Dec. 20, 1960 D. LOVINGER 2,965,808

INDUCTIVE DEVICE

Filed July 23, 1959

2 Sheets-Sheet 1

Fig. 1.

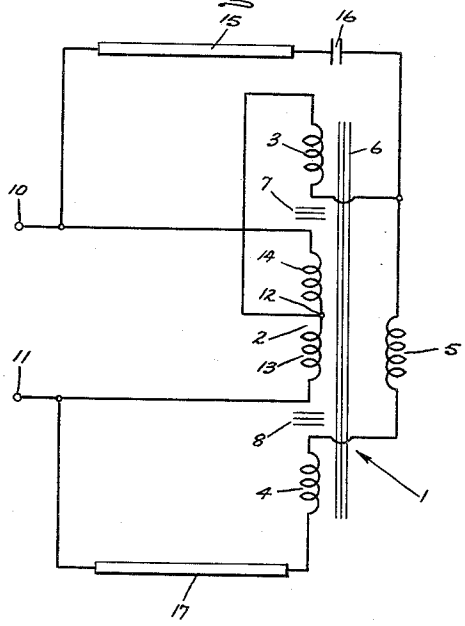
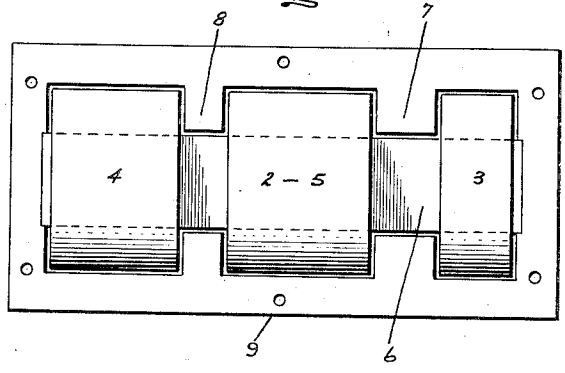


Fig. 2.



Inventor:
Daniel Lovinger;
by Andrew J. Boots
Attorney.

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Fig. 3.

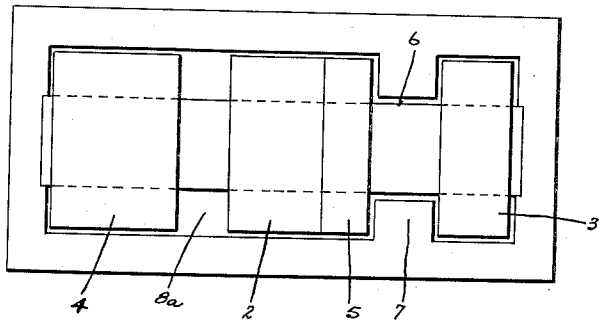


Fig. 4.

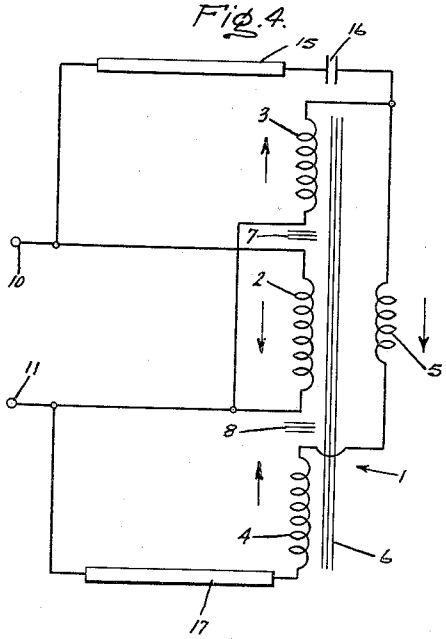
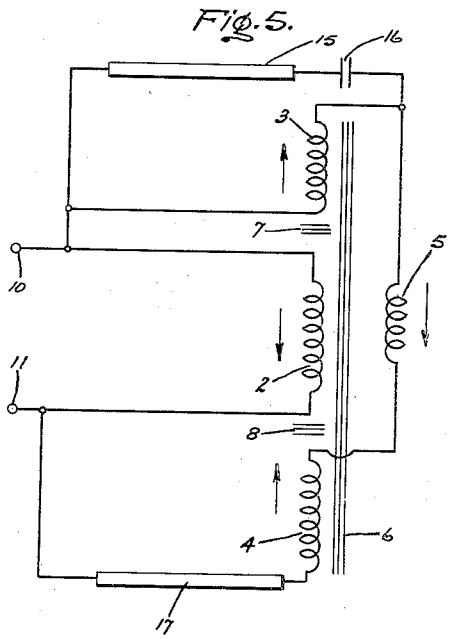


Fig. 5.



