

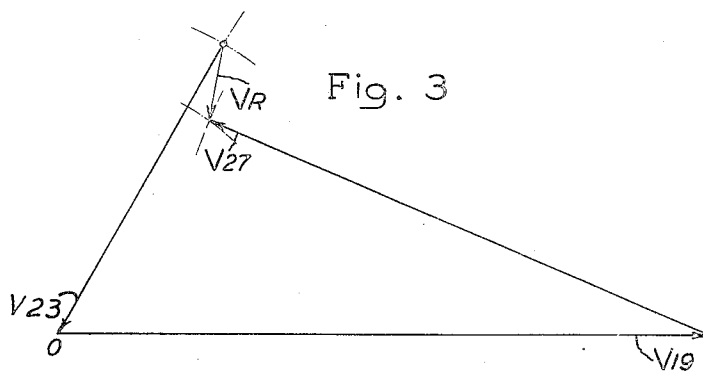
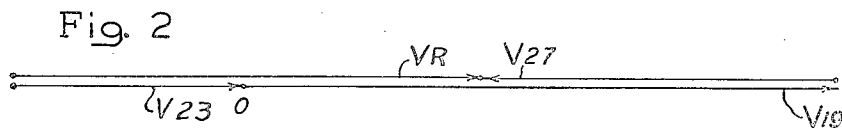
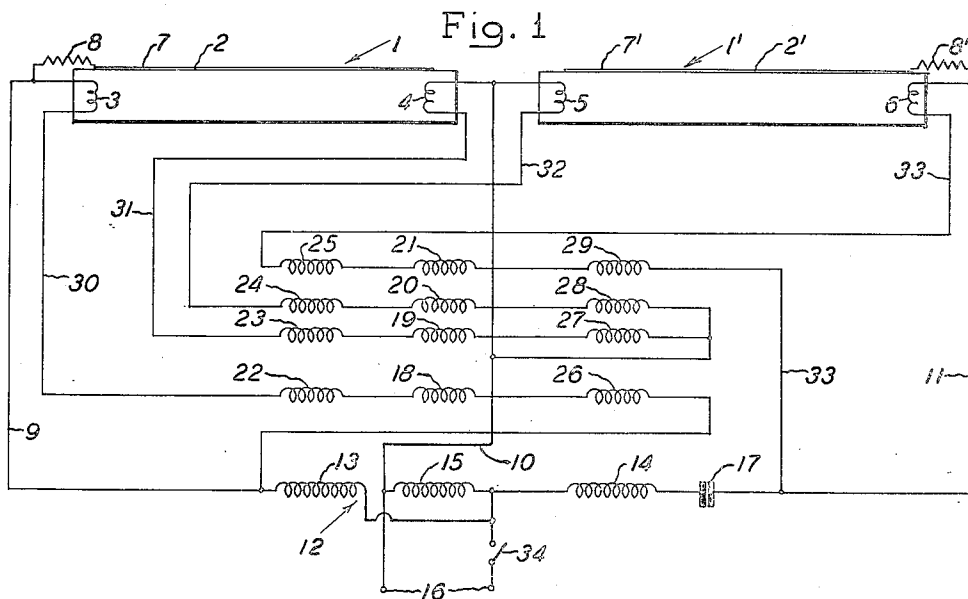
April 18, 1950

E. LEMMERS ET AL
STARTING AND OPERATING CIRCUIT FOR
ELECTRIC DISCHARGE DEVICES

2,504,549

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2 Sheets-Sheet 1



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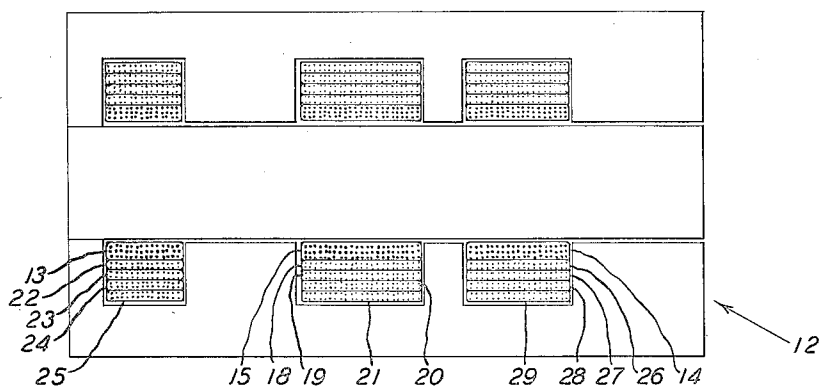
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Fig. 4



