United States Patent [19]

Willis, Jr.

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[54] **BALLAST CONTROL DEVICE**

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[52] **U.S. Cl.** **323/6**, 315/194, 315/278, 323/50, 336/165

[51] **Int. Cl.** **G05f 7/00**

[58] **Field of Search** 323/6, 50, 85, 86, 45, 323/48; 336/160, 165; 315/125, 126, 194, 199, 276, 278, 279

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[57] **ABSTRACT**

Ballast control device for varying the brightness of a lamp includes a closed magnetic core having a main gap therein and a gapped shunt across the core window. A main winding arranged on the core on one side of the shunt is connected in series with the alternating current supply and the lamp, and a control winding arranged on the core on the opposite side of the shunt has a series connected switch such as a triac which operates to vary the wattage supplied to the lamp for providing the desired amount of brightness.

9 Claims, 7 Drawing Figures

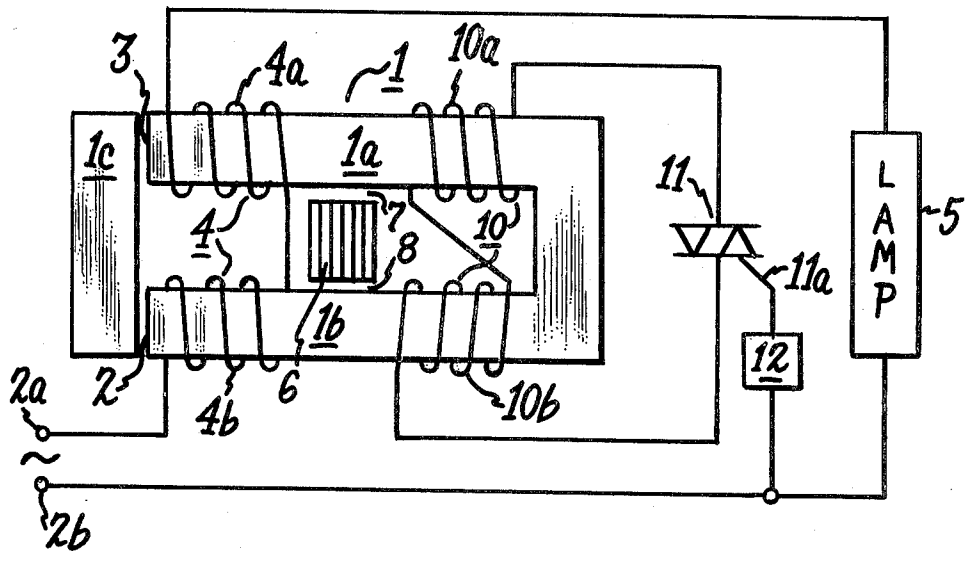


Fig. 1.

