Dec. 26, 1950 J. G. SOLA 2,535,169

ALTERNATING CURRENT SUPPLY SYSTEM

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Fig. 1

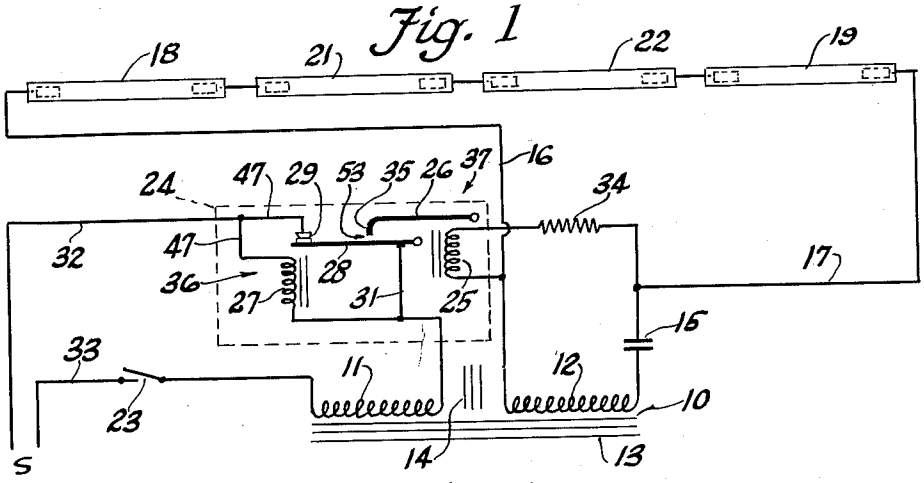


Fig. 2

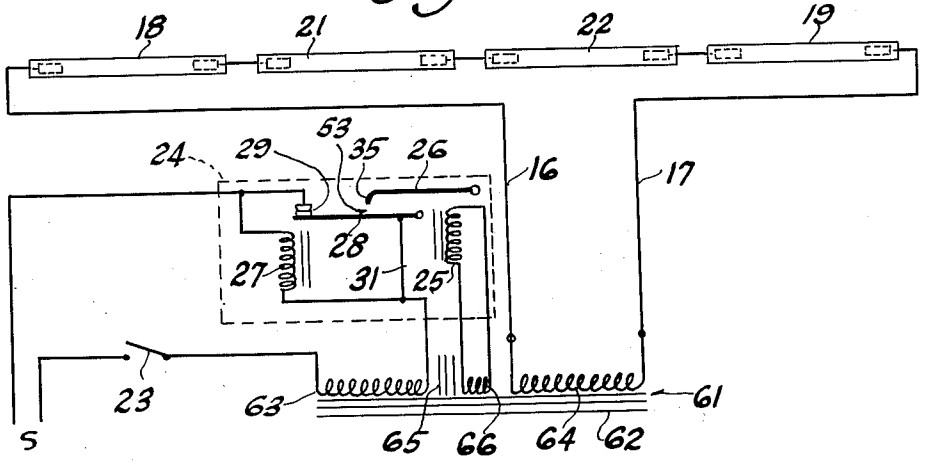
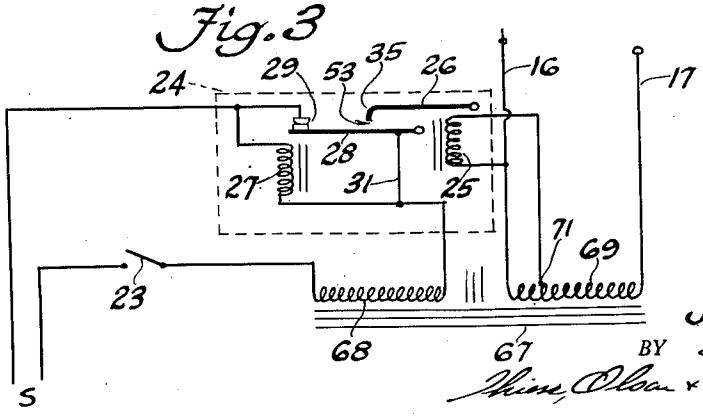


