Oct. 30, 1962 M. SPECTOR 3,061,759

CIRCUIT FOR STARTING AND OPERATING DISCHARGE TUBES

Original Filed June 27, 1951

FIG. 1

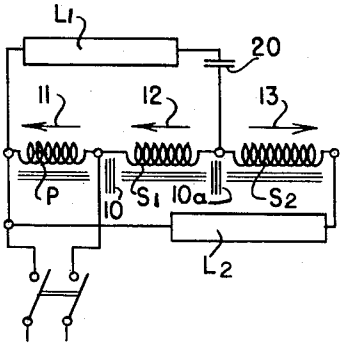


FIG. 2

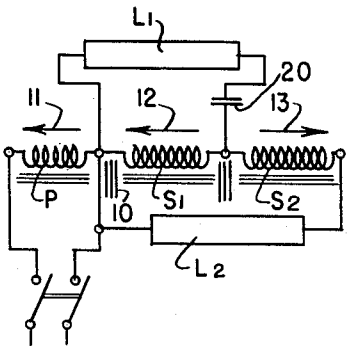


FIG. 3

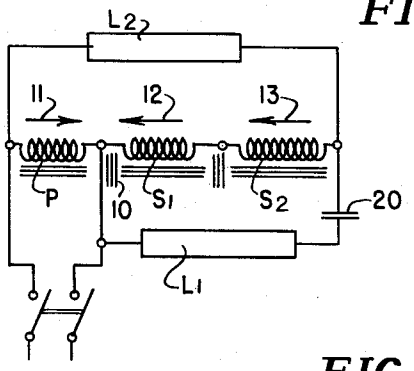


FIG. 4

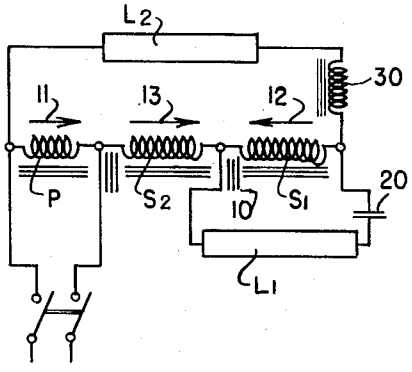
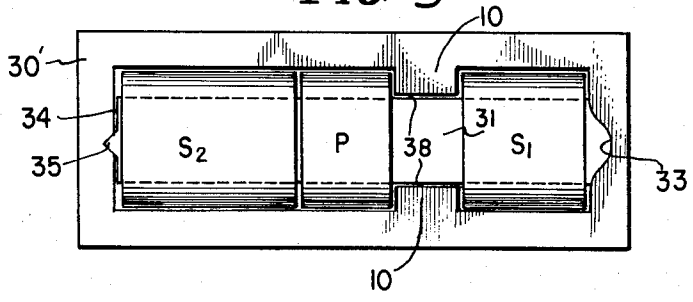


FIG. 5



INVENTOR.
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CIRCUIT FOR STARTING AND OPERATING DISCHARGE TUBES

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Original application June 27, 1951, Ser. No. 233,850. Divided and this application Aug. 20, 1957, Ser. No. 679,304

6 Claims. (Cl. 315—257)

This application is a division of my pending application, Serial No. 233,850 filed June 27, 1951, and issued as Patent No. 2,848,652 on August 19, 1958.

This invention relates to circuits for starting and operating one or more discharge tubes of the hot cathode or cold cathode type.

There has recently been developed a ballast for starting two discharge tubes in sequence and thereafter operating them in series. Because the tubes are started in sequence the ballast need supply the starting voltage for only one of the tubes at a time, whereas in a two tube series circuit if the tubes were to start at the same instant the ballast would have to supply double the open circuit starting voltage required for a single lamp. Because of the sequential starting the high starting voltage is applied first to one end and then to the other glow discharge lamp. The time lapse in the sequential starting is so slight that it is not noticeable and the lamps appear to start simultaneously. It is one of the objects of the present invention to provide a new and desirable circuit for a ballast of the above type which will start two lamps in sequence and then operate them in series.

