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TRANSFORMER FOR OPERATING ELECTRIC DISCHARGE TUBES

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FIG. 1

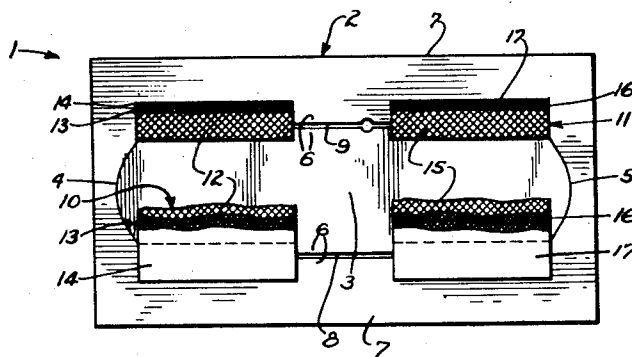
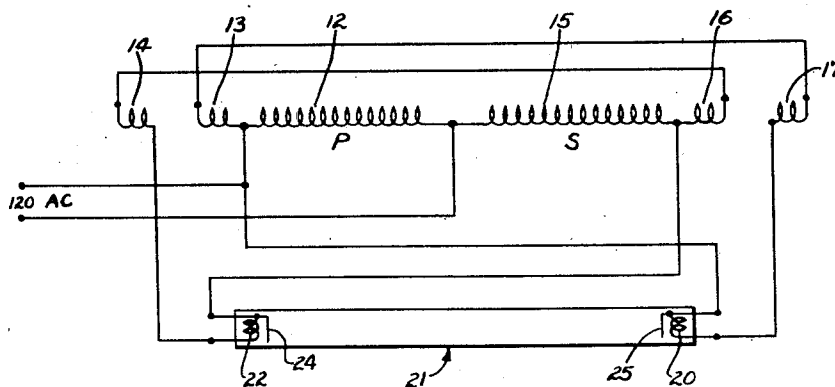


FIG. 2



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TRANSFORMER FOR OPERATING ELECTRIC DISCHARGE TUBES

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11 Claims. (Cl. 323—45)

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This invention relates to transformers for furnishing the filament heating current for a hot cathode electric discharge tube and for furnishing also the discharge current for the tube.

It is one of the objects of the present invention to provide a transformer for the above mentioned purposes which will automatically regulate the filament voltage and current as the requirements change in going from starting conditions to normal operating conditions, and which will automatically regulate the applied ignition voltage as the requirements change from the high initial voltage required to start the discharge to the lower voltage required after the glow discharge has started.

It is a further object of the present invention to provide a transformer which will operate a hot cathode electric discharge device in the manner above set forth when connected thereto, without requiring any additional external equipment.

It is another object of the present invention to provide a transformer of the above mentioned character which will be quite compact and which will be economical of construction and efficient in operation.

It is a still further object of the present invention to provide a transformer of the above character which will provide sufficient filament current to cause a very quick start of the glow discharge and which will thereafter immediately reduce the filament current to a low value to prolong the life of the filament.

In the preferred embodiment of the present invention the filament voltage is obtained from two series connected transformer coils which are so located on the core that the voltage of one of them is determined by the flux through the transformer primary, the voltage of the other being determined by the flux through the transformer secondary. The coils are connected so that their voltages are additive upon energization of the transformer primary and before the secondary is furnishing any ignition current. When ignition takes place lamp current flows through the secondary. The secondary flux actually substantially reverses itself so that the voltages of the two filament coils are then out of phase approximately 160°.

The attainment of the above and further objects of the present invention will be apparent from the following specification taken in conjunction with the accompanying drawing forming a part thereof.

In the drawing:

Figure 1 is a diagrammatic view of a trans-

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former constructed in accordance with the principles of the present invention; and

Figure 2 is a circuit diagram showing the connections of that transformer to a hot cathode lamp.

In the accompanying drawing like reference numerals designate like parts throughout.

