The present invention relates to circuits for electric discharge lamps, and is a modification of the invention disclosed and broadly claimed in application Serial No. 731,559, filed February 28, 1947, in the name of Harold W. Lord and assigned to the same assignee, now abandoned.

It is often required to use capacitive circuits for operating discharge lamps since such circuits can be run in parallel with inductive circuits with the results that the over-all power factor can be made nearly unity and the combined light from a lamp in a capacitive circuit and one in an inductive circuit exhibits less stroboscopic flicker than that from either lamp alone.

When a lamp in a capacitive circuit is operated directly from supply mains, the usual form of a ballast consists of a capacitor in series with a choke, the latter being essential to render the circuit stable and to make the wave form of the current approximately sinusoidal. The impedance of the capacitor is usually made about double that of the choke and during normal running of the lamp the voltage across the capacitor is about double that across the choke, and also about double the supply voltage. If the impedance of the choke is made too small, the current wave form becomes peaky, flicker may be noticeable and the life of the lamp may be adversely affected.

Where it is required to step-up the voltage applied to the lamp, it is advantageous to use a stray-field (high leakage reactance) transformer which performs the functions of an ideal transformer and a series choke. There are obvious advantages in using a stray-field transformer with a capacitive circuit since a separate choke is then unnecessary.

Assuming that such an arrangement is used and that the open circuit voltage across the output terminals of the transformer is \( V_0 \), the voltage across the capacitor and that across the output terminals will be of the order of twice \( V_0 \) when the lamp is operating normally. Hence if the transformer is designed to have, on open circuit, a suitable flux density in the iron associated with the primary and secondary coils (for example, with silicon steel a peak value of about 10,000 lines per square centimeter) then, when the lamp is operating normally, the flux density in the iron associated with the secondary coil will reach a saturation value and give rise to objectionable flicker in the lamp. The flux density in the iron associated with the primary coil remains constant since the voltage across this coil remains constant.

Such saturation can be avoided by sufficiently increasing the cross section of the iron associated with the secondary coil, but the flux density in this part of the iron will then be relatively low on open circuit and if the cross-section of the iron associated with the primary winding were the same, as is usually convenient, the flux density in this part of the iron would be unnecessarily low under all conditions. Such a transformer would clearly be large and expensive.

It is an object of the present invention to provide a capacitive circuit for an electric discharge lamp, employing a stray-field transformer, in which the above-mentioned disadvantage is removed or substantially reduced.

According to the present invention, a capacitive circuit for an electric discharge lamp comprises a stray-field transformer having a primary and a secondary winding arranged upon a core of magnetic material. A magnetic leakage path is provided for magnetic flux between the said windings, and the said core is provided with an air gap which lies in the path of flux passing through the said secondary winding and wholly or largely on the side of the said leakage path remote from the primary winding.

The effect of this air gap is to increase substantially the reluctance of the flux path associated with the secondary winding. By a suitable choice of the size of this air gap, and of the reluctance of the said leakage path, the cross-section of the magnetic material associated with the two windings can be made the same and such that the flux density in the primary winding has a suitable, relatively high, value and nevertheless, the flux density in the secondary winding when the lamp is operating normally may be arranged to have a suitable value below saturation.

The invention will be better understood from the following description taken in connection with the accompanying drawing and its scope will be pointed out in the appended claims.

In the drawing, Fig. 1 illustrates diagrammatically an embodiment of the invention using a shell-type core with an auto-connected reactance transformer, Figs. 2, 3, 4 and 5 show modified core arrangements and winding connections, and Fig. 6 illustrates a double reactance auto-transformer for energizing separate lead and lag discharge lamp circuits.
In Fig. 1 a shell-type transformer is used and the primary and secondary windings and are arrayed upon the central limb with reac-
tance iron stampings, providing the leakage path, between them. Air or other non-magnetic gaps are provided in the usual manner between the ends of the reactance stampings and the limbs of the core. In addition, an air gap is provided between the central limb and the end limbs uniting the two outer limbs at the end of the transformer at which the secondary winding is disposed. All the magnetic flux linking the secondary winding thus passes through this air gap.

One such transformer has the following dimensions in inches. The outside dimensions of the main core stampings in length in a direction parallel to the axis of the central limb and the side width and thickness of the stack of stampings is 2 1/2. The width of the side 1 and end limbs 9 and 10 and that of the central limb 4 is 1 1/2. The reactance stampings on each side of the central limb 4 have a length equal to the thickness of the main core, i.e. 2 1/2. Each stack is 1 1/2 thick and the width of the stampings is 3 3/4, namely such that they extend from the central limb 4 to within 1 1/2 of the side limbs 7. The air gap is 3 between the central limb 4 and the end limb 9 at the secondary winding end is 3/4.

