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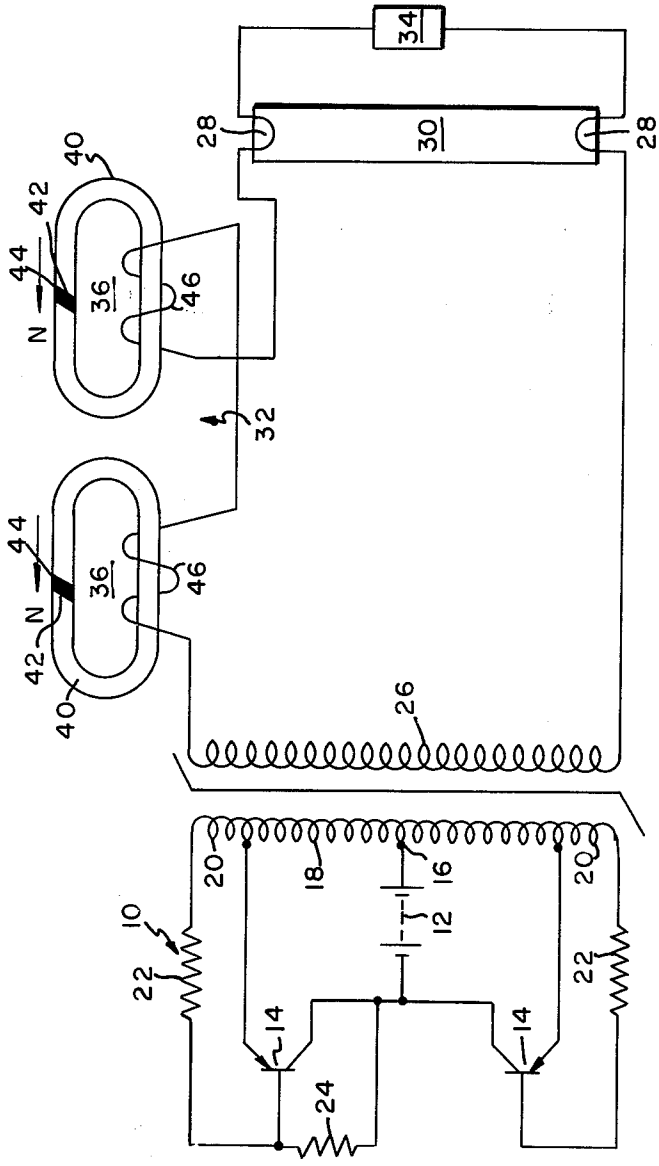

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CIRCUIT FOR FLUORESCENT DISCHARGE LAMP INCLUDING SATURABLE REACTORS

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This invention relates to fluorescent discharge lamp operating circuits and is concerned with ballast impedance devices for use in such circuits.

As is well known a fluorescent discharge lamp requires ballast impedance in its operating circuit because of its negative resistance characteristic at the operating point. A resistive ballast impedance is undesirable as wasted power is dissipated. A reactive ballast impedance having a low impedance at normal load currents and a high impedance when the tube current becomes excessive is desirable.

It has already been proposed to use as a ballast impedance device a pair of series connected saturable reactors (inductors) which are, in operation, both biased to saturation, negative and positive half cycles of the discharge current tending to drive the two reactors respectively out of saturation.

So long as the saturating bias is not completely overcome the overall impedance presented by the device is low. An increase of discharge current beyond the point where the net ampere turns applied to one reactor fall to zero results in a back E.M.F. proportional to the effective unsaturated inductance. The device then presents a high impedance and further increase of discharge current is inhibited.

This ballast impedance device is suitable for use with a square wave supply, obtained for example from a push-pull transistor power converter supplying the discharge lamp with alternating current from a battery supply.

In the earlier proposals the two reactors are biased by means of series windings energised from the battery supply. Since a steady output from the lamp is usually required it is necessary to keep the current in these coils constant. It has been proposed to do this by connecting a pair of Zener diodes and a small resistor in series across the battery, giving a stabilised potential across the diodes for application to the biasing coils. An inductor has also been connected in series with the coils to keep induced A.C. out of the biasing circuit.

Whilst effective, this arrangement has two major disadvantages. The cost is high, particularly on account of the Zener diodes, and the power consumed by the biasing circuit is not negligible. The object of using saturable reactors to avoid undesirable power loss is thus partially defeated.

It is now proposed to overcome these disadvantages by biasing the two saturable reactors into saturation by means of permanent magnets in series in the magnetic circuits forming the cores of the saturable reactors.