Fig. 3



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Fig. 4

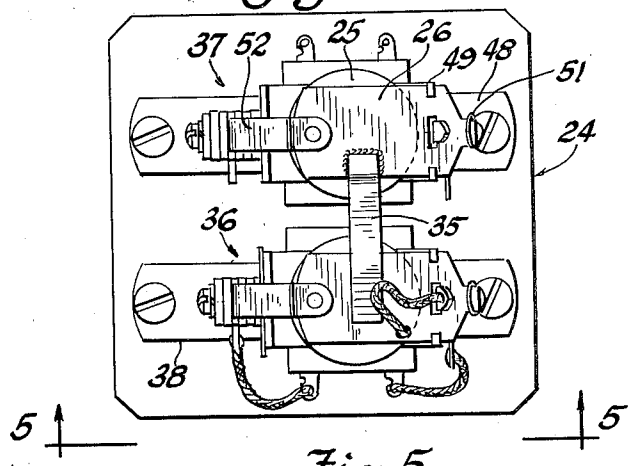


Fig. 5

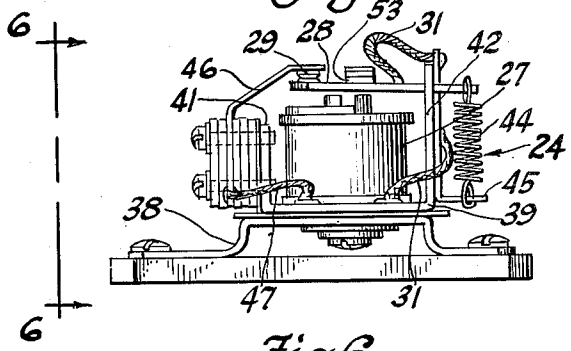


Fig. 6

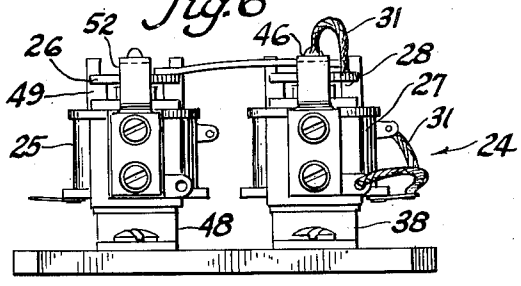
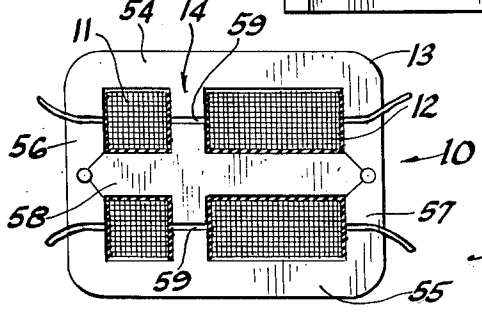


Fig. 7



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Patented Dec. 26, 1950 2,535,169

UNITED STATES PATENT OFFICE

2,535,169

ALTERNATING CURRENT SUPPLY SYSTEM

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Application February 26, 1948, Serial No. 11,021

14 Claims. (Cl. 323—61)

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This invention relates to an alternating current supply system for discharge apparatus having a negative resistance characteristic wherein the discharge apparatus is supplied with voltage through a transformer, more particularly to such an alternating current supply system wherein the voltage available for application to the discharge apparatus is reduced to a desired value when the discharge apparatus becomes open circuited, and it is an object of the invention to provide an improved alternating current supply system of this character.

While the invention is not limited thereto, it has particular application to, and will be described in connection with, gaseous discharge tubes, such for example as cold cathode fluorescent tubes for lighting purposes.

Cold cathode fluorescent lighting tubes require the application of a high starting voltage, and after the tube becomes conducting, the voltage necessary to maintain current flow therethrough drops to a much lower value. This property is referred to as one form of a negative resistance characteristic, the invention having application to other forms thereof and particularly to any apparatus wherein there is a substantial decrease in voltage from starting to operating conditions. For example, in the operation of hot cathode fluorescent lighting tubes there is a large drop from starting voltage to operating voltage even though the starting voltage is much lower than that for a cold cathode tube.

