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APPARATUS FOR IGNITING AND OPERATING
GASEOUS DISCHARGE DEVICES

3,198,983

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2 Sheets-Sheet 2

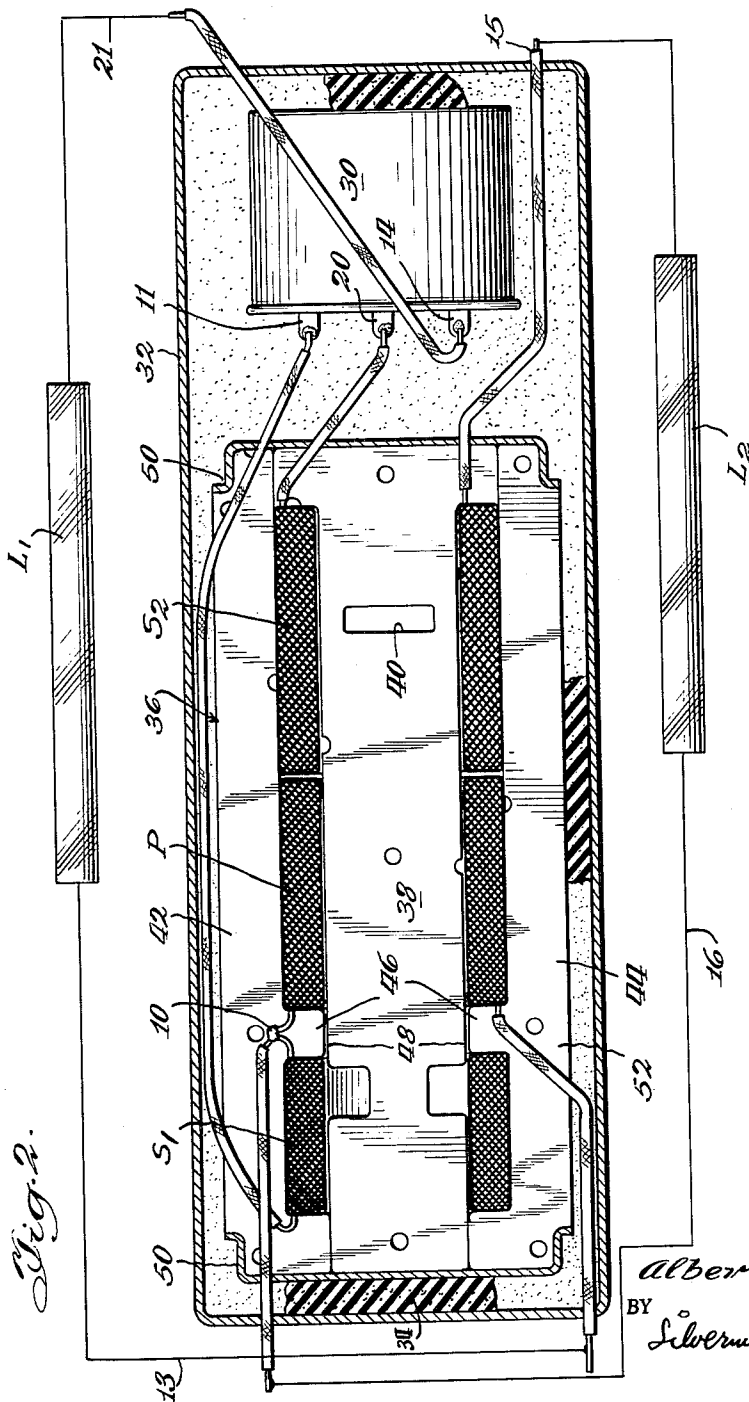


Fig. 2.

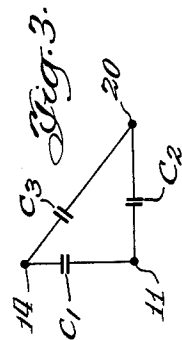


Fig. 3.

