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LIGHTING TRANSFORMER

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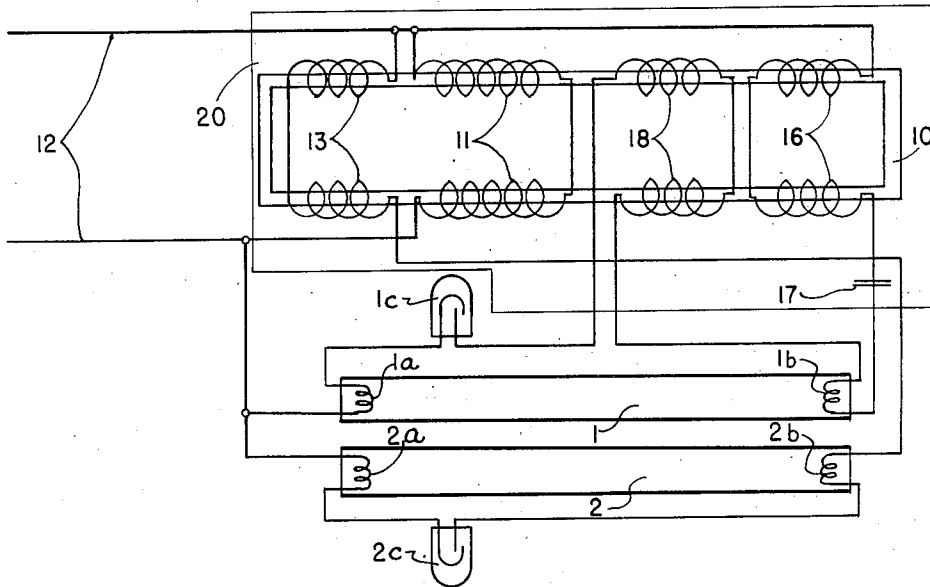


FIG. 1

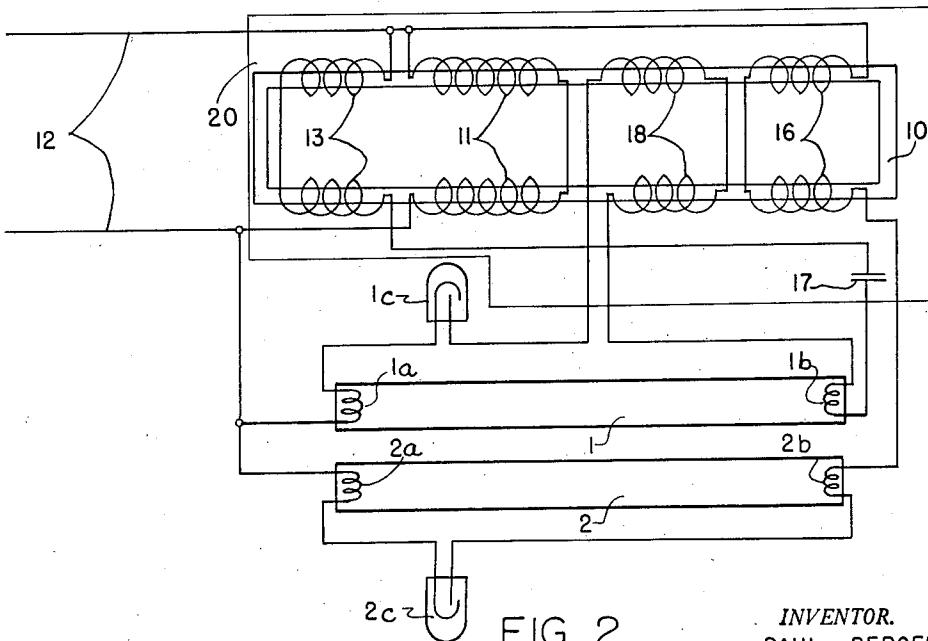


FIG. 2

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LIGHTING TRANSFORMER

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4 Claims. (Cl. 315-97)

1

This invention relates to a transformer and more particularly to a transformer for operating a plurality of hot cathode glow-discharge lamps, such as fluorescent tube lamps.

In order to improve the power factor of lighting circuits of fluorescent tube lamps it has been customary to operate the tubes in pairs off of a single transformer. There is provided an operating transformer having a pair of secondaries, one for each fluorescent tube. A condenser is provided in series with only one of the tubes to cause that tube to draw a leading current. This leading current compensates for the lagging current taken by the other tube, whereby the power factor of the load of the two tubes is improved.

