

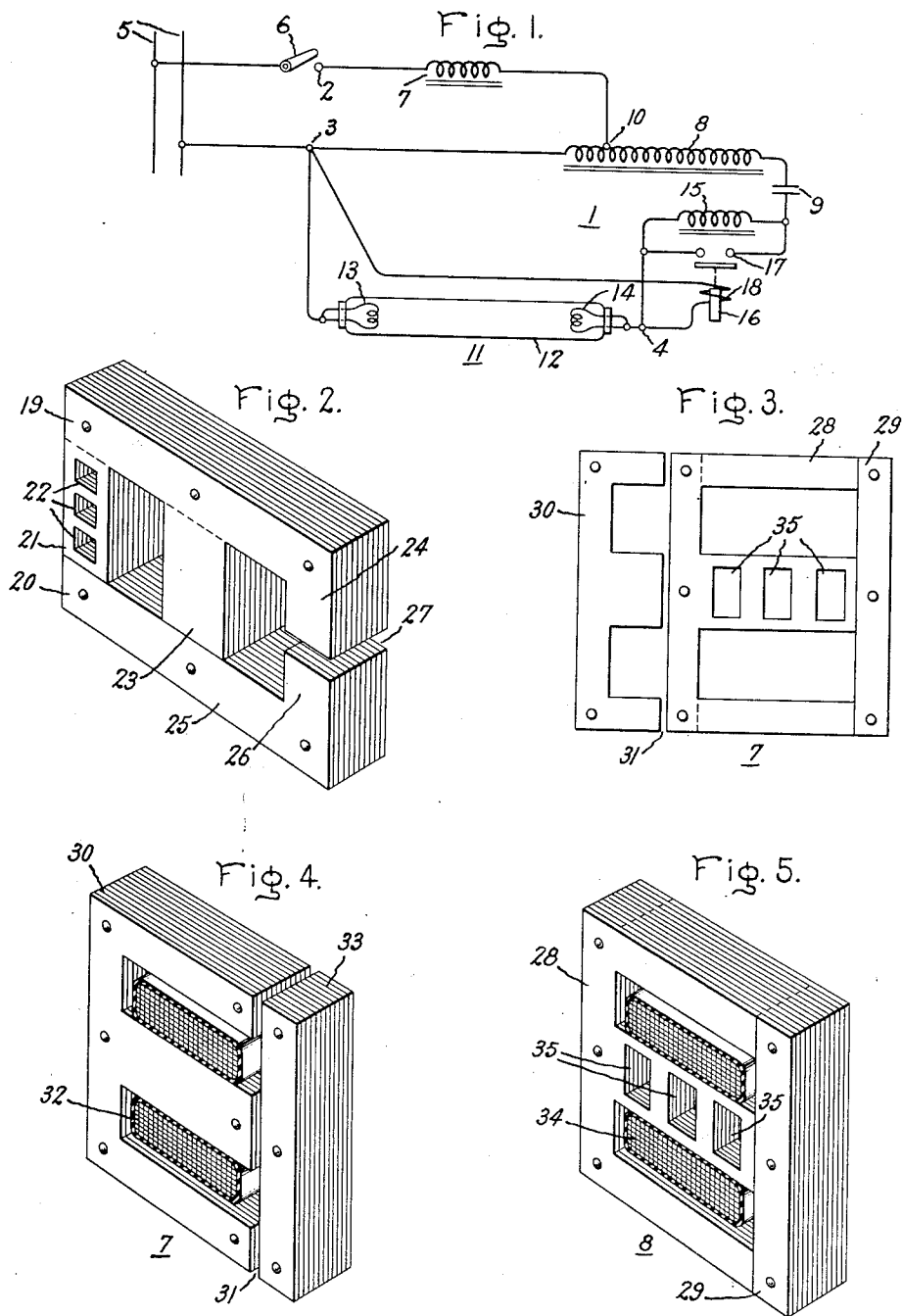
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ELECTRIC BALLAST

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ELECTRIC BALLAST

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This invention relates to electric ballasts and, more particularly, to improvements in stabilized ballasts for mercury vapor electric discharge lamps.

