April 22, 1958 A. E. FEINBERG 2,832,008

CIRCUIT FOR STARTING AND OPERATING GASEOUS DISCHARGE DEVICES

Original Filed May 17, 1951

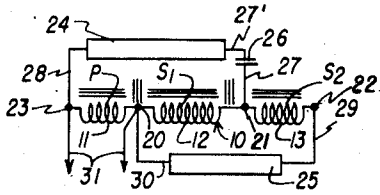


FIG. 1

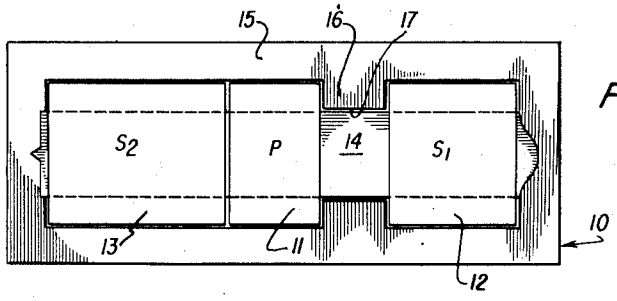


FIG. 2

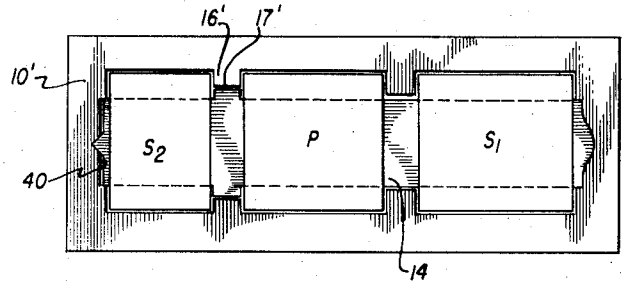


FIG. 3

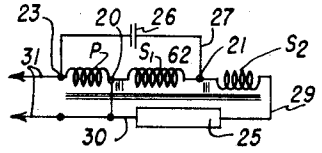


FIG. 4

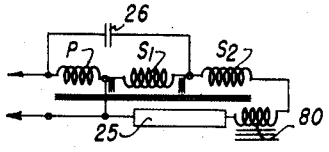


FIG. 5

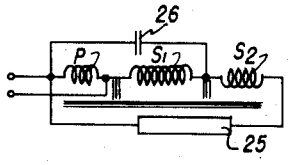


FIG. 6

INVENTOR.
Albert E. Feinberg
BY Morris Spector
Atty.

United States Patent Office 2,832,008 Patented Apr. 22, 1958

2,832,008

CIRCUIT FOR STARTING AND OPERATING GASEOUS DISCHARGE DEVICES

Albert E. Feinberg, Chicago, Ill., assignor to Advance Transformer Co., Chicago, Ill., a corporation of Illinois

Original application May 17, 1951, Serial No. 226,820. Divided and this application April 16, 1952, Serial No. 282,575

9 Claims. (Cl. 315—138)

This application is a division of my application Serial No. 226,820, filed May 17, 1951, now Patent 2,813,228, which was co-pending with and is a continuation in part of application Serial No. 135,669, filed December 29, 1949, and issued June 26, 1951, as Patent No. 2,558,293, and relates to circuits for gaseous discharge lamps.

It is one of the objects of the present invention to provide a highly efficient circuit for initiating the discharge of a plurality of gaseous discharge devices, which circuit and the apparatus required therefor will be extremely simple and economical of contruction and operation.

In connection with the above object it is pointed out that my new invention utilizes a simple three winding transformer, the general construction of which is similar to that type of transformer used in circuits for starting preheated filament fluorescent lamps. Specifically, no special cores are required, no chokes or inductances need be used in the circuit, and one relatively cheap condenser may be used. The invention lies in the connections of the circuit, the manner of forming and the proportions of the windings, as well as other factors to be pointed out which give rise to the advantages of my invention.

