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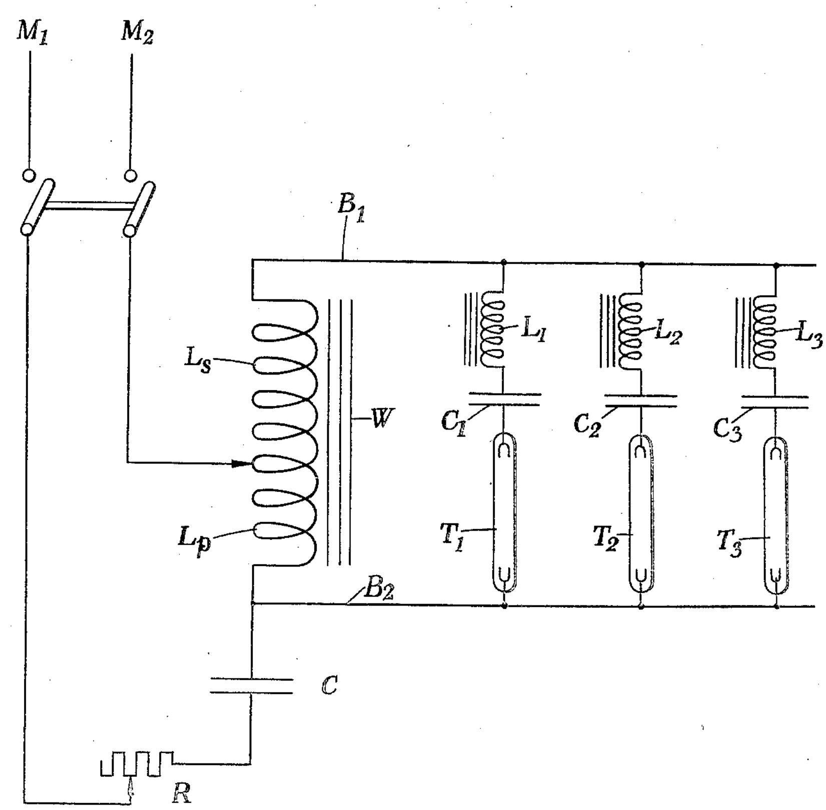

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ELECTRICAL SUPPLY EQUIPMENT FOR DISCHARGE TUBES

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6 Claims. (Cl. 176—124)

This invention relates to illuminated signs in which use is made of luminous discharge tubes, and particularly of tubes having a filling of a vapour or gas such as neon. The object of the present invention is to provide a satisfactory method of energizing such discharge tubes which are to be connected in parallel across a source of supply so that, among other advantages, if one of the tubes becomes disconnected or short-circuited, the remaining tubes are not affected.

The characteristics of discharge tubes of the kind referred to involve certain difficulties because the resistance of a tube when no current is flowing is, for practical purposes, infinite, but falls to a very small value when a current flows. Consequently the application of a voltage which is suitable as a normal running voltage to a tube for starting purposes has no effect and cannot cause the flow of current through the tube. In other words, the starting voltage applied to a tube has to be much larger than the running voltage in order to overcome the initial resistance and to ionize the gas or vapour in the tube, thus rendering it conductive, by a breaking-down process. The use of transformers with open magnetic circuits and consequently large stray fields has been suggested for supplying such tubes because the characteristic of such a transformer ensures that while the open circuit voltage of the secondary winding may be high, as soon as a load current passes to one or more tubes, the available voltage of the secondary winding drops considerably. It has also been sought to increase the effectiveness of the high starting voltage by producing a powerful starting surge, and in particular it has been suggested to employ for this purpose a condenser in the primary circuit or the secondary circuit of such a transformer, the condenser being of a sufficiently large capacity to produce such a starting surge.

The present invention makes use of the phenomenon of electrical resonance which occurs in circuits having inductive and capacitative reactance of suitable magnitudes, and also provides self-regulating circuit arrangements for automatically controlling the voltage availabe from a circuit in which the conditions approach electrical resonance.

Thus, according to the present invention, a coil and condenser are included in a circuit to which a low tension alternating current is supplied, and their inductance and capacity respectively are such in relation to the frequency of the alternating current, or to a harmonic of that frequency, that a potential difference due to electrical resonance effects is available for starting and operating one or more discharge tubes, while in series with that tube or each of the tubes, there is a suitable impedance of such a character that when the tube and the impedance are brought into circuit, the said potential difference remains substantially constant at least or even increases. The voltage attained in this way may be much higher than that of the source of supply as an amplification factor as high as 30 may be easily obtained in the case of a supply having a frequency of 50 cycles per second. The actual inductance in the low tension circuit may consist only of a portion of the winding of a coil with an iron core, and the tube or tubes to be illuminated are then connected across the outer terminals of that coil.

