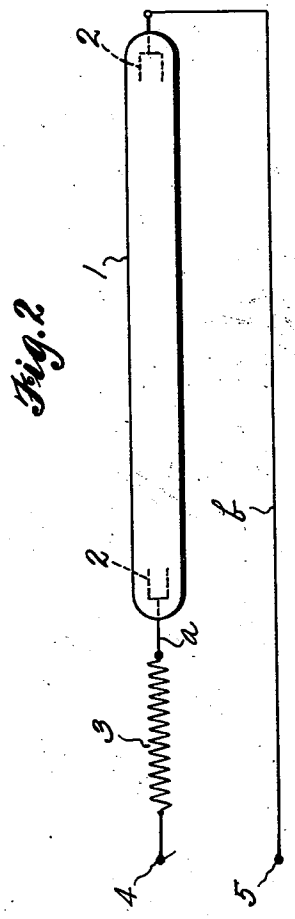

Fig. 2

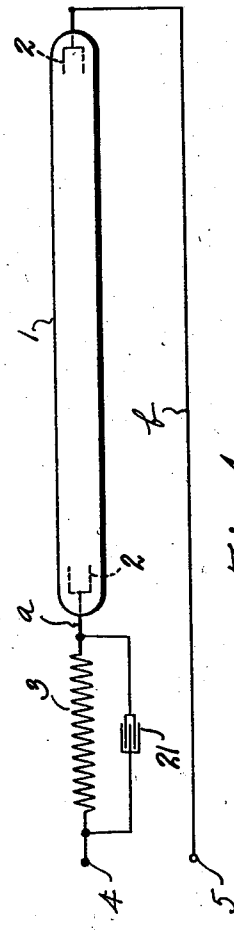

Fig. 4

INVENTOR
HURT F. J. KIRSTEN
BY
Cook & Robinson
ATTORNEY

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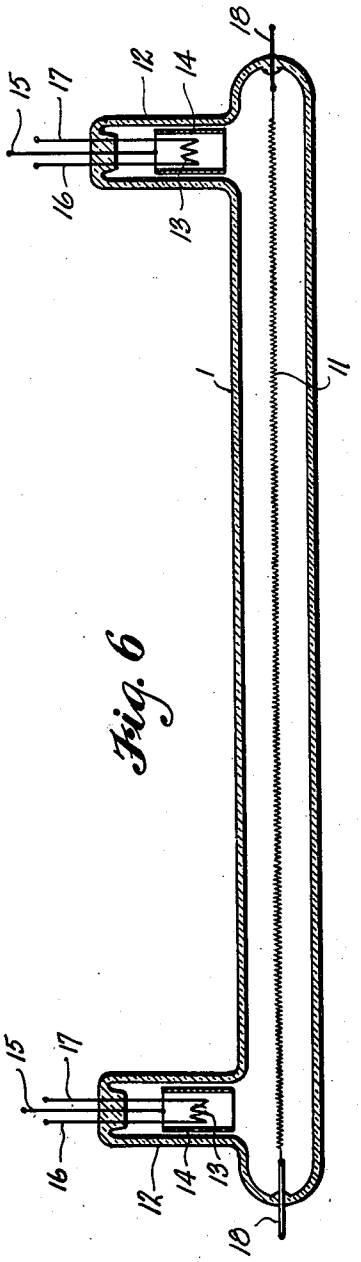