It is a further object of the present invention to provide a circuit for initiating the discharge of a pair of instant start gaseous discharge devices seriatim and thereafter providing good regulation for the flow of current therethrough. It is a still further object of the present invention to provide a circuit for initiating the discharge of a pair of gaseous discharge devices in which following the initiation of the discharge and during operation of the devices the devices are in effect connected in substantially a series circuit. It is a further object of the present invention to provide a circuit of the above mentioned character which may be used for initiating the discharge of a single instant start gaseous discharge device.

It is a still further object of the present invention to provide a circuit for one or more gaseous discharge devices which will utilize a simple transformer for the purpose of providing the necessary starting voltage and regulating inductance. It is a still further object of the present invention to provide a circuit for one or more gaseous discharge devices that utilize a high leakage reactance winding that facilitates the building up of the necessary ignition voltage but which after ignition is so arranged in the circuit that very little current passes therethrough, whereby the remainder of the circuit including the gaseous discharge device or devices constitutes in effect a series circuit substantially by-passing the high leakage reactance winding. It is a still further object of the present invention to provide a circuit for one or more gaseous discharge devices wherein a capacity reactance is associated with a high leakage reactance winding in such a manner as to build up a voltage across the reactor during starting, which will be of reverse relationship to the normal direction of voltage in said high leakage reactance winding, whereby the voltage will be added to other voltages of the apparatus to ignite one or more of the gaseous discharge devices.

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 drawings forming a part thereof.

In the drawings:

Figure 1 is a schematic electrical diagram showing one circuit embodying the present invention;

Figure 2 is a side elevational view of a transformer of the circuit of Figure 1;

Figure 3 is a view similar to that of Figure 2 but showing a modified form of transformer; and

Figures 4, 5 and 6 are schematic electrical diagrams showing modified forms of circuits embodying the present invention.

Reference may now be had more particularly to the drawings wherein like reference numerals designate like parts throughout.

In the drawings, **10** designates generally a transformer which forms an important part of my apparatus. The same is formed of three independently formed windings **11**, **12**, and **13** comprising a primary (P), first secondary (S_1) and second secondary (S_2) respectively. All of the windings are mounted upon a central winding leg **14** which is pressed into an elongate shell **15**, there being a magnetic shunt **16** and an air gap **17** between the windings **11** and **12**. The shell **15** and the winding leg **14** are formed of electrical steel laminations in the usual manner, thereby providing an iron core for the transformer **10**.

The windings are mounted upon the shell **15** in a manner such that the primary **11** is in the center of the shell **15**, the second secondary **13** is on the left end of the shell **15** although mounted on the central winding leg **14**, and the first secondary **12** is on the right end of the shell **15**, separated from the winding **11** by the magnetic shunt **16**, and thereby constituting the winding **12** a high leakage reactance. It is obvious that the windings **12** and **13** are both loosely coupled with the primary **11**, but that the first secondary **12** is what may be termed "very loosely" coupled to the primary, when comparing it with the second secondary coupling.

Although both coils **12** and **13** have high leakage reactance, it may be advisable under certain operating conditions to place a small magnetic shunt **16'** and a gap **17'** between coils **11** and **13** to provide additional leakage reactance as shown in transformer **10'** (Fig. 3).

The windings **11** and **12**, namely the primary P and the first secondary S_1 are wound in the same direction to provide additive voltage, while the winding **13** comprising the second secondary S_2 is wound in an opposite direction to provide bucking voltage.

Referring to Fig. 1, note that the windings **11**, **12**, and **13** are connected in series providing junctures **20** and **21** therebetween, the right hand end of the transformer **10** being designated **22** and comprising the free end of the winding **13** while the left hand end of the transformer being designated **23** and comprising the free end of the winding **11**. Note that the windings are not mounted in the order in which they are connected.

