

June 22, 1954

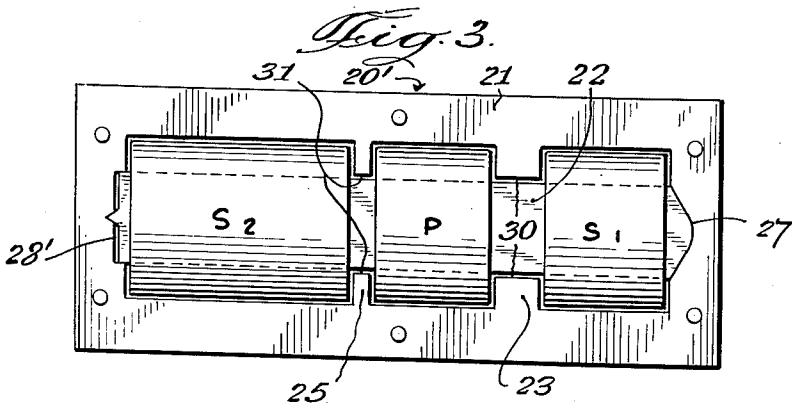
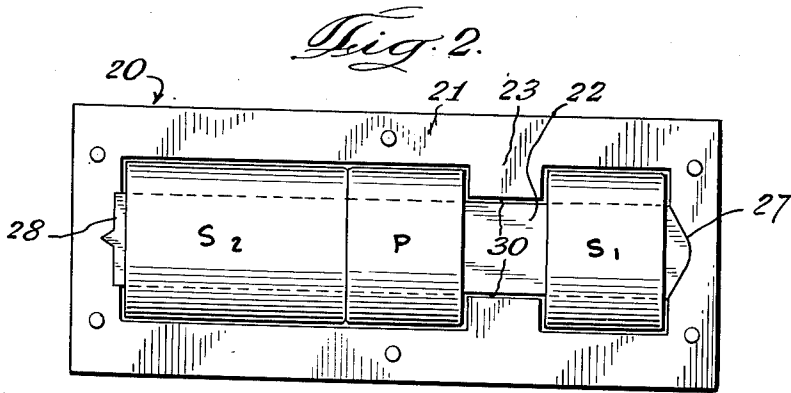
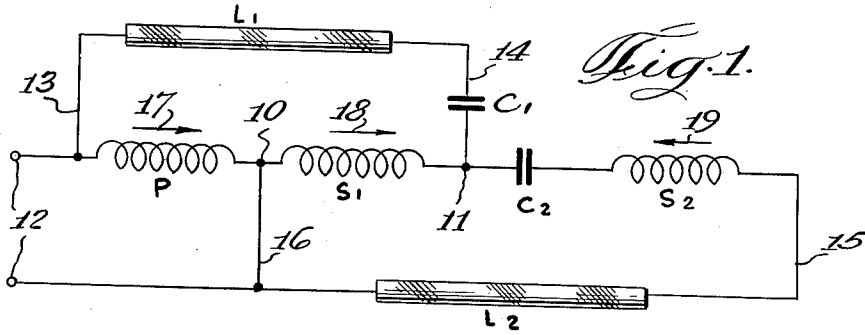
A. E. FEINBERG