In general the impedance in series with the tube or with each tube, will include both inductance and capacity, and it is believed that the maintenance of the potential difference or the rise in potential difference may be due to the fact that the switching in of a tube and its series impedance causes the conditions in the circuit to approach more nearly to electrical resonance.

In order to deal with the conditions on starting the tubes, the voltage available is much higher than is necessary for normally supplying the tubes, but the inductance and capacity in series with each tube have such magnitudes that after a tube is started, the potential difference across its terminals is only that required for running conditions. In other words, at the moment of switching on or introducing an additional discharge tube, the almost infinite resistance of the tube is the controlling factor in the branch including the tube so that the full voltage produced by the resonant circuit is available for breaking down the resistance of the tube. As soon, however, as the tube strikes and its resistance drops very considerably, the voltage conditions in the branch circuit are controlled by the impedance consisting of the condenser and inductance.

In explanation it may be stated that if the inductance in the circuit connected to the alternating current supply is less in relation to the capacity in that circuit than is required for resonance conditions, it may be demonstrated mathematically that the effect of adding shunt circuits each with a luminous tube in series with an inductance and condenser as described above, is to make the system more nearly approach the conditions of electrical resonance. It may, in fact, be shown that by including a condenser in a branch, an effective increase is caused in the inductance in the circuit connected to the alternating current supply, which increase depends upon the value of the capacity of that condenser and on the resistance of the luminous tube under running conditions, yet, at the same time, as the capacity must be kept below a certain value to prevent over running of the tube, the self-regulating effect is controlled by employing a choke coil of the correct inductance in series with the condenser.

In order that the invention may be clearly understood and readily carried into effect, one form of supply circuit for a set of luminous tubes in parallel will be described more fully, by way of example, with reference to the accompanying drawing, which is a diagram of connections of the novel circuit arrangement.

In this diagram, alternating current mains, which may be considered as 240 volts mains giving a supply at a frequency of 50 cycles per second are shown at M_1 and M_2. The main inductance is an iron-cored choke coil W with a tapping point connected to one of the mains M_2. The portion of this coil L_p which is in the mains circuit in the particular example under consideration, is wound with 1,500 turns of 21 gauge wire, while the portion of this coil L_s on the other side of the tapping point is wound with 3,000 turns of 30 gauge wire, the core having a cross-sectional area of about 1.5 square inches, so that the approximate inductances of the two parts when they are disconnected are 5 henries and 20 henries respectively. The respective resistances of the portions L_p and L_s of the coil are about 16 ohms and 250 ohms. The condenser C in series with the mains and the portion L_p of the coil W has a capacity of 3 mfd.

Bus-bars B_1, B_2 are run from the terminals of the coil W, and the tubes T_1, T_2, T_3 are connected across these bus-bars in parallel branches; three tubes are shown merely as an example, and naturally further tubes can be added as desired. The inductances L_1, L_2, L_3 in series with the several tubes have a value of about 45 henries each with a magnetising current of 18 milliampres, the direct current resistance of each coil being 775 ohms. The condensers C_1, C_2, C_3 in each branch have a capacity each of .01 mfd. In order to afford some adjustment of the voltage available, a variable resistance R of a few ohms is connected in the low tension circuit from the mains. It was found that with no load across the bus-bars, the current flowing in the low tension circuit was 30 milliamperes.

Each element comprising a discharge tube such as T_1 with its series condenser C_1 and choke coil L_1, may be mounted in a single box or casing so that the only connections made to the outside of each casing are those from the insulated bus-bars B_1, B_2 and the continuation of the bus-bars which pass on to the next unit of the system.

Upon switching on the current, the approximate series resonance existing in the low tension supply circuit by reason of the relationship of the capacitative reactance of the condenser C to the inductive reactance of the coil W, causes an amplified potential difference to be established across the portion L_p; and thus an amplified potential difference is available at spaced points of the coil W, e. g. on the bus-bars B_1, B_2. Each tube receives an initial striking voltage at least equal to the potential difference across the choke coil W, but directly a tube becomes illuminated and current commences to flow through it, the current is controlled by the condenser C_1, C_2 or C_3 in its circuit, which becomes the controlling impedance in each branch. The condensers C_1, C_2, or C_3 in the branch circuit, however, also operate, so to speak, by modifying the effective reactance in the low tension supply circuit corresponding to a change in the inductive reactance of the coil, and thus operate to bring the capacitative and inductive reactance of the low tension supply circuit more nearly into series resonance, so that each branch circuit may be considered as having an impedance cooperative with the reactance in the supply circuit for bringing the supply circuit nearer to series resonance when the device is in normal operation, or at least cooperating therewith for preventing departure of this supply circuit away from series resonance.