There are shown two gaseous discharge devices, comprising a first fluorescent lamp **24** and a second fluorescent lamp **25**. My apparatus includes a condenser **26** in a load connecting lead **27** which is connected to the juncture **21**. The lamp **24** is arranged in series with the condenser **26**, having a load connecting lead **27'** from the condenser **26** connected to its right hand side, while the left hand side of the lamp **24** is connected via a load connecting lead **28** to juncture **23**. Thus, it will appear that the first lamp **24** is connected across the pri-

mary and first secondary of the transformer **10**, and in series with the condenser **26**. The second fluorescent lamp **25** has its right hand end connected by the lead **29** to the terminal **22**, and its left hand end by lead **30** to the juncture **20**. Thus it will be obvious that the second lamp is connected across the first and second secondaries. The very loosely coupled secondary **12** is common to the circuits of both lamps **24** and **25**. The usual A. C. line **31** is connected across the primary **11** to provide the necessary power.

The first secondary winding **12** has sufficient turns so that it steps up the line voltage of the primary **11** considerably, in some instances almost four times. This voltage E_{s_1} is additive to the line voltage or primary voltage E_p, and since windings **11** and **12** are in series and across lamp **24**, they add to provide igniting voltage for the lamp **24**. Although the winding **13** is so constituted that it provides an induced voltage E_{s_2} of more than twice E_p, since its voltage is in opposed relationship to voltage of S_1, the voltage across lamp **25**, which is the vector sum of E_{s_1} and E_{s_2} will be very little prior to any current flow, and certainly less than required to ignite the lamp **25**.

The voltage across condenser **26** is negligible prior to ignition of lamp **24**, and hence the voltage E_p combined with E_{s_1} appears across lamp **24**, lights the lamp, and causes current to commence flowing.

Current now flows in the circuit of lamp **24**, and since the inductive ractance of the very loosely coupled secondary S_1 is so great compared to the capacitive reactance of the condenser **26**, the current of such circuit is lagging. The condenser **26** assists in shifting the phase of the voltage in the first secondary **12** by lowering the total reactance of the circuit of lamp **24**. Such effect causes a higher flow of current and a consequently greater induced voltage across S_1 which, of course, aids in causing lamp **25** to ignite.

I have found that the current flow caused by the ignition of the first lamp **24** gives rise to voltage in the winding **12** whose phase is in effect reversed relative to the phase of voltage E_p and hence is additive relative to voltage E_{s_2} of windings **13**, which is the secondary S_2. This voltage is of such magnitude that the combined voltage appearing across lamp **25** is sufficient to ignite the lamp and cause flow of current therethrough.

With current flowing through both lamps **24** and **25**, the high inductive reactance of winding **12** serves to resist flow of current therethrough and thus the effective circuit is a series circuit with both lamps **24** and **25** which may be traced as follows: Juncture **23**, lead **28**, lamp **24**, lead **27** and condenser **26**, juncture **21**, winding **13**, terminal **22**, lead **29**, lamp **35**, lead **30**, juncture **20**. The winding **12** is thus not an effective part of the operating circuit. The leading current of the secondary S, caused by condenser **26**, and the lagging magnetizing current of the primary may so neutralize their respective effects that the power factor of current drawn from the line leads **31** is almost unity. It is obvious that the lead **28** and the left hand one of the line leads **31** may constitute a single lead and that the lead **30** and the right hand one of the line leads **31** may also constitute a single lead.

In the event the current drawn from the line is leading, an additional gap **40** may be formed at the end of the winding leg **14** thereby increasing the leakage reactance of the apparatus while incidentally preventing saturation of the core from too greatly distorting the wave shape.

An example of apparatus embodying my invention readily could be constructed for initiating the discharge and providing regulation from a pair of fluorescent lamps known commercially as T–12 lamps having an effective length of 48 inches and being rated at forty watts each. Such apparatus has been successfully produced and operated. The laminations of the shell **15** of the transformer had the dimensions of approximately two and one-eighth by five and one-quarter inches, and the stack thickness was approximately one inch. The magnetic shunt may be approximately one-half inch wide, and the gap **17** approximately .010 inch. The windows for the windings **11**, **12**, and **13** may be adjusted in size in accordance with the physical volume of the windings.