The transformer of the present invention, indicated in general by the reference numeral 1, includes a conventional shell type magnetic structure comprising open rectangular laminations 2 stacked to form a group of sufficient thickness, and a stack of core laminations 3 on which are mounted the transformer coils and which core laminations 3 with the windings assembled thereon are then positioned in the shell laminations 2 to provide substantially no gap at the abutting joints 4—5, and to provide magnetic shunts 6—6 for leakage flux from the core 3 to the longitudinal sides 7—7 of the shell 2 substantially midway of the length of the transformer, which shunts include equal air gaps 8—9. These air gaps are of a combined thickness of the order of .035 inch. This is a standard shell type magnetic structure for transformers that supply current to hot cathode type of fluorescent lamps.

The coils of the transformer include a group of primary coils 10 and a similar but not identical group of secondary coils 11. The primary coil group 10 includes a primary coil or winding 12 and two auxiliary coils 13 and 14 concentric therewith. The coils 12, 13 and 14 are all wound in the same direction, the primary coil 12 being on the inside and surrounded by the coil 13 which in turn is surrounded by the coil 14. The coils 12, 13 and 14 are suitably insulated for the voltages encountered. The secondary coil assembly 11 likewise includes a central secondary coil 15 surrounded by an auxiliary coil 16 which in turn is surrounded by another auxiliary coil 17, the three coils being all wound in the same direction and suitably insulated for the voltages encountered. In one preferred construction the primary coil 12 had 780 turns and the auxiliary coils 13 and 14 each had 55 turns, the three coils being of number 27½ wire. In that same construction the secondary 15 had 840 turns and the auxiliary coils 16 and 17 each had 60 turns, those three coils being of number 28 wire.

The primary 12 is connected to a source of 60 cycle alternating current. The primary auxiliary coil 13 and the secondary auxiliary coil 17 are connected in series and supply heating current to the heating filament 20 of a conventional filament type hot cathode fluorescent lamp 21. The primary auxiliary coil 14 and the secondary auxil-

lary coil 16 are connected in series and supply heating current to the heating filament 22 of the lamp 21. The secondary 15 is connected in step-up auto transformer relationship with the primary 12 and supplies the ignition current for the lamp 21.

Before ignition takes place in the lamp, that is, when the cathodes 24—25 of the lamp are open circuited, the voltages of the coils 12 and 13 are additive and the voltages of the coils 15 and 16 are additive. The voltage of the coil 14 is additive to the voltages of the coils 15 and 16, and the voltage of the coil 17 is additive to the voltage of the coils 13 and 12. It is thus apparent that the voltage applied to the filament 20 is the sum of the voltages induced in the coils 14 and 17, which voltages are substantially in phase, and the voltage applied to the filament 22 is the sum of the voltages induced in the coils 14 and 16, which voltages are also substantially in phase. In the construction above set forth the voltages induced in each of the coils 13 and 14 was of the order of seven volts, and the voltages induced in each of the coils 16 and 17 was in each case of the order of eight volts before ignition takes place between the cathodes 24—25. After ignition takes place the voltages across the coils 13, 14, 16 and 17 drop in each case to of the order of six and three-quarters volts. However, after lamp ignition takes place and lamp current flows between the cathodes, the secondary flux actually substantially reverses itself so that the voltages in the coils 16 and 17 are approximately 160° out of phase with the voltages in the coils 13 and 14. Because of the phase displacement the vector sum of the voltages of the coils 13 and 16 or of the coils 14 and 17 now drops to approximately 2.5 volts. As a result the filament current drops from the previous value of approximately .8 ampere to approximately $\frac{1}{6}$ of that amount.