The primary winding consists of 477 turns of 19/56 S. W. G. enameled wire and the secondary winding consists of 552 turns of 20/56 S. W. G. enameled wire. The transformer is auto-connected.

This transformer is suitable for operating from a supply of 240 volts 60 cycles a fluorescent, low-pressure, arc and cathode mercury vapor lamp rated at 80 watts, of length 60 inches and diameter 1 1/2 inches. A capacitor 11 of 5.5 mfd. rated at 500 volts A. C. is used and a starter switch 12 of light kind may be employed.

The reactance stampings are preferably inserted in such a way that they extend over substantially the whole thickness of the main core. If they are withdrawn unduly the wave form of the discharge current deteriorates and flicker is noticeable.

In a modification shown in Fig. 2 of the transformer above described, instead of the air gap being between the central limb and the end limb adjacent to the secondary winding, it may be disposed in the central limb between one end of the secondary winding and the reactance stampings. Instead of, or in addition to, the air gaps described above, air gaps may be provided in the side limbs 7 in the path of the magnetic flux linking the secondary winding and wholly or largely on the side of the reactance stampings remote from the primary winding. This is shown in Fig. 3.

In another construction shown in Fig. 4, two E-shaped cores and are used, one having the secondary winding on its central limb and the other having the primary winding on its central limb and the reactance stampings between the extremity of the central limb and the outer limbs. These two cores are then clamped together with the extremities of their limbs close together but separated by non-magnetic material to provide the required air gaps.

In a further transformation, shown in Fig. 5, which may be employed, two approximately U-shaped cores and are used, two secondary windings and being preferably provided on the limbs of one core and two primary windings and being preferably provided on the limbs of the other core, one set of reactance stampings being disposed between the limbs of the latter core and spaced therefrom by suitable air gaps. These two cores are clamped together with the limbs separate. In addition, an air gap is provided between one end of the central limb and one end limb. The secondary winding at this end is connected to supply the capacitive circuit and that (3") at the other end supplies the inductive circuit. It may be found desirable, in order to make the open circuit voltage substantially the same on both secondary windings, to connect the latter secondary winding 3" to a tapping 17 on the primary winding rather than to one end thereof and to connect the former secondary winding 3 to one end of the primary winding. The other forms of transformer described can also be modified to operate two lamps.

Instead of a connected stray-field transformer, a double-wound, stray-field transformer can be used as shown in Figs. 2 and 4. Moreover, the invention is applicable both to hot cathode and cold cathode discharge lamps.

The open circuit voltage across a secondary coil can be adjusted by altering (1) the number of turns on the secondary coil, (2) the point on the primary winding to which the secondary coil is connected (in the case of a connected transformer), (3) the length of the air gaps or gaps in the main iron core, (4) the length of the air gaps or the depth of iron in the reactance paths, or by a combination of two or more of these steps.

It is also necessary that the secondary winding associated with a capacitive circuit should have a high enough inductance since if the inductance is too low bad flicker may occur.

While there have been shown and described particular embodiments of this invention, it will be obvious to those skilled in the art that various changes and modifications can be made therein without departing from the invention and, therefore, it is aimed in the appended claims to cover all such changes and modifications as fall within the true spirit and scope of the invention.

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

1. In combination, a magnetic core, a primary winding and a secondary winding on said core, said core including magnetic leakage flux paths between said primary winding and said secondary windings, said core including a high inductance section between one secondary winding and the leakage flux path which is between it and said primary winding, a capacitor, an electric discharge lamp connected in series with said capacitor across said last-mentioned secondary winding and said primary winding in series, and a second electric discharge lamp connected in
series with the other secondary winding and a fraction of said primary winding.

2. In combination, a magnetic core, a primary winding and two secondary windings on said core, said core including magnetic leakage flux paths between said primary winding and both of said secondary windings, said core including a high reluctance section between one secondary winding and the leakage flux path between it and said primary winding, said last-mentioned secondary winding and said primary winding being serially connected for energizing a leading current circuit for an electric discharge lamp, the other secondary winding and a fraction of said primary winding being serially connected for operating a lagging current circuit for an electric discharge lamp.

JULIUS CATES.

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Certificate of Correction

Patent No. 2,541,083

February 13, 1951

JULIUS CATES

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows:

Column 1, line 6, after "assignee" strike out the comma and words "now abandoned";

and that the said Letters Patent should be read as corrected above, so that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 26th day of June, A.D. 1951.

[SEAL]

THOMAS F. MURPHY,
Assistant Commissioner of Patents.
Certificate of Correction

Patent No. 2,541,033

JULIUS CATES

February 13, 1951

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction as follows:

Column 1, line 6, after “assignee” strike out the comma and words “, now abandoned”;

and that the said Letters Patent should be read as corrected above, so that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 26th day of June, A. D. 1951.

[SEAL]

THOMAS F. MURPHY,
Assistant Commissioner of Patents.