In the operation of circuits using cold cathode fluorescent lighting tubes the starting voltage is not only relatively high compared to the operating voltage, but it may be a voltage so high that it becomes dangerous. For example, one well known form of cold cathode fluorescent lighting tube breaks down on the application of approximately 700 volts and thereafter produces the required light with the application of 250 volts.

It is frequently desirable to place one or more of such tubes in series for starting as well as for operating conditions. If four of the tubes referred to are placed in series, a starting voltage of approximately 2800 volts is required while an operating voltage of approximately 1,000 volts is needed. In well known apparatus both of these voltages are supplied from a single system and when one of the fluorescent lighting tubes becomes broken such that it does not conduct thereby opening the circuit, the high voltage, 2800 volts, appears across the supply terminals. Consequently, a workman replacing the damaged tube without first removing the voltage from the

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circuit would be in danger of coming across the 2800 volt circuit and of being seriously injured.

Supply circuits for discharge devices such as cold cathode fluorescent lighting tubes usually comprise a transformer having primary and secondary windings with the fluorescent tubes connected in circuit with the secondary winding, a source of voltage being connected to the primary winding through a switch. The transformers are constructed to provide a sufficiently high starting voltage, and means are provided to reduce the voltage across the tubes after they have become conducting. One form of such a supply system is disclosed and claimed in my Patent No. 2,346,621, assigned to the same assignee as the present application.

It has been suggested to provide a circuit breaker in the primary or supply circuit of a fluorescent lighting transformer, which circuit breaker is adapted to be operated by the high voltage appearing across the tubes whenever the tube circuit becomes open. Such circuit breakers are of the trip-free type so that if the circuit breaker is closed while the lamp circuit is still open, the circuit breaker automatically re-opens. Using trip-free circuit breakers is disadvantageous inasmuch as it requires that the switch supplying voltage to the transformer primary winding be opened, the circuit breaker closed, and then the switch re-closed. If the tube circuit is then complete, the circuit breaker will remain closed and the system will function normally, but if the lamp circuit is still open, the circuit breaker will trip out. Moreover, trip-free mechanisms may be relatively complicated, bulky, and expensive.

Accordingly, it is a further object of the invention to provide improved means for decreasing the voltage available for application to fluorescent tubes when the tube circuit becomes open which is compact, inexpensive, reliable, and has few working parts.

In carrying out the invention in one form, a circuit including a transformer and condenser, corresponding to that shown in my Patent No. 2,346,621, is provided together with a voltage sensitive device connected across the output circuit of the transformer and condenser. A pair of normally closed contacts are provided in series with the transformer primary winding, and a coil having a relatively high impedance is connected across the contacts, the coil being arranged to attract an armature holding one of the contacts, thereby holding them open whenever the coil is energized. The voltage sensitive device is ar-

ranged so that when the voltage becomes high, as when the tube circuit opens, it causes the contacts in series with the primary winding to open. Accordingly, current flows through the high impedance coil reducing the transformer exciting current. Consequently, the voltage appearing across the tube circuit is very small. After the defective lamp has been removed and the lamp circuit is again complete, it is only necessary to open the switch in the primary circuit and re-close it.

For a more complete understanding of the invention reference should be had to the accompanying drawings in which:

Figure 1 is a schematic diagram of apparatus embodying the invention;

Fig. 2 is a schematic diagram of another embodiment of the invention;

Fig. 3 is a schematic diagram of a further embodiment of the invention;

Fig. 4 is a top view of a pair of relay units shown diagrammatically in Figs. 1, 2 and 3;

Fig. 5 is an elevational view taken substantially in the direction of arrows 5—5 of Fig. 4;

Fig. 6 is an elevational view taken substantially in the direction of arrows 6—6 of Fig. 5, and

Fig. 7 is a somewhat schematic view of a core and coils which may be employed in carrying out the invention.

Referring to Fig. 1 of the drawings, there is shown an alternating current supply system including a transformer 10 having a primary winding 11 and a secondary winding 12 wound on an iron core 13. A high reluctance shunt 14 is magnetically disposed between windings 11 and 12, and a condenser 15 is connected in circuit with the secondary winding. From secondary winding 12 and condenser 15 a pair of conductors 16 and 17 extend and are connected to respective terminals of a pair of cold cathode fluorescent tubes 18 and 19, the tube circuit being completed by a second pair of fluorescent tubes 21 and 22.