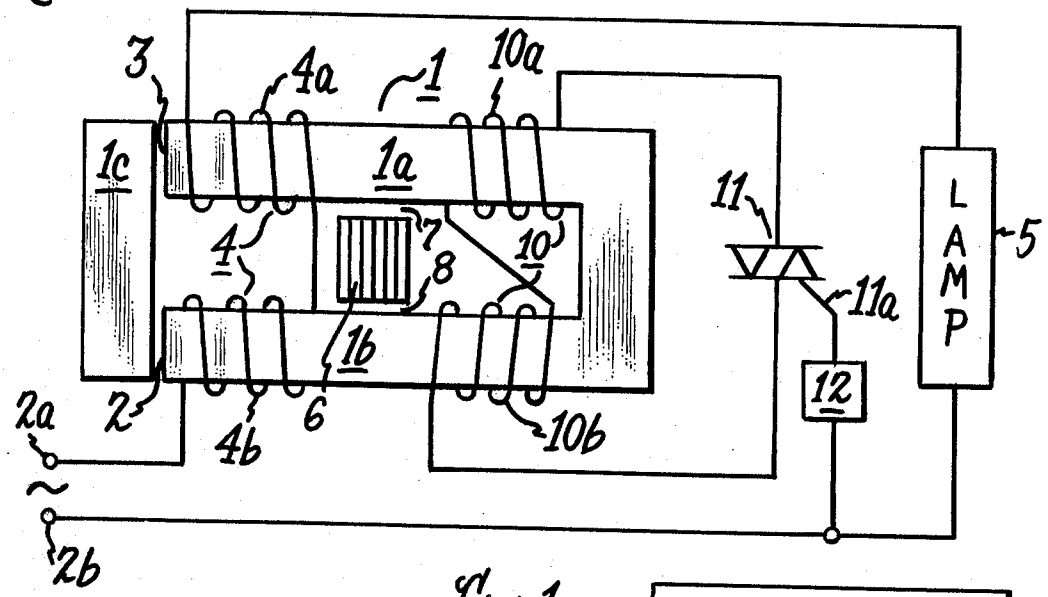


Fig. 1a.

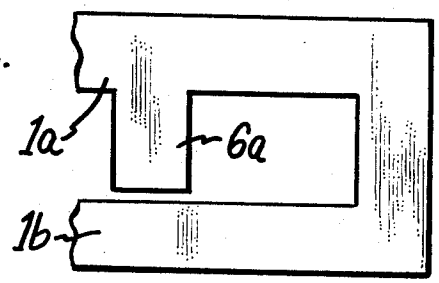


Fig. 2.

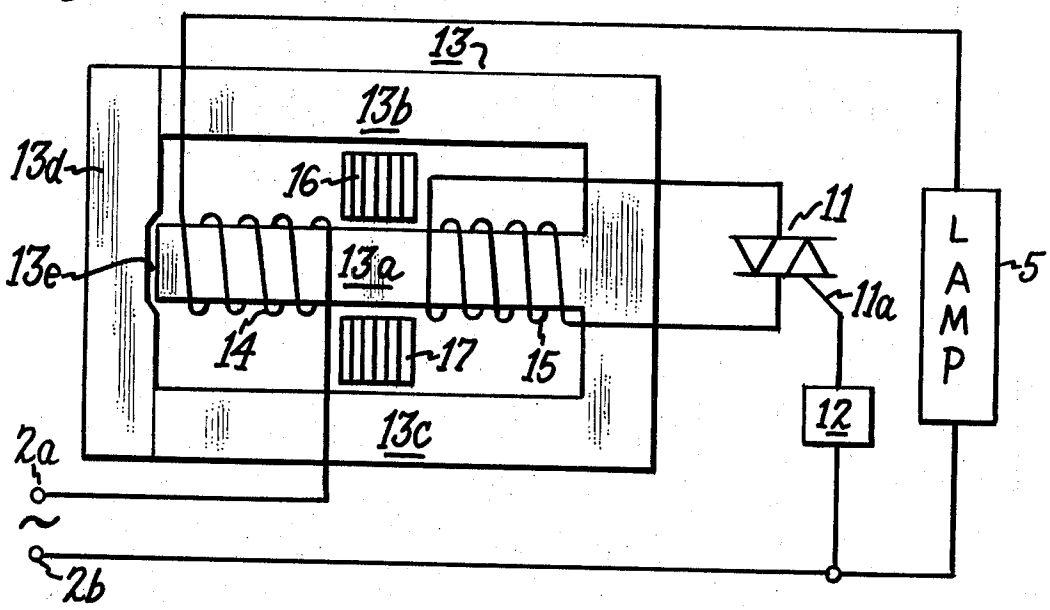


Fig. 3.

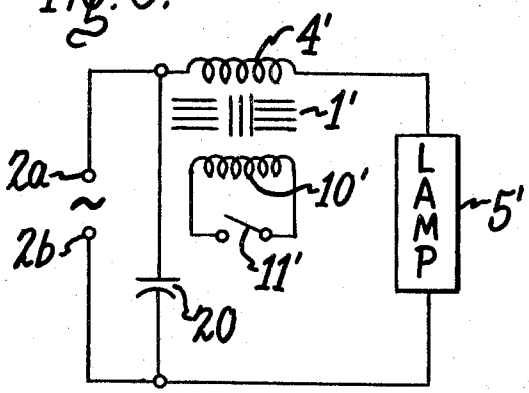


Fig. 4.