Fig. 6

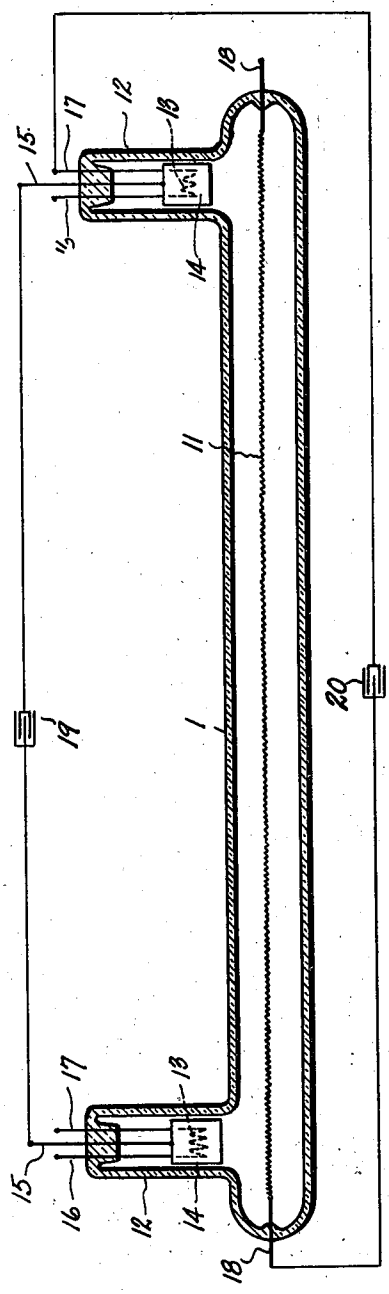

Fig. 7

INVENTOR
KURT F. J. KIRSTEN
BY
Cook & Robinson
ATTORNEY

Patented Oct. 29, 1935

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UNITED STATES PATENT OFFICE

2,018,856

GAS ARC LAMP

Kurt F. J. Kirsten, Seattle, Wash., assignor to Kirsten Lighting Corporation, a corporation of Washington

Application June 6, 1933, Serial No. 674,550

3 Claims. (Cl. 176—124)

This invention relates to the art of electrical illumination and it has reference in particular to gas arc lamps of low voltage, suitable for purposes of general as well as commercial sign and display illumination.

It is recognized that many difficulties and various objectionable features experienced in time past in the construction of long tubes containing rare gases and electrodes for the purpose of illumination by an arc in said gases, have been overcome, however, all such devices known to the present applicant require a supply voltage considerably higher than the normal arc voltage after the arc is once established. Many of the devices of the prior art employ a high frequency, high potential impulse temporarily applied to the tube on starting and besides this arc "stimulator" a supply voltage of about twice the normal circuit voltage is momentarily applied by the use of an auto-transformer containing a magnetic shunt. This auto-transformer usually has about twice the open circuit voltage which it yields after the arc is struck. Through the use of the magnetic shunt, this transformer operates at the same time as a reactor with an automatic decrease of its terminal voltage to the normal circuit voltage. Since it is the open circuit voltage which must be considered from the standpoint of possible danger to life, the transformer must therefore be effectively insulated against the open circuit voltage.

It has been the principal object of this invention to provide a gas arc lamp from which all high potential starting or operating circuits have been eliminated and which has a service circuit which at no time requires a potential surge above the normal operating voltage of the lamp.

More specifically stated, it is the principal object of this invention to provide a gas arc lamp capable of being kindled and operated on the ordinary domestic one hundred ten or two hundred twenty volt circuit and which at no time or in any part either in starting or operating, rises above the voltage of the supply circuit.

Other objects of the invention reside in the specific use of condensers, at various points in the circuit; in the use of a metallic conductor along the arc path as an aid to kindling the arc and in the application of and novel use in the circuit of a reactor and filament transformer.

In the accompanying drawings—

Fig. 1 is a view diagrammatically illustrating a gas arc lamp and typical circuit therefor, showing all parts of the present invention.

Fig. 2 is a view, shown for the purpose of better explanation, diagrammatically illustrating a gas arc lamp of the prior art.

Fig. 3 is a vector diagram illustrating voltage relations of the circuit of the lamp of Fig. 2.

Fig. 4 is a view diagrammatically illustrating an improvement in the circuit of the prior art lamp of Fig. 2.

Fig. 5 is a graph illustrating performance of the lamp of Fig. 4.

Fig. 6 is a view illustrating in a simple form, a lamp embodied by the present invention.

Fig. 7 is a view illustrating use of condensers in the lamp of Fig. 6 for lowering the kindling voltage of the lamp.

As was set forth in applications previously filed by me, under Serial No. 580,400 filed December 11, 1931; No. 596,753 filed on March 4, 1932 and No. 603,245 filed on April 5, 1932, an electric arc operating in a gaseous medium has negative resistance characteristics, that is, the greater the current intensity of the arc, the smaller is the voltage required to maintain it between its terminal electrodes. In order to operate such an arc and at the same time to maintain the stability of the electric circuit of which it is a part, prior art devices have made extensive use of a reactor. For purposes of comparison and for better explanation, a prior art lamp and its circuit, including the reactor, has been herein illustrated in Fig. 2 and the voltage relations of the lamp circuit have been shown by the vector diagram of Fig. 3.