2,682,014

APPARATUS FOR STARTING AND OPERATING GASEOUS DISCHARGE DEVICES

Filed May 19, 1952

2 Sheets-Sheet 1



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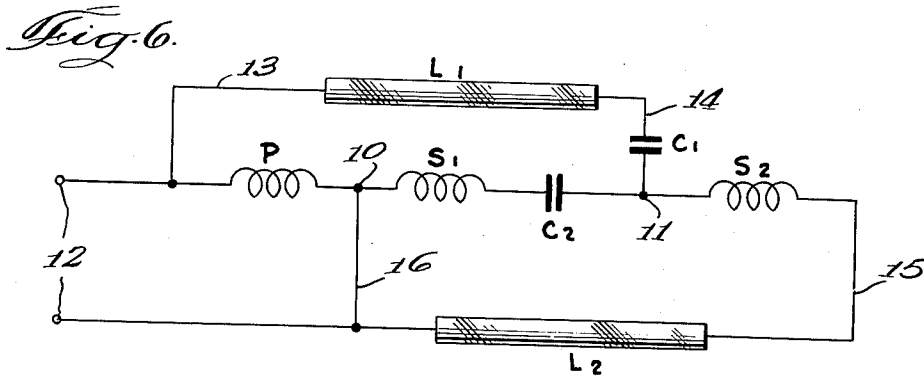
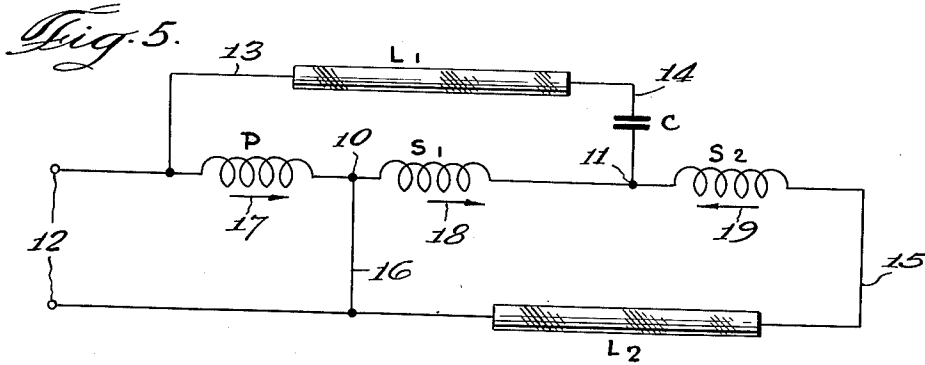
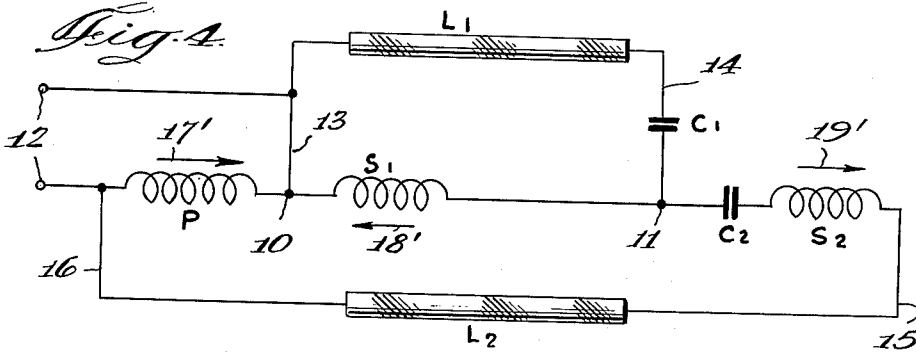
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APPARATUS FOR STARTING AND OPERATING GASEOUS DISCHARGE DEVICES

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2 Sheets-Sheet 2



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UNITED STATES PATENT OFFICE

2,682,014

APPARATUS FOR STARTING AND OPERATING GASEOUS DISCHARGE DEVICES

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Application May 19, 1952, Serial No. 288,652

9 Claims. (Cl. 315-138)

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This invention relates generally to apparatus for starting and operating gaseous discharge devices such as fluorescent lamps.

Particularly, this invention is directed to apparatus in which burn-outs or excessive heat is prevented in certain of the windings of the apparatus under certain emergency conditions. When a fault occurs in a discharge device such conditions arise, and unless some steps are taken to incorporate means into the apparatus to prevent the damage, considerable expense results.