Transformer 10 and condenser 15 are constructed in accordance with the principles disclosed in the patent already referred to. Hence, when switch 23 leading to primary winding 11 is closed, thereby supplying the desired voltage thereto, a sufficiently high starting voltage for the fluorescent tubes appears across conductors 16 and 17. After the tubes strike, that is, become conducting, the voltage across conductors 16 and 17 is reduced to a stable self-regulating value so that the proper current flows through the tube for optimum brilliancy.

It is evident from Fig. 1 that when any one of the fluorescent tubes becomes non-conducting and the circuit to primary winding 11 remains complete, initially high voltage again appears across conductors 16 and 17. This may be dangerous and particularly so when a series of tubes, i. e. four, each requiring approximately 700 volts to start, are placed in series inasmuch as this necessitates an availability of about 2800 volts across conductors 16 and 17.

Associated with transformer 10 is relay apparatus 24 shown schematically in Figs. 1, 2 and 3, and shown in detail in Figs. 4, 5 and 6.

Referring to Fig. 1, relay apparatus 24 is a system comprising two relay units 36 and 37, relay 37 including a coil 25 arranged to attract a pivotally mounted armature 26, and relay 36 including a coil 27 arranged to attract a pivotally mounted armature 28. Armature 26 includes a portion overlying armature 28 so that whenever armature 28 is attracted, armature 28 is caused to move thereby opening a pair of normally closed contacts 29. Coil 27 is connected across contacts 29 inasmuch as one end of the coil is connected to armature 28 by a conductor 31 and the other end is connected to a conductor 32 connecting with one of the contacts, as shown. The circuit for supplying voltage to primary winding 11 may be traced as follows: From a source S through conductors 32 and 47, normally closed contacts 29, armature 28, and conductor 31 to one end of winding 11, and from the other end of winding 11 through switch 23 and conductor 33 to the source S. One end of coil 25 is connected to conductor 16 and the other end thereof is connected through a resistor 34 to conductor 17. Resistor 34 has a high value of resistance in order that when full voltage, for example 2800 volts, appears across conductors 16 and 17, coil 25 which may function alone on about 110 volts will receive its normal actuating current.

With relay apparatus 24 as thus far described, the operation of the structure shown in Fig. 1 may be envisioned. Suppose, for example, that transformer 10 and condenser 15 are constructed according to the principles of the patent referred to and that approximately 110 volts are supplied to the primary winding through the circuit described. Hence, with a proper transformation ratio, sufficient voltage appears across conductors 16 and 17 to cause tubes 18, 21, 22 and 19 in series to light, contacts 29 being closed and thereby short circuiting coil 27. Just prior to the tubes lighting or striking, the high voltage is of course applied to coil 25 and resistor 34, and coil 25 receives its normal current and begins to attract its armature 26 thereby moving this member in a direction to contact armature 28. It will be noted, however, that the end of an arm 35 projecting from armature 26 is spaced upwardly from armature 28 whereby a small interval of time elapses before armature 36 moves sufficiently for the arm 35 to contact armature 28. During this small interval the tubes in series have lighted and the voltage appearing across conductors 16 and 17 drops to the stable value at which the lamps operate, which, for example, may be 1000 volts. One thousand volts applied to coil 25 and resistor 34 in series produces insufficient current flow through coil 25, and armature 26 moves back to its normal position as shown.

If, however, any one of the lamps becomes open circuited, the voltage appearing across conductors 16 and 17 rises to its high value thereby forcing sufficient current through coil 25 causing it to attract armature 26 and causing point 35 to contact armature 28. Armature 26 continues to move downwardly and consequently armature 28 moves downwardly thereby opening contacts 29, whereupon coil 27 is immediately placed in series circuit with winding 11. The impedance of coil 27 is very high compared to the open circuit impedance of transformer 10 exhibited by winding 11; hence the current flowing through winding 11 is reduced from its normal value to a very low value. Moreover, coil 27 is so arranged that its core attracts armature 28 thereby holding contacts 29 open. With the very small exciting current flowing through winding 11, the voltage appearing across conductors 16 and 17 drops to a negligible value and the current flowing through coil 25 decreases so that armature 26 moves back to its normal position, coil 27, however, remaining excited and holding armature 28 attracted. Transformers constructed according

to the invention described in the patent for operation with 110 volts applied to the primary and having about 2800 volts open circuit secondary voltage may have an open circuit impedance of the order of 100 ohms and have exciting currents of the order of one ampere. Coils 27 and 25 may have impedances of the order of 3500 ohms. In one transformer constructed according to the invention there was a current of .03 amperes in the primary circuit when 110 volts were applied and the tube circuit is open and resistor 34 had an ohmic value of about 90,000 ohms.