Inventor:
Daniel Lovinger,
by H. F. Manbeck, Jr.
Attorney.

United States Patent Office 2,965,808 Patented Dec. 20, 1960

2,965,808

INDUCTIVE DEVICE

Daniel Lovinger, Danville, Ill., assignor to General Electric Company, a corporation of New York

Filed July 23, 1959, Ser. No. 829,148

9 Claims. (Cl. 315—326)

This invention relates to inductive devices and more particularly to ballast apparatus for starting and operating gaseous discharge devices such as fluorescent lamps. It is concerned with an electrical circuit especially advantageous for the so called instant start type of lamp which requires an instantaneously high voltage sufficient to initiate the gaseous discharge in the lamp without the necessity of heating the elements thereof. Once the discharge has been initiated, it is required of the apparatus that current flow be limited for the reasons well known and inherent to gaseous discharge devices. This application is a continuation-in-part of my co-pending application Serial No. 789,701, filed January 28, 1959, now abandoned, and assigned to the same assignee as the present invention.

One popular form of ballast apparatus used with fluorescent lamps, and particularly with instant start lamps, is arranged for sequentially igniting and controlling the current to a pair of lamps connected in series circuit relation with each other. Such ballasts and circuits are described, for example, in United States Patent 2,358,810—Karash and in United States Patent 2,558,293—Feinberg. In such apparatus, an auxiliary high reactance element provides voltage for igniting one of the lamps and the resultant current through this ignited lamp functions in conjunction with other reactance elements in the circuit to ignite the other serially connected lamp. After both lamps are started, they are then operated by the apparatus in series circuit relation with the auxiliary high reactance element being substantially by-passed by the lamp current. For economy and simplicity, all of the desired inductive reactance elements are now generally provided by separate secondary windings on a unitary magnetic core structure forming a single high-reactance transformer in which the starting reactance or winding is arranged on one side of the primary winding and the ballasting reactance or winding is on the other side of the primary winding. This form of ballast apparatus is commonly known as a "series sequence" ballast. Besides this common arrangement, it has also been suggested, as for example in United States Patent 2,683,243—Feinberg, that a portion of the ballasting winding may be wound over the primary winding in additive voltage relation thereto for increasing the voltage applied to the lamps during their operation.

Difficulty has been experienced, however, in economically adapting the series sequence ballast design to "high-voltages," for example, to discharge devices operating from a 277 volt supply source. As is well-known, normal residential and commercial distribution voltage is in the range from 110 to 240 volts; industrial voltages are generally distributed at 220 to 480 volts. In a three phase 480 volt system, the line to neutral of the system is at approximately 277 volts, and there is presently a growing demand for lighting circuits to operate from 277 volt circuits.

Due to the limited demand for lamp systems operating on such high-voltages, it is not economical to design a

separate ballast core for the high-voltage ballasts. It is, therefore, desirable that the 277 volt input ballasts be designed on the 120 volt ballast cores. Without the voltage compensation as disclosed in the instant invention, the voltage in excess of 120 volts would then become a part of the normal operating circuit distorting the lamp balance.

One of the principal objects of my invention is to provide improved ballast apparatus for initiating the discharge of a pair of instant start fluorescent lamps and for thereafter operating the same, which is economically capable of being adapted to operate on high-voltage sources.

Another object of the invention is to provide an improved ballast apparatus which is arranged for energization from a high-voltage source, but may use the same magnetic core as ballast apparatus adapted for energization from a lower voltage source.

A further object is to provide an improved electrical system for igniting and operating a pair of gaseous discharge devices, which is particularly adapted for energization for a relatively high voltage source.