The invention is directed to a type of apparatus known as a "ballast" which is connected with a source of low alternating voltage, such as for example, a 118 volt A. C. line which ignites gaseous discharge devices of the so-called "instant start" variety. Such devices are exemplified in commercially known fluorescent lamps and require very high ignition voltages, and when operating, also require voltages substantially greater than the line voltage. In Feinberg Patent No. 2,558,293, issued June 26, 1951, to the assignee of the instant application and entitled "Apparatus for Starting and Operating Gaseous Discharge Devices" I described and claimed a ballast of this type which has gone into extensive commercial use.

The ballast of Feinberg Patent No. 2,558,293 comprises a three-winding transformer having a primary winding P, a first secondary winding S₁ and a second secondary winding S₂, all of the windings being connected serially in the order named with the secondary windings arranged in voltage bucking relationship one to the other. The windings are all mounted on a unitary elongate core side by side, with the two secondary windings on opposite sides of the primary winding. There is a shunt between the winding S₁ and the primary winding P such that certain benefits are obtained from this winding during starting and during operation.

The loose coupling of the primary winding P and the first secondary S₁ gives rise to a very high leakage reactance in the first secondary winding. The gaseous discharge devices are adapted to be connected one across the two secondaries and another across the primary and first secondary winding S₁ in one case, and one across the first secondary winding S₁ alone and another across all of the windings in the second case. Variations are of course possible, but generally there is one gaseous discharge device connected across windings excluding the second secondary S₂ and including at least the first secondary S₁, and a second gaseous discharge device

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across windings which include at least both of the secondary windings.

The operation of the ballast is fully set forth in the said patent, but will be repeated briefly here. Presume a ballast in which one gaseous discharge device is connected across both the primary P and first secondary winding S₁ and the second gaseous discharge device is connected across both secondary windings S₁ and S₂ together. Such a ballast is shown generally in Fig. 5 hereinafter described. When the primary winding P is energized a voltage will be produced in both the primary winding P and the first secondary winding S₁ which will be sufficient to ignite the first gaseous discharge device. When current flows through the winding S₁, because of its high leakage reactance, a voltage will be produced therein which has a phase such as to produce a substantial component additive relative to the voltage induced in the second secondary winding S₂. Thus the second gaseous discharge device will now ignite. With both of the gaseous discharge devices operating, there will be a series path for the major portion of the current through the devices, and the second secondary winding S₂, the first secondary winding S₁ being by-passed because its high leakage reactance impedes the flow of current therethrough. Because of this, the winding S₁ can be, and in commercial versions has been made of a large number of turns of very fine wire. Obviously since it carries so little current during operation, it permits of this and the ballast is thereby rendered very small and compact. Likewise very high ignition voltages can be achieved with very little copper.

Normally, no difficulties arise in the operation of such ballasts, and same are now successfully being used in large quantities. Gaseous discharge devices used on A. C. circuits are designed to be bi-directional with respect to the flow of current. In the case of fluorescent tubes, there are two filaments, one at each end, each of which serves both as cathode and anode, but on alternating cycles. If the emissive properties of a filament are destroyed for some reason or the other, either through long use or jarring, or the like, then that filament loses its ability to be a cathode. It can only be an anode. The result is that the discharge device now functions only as a rectifying tube. Fluorescent tubes do not last long on direct current and their ends become blackened through uni-directional flow of current, bombardment of the anode end, and perhaps other causes. Their efficiency is less, and

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their use on direct current is avoided also because the ballasts function only to provide D. C. resistance.

In the event the above occurs in an ordinary ballast, there is no great problem of removing the discharge device and replacing it, but in the case of the type of ballast above described another problem arises. In order to adjust the line power factor, and as an aid in starting, a condenser is usually placed in series connection with the first described gaseous discharge device. In the event that one of the filaments of the first gaseous discharge device becomes inoperative as a cathode, there will be no direct current passing through the windings of the ballast and no harm outside of the possible eventual loss of the fluorescent tube. If, on the other hand, this occurs in the second tube, the current will be forced through the first secondary winding S_1 . Since the winding is built for extremely low currents, it will either heat up excessively or burn out. Thus, the ballast must be removed from the installation and replaced with considerable expense and inconvenience.