Assuming now that the imperfect tube has been replaced, the tube circuit is again complete. No high voltage appears across conductors 16 and 17 and the lamps do not re-strike even though the primary circuit is closed. That is, completing the secondary circuit, once it has been opened, is not sufficient to produce any substantial voltage therein. In order to re-strike the tubes, it is necessary first to open switch 23. When this is done, excitation is removed from coil 27 thereby allowing armature 28 to move to its normal position closing contacts 29. Thereafter, when switch 23 is closed the normal exciting circuit for winding 11 is completed and the necessary high voltage appears across conductors 16 and 17. Consequently, the lamps re-strike and the system is in condition for a second operation.

Coil 25 is responsive to the change in voltage across the tubes. It will be understood that other forms of voltage responsive devices may be used, for example bi-metallic means, without departing from the spirit and scope of the invention.

Referring more particularly to Figs. 4, 5 and 6, the construction of relay apparatus 24 comprises a base with relay units 36 and 37 mounted thereon. Relay unit 36 includes a base 38 upon which a relatively U-shaped frame 39 is mounted, together with coil 27 which is mounted between legs 41 and 42 of frame 39. The armature 28 is pivoted adjacent its rear end to the upper end of leg 42, a spring 44 engaging the rear end thereof, and a bracket 45 attached to leg 42 for biasing armature 28 upwardly. The upward movement of the armature is limited by a yoke 46 which is attached to, and insulated from leg 41, contacts 29, one of which is on the end of yoke 46 and the other of which is on armature 28, engaging in the upper position of the armature. Armature 28 is connected by means of conductor 31 including a portion of bracket 45 to one terminal of coil 27, the end of yoke 46 opposite to contacts 29 being connected by a conductor 47 to the other terminal of coil 27. Hence, coil 27 is connected across contacts 29.

Relay unit 37 is similar to relay 36 in that it includes a base 48, a U-shaped member 49 to the rear end of which the armature 26 is pivoted. Likewise, coil 25 of this relay unit is mounted in between the two arms of the U-shaped member and a spring 51 is adapted to hold the armature in its upward position against a yoke 52. The terminals of coil 25 are brought out and connected as shown in Fig. 1; that is, one terminal is connected to resistor 34 and the other terminal is connected to the conductor 16. Yoke 52 does not have any electrical function in relay unit 37, it merely limiting the upward movement of the armature. Attached to armature 26 by some suitable means, such as welding or soldering, is the arm 35 which spans across to overlie armature 28 of relay unit 36. Arm 35 may be formed integral with armature 26, for example. The end of arm 35 overlying armature 28 is spaced upwardly therefrom by a gap 53. Thus, when energization is supplied to coil 25, arm 35 moves downwardly and contacts armature 28. The space 53 provides a minute time delay before continued movement of arm 35 causes armature 28 to separate contacts 29. When contacts 29 are separated, energization of coil 27 of course attracts armature 28 and maintains contacts 29 open.

One form of core and coils suitable for operation in connection with relay 24 and the four fluorescent tubes of Fig. 1 is shown in Fig. 7, corresponding reference numerals being used. Hence, in Fig. 7 the transformer 10 has primary winding 11 and a secondary winding 12 wound on an iron core 13 having high reluctance shunts 14. Core 13 comprises an assembly of stampings having legs 54 and 55 and ends 56 and 57. A central member 58 may also be an assembly of stampings and is assembled to the core in suitably provided cut-out portions in the end members as shown. Extending inwardly from legs 54 and 55 and outwardly from member 58 are projections providing air gaps 59 between them, the projecting members and the air gaps resulting in high reluctance shunts 14 for diverting flux created by one winding from the other winding.