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APPARATUS FOR IGNITING AND OPERATING GASEOUS DISCHARGE DEVICES

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8 Claims. (Cl. 315-144)

This invention relates generally to ballast apparatus for starting and operating gaseous discharge devices, and more particularly is concerned with the construction of a ballast of the so-called series-sequence type in which means are provided to prevent burning out of windings of the ballast because of rectification of current in one of the gaseous discharge devices, such as a fluorescent lamp.

The invention herein is specifically applicable to ballasts of the construction of Feinberg U.S. Patent No. 2,558,293 which have become known as series-sequence ballasts. The basic structure of the ballast comprises an elongate iron core mounting three windings, a primary, a first secondary and a second secondary connected terminal to terminal in that order but mounted along the core with the primary winding in the center and the first secondary winding separated from the primary winding by a relatively large shunt. The transformer is disposed in the metal canister along with the condenser which has one terminal thereof connected to the junction between the two secondary windings and the other extending out of the canister and adapted to be connected to a first fluorescent lamp. The other end of that lamp, in one version of the structure of Feinberg Patent 2,558,293, is adapted to be connected to one side of the usual power line such as, for example, a 120 volt 60 cycle A.C. line. The free end of the primary winding, that is, that portion opposite the terminal connected to the first secondary winding, is also connected to the same line and extends out of the canister for that purpose. The junction between primary and first secondary windings is extended by way of a lead outside of the canister also, and this lead is adapted to be connected to the other side of the power line and also to one terminal of the second gaseous discharge lamp. The remaining terminal which is the second terminal of the second secondary winding also extends outside of the canister and is adapted to be connected to the second terminal of the second gaseous discharge device or fluorescent lamp.

In operation, the combined voltages of the primary and first secondary windings are applied across the first fluorescent lamp. Together they are sufficient to ignite the lamp. As soon as current flows through this lamp, it flows in a loop which includes the condenser, the first secondary winding and the primary winding. In view of the high leakage reactance afforded by the shunt between the primary and first secondary windings, there will be reversal of phase of the voltage in the first secondary winding. The first and second secondary windings are connected to buck one another normally, but when the reversal of phase of the voltage in the first secondary winding occurs, it causes a component of voltage to combine with the voltage induced in the second secondary winding so that the resultant is sufficient to ignite the second fluorescent lamp. Thereafter, since the two lamps have a low impedance and the first secondary winding has a high impedance, current for the most part will flow through the lamps, the condenser and the second secondary winding substantially by-passing the first secondary winding.

Many advantages are inherent in this structure including a variation thereof in which only the voltage of the first secondary winding is used to ignite the first lamp. One of the principal advantages has been that since the first secondary winding is used only during the short period of time that the gaseous discharge devices are being ig-

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nited, it is not required to carry a great deal of current. Consequently, this winding normally is made of a large number of turns of very fine wire. Besides a saving of copper, a large ignition voltage can be generated in a very small space.

Ballasts of the construction described are manufactured in extremely large quantities and millions of them are in use today. These structures function satisfactorily, but it was recognized that some disadvantages obtained.

In Feinberg U.S. Patent 2,682,014, a structure is described, the purpose of which it was to prevent the fine wire winding, namely, the first secondary winding from burning out when a fault occurs in the second gaseous discharge device.

A study of the basic circuits of Feinberg Patent 2,558,293 will show that while there is a condenser in series with the first-to-ignite gaseous discharge device, there is no condenser in series with the second-to-ignite gaseous discharge device. If one of the filaments of the second gaseous discharge device should become faulty and cease functioning, as for example, by losing its oxide coating, it can only function as an anode; then the current which flows through that lamp will be rectified. This will be a direct current. The second secondary winding is of sufficient size normally to handle such current, but the current will be blocked from the first gaseous discharge device by the condenser in series therewith and will therefore flow through the first secondary winding. Since the first secondary winding is made of very fine wire, the ballast temperature will be raised. If this occurs for any substantial length of time, the first secondary winding will burn out resulting in loss of the entire ballast, not to mention damage which could occur because of the melting potting compound, etc.

