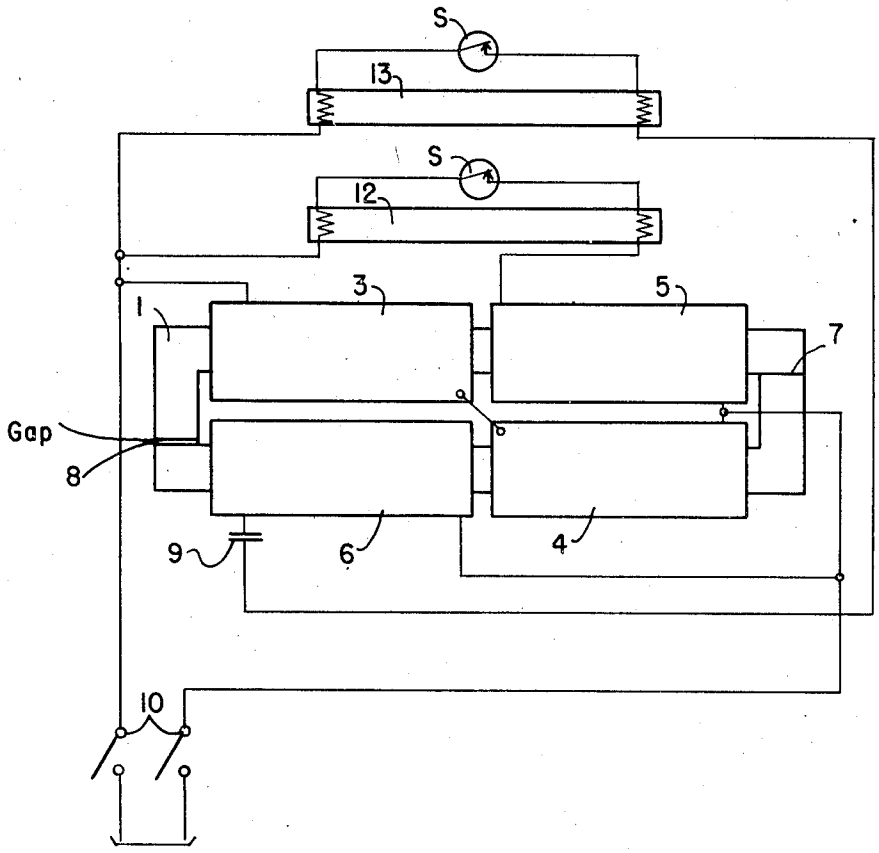
June 14, 1949. E. H. FREEMAN 2,473,420

TRANSFORMER

Filed Jan. 26, 1946



INVENTOR.

ERNEST H. FREEMAN

BY Morris Spector

Attorney

Patented June 14, 1949 2,473,420

UNITED STATES PATENT OFFICE

2,473,420

TRANSFORMER

Ernest H. Freeman, Wilmette, Ill., assignor, by mesne assignments, of one-half to Hirsch Epstein and one-half to Louis R. Duman, both of Chicago, Ill.

Application January 26, 1946, Serial No. 643,662

5 Claims. (Cl. 323—44)

1

This invention relates to electric transformers for hot cathode discharge lamps, particularly of the fluorescent type. Transformers of the type of the present invention are designed generally to operate a plurality of lamps, the circuit including a condenser in series with one of the lamps to cause it to take a leading current to correct for the lagging current taken by the other lamp.

It is one of the objects of the present invention to provide a transformer of an economical construction which will improve the wave form of the current in the lamp which has a condenser in series therewith. The improvement in wave form reduces the stroboscopic effect when two lamps are operated from the same transformer.

In the operation of a pair of glow discharge hot cathode tubes from a single transformer wherein one lamp is caused to take a leading current, it is important to provide means for preventing the leakage flux caused by one lamp to adversely affect the second lamp. Efforts have been made to overcome this difficulty by providing concentric secondaries for the respective lamps. This has resulted in a large square type transformer which is not readily adapted to the small space requirements of such transformers. Others have suggested dividing each secondary in two and each primary in two so that in effect the transformer has two primary coils and four secondary coils. This has resulted in a longer transformer and in such a transformer the leakage flux caused by the current in the leading lamp has adversely affected the other lamp, particularly during starting.