It is a further object of the present invention to provide a new and useful circuit for starting and operating even one lamp and wherein the portion of the ballast circuit that is used to provide the high starting voltage is to all intents and purposes out of the circuit during the operating time. Since it is in circuit for only a negligibly small proportion of the total operating time the output efficiency of that portion of the ballast is not important and therefore that portion of the coil may be made of very fine wire, thereby reducing the amount of copper used and, in many instances, also reducing the amount of iron used in the ballast.

The attainment of the above and further objects of the present invention will be apparent from the following specification taken in conjunction with the accompanying drawing forming a part thereof.

In the drawing:

FIGURES 1 through 4 are circuit diagrams illustrating different modifications of the present invention; and

FIGURE 5 is a plan view of one form of ballast suitable for use with the circuits of the present invention.

In FIGURE 1 there is shown a circuit for starting and operating two glow discharge devices, which in this instance are fluorescent type instant start cold cathode lamps L_1 and L_2, by means of a ballast that includes a primary P, a secondary S_1 and another secondary S_2. The ballast may be of a physical construction such as shown in FIGURE 2 or 3 of the application of Albert E. Feinberg, Serial No. 135,669, that issued as Patent No. 2,558,293 the 26th day of June, 1951, to which reference may be had for a more complete description of the physical structure of the ballast. It is sufficient here to state that the ballast is a shell type iron core on which the three coils P, S_1 and S_2 are mounted, the secondaries being physically at opposite ends of the core with the primary between them. A magnetic shunt 10 is provided between the primary and the secondary S_1 and a similar magnetic shunt may be provided between the primary and the secondary S_2, the magnetic shunts including

air gap. The windings S_1 and S_2 have a high leakage reactance and both are loosely coupled with the primary, but the secondary S_1 is more loosely coupled to the primary than is the secondary S_2. The primary and the secondaries are so electrically connected that when alternating current voltage is supplied to the primary the relative directions of the induced open circuit voltages in the primary and secondaries S_1 and S_2 are as shown by the arrows 11, 12, and 13, respectively, namely, the direction of the secondary voltage S_1 is the same as that of the primary, whereas the direction of the induced voltage of the secondary S_2 is opposite that of the primary.

The lamp L_1 is connected in series with a condenser 20 across the primary and the secondary S_1, the secondary S_1 being, during the open circuit condition, in step-up autotransformer relationship with the primary.

The instant that voltage is applied to the primary the combined voltages of the primary and the secondary are available to start the lamp L_1. On the other hand, at that instant the total voltage applied to the lamp L_2 is the voltage of the primary plus the voltage of S_1, minus the voltage of S_2. This is insufficient to start the lamp L_2. The lamp L_1 starts. The condenser is of smaller capacity reactance than the inductive reactance of the circuit including the primary, the secondary S_1 and the lamp L_1, so that current flowing in this lamp circuit is lagging. As soon as this lamp starts and current commences to flow through the secondary S_1 the high leakage reactance of the lagging current secondary S_1 induces therein a voltage having a component in a direction substantially opposite the direction indicated by the arrow 12. At this instant the voltage now applied to the lamp L_2 is the sum of the voltage of S_2 plus that reverse component of S_1 minus the voltage of P. This is sufficient to start the lamp L_2. Once the lamp L_2 starts, the lamp L_1 having already started, the two lamps L_1 and L_2 operate in series with the condenser 20 and are supplied with operating current by the secondary S_2.

FIGURE 2 shows an alternate circuit wherein the lamp L_1 in series with the condenser is connected directly across the secondary winding S_1, whereas the lamp L_2 is connected across the secondaries S_1 and S_2 in series. During starting the lamp L_1 has an initial voltage applied thereto equal to that of S_1. This is sufficient to start the lamp. The lamp L_2 has a voltage thereacross which is the difference between the voltage S_1 and the voltage of S_2. That is insufficient to start the lamp. Immediately upon starting of the lamp L_1 current commences to flow through the coil S_1. This current is a lagging current because the reactance of the condenser 20 is chosen of such a value as to be less than the inductive reactance of the secondary S_1. The lagging current flowing through S_1 induces therein a voltage having a component substantially opposite to that indicated by the arrow 12. The voltage across the lamp L_2 is now the sum of the voltages of S_1 and S_2 and that is sufficient to start the lamp L_2. Once the lamp L_2 starts current then flows through both lamps in series, the series circuit including the lamp L_1, condenser 20, secondary coil S_2 and the lamp L_2. The secondary S_1 is at this time shunting the lamp L_1 and the condenser 20. Due to the high leakage reactance of the secondary S_1 negligible current flows through the secondary S_1.