This invention comprises an improvement on the type of series sequence ballast apparatus described and claimed in the aforesaid Patents 2,358,810—Karash, 2,558,293—Feinberg and 2,683,243—Feinberg. As mentioned above, the series sequence ballasts commonly used today have all of their windings positioned on a single magnetic core. In particular, one popular ballast comprises an autotransformer having a primary, a loosely coupled first or auxiliary starting secondary having one side connected to one side of the primary and in additive voltage relationship thereto, and a loosely connected second or operating secondary more closely coupled to the primary than the first secondary and having one side connected to the other side of the first secondary and in opposing or bucking voltage relationship to the first secondary. One of the discharge devices with a capacitive reactor in series is connected across the primary and the first secondary, and the second of the discharge devices is connected across the first and second secondaries in series. It has been found, according to the present invention, that the above transformer may be modified for high-voltages in excess of the normal commercial and residential voltage by the addition of a third secondary coil closely coupled to the primary coil and bucking the combined terminal voltage of the primary coil and second or operating secondary. Also, according to the present invention, the closely coupled bucking coil may be advantageously used in a modification of this transformer in which the auxiliary starting secondary is connected in voltage opposing relationship to the primary and the lamps are connected respectively across the auxiliary winding and across the entire autotransformer in series with the capacitive reactor.

The invention together with additional objects and advantages will be best understood from the following description of specific embodiments thereof, when read in connection with the accompanying drawings, in which:

Fig. 1 is a schematic diagram illustrating one embodiment of my invention;

Fig. 2 is a plan view of an improved high reactance ballast transformer included in the embodiment of Fig. 1;

Fig. 3 is a plan view of an equivalent high reactance ballast transformer which may be used in the circuit of Fig. 1;

Fig. 4 is a schematic diagram showing another embodiment of my invention, this embodiment including a ballast transformer such as shown in Fig. 2 or Fig. 3; and

Fig. 5 is a schematic diagram showing a third embodiment of my invention, this embodiment likewise includ-

ing a ballast transformer such as shown in Fig. 2 or Fig. 3.

Referring to Figs. 1 and 2, a transformer 1, according to the present invention, includes a center winding leg 6 and an enclosing yoke 9. According to the instant invention, the transformer 1 has several independently formed windings on the center leg 6, including a primary winding 2, a first or auxiliary starting secondary 3, a second or operating secondary 4, and a third or voltage compensating secondary 5. The windings are in inductive relationship to the primary, all being wound on the common magnetic winding leg 6. The first secondary 3 and the second secondary 4 are both loosely coupled with the primary 2, due to their being spaced apart from the primary and by the addition, if desired, of magnetic shunts 7, 8 in the magnetic circuits, thereby both constituting high leakage reactance windings on the transformer. The first secondary 3, however, is what may be termed "very loosely" coupled to the primary, when comparing it to the second secondary 4 coupling; the second secondary 4 being more closely coupled to the primary than the first secondary 3. The third secondary 5 is closely coupled to the primary 2 and is preferably wound on top of the primary 2.

The primary winding 2 and the first secondary winding 3 are connected in the same electrical direction to provide additive voltage with respect to the first discharge device loop or starting loop (as hereinafter defined), while winding 4, comprising the second secondary, is connected in an opposite electrical direction to provide bucking or opposing voltage to the first secondary winding 3 and additive voltage to the primary 2 with respect to the normal operating loop including both the discharge devices. The third secondary 5 is wound to provide bucking or opposing voltage with respect to the second secondary 4. The primary winding 2 is adapted to have its ends 10, 11 secured to a source of voltage (not shown) and contains a tap 12 dividing it into first and second winding portions 13, 14. One end of the first secondary 3 is connected to the tap 12 placing the portion 14 and the first secondary 3 in autotransformer relation having additive voltages. The second secondary 4 and third secondary 5 are serially connected in opposing or bucking voltage relation; one end of the third secondary 5 is connected to the second end of the first secondary 3.

The portion 14 of the primary winding 2 and the first or auxiliary starting secondary 3 are adapted to have a first discharge device or lamp 15 connected in parallel therewith between one end of the primary 2 and the second end of the first secondary 3. A capacitive reactor or condenser 16 is in series with the discharge lamp 15 across portion 14 and the first secondary 3. The transformer is further adapted so that a second discharge device or lamp 17 can be connected between the second secondary 4 and the other end of the primary 2.

