Oct. 15, 1957 C. E. STRECKER 2,810,100

TRANSFORMER

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Fig. 1.

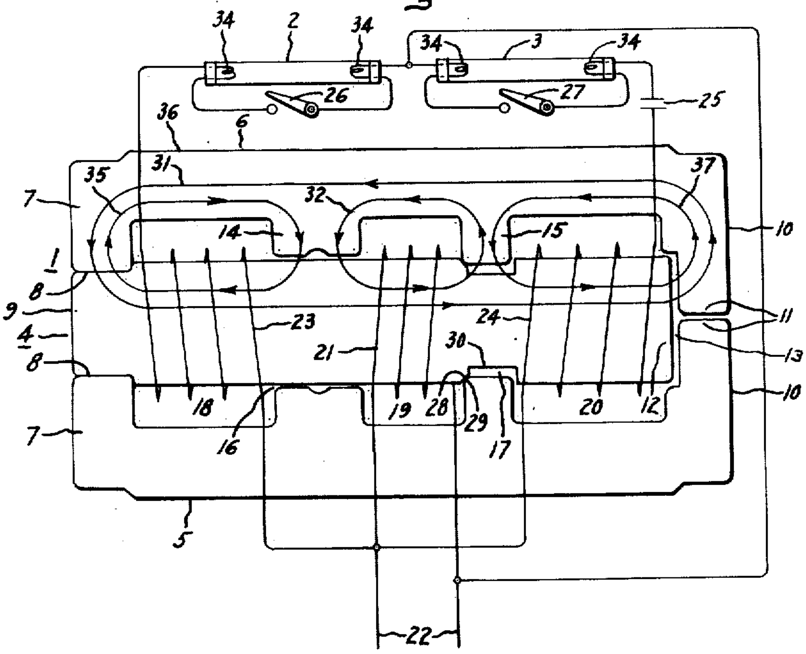
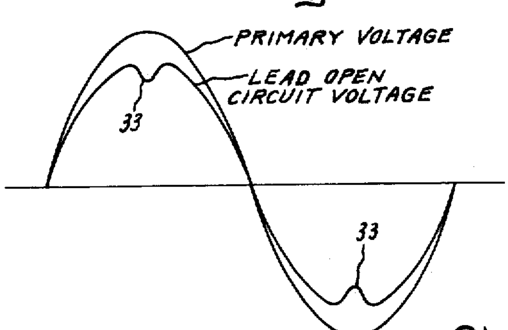


Fig. 2.



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TRANSFORMER

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5 Claims. (Cl. 315—97)

This invention relates to transformers and more particularly to high reactance ballasting transformers for use with arc discharge devices, such as fluorescent lamps.

Fluorescent lamps ordinarily require a voltage higher than the commercial line voltage for starting and thus ballasting transformers are provided for energizing the lamps. These transformers conventionally have a magnetic core with a primary winding adapted to be connected to an external source of alternating current and one or more secondary windings connected to the lamps. Furthermore, these ballasting transformers are conventionally constructed to provide a high reluctance path for the leakage flux, i. e. the flux produced by load current flowing in the secondary windings, this high reactance producing the necessary ballasting, or current limiting effect after the lamps have fired.

When a fluorescent lamp is directly connected to the secondary winding of a ballasting transformer, the lamp current flowing in the secondary winding is lagging therefore producing a poor power factor. In order to effect a power factor correction, a capacitor may be connected in series with the lamp thereby producing a leading lamp current flowing in the secondary winding. Furthermore, two lamps are frequently respectively connected to two secondary windings of the same transformer and in such arrangements, the stroboscopic effect of the lamps is conventionally corrected by connecting a capacitor in series with one of the lamps so that one lamp operates with leading current while the other operates with lagging current.

When a ballasting transformer is connected to a fluorescent lamp and a capacitor is used to provide leading current, the resultant leading load current produces leading leakage flux in the transformer core which aids the primary or exciting flux thus tending to saturate the core in the region of the leading current secondary winding. This condition may be corrected by enlarging the core cross-section in the region of the leading current secondary winding, however, the more conventional approach is to provide a series air gap in the core thereby preventing saturation. In addition, shunt gaps are also provided to provide the high leakage reactance necessary for the ballasting action.

It is necessary to maintain the width of both the series and shunt air gaps in production in order to provide the desired electrical characteristics. In the past, both the series and shunt air gaps have been maintained by a magnetic bridge at the series gap, as more fully shown and described in Patent 2,562,693 to W. W. Brooks, assigned to the assignee of the present application. In addition to mechanically controlling the series and shunt air gaps, this magnetic bridge in some cases is of some electrical advantage since it produces a higher open circuit secondary peak voltage. This higher peak voltage may be desirable for cold cathode starting of lamps. However, the high peak voltage has been found to be undesirable in certain other connections, such as the

switch starting of lamps since the high peak voltage may cause the lamps to fire without the switches being closed.