Fluorescent tubes of the hot cathode type are started by providing a temporary series connection between the filaments at the opposite ends of the tube. A current of sufficient magnitude to heat the filaments is caused to flow through them. After a time interval adequate to allow the filaments to reach a temperature sufficient for the glow discharge arc to form, the series circuit between the filaments is automatically interrupted by a starter provided in the circuit, as is known in the art. In starting two lamps of the above mentioned character, which are connected to be operated from a single circuit, it has been found that the condenser which is in series with the filaments of only one of the lamps reduces the current flow to that lamp to a degree which is undesirable for satisfactory starting in many instances. In addition, in many instances there is sufficient reactance between the secondary coils of the transformer so that a reduction of the current flowing in the secondary which is in series with the condenser results in an increase in the current flowing in the other secondary which is connected to the other lamp. Thus the condenser not only diminishes, to an undesirable degree, the amount of current flowing in the starting circuit of one of the lamps but likewise also frequently increases, to an undesirable degree, the amount of current flowing to the other lamp. It has heretofore been proposed to remedy this condition by providing an additional inductance outside of the transformer, which additional inductance is temporarily connected in circuit with the condenser to reduce the reactance of the associated circuit during starting. This substantially increases the expense of the equipment required for each pair of fluorescent lamps.

It is one of the objects of the present invention to provide a circuit arrangement whereby the voltage of and consequent current in the starting

2

circuit of the lamp having the leading power factor is increased without substantially increasing the total cost of the equipment used. This is accomplished, in the preferred embodiment of the present invention, by providing an auxiliary coil on the transformer which supplies the power to the pair of fluorescent lights. This auxiliary coil is arranged to be treaded by the magnetic flux that treads at least one of the secondary windings, or the primary winding. During starting the auxiliary coil is connected in series with that secondary coil which supplies current to the leading lamp and with the voltages of the series connected coils cumulative. This auxiliary coil compensates for the reactance of the condenser in that circuit and, in addition, increases the voltage of that circuit. This auxiliary coil is disconnected from the circuit upon operation of the starter to interrupt the series connection between the heating coils of the two cathodes of the lamp. By this arrangement I have found that the starting current in the leading tube, which previously was too low, is increased, and the starting current in the lagging tube, which previously was too high, is decreased. Thus the starting currents in both tubes tend to equalize and therefore the circuit, including the transformer, may be designed so that the starting currents in both the leading and the lagging tubes may be brought to the desirable values set by the Electrical Testing Laboratories, Inc.

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 transformer embodying the present invention, connected in circuit with two fluorescent lighting tubes; and

Figure 2 illustrates an alternate circuit.

At 1 and 2 there has been shown a pair of hot cathode glow discharge fluorescent tubes or lamps of conventional construction having heating filaments 1a and 1b and 2a and 2b. The two lamps are adapted to be energized by a transformer 10. The transformer 10 includes a substantially closed magnetic circuit having a pair of series connected primaries 11-11 connected across the alternating current power line 12. The transformer has a pair of series connected secondary coils 13-13 on the same core structure 10, which coils 13 are connected at one end to one side of the line and at the other end in series with the filaments 2a-

2b and with a starter 2c, thence to the other side of the line. This constitutes the coil 13 part of an auto-transformer. This is the circuit for the tube 2, which is the lagging tube, and is a conventional circuit. The starter 2c comprises merely an evacuated tube having a pair of contacts spaced apart in a gaseous atmosphere such a distance that a discharge takes place when subjected to the high starting voltage, so that the resulting arc sufficiently heats one of the contacts, which is a thermal element, to cause a short circuit within the starter 2c, thereby establishing a series circuit between the filaments 2a and 2b. By the time the contacts in the starter 2c have sufficiently cooled to separate from one another the filaments 2a—2b have heated sufficiently so that upon separation of the contacts of the starter the resulting voltage causes an arc to be established between the cathodes at opposite ends of the tube 2.

The transformer 10 also has another pair of series connected secondary windings 16—16 similar to the windings 13 and preferably of the same number of turns. One end of a winding 16 is connected to one side of the line 12 and the other end of the other winding 16 is connected in series with a condenser 17, the filament 1b, thence through a pair of starting coils 18 connected in series and located upon the magnetic structure 19, thence in series through a starter 1c, similar to the starter 2c, thence in series with the filament 1a to the opposite side of the line. The coil 16, like the coil 13, acts as part of an auto-transformer. The starting circuit through the leading tube 1 includes the starting coil 18 which compensates for the reactance of the condenser 17 and, being on the iron core of the transformer 19, increases the voltage of the starting circuit of the tube 1 over what would have prevailed if the coil 18 had been omitted. This thereby increases the current flowing through the starting circuit of the filaments 1a—1b and at the same time reduces the current through the starting circuit of the filaments 2a—2b over what would have been the current flow had the coils 18 been omitted. After the starting operation has been completed and the starter switch 1c opens its circuit and the current flows across the space between the filaments 1a—1b, the coil 18 is open circuited and therefore performs no function.

For the sake of compactness the condenser 17 is mounted in the same case 20 in which the transformer is located, so that together they constitute one unit with the necessary connections between the condenser and the secondary 16, contained within the casing. Therefore only six leads need extend from the casing.

An analysis of the circuit illustrated shows that during the starting operation the coil 18 acts not only as an inductance but also as an auto-transformer. Because of this fact the coil 18 may be made of appreciably fewer turns than would be necessary if the coil 18 were outside of the magnetic circuit of the core 10. In one construction wherein the total primary windings 11 had 2200 turns and there were 1700 turns in the secondaries 13 and 1700 turns in the secondaries 16, it was found that 250 turns for the auxiliary winding 18 were adequate. The coils 18 were therefore so narrow as not substantially to increase the space between the coils 11—16 compared with the space between the coils 11—13.