Patent 2,682,014 proposed inserting a condenser in series with the second secondary winding or, in a variation, in series with the first secondary winding, thereby blocking the flow of direct current in case there is rectification in the second gaseous discharge lamp.

Considering the ordinary series-sequence circuit, the condenser was expected to perform two functions. During ignition, after the first lamp had ignited, it was expected to increase the flow of current through the first secondary winding in order that there be a substantial phase shift and a high voltage generated therein. Secondly, it was expected to function as a power factor correcting condenser in the series operation of the two lamps.

It would seem rather simple to provide a three-foil condenser with the center foil connected to the first secondary winding and the two outside foils connected, respectively, to the second secondary winding and the lead extending to the first lamp. Assuming a capacitance for the conventional series condenser which operates satisfactorily in both functions, it would be appreciated that the two condensers to be connected in accordance with the teachings of Feinberg Patent 2,682,014 are required, respectively, to have twice the capacitance of the ordinary series condenser, although the voltage requirements are halved. The difficulty here would be that while the series condensers function satisfactorily with respect to power factor, the condition for ignition of the first gaseous discharge device has been upset. With twice the capacitance, an adjustment would have to be made in the number of windings of the first secondary winding in order to have sufficient inductance to provide the necessary phase shift component for aid in igniting the second lamp. This, of course, results in an increase in the cost of the ballast, which, when added to the cost of a multiple foil condenser and the labor of assembling the same prevented the structures of Feinberg Patent 2,682,014 from becoming popular and in wide use.

In recent times, the need for preventing overheating

of the ballast of the series-sequence construction and the greater attention being paid to stringent safety controls has called for a reappraisal of the principles of Feinberg Patent 2,682,014.

The primary object of this invention is to overcome the disadvantages of the two-condenser structure of Feinberg Patent 2,682,014 by keeping the capacitance of the starting loop low without substantially increasing the capacitance of the series operating circuit.

Because of the object immediately stated above, through the teachings of the invention herein, it is possible to construct a ballast with all of the advantages of Feinberg Patent 2,682,014 without making any changes in the transformer used in the commercial version of the series-sequence ballast of construction of Feinberg Patent 2,558,293 by connecting the same in a manner taught by the invention herein.

A still further object of the invention is to provide a structure of the character described in which a delta condenser arrangement is connected between the first-to-ignite gaseous discharge lamp and the two secondaries whereby to provide the proper capacitance for the series operating circuit and the starting circuit while maintaining the necessary voltage ratings for such capacitances.

A still further object of the invention is to provide a novel condenser construction in the form of a delta connection, the branches of which are of different capacitances and voltage rating.

Many other objects of the invention will become apparent as the description thereof proceeds in connection with which preferred embodiments are illustrated and described.

In the drawings in which the same characters of reference are used to refer to the same or equivalent components throughout the several figures thereof:

FIG. 1 is a schematic electrical diagram of a ballast connected into a fluorescent lighting arrangement, the ballast being constructed in accordance with the invention.

FIG. 2 is a somewhat diagrammatic view taken through a ballast constructed in accordance with the invention showing the arrangement and construction of the components thereof and the manner in which they are connected into the circuit of FIG. 1.

FIG. 3 is a schematic circuit diagram of the delta connected condenser.

FIG. 4 is an exaggerated fragmentary sectional view through a delta condenser constructed in accordance with the invention taken through the layers thereof.

FIG. 5 is an electrical diagram similar to that of FIG. 1 but showing the application of the invention to a modified form of the series-sequence circuit.

FIG. 6 is a circuit diagram of one form of the series-sequence arrangement of Feinberg Patent 2,558,293, this being prior art.

Basically, the invention is concerned with providing a delta condenser connection between the first-to-ignite lamp and the two secondary windings of a series-sequence circuit so that while the voltage requirements are maintained, the capacitance in the igniting and operating circuits are not changed to an extent requiring expensive modification of the transformer, while current rectification in the second to start gaseous discharge lamp cannot either increase the temperature or damage the windings of the ballast.