In this manner, a starting loop or circuit including the first discharge device is composed of the portion 14 of the primary winding 2, the first secondary 3, a capacitive reactance 16, and the first discharge device 15 in series, as well-known in the art and as more fully described in the above referenced Feinberg patent, 2,583,293. Because of the loose coupling of the auxiliary starting secondary 3, it produces very little operating current, therefore, the operating loop or circuit of the system consists of the first discharge device 15, the capacitive reactance 16, the third secondary 5, the second or operating secondary 4, and the second discharge device 17, all serially connected across the source.

As can be readily appreciated, where the source voltage is higher than the normal 120 volt commercial and residential voltage, for example, as the above-mentioned 277 volt high-voltage, the voltage across this operating circuit, without modification, would exceed the normal operating voltage thereby distorting the lamp balance; however, according to the instant invention, the provision of the bucking voltage produced by the third secondary 5 opposing the voltage generated by the second or operating secondary 4 permits normal operation of the lamp circuit as it is not necessary to sacrifice second secondary 4 reactance. It may not always be necessary to add the full difference between the normal commercial and residential voltage of 120 volts and whatever the high-voltage may be, as, in this case, 277 volts; still an appreciable amount of voltage should be produced in the third or bucking secondary 5. A successful embodiment of the apparatus as described above has been built wherein this bucking voltage amounts to 120 volts.

Referring now to Fig, 3, I have shown therein an inductive or ballast transformer 1*a* which includes generally the same windings as the transformer 1 and which produces the same operating results. Equivalent parts of the transformer 1*a* are identified by the same reference numbers as are used in Figs. 1 and 2. In the transformer 1*a*, the closely coupled secondary 5 is positioned immediately beside the primary 2 on the winding leg 6 instead of being wound over the primary. It will be understood that this positioning of the secondary 5 results in it being more closely coupled to the primary 2 than either of the operating and starting secondaries 3 and 4, both of which are positioned more remote from the primary on the winding leg 6.

As shown, the first or starting secondary 3 is positioned adjacent one end of the winding leg 6 spaced from the third secondary 5 and with a flux leakage path or shunt 7 formed between it and the third secondary 5. The leakage path 6 is formed by oppositely disposed projections on the yoke 9 which project inwardly toward the winding leg 6, with an air gap between them and the winding leg at their inner ends. With this arrangement, the starting secondary 3 is loosely coupled to the primary 2, having a rather high leakage reactance. The other or operating secondary 4 is positioned on the opposite end of the winding leg with a flux leakage path or shunt 8*a* formed between it and the primary 2. With this arrangement, the winding 4 is also a high reactance winding, loosely coupled to the primary 2, but its arrangement is such that it is more closely coupled to the primary than the starting secondary 3. It will be understood, incidentally, that the present invention is not limited to any particular arrangement for providing flux leakage paths or shunts between the primary 2 and the secondaries 3 and 4 since depending upon the design of the transformer, either air leakage paths or projections on the core may be used to provide the desired flux leakage arrangements. Whatever arrangement is used, however, the starting secondary 3 will be more loosely coupled to the primary than the operating secondary 4.

The windings of the transformer 1*a* may be connected, in one embodiment of my invention, in the circuit of Fig. 1, and they operate therein in autotransformer relationship in the same manner as the identically numbered windings of the transformer 1. As described above, in this embodiment the primary 2 is provided with a tap 12, and a series starting loop is formed for the lamp 15 comprising the portion 14 of the primary, the starting secondary 3, the capacitive reactor 16, and the lamp 15 itself. In this starting loop the starting secondary 3 is connected so that its open circuit voltage is additive to that of the portion 14 of the primary, whereby sufficient voltage is provided for starting the lamp 15.

After the lamp 15 has started, current now flows in the first starting loop including lamp 15, and since the inductance reactance of the very loosely coupled starting secondary 3 is great compared to the capacitive reactance of the reactor 16, the current of such circuit is lag-

ging. The lagging current flow caused by the ignition of the first lamp 15 gives rise to reactive voltage in the starting secondary 3 whose phase is in effect reversed relative to the phase of the voltage in the primary 2 and hence is additive relative to the voltage induced in the operating secondary 4. Although winding 5 provides a bucking voltage to the voltage induced in the operating secondary 4, the resultant combined voltage appearing across lamp 17 is of sufficient magnitude to ignite lamp 17. This voltage is, of course, applied by the series loop comprising the lamp 17 itself, the operating secondary 4, the bucking secondary 5, the starting secondary 3, and the portion 13 of the primary, in which loop, all the voltages are then generally additive except for the bucking secondary 5. Lamps 15 and 17 are thereby started sequentially. Because of the very loose coupling of the auxiliary starting secondary 3, it produces very little operating current, and being of high reactance, it is generally by-passed by the steady lamp current. The operating loop or circuit of the system thus consists of the first discharge lamp 15, the capacitive reactor 16, the third secondary 5, the second or operating secondary 4, and the second discharge lamp 17, all serially connected across the source or primary 2.