During starting the number of turns of secondary winding that produces an auto-transformer effect for supplying current to the lamp

1 is equal to the sum of the turns on the coils 16 and 18. When the coils 18 are located in the proximity of the coils 16 the coils 18 have a small effect upon the flux through the coils 13. If the coils 18 are physically located on the core 10 adjacent the secondary coils of the lagging lamp, instead of adjacent the secondary coils of the leading lamp, then the effect of the coils 18 in reducing the amount of current flowing through the lagging lamp circuit during starting is accentuated without altering the cumulative effect of the series connected coils, including the auxiliary coil 18, insofar as concerns the starting action of the leading hot cathode glow discharge tube.

In those instances where it is found that the starting current for the lagging lamp 2 is too great, the compensating coils 18 in series with the leading lamp are located adjacent the secondaries that supply the current to the lagging tube in order to reduce the starting current in the filaments 2a—2b. This is illustrated in Figure 2 wherein the connections from the coils 13—16 have been interchanged over that shown in Figure 1.

From the above description it is apparent that there is provided a transformer and a circuit therefor for providing a sufficient starting current for leading and lagging hot cathode glow discharge tubes and wherein the difference in starting current taken by the two tubes is so substantially reduced that the current values taken by each tube are within the maximum and minimum starting currents established by Electrical Testing Laboratories, Inc.

In compliance with the requirements of the patent statutes I have here shown and described a few preferred embodiments 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. In combination with a pair of hot cathode glow discharge tubes each having cathode heating means at opposite ends thereof and each having a starting switch for connecting its heating means in series to effect starting of the tube and then opening the series connection, a transformer having a primary and a pair of secondaries, each secondary being connected in circuit to one of said tubes, a condensive reactance in circuit with one of the secondaries for power factor compensation whereby one of said tubes takes a leading current and the other tube a lagging current, and a starting coil in series connection with the starting switch of the tube taking the leading current, said starting coil and its series connected switch being connected in series with and between the cathode heating means at the ends of the tube taking the leading current, said starting coil being magnetically coupled with the primary and with its voltage additive to the voltage of the secondary in circuit with the leading tube when the starting coil is connected in circuit by its associated starting switch, said starting coil being located between the primary and one of said two pairs of secondaries.

2. In combination with a pair of hot cathode glow discharge tubes each having cathode heating filaments at opposite ends thereof and each having a starting switch for connecting its filaments in series to effect starting of the tube and then opening the series connection, a transformer

5

having a primary and a pair of secondaries each of which secondaries is connected to the primary to form an auto transformer, each secondary being connected in circuit across the cathodes of one of said tubes, a condensive reactance in series with one of the secondaries for power factor compensation whereby one of said tubes takes a leading current and the other tube a lagging current, and means for increasing the voltage across the leading tube during starting to compensate for the voltage drop through the condensive reactance, said means comprising a starting coil in series connection with the starting switch of the tube taking the leading current, said starting coil and its series connected switch being connected in series with and between the cathode heating means at the ends of the tube taking the leading current, said starting coil being magnetically coupled with the primary and with its voltage additive to the voltage of the secondary in circuit with the leading tube when the starting coil is connected in circuit by its associated starting switch, said starting switch in its open position open circuiting the starting coil, said starting coil being located between the primary and one of said two pairs of secondaries.

3. A transformer for supplying electrically displaced currents for operating a plurality of separately operable hot cathode tubes, said transformer having an elongated magnetic core, a primary coil positioned on said core intermediate the ends thereof, a pair of secondary coils positioned on the core on opposite sides of the primary coil, each of said secondaries being connected to the primary to form an auto transformer, separate load leads extending from the secondaries, a starting coil on said core adjacent to the primary coil and located between it and one of the secondary coils, a casing for said transformer, separate leads for the starting coil extending out of the casing, starter switch means connected to one of the leads of the starting coil for establishing switching connections for con-

6

necting and disconnecting said starting coil in circuit with one of the secondary coils, and a condenser in said casing, said condenser being connected in series with the last mentioned secondary coil.

4. A transformer for supplying electrically displaced currents for operating a plurality of separately operable hot cathode tubes, said transformer having an elongated magnetic core, a primary coil positioned on said core intermediate the ends thereof, a pair of secondary coils positioned on the core on opposite sides of the primary coil, each of said secondaries being connected to the primary to form an auto-transformer, separate load leads extending from the secondaries, a starting coil on said core adjacent the primary coil and located between it and one of the secondary coils, separate leads for the starting coil extending outwardly of the transformer, starter switch means connected to one of the leads of the starting coil for establishing switching connections for connecting and disconnecting said starting coil in circuit with one of the secondary coils, and a condenser, said condenser being connected in series with the last-mentioned secondary coil.

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