The magnetic shunts 6—6 are of substantially no effect prior to the time that ignition takes place between the electrodes 24—25 of the lamp 21. This is due to the fact that the flux density in the entire iron structure of the transformer is at a value sufficiently below saturation that the reluctance of the air gaps 8—9 prevents any appreciable portion of the flux to leak across the shunts 6—6. However, after ignition takes place between the electrodes and the direction of the secondary flux substantially reverses itself the flux relationship in the central core leg 3 changes so that the reluctance of the small air gap 6—6 is now no longer of tremendously greater value than the reluctance of the magnetic flux path through the secondary coil sections, and as a result a substantial amount of leakage flux passes through the shunts 6—6 and the air gaps 8—9 thereby permitting reversal of the magnetic flux at the secondary end of the transformer.

In compliance with the requirements of the patent statutes I have here shown and described a preferred embodiment of my invention. It is, however, to be understood that the invention is not limited to the precise construction here shown, the same being merely illustrative of the principles of the invention. What I consider new and desire to secure by Letters Patent is:

1. A transformer for supplying current to a hot cathode electric discharge tube comprising a primary coil and a secondary coil connected in step up auto transformer relationship, the primary and the secondary each having two auxiliary windings, the four auxiliary windings being connected in two series circuits each of which in-

cludes one primary auxiliary winding and one secondary auxiliary winding connected with their voltages additive when the secondary coil is under no load, and a magnetic structure for the coils, said magnetic structure including a magnetic shunt between the two coils for facilitating leakage flux paths for the coils.

2. A transformer for supplying current to a hot cathode electric discharge tube comprising a primary coil and a secondary coil connected in step up auto transformer relationship, the primary and the secondary each having two auxiliary windings concentric therewith, the four auxiliary windings being connected in two series circuits each of which includes one primary auxiliary winding and one secondary auxiliary winding connected with their voltages additive when the secondary coil is under no load, and a magnetic structure for the coils, said magnetic structure including a magnetic shunt between the two coils for facilitating leakage flux paths for the coils.

3. A transformer for supplying current to a hot cathode electric discharge tube comprising a first group of three concentric coils including a primary coil and two auxiliary coils, a second group of three concentric coils including a secondary and two auxiliary coils, a magnetic coupling for the two groups of coils, the auxiliary coils of the two groups being connected in two circuits each of which includes one auxiliary coil of one group and one auxiliary coil of the other group connected in series with their voltages additive when the secondary coil is carrying substantially no load.

4. A transformer for supplying current to a hot cathode electric discharge tube comprising a first group of three concentric coils including a primary coil and two auxiliary coils, a second group of three concentric coils including a secondary and two auxiliary coils, the coils of the second group having each a larger number of turns than the coils of the first group, a magnetic coupling for the two groups of coils, the coupling including a magnetic flux shunt path between the two groups of coils which shunt path has an air gap therein, the auxiliary coils of the two groups being connected in two circuits each of which includes one auxiliary coil of one group and one auxiliary coil of the other group connected in series with their voltages additive when the secondary coil is carrying substantially no load.

5. A transformer for supplying current to a hot cathode electric discharge tube comprising a first group of coils including a primary coil and two auxiliary coil windings, a second group of coils including a secondary coil and two auxiliary coils, a magnetic structure magnetically coupling the two groups of coils in a closed magnetic circuit and including a magnetic shunt between the two groups of coils for increasing leakage reactance between them, the auxiliary coils of the two groups being connected in two circuits each of which includes one auxiliary coil of one group and one auxiliary coil of the other group connected in series and with their voltages additive when the secondary coil is carrying substantially no current so that when the secondary carries its full load the voltages induced in the auxiliary coils of the secondary group are substantially reversed thereby reducing the voltages across each of the two series circuits.

6. A transformer for supplying current to a hot cathode electric discharge tube comprising a first group of coils including a primary coil and two

auxiliary coil windings, a second group of coils including a secondary coil and two auxiliary coils, a magnetic structure magnetically coupling the two groups of coils in a closed magnetic circuit and including a magnetic shunt between the two groups of coils for increasing leakage reactance between them, said shunt including an air gap to minimize the effect of the shunt at low flux densities, the auxiliary coils of the two groups being connected in two circuits each of which includes one auxiliary coil of one group and one auxiliary coil of the other group connected in series and with their voltages additive when the secondary coil is carrying substantially no current so that when the secondary carries its full load the voltages induced in the auxiliary coils of the secondary group are substantially reversed thereby reducing the voltages across each of the two series circuits.