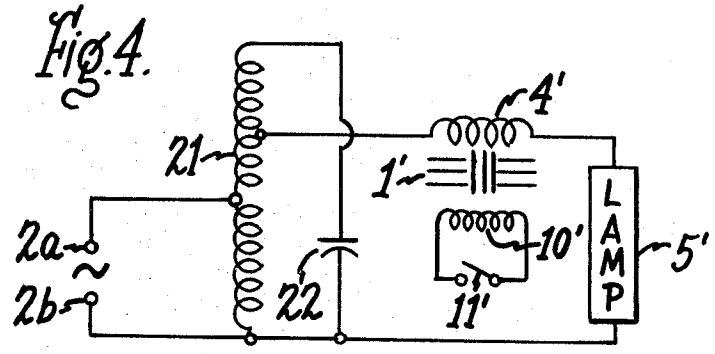


Fig. 5.

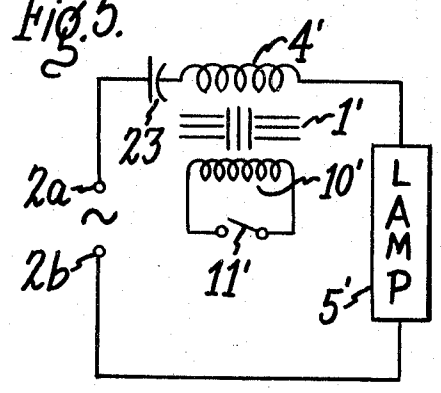
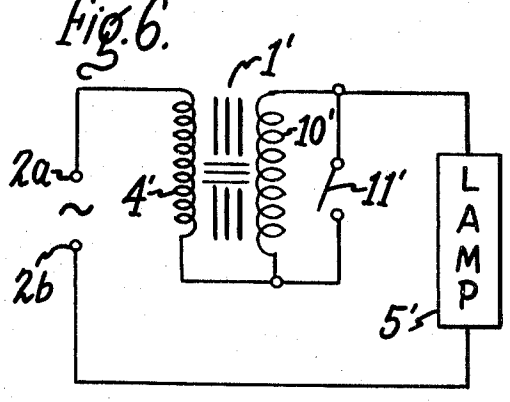


Fig. 6.



BALLAST CONTROL DEVICE

The present invention relates to electrical ballast control devices and more particularly to variable inductance devices for providing controlled power to a load such as a lamp.

It is an object of the invention to provide an electrical ballast control device of the above type which is simple in construction, is inexpensive to manufacture and enables a relatively wide variation in power applied to a load.

It is a particular object of the invention to provide an electrical ballast control device of the above type which is suitable for use for dimming lighting devices, especially those having lamps of high intensity gaseous discharge type.

Other objects and advantages will become apparent from the following description and the appended claims.

With the above objects in view, the present invention relates to an electrical ballast control device comprising, in combination, a magnetic core forming a closed magnetic circuit and having spaced leg portions, magnetic shunt means extending between the spaced leg portions and spaced from at least one of the leg portions by non-magnetic gap means, a main winding arranged on the core on one side of the magnetic shunt means and adapted to be connected in series with an alternating current source and a gaseous discharge device, and control means for controlling the power applied to the gaseous discharge device comprising a control winding on the core on the opposite side of the magnetic shunt means and adapted to have current induced therein by current passing through the main winding, and switch means connected in series with the control winding, whereby operation of the switch means controls the current in the control winding and thereby the reactance of the ballast control device and the power supply to the gaseous discharge device.

In a preferred embodiment, an air gap or other non-magnetic gap means is also provided in the magnetic core itself.

The invention will be better understood from the following description taken in conjunction with the accompanying drawings, in which:

FIG. 1 is a schematic diagram of a ballast device illustrating an embodiment of the invention;

FIG. 1*a* shows a modified form of the shunt in the core of the FIG. 1 device;

FIG. 2 is a schematic diagram of a ballast device having a different form of magnetic core; and

FIGS. 3 – 6 are circuit diagrams of various types of ballast circuits which may be employed in conjunction with the invention.