The primary winding **11** was formed of 540 turns of number 25 wire; the first secondary winding **12** was formed of 2360 turns of number 35 wire; and the second secondary winding **13** was formed of 1270 turns of number 27 wire. The condenser **26** had a capacity of 2.6 microfarads and a rating of 440 volts maximum voltage. This apparatus operated in a highly satisfactory manner and the lamps **24** and **25** were ignited with such speed that it almost appeared that they ignited simultaneously when the power was turned on.

With a 118 volt 60 cycle A. C. line connected across the primary **11**, the voltage E_{s_1} was 405 volts, and the voltage E_{s_2} was 270 volts. E_{s_1} and E_p (the line or primary voltage) are additive because the windings **11** and **12** are formed in the same wound direction. E_{s_2} on the other hand is a bucking voltage because the winding **13** is formed in the reverse manner. These voltages exist before the lamps **24** and **25** are ignited. Measurements taken across the various windings bear this out in the following manner: The voltage measured from juncture **23** to juncture **21** was found to be 520 volts; the voltage measured from juncture **20** to terminal **22** (across both secondaries **12** and **13**) was found to be 150 volts; and the total sum of voltages across the entire transformer **10** taken from juncture **23** to **22** was found to be 270 volts. Since the type of lamp in the circuit requires approximately 450 volts to ignite, obviously the first lamp **24** will ignite since it has almost 520 volts appearing across its terminals, while the second lamp **25** will not ignite because the total voltage across it is only approximately 150 volts. These measurements may be taken by removing the lamps **24** and **25** from the circuit.

Once the lamp **24** has ignited and the gas therein has broken down, current flows through that lamp, said current being limited by the reactance of the circuit including the high leakage reactance of the secondary **12**.

With the lamp **24** operating, measurements can be taken of the voltages and currents in the apparatus while the lamp **25** is omitted, and such measurements are as follows: E_{s_1} is now only 210 volts and E_{s_2} appears to be 258 volts, while E_p remains at 118 volts; the voltage measured from juncture **23** to juncture **21** is now 162 volts indicating a radical change which I believe is caused by a phase shift having the effect of providing a voltage vector component additive to the voltage across S_2 the secondary winding **13**, and bucking the voltage E_p across the primary P; the voltage across the lamp **25** measured from juncture point **20** to **22** is now 440 volts, or sufficient to ignite the lamp **25**; the voltage across the entire transformer **10** from juncture **23** to **22** is 315 volts; the voltage at the terminals of the lamp **24** is 140 volts and that across the condenser **26** is 105 volts; the current in the primary **11** is found to be .8 ampere and the current in the lamp **24** is found to be .120 ampere.

The above measurements are static, that is, made with only the lamp **24** operating and the lamp **25** not in the circuit. This situation will arise if the lamp **25** burns out, and it will be obvious from the values given that the apparatus is operating satisfactorily and may continue to do so, providing an important emergency feature for my apparatus.

It is probable that the initial surge of current occurring with ignition of lamp **24** will produce voltages in the first secondary **12** and the second secondary **13** whose sum will be considerably greater than 440 volts, but in any event, even this sum static voltage is sufficient to ignite lamp **25** when in place.

After lamp **25** has also become ignited, current flows in its circuit, and the condition of voltages and currents

in the apparatus as determined by measurements is as follows: The primary voltage E_p is still 118 volts; the voltage across S_1 the first secondary winding **12** is 310 volts; across the second secondary S_2 the voltage is 308 volts; the voltage measured from juncture **23** to juncture **21** is 415 volts; the voltage across the second lamp **25** from juncture **20** to **22** is 107 volts; the voltage measured across the entire transformer **10** from juncture **23** to **22** is 130 volts; the voltage across the lamp **24** at its terminals is 107 volts; the condenser voltage is 418 volts; the current flowing in each lamp is approximately .435 ampere; and the current in the primary **11** is found to be .580 ampere. With both lamps **24** and **25** operating the current measured in secondary S_1 is only .030 ampere, which demonstrates that the high reactance of the winding **12** has the effect of forcing the entire circuit to act as a series arrangement so that the major flow of current is through the lamps **24** and **25**, the winding **13**, and the condenser **26**. With such a circuit, the reactance occasioned by the presence of the condenser **26** is effective to counterbalance the inductive reactance of the transformer primary, so that there is very good power factor correction and the current drawn from the line **31** can be adjusted practically to be almost in phase with the line voltage.

