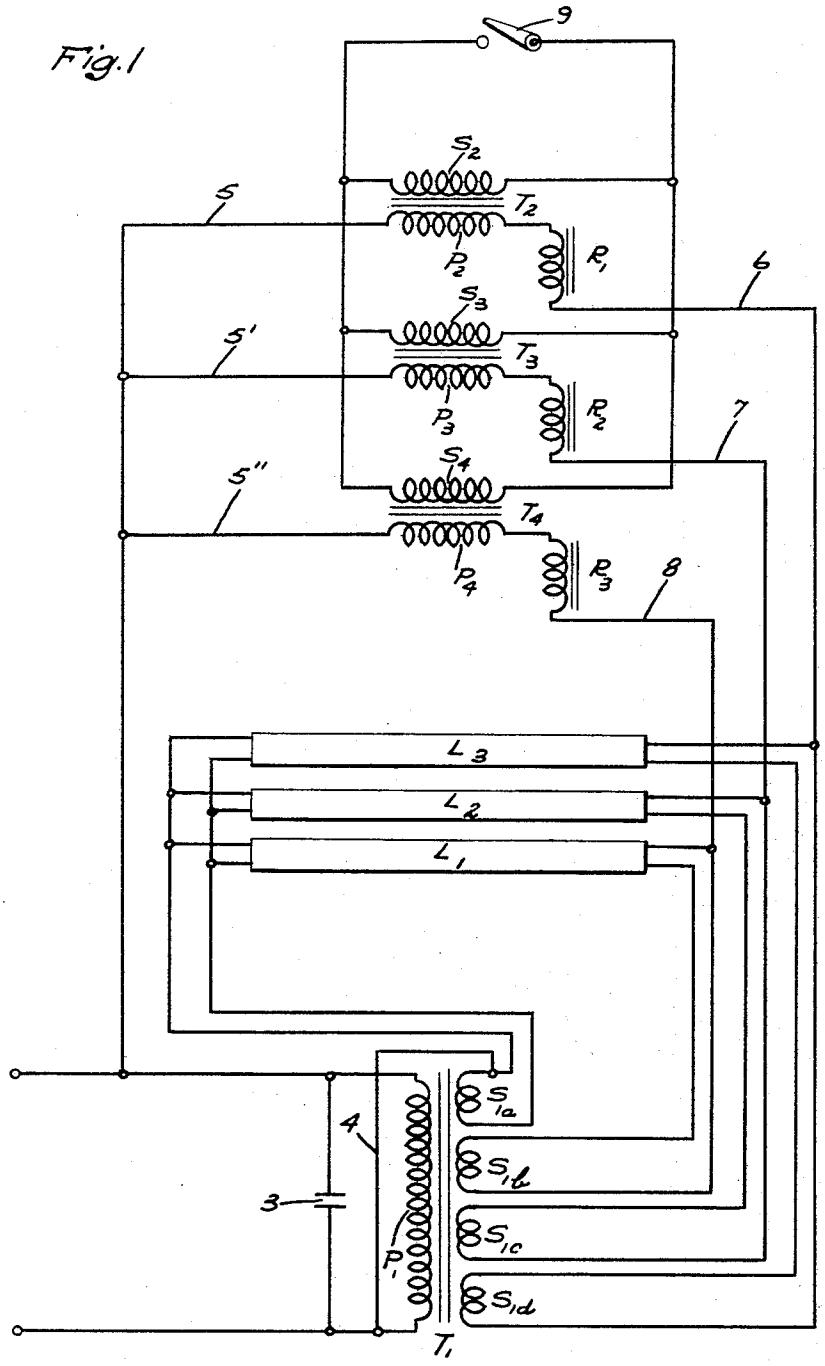
July 25, 1967 F. P. EPPERT 3,333,150

MULTI-LEVEL BALLAST CIRCUIT INCLUDING AN ISOLATION TRANSFORMER FOR SERIES CIRCUIT CONNECTION WITH A FLUORESCENT LAMP

Filed Sept. 30, 1964 2 Sheets-Sheet 1

Fig. 1



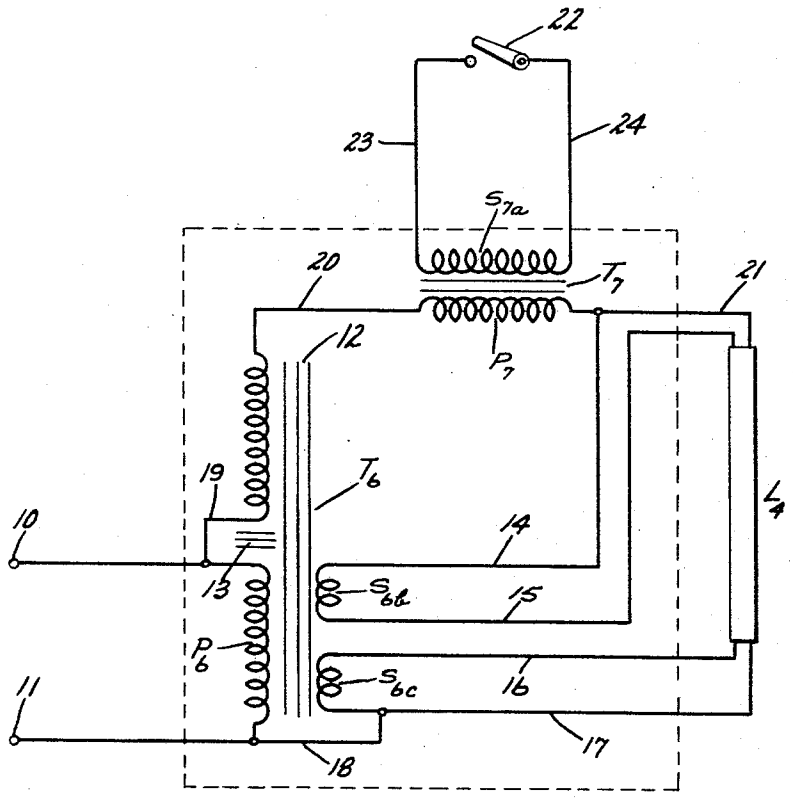
INVENTOR.
Franklin P. Eppert,
BY Henry J. Marcinak
Attorney.

July 25, 1967 F. P. EPPERT 3,333,150

MULTI-LEVEL BALLAST CIRCUIT INCLUDING AN ISOLATION TRANSFORMER FOR SERIES CIRCUIT CONNECTION WITH A FLUORESCENT LAMP

Filed Sept. 30, 1964 2 Sheets-Sheet 2

Fig. 2



INVENTOR.
Franklin P. Eppert,
BY /Henry J. Marcinek
Attorney.

United States Patent Office 3,333,150 Patented July 25, 1967

3,333,150

MULTI-LEVEL BALLAST CIRCUIT INCLUDING AN ISOLATION TRANSFORMER FOR SERIES CIRCUIT CONNECTION WITH A FLUORESCENT LAMP

Franklin P. Eppert, Danville, Ill., assignor to General Electric Company, a corporation of New York

Filed Sept. 30, 1964, Ser. No. 400,447
7 Claims. (Cl. 315—97)

This invention relates to an improved ballast circuit for use with fluorescent lamps. More specifically, it relates to a ballast circuit arrangement which provides two-level operation of fluorescent lamps.

In present commercial practice when using two-level ballasts with parallel connected fluorescent lamps it is necessary to include in the lamp circuits a separate pair of switching contacts for each ballast. If the separate switching contacts are not provided it has been found that unbalanced lamp operating levels result, with one lamp burning brighter than the others. Also, with a single switch in series with several parallel connected lamps it is impossible to uniformly control the lamp currents at lower levels.

It is an object of this invention to provide an improved ballast circuit useful for operating fluorescent lamps at two levels of output.

It is an object of this invention to provide a ballast circuit arrangement wherein the impedances of several ballasts, each of which is connected in series with one of several parallel connected fluorescent lamps, can be changed by the operation of a single pair of switching contacts.

It is a further object of this invention to provide a ballast circuit arrangement wherein two levels of operation of fluorescent lamps are provided with uniform output of the lamps at each level.