It is therefore the principal object of the invention to provide apparatus of the character described in which all of the benefits of invention of the said Feinberg patent are achieved, but in which the possibility of burn-outs or excessive temperature occurring in the windings is eliminated.

Still a further object of the invention is to provide apparatus of the character described in which direct current caused by rectifying action of a faulty gaseous discharge device is prevented from passing through the transformer secondaries.

Another object of the invention is to achieve the above objects without in any way adversely affecting the operation of the apparatus and without materially increasing the costs thereof.

Still a further object of the invention is to provide apparatus of the character described in which there are a pair of condensers in the series circuit evolved after both of the gaseous discharge devices are operating, one of the condensers being in series with the first gaseous discharge device and the other being in series with the second secondary winding.

Other objects of the invention will occur as the description proceeds in which I have illustrated two examples of an embodiment of the invention. The basic apparatus is capable of considerable variation and the modification thereof which comprises the invention herein is capable of being applied to all of these variations, whether two gaseous discharge devices or more are used and whether there are more than the three windings described herein.

In the drawing, in which like characters represent the same or similar parts throughout the several figures thereof:

Fig. 1 is an electrical circuit diagram of apparatus embodying the invention.

Figs. 2 and 3 are side elevational views showing transformer constructions capable of being used with my invention.

Fig. 4 is an electrical circuit diagram of apparatus embodying the invention showing a variation thereof.

Fig. 5 is an electrical circuit diagram similar to that of Fig. 1 but not embodying the invention hereof, same being a diagram of the circuit of the apparatus of the patent hereinabove referred to.

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Fig. 6 is an electrical circuit diagram similar to that of Fig. 1 but embodying a modified form of the invention.

Referring first to Fig. 5, same is an illustration of the basic circuit of apparatus described and claimed in the above referred to Feinberg patent. The invention comprises a modification thereof whereby the results and objectives are achieved.

As noted above, the said circuit comprises three windings, the primary winding P, a first secondary winding S_1 , and a second secondary winding S_2 , all connected end to end in the order named. The said windings are mounted upon a laminated iron core of the kind illustrated in Figs. 2 and 3 and described hereinafter, but not in the same order as connected together. The conventional symbols representing shunts and the core are not illustrated in order to keep the diagrams as simple as possible, and to enable their illustration in the form shown, i. e., with the windings placed in the circuit one after the other. The junction between the primary winding P and the first secondary winding S_1 is designated 10 and the junction between the secondaries is designated 11. The gaseous discharge devices are symbolically illustrated as fluorescent lamps and are designated L_1 and L_2 , that being the ignition order. The left hand terminal of the winding P is connected to one side of the line 12 and the left hand terminal of the lamp L_1 is connected by way of lead 13 to the same terminal. The right hand terminal of the lamp L_1 is connected by way of the lead 14 with the juncture 11. The right hand terminal of the lamp L_2 and the right hand terminal of the second secondary winding S_2 are connected together by way of the lead 15. The left hand terminal of the lamp L_2 is connected with the juncture 10 by way of the lead 16. The juncture 10 is also connected with the second side of the line 12.

The voltage sense of each of the windings relative one to the other is indicated by the arrows 17, 18 and 19. The manner in which such relationship is achieved is well-known in the art, it being a practical matter that all of the windings are wound in the same manner, but the connections relative to orientation on the core adjusted to achieve the additive or bucking relationships of their instantaneous voltages.

In operation, as explained, when voltage is applied by the line 12 to the primary winding P, there is a voltage induced in S_1 which will be seen to be additive. The resultant of voltages of primary winding P and first secondary winding S_1 appears across the lamp L_1 and is sufficient to ignite the said lamp. After ignition, current flows through leads 13 and 14 and through the first secondary winding S_1 . Since that winding is very loosely coupled relative to the primary, there is a high leakage reactance produced, and the voltage that occurs as a result of the flow of current includes a component that is additive to the voltage induced by the primary winding P in the winding S_2 .