One transformer construction which was found satisfactory for operating four fluorescent lamps in series having a total starting voltage of approximately 2800 volts had the following constants: Legs 54 and 55 are $4\frac{3}{16}$ inches long, ends 56 and 57 are 4 inches long, and the width of these members is $\frac{7}{16}$ inch. The width of member 58 is $\frac{7}{8}$ inch, and the width of the shunt members is $\frac{13}{32}$ inch with gaps 59 being .05 inch. A stack of laminations $2\frac{5}{8}$ inches thick is used. Primary winding 11 has 195 turns of No. 16 copper wire, secondary winding 12 has 4680 turns of No. 27 copper wire, and condenser 15 has a capacity of .02 microfarad. The manner of constructing the transformer and condenser is in conformance with the principles disclosed in my Patent No. 2,346,621.

In Fig. 2 there is shown an embodiment of the invention suitable for use in connection with an ordinary high reactance transformer such as may be used for starting and operating cold cathode fluorescent lamps. Thus, lamps 18, 21, 22 and 19 may be supplied through a high reactance transformer 61 comprising an iron core 62, a primary winding 63, and a secondary winding 64 wound thereon. A shunt 65 or other constructional means may be used to provide a leakage path between windings 63 and 64 so that the transformer has sufficient reactance to cause the voltage across conductors 16 and 17 to drop after the tubes light. The turn ratio between windings 63 and 64 is such that sufficient voltage is generated in winding 64 to strike the tubes initially.

Relay combination 24 shown in connection with Fig. 2 is the same as that shown in connection with Fig. 1. However, coil 25 is connected to a winding 66 wound on the same portion of the core as secondary winding 64, the number of turns of winding 66 being so chosen that the high voltage applied to coil 25 is within the rating of the coil, and moreover may be the same voltage as supplied to coil 25 in the construction of Fig. 1.

With the connection as shown in Fig. 2, the operation of the system will be substantially that described for Fig. 1. Thus, when the switch 23 is closed, the voltage appearing across winding 64 is sufficiently high to cause the lamps

in series to strike. Consequently, sufficient voltage is generated in winding 66 to cause coil 25 to begin attracting armature 26. As soon as the lamps strike, the voltage appearing across conductors 16 and 17 drops due to the reactance drop within the transformer. The voltage generated within winding 66 also drops so that the coil 25 does not attract armature 26 sufficiently far to cause armature 28 to open contacts 29. Hence the circuit remains as shown and the lamps operate properly.

When one of the lamps becomes inoperative, thereby opening the secondary circuit, the high voltage of the transformer appears across conductors 16 and 17, and correspondingly a high voltage is generated in winding 66. Accordingly, coil 25 attracts armature 26 completely, thereby causing armature 28 to open contacts 29 and place coil 27 in series with primary winding 52 which maintains contacts 29 open. The primary winding circuit now includes the high impedance of coil 27 whereby the exciting current flowing therein is very much reduced and the voltage generated across the secondary winding is negligible. After the defective lamp is replaced, opening and closing switch 23 completes the circuit again, as already explained.

In Fig. 3 a further modification of the invention is shown in which the transformer is generally similar to the transformer 16 of Fig. 2. A core 67 and primary and secondary windings 68 and 69, respectively, are provided together with means for producing a high reactance drop through the transformer, for example, a shunt. The voltage applied to coil 25 of the relay combination 24 is obtained from a tap 71 on the secondary winding rather than by a separate winding. The system functions in the same manner as in Fig. 2 in that when the high tube striking voltage appears across the conductors 16 and 17 there is sufficient voltage generated between conductor 16 and tap 71 to cause coil 25 to attracts its armature. If the lamp circuit is open, this voltage energizes coil 25 for causing armature 26 to move armature 28 thereby opening contacts 29 and placing winding 27 in the primary circuit. Consequently, the secondary voltage is reduced, as has been explained in connection with Fig. 1.

While particular embodiments of the invention have been shown, it will be understood, of course, that the invention is not limited thereto since many modifications may be made, and it is, therefore, contemplated by the appended claims to cover any such modifications as fall within the true spirit and scope of the invention.