These objects are accomplished in accordance with this invention, in one form thereof, by including one winding of an isolation transformer in series with each fluorescent lamp. A switch is connected in series with the other windings of the isolation transformers, which are connected in parallel if more than one is used. The windings may be open-circuited or short-circuited by the switch. When the contacts are operated to short circuit the windings, the impedances of the windings in series with the lamps are reduced, thereby raising the output levels of the lamps.

Other objects and further details of that which is believed to be novel will be clear from the following description and claims taken with the accompanying drawings wherein:

FIGURE 1 is a schematic circuit diagram of a ballast circuit for several parallel connected fluorescent lamps including the improved circuitry of this invention.

FIGURE 2 is a schematic circuit diagram of a ballast circuit for a single fluorescent lamp including the improved circuitry of this invention.

FIGURE 1 shows a first embodiment of the subject invention in which three fluorescent lamsp L_1, L_2, and L_3 are connected in parallel. A transformer T_1 is provided with a primary winding P_1 which is energized by an AC power source having terminals **1** and **2**. A capacitor **3** is connected in parallel with the primary winding P_1 for power factor correction. Transformer T_1 has four secondary windings, S_{1a}, S_{1b}, S_{1c}, and S_{1d}. These secondary windings are used to heat the cathodes in lamps L_1, L_2, and L_3. Secondary winding S_{1a} is used to heat one of the cathodes in each of the three lamps, while windings S_{1b}, S_{1c}, and S_{1d} are used to heat the other cathodes in lamps L_1, L_2, and L_3, respectively. One cathode of each of the three lamps is connected to terminal **1** of the AC power supply by lead **4**.

Isolation transformers T_2, T_3, and T_4 are provided with primary windings P_2, P_3, and P_4, respectively, all of which are connected to terminal **2** of the AC power supply by leads **5**. The other terminals of the primary windings P_2, P_3, and P_4 are connected to one of the terminals of ballast reactors R_1, R_2, and R_3, respectively. The other terminals of the reactors R_1, R_2, and R_3 are connected to the second terminals of the lamps L_3, L_2, and L_1, respectively, by leads **6**, **7**, and **8**, respectively. Each of the isolation transformers T_2, T_3, and T_4, is provided with a secondary winding S_2, S_3, and S_4, respectively. Corresponding terminals of the three secondary windings are connected to each other and the parallel connected secondary windings are also connected in parallel with contacts of an "on-off" switch **9**.

With the switch **9** in the "off" position, as shown, the reactances of the primaries P_2, P_3, and P_4 of transformers T_2, T_3, and T_4 are large. Therefore, the lamps L_1, L_2, and L_3 operate at a low level as the power supplied to each lamp is limited by the reactances of a transformer primary winding and a ballast reactor.

With the switch **9** in the "on" position, the reactances of the primary windings P_2, P_3, and P_4 are reduced according to well-known transformer principles, and therefore increased power is supplied to the lamps L_1, L_2, and L_3. Thus, with switch **9** in the "on" position the lamps are operated at a higher output level than with the switch **9** in the "off" position. Without the physical interruption of the three parallel circuits, each including in series a ballast reactor, a transformer primary winding and a lamp, it is possible to alter the impedance of each of the three parallel circuits by closing or opening the contacts of switch **9**.

The turns ratios of the isolation transformer windings are chosen such that the current in the secondary winding and the voltage developed across it are compatible with the voltage and current ratings of the switch **9**.

With the control circuit shown in FIGURE 1, the operating level of each of the three lamps is controlled by a single switch **9**, but the failure of an individual isolation transformer, reactor, or lamp, affects only its circuit, the remainder of the lamps continue to operate in a normal manner with the switch **9** continuing to control their output level.

It can easily be seen that a greater number of parallel lamp circuits could be added to this ballast circuit, with the operating level of all of the lamps being controlled by a single switch **9**. The cathodes of these additional lamps could be energized by transformer T_1, or a separate transformer could be provided for each additional group of three lamps. In either case, the secondary windings of the isolation transformers whose primaries are each connected in series with one of the lamps would all be connected in parallel, whereby the switch **9** would control the operating level of all of the lamps.