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UNITED STATES PATENT OFFICE

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STARTING AND OPERATING CIRCUIT FOR
ELECTRIC DISCHARGE DEVICES

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15 Claims. (Cl. 315—278)

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This invention relates generally to circuits for electric discharge devices and more particularly to an improvement in the starting and operating circuits for electric discharge devices or lamps such as low pressure positive column lamps.

Circuits now in wide use with fluorescent lamps are provided with means for heating the filamentary electrodes and for impressing a high voltage for short duration across the electrodes for starting an electrical discharge therebetween. Means are provided to delay the application of the high voltage until the electrodes have reached the desired electron emitting temperature. In prior art arrangements the delay means or switch requires careful design, periodic replacement, relatively slow starting occasioned by the preheating period, and varying operating characteristics with age.

In the "instant start" circuit arrangements, switches are usually dispensed with; however, the transformer voltage necessary to supply potential great enough to break down the gas column between the electrodes is over and above that necessary for lamp operation. In addition, there is a relatively high voltage gradient at the cathodes during starting without preheating of the activated electrodes, which shortens electrode life.

An object of our invention is to provide a new and improved circuit for starting and operating electric discharge devices employing filamentary electrodes.

Another object of our invention is to provide a new and improved means for impressing starting and operating voltages across filamentary electrodes of an electric discharge device which will vary in phase and magnitude in accordance with the state of ionization of the discharge medium.

Further features and advantages of our invention will appear from the following description of species thereof. For a better understanding of our invention reference may be had to the following description taken in connection with the accompanying drawings and its scope will be pointed out in the appended claims. Fig. 1 is a diagrammatic view of an electric discharge device and a starting and operating circuit therefor incorporating our invention. Fig. 2 illustrates vectorially starting characteristics of the circuit illustrated in Fig. 1. Fig. 3 illustrates vectorially operating characteristics of the circuit illustrated in Fig. 1. Fig. 4 is a diagrammatic representation of a transformer embodying certain features of our invention.

Referring to Fig. 1, electric discharge devices

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1, 1', such as fluorescent lamps, therein illustrated comprise elongated tubular or cylindrical envelopes 2, 2' having sealed into the ends thereof filamentary electrodes 3, 4 and 5, 6, respectively, each herein illustrated as comprising a coil, preferably in the form of a coiled coil of tungsten wire activated with oxides of alkaline earth metals such as a mixture of barium and strontium oxides. The envelopes 2, 2' contain gaseous atmospheres such as a rare gas like krypton, neon, argon or mixtures thereof at a pressure of a few millimeters and a small quantity of mercury which, during operation of the lamps, has a low pressure of the order of ten microns. The devices 1, 1' may be low pressure positive column lamps of the fluorescent type provided with a suitable phosphor or fluorescent coating. This fluorescent coating upon excitation by the radiation produced by an electric discharge between the electrodes, transforms the shorter-wave radiation due to the discharge into longer wave radiation such as radiation within the visible range. For use of starting, stripes or strips 7, 7' of conductive material which for example may be a metallic paint or graphite mixed with potassium silicate, may be applied to the surface of devices 1, 1'. Each starting strip may be connected to one or both of the electrodes. It may be desirable, as set forth and claimed in application Serial No. 671,189, filed May 21, 1946, now abandoned, and which is assigned to the assignee of this application, to connect the starting strips 7, 7' through resistances, inductors, or capacitances having relatively large predetermined values of the order of megohms, to one or both filamentary electrodes of each lamp in order to reduce the starting voltage required to initiate an arc discharge between the electrodes and to reduce or completely eliminate personnel shock hazard incident to the presence of starting strips 7, 7' on the exterior surface of the envelopes. These separate or individual impedance 8, 8' may be resistances ranging in values of from one to ten megohms and preferably from two to eight megohms for application to 40 watt size fluorescent lamps. The starting strip and associated impedance is a starting aid and is not required with all types of lamps for the successful operation of our invention.