In Fig. 2, 1 designates a sealed, tubular vessel containing a suitable rare gas, such as neon, in which an arc may be established and operated between the terminal electrodes 2—2' located within opposite ends of the tube and connected, respectively, by wires "a" and "b" with terminals 4 and 5 of an electric circuit upon which a suitable voltage is impressed for operating the lamp. This lamp is connected in series with reactor, designated at 3, interposed in the wire "a".

It is known that the circuit of the lamp of Fig. 2 will operate satisfactorily if the impressed voltage is sufficiently high to kindle the arc and if the reactance 3 is of sufficient magnitude. The voltage relations of the circuit are shown by the vector diagram of Fig. 3 wherein vector 6 represents the voltage impressed upon the terminals 4 and 5; vector 7 represents the voltage drop across the electrodes 2 and 2' of the lamp, and vector 8 represents the voltage drop across the reactor 3; the current in the circuit being in phase with vector 7.

Since every practically operating reactor must

contain some resistance, vector 8 is shown to be made up of the two component vectors 9 and 10; the former representing the resistance drop of the reactor and the latter its pure reactance drop.

It has been found that for stable operation of a circuit such as shown in Fig. 2, the angle between vectors 6 and 7 cannot be less than forty-five degrees, that is, vector 8 is always greater than vector 7. Hence, the maximum power factor of the circuit is .707.

The above relations, as well known in the prior art, are mentioned here only because the present invention has changed them and has established a new range over which the operation of an electric arc is possible.

In the vector diagram of Fig. 3, which indicates voltage relationship in the circuit after the arc has been established, the circuit voltage as indicated in magnitude and phase relation by vector 6 is not sufficiently great to initiate and "kindle" the arc. In order to ionize the gas so that an arc will form a voltage approximately twice as great as that represented by vector 6 is required, or a high frequency, high potential impulse must be applied to the wall of the lamp.

In the lamp of the present invention, I utilize the reactance 3 in the same manner, as disclosed in Fig. 2, with the addition of a condenser connected across the terminals of the reactor. Such a condenser is designated at 21 in Fig. 4.

It has been found that an arc formed in a tube filled with a rare gas, or metallic vapor, does not grow to its final stable current intensity on a fixed electric circuit but that the arc rapidly rises to a maximum value as soon as the circuit is connected to the energy supply. After a few moments it decreases again to a minimum value and then gradually rises to the stable value which is somewhat below the initial maximum value. Similarly the voltage across the arc is at first slightly below the final stable value and as the arc current decreases, the voltage across the arc rises. After reaching a maximum value it again drops rather slowly to its final stable value. This performance is shown by Fig. 5 wherein the current is shown by the full line and the arc voltage by the dotted line. The voltage and current variations during the first one or two minutes, after the circuit switch is closed, with regard to their magnitude, depend a great deal upon the nature of the rare gases used in the lamp. For neon gas these variations are very slight and the arc reaches stability in but a few seconds. However, in metallic vapor these variations are very large and the adjustment to the final stable values is a process of several minutes duration. For mercury vapor tubes the peak of the voltage curve has an ordinate of about one and one-half times the final value.

It is important to note that a fixed electrical circuit, arranged to stabilize the arc when finally it reaches its permanent current value does not always stabilize the arc when it passes through its critical minimum current value in the starting cycle. The voltage required by the minimum current rises to such a value that, together with the reactance drop, it becomes greater than the voltage of the main, and as a result, the arc is extinguished. It has been found that by connecting the condenser 21 across the reactor 3, as shown in Fig. 4, these current and voltage variations are greatly diminished during the starting period and a much lower circuit voltage can be used to carry the arc over its critical period in starting. Contrary to what might be expected by an analysis of the vector diagram of Fig. 3, this condenser also is highly effective in reducing the required circuit potential after the arc has passed over the critical starting condition. While this is not clearly understood by the applicant, many experiments have definitely proven that a condenser connected across the stabilizing reactor of a rare gas arc lamp greatly reduces the required circuit potential and diminishes the high and low peaks in the current and voltage respectively while the arc is passing through the starting period.

One of the principal features of the present invention resides in the means for and method of kindling the arc in a lamp of this character without increasing the circuit voltage above the minimum which is required to maintain the arc after it is kindled. The various methods are based upon the use in the lamp circuit of the condenser as above outlined in connection with what I have termed a "kindling element"; this being in the form of a metallic conductor extending within the tube, terminating at its opposite ends slightly spaced from the terminal electrodes of the lamp and along which a current, produced by corona discharge from the electrodes, will flow to ionize the arc path, thereby to stimulate the formation and striking of the arc. However, this element is of such character electrically that no part of the arc current will flow in it after the arc is established.