Similarly, two or more lamps connected in series could replace each of the lamps L_1, L_2, and L_3, to increase the number of lamps controlled by the single switch **9**. If two or more lamps were connected in series, additional ballast reactance would also be required, and could be obtained by connecting an additional reactor in series with each isolation transformer primary.

By reference to FIGURE 2, it will be seen that a single fluorescent lamp L_4 is energized by a ballast transformer T_6. This transformer has a primary P_6 which is connected by lines **10** and **11** to the terminals of an AC power supply. The transformer T_6 has a main magnetic core **12**, and also a bridging core portion **13** which provides a high leakage reactance between the primary winding P_6 and a secondary winding S_{6a}. It will be understood, of course, that various other arrangements for providing leakage flux paths or shunts between the pri-

mary winding P_6 and the secondary winding S_{6a} may be employed. Depending upon the design of the particular ballast transformer, either air leakage paths, inserted shunts, or shunts integrally formed on the magnetic core **12** may be employed.

Transformer T_6 is also provided with two additional secondary windings S_{6b} and S_{6c} which are used to heat the cathodes of lamp L_4. Winding S_{6b} is connected to one of the cathodes of lamp L_4 by leads **14** and **15**, while winding S_{6c} is connected to the other cathode of tube L_4 by leads **16** and **17**. The cathode of lamp L_4 which is connected to secondary winding S_{6c} is also connected to one side of the primary winding P_6 and therefore to terminal **11** of the AC power supplied by lead **18**.

One terminal of the secondary winding S_{6a} is connected to a terminal of the primary winding P_6, and to terminal **9** of the AC power supply by lead **19**. An isolation transformer T_7 is provided with a primary winding P_7 which is connected in series with the secondary winding S_{6a} and the lamp L_4 by leads **20** and **21**, respectively. The contacts of an "on-off" switch **22** are connected to a secondary winding S_{7a} on transformer T_7 by leads **23** and **24**.

The operation of this ballast circuit is similar to that shown in FIGURE 1. With the switch **22** in the "off" position, as shown, the reactance of the primary winding P_7 of the transformer T_7 is large, and therefore the lamp L_4 operates at a low level. The power supplied to the lamp L_4 being limited by the reactances of the transformer windings S_{6a} and P_7. With the switch **22** in the "on" position, the reactance of a primary winding P_7 is reduced according to well-known transformer principles, and therefore increased power flows to the lamp L_4, with the output of lamp L_4 thereby being increased.

While particular embodiments of the invention have been shown, other embodiments of the invention, such as the use of two or more isolation transformers in series with each lamp to give multilevel lamp operation, will be apparent to those skilled in the art, and it is intended to cover by the appended claims all embodiments falling within the scope thereof.

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

1. A ballast circuit for varying the output level of a hot cathode fluorescent lamp energized by an alternating current source, said circuit comprising:

(a) a first transformer having a primary winding and a plurality of secondary windings,

(b) a capacitor connected to said transformer for correcting the power factor of said circuit,

(c) means for connecting said secondary windings to heat the cathodes of the lamp,

(d) an isolation transformer having a primary and a secondary winding,

(e) a reactor for limiting current to the lamp during operation,

(f) means for connecting said isolation transformer primary winding and said current limiting reactor in series between the lamp and the source,

(g) a bilaterally conducting switch connected to said secondary winding whereby with said switch closed said secondary winding is short circuited during successive half cycles of applied voltage and said lamp operates at a higher level, and with said switch open, said lamp operates at a lower level.

2. A ballast circuit for varying the output level of a fluorescent lamp energized by an alternating current source, said circuit comprising:

(a) a transformer having a first winding, and a high reactance secondary winding,

(b) means for connecting said first winding to the alternating current source,

(c) an isolation transformer having a primary and a secondary winding,

(d) means for connecting said high reactance secondary winding and said primary winding in series between the lamp and the source,

(e) bilaterally conducting switch means connected to said secondary winding whereby with said switch means in a closed condition said secondary winding is short circuited during successive half cycles of applied voltage and said lamp operates at a higher level, and with said switch means in an open condition, said lamp operates at a lower level.