Referring now to the drawings, and particularly to FIG. 1, there is shown a ballast and control apparatus constructed in accordance with the invention and comprising a magnetic core 1 of U-I type having spaced legs 1*a*, 1*b* and yoke member 1*c* arranged at the ends of legs 1*a*, 1*b* as shown. In a preferred embodiment, yoke member 1*c* is spaced slightly from the ends of core legs 1*a*, 1*b* to provide non-magnetic gaps 2, 3 of predetermined distance. Gaps 2, 3, referred to herein as main gap means, may be air gaps or spaces occupied by electrically insulating spacer material such as Kraft paper. Main winding 4 comprises winding 4*a* wound on core leg 1*a* in series with winding 4*b* wound on opposite core leg 1*b* and is connected at one side to terminal 2*a* of a source of alternating current. At its other side, main winding 4 is connected in series with lamp 5, which is typically a mercury vapor or other gaseous discharge lamp. Lamp 5 is connected at its other side to terminal 2*b* of the alternating current supply.

Magnetic shunt 6 is arranged extending across the space or window of core 1 for providing leakage reactance in the core. Shunt 6 typically comprises an assembly of superposed magnetic laminations and is spaced at its opposite ends from the opposite core legs 1*a*, 1*b* by non-magnetic gaps 7, 8 which, like gaps 2 and 3, may be air gaps or spaces occupied by electrically insulating spacer material. While shunt 6 is shown in FIG. 1 as a separate component, the shunt may be in the form of a projection 6*a* integral with one of the core legs as shown in FIG. 1*a* or in the form of two projections extending integrally from the opposite core legs with a gap therebetween (not shown).

In accordance with the invention, a control winding 10 is provided on core 1 on the opposite side of shunt 6 from main winding 4. In the illustrated embodiment, control winding 10 comprises winding 10*a* wound on core leg 1*a* in series with winding 10*b* wound on core leg 1*b* and is connected in series with a switch constituted by triac 11. As well understood in the art, a triac is an alternating current semiconductor controlled switch having a single control electrode 11*a* which, when gated, causes the switch to conduct current in the direction as indicated by the forward bias condition of the semiconductor. A triac may also be described as a bi-directional (bi-lateral) triode for gate control of alternating current power.

Connected to control electrode 11*a* of triac 11 is an actuating or triggering circuit 12 for actuating triac 11 to conductive condition in opposite directions at predetermined times. Actuating circuit 12 may be of any desired or well-known type for actuating the triac, as, for example, those shown in U.S. Pat. Nos. 3,500,124 and 3,629,683. It will be also understood that other types of switches may be employed if desired, such as oppositely arranged SCR's, vacuum or gas-filled tubes, relays and mechanical switches, as broadly depicted in FIGS. 3 – 6.

While it is preferred to provide a gap between the yoke member 1*c* and core legs 1*a*, 1*b* for the purpose of providing the minimum wattage when control winding 10 is open, yoke member 1*c* may be arranged directly in contact with the core legs with no intervening gaps, if desired.

FIG. 2 shows another embodiment of the ballast device employing a magnetic core 13 of E-I type having central leg 13*a* and outer legs 13*b*, 13*c*. In this device, main winding 14 is wound near one end of central leg 13*a* and control winding 15 is wound near the opposite end of central leg 13*a*. Arranged in the windows of core 13 between the main and control windings are magnetic shunts 16 and 17 respectively spaced at opposite ends from the adjacent core legs to provide non-magnetic gaps as described in connection with the FIG. 1 embodiment.

Yoke member 13*d* in the illustrated embodiment is arranged in direct contact with outer core legs 13*b*, 13*c* and is formed with a recess 13*e* in its intermediate portions so as to provide for a non-magnetic gap between the yoke member and the end of central core leg 13*a*. The electrical circuits of the FIG. 2 embodiment are

otherwise essentially the same as that described in connection with FIG. 1.

In the operation of the disclosed device, with reference particularly to the FIG. 1 embodiment, when it is desired to increase the brightness of lamp 5, triac switch 11 is closed, thereby providing for flow of current, induced in control winding 10 by the current in main winding 4, through the control winding circuit. As a result, a magnetomotive force is generated in the portion of the core under control winding 10 which opposes the corresponding force generated in the core under main winding 4, and the flux path generated by the latter winding is consequently forced to pass through shunt 6. This causes increased current to flow in the main winding circuit, resulting in higher wattage being applied to lamp 5 to brighten it. As will be understood by those versed in the art, the magnetic flux path through gap shunt 6 has a higher reluctance than the flux path around closed core 1, causing higher current to be drawn through the main winding circuit under those conditions. In this situation, the reactance of the ballast is determined by the series combination of main air gaps 2 and 3 and shunt gaps 7 and 8.