Until this occurs, there is not sufficient voltage across the second lamp L_2 to ignite the same, since the open circuit voltages of the respective windings S_1 and S_2 are in opposition, and their resultant far less than the ignition voltage of the said lamp L_2 . Now, however, with a voltage component additive to the induced voltage occurring across the winding S_2 , there is sufficient voltage across the lamp L_2 to ignite the same. When this occurs, the high reactance of the winding S_1 opposes flow of current therethrough. Thus cur-

rent will flow during operation substantially through the lamps and the second secondary winding S_2 , by way of the leads 13, 14, and 15. Most of the current of operation will by-pass the winding S_1 with a result that the said winding can be made of extremely fine wire and with a great many turns. In order to aid the starting at least to some extent and to provide some provision for adjustment of the power factor of the operating circuit, a series condenser C is inserted in the lead 14.

Just to illustrate the nature of the circuit, in the above referred to patent I described an example which was intended for use with what are commercially known as "T-12" fluorescent lamps, same being 48 inches in length, $1\frac{1}{2}$ inches in diameter, and having a rating of forty watts each. The windings are formed with the primary winding P having 540 turns of No. 25 wire, the second secondary S_2 having 1270 turns of No. 27 wire, but with the first secondary winding S_1 having 2360 turns of No. 35 wire which is very fine. Under the operating conditions, the first secondary winding was found to carry a current of about .030 ampere, which of course is very little. Under these circumstances, the current through the lamps, that is, in the series portion of the circuit, is about .435 ampere.

Presume that in a construction of this kind something occurs which adversely affects the operation of the lamp L_2 such that one of its cathodes ceases functioning as such. The gaseous discharge is now only uni-directional and the lamp is operating as a rectifier. As a rectifier, the only current which flows through the lamp L_2 and through the second secondary winding is direct current. It will be blocked out of the lamp L_1 by the condenser C; it will not be affected by the high leakage reactance of the first secondary winding S_1 ; and consequently it will pass through the said winding. This current in the winding S_1 under these circumstances may reach almost .300 ampere, or about ten times the current for which the winding is designed.

Under the adverse conditions described above, the winding S_1 is certain to overheat and promote dangerous conditions to exist in the vicinity thereof. For example, if occurring in a fixture, it may well become a fire hazard, and do other damage. If the wire cannot carry the added current, which is most likely, the winding will burn out and destroy the ballast. Since these ballasts are assembled in metal containers, with varnished windings in pitch, and usually installed in fixtures, it can be appreciated that in addition to the cost of a new ballast, there is the expense of replacement and the inconvenience of loss of function.

My invention results in the alleviation and prevention of the above described difficulty. The manner in which this is done without materially increasing the cost of the ballast or destroying the efficiency of operation thereof is basically to utilize two condensers to perform the function of the condenser C, but to place them in a manner which is advantageous and which will prevent burn-outs or heating of the winding S_1 , thereby adding an additional function. The arrangement of the condensers of the invention further produces a ballast in which when a lamp commences to act as a rectifier, it will cease functioning such that an observer may immediately know what has occurred. It is to be remembered that in the case of the circuit of Fig. 5, the rectifying lamp will continue to burn (if the wind-

ing S_1 does not burn out) such that the user may not immediately realize that there has been a mishap to the lamp.

Practically speaking, I have substituted for the condenser C a pair of condensers each having twice the capacity of C but half the rating (for any given set of conditions), one being placed in the lead 14 as C was positioned, and the other being placed in series with the second secondary winding S_2 , preferably between the juncture 11 and the left hand terminal of the said winding S_2 .