Reference perhaps should be made first to FIG. 6 which illustrates the basic series-sequence circuit of Feinberg Patent 2,558,293. In this circuit diagram, there is no conventional designation for the magnetic shunt or the usual straight lines designating iron core, but it may be assumed that these are present. Line voltage across the ballast terminals 12 energizes the primary P and induces voltages in the first secondary winding S₁ and the second secondary winding S₂ whose open circuit instantaneous relationships are shown by the arrows 17, 18 and 19. Upon open circuit, the voltages induced in the primary and first secondary windings P and S₁, respectively, are additive, while the voltages induced in the first secondary winding S₁ and second secondary winding S₂ are bucking as indicated by the arrows 18 and 19.

Initially, the induced voltage in the first secondary S₁ combines with the voltage of the primary P to produce a resultant applied through the condenser C across the leads 13 and 21 to the lamp L₁ sufficient to ignite this lamp. At the same time, the resultant of the voltages of the first secondary winding S₁ and the second secondary winding S₂ when combined are insufficient to ignite the lamp L₂ although applied across the leads 15 and 16.

As soon as current flows through the lamp L₁, the condenser C increases the flow of this current. Due to the high leakage reactance of the first secondary winding S₁, it being separated from the remainder of the windings by a large shunt as will be described, there will be a substantial phase reversal of the voltage in the secondary winding S₁. This will provide a component which when added to the voltage of the winding S₂ will be sufficient to ignite the lamp L₂. As soon as the lamp L₂ ignites and current flows through it, the operating circuit will become lead 13, lamp L₁, lead 21, condenser C, second secondary winding S₂, lead 15, lamp L₂, lead 16 and back to the primary. Very little current will, therefore, flow through the first secondary winding S₁ between the junctions 10 and 11 since the impedance of the remainder of the circuit is substantially lower than that of the first secondary winding.

Because of this, as has been explained, the first secondary winding is usually made up of a large number of turns of very fine wire.

In this operating circuit, the condenser C now functions as a power factor correcting condenser to offset the total inductance of the circuit provided primarily by the inductance of the secondary winding S₂. In a typical commercial structure intended for use in igniting and operating two 75 watt fluorescent lamps, the transformer was constructed as shown in FIG. 2 (described hereinafter). The primary winding P had 540 turns of 21½ gauge wire, the first secondary winding S₁ had 3480 turns of No. 33 gauge wire, and the second secondary winding S₂ had 2230 turns of No. 28 gauge wire. For this construction, the stack of laminations was .850 inch in height, and the condenser C had a capacitance of 1.7 microfarads with a voltage rating of about 550 volts.

It will be seen that if instead of using a condenser C as in FIG. 6, one would use two condensers as shown in Feinberg Patent 2,682,014. If located at the same location as condensers C₁ and C₂ of FIG. 1, although the voltage rating for each condenser would have to be 275 volts, the capacitance of each condenser would have to be 3.4 microfarads in view of the effect of series capacitors. The problems posed for the starting circuit have been discussed above.

In accordance with the invention, a structure as illustrated in FIG. 1 is used. In this instance, there is provided a delta connection of condensers C₁, C₂ and C₃ between the terminals 11, 14 and 20 of the first secondary winding S₁, the lead 21 from the lamp L₁ and the second secondary winding S₂, respectively. In such an arrangement, the starting capacitance between the terminal 11 and 14 is defined as follows:

$$C_{(11-14)} = C_1 + \frac{C_2 \cdot C_3}{C_2 + C_3}$$

On the other hand, the power factor capacitance existing between the terminals 14 and 20 is equal to:

$$C_{(14-20)} = C_3 + \frac{C_1 \cdot C_2}{C_1 + C_2}$$

Without making any other changes in the ballast of FIG. 6, C₁ was chosen as 1.54 microfarads with a voltage rating of 275 volts, C₂ was 1.54 microfarads with a voltage rating

of 275 volts, and C_3 was .94 microfarad with a voltage rating of 550 volts.

Applying the formulas given above, the power factor capacitance C_{14-20} becomes 1.7 microfarads and the starting circuit capacitance $C_{(11-14)}$ becomes 2.02 microfarads.