By the term "stabilized ballast" is meant a ballast which maintains substantially uniform lamp operation over a considerable range of variations in supply voltage. While there are a number of different kinds of stabilized ballasts, none of them are particularly suitable for operation with ultraviolet radiation producing arc lamps of the photochemical type having a mercury vapor discharge at substantially atmospheric pressure in a quartz crystal envelope, because they provide an abnormally long warm-up period of the order of 15 or more minutes before the lamp reaches a stable operating condition and comes up to full wattage operation.

In accordance with this invention, there is provided a novel and simple stabilized ballast which develops relatively little internal heating and which is easy to manufacture because its parts do not have to be held to close manufacturing tolerances and which is relatively quiet in comparison with ordinary stabilized ballasts because it has very little stray flux. It utilizes a linear characteristic main reactor, a transformer having a normally saturated core section and a capacitor, these elements being so interconnected that the main reactor is connected in series with the primary winding of the transformer across the source of current supply and the lamp to be operated is connected across the secondary winding of the transformer and the capacitor in series, with the main reactor so connected that it is in the input line to the ballast so that it carries the line current rather than only the primary winding current of the transformer.

In addition, automatic means is provided for increasing the lamp current during the starting warm-up period so that the lamp reaches its stable operating condition and full wattage in a much shorter time which, in the case of a 1000 watt lamp, will be of the order of 3 to 5 minutes, whereas for the conventional stabilized ballast, it would require substantially 15 minutes.

An object of the invention is to provide a new and improved ballast for an electric discharge device.

Another object of the invention is to provide a new and improved stabilized ballast for electric discharge lamps.

A further object of the invention is to provide a new and improved stabilized ballast which provides a relatively short warm-up time for a mercury vapor arc lamp operated thereby.

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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 is a circuit diagram of a discharge lamp system which includes an embodiment of the invention; Fig. 2 is a perspective view of a preferred form of core for a combined main reactor and transformer for use in the embodiment of the invention shown diagrammatically in Fig. 1; Fig. 3 is a perspective view of a modified form of core for a combined reactor and transformer; Fig. 4 is a perspective view of a suitable form of separate reactor; and Fig. 5 is a perspective view of a suitable form of separate transformer.

Referring now to the drawing, and more particularly to Fig. 1, the ballast which is indicated generally by the reference numeral 1 is shown as being provided with three main terminals 2, 3 and 4, terminals 2 and 3 being the input terminals and terminals 3 and 4 being the output terminals, so that terminal 3 is a common terminal. The system may be energized in any suitable manner, such as from an alternating current supply circuit 5 of say 110 to 130 volts, 60 cycle per second alternating current, and the input terminals 2 and 3 may be selectively connected to the circuit 5 by means of a simple on-off switch 6.

The principal elements of the ballast are a main linear iron cored reactor 7, an iron cored transformer 8, and a capacitor 9. The transformer 8 may be of any type and is shown, by way of example, as being a voltage step-up autotransformer, although it will of course be understood that an insulating transformer may be used, and also the transformer may have any desired ratio for either stepping up the voltage or stepping the voltage down. The reactor 7 is connected between the input terminal 2 and a tap 10 on the winding of the transformer 8 which may, for example, be located about $\frac{1}{3}$ of its entire electrical length from its left-hand end, as viewed in the drawing, so as to produce a voltage step-up of about 5 to 1. The left-hand end of the winding of the transformer 8 is connected to the input terminal 3 and, in this manner, the portion of the winding 8 between its left-hand end and the tap 10 constitutes the primary winding of the transformer and the voltage of the entire winding under open load circuit conditions will be typically of the order of 500 volts. Serially connected between the output terminals 3 and 4 are the entire winding of the transformer 8, which constitutes its secondary winding, and the capacitor 9. It is to be noted that the main re-

actor 7 is excluded from the circuit of the ballast between its output terminals 3 and 4 so that the main reactor carries the line current, that is to say, it carries the entire load current of the unit which flows between its input terminals.

The load for the ballast, which is connected externally to the ballast proper between its output terminals 3 and 4, comprises a mercury vapor arc discharge lamp 11. Such a lamp consists typically of a quartz crystal tube or envelope 12, for transmitting the ultraviolet radiation of the excited mercury vapor, at whose ends are mounted main electrodes 13 and 14. Inside the tube or envelope is a small amount of argon gas and sufficient mercury so that when all of it is vaporized the mercury vapor pressure will be about normal atmospheric pressure.