During the normal series operation of the lamps, the closely coupled secondary 5 of the transformer 1*a* operates in the same manner as the equivalent secondary in the transformer 1 to reduce the voltage in the lamp operating circuit to the desired amount for proper lamp operation, without affecting the inductive ballasting reactance in the circuit. In other words, the provision of the bucking secondary 5 allows the operating or ballasting secondary 3 to include the proper number of winding turns for the desired amount of inductive ballasting, even though those turns produce more generated voltage than is desirable. Without the bucking voltage of the winding 5 it would be necessary to sacrifice winding turns in the operating secondary 4, which would, of course, reduce its inductive reactance, but would also adversely affect the lamp current and the lamp operating characteristics.

Fig. 4 illustrates an embodiment of the instant invention, generally similar to the embodiment of Fig. 1, but wherein the full primary voltage is used in the first starting loop of the lighting system. The same numbers are used to designate the equivalent parts of the two embodiments. The embodiment of Fig. 4 includes a transformer, such as the autotransformer 1 or 1*a*, having a magnetic core 6 including a primary winding 2, a first or auxiliary starting secondary 3, a second or operating secondary 4 and a third or voltage compensating secondary 5 formed on the core. The windings are in inductive relationship to the primary all being wound on winding leg 6 of a common magnetic core. The operating secondary 4 and the starting secondary 5 are both loosely coupled with the primary 2 due to the provision of flux leakage paths or shunts 7, 8 in the magnetic circuit between the secondary windings 3 and 4 and the primary winding 2. As heretofore explained, the leakage reactance paths 7, 8 may, depending upon the design of the transformer, be formed of magnetic material as illustrated by shunt 7 in Fig. 3 or may be formed of an air leakage path as shown at 8*a* of Fig. 3. The starting secondary 3 is what may be termed "very loosely" coupled to the primary 2, when comparing it to the operating or ballasting secondary 4, the operating secondary 4 being more closely coupled to the primary winding than the first secondary 3. The third secondary 5 is closely coupled to the primary 2 and, as shown in the transformer of Fig. 2, is preferably wound on top of the primary 2. It may, however, be spaced immediately beside the primary winding 2 with little flux leakage therebetween and in this manner be relatively closely coupled to the primary winding 2, as illustrated in Fig. 3.

The primary winding 2 and the first secondary 3 are connected in the same electrical direction to provide additive voltage with respect to the first discharge lamp or starting loop (as hereinafter defined) while the second operating secondary 4 is connected so that it supplies opposing voltage to the open circuit voltage of the starting secondary 4 in a loop including both secondaries. The operating secondary 4 is, however, connected in voltage additive relation to the primary 2 in autotransformer relationship therewith in the normal operating loop including both the discharge lamps. The third secondary winding 5 is wound and connected to provide bucking or opposing voltage with respect to the second or operating secondary 4. The arrows next to the various windings indicate the direction of the open circuit voltages across the windings prior to current flow in the apparatus.

The primary winding 2 is adapted to have its end or input leads 10, 11 connected to a source of voltage (not shown). Leads are provided for connecting the first lamp 15 and a capacitive reactor 16 in series across the primary winding 2 and the starting secondary winding 3 to provide a first starting loop. The open circuit additive voltages of the primary 2 and the starting secondary 3 are sufficient to ignite lamp 15.