The lamps and connected circuits forming a lagging power factor load circuit 9, 10 and a leading power factor load circuit 10, 11, are connected across a suitable source of potential, preferably a voltage step-up auto-transformer 12 in which a pair of secondary windings 13 and 14 serving as ballasts for devices 1, 1', respectively,

are coupled loosely to the power source or primary winding 15 by means of leakage reactance. The auto-transformer primary winding 15 in turn is connected across a source of power 16 which, for example, may be 115 volt, 60 cycle supply circuit. The usual capacitor 17 is added to the lead circuit to effect phase correction in the two lamp circuit.

In accordance with our invention starting and operating voltages may be impressed across the filamentary electrodes of an electric discharge device by three sources of voltage having one predetermined phase position to provide a resultant voltage of predetermined magnitude to assist in the starting operation of an electric discharge device or lamp, and which vary in phase, or vary in phase and magnitude to produce a substantial reduction in the voltage upon and after establishment of an arc discharge in the lamp. For example we may employ three windings producing voltages at least one of which differs in phase from the voltage of the others. This potential source, for example, may be an auto-transformer with the primary winding section serving as one source of voltage, and a pair of secondary winding sections serving as the other two sources of voltage. The phase relationships of these winding sections vary with the state of ionization of the medium in the lamps as hereinafter explained. Thus, by using induced voltages from three different sources of voltage or flux varying in phase relationship in accordance with the ionization of the discharge medium, or the current incident thereto, selective control of electrode energization can take place in the heating circuits by proper proportioning and phasing between the three induced voltages. By control of the relative magnitudes and phases of these induced voltages, we can reduce the resultant electrode voltages to a very low value, or to substantially zero, in response to the state of ionization of the medium through which the arc discharge takes place or in response to an electrical condition such as the current conducted by the lamps. This reduction in voltage or bucking action may be accomplished by using a means responsive to the flow of current, such as a means responsive to the lamp current. Therefore, we provide a plurality of tertiary coils or windings 18, 19, 20 and 21 on the core of auto-transformer 12 and inductively coupled to the transformer's primary winding section 15; coils or windings 22, 23, 24 and 25 on the core of auto-transformer 12 are inductively coupled to the transformer's secondary winding section 13; and coils or windings 26, 27, 28 and 29 on the core of auto-transformer 12 are inductively coupled to the transformer's secondary winding section 14. The filamentary electrodes, in this case, are each connected in series with windings inductively coupled to the primary winding section 15 of the auto-transformer 12, and secondary winding sections 13 and 14. Thus, electrodes 3, 4, 5 and 6 are connected in series with inductively coupled auto-transformer windings 22, 18 and 26; 23, 19 and 27; 24, 20 and 28; and 25, 21 and 29; respectively, and comprise the starting and electrode control or heating circuits 9—30, 10—31, 10—32 and 11—33, respectively.