It is therefore desirable to provide a ballasting transformer construction in which the series and shunt gaps are maintained without producing a high open circuit secondary peak voltage.

An object of this invention is therefore to provide an improved transformer construction incorporating the desirable features set forth above.

Further objects and advantages of this invention will become apparent by reference to the following description and the accompanying drawing, and the features of novelty which characterize this invention will be pointed out with particularity in the claims annexed to and forming a part of this specification.

This invention in its broadest aspects provides a high reactance transformer having a magnetic core with a winding leg member and a multi-leg yoke member associated therewith. One end leg of the yoke member is arranged abutting one end of the winding member while the other end leg of the yoke member defines a series air gap with the other end of the winding leg. The yoke member has a leakage leg intermediate its end legs extending toward the winding leg member and defining a shunt air gap therewith. A magnetic bridge connects the winding leg and the leakage leg thereby providing a bridged gap. Thus, when a secondary winding is positioned on the winding leg intermediate the leakage leg and the end leg defining the series air gap and this winding is connected for leading current operation with a lamp and a capacitor, the series and shunt air gaps are maintained and the open circuit secondary peak voltage is reduced rather than increased.

In the drawing, Fig. 1 is a schematic illustration showing the improved high reactance ballast transformer construction of this invention; and

Fig. 2 illustrates the open circuit secondary voltage wave form produced by the construction of Fig. 1.

Referring now to Fig. 1, there is shown a high reactance ballasting transformer, generally identified as **1**. The transformer shown is of the shell type and is connected to a pair of fluorescent lamps **2** and **3**. This transformer is therefore commonly referred to as a lead-leg type, as will be hereinafter more fully described.

Transformer **1** is formed of a magnetic core including a center winding leg **4** and multi-leg yoke members **5** and **6** all formed of a plurality of relatively thin laminations of magnetic material. It will be seen that yoke members **5** and **6** are each provided with end legs **7** which are respectively seated in cutout portions **8** on the sides of center winding leg **4** adjacent its end **9**. Thus, end legs **7** of yoke members **5** and **6** abut the end **9** of center winding leg **4**. The other end legs **10** of yoke members **5** and **6** are arranged so that their ends **11** are spaced apart and are axially spaced from the other end **12** of center winding leg **4** thereby defining a series air gap **13**. Yoke members **5** and **6** are respectively provided with two leakage legs **14** and **15** extending toward center winding leg **19**. Leakage legs **14** define shunt air gaps **16** with the sides of center winding leg member **4** while leakage legs **15** extend partially into cutout portions **17** in the sides of center winding leg member **4** thereby defining shunt air gaps **30**. Leakage legs **15** are narrower than leakage legs **14**, as will be hereinafter more fully described, and leakage legs **14** and **15** respectively define winding windows **18**, **19**, and **20** with center winding leg **4**.

A primary winding **21** is arranged on center winding leg **4** in winding window **19** and is adapted to be connected to an external source of alternating current (not shown) by supply lines **22**. A lagging current secondary winding

23 is arranged on center winding leg 4 in winding window 18 and is connected to lamp 2 and primary winding 19 by an autotransformer connection as shown. A leading current secondary winding 24 is also arranged on center winding leg member 4 in winding window 20 and is connected to lamp 3 by a primary winding 21 and autotransformer connection. A capacitor 25 is connected in series between lamp 3 and secondary winding 24 to provide leading current operation. Lamps 2 and 3 are started by conventional starting switches 26 and 27, as is well-known in the art.

In order to mechanically maintain series air gap 13 and shunt air gaps 16 and 17, corners 28 of cutout portions 17 of center winding leg member 4 are arranged abutting corners 29 of leakage legs 15. This arrangement also provides a magnetic bridge between the center winding leg member 4 and the leakage legs 15 thereby bridging shunt gaps 17.

In operation, with lamp starting switches 26 and 27 open, and with primary winding 21 connected to external source of alternating current, exciting primary or exciting flux will traverse the core as shown by the lines 31 and 32. Referring now to Fig. 2 in addition to Fig. 1, it will be seen that as the voltage impressed on the primary winding 21 passes through zero so that the primary or exciting flux has a low density value, the bridge 28—29 presents a lower reluctance and thus more attractive path for the exciting flux than does the series gap 13. Thus, a substantial percentage of the exciting flux will traverse the bridged section 28—29 as shown by the line 32. A relatively small amount of exciting flux will cross the series gap 13 thus linking the secondary winding 24 and thereby producing a relatively low open circuit output voltage across secondary winding 24, as shown by 33 in Fig. 2. However, as the impressed primary voltage rises and thus the exciting flux increases, the bridged section 28—29 will saturate thus greatly increasing the apparent reluctance of the bridged gap 17. The bridged section 28—29 is therefore no longer as attractive and an increased proportion of the exciting flux will traverse the series gap 13 thus linking the secondary winding 24. The open circuit voltage of the secondary winding 4 will therefore be proportionately higher and more nearly approximating the desired sine wave configuration. It is thus seen that the provision of the bridged section 28—29 across shunt gap 17 produces a depressed open circuit secondary peak voltage but an otherwise substantially normal open circuit wave form.