Leads are provided for connecting the second lamp 17 across all of the secondary windings to form a starting loop for it. Starting at line 11, this loop comprises the second lamp 17 itself, the operating secondary 4, the bucking secondary 5 and the starting secondary 3. After ignition of the first lamp 15, but prior to the starting of the second lamp 17, a phase shift occurs in the starting secondary 3 due to the lagging current drawn therethrough, whereby its voltage becomes generally additive to that of the operating secondary 4 in this loop. Although the third secondary winding 5 provides a bucking voltage to that of the operating secondary winding 4, the combined open circuit voltage of the secondary 4 and the additive voltage component of the starting secondary 3 are much greater than the voltage of the secondary 5 so that sufficient voltage is supplied to lamp 17 to start the lamp. Once the lamp 17 has started, the lamps 15 and 17 are operated in a series circuit operating loop comprising the first lamp 15, the capacitive reactor 16, the bucking secondary 5, the operating or ballasting secondary 4, the second lamp 17 and the source or primary winding 2. While the voltage of the third secondary 5 is bucking or opposing the voltage of the primary 2 and the operating secondary 4, sufficient voltage is provided by the primary 2 and the second or operating secondary 4, whereby the lamps operate satisfactorily in the series circuit. Due to the high reactance of the starting secondary 5 it is generally by-passed by the lamp current and does not contribute to any considerable extent to the steady state operation of the lamps.

As can be readily appreciated, where the source voltage is higher than the normal 120 volt commercial and residential voltage, for example, as the above-mentioned 277 volt high-voltage, the voltage across the operating circuit or loop, without modification, would exceed the proper lamp operating voltage thereby distorting the lamp balance. However, according to the instant invention, the provision of the buckling voltage produced by the third secondary 5, opposing the combined voltage generated by the second or operating secondary 3 and the voltage of the source or primary 2, permits the proper operation of the lamp circuit; it is not necessary to remove winding turns from the operating or ballasting secondary winding 4 and thereby sacrifice reactance in the operating secondary 4. The bucking secondary, in other words, reduces the voltage in the lamp circuit to the correct amount without reducing the inductive ballasting reactance in the operating circuit.

Fig. 5 illustrates still another embodiment of the instant invention, generally similar to the other embodiments except that none of the primary voltage is included in the first starting loop. The same numbers are used to designate equivalent parts to those appearing in the

other embodiments. In Fig. 5, one end of the first or starting secondary winding 3 is connected to one end 10 of the primary winding 2, but the windings are connected in bucking or opposing open circuit voltage relationship. The first or starting secondary winding 3 is also arranged with its open circuit voltage in bucking voltage relation to the operating secondary 4. As in the other embodiments, the third secondary winding 5 is connected in bucking voltage relation with the operating secondary winding 4.

The arrows next to the various windings indicate the direction of the open circuit voltages across the windings prior to current flow in the apparatus. Leads are provided for connecting the first discharge lamp 15 and a capacitive reactor 16 in series circuit relation across the starting secondary 3. When the primary winding 2 is energized, the open circuit voltage induced in the first secondary 3 is sufficient to start lamp 15. As heretofore explained, a phase shift then occurs in the starting secondary 3 due to the lagging current flowing therein, with a reactive component of the resultant voltage being additive to the voltage induced in the operating secondary 4. As a result of this additive component, enough voltage is then applied across the second lamp 17 to start it. Specifically, the reactive voltage across the starting secondary 3 adds to the voltages of the operating secondary 4 and the source or primary 2 to start the lamp. The starting loop comprises the lamp 17 itself, the operating secondary 4, the bucking secondary 5, the starting secondary 3 nad the primary 2 or the source; and even though the third secondary winding 5 provides a bucking or opposing voltage to the other voltages, the resultant voltage across lamp 17 is now sufficient to start the lamp.

Once lamp 17 starts the operating loop includes the first lamp 15, the capacitive reactor 16, the third secondary winding 5, the second or operating secondary winding 4, the second lamp 17 and the source or primary 2. Even though the voltage induced in the third secondary 5 is bucking or opposing the voltages of the primary 2 and the operating secondary 4, the resultant voltage in the loop is sufficient that the lamps 15 and 17 are operated thereby. The starting secondary 5, as in the other embodiments, is generally by-passed by the lamp current during steady state operation because of its high reactance.