By considering each filamentary electrode heating circuit as a single unit, proper initial and substantially instantaneous heating current is supplied by the windings in series therewith during starting, and is automatically removed by the bucking or neutralizing action of these windings

upon initiation of an arc discharge and during operation of the lamps. In order to control the energization of the electrodes, proper phase relationship is necessary. For example, a ballast or auto-transformer 12 may be constructed wherein four electrode heating windings, consisting of the same total number of turns, supply the necessary voltages. Each heating section, for example, may have a total of 173 turns of wire on the transformer core of which 41 may be wound over the secondary winding section 13, 76 turns of wire wound over the auto-transformer primary winding section 15, and 56 turns of wire wound over the secondary winding section 14. The coils or windings serving electrode 3 and electrode 5 may be wound in the following manner: the windings 22 and 24 are wound over the secondary winding section 13 of the auto-transformer 12 in the opposite direction to that of secondary winding section 13; the winding sections 18 and 20 are wound over the primary winding section 15 of the auto-transformer 12 in the same direction as the auto-transformer's primary winding section 15; and the winding sections 26 and 28 for the above electrodes 3 and 5 are wound over the secondary winding section 14 of the auto-transformer 12 wound in the reverse direction to the secondary winding section 14. The secondary winding section 13 of the auto-transformer 12, however, is wound in the reverse direction to the primary winding section 15 and the secondary winding section 14 of the auto-transformer 12. The heating sections serving electrodes 6 and 4 may be wound on the transformer core exactly in reverse to that of the above mentioned electrode windings for electrodes 3 and 5.

When switch 34 is closed, power is supplied to the auto-transformer 12, and its associated inductively coupled windings are energized. Cathode heating current, sufficient for raising the temperature of the electrodes of each discharge device to produce electron emission and to facilitate breakdown of the positive column therebetween is supplied thereto. A proper voltage for starting an arc discharge between the filamentary electrodes is also provided therebetween. Before an arc discharge occurs in lamps or devices 1 and 1' the induced voltages in each inductively coupled winding of a particular heating circuit, for example, control or heating circuit 10—31, is either in phase or 180° out of phase with the voltages of the other inductively coupled windings of that heating circuit. Fig. 2 illustrates vectorially the phase relationship and magnitudes of the induced starting voltages in the windings of heating circuit 10—31. V_{19} represents the induced voltage of winding 19; V_{27} represents the induced voltage of winding 27; and V_{23} represents the induced voltage of winding 23. Thus, the resultant voltage V_R is that voltage supplied to the control or heating circuit 10—31 for impressing across the filamentary electrode 4 a voltage for raising the electrode temperature to facilitate breakdown of the positive column in the lamp and for starting an arc discharge between the electrodes. For example, the induced voltage $V_{19}=11.9$ volts; $V_{27}=7.1$ volts; $V_{23}=5$ volts and in the phase relationship indicated in Fig. 2. The resulting voltage $V_R=9.8$ which is applied across the filamentary electrode 4 for heating purposes.

After the arc discharge has been established the magnitudes and phase relationship between the induced voltages of the control or heating

circuit 10—31 change. As indicated in Fig. 3, the resultant voltage V_R may be substantially reduced to a predetermined operating value by proper proportioning and phasing of the three induced voltages of the control or heating circuit 10—31. Perfect bucking or neutralization is difficult to obtain because of the potential drop caused in the lamp filamentary electrode by the phase and magnitude of its arc current. The resultant voltage V_R , however, is small enough to be negligible. Perfect correlation between the voltages of the windings to obtain substantially zero operating voltage during lamp conduction is not necessary for the successful operation of the circuit. In fact, a small amount of additional cathode heat is sometimes desirable during operation of the lamp to lower cathode voltage or arc drop.

It is possible that the heating of one of the electrodes of each lamp may be dispensed with. In that event, one heating circuit may be eliminated and the electrode associated therewith short-circuited.

Fig. 4 is a diagrammatic representation of a transformer described in application Serial No. 690,855 of Charles W. Kronmiller, filed August 16, 1946, which is assigned to the assignee of this application and which may embody the heating and bucking windings comprising our invention.

One aspect of our invention relates to a further improvement of devices of this nature wherein additional means or windings are provided to furnish variable magnitude and variable phase voltages which may be utilized to control selectively the energization of associated load circuits, such as filamentary electrodes, in response to a predetermined electrical quantity such as the arc current of an electric discharge device.