Ideally, all three condensers C_1 , C_2 and C_3 are mounted in a single canister such as shown at 30 in FIG. 2 with their terminals extending out of the canister. A description of the specific structure will shortly be given, but in the meantime attention is invited to the physical construction of the ballast itself.

As usual, the ballast is mounted in a steel canister 32 and filled with pitch or other potting compound as indicated at 34. The transformer portion of the ballast is shown at 36, and as will be seen, it is in the form of elongate iron laminations arranged in stacks. There is a central T-shaped winding leg 38 provided with a slot 40 located beneath the second secondary winding to prevent saturation in the vicinity of the second secondary winding and for other reasons. F-shaped side legs 42 and 44 are also formed of stacks of laminations, all of the laminations preferably being stamped in a manner to produce a minimum of scrap, thereby giving rise to the shunt projections 46 suitably gapped at 48. The usual windows formed and the core assembly are maintained by clamping members 50 engaging the ends of the stacks of laminations and having (not shown) over the surfaces of the laminations.

As noted, the projections 46 and gaps 48 produce the required shunt 52 between the primary winding P and the first secondary winding S_1 . The second secondary winding S_2 is butted against the primary winding P although there may be an additional shunt provided between them if desired.

The particular version shown is a commercial structure. The laminations are drawn to scale, and the dimensions may be ascertained proportionally. The overall length of the central winding leg is 7 inches and the total width across all the laminations is 2.9 inches.

As will be seen, the various connections to the exterior of the canister are shown diagrammatically, since there usually will be terminal boards, terminals and other structure commonly used in constructing ballasts of this kind. Likewise there will be radio interference condensers and bleed resistors connected across the terminals of the condenser arrangement.

An ideal manner of constructing the delta condenser arrangement of FIG. 1 would be to use common condenser manufacturing techniques, winding the same by the use of multiple foils separated by layers of paper on a mandrel bringing out terminals from the respective foils to terminals of a header, inserting the assembly in a can, filling the same with insulating oil and sealing the same from the atmosphere.

A delta arrangement of condensers, the circuit diagram of which appears in FIG. 3 may be constructed of alternate layers of foil and insulating paper wound on a mandrel. FIG. 4 is a fragmentary view through a portion of such an arrangement shown in exaggerated proportions. The foils are numbered in accordance with the terminals of FIG. 3, and as will be seen since it is desired to have less capacitance and greater voltage between the terminals 14 and 20, a thicker layer or several layers of insulating material 60 are shown between foils 20 and 14. Thinner layers 62 and 64 are shown between the other combinations of terminals.

Almost any desired proportion of capacitance may be chosen by this simple method, and the foils wound with the use of ordinary winding techniques to produce a compact and highly effective arrangement.

FIG. 5 illustrates a circuit diagram of a modified form of ballast in which only the first secondary winding S_1 is used in the starting circuit. Reference may be made to Feinberg Patent 2,558,293 for the exact operation of

this structure but it is not materially different from that described above.

While it is preferred to use a delta connection of condensers constructed as an integral unit in accordance with the techniques of modern foil winding methods, the condensers C_1 , C_2 and C_3 may be independent components connected as described with the same results. It has been found that the integral delta arrangement in a single can will cost less to manufacture than a combination of three foils which would simply give two capacitors as taught in Patent 2,682,014, and yet the delta structure is effective to prevent lamp rectification without requiring extensive modification of ballast windings.

Variations are capable of being made without departing from the spirit and scope of the invention as defined in the appended claims.

What it is desired to secure by Letters Patent of the United States is:

1. In a device of the character described adapted seriatim to ignite and series operate a pair of gaseous discharge devices from an alternating current source and which comprises a three-winding transformer having a primary winding, a high leakage reactance first secondary winding and a second secondary winding, the windings adapted to be connected end to end in the order named, and in which electrical leads are provided for connecting one device in a conducting loop which includes at least said first secondary winding, said loop being connected exteriorly to terminals of the second secondary winding, and which loop is required to have a series capacitor therein and leads are provided for connecting the second device in a second conducting loop which includes at least both secondary windings series-connected therein, means for blocking the direct current resulting from abnormal operation of the second gaseous discharge device through the first secondary winding without affecting the normal operation of the apparatus which comprises a delta arrangement of three condensers presenting three terminals, two terminals connected respectively to the secondary windings between said windings, and the third terminal of said delta arrangement being connected to one of said leads adapted to connect with the first gaseous discharge device.