In Figs. 1 and 4 I have illustrated the manner in which the invention is applied to two variations of the circuit for preventing the flow of excess current through the winding S_1 . Each of the circuits of the said Figs. 1 and 4 is capable of being utilized in connection with a transformer of the construction of either of Figs. 2 or 3. In both transformers, designated respectively 20 and 20', there is a rectangular, elongate, shell-like core 21 of laminated electrical steel structure having a central elongate winding leg 22 matingly seated in the shell-like core 21. The windings are all pre-mounted upon the central winding leg 22 and the whole assembly pressed home into the core. Note that the winding P is disposed in the center of the transformer and the secondary windings S_1 and S_2 are on opposite sides. In each case there is a magnetic shunt 23 which separates the primary winding P from the first secondary winding S_1 in order that the high leakage reactance which has been described be engendered. It is pointed out that the winding S_2 is also loosely coupled with the primary winding P, but of course to a substantial degree less than the first secondary winding S_1 . In the case of the transformer 20 of Fig. 2, the windings S_2 and P are arranged side by side, but in the case of the transformer 20' there is a small shunt 25 which separates the two windings. This provides additional leakage reactance for the winding S_2 if desired.

The transformers 20 and 20' are formed with the ends of the winding legs 22 seated in appropriately mating joints such as shown at 27 and 28. Leakage reactance may be increased and likelihood of saturation decreased by providing an additional gap at 28'. The shunts 23 have gaps 30 and the shunt 25 has gaps 31.

In Fig. 1, the construction of the apparatus and the characters of reference are identical to the construction and reference characters of Fig. 5, except that I have removed the condenser C of Fig. 5 and have substituted instead another condenser C_1 . The electrical conductor between the junction 11 and the left hand terminal of the second secondary winding S_2 has been opened and another condenser C_2 has been inserted therein.

Under normal conditions the apparatus of Fig. 1 will operate exactly the same as the apparatus of Fig. 5. The condensers C_1 and C_2 are chosen such that their combined capacitance is substantially the same as the capacitance of the condenser C of Fig. 5. Thus, if the example referred to for operation in connection with a pair of 40 watt T-12 fluorescent lamps uses a condenser C with a capacitance of 2.6 micro-farads and a rating of 440 volts, then the condensers C_1 and C_2 for use with the modified apparatus will each have a capacitance of 5.2 micro-farads, but need only have a voltage rating of 220 volts. The increased size of the condensers is offset cost-

wise by the fact that less expensive insulation may be used.

In the event that the fluorescent lamp L_2 becomes faulty, such that it begins to function as a rectifier, no direct current can pass through the winding S_1 because it is blocked by the condenser C_2 . Therefore, the winding S_1 will not heat up, and certainly not burn out. The lamp L_2 will therefore become extinguished, since no current can pass through the series connected winding S_2 either. This indicates immediately that the lamp L_2 is defective. During operation, the series capacitance of the condensers C_1 and C_2 is the same as a condenser C having half the capacitance of either and placed in the lead 14. During ignition of the lamp L_1 the condenser C_1 serves the same purpose as the condenser C notwithstanding its higher capacitance and lower voltage rating.

In Fig. 4, I have shown a modified form of the circuit with the invention embodied therein. Thus, the same arrangement of windings is used as previously described except that the primary winding P is connected such that its voltage sense as indicated by the arrow 17' is opposed to the voltage sense of the winding S_1 as indicated by the arrow 18' and is additive to the voltage sense of the winding S_2 indicated by the arrow 13'. In this case the lamp L_1 is connected across the winding S_1 alone by the leads 13 and 14, and the lamp L_2 is connected across all three windings by the leads 15 and 16. On open circuit, the voltage across all windings is the resultant of the voltages of all three windings, and since the two windings P and S_2 are in opposition to the voltage of the winding S_1 , said resultant is insufficient to ignite the lamp L_2 . The voltage induced in winding S_1 is however sufficient to ignite lamp L_1 and thereafter, due to the high leakage reactance of the winding S_1 , a voltage is produced in S_1 having a component additive to the voltages of the windings P and S_2 . At this time the lamp L_2 ignites.