In the circuit of FIGURE 3 the primary P is connected across a source of 120 volt 60 cycle alternating current as before, the lamp L_1 in series with the condenser 20 is connected across the secondaries S_1 and S_2, and the lamp L_2 is connected across all three of the windings. The connections are such that when alternating voltage is applied to the primary P and when the lamps L_1 and L_2 are out of the circuit the voltages induced in the

secondaries S_1 and S_2 are always in the same direction, which is a direction opposite that of the direction of the voltage of the primary P, as indicated by the arrows 11, 12 and 13, which indicate the relative directions of the voltages when the lamps L_1 and L_2 are open circuited. This means that the voltage across the ballast is the difference between the line voltage and the sum of the voltages across S_1 and S_2. This voltage is insufficient to start the lamp L_2. The sum of the voltages across the secondaries S_1 and S_2 is sufficient to start the lamp L_1. The condenser 20 is of a capacity less than the inductive reactance of the secondaries S_1 and S_2 so that the current flowing is lagging. This induces in the secondaries S_1 and S_2 a component voltage opposite to that indicated by the arrows 12 and 13 or in the same direction as that indicated by the arrow 11. This is sufficient to start the lamp L_2. Once this lamp starts current thereafter flows through the lamp L_2, condenser 20 and lamp L_1 in series, this series circuit being connected across the primary P, which has the line voltage applied thereto. This voltage is sufficient to maintain both lamps operating. At this time the windings S_1 and S_2 shunt the lamp L_1 in series with the condenser 20. Due to the high leakage reactance of the secondary S_1 negligible current flows through the shunting circuit.

In the description of FIGURE 3 it is noted that S_1 and S_2 are connected in series. It is thus possible to combine the coils S_1 and S_2 to constitute a single high leakage reactance coil. It is also possible to maintain the two coils S_1 and S_2 physically separate, as shown in the above referred to Feinberg patent, and as illustrated in FIGURE 3, and making the leakage reactance of the two coils such that when current commences to flow through the lamp L_1 there will be a reversal of voltage in only one of the two coils S_1—S_2. As a result, after the lamp L_1 starts, the resulting voltage that is applied to the lamp L_2 is the primary voltage plus the difference between the voltages of the secondary S_1—S_2. For instance, if the coil S_1 is the one which due to its leakage reactance produces upon the commencement of flow of lagging current therethrough a voltage component opposite to the component indicated by the arrow 12, then the coil S_1 is made of many more turns than the coil S_2 so that its voltage is of the order of twice that of the coil S_2. The arithmetic sum of these voltages as applied during the instant of starting of the lamp L_1 is sufficient to start that lamp. The difference of these voltages, after starting of the lamp L_1, added to the voltage of the primary P is sufficient to start the lamp L_2. After starting of the lamp L_2 both lamps L_1 and L_2 and the condenser 20 operate in series from the voltage of the primary P. The shunting circuit across the lamp L_1 and the condenser 20 not only has a high leakage reactance to limit the current flow therethrough but the voltages of the two coils S_1 and S_2 are bucking, thereby further limiting the flow of current therethrough.

