Aug. 20, 1935. H. M. CAVANAUGH 2,011,969

LIGHTING SYSTEM

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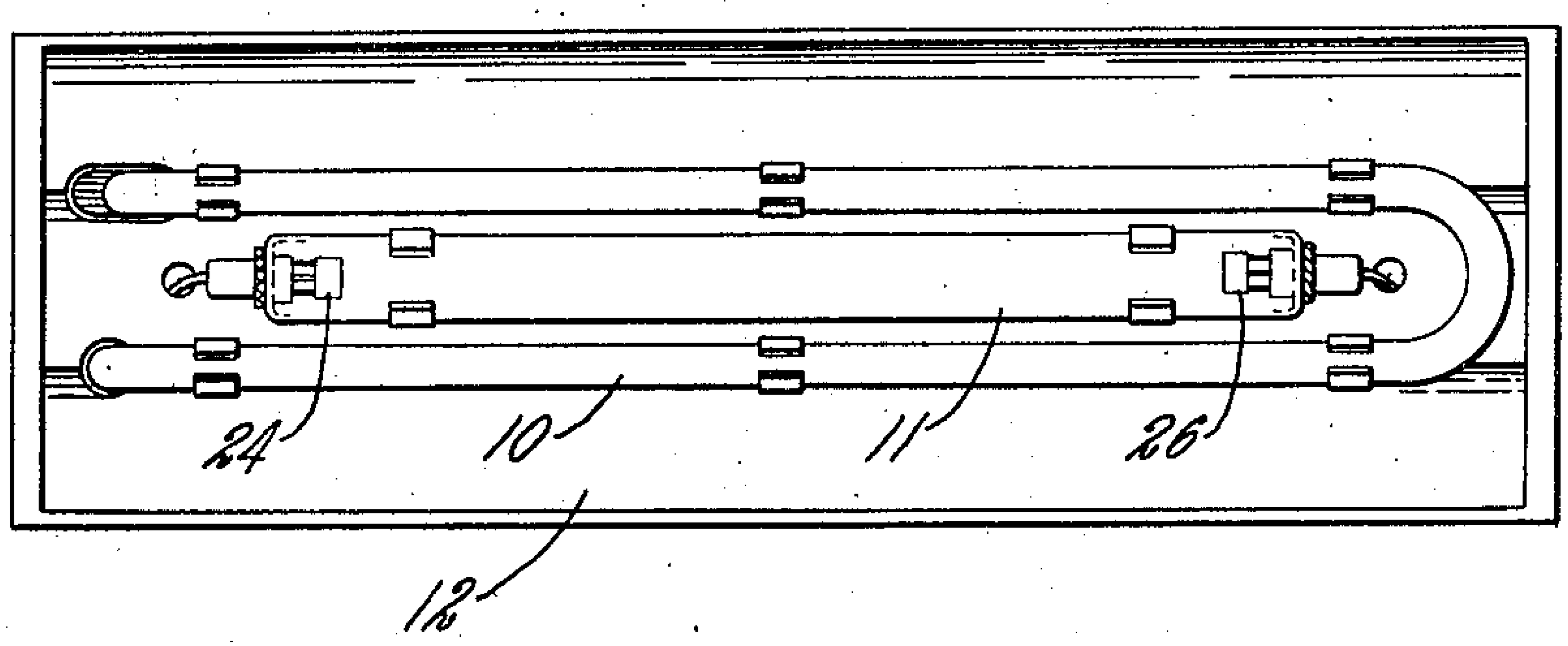