Again, the circuit as described and claimed in my previous patent has a condenser placed as C of Fig. 5, i. e., in the lead 14. If the lamp L_2 became defective and commenced to rectify, the direct current flowing in the winding S_1 would either heat it dangerously or burn it out. I therefore utilize the same modification as described in connection with Fig. 1. I place one condenser C_1 in the lead 14 and another condenser C_2 in the electrical connection between the juncture 11 and the second secondary winding S_2 . The capacitance of each of the condensers C_1 and C_2 may be about twice that of a single condenser placed in series with the lamp L_1 , and the voltage rating half of such single condenser (which is not shown). The operation and benefits are the same as described in connection with Fig. 1.

Note that the placement of the condenser C_1 may be in the leads 13 or 14, and that the placement of the condenser C_2 may be at any place of convenience in that branch of the circuit which includes the winding S_2 , leads 15 and 16, and the lamp L_2 .

In another modified form shown in Fig. 6, the second condenser C_2 is spaced between juncture 11 and the right hand end of the winding S_1 . In this case, the condenser C_1 need not be changed in value from the capacitance of condenser C_1 while condenser C_2 may be of lower rating and relatively larger capacitance. There will be very little change in starting characteristics for lamp L_1 , but a slight decrease in total available starting voltage for lamp L_2 .

The circuits illustrated herein and in connection with which I have illustrated and described my invention are capable of wide variation and application. In all cases where a winding equivalent to the first secondary winding S_1 is used having a large number of turns and fine wire, the same is capable of being protected by the use of the invention herein. For example, I have applied the invention of my previous Patent No. 2,558,293 to ballasts having more than two gaseous discharge devices associated therewith, and the herein invention is suitable for use therewith and contemplates coverage thereof.

It is desired that the scope of the invention be commensurate with the claims appended hereto as interpreted in their broadest sense in view of the prior art.

I claim:

1. In apparatus of the character described for igniting and thereafter regulating the operation of a gaseous discharge device from a source of A. C. voltage substantially less than the igniting voltage of the device, which comprises a multiple winding transformer having a primary winding, a pair of secondary windings arranged in voltage bucking relationship one to the other with respect to a circuit containing both secondary windings, the primary, a first secondary, and the second secondary windings being connected one after the other in the order named an electrically conducting path connected across winding means of the transformer including at least the first secondary and excluding the second secondary, a series capacitor in said path and a gaseous discharge device connected across windings of the said transformer including at least both secondaries, the said first secondary winding having a high leakage reactance and being a starting winding such that substantially all discharge device current by-passes the same through said electrically conducting path during operation, means for preventing flow of direct current through said first secondary winding in the event that the said gaseous discharge device commences rectifying, comprising a second capacitor in series with the said second secondary winding.

2. Apparatus as described in claim 1 in which the value of capacitance of each of said capacitors is approximately equal to two times the capacitance required for power factor correction of the series operating circuit including the second secondary winding.

3. In apparatus of the character described for igniting and thereafter regulating the operation of a pair of gaseous discharge devices from a source of A. C. voltage substantially less than the ignition voltage of the devices, which comprises a transformer having a primary winding, a first secondary winding, and a second secondary winding, the windings all being mounted on a unitary iron core with the first secondary winding very loosely coupled relative to the primary so as to provide a high leakage reactance therein, and the windings all being connected end to end in the order named but with the voltage sense of the secondaries reversed one relative to the other, an electrical path having a first gaseous discharge device and a series capacitor therein and extending across windings of the transformer including at least the first secondary and excluding the second secondary, and a second gaseous discharge device connected across windings of the transformer including at least the secondaries in the resulting loop, means for

preventing the flow of direct current through the first secondary in the event of rectifying operation of the said second gaseous discharge device which comprises a second capacitor in series with the said second secondary winding.