FIGURE 4 shows another modification of the present invention. In this instance the lamp L_1 and the condenser 20 are connected across the secondary S_1 which is of sufficient number of turns to provide a sufficient voltage for starting the lamp L_1. The condenser 20 is of a capacity reactance less than the inductive reactance of the winding S_1 plus the lamp L_1, so that the starting current flowing through the coil S_1 is lagging. The voltage across the transformer when the lamps L_1 and L_2 are open circuited is the sum of the voltages of the primary or line voltage plus the voltage of the secondary S_2, minus the voltage of the secondary S_1. This is insufficient to start the lamp L_2 which is connected in series with a choke 30. After starting of the lamp L_1 the lagging current flowing through the winding S_1 produces a reverse component of voltage therein which is now additive to the voltages of the primary P and secondary S_2 and is sufficient to start the lamp L_2. The lamp L_2, in series with the choke 30, lights. Once this happens a circuit is formed including the lamp L_2, choke 30, condenser 20 and lamp L_1 in series, connected across the primary P and secondary S_2 in series. The primary P and secondary S_2 are in step-up auto-transformer relationship. The secondary S_1 at this time shunts the lamp L_1 and condenser 20. Due to the high leakage reactance of the secondary S_1 this shunt circuit takes a negligible current. The choke 30 is a conventional iron core choke such as is commonly used in fluorescent lamp circuits. It may comprise, for instance, an E-shaped magnetic core having a winding 30 on the center leg and a bridging bar or iron extending across the three legs of the E to complete the magnetic circuit.

In each of the circuits above described there is shown an arrangement for starting two glow discharge lamps in sequence and operating them in series. Each of the circuits is operative for controlling a single lamp if desired. In such case the respective circuits are used for operating the lamp L_2, the lamp L_1 being omitted and, when omitted, being replaced by the equivalent of a short circuit across the terminals of the lamp L_1. Thus, in FIGURE 1 the condenser 20 would be connected directly across the primary P and secondary S_1. In FIGURES 2 and 4 the condenser 20 would be connected directly across the secondary S_1 whereas in FIGURE 3 the condenser 20 would be connected directly across the secondaries S_1—S_2 in series with one another. In each such circuit the operation would be as previously explained, that is, when line voltage is applied it first induces a current flow through the condenser 20 in series with its associated coil S_1. The current is a lagging current because the capacity reactance of the condenser 20 chosen is less than the inductive reactance of the circuit which includes the condenser, and the lagging current results in a reverse component of voltage in the secondary S_1. This then provides a sufficient voltage for starting of the one lamp L_2. Upon starting of the lamp L_2 the condenser 20 operates in series, with the lamp L_2 being shunted by the winding S_1 in FIGURES 2 and 4, by the winding S_1 and P in FIGURE 1, and by the windings S_1 and S_2 in FIGURE 3.

While I have herein shown the present invention as applied to instant start for cold cathode tubes, it is within the purview of the present invention to apply the principles thereof to hot cathode tubes by providing a conventional heating circuit for the filaments of the tubes.

In FIGURE 5 I have shown one form of ballast that may be used in connection with the present invention, this being one of the two ballasts shown in the Feinberg patent above referred to. In this construction the ballast comprises a rectangular core 30′ formed by a stack of iron transformer laminations, and a similarly formed central core leg 31 on which the windings S_1, P and S_2 are located. The central core leg makes a snug fit with one end of the shell, as indicated at 33, and provides at the opposite end 34 a gap in the magnetic circuit, which gap is bridged at 35, for reasons well known in the art. The core 30′ has magnetic shunts 10—10 which approach the central core member 31 and are spaced therefrom by air gaps 38—38. If desired shunts 10*a*—10*a* (FIG. 1) similar to the shunts 10—10 may be provided between the primary P and the secondary S_2. The secondary S_1 is of finer wire than is the secondary S_2. The secondary S_1 may have of the order of four times as many turns as the primary, whereas the secondary S_2 may have a number of turns two and one-half times that of the primary. This is merely by way of example, as other relative ratios may be chosen depending upon which of the circuits are used, and depending upon the constants of the circuits in accordance with known engineering principles.