It should be obvious that for different types of lamps the circuit constants of my apparatus can be adjusted.

The circuit of Fig. 4 is essentially the circuit of Fig. 1 except that the lamp **24** of Fig. 1 has been omitted and the condenser **26** is connected directly across the terminals **21**—**23**. It is believed that the operation of this circuit will be apparent from the description above given of the operation of the circuit of Fig. 1.

In Fig. 5 there is shown a circuit substantially that of Fig. 4 except that there has been added an iron core choke **80** to improve the wave shape of the currents supplied to the lamp **25**. The power factor of the apparatus as described will be capacitive, the lamp **25** drawing a leading current, since the impedance of the condenser **26** is greater than the impedance of the secondary S_2. This leading power factor could be corrected by increasing the magnetizing current in the primary (P). In certain cases this can be done by varying the number of turns and the physical constants of the apparatus. An increase of the magnetizing current in the primary can be obtained by decreasing the number of primary turns or increasing the width of the end air gap **40** in the case of the core of Fig. 3. While the core structure of Fig. 2 does not have an end air gap such as the gap **40**, this may be provided if desired. Two difficulties arise if an attempt is made to increase the primary magnetizing current by decreasing the number of primary turns or increasing the width of the air gap **40**. In the case of increasing the width of the end air gap, less flux will link with the secondary S_2 since such flux is being forced through other leakage and shunt paths, as is illustrated with reference to the core shown in Fig. 3. Increasing the width of the gap **40** increases its magnetic reluctance and thereby forces more flux to go through the shunt **16'**.

The addition of the choke **80** operating below saturation introduces sufficient inductance reactance without upsetting the characteristics of the apparatus, so that the wave shape is improved and greater lighting efficiency is achieved. It permits reduction in the size of the wire in the secondary S_2 since the current therein is reduced. The saving in copper in the winding S_2 partially offsets the cost of the additional choke **80**. In the circuit of Fig. 4 the choke may be separate from the transformer or it may be embodied in a combined structure therewith, as shown in my application Serial No. 182,212 filed August 30, 1950, entitled, "Magnetic Apparatus for Gaseous Discharge Circuits."

Still another embodiment of the present invention is illustrated in the circuit of Fig. 6. Here the condenser **26** is connected across the primary and the secondary S_1, as in the circuits of Figs. 4 and 5. The lamp **25** is connected across all three of the transformer windings. The secondary windings S_1 and S_2 are in opposition.

In the circuit of Fig. 6, current is first developed in the circuit including the condenser **26** connected across the primary and the secondary S_1. The voltage across the secondary S_2 under open circuit conditions, that is, with the lamp **25** omitted and the condenser **26** open circuited, is greater than the line voltage. Before current commences to flow in the secondary S_1 the voltage across all three coils is insufficient to ignite the lamp **25**. However, after current commences to flow through the condenser and the primary and secondary S_1 the reverse phase current in the secondary S_1 combines with the voltage in the secondary S_2, and the vector sum of the voltage across all the windings is sufficient to ignite the lamp **25**, after which the device acts as a straight transformer.

In the above described apparatus, while I have referred to the use of a separate choke, I do not require such an element as a part of the invention. I believe that the use of my apparatus in connection with such a choke is an improved version of that which I consider the basic novelty. In some cases the use of a choke may give more satisfactory results, but the manner of operation and construction of the apparatus is not essentially altered by the addition.

It is also desired to point out that the two windings P and S_2 are relatively closer coupled together than the winding S_1 is to either. The winding S_1 must in all cases have a large leakage reactance in order to give the desired results, and hence it is preferably placed on the end of the transformer core. There is a magnetic shunt between it and the remainder of the transformer. As the number of turns of S_1 increases the shunt may be made smaller in width and conceivably may be dispensed with due to the high inductance provided by a great many turns. As for the other two windings, they can physically be interchanged as to position, and may even be wound on top of one another with the addition of some means providing a lagging reactance to supply that which is eliminated by this expedient. In the circuit of Fig. 5, for example, the windings P and S_2 can be wound one on top of the other, giving excellent results, and a choke **80** supplies the lagging reactance needed for good regulation.