It is one of the objects of the present invention to provide a transformer for a pair of hot cathode glow discharge lamps which are corrected as to power factor by the use of a condenser, wherein the transformer is small and compact and wherein the wave form of the current in the leading lamp more closely approximates a sine wave.

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 the single figure is a diagrammatic view of a transformer embodying the present invention shown as connected in a typical circuit.

The transformer of the present invention comprises an elongated rectangular core 1 of laminated material such as is customary in trans-

2

former design. The core comprises two similar L-shaped stacks of laminations which have primary coils 3—4 thereon and secondary coils 5—6 thereon. The coils 3—5 are located on the long leg of one of the stacks of laminations comprising the core and the coils 4—6 are placed on the other long leg of the stack of laminations comprising the core. The two stacks of laminations are positioned in rectangular formation with the short leg of one stack in abutment with the long leg of the other, as indicated at 7. At the diagonally opposite corner of the rectangle the short leg of one stack is spaced from the long leg of the other stack by a non-magnetic spacer 8. The spacer 8 may consist of one or more sheets of paper or other non-magnetic material of a combined thickness of the order of .01 to .03 inch. This dimension is given, of course, merely by way of illustration and may be departed from to a considerable extent.

The coils 3—4 which constitute the primary of the transformer are connected in series and connected across a line 10 which constitutes a source of alternating current, say, a 60 cycle 110 volt source. The secondary coil 5 is connected to the primary coils so as to form a step-up autotransformer to supply power to a fluorescent lamp 12. The secondary coil 6 is also connected to the primary coils to form a step-up autotransformer to supply power through a condenser 9 through a lamp 13. The lamps 12 and 13 are both of the hot cathode glow discharge type of lamp and are adapted to be started by the passage of current through filaments thereof that are connected in series by a starter S which may be of any standard type and which opens the series circuit after a short time interval and leaves that series circuit open so that the arc forms and is maintained in the ionized gap between the electrodes, all as is well known in the art.

The two lamps 12 and 13 are considerably out of phase with each other and thereby the stroboscopic effect of the two lamps combined is sufficiently less than the stroboscopic effect of either lamp alone.

The secondaries 5 and 6 are separated from each other as far as possible to minimize the electro-magnetic coupling between them. With this separation the current in one lamp is less affected by a change of current in the other lamp such as may happen when a lamp burns out.

The lamp 12 takes a lagging current and the lamp 13 takes a leading current. The air gap 8 is introduced in the magnetic circuit adjacent

the coil 6 that supplies the leading current to the lamp 13. This air gap improves the wave form of the current taken by the leading lamp 13. The leakage flux about the coil 6 produced by this leading current increases the flux within the coil 6. Without an air gap in the main magnetic circuit near the coil 6 the resulting flux in the core within the coil 6 saturates the core and distorts the wave form in the current of the lamp 13 unless an uneconomically large core is used. The air gap acts to reduce the flux in the core within the coil 6 so that there is less saturation in the core within this coil and consequently less distortion of the current wave. As a consequence the resulting wave form of the light output from the lamp 13 is improved.

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 providing leading and lagging currents respectively for operating a plurality of separately operable glow discharge tubes comprising a core having two opposite side legs connected in a magnetic circuit, primary coils one on each leg and connected together in series, a leading current secondary and a lagging current secondary one on each leg, the four coils being in quadrilateral formation with the two primaries at diagonally opposite ends of the quadrilateral and the two secondaries at the other diagonally opposite ends of the quadrilateral, each of said secondaries being connected to the primary to form a step up auto transformer, the core having a gap in the magnetic flux path thereof which gap is included in the leakage flux path of one of the primary coils and included in the leakage flux path of the leading current secondary and excluded from the leakage flux path of the other secondary.