In compliance with the requirements of the patent statutes I have here shown and described a few preferred embodiments of my invention. It is, however, to be understood that the invention is not limited to the precise constructions here shown, the same being merely

illustrative of the principles of the invention. What I consider new and desire to secure by Letters Patent is:

1. In combination, a pair of gaseous discharge devices, an alternating current supply for the devices comprising a three-winding auto-transformer having a primary, a loosely coupled first secondary having one end connected with the said primary, a loosely coupled second secondary, the said first secondary having its second end connected with the second secondary and in bucking voltage relationship to the second secondary, means including a capacitive reactor connecting one of said devices across the primary and the first secondary, means connecting the second of said devices across the primary and the first and second secondaries, and means for connecting the primary across a source of alternating current, the secondaries having a turn relationship to the primary to cause seriatim ignition of said first and second devices, and the reactance of the first secondary being very high relative to the second secondary whereby after the said devices are both operating the apparatus will form in effect a series circuit including the devices, the capacitive reactor, and the second secondary.

2. In combination with two gaseous discharge devices, an auto-transformer having a primary, a loosely coupled high leakage reactance first secondary of more turns than the primary and connected in step-up auto-transformer relationship with the primary, and a second loosely coupled high leakage reactance secondary of more turns than the primary but arranged in bucking relation thereto, said primary and said first secondary and said second secondary being connected one after the other, means including a capacity reactor connecting one of said devices across the primary and only the first of the two secondaries, and means connecting the second of said devices across the primary and the two secondaries.

3. In combination with two gaseous discharge devices, means for operating the devices from a source of alternating current whose voltage is substantially less than the starting voltage of either of the devices, said means including reactive means having a primary winding and first and second secondary windings loosely coupled to the primary and to one another, the coupling of the first secondary winding being substantially looser relative to the other two windings whereby to constitute same a high leakage reactance winding, the windings being connected one after the other with the first secondary winding connected between the other two windings, and the second secondary winding being connected in bucking voltage relationship to the first secondary winding, a capacitive reactor having one side thereof connected to the common juncture of the secondaries, means connecting the first of said discharge devices between the second side of the capacitive reactor and that end of the primary winding which is remote from the first secondary and means connecting the second of said discharge devices across the primary and both secondaries.

4. In combination, two instant start gaseous discharge devices, means for operating the same from an A.C. source of voltage insufficient to ignite either device comprising an auto-transformer having a primary, a first inductively reactive portion of said transformer of high leakage and of relationship relative to the primary for having a voltage induced therein greater than that of the primary voltage, a second inductively reactive portion of said transformer of high leakage and of relationship relative to the primary for having a voltage induced therein, means for impressing the combined voltages of the primary and the said first reactive portion across one of said devices for igniting same, means connecting the second discharge device across the primary and the two reactive portions with the voltages of the two reactive portions in opposition to one another, said first portion producing after ignition of the first device a voltage having a component in reverse relation to the voltage across the first reactive portion prior to such ignition whereby it is additive relative to the voltage of the second reactive portions, the sum of the primary voltage plus said component voltage and the voltage of the second reactive portion being sufficient to ignite the second device.

5. A system comprising two instant start gaseous discharge devices, an auto-transformer supplying alternating current thereto said transformer having a primary, a loosely coupled first secondary having one side connected to one side of said primary and in additive voltage relationship thereto, and a loosely coupled second secondary having one side connected to the second side of said first secondary and in voltage bucking relationship to said primary, a capacitive reactor, one of said devices being connected across the primary and the first secondary and in series with the capacitive reactor and excluding the second secondary, the second of said devices being connected across the primary and the two secondaries.

6. A system of the character described comprising an auto-transformer having a primary and two secondaries, the two secondaries being arranged in voltage bucking relationship one to the other in a circuit containing both secondaries, a capacitive reactor, a gaseous discharge device in series with the reactor and connected across a part of the said auto-transformer including at least a part of the primary and the first secondary and excluding the second secondary, a second gas discharge device connected across windings of said transformer including at least both of said secondaries and including at least a part of the primary, said windings and primary having a turn relationship to produce upon energization of said primary a voltage across the first device sufficient to ignite the same, but across the second device insufficient to ignite the same, said first secondary having a high leakage reactance and taking a lagging current upon initiation of the flow of current through the first device whereby after ignition of said first device there will be a phase shift in the voltage thereof providing a component additive to the second secondary to increase the voltage across said second device to a value sufficient to ignite the same.

No references cited.