For decreasing the warm-up or starting time of the lamp 11 an auxiliary reactor 15 is connected in series with the lamp 11 in the output circuit of the ballast and a voltage responsive relay 16 is provided having contacts 17 for short-circuiting the reactor 15 and having an operating coil 18 connected across the output of the ballast, that is to say, having its ends connected respectively to the output terminals 3 and 4 of the ballast.

The operation of Fig. 1 is as follows. When the starting switch 6 is closed, the full voltage of the secondary winding of the transformer 8 is impressed between the electrodes 13 and 14, thus ionizing the argon gas in the lamp 11 and causing an arc discharge between those two electrodes. The heat developed by this argon gas discharge vaporizes the mercury and, when all of the mercury becomes vaporized and the mercury vapor pressure rises to about normal atmospheric pressure, the arc between the main electrodes becomes primarily a mercury arc discharge. The complete vaporization of the mercury takes an appreciable length of time, because of mercury condensation behind the electrodes 13 and 14, which time is materially reduced if the starting current, that is to say the current between the main electrodes during the argon gas discharge phase of the starting operation, is relatively high. During this starting phase of the operation of the lamp, the arc drop between its main electrodes is relatively low even at relatively high values of current and the lamp wattage is relatively low.

The purpose of the auxiliary reactor 15 is to neutralize some or all of the capacitive reactance of the capacitor 9 so as to decrease the effective impedance of the lamp circuit and thus increase the lamp current and decrease its warm-up or starting time. As the lamp voltage during this starting period is relatively low, the relay 16 remains dropped out in its illustrated position. However, as soon as the lamp has been nearly warmed up and its mercury vapor pressure has increased to near its final value, the lamp voltage and watts increase and the relay coil 18 responds to the attainment of rated lamp voltage by pulling in and closing its contacts 17 so as to short-circuit the auxiliary reactor 15.

Stabilization of the output of the ballast, that is to say, stabilization of the lamp current and voltage with variations in the voltage of the supply circuit 5 results from the fact that the leading current taken by the capacitor 9, in flowing through the transformer 8, magnetically saturates a portion of its core so that the magnetizing or exciting current of the transformer is very sensitive to variations in supply voltage and the relatively large changes in exciting or magnetiz-

ing current, resulting from changes in supply voltage, which flow through the linear reactor 7 produce a regulating voltage drop in the linear reactor 7 which, in effect, neutralizes substantially all of the changes in supply voltage.

The magnetic saturation of the core of the transformer 8 produces a non-sinusoidal output current which has a relatively low heating value and that is another reason why I have found that the relay 16, in combination with the auxiliary reactor 15, produces a marked decrease in the warm-up time necessary for the lamp.

The capacitor 9 typically has a volt-ampere rating of approximately four times the volt-ampere rating of the lamp 11.

A preferred magnetic core construction for the reactor 7 and the transformer 8 of Fig. 1 is shown in Fig. 2. This comprises a plurality of lamination layers each containing a special E-shaped lamination 19 and an L-shaped lamination 20. As shown in the drawing, the lamination 19 comprises an end leg 21 having a plurality of windows 22 therein for providing saturated restricted sections or bridged gaps. Member 19 is also provided with a center leg 23 of the same length as the leg 21 and is provided with a short end leg 24. The L-shaped punching or lamination piece is provided with a long side 25 and a short end 26. Alternate lamination layers are reversed so that the butt joints between the ends of the legs 21 and 23 and the side of the long leg 25 of the punching 20 are interleaved, as shown by the dashed lines. A nonmagnetic air gap 27 is formed between the ends of the short legs 24 and 26. The winding of the transformer 8 is mounted on the leg 21 and the winding of the reactor 7 is mounted on the leg consisting of the short legs 27 and 26 and which contains the air gap 27.

In Fig. 3 the transformer core is shown as comprising a plurality of interleaved E and I-shaped punchings 28 and 29. The center leg of the E-shaped punching 28 is provided with a plurality of windows 29 for providing saturated, restricted sections or bridged gaps and the winding of the transformer 8 is mounted on this center leg. The core of the reactor 7 consists of a plurality of stacked E-shaped punchings 30 butted up against a side of the transformer core and a suitable nonmagnetic gap 31 may be provided by any spacing means between these parts. The winding of the reactor 7 will be mounted on the center leg of the stacked punchings 30.