In order to explain the action of self-regulation of the circuit as additional tubes are added, it may be mentioned that in a particular example, the voltage across the main condenser C was approximately 660 volts and across the inductance L_p in the low tension circuit about 524 volts. The open circuit voltage across the bus-bars B_1 B_2 was 1,340 volts. With a single tube T_1 across the bus-bars in series with its inductances L_1 and capacity C_1 of the magnitudes mentioned above, the voltage across the terminals of the coil W increased to 1,346 volts; when two equal tubes 3 feet long were connected with their branch circuits in parallel, the voltage increased to 1,356 volts. The current through the first tube was 12 milliamperes in both cases, and the current through the second tube was 13.5 milliamperes. When two unequal tubes were connected in parallel branches, one tube being 3 feet long and the other 1 foot six inches long, the voltage across the coil W was 1,360 volts, the current in the first tube 12 milliamperes and in the second tube 13.5 milliamperes. In a further test, tubes T_1, T_2 each 3 feet long were connected in parallel branches and three similar additional tubes connected in three further parallel branches. The current in the tube T_1 was 12.3 milliamperes and in the tube T_2 13.6 milliamperes, while the voltage across the terminals of the coil W now increased to 1,380 volts.

It is clear that with the dimensions set out above, the feed system to the tubes acts as a compounded system with a slightly rising voltage characteristic curve, while the current through any one tube does not decrease when further tubes are added in parallel. The amount of the rise in voltage when the number of tubes is increased is entirely under control as it depends entirely upon the design of the choke coils L_1, L_2, L_3.

The invention is not, of course, limited to the precise system shown in the diagram. For example, the ratio between the parts of the coil W would be modified to suit the voltage of the mains and the voltage required for the tubes, and even the whole of the coil W might be included in the low tension circuit connected to the mains.

I claim:—

1. An electrical supply equipment for luminous tube and like devices which require a high potential for starting, comprising a supply circuit connected to a low tension source and including a coil and a condenser, and circuit connections from spaced points of said coil to a said device and including an impedance, said coil and condenser being near series resonance at a frequency

of the alternating current flowing in said supply circuit whereby an amplified potential difference is set up between said points of said coil for starting said device, and said impedance having a reactance cooperative with the reactance of said supply circuit for preventing departure of said supply circuit away from series resonance when said device is in normal operation.

2. An electrical supply equipment for luminous tube and like devices which require a high potential for starting and a lesser potential for normal operation, comprising a supply circuit connected to a low tension source of potential insufficient for starting a device and including a coil and a condenser, and circuit connections from spaced points of said coil to a said device and including means providing an impedance, said coil and condenser being near series resonance at a frequency of the alternating current flowing in said supply circuit so that an amplified potential difference is set up between said points of said coil for starting said device, and said impedance having a reactance cooperative with the reactance of said supply circuit for bringing said supply circuit near to series resonance when said device is in normal operation, said impedance functioning during such normal operation to prevent overrunning of the device.

3. An electrical supply equipment for luminous tube and like devices which require a high potential for starting and a lesser potential for normal operation, comprising a supply circuit connected to a low tension source and including a coil and a condenser, and circuit connections from spaced points of said coil to a plurality of said devices, each connected in an independent parallel branch circuit, said coil and condenser being near series resonance at a frequency of the alternating current flowing in said supply circuit whereby an amplified potential difference is set up between said points of said coil for starting any of said devices, each said branch circuit having a reactance cooperative with the reactance of said supply circuit for preventing departure of said supply circuit away from series resonance when said corresponding device is in normal operation.

4. An electrical supply equipment for luminous tube and like devices which require a high potenial for starting and a lesser potential for normal operation, comprising a supply circuit connected to a low tension source and including a coil and a condenser, and circuit connections from spaced points of said coil to a said device and including a second condenser, said coil and condenser being near series resonance at a frequency of the alternating current flowing in said supply circuit, the inductance of said coil in the supply circuit being less in relation to the capacity in said supply circuit when said connections are open-circuited than is required for resonance, said second condenser having a reactance cooperative with the reactance of said supply circuit for preventing departure of said supply circuit away from series resonance when said device is in normal operation.

5. A supply equipment as in claim 4, in which said second condenser and a choke coil are connected in series circuit with said device by said circuit connections, said choke coil operating to prevent overrunning of said device under the amplified potential difference.

6. An electrical supply equipment for luminous tube and like devices which present a high resistance at starting and a lesser resistance during normal operation, comprising a supply circuit connected to a low tension source of potential insufficient for starting a device and including means for providing capacitative and inductive reactances which are near series resonance at a frequency of the alternating current flowing in said supply circuit, and circuit connections from said coil to a plurality of said devices and including individual branch circuits for said devices, each said branch circuit including means for providing an impedance cooperating with the reactance of said supply circuit for bringing the supply circuit near to series resonance as each said device comes into normal operation and for limiting the potential difference across the terminals of the associated device during normal operation.

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