3. A ballast circuit for varying the output level of a hot cathode fluorescent lamp energized by an alternating current source, said circuit comprising:

(a) a transformer having a first winding, a high reactance secondary winding, and additional secondary windings,

(b) means for connecting said first winding to the alternating current source,

(c) means for connecting each of said additional secondary windings to heat one of the cathodes of the lamp,

(d) an isolation transformer having a primary and a secondary winding,

(e) means for connecting said high reactance secondary winding and said primary winding in series between the lamp and the source,

(f) a switch connected to said secondary winding whereby with said switch closed said secondary winding is short circuited during successive half cycles of applied voltage and said lamp operates at a higher level, and with said switch open, said lamp operates at a lower level.

4. A ballast circuit useful for operating fluorescent lamps at two output levels from an alternating current source, said circuit comprising:

(a) isolation transformers, each having a primary and a secondary winding,

(b) means for connecting each of said primary windings in series with one of the lamps,

(c) means for connecting all of said secondary windings in parallel with each other,

(d) switch means connected in parallel with said secondary windings, whereby with said switch means in a closed condition said secondary windings are short-circuited and said lamps operate at a higher level, and with said switch means in an open condition, said lamps operate at a lower level.

5. A ballast circuit useful for operating fluorescent lamps at two output levels from an alternating current source, said circuit comprising:

(a) ballast reactors, and means for connecting each ballast reactor in series with one of the lamps,

(b) isolation transformers, each having a primary and a secondary winding,

(c) means for connecting each of said primary windings in series with one of the lamps,

(d) means for connecting all of said secondary windings connected in parallel with each other,

(e) switch means connected in parallel with said secondary windings, whereby with said switch means in a closed condition said secondary windings are short-circuited and said lamps operate at a higher level, and with said switch means in an open condition, said lamps operate at a lower level.

6. A ballast circuit useful for operating hot cathode fluorescent lamps at two output levels from an alternating current source, said circuit comprising:

(a) a transformer having a first winding and several secondary windings,

(b) means for connecting said first winding to the alternating current source,

(c) means for connecting one of said secondary windings to heat one of the cathodes in each of the lamps,

(d) means for connecting each of said other secondary

windings to heat the other cathode in one of the lamps,

(e) isolation transformers, each having a primary and a secondary winding,

(f) means for connecting each of said primary windings in series with one of the lamps,

(g) means for connecting all of said secondary windings in parallel with each other,

(h) a switch connected in parallel with said secondary windings, whereby with said switch closed said secondary windings are short-circuited and said lamps operate at a higher level, and with said switch open, said lamps operate at a lower level.

7. A ballast circuit useful for operating hot cathode fluorescent lamps at two output levels from an alternating current source, said circuit comprising:

(a) a transformer having a first winding and several secondary windings,

(b) means for connecting said first winding to the alternating current source,

(c) means for connecting one of said secondary windings to heat one of the cathodes in each of the lamps,

(d) means for connecting each of said other secondary windings to heat the other cathode in one of the lamps,

(e) ballast reactors, and means for connecting each ballast reactor with one of the lamps,

(f) isolation transformers, each having a primary and a secondary winding,

(g) means for connecting each of said primary windings in series with one of the lamps,

(h) means for connecting all of said secondary windings in parallel with each other,

(i) a switch connected in parallel with said secondary windings, whereby with said switch closed said secondary windings are short-circuited and said lamps operate at a higher level, and with said switch open, said lamps operate at a lower level.

References Cited

UNITED STATES PATENTS

1,926,423	9/1933	Barclay	315—255
2,665,394	1/1954	Arvidsson et al.	315—97
2,774,917	12/1956	Passmore	315—97
2,961,579	11/1960	Roney et al.	315—170
3,070,743	12/1962	Harper	323—86 X
3,182,249	5/1965	Pahlavan	323—50 X

JAMES W. LAWRENCE, *Primary Examiner.*

C. R. CAMPBELL, *Assistant Examiner.*

UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,333,150 July 25, 1967

Franklin P. Eppert

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 6, line 2, after "reactor" insert -- in series --.

Signed and sealed this 24th day of September 1968.

(SEAL)
Attest:

Edward M. Fletcher, Jr.
Attesting Officer

EDWARD J. BRENNER
Commissioner of Patents