Fig. 1

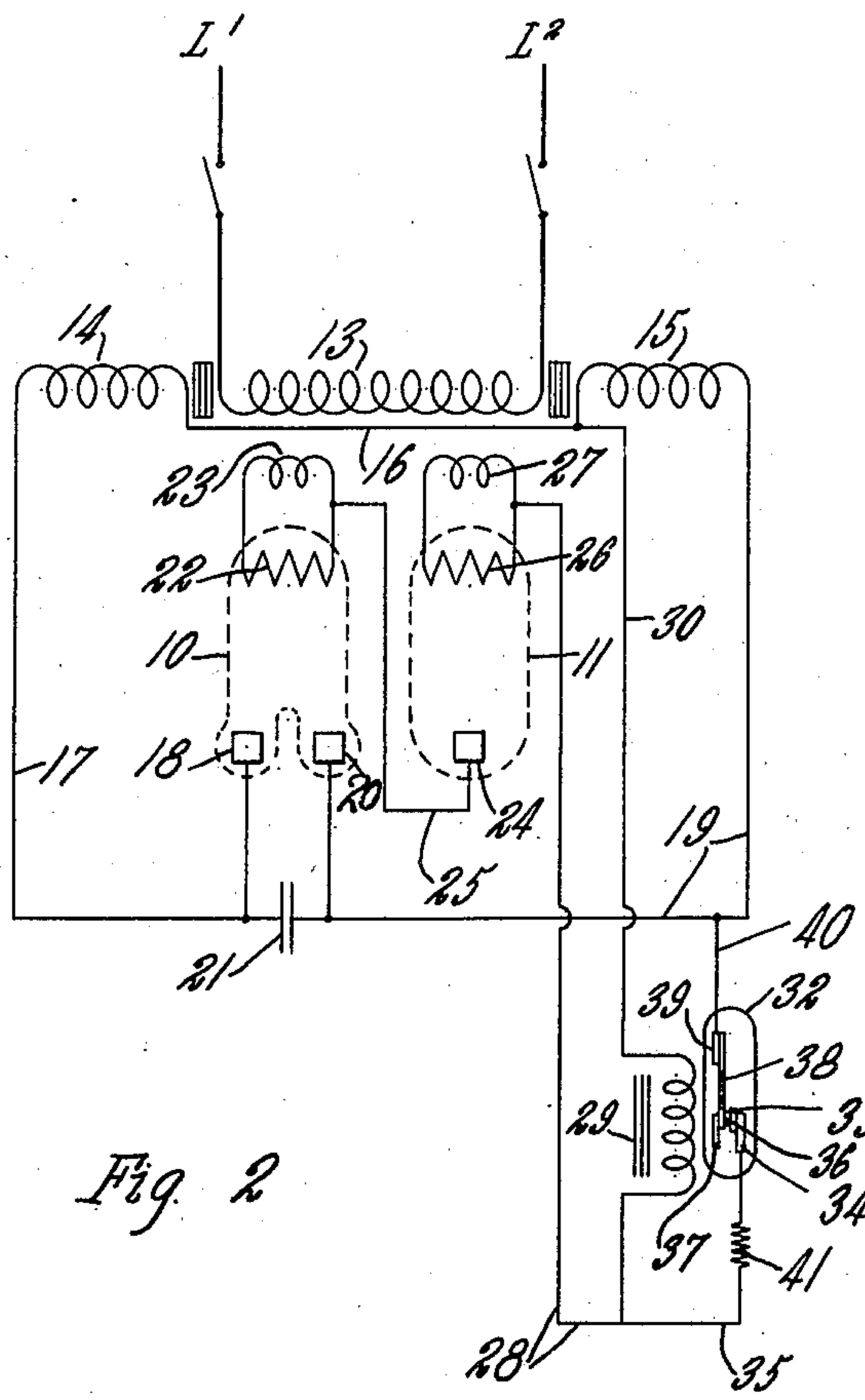

Fig. 2

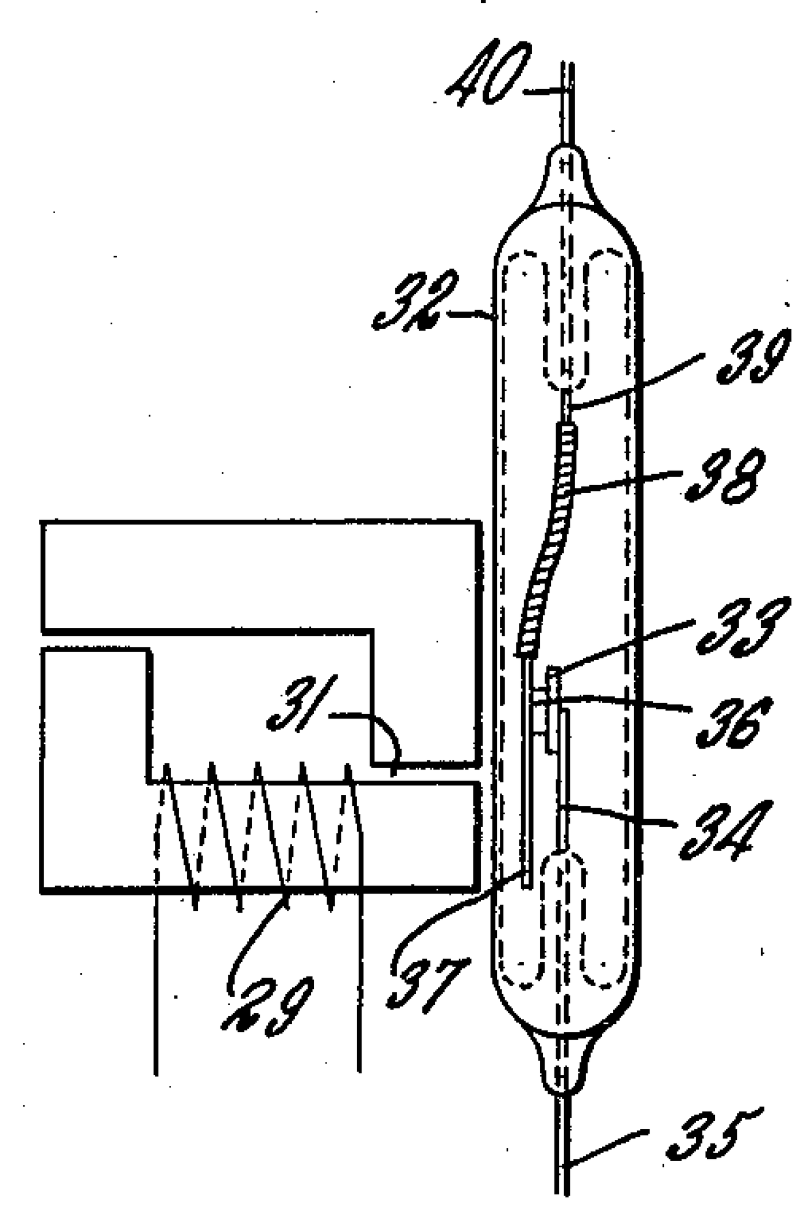

Fig. 3

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LIGHTING SYSTEM

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7 Claims. (Cl. 176—124)

This invention relates to gaseous illuminating tubes, and particularly to lighting systems and apparatus therefor. When such tubes are operated by a current of relatively low voltage, it is necessary to ionize the gas therein before current will pass through the tubes. This application is a continuation in part of my application Ser. No. 671,886 filed May 19, 1933.

An object of the invention is to provide an improved lighting system for gaseous illuminating tubes, with which greater efficiency in the operation of said tubes may be obtained; with which the flow of illuminating current through the illuminating tubes may be initiated in a simple manner; with which the apparatus required to initiate the flow of lighting current through such illuminating tubes may be reduced to a minimum; and with which the starting of the illumination of the tubes of the system may be accomplished automatically merely by applying the illuminating current to the system.

Another object of the invention is to provide improved means for causing ionization of the gas of low voltage gaseous illuminating tubes to initiate the flow of current therethrough, which will be automatic in action, have a long life, and be dependable and relatively simple and inexpensive in construction.

Another object of the invention is to provide an improved starting tube which may be advantageously used as a part of the starting mechanism for low voltage gaseous illuminating tubes.