In order to dim the light from lamp 5, switch 11 is opened, so that no current flows in control winding 10. As a result, the magnetic flux path extends around closed core 1 without going through magnetic shunt 6, and the reactance of the ballast is thus determined by the main air gaps 2 and 3 only. Accordingly, the lower reluctance of the magnetic path leads to a lower current flow in the main winding circuit and less power to lamp 5, causing a dimming of the light.

By suitable adjustment of the triggering means 12, the triac may be fired at a desired time in each half cycle to produce intermediate values of current in main winding 4, and thus the wattage applied to lamp 5 may be smoothly and continuously varied over a desired range by adjusting the firing angle.

FIGS. 3 – 6 show various circuit arrangements which may be used in practicing the present invention.

FIG. 3 depicts a circuit including a capacitor 20 connected across the alternating current source to serve as a power factor correcting capacitor such as conventionally used in lamp ballast circuits. The ballast device of the invention, shown in diagrammatic form for simplicity, comprises main winding 4', control winding 10', shunted core 1', switch 11', and lamp 5', corresponding to the arrangement shown in FIG. 1.

FIG. 4 shows a circuit which includes an autotransformer 21 connected between the *a–c* source and the ballast device of the invention for the purpose of adapting the device for use with a wide range of line voltages, as well understood by those versed in the art. A power factor correction capacitor 22 may also be connected across the autotransformer winding as shown.

FIG. 5 is a circuit diagram of the invention in which a capacitor 23 is connected in series with main winding 4' to provide leading current in the ballast circuit where this is necessary or desirable.

FIG. 6 shows a circuit of the invention wherein control winding 10' is connected in series with main winding 4' to provide a light dimming device which has a broad range of wattage adjustment.

A typical construction of the described device which has proved satisfactory has the following specific characteristics, it being understood that the invention is not intended to be limited to this particular construction: The core has an E-I form with a central leg width of 1.37 inches and a stack height of 3.04 inches. The main winding consists of 225 turns of No. 14 aluminum wire. The control winding consists of 210 turns of No. 18 aluminum wire. The main air gap is 0.050 inch and the shunt air gaps are each 0.010 inch. The shunt stack height is 0.500 inch.

While the present invention has been described with reference to particular embodiments thereof, it will be understood that numerous modifications may be made by those skilled in the art without actually departing from the scope of the invention. Therefore, the appended claims are intended to cover all such equivalent variations as come 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. Electrical ballast control device comprising, in combination, a magnetic core forming a closed magnetic circuit and having spaced leg portions, magnetic shunt means extending between said spaced leg portions and spaced from at least one of said leg portions by non-magnetic gap means, a main winding arranged on said core on one side of said magnetic shunt means, means for connecting said main winding in series with an alternating current source and a gaseous discharge lamp for forming a single series loop thereof, and control means for controlling the power applied to the gaseous discharge lamp comprising a control winding on said core on the opposite side of said magnetic shunt means and having current induced therein when current passes through said main winding, and switch means connected in series with said control winding, whereby operation of said switch means controls the current in said control winding and thereby the reactance of the ballast control device and the power supplied to the gaseous discharge lamp.

2. A device as defined in claim 1, said switch means comprising a controlled bi-lateral semiconductor device, and actuating means for actuating said controlled device.

3. A device as defined in claim 1, said main winding and said control winding each comprising winding portions arranged on said spaced core leg portions.

4. A device as defined in claim 1, said magnetic core comprising a U-shaped portion and a yoke member at the open end of said U-shaped portion.

5. A device as defined in claim 4, said yoke member spaced from said U-shaped portion by non-magnetic gap means.

6. A device as defined in claim 1, said magnetic core comprising an E-shaped portion and a yoke member at the open end of said E-shaped portion.

7. A device as defined in claim 6, said E-shaped portion comprising a central leg and a pair of outer legs, said magnetic shunt means comprising shunt members extending between each of said outer legs and said central leg, said yoke member arranged in contact with said outer legs and spaced from said central leg by non-magnetic gap means.

8. A device as defined in claim 7, said main winding and said control winding being arranged on said central core leg.

9. A device as defined in claim 1, said control winding being connected in series with said main winding.

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