4. In a device of the character described adapted to seriatim ignite and series operate a pair of gaseous discharge devices from a low voltage A. C. source and which comprises a three-winding transformer made up of a primary winding, a high leakage reactance first secondary winding, and a second secondary winding, the windings being connected end to end in the order named, and in which electrical leads are provided connecting one device in a conducting loop which includes the said first winding but not the secondary winding, and which loop has a series capacitor therein, and leads are provided connecting the second device in a second conducting loop which includes the second secondary series-connected therein, means for blocking flow of D. C. current resulting from abnormal operation of the second gaseous discharge device through the said first secondary winding without in any way affecting the normal operation of the apparatus which comprises a series capacitor in said second conducting loop.

5. In a device of the character described adapted to seriatim ignite and series operate a pair of gaseous discharge devices from a low voltage A. C. source and which comprises a three-winding transformer having a high leakage resistance first secondary winding electrically connected between a primary winding and a second secondary winding, and in which the said first secondary winding is formed of a great number of windings of fine wire compared with the other windings, and is in reverse voltage relationship to the second secondary winding, and in which one device is connected in a loop having a series capacitor, said loop including the primary and first secondary windings, and in which the second device is connected in a second loop including both of the said secondaries, the turn ratios of the windings being such that when the primary winding is energized first the first device will ignite and then a voltage will be produced in the first secondary winding additive to the voltage of the second secondary winding whereby to cause ignition of the second device, and thereafter due to the high leakage reactance of the said first secondary winding substantially all the current will flow in series circuit including the devices, the capacitor, and the second secondary winding, the said first secondary winding being by-passed, the herein invention which comprises means for preventing flow of direct current through the said first secondary winding due to abnormal operation of the second device comprising a second condenser connected in series with the said second secondary winding at a point in said second loop where all of the current passing through the said second secondary winding will be required to pass through said second capacitor.

6. The structure of claim 5 in which each capacitor has a capacitance approximately twice that required for power factor correction of said series circuit.

7. Apparatus of the character described adapted to ignite and operate a pair of gaseous discharge devices from an A. C. source of relatively low voltage which includes an auto-transformer

having a primary, two gaseous discharge devices, 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 the primary, means including a capacitive reactor connecting one of said devices across the primary and first secondary, the second of said devices being connected across the first and second secondaries together, the source being connected across the primary, and a second capacitive reactor inserted in the connection between first and second secondaries.

8. Apparatus of the character described adapted to ignite and operate a pair of gaseous discharge devices from an A. C. source of relatively low voltage which includes a transformer having a primary winding, two gaseous discharge devices, a loosely coupled first secondary winding having one side connected to one side of said primary winding and in reverse voltage relationship thereto, and a loosely coupled second secondary winding having one side connected to the second side of the said first secondary winding and being in bucking voltage relationship thereto but in additive voltage relationship with the primary winding, one of said devices being connected in series with a capacitive reactor and together therewith being connected across the first secondary winding only, the second device being connected across all three windings together, the source being connected across the primary winding, and a second capacitive reactor connected in series with the second device.

9. Apparatus of the character described which comprises a pair of gaseous discharge devices, a source of A. C. voltage of a value substantially less than the igniting voltage of either of the devices, a three winding auto-transformer having a unitary iron core and mounting three windings comprising a primary winding, a first secondary winding and a second secondary winding, the primary winding being disposed in the center of the core and having a magnetic shunt between itself and the first secondary winding, the second secondary winding being closer coupled to the primary winding than the first secondary winding, the primary winding being connected across the source, one terminal of the primary winding being connected to one terminal of the first secondary winding, one of said devices being in series with a condenser and together with the condenser connected from the second terminal of the primary winding to the second terminal of the first secondary winding, the second device being in a series circuit with a second condenser and the second secondary winding and the said series circuit being connected from the second terminal of the first secondary winding to the first terminal of the first secondary winding, the instantaneous voltage senses of the secondaries being bucking one relative to the other.

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