Another object of the invention is to provide an improved illuminating device using gaseous illuminating tubes of the low voltage type, with which one may produce a white light which closely resembles daylight in its characteristics and which will have maximum efficiency, uniformity and dependability.

Various other objects and advantages will be apparent from the following description of an embodiment of the invention, and the novel features will be particularly pointed out hereinafter in connection with the appended claims.

In the accompanying drawing:

Fig. 1 is a plan of a lighting device constructed in accordance with this invention.

Fig. 2 is a diagram of a system by which the lighting of low voltage gaseous illuminating tubes may be initiated and maintained in accordance with this invention.

Fig. 3 is a side elevation of a starter tube which may be used to ionize the gas in the illuminating tubes, and a choke coil, schematically shown, arranged in operative relation to the starter tube.

In the illustrated embodiment of the invention, the lighting system is applied to a pair of low voltage, gaseous illuminating tubes **10** and **11**, Fig. 1, which are arranged in a close or compact relation to one another so that the light rays emitted by both tubes will largely or entirely mix immediately after leaving the tubes. The tubes contain gases which impart color to the light rays that are emitted by such tubes when illuminated, and the gases selected for the tubes are those which will cause the tubes to emit different colored lights which are complementary to one another, such as blue and red. For example, one tube may contain a gas, such as argon, krypton, or xenon, each plus mercury, which causes it to emit a blue color when lighted, and the other tube may contain a gas, such as neon, which causes it to emit a red color when lighted.