Having thus described the invention, what is claimed and desired to be secured by Letters Patent is:

1. Alternating current supply apparatus for discharge apparatus having relatively high starting and low operating voltages comprising, a transformer having input and output circuits, said output circuit being adapted to be connected to said discharge apparatus, circuit interrupting means connected in series with said input circuit, responsive means connected across said output circuit for opening said circuit interrupting means, and second responsive means having relatively high impedance connected across said circuit interrupting means for holding said circuit interrupting means open.

2. Alternating current supply apparatus for discharge apparatus having relatively high starting and low operating voltages comprising, a

transformer having primary and secondary windings, said secondary winding being adapted to be connected in a circuit including said discharge apparatus, circuit interrupting means connected in series with said primary winding, responsive means for opening said circuit interrupting means, means deriving a voltage proportional to that applied to said discharge apparatus connected to said responsive means, and second responsive means having relatively high impedance connected across said circuit interrupting means for limiting the current through said primary winding after said circuit interrupting means are open and for holding said circuit interrupting means open.

3. In combination with a transformer having a large variation in secondary voltage from no load to full load, means for reducing the secondary voltage when the load circuit becomes open comprising, normally closed contacts in the primary winding circuit of said transformer, means operable upon a predetermined increase in said secondary voltage for opening said normally closed contacts, and means made effective by the opening of said contacts for reducing the current through said primary winding when said contacts are open and for holding said contacts open.

4. In combination with a transformer having a large variation in secondary voltage from no load to full load. means for reducing the secondary voltage when the load circuit becomes open comprising, normally closed contacts connected in circuit with the primary winding of said transformer, a high impedance connected across said contacts, means operable upon a predetermined increase in said secondary voltage for opening said contacts thereby inserting said high impedance in circuit with the primary winding of said transformer, said impedance being adapted to hold said contacts open.

5. In combination with a transformer having primary and secondary windings wound on an iron core, a high reluctance shunt disposed magnetically between said windings and a condenser of predetermined capacity connected to said secondary winding, means for reducing the voltage across said condenser and secondary winding on removal of load comprising, a voltage sensitive device connected across said secondary winding and said condenser, a pair of normally closed contacts in series circuit with said primary winding, and a relatively high impedance connected across said contacts, said voltage responsive device being operable upon removal of said load for opening said contacts.

6. Alternating current supply means for discharge apparatus having a high starting voltage and a low operating voltage comprising, a transformer having primary and secondary windings wound on an iron core, a high reluctance shunt disposed magnetically between said windings, and a condenser connected in series circuit with said secondary winding, said secondary winding and said condenser being adapted to be connected to said discharge apparatus, a device sensitive to voltage rise connected across said condenser and secondary winding, a pair of normally closed contacts connected in series with said primary winding, and a relatively high impedance connected across said contacts, said voltage sensitive device being adapted to open said contacts upon open circuiting of said discharge apparatus.

7. Alternating current supply means for discharge apparatus having a high starting voltage and a low operating voltage comprising, a trans-

former having primary and secondary windings wound on an iron core, a high reluctance shunt disposed magnetically between said windings, and a condenser connected in series circuit with said secondary winding, said secondary winding and said condenser being adapted to be connected to said discharge apparatus, a device sensitive to voltage rise connected across said condenser and secondary winding, a pair of normally closed contacts connected in series with said primary winding, and a relatively high impedance connected across said contacts, said voltage sensitive device being adapted to open said contacts upon open circuiting of said discharge apparatus, said impedance device being adapted to hold said contacts open after opening thereof by said sensitive device.

8. Alternating current supply means for discharge apparatus having a high starting voltage and a low operating voltage comprising, a transformer having primary and secondary windings wound on an iron core, a high reluctance shunt magnetically disposed between said windings, and a condenser connected to said secondary winding, said condenser and said secondary winding being adapted to be connected in series circuit with said discharge apparatus, a device responsive to voltage changes connected across said secondary winding and said condenser, normally closed contacts in series with said primary winding, means responsive to current flow for holding said contacts open connected across said contacts, said current flow responsive means having a relatively high impedance, and operating means actuated by said responsive device on a certain increase in voltage across said secondary winding and condenser for opening said contacts.