The permanent magnets can be ceramic magnets of barium ferrite, for instance that known under the trade name of Magnadur. The core of each reactor can be an almost complete ring of magnetically soft material, a small gap in the ring being filled by a slab magnet, that is a magnet of length between the N and S pole faces small compared with its transverse dimensions. The gap and magnet can be skewed in order to match the flux density produced by the magnet to the flux density required in the core.

Each reactor will have unsaturated inductance and it can be arranged that this is sufficient for the reactors to

fulfill the additional function of starting inductance, a simple starter switch which initially connects the two lamp heater filaments in series with the starting inductance across the supply being used.

Thus the operating circuit need comprise no more than two permanent magnet-biased saturable reactors and a conventional starter switch.

It is one object of the present invention therefore to provide a ballast impedance device for a fluorescent discharge lamp operating circuit comprising a pair of series connected saturable reactors biased by means of permanent magnets included in series in their core magnetic circuits into saturation.

It is a further object to provide a fluorescent discharge lamp operating circuit comprising a ballast impedance device and a starter switch wherein the starting inductance is furnished solely by the ballast impedance device.

The invention will now be described in greater detail by way of example, with reference to the accompanying drawing in which the sole figure shows one embodiment somewhat schematically.

A battery-operated fluorescent lighting system comprises a push-pull transistor power converter **10** supplied by the battery **12**, which may be nominally 24 volts for example. The collectors of the two transistors **14** are connected in common to one battery terminal. The other terminal is connected to a transformer primary centre tap **16**, the ends of the primary **18** being connected to the emitters respectively. Regenerative feedback to each transistor base is provided by a feedback transistor winding **20** in series with a small resistor **22** between the base and emitter of the transistor. These resistors swamp the base-collector resistances which may be unequal and, if not swamped, give rise to unequal switching times. A starting resistance **24** is connected between the base and collector of one transistor.

This power converter is well known and produces a square wave output which may be of 150 volts R.M.S. for example at the transformer secondary **26**.

The frequency is conveniently around 1000 c.p.s. which gives a higher lamp efficiency than 50 or 60 c.p.s. The actual switching time may be around 10 microseconds.

The two ends of the secondary winding **26** are connected to one end of two filaments **28** respectively of a 40 watt fluorescent lamp **30**. One of these connections is direct. The other is made through a ballast impedance device **32**.

The other ends of the heater filaments are connected to a starter switch **34**. When cold, the switch connects these ends of the filaments together but opens a short time after switching on. Such a switch is very well known and details of construction are not therefore given herein.

The ballast impedance device **32** also functions as the starting inductance, having sufficient inductance to give the voltage surge necessary on opening the starter switch **34** to strike the discharge.

The device comprises two saturable reactors **36**. Each has a core **40** of magnetically soft material, one limb of the otherwise closed core being interrupted by a skewed gap **42**. A barium ferrite permanent slab magnet **44** fills the gap and drives the core **40** into saturation. A winding **46** is provided on one limb of the core.

The two windings **46** are connected in series in such a manner that positive and negative half-cycles of the discharge current flowing through the ballast impedance device tend to drive the two reactors **36** respectively out of saturation.

The barium ferrite material can be Magnadur No. 2 or Magnadur No. 3 for example with a remanent flux of 3 to 3.6K gauss per sq. cm. This flux falls almost linearly with an increasing demagnetising field until zero flux is

reached at a demagnetising field of 1,400 to 1,900 Oersteds.

The magnetically soft core material can be HCR metal, radiometal or a magnesium/manganese/zinc ferrite. HCR metal is a grain-oriented nickel-iron alloy of nearly rectangular hysteresis loop, as shown in the book, "Transductors and Magnetic Amplifiers," by A. G. Milne, published in 1957 by Macmillan & Co., Ltd., London, England. The saturation flux of the ferrite can be in the range 2 to 3K gauss per sq. cm.

I claim:

1. A fluorescent discharge lamp operating circuit comprising a source of alternating current, two saturable reactors, a lamp with two filaments, means connecting said reactors in series circuit with said source between first ends of said two filaments respectively and permanent magnet means biasing said reactors into saturation in opposite senses with respect to said series circuit.

2. A fluorescent discharge lamp operating circuit comprising a source of alternating current, two saturable reactors, each reactor comprising a gapped ferromagnetic core and a permanent magnet filling the gap and biasing the core to saturation and a winding on said core, a lamp having a filament at each end and a starter switch, means

connecting said source, reactor windings, filaments and starter switch electrically in series so that positive and negative half cycles of alternating current tend to drive the two reactors respectively out of saturation and wherein the saturable reactors have sufficient residual inductance to provide the sole series starting inductance required by said lamp.

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