2. A structure as claimed in claim 1 in which the condensers have unequal capacitance and different voltage ratings.

3. A structure as claimed in claim 1 in which said delta is formed of one capacitive leg between the secondary windings, a second capacitive leg between the first secondary winding and said one lead and a third capacitive leg between the second secondary winding and said one lead, and in which the capacitance of the third leg is substantially less than the respective capacitances of the other two legs.

4. A structure as claimed in claim 3 in which the capacitances of the first two legs are equal.

5. A structure as claimed in claim 1 in which the delta is formed of one capacitive leg between the secondary windings, a second capacitive leg between the first secondary winding and said one lead and a third capacitive leg between the second secondary winding and said one lead, and in which the voltage rating of said third leg is substantially twice the voltage ratings of the other two legs.

6. Apparatus of the character described adapted to ignite and operate a pair of gaseous discharge devices from an alternating current source which includes a transformer having a primary winding, a first secondary winding in high leakage reactance relation to the first winding and a second secondary winding loosely coupled with the primary winding but closer coupled thereto than said first secondary winding, the transformer adapted to be connected with a pair of gaseous discharge devices in a series-start, sequence-operate circuit, the starting loop for the first device including at least the first secondary

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winding of said windings and excluding the second secondary winding, the second starting loop including at least both secondary windings, and the operating loop for both devices substantially excluding said first secondary winding, the first starting loop adapted to have a series starting capacitance and the operating loop adapted to have a series running capacitance, and said apparatus having means providing said capacitances while preventing excess current flow in said first secondary winding in the event of abnormal operation of the second gaseous discharge device, said means comprising a delta arrangement of three capacitors providing three terminals, the primary winding having one end thereof connected to one end of said first secondary winding, the second end of said first secondary winding being connected to a terminal of said delta arrangement, the second terminal of said delta arrangement being connected to one end of said second secondary winding, leads including one connected to the third terminal of said delta arrangement for connecting said one device in said first starting loop, and leads for connecting the second gaseous discharge device in said second starting loop.

7. Apparatus as claimed in claim 6 in which the leads of the first starting loop include one extending to the opposite end of the primary winding, and the leads of the second starting loop include one extending to the connection between the primary and first secondary winding.

8. A ballasting circuit for fluorescent lamps which is adapted to be connected to an alternating current source which comprises, a pair of fluorescent lamps, each having

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first and second filaments, a transformer having a primary winding and two secondary windings arranged on opposite physical sides of the primary winding respectively, with one secondary winding having a shunt between it and the primary winding, the primary winding having first and second terminals, the secondary windings having first and second terminals, the second terminal of the primary winding being connected to the first terminal of said one secondary winding, a delta arrangement of condensers having three terminals, the second terminal of the said one secondary being connected to one delta terminal, the first terminal of the second secondary being connected to the second delta terminal, one filament of the first lamp being connected to the third terminal of the delta, the second filament of the first lamp being connected to one of the first and second terminals of the primary winding, the first filament of the second lamp being connected to the second terminal of the second secondary winding, and the second filament of the second lamp being connected to the other of said first and second terminals of the primary winding.

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GEORGE N. WESTBY, *Primary Examiner.*

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,198,983

August 3, 1965

Albert E. Feinberg

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 4, line 51, after "would" insert -- only --;
column 5, line 4, for "C₁₄₋₂₀" read -- C₍₁₄₋₂₀₎ --; same column
5, line 27, after "having" insert -- fingers --.

Signed and sealed this 25th day of January 1966.

(SEAL)

Attest:

ERNEST W. SWIDER

Attesting Officer

EDWARD J. BRENNER

Commissioner of Patents