When switches 26 and 27 are closed, a circuit is provided through cathodes 34 of lamps 2 and 3. With lagging load current flowing in secondary winding 23, the leakage flux, as shown by the line 35, opposes the exciting flux 31 in the center winding leg member 4, end legs 7 and connecting portion 36 of yoke member 6, however it aids the exciting flux 32 in leakage leg 14 thus requiring that the legs 14 be of increased cross-section in order to accommodate the total flux density and to prevent saturation. On the other hand, by virtue of capacitor 25, the load current flowing in secondary winding 24 is leading and thus the leakage flux shown by the line 37 aids the exciting flux 31 in end leg 10, the center winding leg 4 and the connecting portion 36 of yoke member 6. Thus, the series gap 13 is provided to prevent saturation of end leg 10 and connecting portion 36 of yoke member 6 while leakage legs 15 can be of smaller cross-section since leakage flux 37 and exciting flux 32 oppose therein.

While a two lamp lead-lag high reactance ballast transformer is shown, it will be readily apparent that the improved bridged gap construction of this invention can be incorporated in any high reactance ballasting transformer wherein it is necessary to maintain series and shunt air gaps. It will now be readily seen that this invention provides an improved and simplified ballast construction in which not only are the series and shunt air gaps maintained, but also in which the open circuit voltage of the lead secondary winding has a low peak value thus preventing starting of the lamps when the switches are not closed.

While I have shown and described a particular embodiment of this invention, further modifications and improvements will occur to those skilled in the art. I desire that it be understood therefore that this invention is not limited to the form shown and I intend in the appended claims to cover all modifications which do not depart from the spirit and scope of this invention.

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

1. A high reactance transformer comprising a magnetic core having a winding leg member and a multileg yoke member, one end leg of said yoke member abutting one end of said winding leg member and the other end leg of said yoke member defining a series air gap with the other end of said winding leg member, a primary winding and a secondary winding in spaced relation on said winding leg member, said yoke member having a leakage leg extending intermediate said primary and secondary windings toward said winding leg member and defining a shunt air gap with said winding leg member, and a magnetic bridge across the shunt air gap between said leakage leg and said winding leg, said bridge maintaining the spacing and position of both said series and shunt air gaps and reducing the open circuit peak voltage of said secondary winding.

2. The high reactance transformer of claim 1 wherein the magnetic bridge comprises a portion of the leakage leg abutting said winding leg member.

3. The high reactance transformer of Claim 1 wherein the winding leg member has a cutout portion opposite said leakage leg, and said magnetic bridge comprises a corner of said leakage leg abutting a corner of said cutout portion of said winding leg member.

4. A high reactance transformer comprising a magnetic core having a winding leg member and a multileg yoke member, one end leg of said yoke member abutting one end of said winding leg member, the other end leg of said yoke member defining a series air gap with the other end of said winding leg member, a primary winding and two secondary windings on said winding leg member, said secondary windings being on opposite sides of said primary winding in spaced relation thereto, said yoke member having two leakage legs each extending between said primary winding and one secondary winding toward said winding leg member and defining shunt air gaps with said winding leg member, and a magnetic bridge across the shunt air gap between the winding leg member and the leakage leg nearest the series air gap, said bridge maintaining the spacing and position of all said air gaps and reducing the open circuit peak voltage of the secondary winding adjacent to said series air gap.

5. A ballast circuit comprising a pair of fluorescent lamps, a pair of switches each connected across a different one of said lamps, a high reactance transformer comprising a magnetic core having a winding leg member and a multileg yoke member, one end leg of said yoke member abutting one end of said winding leg member and the other end leg of said yoke member defining a series air gap with the other end of said winding leg member, a primary winding and two secondary windings on said winding leg member, said secondary windings being on opposite sides of said primary winding in spaced relation thereto, each lamp being connected in series with one of said secondary windings across said primary winding, a capacitor connected in series with the secondary winding adjacent said series air gap, said yoke member having two leakage legs each extending between said primary wind-

ing and one of said secondary windings towards said winding leg member and defining shunt air gaps with said winding leg member, and a magnetic bridge extending across the shunt air gap between the winding leg member and the leakage leg nearest the series air gap, said bridge maintaining the spacing and position of all said air gaps and reducing the open circuit peak voltage of the secondary winding adjacent said series air gap.

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