One of these tubes, such as the tube **10**, is made approximately of a narrow U-shape, and the other tube **11** is disposed between the arms of the U, so as to provide as concentrated a source of light as possible. Any other arrangement by which the two tubes may be placed in close proximity to one another and cause a mixing of the light rays promptly after emission from the tubes may be utilized, and suitable reflecting means **12** may be disposed back of these tubes **10** and **11** so as to direct as many as possible of the light rays from the tubes into crossing paths whereby a maximum portion of the light from the different tubes will mix.

In the illustrated example of the invention, the tube **10** is of the double anode type, and the tube **11** of the single anode type, and the tubes are connected electrically in series to one another. The lighting current for such tubes is alternating current of any suitable frequency, which is supplied from line wires L^1, L^2. The line wires L^1, L^2 are connected to the primary winding **13** of a suitable transformer, preferably one of the leakage type, and magnetic shunts may be provided for a pair of secondary windings **14** and **15** of this transformer so as to limit or regulate the amount of magnetic flux which may pass through each secondary winding **14** and **15**.

When current passes through the primary winding **13**, it will cause currents to be induced in the secondary windings **14** and **15** which are connected in series by a wire **16**, and one end of the winding **14**, opposite to the connection to the wire **16**, is connected by a wire **17** to the anode **18** of the double anode tube **10**. The secondary winding **15** of the transformer is connected, at the end opposite its connection to the wire **16**, by a wire 19 to the other anode 20 of the double anode tube 10. A suitable condenser 21 is connected between the wires 17 and 19 which lead to the anodes 18 and 20 and serves as a power factor correction for the tube 10.

The cathode 22 of the tube 10 is thermionic and, by way of example, is shown as of the filament type which is heated by a low voltage current obtained from a secondary winding 23 arranged in inductive relation to the primary winding 13. The anode 24 of the single anode tube 11 is connected by a wire 25 to the cathode 22 of the tube 10. The cathode 26 of the tube 11 is also thermionic and is illustrated as of the filament type, similarly heated by a low voltage current obtained from a secondary winding 27 that is also arranged in inductive relation to the primary winding 13. A wire 28 connects the cathode 26 of the tube 11 to one side of a choke coil 29, the other side of the choke coil being connected by a wire 30 to the wire 16 which connects in series the secondary transformer windings 14 and 15. The windings 14 and 15 may be considered as one secondary, with the wire 30 connected to an intermediate point of that one secondary.

The choke coil 29 may, for convenience, be constructed as shown diagrammatically in Fig. 3, so as to have a partially closed magnetic circuit with an air gap 31, and this air gap is utilized as part of the apparatus for the ionizing of the gas in the illuminating tubes 10 and 11, and when illumination of those tubes is to be started. For this purpose I provide a tube or envelope 32 which may, for convenience, be made of glass, and in this envelope or tube is provided a fixed contact 33 suitably supported by a stem 34, to which is connected a conductor 35 which extends through one end of the envelope to the exterior thereof for connection to the lighting system. Similarly a contact 36 is mounted on a small plate 37 carried upon one end of a helical spring 38, the other end of the spring being connected to and carried by a stem 39 projecting from one end of the envelope.

A conductor 40 extends through the wall of the envelope and is connected to the stem 39 so as to supply current thereto. The plate 37 is of magnetic material, or material such as soft iron, and is, in effect, an armature carried by the spring 38, which serves as a resilient support therefor. The spring 38 yieldingly and resiliently urges the contact 36, carried thereby, into engagement with the fixed contact 33, and at this time the armature or plate 37 is spaced from the walls of the envelope so that the armature or plate 37 and the contact 36 may move away from the fixed contact 33 and break the engagement or connection between the contacts 33 and 36.

The envelope or tube 32 is disposed in proximity to the air gap 31 of the choke coil, or otherwise in a position to be influenced by the magnetic field set up by the choke coil at the air gap 31 thereof, when the choke coil is energized. The tube or envelope 32 is so disposed with respect to the air gap or choke coil that when the choke coil is energized the magnetic field set up thereby will attract the armature or plate 37 and magnetically pull it, against the stress of the spring 38, away from the contact 33, and open the connection between the conductors 35 and 40. When the choke coil 29 is de-energized, the magnetic attraction on the plate 37 will stop, and the spring 38 will return the contact 36 into engagement with the contact 33.

