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BALLAST DEVICE AND CIRCUIT FOR GAS DISCHARGE LAMPS

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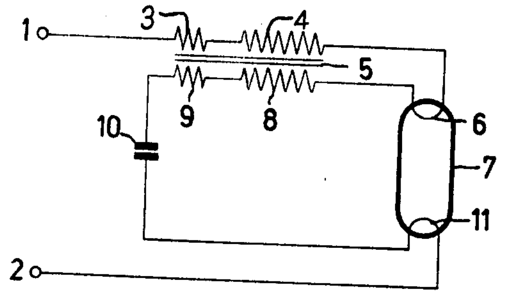

FIG.1

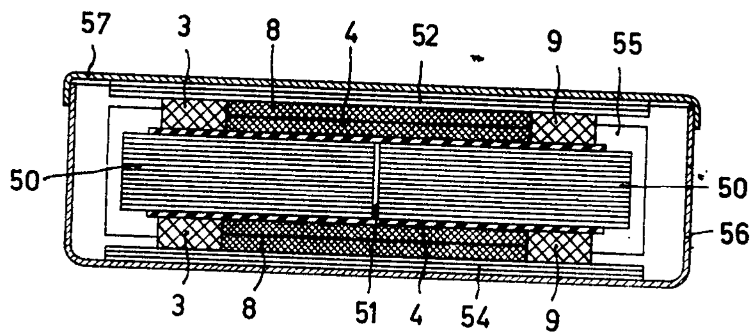

FIG.2

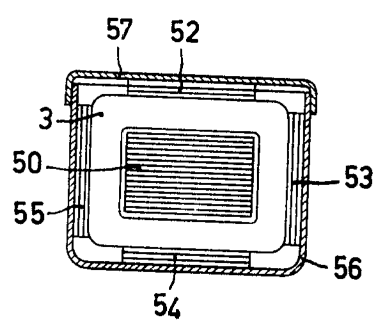

FIG. 3

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BALLAST DEVICE AND CIRCUIT FOR GAS DISCHARGE LAMPS

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9 Claims. (Cl. 315—99)

The invention relates to a ballast device for gas and/or vapour discharge tubes provided with a choke coil arranged in a container of constant cross-section and having a main and an auxiliary winding. In operation, the windings are connected in series with each other, with a capacitor and with two thermionic electrodes of the tube to an alternating current source in a manner such that the tube is shunted by the series combination of the capacitor and the auxiliary winding.

If, with the cross-section of the container unaltered, the apparent power of the choke coil is to be increased, difficulties may present themselves.

At a given value of the magnetic flux density, the current density and the space factors of the magnetic and current conducting material used, the power per unit of volume of the container is substantially constant.

If the power is to be increased, with the cross section of the container unaltered, the choke coil becomes longer and consequently its inductance larger. In the normal case, in which the supply voltage remains unaltered, the inductance should become smaller, however, so as to pass more current. If the windings can no longer be arranged nearer to each other, it has been necessary in the past to increase the cross-section of the container.

The object of the present invention is to mitigate this drawback.

According to the invention, the load of the cross-section of the container is larger than 8α va./cm.^{2} and each of the windings is divided into two series-connected parts in a manner such that a part of each winding is provided on the same part of the core of the choke coil and the other part is provided on separate parts of the core, on both sides of the common part of the core, in that sense that

$$\alpha=\frac{a.i\times b.B}{12000}$$

in which:

a is the volume of the winding wire divided by the volume of the windings,
i is the average current density in a./mm.^{2},
b is the volume of the magnetic material divided by the internal volume of the container enveloping the choke coil decreased by the volume of the windings, and
B is the magnetic flux density in gauss units in the core of the choke coil.

It has appeared that, in the case of double choke coils of the said type, the said limit occurs at a load of the cross-section of the container with approximately 8 voltampere per cm.^{2}, in as far as a maximum inductance of 13000 gauss, an average current density of 3.5 ampere per mm.^{2} of the cross-section of the wire and values of the space factors of 0.35 and 0.75 respectively indicated by a and b are used. In the case of loads which deviate from these values appreciably, they should be multiplied by the correction factor α.

Under no-load conditions (with the tube not yet ignited) the parts of the main and auxiliary winding provided on the same part of the core are substantially neutralized. By providing these winding parts between the winding parts provided on the separate parts of the

core, the inductance under no-load conditions and with the same structural length is decreased for two reasons: first, a definite volume is occupied by windings neutralizing each other magnetically and, secondly, the volume of inductance-supplying windings consequently is smaller.

If the parts of the windings which are provided on the common part of the core are constructed as cylindrical coils placed one over the other, it is recommended that the upper coil be the auxiliary winding. This promotes heat dissipation.

The yokes of the choke coil preferably consist of laminations which are at right angles to the planes through the longitudinal axes of the core and the yoke in question. This construction of the yokes is very simple and cheap but usually results in large eddy-current losses. However, in combination with the construction of the coil acccording to the invention, these losses become rather small.

In order that the invention may be readily carried into effect, one embodiment thereof will now be described in greater detail, by way of example, with reference to the accompanying drawing, in which:

FIGURE 1 is the diagram of the circuit arrangement used;

FIGURE 2 is the longitudinal, and

FIGURE 3 the cross-sectional view of the choke coil with container.