In accordance with our invention, we provide a new and improved means for impressing a starting and operating voltage across the filamentary electrodes of an electric discharge device which will vary in phase and magnitude in accordance with the state of ionization of the discharge medium, or which may vary in accordance with or in response to an electrical quantity such as lamp current. Accordingly, we provide a means for heating the filamentary electrodes and, after an arc discharge occurs in the lamp, reduce electrode energization by bucking or neutralization.

Generally speaking, we effect these desired results by providing windings inductively coupled to three potential sources differing in phase one from the other. By this means neutralization can take place in the heating circuits by proper proportioning between the three induced voltages.

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

1. In combination, an alternating current supply circuit, a lagging power factor load circuit, a leading power factor load circuit, transforming means connected between said supply circuit and the load circuits and comprising a core member, a primary winding section and a pair of secondary winding sections, one of said secondary winding sections connected to said lagging power factor load circuit and the other connected to said leading power factor load circuit, a control circuit, and means comprising three serially connected windings inductively coupled with said primary and secondary winding sections, respectively, for supplying to said control circuit a resultant voltage the magnitude of which varies in accordance with the current in the load circuits.

2. In combination, an alternating current supply circuit, a lagging power factor load circuit, a leading power factor load circuit, transforming means connected between said supply circuit and the load circuits and comprising a core member, a primary winding section and a pair of secondary winding sections loosely coupled to said primary winding section, one of said secondary winding sections connected to said lagging power factor load circuit and the other connected to said leading power factor load circuit, a control circuit, and means comprising three serially connected windings inductively coupled with said primary and secondary winding sections, respectively, for supplying to said control circuit a voltage of predetermined magnitude under no load conditions of the load circuits and for reducing said voltage in magnitude upon flow of current in said load circuits.

3. In combination, an alternating current supply circuit, a lagging power factor load circuit, a leading power factor load circuit, transforming means connected between said supply circuit and the load circuits and comprising a core member, a primary winding section and a pair of secondary winding sections loosely coupled to said primary winding section, one of said secondary winding sections connected to said lagging power factor load circuit and the other connected to said leading power factor load circuit, a plurality of control circuits, and means including sets of three serially connected windings inductively coupled with said primary and secondary winding sections, respectively, for supplying to each of said control circuits a resultant voltage the magnitude of which is reduced to substantially zero upon the flow of current in the load circuits.

4. In combination, an alternating current supply circuit, a lagging power factor load circuit, a leading power factor load circuit, transforming means connected between said supply circuit and the load circuits and comprising a core member, a primary winding section and a pair of secondary winding sections, one of said secondary winding sections connected to said lagging power factor load circuit and the other connected to said leading power factor load circuit, a pair of control circuits, and means including three serially connected windings inductively coupled with said primary and secondary winding sections, respectively, for supplying to said control circuits a resultant voltage the magnitude of which varies in accordance with a predetermined electrical condition of said load circuits.

5. In combination, an alternating current supply circuit, a pair of electric discharge devices each comprising at least one filamentary electrode and employing an ionizable medium, and an electric transforming means connected to said supply circuit and comprising a primary winding section and a pair of secondary winding sections, the primary winding section and one of said secondary winding sections constituting a lagging power factor circuit connected to the electrodes of one of said discharge devices for supplying thereto a starting and operating voltage, said primary winding section and the other secondary winding section connected in circuit with a leading power factor means for supplying to the second mentioned discharge device a starting and operating voltage, said electric transforming means comprising three serially connected windings each inductively coupled with said primary winding section and secondary winding sections, respectively, for supplying to

said filamentary electrode of one of said devices a resultant voltage variable in accordance with the state of ionization of said medium.

6. In combination, an alternating current supply circuit, a pair of electric discharge devices each comprising at least one filamentary electrode and employing an ionizable medium, and an electric transforming means connected to said supply circuit and comprising a primary winding section and a pair of secondary winding sections, the primary winding section and one of said secondary winding sections constituting a lagging power factor circuit connected to the electrodes of one of said discharge devices for supplying thereto a starting and operating voltage, said primary winding section and the other secondary winding section connected in circuit with a leading power factor means for supplying to the second mentioned discharge device a starting and operating voltage, said electric transforming means comprising a winding inductively coupled to the primary winding section for producing a voltage of substantially constant magnitude and phase, and a pair of windings serially connected therewith each inductively coupled with said secondary winding sections, respectively, for supplying to said filamentary electrode of one of said devices a resultant voltage variable in accordance with the state of ionization of said medium.