9. Alternating current supply means for discharge apparatus having a high starting voltage and a low operating voltage comprising, a transformer having primary and secondary windings wound on an iron core, a high reluctance shunt magnetically disposed between said windings, and a condenser connected to said secondary winding, said condenser and said secondary winding being adapted to be connected in series circuit with said discharge apparatus, a device responsive to voltage changes connected across said secondary winding and said condenser, normally closed contacts in series with said primary winding, means responsive to current flow for holding said contacts open connected across said contacts, said current flow responsive means having a relatively high impedance, and operating means actuated by said responsive device on a certain increase in voltage across said secondary winding and condenser for opening said contacts, said operating means opening said contacts a short time interval after beginning of actuation by said responsive means.

10. Alternating current supply means for discharge apparatus having a high starting voltage and a low operating voltage comprising, a transformer having primary and secondary windings wound on an iron core, a high reluctance shunt magnetically disposed between said windings, and a condenser connected to said secondary winding, said condenser and said secondary winding being adapted to be connected in series circuit with said discharge apparatus, a device responsive to voltage changes connected across said secondary winding and said condenser, normally closed contacts in series with said primary winding, means responsive to current flow for holding said contacts open connected across said contacts, said current flow responsive means having a relatively high impedance, operating means actuated by said responsive device on a certain increase in voltage across said secondary winding and condenser for opening said contacts, and means effecting a short time delay between the beginning of actuation of said operating means and the opening of said contacts by said operating means.

11. Alternating current supply means for discharge apparatus having a high starting voltage and a low operating voltage comprising, a transformer having primary and secondary windings wound on an iron core, a high reluctance shunt magnetically disposed between said windings, and a condenser connected to said secondary winding, said condenser and said secondary winding being adapted to be connected in series circuit with said discharge apparatus, a device responsive to voltage changes connected across said secondary winding and said condenser, a first armature movable by said responsive device, normally closed contacts in series with said primary winding, means responsive to current flow connected across said contacts, said current flow responsive means having a relatively high impedance, a second armature for opening and closing said contacts, said second armature being operated by said current flow responsive means to hold said contacts open, said first armature actuating said second armature only after an initial movement of said first armature to open said contacts.

12. Alternating current supply means for discharge apparatus having a high starting voltage and a low operating voltage comprising, a high reactance transformer having primary and secondary windings wound on an iron core, said secondary winding being adapted to be connected in circuit with said discharge apparatus, a winding magnetically coupled with said secondary winding, a device responsive to voltage changes connected to said winding, a first armature movable by said responsive device, normally closed contacts in series with said primary winding, means responsive to current flow connected across said contacts, said current flow responsive means having a relatively high impedance, a second armature for opening and closing said contacts, said second armature being operated by said current flow responsive means to hold said contacts open, said first armature actuating said second armature to open said contacts only after an initial movement of said first armature.

13. Alternating current supply means for discharge apparatus having a high starting voltage and a low operating voltage comprising, a transformer having primary and secondary windings wound on an iron core, said secondary winding being adapted to be connected in said series circuit with said discharge apparatus, a low voltage tap on said secondary winding, a device responsive to voltage changes connected to said tap, a first armature movable by said responsive device, normally closed contacts in series with said primary windings, means responsive to said current flow connected across said contacts, said current flow responsive means having a relatively high impedance, a second armature for opening and closing said contacts, said second armature being operated by said current flow responsive means to hold said contacts open, said first armature actuating said second armature to open said contacts only after an initial movement of said first armature.

14. Alternating current supply means for discharge apparatus having a high starting voltage

and a low operating voltage comprising, a high reactance transformer having primary and secondary windings wound on an iron core, said secondary winding being adapted to be connected in circuit with said discharge apparatus, a winding magnetically coupled with said secondary winding, a responsive device for deriving a voltage proportional to that applied to said discharge apparatus, a first armature movable by said responsive device, normally closed contacts in series with said primary winding, means responsive to current flow connected across said contacts, said current flow responsive means having a relatively high impedance, a second armature for opening and closing said contacts, said second armature being operated by said current flow responsive means to hold said contacts open, said first armature actuating said second armature to open said contacts only after an initial movement of said first armature.

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