As heretofore explained, where the source voltage is higher than the normal 120 volt commercial and residential voltage, for example, as the above-mentioned 277 volt high voltage, the voltage in the operating circuit, without the addition of the bucking voltage of the third secondary 5, would exceed the normal operating voltage needed for the lamps, thereby distorting the lamp balance. The provision of the bucking voltage produced by third secondary winding 5, according to the instant invention, permits normal operation of the lamp circuit; it is not necessary to sacrifice operating secondary reactance by the removal of turns from the operating or ballasting secondary 4. The voltage of the secondary 5 reduces the total voltage in the operating circuit to the desired amount without reducing the inductive ballasting reactance and thereby provides for efficient lamp operation.

It will be seen that in all of the illustrated embodiments, an advantageous ballast apparatus is provided for use with a relatively high source of voltage. In all the embodiments, the ballast transformer may utilize the same magnetic core as is used for the higher volume 110–120 volt ballasts, whereby it may be produced without the design, tooling and other expense necessary for a special core. The provision of the bucking winding, whereby the lamp operating voltage is reduced without any sacrifice of the inductive ballasting reactance, thus not only results in a ballast giving efficient lamp operation but also in a relatively inexpensive ballast.

In accordance with the Patent Statutes, I have described what at present are considered to be the preferred embodiments of my invention. However, it will be obvious to those skilled in the art that various changes and modifications may be made in the disclosed structure without departing from my invention, and it is, therefore, aimed in the appended claims to cover all such changes and modifications as fall within the true spirit and scope of my invention.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. A ballast transformer for sequentially initiating and operating a pair of gaseous discharge lamps in a series operating circuit from a source of high-voltage supply comprising a primary winding, a first high-reactance secondary winding, a second high reactance secondary more closely coupled to said primary than said first secondary, and a third secondary closely coupled to said primary, said primary having a tap dividing it into a first and a second winding portion, one end of said first secondary being connected to said tap in voltage aiding relation to said primary, said third secondary and said second secondary being serially connected in opposing voltage relation, one end of said third secondary being connected to the second end of said first secondary, means for connecting a capacitive reactance and a first discharge lamp between said second end of said first secondary and one end of said primary, means for connecting a second discharge lamp between said second secondary and the other end of said primary, said reactance of said first secondary being sufficient to cause said first secondary winding to be substantially isolated from the series operating circuit and means for connecting said primary across a voltage source.

2. Ballast apparatus for igniting and operating a pair of gaseous discharge lamps from a relatively high voltage source, comprising a multiple winding transformer including a magnetic core having mounted thereon a primary winding, a first high reactance secondary winding loosely coupled to the primary winding, a second high reactance secondary winding loosely coupled to the primary winding but more closely coupled thereto than said first secondary winding, and a third secondary winding closely coupled to said primary winding, said first secondary winding being connected at one end to said primary winding and at its other end to one end of said third secondary winding, said second secondary winding being connected to the other end of said third secondary winding, with said third secondary winding being connected in voltage bucking relationship to said second secondary winding, means for connecting one of said lamps across windings of said transformer including at least said first secondary winding and excluding said second and third secondary windings for igniting said one lamp, means for connecting the second of said lamps across windings of said transformer including at least all the secondary windings for igniting said second lamp, and means for connecting both of said lamps in a series operating circuit with said second and third secondary windings across said primary winding for operating said lamps after the sequential ignition thereof, said reactance of said first secondary being sufficient to cause said first secondary to be substantially isolated from said series operating circuit whereby said lamps are operated in series and said third winding reduces the operating voltage applied to said lamps without substantially affecting the inductive ballasting reactance in said operating circuit.

3. Ballast apparatus for starting and operating a pair of gaseous discharge lamps from an alternating current source, comprising a multiple winding transformer having a primary winding for connection to said alternating current source, a ballasting secondary winding loosely coupled to said primary winding, a starting secondary winding loosely coupled to said primary winding, and a third secondary winding closely coupled to said primary wind-

ing, means for connecting a part of said transformer including at least said starting secondary winding for applying igniting voltage to one of said lamps, said ballasting winding and said third winding being serially interconnected for connection with both of said lamps across said primary to form a series operating circuit for said lamps, said starting secondary winding having a reactance sufficient to cause said starting secondary winding to be substantially isolated from said series operating circuit when both of said lamps are ignited, and said third winding being connected in voltage bucking relation to said ballasting winding in said operating circuit thereby to reduce the operating voltage applied to said lamps.