The conductor 40 of the starter tube is connected to the wire 19 leading from the secondary 15 to the anode 20 of the tube 10, and conductor 35 of the starter tube is connected to the wire 28 which connects the cathode of the tube 11 to the choke coil 29. The envelope or tube 32 is preferably gas tight and exhausted to a high vacuum, such as one of approximately 0.1 microns of mercury pressure, and all parts within the envelope or tube as well as the walls of the tube are thoroughly degasified so as to remove all impurities.

It will be noted that the tubes 10 and 11 are connected electrically in series to one another and the operation is as follows:

When the current is applied to the primary winding 13 of the transformer, it induces alternating currents in the secondary windings 14, 15, 23 and 27. The currents induced in the windings 23 and 27 will immediately flow through the cathode filaments 22 and 26 respectively and heat them to emission temperatures. Currents induced in the secondary windings 14 and 15 will tend to flow through the wires 17 and 19 to the anodes 18 and 20 of the tube 10. From the wire 16, connecting the windings 14 and 15, the circuit to the tube 10 is completed through wire 30, choke coil 29 and wire 28 to the tube 11, and through the tube 11 and wire 25 to the cathode of the tube 10. By this arrangement in which the A. C. current is applied to the tube 10, a current will flow in tube 10 between the anodes 18 and 20 and the cathode 22, one half of each complete current wave passing between the anode 18 and cathode 22, and the other half between the anode 20 and the cathode 22.

Alternating current so passing through the tube 10 will be rectified, and will flow through the wire 25 to anode 24 of the tube 11, thence through the tube 11 to the cathode 26 of that tube, and thence through wire 28, choke coil 29 and wire 30 back to the transformer windings 14 and 15. It will be noted that the rectified current which passes through the tube 10 is also the illuminating current for the tube 11, and we have a condition of having two low voltage, gaseous illuminating tubes connected in series to one another, with one of such tubes, such as the tube 11, operated by the direct current which is rectified in the other or double anode tube 10.

When current is applied to the primary winding 13 to start the illumination of the tubes 10 and 11, no current will flow through the tubes 10 and 11 until the gas in such tubes has first been ionized, and in the illustrated example of the invention, this ionization is accomplished through the starter tube 32. Current will, however, immediately flow through the cathode filaments 22 and 26 to heat them. The contacts 33 and 36, together, form a switch which is normally closed, but magnetically operated into open position by the magnetic flux set up in the choke coil when the latter is energized.

With the circuit connections as shown in Fig. 2, and after the tubes 10 and 11 have been extinguished or the lighting circuit therefor cut off, let it be assumed that one now desires to start illumination of the tubes 10 and 11. The current is applied to the primary winding 13 of the transformer through the power lines L^1, L^2, but no current will flow through the tubes 10 and 11 because the gases in those tubes are not ionized. However, the current induced in the secondary winding 15 will flow through the special or branch circuit formed of wire 19, conductor 40, spring 38 of the starting tube, contacts 36 and 33, stem 34 and conductor 35, wire 28, choke coil 29 and wire 30 back to the other side of the secondary winding 15. A closed circuit now exists between the secondary winding 15 and choke coil 29.

There may be some slight lag in the building up of the current through the choke coil 29, owing to the impedance thereof, and during this slight lag the filament cathodes 22 and 26 will be heated somewhat by the current flowing therethrough. The magnetic field set up by the current in the choke coil will attract the armature or plate 37 and open the special or branch circuit through the envelope 32 and the choke coil 29. At this opening of the special circuit, the choke coil will discharge its stored-up energy, and this discharge cannot occur through the tube or envelope 32 because of the open condition of the switch in that tube, and, therefore, there will be a momentary discharge of the stored energy of the choke coil through the tubes 10 and 11. This momentary discharge of energy through the tubes 10 and 11 is sufficient to ionize the gas therein and strike an arc in each tube, and immediately thereupon the illuminating current induced in the secondary windings 14 and 15 will flow through the tubes 10 and 11 and through the choke coil 29.

Since the flow of current through the tubes 10 and 11 from the secondary windings 14 and 15, that is, the striking of an arc in each tube, occurs immediately upon discharge of energy from the coil 29, the resulting flow of current through the choke coil 29 as a part of the lighting circuit will be sufficient to keep up the magnetic field and hold the armature or plate 37 attracted, thereby keeping the special circuit through the envelope open. The tubes 10 and 11 will then be operated in a normal manner so long as current is supplied to the transformer from the line wires L^1, L^2, but if the current is cut off from the primary winding 13, the choke coil 29 will be deenergized and the contact 36 will be urged into closed position by the spring 38, thereby placing the apparatus automatically in a position to start a new operation of the system whenever current is reapplied to the primary winding 13.