A suitable separate form of reactor 7 is shown in Fig. 4 as comprising a stack 30 of E-shaped magnetic steel punchings having a coil 32 mounted on the center leg of the stack and having a stack of I-shaped punchings 33 placed across the ends of the legs of the E-shaped stack 30 with a nonmagnetic air gap 34 therebetween for providing the desired linearity in the magnetization characteristic of the reactor.

A suitable form of separate transformer 8 is shown in Fig. 5 as comprising interleaved or reversely stacked layers of E- and I-shaped punchings 28 and 29 so as to interleave the butt joints between the E- and I-shaped members of each layer with a winding 34 on the center leg and with windows 29 in the center leg so as to provide bridged gaps or magnetically restricted sections in the center leg which will saturate at a lower value of flux density than the rest of the core.

While there have been shown and described particular embodiments of the invention, it will

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be obvious to those skilled in the art that changes and modifications may be made without departing from the invention, and it is therefore 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. A stabilized output ballast for electric discharge devices comprising, in combination, a pair of input terminals, a pair of output terminals, a reactor winding, a transformer having primary and secondary winding sections, said reactor winding and said primary section being serially connected between said input terminals, a capacitor, said capacitor and said secondary section being serially connected exclusive of said reactor winding between said output terminals, a magnetic core for said reactor winding having a non-magnetic gap therein for preventing saturation and providing a linear magnetizing characteristic, and a magnetic core for said transformer having a saturable restricted section which saturates when discharge device current flows through said capacitor and said secondary section.

2. A stabilized output voltage ballast for an electric discharge lamp comprising, in combination, a pair of input terminals for connection to a source of alternating current supply, a reactor winding, an autotransformer winding having a primary section and a secondary section, said reactor winding and said primary section being serially connected between said input terminals, a capacitor, a pair of output terminals for connection to opposite electrodes of an electric discharge lamp, said secondary section and said capacitor being serially connected between said output terminals to the exclusion of said reactor winding, a substantially closed magnetic core for said reactor winding having a non-magnetic gap for preventing saturation and providing a linear magnetizing characteristic, and a closed magnetic core for said autotransformer having a central winding leg and oppositely disposed yokes, said winding leg having a saturating restricted section.

3. A stabilized output ballast for electric discharge devices comprising, in combination, a pair of input terminals, a pair of output terminals, a main reactor winding, a transformer having primary and secondary winding sections, said main reactor winding and said primary section being serially connected between said input terminals, a capacitor, said capacitor and said secondary section being serially connected exclusive of said main reactor winding between said output terminals, a magnetic core for said main reactor winding having a nonmagnetic gap therein for preventing saturation and pro-

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viding a linear magnetizing characteristic, a magnetic core for said transformer having a saturable restricted section which saturates when discharge device current flows through said capacitor and secondary section, an auxiliary reactor connected in series circuit relation with said capacitor in the output circuit of said ballast between said output terminals, and a voltage sensitive relay having normally open contacts connected for short-circuiting said auxiliary reactor and having an operating coil connected between said output terminals.

4. A stabilized output voltage ballast for a mercury arc discharge lamp comprising, in combination, a pair of input terminals for connection to a source of alternating current supply, a main reactor winding, an autotransformer winding having a primary section and a secondary section, said main reactor winding and said primary section being serially connected between said input terminals, a capacitor, a pair of output terminals for connection to opposite main electrodes of a mercury arc discharge lamp, said secondary section and said capacitor being serially connected between said output terminals to the exclusion of said main reactor winding, a substantially closed magnetic core for said main reactor winding having a nonmagnetic gap for preventing saturation and providing a linear magnetization characteristic, a closed magnetic core for said autotransformer having a central winding leg and oppositely disposed yokes, said winding leg having a saturating restricted section, an auxiliary reactor serially connected with said capacitor and said secondary section between said output terminals, and a voltage responsive relay having a set of normally open contacts connected for short-circuiting said auxiliary reactor when they are closed, said voltage responsive relay having an operating coil connected between said output terminals and responsive to the attainment of a predetermined voltage therebetween for operating said relay so as to close its contacts.

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