7. In combination, an alternating current supply circuit, a pair of electric discharge devices each comprising at least one filamentary electrode and employing an ionizable medium, an electric transforming means connected to said supply circuit and comprising a primary winding section and a pair of secondary winding sections loosely coupled to said primary winding section, the primary winding section and one of said secondary winding sections constituting a lagging power factor circuit connected to the electrodes of one of said discharge devices for supplying thereto a starting and operating voltage, said primary winding section and the other secondary winding section connected in circuit with a leading power factor means for supplying to the second mentioned discharge device a starting and operating voltage, said electric transforming means comprising three serially connected windings providing voltages two of which are variable in phase and which are inductively coupled with said primary winding section and secondary winding sections, respectively, for supplying to said filamentary electrode of one of said devices a resultant voltage variable in magnitude in accordance with the current conducted by said electric discharge devices.

8. In combination, an alternating current supply circuit, a pair of electric discharge devices each comprising at least one filamentary electrode and employing an ionizable medium, an electric transforming means connected to said supply circuit and comprising a primary winding section and a pair of secondary winding sections, the primary winding section and one of said secondary winding sections constituting a lagging power factor circuit connected to the electrodes of one of said discharge devices for supplying thereto a starting and operating voltage, said primary winding section and the other secondary winding section connected in circuit with a leading power factor means for supplying to the second mentioned discharge device a starting and operating voltage, said secondary winding sections being loosely coupled to said primary winding section and serving as ballast

inductances for said devices, and said electric transforming means comprising three serially connected windings each inductively coupled with said primary winding section and secondary winding sections, respectively, for supplying to said filamentary electrode of one of said devices a resultant voltage variable in accordance with the state of ionization of said medium.

9. In combination, an alternating current supply circuit, a pair of electric discharge devices each comprising at least one filamentary electrode and employing an ionizable medium, means facilitating the starting of an arc discharge between said electrodes comprising a strip on each of said devices extending an appreciable distance between associated electrodes and connected to one of said electrodes, and an electric transforming means connected to said supply circuit and comprising a primary winding section and a pair of secondary winding sections, the primary winding section and one of said secondary winding sections constituting a lagging power factor circuit connected to the electrodes of one of said discharge devices for supplying thereto a starting and operating voltage, said primary winding section and the other secondary winding section connected in circuit with a leading power factor means for supplying to the second mentioned discharge device a starting and operating voltage, said electric transforming means comprising three serially connected windings each inductively coupled with said primary winding section and secondary winding sections, respectively, for supplying to said filamentary electrode of one of said devices a resultant voltage variable in accordance with the state of ionization of said medium.

10. In an inductive device, the combination comprising a magnetic core structure having wound thereon primary winding means for connection to an alternating current supply circuit and a pair of secondary winding means, and a plurality of tertiary winding means for producing a resultant voltage the magnitude of which varies in accordance with the current conducted by said secondary winding means and comprising a tertiary winding inductively associated with said primary winding means for producing a reference voltage of substantially constant magnitude, a second tertiary winding inductively associated with one of said secondary winding means for producing a component of voltage variable in magnitude and phase in response to the current conducted by said one secondary winding means, and a third tertiary winding inductively associated with the other of said secondary winding means for producing a second component of voltage variable in magnitude and phase in response to the current conducted by said second secondary winding means, the sum of said reference voltage and said components being reduced upon the flow of current through said secondary winding means.