A few additional examples of the constants of the transformers used in connection with the circuits shown in Figs. 4, 5 and 6 are given below. In each case each lamination of the transformer was of electrical steel 2.125 by 5.25 inches, the framing portion being generally ⅜ inch wide all around, and the central winding leg being ⅞ inch wide. One construction of the transformer was as follows:

Example 1.—(Transformer of Fig. 3)

Stack height 15/16 inch
Primary winding P—590 turns of No. 26 wire
Secondary winding S_1—2000 to 2200 turns of No. 32 wire
Secondary winding S_2—930 turns of No. 28 wire
Gap 49—.016 inch
Gap 17'—.015 inch
Gap 17—.010 inch
Shunt 16'—¼ inch
Shunt 16—¼ inch
Capacitor **75**—3½ mfds., 400 v. A. C. R. M. S.

On a 115 volt A. C. line, a 48" T–12 40 watt instant start, hot cathode fluorescent lamp was ignited and satisfactorily operated, by the use of the apparatus described above. The open circuit voltage across the lamp, measured with the lamp removed was between 400 and 450 volts. During starting the current in the winding S_1 was .25 amp. After starting, the current in the winding S_1 was .06 amp. The total current drawn from the line during operation was 0.75 amp.

Example 2.—(Transformer of Fig. 3)

Stack height—1 inch
Primary winding P—610 turns of No. 26 wire
Secondary winding S_1—2210 turns of No. 35 wire
Secondary winding S_2—820 turns of No. 27 wire
Gap **17**—.015 inch
Shunt **16**—⅝ inch
Capacitor **26**—2.75 mfd. 400 v. A. C. R. M. S.
Choke **80** (where used)—⅝ inch square E–I stack of laminations ⅝ inch thick having 1000 turns of No. 29 wire

On a 115 volt A. C. line, a 48" T–12 40 watt instant start fluorescent lamp was ignited and satisfactorily operated. In the case a choke was not used, an end gap of approximately .015 inch was used. The open circuit voltage across the lamp was approximately 430 volts. The current in S_1 during starting was .200 ampere and after starting it was .050 ampere. The total current drawn during operation was .600 ampere and the voltage across the lamp was approximately 110 volts. The current in the secondary S_2 during operation was .46 ampere. During starting the current in the primary (drawn from line) was 1.1 amperes.

Although the examples which have been illustrated and described show the three windings P, S_1 and S_2 connected respectively in series, it will be obvious to one skilled in the art, after becoming cognizant of the teachings hereof, that the invention can be applied with substantially the same effect in case the windings are connected in a different order. Thus, for example, the primary may be connected between the two secondaries, or the secondaries as illustrated and described may be interchanged as to electrical position. By adjustment of the physical constants, the results described herein and the advantages derived from the invention can be secured.

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. Lighting apparatus comprising, in combination, a pair of positive column type gaseous discharge lighting 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 first and second secondaries, 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 connected across the primary, said circuit including the devices, the capacitive reactor, and the second secondary.

2. Lighting apparatus comprising, in combination with two positive column type gaseous discharge lighting 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 two secondaries.

3. Lighting apparatus comprising, in combination with two positive column type gaseous discharge lighting 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 other two windings, 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 both secondaries.

4. An operating circuit for two positive column type discharge devices, comprising a transformer having a primary, a first secondary and a second secondary, a first positive column type gas discharge device connected in a loop with the two secondaries and the voltages of said secondaries in opposition to one another in said loop prior to the flow of current through the secondaries whereby at that time their effective voltage is a function of the difference between the voltages across the two secondaries, a second positive column type gas discharge device connected across at least a major portion of the primary and the first but not the second of the two secondaries, the first secondary being in step-up auto-transformer relationship to the primary, a magnetic structure coupling the primary with the two secondaries, the secondaries being more closely coupled to the primary than to one another, said first secondary taking a lagging current upon starting of current flow therethrough whereby after current commences to flow therethrough the direction of the voltage across the first secondary is substantially reversed with respect to the voltage induced in the other secondary and the voltage across the device in said first loop becomes a function of the sum of the voltages across the two secondaries, said first secondary being of substantially higher reactance than that of the other secondary, and a condenser in series with the first secondary and of a capacity reactance less than the inductive reactance of the first secondary.