While the gases contained in the tubes 10 and 11 to give color to the light emitted by the tubes may be varied as desired, I have found that it is easier and preferable to rectify the current in the tube which emits the blue light because it usually requires a higher voltage to operate, on alternating current, a tube containing a gas that emits a red light than one that emits a blue light. Since a higher voltage would be required when a red light emitting tube is used as the rectifying tube in the A. C. circuit, it leaves less available voltage for the other tube which operates on the rectified or D. C. For this reason I have found that greater efficiency is obtained when the A. C. tube 10 is the one which emits the blue light, and the tube 11 is then the tube which emits the red light. The colors of the light rays which are emitted by the tubes 10 and 11 should be complementary, so that when mixed immediately upon leaving the tubes, there is produced an approximately white light.

It has long been the desire of engineers to obtain a white light closely resembling daylight, and I have discovered that this can be done when the two tubes are operated concurrently while in close proximity to one another, by obtaining the proper ratio between the current densities or power in the two tubes. In the case of current densities, I have discovered that the current density per square centimeter of cross sectional area in the blue tube should be at least three times that of the red tube and not more than six times that of the red tube, and preferably the current density in the blue tube should be approximately 4.4 times as great as that of the red tube. When the current density in the blue tube is 4.4 times as great as that in the red tube, and with the tubes arranged in close relation to one another, the transmitted mixture of light from the tubes is a white light that very closely resembles daylight in its characteristics. If the computation is not based upon current densities, the power passing through the tube emitting blue light should be from one to three times that passing through the tube which emits red light. Preferably the power passing through the blue light emitting tube should be substantially twice that passing through the red light emitting tube, because I have found that by this ratio a white light may be obtained which has characteristics very closely approaching daylight. I prefer to use this ratio of current densities and power in the system herein disclosed and claimed.

It will be noted that the breaking of the special circuit through the choke coil ionizes the gas in both tubes 10 and 11 and starts the flow of illuminating current therethrough although one tube is being operated by direct current and the other by alternating current. Hence the gas in each tube is ionized in the same manner, regardless of the character of the illuminating current applied to that tube. If any gaseous illuminating tube is to be lighted or started by direct current, I find it advantageous to provide a resistance 41 in series in the special circuit, such as in series in the wire 35, so that the direct current passing through the special circuit, and which must be broken by the contacts 33 and 36, will not be too great to handle. The resistance of the choke coil 29 is not great, although that coil has sufficient reactance when used in an A. C. circuit with a leakage type transformer to prevent passage of heavy currents therethrough in the special circuit. When the choke coil is used with direct current in the special starting circuit, the resistance 41 should be included in series in the special circuit to prevent substantial short circuits that must be broken by separation of the contacts 33 and 36.

The gaseous illuminating tube emitting red light will operate to produce more light per watt of power when operating on direct current than when operating on alternating current, and since the red light emitting tube is more inefficient than the blue light emitting tube for light production, it is feasible and desirable to use it in the illuminating circuit as the direct current tube.

It will be understood that various changes in the details, which have been herein described and illustrated in order to explain the nature of the invention, may be made by those skilled in the art within the principle and scope of the invention as expressed in the appended claims.

I claim as my invention:

1. In a lighting system for gaseous illuminating tubes, a double anode low voltage gaseous illuminating tube, a single anode low voltage gaseous illuminating tube, a source of alternating current, a lighting circuit for said double anode tube including said double anode tube and said source, whereby current from said source will pass

through said double anode tube and be rectified thereby, said single anode tube being included in series in said lighting circuit at the cathode side of said double anode tube, and with the anode of said single anode tube connected to the cathode of the double anode tube, whereby said single anode tube will be operated by the rectified current from said double anode tube, and a choke coil in series with said single anode tube at a point between said source and said cathode of said double anode tube.