A lamp illustrating the use of this kindling element is disclosed in Fig. 6 wherein 1 designates a sealed, transparent, tubular container and 11 designates the element in the form of a metallic conductor located within and extending the length of the tube and attached at its ends to metallic supports 18—18 sealed in the tube ends; the ends of the conductor 11 terminating slightly spaced from the terminal electrodes of the lamp which, in this instance, are shown as being contained within laterally extending portions 12—12' of the tube. These electrodes may be of many forms but I have herein shown them each as comprising an oxide coated filament 13 surrounded by a cylindrical metal tube 14 spaced therefrom. The filaments are to be heated by an electrical source, not shown, independent of the main circuit of the lamp. Connections from the metal shields are brought out through suitable seals and form the terminals 15—15, and opposite ends of the filaments have sealed in connections 16 and 17; the use of these terminals and connections later being understood by reference to Fig. 1.

As was previously stated, the conductor 11 must be of such character electrically that no part of the arc current will flow in it after the arc is established. A great many experiments have shown that these required characteristics are two fold. First, the material of which the conductor consists must preferably have a cathode drop higher than the terminal voltage of the lamp, and if no such material is available, or if the terminal voltage of the lamp is higher than the cathode drop of the material, the resistance of the conductor 11 must be such that the cathode drop and reactance drop due to a current flow therein are greater than the voltage across the arc electrodes.

In Figs. 1 and 6 I have shown the conductor in the form of a long coil of fine wire, however, it may consist of a straight ribbon of nickel or other material as in Fig. 7, of sufficient cathode drop if the terminal voltage of the lamp is kept below the critical limit. It has been found that if the

lamp voltage is kept below one hundred twenty volts effective, a large metallic conductor, such as a wire of pure nickel of 0.05 inch diameter may be used, but if the lamp is very long, necessitating the use of two hundred twenty volts or more for its operation, the arc current will flow in the wire rather than through a path of ionized gas with the result of sputtering at the points where the wire develops a cathode and through rapid blackening of the lamp its usefulness is greatly impaired.

While various types of electrodes may be employed in a lamp embodying the present principles, the function of the conductors 11 will be the same for all types and that is to carry a corona current and thereby to stimulate ionization of the gas all along the arc path when an electromotive force is impressed upon the electrodes of the lamp; it being apparent that when such a force is impressed, a corona current will flow between the electrodes and adjacent ends of the conductor and a corona discharge will emanate from the conductor along its length and this will ionize a path through the gas of the tube as an aid to the striking of the arc. This use of the conductor provides, first, for the kindling of the arc at a lower voltage, that is, a lower terminal voltage may be used for a given lamp. Second, the operating voltage of the lamp may be lowered because of an increase in the power factor of the lamp circuit. Many experimental tests have proven that, due to the presence of the conductor 11 in the lamp, conditions of the vector diagram of Fig. 3 will be changed and vector 8 may be smaller than vector 7, a condition which has heretofore, in the prior art, been considered inoperative.

A further development of the lamp of Fig. 6 has been illustrated in Fig. 7 in which I have disclosed use of condensers for aiding in the emission of electrons from the filaments to the filament shields, and for enhancing in magnitude, the formation of corona along the conductor 11.

The lamp of Fig. 7 is constructed like that of Fig. 6 except that the terminals 15—15 of the shields 14—14 are connected by wires *c* and *d* through a condenser 19 and wires *e* and *f* connect one terminal 18 of conductor 11 with a connection 17 of the electrode at the opposite end of the lamp; this connection may, if desired, be reversed with respect to the ends of the tube.

The reason for this above use of condensers is: It has been demonstrated by many experiments that, if the filament shields of the lamp shown are connected through a condenser, a powerful emission of electrons from the filaments to the shields is stimulated. Likewise, the corona formation along the conductor 11 will be greatly enhanced in magnitude and, as a result, the arc will kindle at a much lower voltage.

Similarly, condenser 20 serves to stimulate corona formation along conductor 11 thus ionizing the gas along the arc path. In fact, the stimulation of corona is so powerful that the arc kindles at a voltage equal to that which is sufficient to stabilize the lamp circuit after the arc is established. While the circuit through the condenser 19 is not essential in the kindling or operation of the arc, it does aid materially in reducing the kindling potential for the arc. After the arc is once formed, the condenser may be disconnected, or if the capacity of condenser 20 is properly increased, then condenser 19 may be omitted.