5. A lighting system comprising a transformer having a primary, a first secondary, a second secondary, an instant start positive column type discharge lamp connected in a loop with the two secondaries and the voltages of said secondaries in opposition to one another in said loop prior to the flow of current through the secondaries whereby at that time their effective voltage is a function of the difference between the voltages across the two secondaries, a load including a condenser connected across at least a major portion of the primary and the first but not the second of the two secondaries, the first secondary being in step-up auto-transformer relationship to the primary, a magnetic structure coupling the primary with the two secondaries, said structure including a rectangular shell and a central winding leg between the transverse ends of the shell, the secondaries being at the ends of the central leg and the primary being between the secondaries so that the secondaries are more closely coupled to the primary than to one another, magnetic shunts bridging a major portion of the space from the central leg to the shell to provide high leakage reactance for the secondaries, said first secondary taking a lagging current upon starting of the current flow therethrough whereby after current com-

mences to flow therethrough the direction of its induced voltage is substantially reversed with respect to the voltage induced in the other secondary and the voltage across said lamp becomes substantially a function of the sum of the voltages across the two secondaries, said first secondary being of substantially higher reactance than the other secondary, and means for preventing saturation of the central core leg adjacent the second secondary, comprising a bridged air gap between the adjacent end of the core leg and the shell.

6. A system comprising two positive column type 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, the second of said devices being connected across the two secondaries.

7. A lighting system, at least two positive column type instant start gaseous discharge devices, means for operating the devices from a source having a voltage substantially lower than the igniting voltage of either of said devices, said means comprising an auto-transformer having a primary, a first secondary, and a second secondary connected one after the other, one of the devices being connected across the primary and one secondary together, the other of said devices being connected across the secondaries together and with the secondaries in voltage opposition to one another, the primary and first secondary being in step-up auto-transformer relationship to provide a voltage for igniting said one of said devices, and the combined voltages of the secondaries being sufficient for igniting the other device but the secondaries being inductively arranged additively to combine their voltages only after ignition of said one device, and means comprising a magnetic shunt establishing a high leakage reactance in said first secondary to prevent substantial passage of current therethrough after ignition of both devices.

8. An operating circuit for two discharge devices, comprising a transformer having a primary, a first secondary and a second secondary, a first gas discharge device connected in a loop with the two secondaries and the voltages of said secondaries in opposition to one another in said loop prior to the flow of current through the secondaries whereby at that time their effective voltage is a function of the difference between the voltages across the two secondaries, a second gas discharge device connected across at least a major portion of the primary and the first but not the second of the two secondaries, the first secondary being in step-up auto-transformer relationship to the primary, a magnetic structure coupling the primary with the two secondaries, the secondaries being more closely coupled to the primary than to one another, said first secondary taking a lagging current upon starting of current flow therethrough whereby after current commences to flow therethrough the direction of the voltage across the first secondary is substantially reversed with respect to the voltage induced in the other secondary and the voltage across the device in said first loop becomes a function of the sum of the voltages across the two secondaries, said first secondary being of substantially higher reactance than that of the other secondary.

9. A lighting system comprising two instant start gaseous discharge devices, an auto-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 capacity reactor, the second of said devices being connected across the first and second secondaries, the second secondary being of lower reactance than the first secondary and being more closely coupled to the primary than is the first secondary.

References Cited in the file of this patent

UNITED STATES PATENTS

2,269,978	Kronmiller	Jan. 13, 1942
2,382,638	Keiser	Aug. 14, 1945
2,558,293	Feinberg	June 26, 1951