11. In a voltage transforming means of the auto-transformer type, the combination comprising a magnetic structure having wound thereon primary winding means for connection to an alternating current supply circuit and a pair of secondary winding means and three serially connected tertiary winding means for producing a resultant voltage the magnitude of which varies in accordance with the current conducted by said secondary winding means and comprising a tertiary winding inductively associated with said primary winding means for producing a refer-

ence voltage of substantially constant magnitude, a second tertiary winding inductively associated with one of said secondary winding means for producing a component of voltage variable in response to the current conducted by said one secondary winding means, and a third tertiary winding inductively associated with the other of said secondary winding means for producing a second component of voltage variable in response to the current conducted by said secondary winding means, the sum of said reference voltage and said components being reduced upon the flow of current through said secondary winding means.

12. In an inductive device, the combination comprising a magnetic core structure having thereon primary winding means for connection to an alternating current supply circuit and a pair of secondary winding means, the primary winding means and one of said secondary winding means constituting a lagging power factor circuit and the primary winding means and the other secondary winding means connected in circuit with a leading power factor means, and a plurality of tertiary winding means for producing a resultant voltage the magnitude of which varies in accordance with the current conducted by said secondary winding means and comprising a tertiary winding inductively associated with said primary winding means for producing a reference voltage of substantially constant magnitude, a second tertiary winding inductively associated with one of said secondary winding means for producing a component of voltage variable in magnitude and phase in response to the current conducted by said one secondary winding means, and a third tertiary winding inductively associated with the other of said secondary winding means for producing a second component of voltage variable in magnitude and phase in response to the magnitude and phase of the current conducted by said second secondary winding means, the sum of said reference voltage and said components being reduced upon the flow of current through said secondary winding means.

13. In a transforming system, the combination comprising primary winding means for connection to an alternating supply circuit and a secondary winding means for energizing a pair of load circuits having different power factors, a control circuit, and three serially connected control windings for energizing said control circuit and for supplying thereto a resultant voltage the magnitude of which varies in accordance with the currents conducted by said load circuits, one of said control windings producing a reference voltage of substantially constant magnitude, a second of said control windings being responsive to the current conducted by one of said load circuits for producing a voltage variable in accordance with the current thereof, and the third of said control windings being responsive to the current conducted by the other of said load circuits for producing a voltage variable in accordance with the current conducted thereby.

14. A transformer having a magnetic core, a

primary winding on said core, a secondary winding on said core, said windings being loosely coupled by means of a leakage flux path therebetween on said core, said windings being connected in auto-transformer relation for providing a relatively high open circuit voltage and a relatively low operating voltage when load current flows therein by reason of the phase displacement of their voltages which is caused by their leakage fluxes, and separate auxiliary windings mounted on said core and closely coupled respectively with said primary and secondary windings, said auxiliary windings being serially connected in a circuit having a predetermined resultant voltage of substantial value when no load current flows in said primary and secondary windings and having a minimum resultant voltage when a load current flows in said primary and secondary windings, said minimum voltage being produced by the phase displacement between the voltages of said auxiliary windings which is caused by the leakage fluxes of said primary and secondary windings.

15. A transformer for the quick starting and efficient stable operation of an arc discharge lamp of the type having two electrodes at least one of which has a heating coil comprising, in combination, a magnetic core having a primary winding section and a secondary winding section, a magnetic shunt on said core between said sections which provides a leakage flux path therebetween, a primary winding on said primary core section, a secondary winding on said secondary core section, said primary and secondary windings being serially connected in auto-transformer relation for providing a relatively high open circuit starting voltage across the electrodes of a lamp of the above-mentioned type and for providing a substantially lower operating voltage for such a lamp when load current flows through said windings by reason of the leakage reactance of said transformer which is produced by said magnetic shunt, a pair of auxiliary electrode heater supply windings mounted respectively on said primary and secondary core sections, said auxiliary windings being serially connected with each other to supply a relatively high resultant starting voltage to a lamp electrode heater coil and to supply a substantially low resultant operating voltage to such a coil when load current flows through said primary and secondary windings by reason of the phase displacement of the voltages of said auxiliary windings which is caused by the primary winding and secondary winding leakage fluxes.

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