2. A transformer for providing leading and lagging currents respectively for operating a plurality of separately operable glow discharge tubes comprising a core having two opposite side legs connected in a magnetic circuit, primary coils one on each leg, secondary coils one on each leg, the four coils being in quadrilateral formation with the two primaries at diagonally opposite ends of the quadrilateral and the two secondaries at the other diagonally opposite ends of the quadrilateral, each of said secondaries being connected to the primary to form a step up auto transformer, means for causing one of the secondary coils to take a leading current, the core having a gap in the magnetic flux path thereof which gap is included in the leakage flux path of said leading current secondary and excluded from the leakage flux path of the other secondary, said gap being in the path of the primary magnetizing flux through all of the coils.

3. A transformer for providing leading and lagging currents respectively for operating a plurality of separately operable hot cathode discharge tubes, comprising an elongated core having comparatively long parallel side legs joined by a pair of comparatively short end legs to form a quadrilateral, a primary coil on each side leg and a secondary coil on each side leg, the two primaries being diagonally opposite one another and the two secondaries being diagonally opposite one another, each of the secondary coils being connected to the primary coils to form a step-up auto transformer, means for causing one of the secondary coils to take a leading current, the two coils on each side leg being of a combined length approximately equal to but less than the distance between the end legs of the core, the spacing between the secondaries being sufficient to prevent leakage flux of one secondary from acting on the other secondary in an amount sufficient to produce an adverse effect in the operation of the connected tube, the two primary coils being connected in series and the core having means in the path of the primary magnetizing flux through all of the secondaries for increasing the reluctance of the leakage flux path between one primary and one secondary as compared with the reluctance of the corresponding path between the other primary and the other secondary.

4. A transformer for providing leading and lagging currents respectively for operating a plurality of separately operable hot cathode discharge tubes, comprising an elongated core having comparatively long parallel side legs joined by a pair of comparatively short end legs to form a quadrilateral, a primary coil on each side leg and a secondary coil on each side leg, the two primaries being diagonally opposite one another and the two secondaries being diagonally opposite one another, each of the secondary coils being connected to the primary coils to form a step-up auto transformer, and each secondary coil having means for connecting it in a tube circuit, the two coils on each side leg being of a combined length approximately equal to but less than the distance between the end legs of the core, the spacing between the secondaries being sufficient to prevent leakage flux of one secondary from acting on the other secondary in an amount sufficient to produce an adverse effect in the operation of the connected tube, the two primary coils being connected in series and the core having means in the path of the primary magnetizing flux through all of the secondaries for increasing the reluctance of the leakage flux path between one primary and one secondary as compared with the reluctance of the corresponding path between the other primary and the other secondary, and a condenser in the circuit of the secondary that is in the leakage flux path of the higher reluctance.

5. A device for providing leading and lagging currents respectively for operating a plurality of glow discharge devices having negative resistance characteristics, said device comprising a transformer core having L-shaped laminations laid together with the end of a short leg of each L lamination adjacent the end of a long leg of another lamination to form a rectangular core constituting the primary magnetizing flux path, four transformer coils placed two on each of the long legs of the rectangle, two diagonally opposite coils being connected in series with one another and constituting the primary of the transformer, the two remaining coils constituting the secondaries and being connected each in auto step-up relationship to the primary, a condenser in circuit with one of the secondary coils to cause it to furnish a leading current, the core having a non-magnetic gap at the corner thereof adjacent said leading current secondary which gap is in the magnetic circuit of the primary magnetizing flux and is also included in the leakage flux path of the leading current secondary and excluded from the leakage flux path of the other

secondary, the leakage flux path of said other secondary being of lower magnetic reluctance than that of the leading current secondary.

ERNEST H. FREEMAN.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
1,698,080	Agnew	Jan. 8, 1929
2,317,844	Boucher	Apr. 27, 1943
2,323,703	Boucher	July 6, 1943
2,402,207	Ranney	June 18, 1946