It has been found that a neon lamp of thirty mm. diameter glass tubing and arc length of four feet with an initial gas pressure of three mm. (mercury) will kindle at a voltage of two hundred forty with the use of condenser 20 of 0.5 microfarad capacity and a condenser 19 of 0.1 microfarad capacity. This same tube will kindle with condenser 20 alone at 1.0 microfarad capacity. This voltage is just sufficient to operate the arc at a power factor of a little more than 0.71. The circuit through the condenser 20 is opened after the arc is kindled so as to reduce the danger of sputtering of conductor 11 and to cut off a slight energy supply which does not produce light.

In Fig. 1 of the present drawings, I have shown in detail a lamp and circuit embodying all of the novel features of the present invention as hereinbefore set forth in connection with the descriptions of Figs. 4 to 7, but in this view the reactor, together with the filament transformer, is shown in greater detail. Also in Fig. 1 I have applied reference numerals to designate parts corresponding to those bearing the same reference numerals in Figs. 1, 2, 4, 6 and 7, and in addition thereto 22 designates the core of the transformer and reactor and 23 designates an air gap provided therein to give it the desired performance characteristics, namely, to prevent the saturation of the reactor core and to insure direct proportionality between the magnetizing ampere turns and the resulting flux through the reactor coil. The primary winding of the filament transformer is designated at 24 and the two secondary windings, one for each filament 13, are designated at 25 and 26; the secondary voltage being approximately four volts. It is to be noted here that this is a step down transformer, creating no voltage increase above the service current. Condenser 21, as in Fig. 4, is shown connected across the terminals of reactor coil 3. A time delay switch 27 of an automatic character, which might be one like that of my co-pending application, Serial No. 603,246 is interposed in the connection from terminal 4 to the reactor coil 3 and this is operable to delay the closing of the main circuit in the lamp until after the filaments have been brought up to sufficient heat. The terminals 4 and 5 of the circuit are connected to a standard one hundred ten or two hundred twenty volt circuit through a switch 28.

To energize the lamp, the switch 28 is closed, and immediately the filaments 13—13 are energized. After a certain interval of time, during which the filaments have become sufficiently heated, the time delay switch 27 closes and this causes full line potential to be impressed upon the lamp circuit.

The current flow through the lamp, with reference to Fig. 1, would be from terminal 4, through switch 27, coil 3, terminal filament 13 at the left hand end of the view, through the tube to filament 13 at the right hand end, then to terminal 4.

When switch 27 closes, the arc kindles at once, especially by the operation of condenser 20, the circuit of which might be disconnected after its chief function, namely the kindling of the arc, is accomplished. This disconnection could be made automatically by leading it through the time delay switch 27 supplied with a special secondary delay control.

By varying the capacity of condenser 21, the distribution of light emissivity of the arc over the cycle and also its intensity may be greatly varied.

Having thus described my invention, what I

claim as new therein and desire to secure by Letters Patent is—

1. A gas arc lamp comprising a sealed transparent vessel with terminal electrodes on which electrical potential may be impressed from a supply circuit to maintain an arc therebetween, a conductor extended along the arc path and passing in close proximity to the electrodes and adapted to carry a corona emitting current produced by corona discharge from the electrodes for ionization of the arc path incident to energization of the electrodes to stimulate the striking of the arc, a current connection between one end of the said conductor and one side of the supply circuit and a condenser interposed in said current connection between the conductor and supply circuit.

2. A gas arc lamp including a sealed transparent vessel with terminal electrodes, a supply circuit having terminal connections with said electrodes for maintaining an arc in the lamp, a reactance in one of said connections and a condenser connected across the reactance.

3. A gas arc lamp comprising a sealed, transparent vessel provided with terminal electrodes on which electrical potential may be impressed to maintain an arc therebetween, a current conductor extending along the arc path and in close proximity to the electrodes and having a potential gradient higher than the arc gradient along the arc path, a metallic shield surrounding each of the electrodes, a conductor connecting the shields and including a condenser therein, and a conductor connecting one end of the first mentioned current conductor and the supply circuit at the opposite end of the tube and also including a condenser therein.

KURT F. J. KIRSTEN.