2. In a lighting system for gaseous illuminating tubes, a double anode low voltage gaseous illuminating tube, a single anode low voltage gaseous illuminating tube, a source of alternating current, a lighting circuit for said double anode tube including said double anode tube and said source, whereby current from said source will pass through said double anode tube and be rectified thereby, said single anode tube being included in series in said lighting circuit at the cathode side of said double anode tube, and with the anode of said single anode tube connected to the cathode of the double anode tube, whereby said single anode tube will be operated by the rectified current from said double anode tube, a choke coil, a branch circuit including said source and choke coil, a switch device disposed within the magnetic field of said choke coil, included in series in said branch circuit, urged yieldingly into closed position and operable into open position by magnetism in said choke coil when said choke coil is energized, whereby the energy stored in said choke coil by closing of said branch circuit and released by the opening of said branch circuit will produce a current surge through both of said gaseous illuminating tubes, causing ionization of the gas therein, and through such ionization starting the flow of lighting current through said tubes.

3. In a lighting system, a double anode low voltage gaseous illuminating tube, a single anode low voltage gaseous illuminating tube, a transformer secondary connected at its ends to the anodes of the double anode tube, means connecting the cathode of the double anode tube to the anode of the single anode tube, means connecting the cathode of the single anode tube to an intermediate point in said secondary, and a choke coil connected in series with said single anode tube, whereby the alternating current applied to said double anode tube will be rectified thereby and will flow through said single anode tube to cause an illumination of both tubes by the same current, said tubes containing gas which causes them to emit colored light when illuminated, the colors emitted by said tubes being different and complementary, and said tubes being arranged in proximity to one another, whereby the mixing of the light emitted by both tubes will produce an approximately white light.

4. In a lighting system, a double anode low voltage gaseous illuminating tube, a single anode low voltage gaseous illuminating tube, a transformer secondary connected at its ends to the anodes of said double anode tube, a wire connecting the cathode of the double anode tube to the anode of the single anode tube, a wire connecting the cathode of said single anode tube to an intermediate point in said transformer secondary,,whereby alternating current will pass through said double anode tube and be rectified thereby, and the rectified current will pass through said single anode tube, one of said tubes containing a gas which causes it to emit a blue light when illuminated, and the other of said tubes containing a gas which, when the tube is illuminated, causes it to emit a red light, the current density per square centimeter in cross sectional area of the blue tube being not less than three times as great as that of the red tube, and not greater than six times as great as that of the red tube, and said tubes being arranged in proximity to one another to cause the mixing of the light emitted from both tubes, whereby the mixed light from said tubes will closely resemble day light.

5. In a lighting system, a double anode low voltage gaseous illuminating tube, a single anode low voltage gaseous illuminating tube, a transformer secondary connected at its ends to the anodes of said double anode tube, a wire connecting the cathode of the double anode tube to the anode of the single anode tube, a wire connecting the cathode of said single anode tube to an intermediate point in said transformer secondary, whereby alternating current will pass through said double anode tube and be rectified thereby, and the rectified current will pass through said single anode tube, one of said tubes containing a gas which causes it to emit a blue light when illuminated, and the other of said tubes containing a gas which, when the tube is illuminated, causes it to emit a red light, said tubes being so arranged with respect to one another that the light from said tubes will mix immediately upon leaving the tubes, and the current density per square centimeter in cross sectional area in the blue tube being approximately 4.4 times as great as that in said red tube, whereby the mixed light from said tubes will closely resemble day light.

6. In a lighting system, a double anode, low voltage gaseous illuminating tube, a low voltage, single anode gaseous illuminating tube, a source of alternating current and connections from said source to said tubes for passing alternating current through said double anode tube to be rectified thereby and for passing the rectified current therefrom through said single anode tube, said double anode tube containing a gas causing it to emit a blue light when illuminated and said single anode tube containing a gas which causes the tube to emit a red light when illuminated, said tubes being arranged to cause an immediate mixing of the light emitted by said tubes, whereby an approximately white light will be produced by the mixing of the light from both of said tubes, the current densities per cross sectional areas of said tubes having a ratio of approximately 4 to 1 in said blue and red tubes respectively, whereby the mixed light from said tubes will closely resemble day light.

7. In a lighting system, a double anode low voltage gaseous illuminating tube, a single anode low voltage gaseous illuminating tube, a transformer secondary connected at its ends to the anodes of the double anode tube, means connecting the cathode of the double anode tube to the anode of the single anode tube, and means connecting the cathode of the single anode tube to an intermediate point in said secondary, whereby the alternating current applied to said double anode tube will be rectified thereby and will flow through said single anode tube to cause an illumination of both tubes by the same current.

HOWARD M. CAVANAUGH.