4. Ballast apparatus for starting and operating a pair of gaseous discharge lamps from an alternating current source, comprising a multiple winding transformer having a primary winding for connection to said alternating current source, a ballasting secondary winding loosely coupled to said primary winding, a starting secondary winding loosely coupled to said primary winding, and a third secondary winding closely coupled to said primary winding, a capacitive reactor, a part of said transformer including at least said starting winding being connected to apply igniting voltage across said capacitive reactor and one of said lamps, said ballasting winding and said third winding being serially connected with at least said starting winding for applying igniting voltage to the other of said lamps and being arranged for series connection with both of said lamps and said capacitive reactor across said primary winding to form a series operating circuit for said lamps, said starting secondary winding having a reactance sufficient to cause said starting winding to be substantially isolated from said series operating circuit when said lamps are ignited and said third winding being connected in voltage bucking relation to said ballasting winding in said operating circuit thereby to reduce the operating voltage applied to said lamps without substantially affecting the inductive ballasting reactance in said circuit.

5. Ballast apparatus for starting and operating a pair of gaseous discharge lamps from an alternating current source, comprising a multiple winding transformer having a primary winding for connection to said alternating current source, a ballasting secondary winding loosely coupled to said primary winding, a starting secondary winding more loosely coupled to said primary winding than said ballasting winding, and a third secondary winding closely coupled to said primary winding, a capacitive reactor, said primary winding and said starting winding being connected in additive voltage relation to apply igniting voltage across said capacitive reactor and one of said lamps, said ballasting winding and said third winding being serially connected with said starting winding for applying starting voltage to the other of said lamps and being arranged for series connection with both of said lamps and said capacitive reactor across said primary winding to form a series operating circuit for said lamps, said starting winding having a reactance sufficient to cause said starting winding to be substantially isolated from said series operating circuit when said lamps are ignited and said third winding benig connected in voltage bucking relation to said ballasting winding in said operating circuit thereby to reduce the operating voltage applied to said lamps without substantially affecting the inductive ballasting reactance in said circuit.

6. Ballast apparatus for starting and operating a pair of gaseous discharge lamps from an alternating current source comprising a multiple winding transformer having a primary winding for connection to said alternating current source, a ballasting secondary winding loosely coupled to said primary winding, a starting secondary winding more loosely coupled to said primary winding than said ballasting winding, and a third secondary winding closely coupled to said primary winding, a capacitive reactor, said starting winding being connected to apply igniting voltage across said capacitive reactor and one of said discharge devices, said ballasting winding and said third winding being serially connected with said starting winding and said primary winding for applying starting voltage to the other of said lamps and being arranged for series connection with both of said lamps and said capacitor reactor across said primary winding to form a series operating circuit for said lamps, said starting winding having a reactance sufficient to cause said starting winding to be substantially isolated from the series operating circuit after said lamps are ignited and said third winding being connected in voltage bucking relation to said ballasting winding in said operating circuit thereby to reduce the operating voltage applied to said lamps without substantially affecting the inductive ballasting reactance in said circuit.

7. Ballast apparatus for sequentially igniting and operating a pair of fluorescent lamps from a relatively high voltage alternating current source, comprising a transformer having a magnetic core with an elongated winding leg and an outer yoke member, a high reactance starting secondary winding, a high reactance ballasting secondary winding, a primary winding and a third secondary winding all located on said winding leg, with said third secondary winding being closely coupled to said primary, a capacitive reactor connected in series circuit relation with said ballasting winding and said third secondary winding for interconnection with both of said lamps across said primary to form a series operating circuit, said starting secondary winding having a reactance sufficient to cause said starting winding to be substantially isolated from said series operating circuit after said lamps are ignited, said third winding being connected in voltage bucking relation to said ballasting winding in the series connection with said capacitive reactor, and said starting winding being connected from one side of said primary winding to the juncture between said capacitive reactor and the serially connected ballasting and third secondary windings.

8. The apparatus of claim 7 wherein said third winding is wound over said primary winding, said ballasting winding and said starting winding are disposed on opposite sides of said primary winding and magnetic shunts are formed on said yoke between said primary winding and said ballasting and starting windings.

9. The apparatus of claim 7 wherein said ballasting winding, said primary winding, said third secondary winding and said starting winding are located on said winding leg in the order named, with said third winding being located immediately adjacent said primary winding, and with a projecting magnetic shunt formed on said yoke member between said third secondary winding and starting winding.

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