7. A transformer for supplying filament current and ignition current to a hot cathode electric discharge tube, said transformer including a magnetic structure having thereon a primary coil and a secondary coil coupled thereto for supplying ignition current to a tube and having a pair of auxiliary coils for supplying filament current to a tube, one of the auxiliary coils being located to be linked by magnetic flux in a direction determined by the direction of the magnetic flux through the primary coil and the other auxiliary coil being located to be linked by magnetic flux in a direction determined by the direction of the magnetic flux through the secondary coil, the two auxiliary coils being connected in a series circuit with their voltages additive when the secondary is under substantially no load.

8. A transformer for supplying filament current and ignition current to a hot cathode electric discharge tube, said transformer including a magnetic structure having thereon a primary coil and a secondary coil coupled thereto for supplying ignition current to a tube and having a pair of auxiliary coils associated with the primary coil and a pair of auxiliary coils associated with the secondary coil, the auxiliary coils being connected in two series circuits each of which includes one of the primary auxiliary coils and one of the secondary auxiliary coils, each circuit being adapted to furnish filament current to one of the filaments of a two filament hot cathode discharge tube, one of the pairs of auxiliary coils being located to be linked by magnetic flux in a direction determined by the direction of the magnetic flux through the primary coil and the other pair of auxiliary coils being located to be linked by magnetic flux in a direction determined by the direction of the magnetic flux through the secondary coil, the two auxiliary coils of each series circuit being connected with their voltages additive when the secondary is under substantially no load.

9. A shell type transformer for supplying filament current and ignition current to a hot cathode electric discharge tube, said transformer comprising a magnetic structure having two longitudinal sides joined by two transverse sides and a longitudinal core extending from one transverse side to the other between the two longitudinal sides, a first group of transformer coils on the core and including a primary coil

and two auxiliary coils, a second group of transformer coils on the core and including a secondary coil and two auxiliary coils, the magnetic structure including a magnetic shunt between the two groups of coils with a gap in the shunt path but outside of the path of the primary magnetizing flux, the secondary supplying the ignition current and the auxiliary coils supplying the filament current, the auxiliary coils being connected in two circuits each of which includes one auxiliary coil of one group and one auxiliary coil of the other group connected with their voltages additive.

10. A shell type transformer for supplying filament current and ignition current to a hot cathode electric discharge tube, said transformer comprising a magnetic structure having two longitudinal sides joined by two transverse sides and a longitudinal core extending from one transverse side to the other between the two longitudinal sides, a first group of concentric transformer coils on the core and including a primary coil and two auxiliary coils, a second group of concentric transformer coils on the core and including a secondary coil and two auxiliary coils, the magnetic structure including a magnetic shunt between the two groups of coils with a gap in the shunt path but outside of the path of the primary magnetizing flux, the secondary supplying the ignition current and the auxiliary coils supplying the filament current, the auxiliary coils being connected in two circuits each of which includes one auxiliary coil of one group and one auxiliary coil of the other group connected with their voltages additive.

11. A shell type transformer for supplying filament current and ignition current to a hot cathode electric discharge tube, said transformer comprising a magnetic structure having two longitudinal sides joined by two transverse sides and a longitudinal core extending from one transverse side to the other between the two longitudinal sides, a first group of transformer coils on the core and including a primary coil and two auxiliary coils surrounding the primary coil, a second group of transformer coils on the core and including a secondary coil and two auxiliary coils surrounding the secondary coil, the magnetic structure including a magnetic shunt between the two groups of coils with a gap in the shunt path but outside of the path of the primary magnetizing flux, the secondary supplying the ignition current and the auxiliary coils supplying the filament current, the auxiliary coils being connected in two circuits each of which includes one auxiliary coil of one group and one auxiliary coil of the other group connected with their voltages additive.

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