In FIGURE 1, the numerals **1** and **2** indicate the terminal of an alternating current source to which are connected, during operation, the series combination of a dual main winding **3**, **4** of a choke coil **5**, a thermionic electrode **6** of a gas and/or vapour discharge tube **7**, for example, a low-pressure mercury vapour discharge tube with fluorescent wall coating, a dual auxiliary winding **8**, **9** of the choke coil, a capacitor **10** and a second thermionic electrode **11** of the tube.

When connected in circuit, a current flows through the thermionic electrodes **6** and **11** which heats the electrodes to emission temperatures and which is substantially determined by the inductance and the capacitance of the electric circuit. These impedances are matched to each other in a manner such that a voltage is set up at the tube which exceeds the supply voltage and which is large enough to ignite the tube with emitting electrodes, but which is too small to ignite the tube with cold electrodes. In this case, the no-load current traverses the two windings in opposite sense.

In the ignited condition of the tube, the windings of the choke coil operate as stabilizing impedance of the tube, the capacitor insures the improvement of the power factor of the plant and the auxiliary winding additionally prevents the capacitor from discharging directly across the tube. Naturally, a considerable phase shift exists in this condition between the currents through the windings.

The choke coil and, if desired, also the capacitor, are housed in a case-shaped container. With a given cross-section of the container, the total size of the choke coil is substantially proportional to the consumed apparent power (in voltamperes) of the choke coil. The larger this power, the larger the choke coil and also the larger the inductance thereof in the normal arrangement of the windings beside each other on the core. In the normal case of unvarying supply voltage, a decreasing inductance is required, however, with the power increasing. When increasing the said load, this requirement has been met by extending the cross-section of the container so as to obtain a smaller choke coil.

According to the invention, it now becomes possible, to exceed this load of the cross-section of the container and to allow the choke coil to become abnormally large by replacing the original main and auxiliary windings by smaller windings **3** and **9**, shifting them apart and using the unoccupied space for windings 4 and 8 of the main and auxiliary branch enveloping one and the same part of the core which substantially neutralize each other in the no-load condition.

FIGURES 2 and 3 show the strucural construction of an embodiment of the choke coil.

On the core 50 consisting of straight strips and interrupted by an air gap 51, the coil elements 3 and 4 of the main winding and the coil elements 8 and 9 of the auxiliary winding are provided in a manner such that the coil elements 4 and 8 are arranged over each other and the coil elements 3 and 9 on either side thereof.

The yoke of the choke coil consists of four parts 52, 53, 54 and 55 consisting of straight strips, which are at right angles to the planes through the longitudinal axes of the core and the part of the yoke in question. The yokes may be connected in the center to the walls of the container 56 with cover 57 by means of a spot weld. The space between the choke coil and the container may be filled with a filling mass, for example, polyester.

In a particular embodiment, the voltage of the alternating current source 1, 2 was approximately 240 volts at a frequency of 50 c./s.

Before the ignition of the tube 7, a series current of 770 milliamperes flows through all the elements and heats the electrodes 6 and 7 to emission temperature within 1 to 2 seconds causing a voltage of only 30 volts at the main winding 3, 4, a voltage of 30 volts at the auxiliary winding 8, 9, a voltage of 300 volts at the capacitor 10 and a voltage of 270 volts at the tube 7.

After igniting the tube, the current through the main winding was 490 milliamperes, through the capacitor 600 milliamperes and through the tube 885 milliamperes. A voltage of 190 volts was set up at each of the total main and auxiliary windings, a voltage of 102 volts at the tube, and a voltage of 238 volts at the capacitor.

The windings 3 and 9 each had 655 turns of copper wire of 0.4 millimeter diameter and the windings 4 and 8 each 1450 turns of copper wire of 0.45 millimeter diameter. The turns were wound on a coil former enveloping the core of 15.5 x 22 millimeters inside cross-section and 0.5 millimeter wall thickness. The height of the windings was 7 millimeters and the length of the coils 3 and 9 each 35 millimeters and that of the coils 4 and 8 each 162 millimeters.

The core 50 consisted of 15 iron strips of 1 x 21.5 millimeters diameter, a total of 256 millimeters long, with a loss figure of 4W/kg. at 10,000 gauss. The air gap 51 was 1.5 millimeters long. Each of the yokes consisted of three iron strips 1 x 28 x 260 millimeters. The container consisting of steel, 0.8 mm. thick, had an inside cross-section of 44 x 37 millimeters. The apparent power was 190 v.$\times$0.49 a.+190 v.$\times$0.6 a.=207 va. Consequently, the cross-section of the container was loaded with 12.7 va./cm.^{2}.

The magnetic flux density in the core was 13,000 gauss, the average current density 3.5 a./mm.^{2} and the factors a and b 0.35 and 0.75 respectively, so that the value of α was approximately 1.

The current through the main winding which is substantially in phase with the supply voltage is, as a result of the lagging tube current and the leading capacitor current, the smallest of all the currents. In order to obtain a satisfactory heat transmission, the winding 8 of the auxiliary winding carrying the larger current is provided on the winding 4 and not conversely.

Between the windings 3 and 9 a magnetic leakage field occurs which extends transversely through the yoke strips 52, 53, 54 and 55 which might cause eddy current losses. Because, however, the windings 3 and 9 are not provided immediately beside each other, the field strength and losses are small. The total losses of the choke coil were approximately 24W which in the present choke coil is a very acceptable value.

What is claimed is:

1. In a ballast device adapted to be disposed with a gas discharge tube and a predetermined source of alternating current signal, said device having a magnetic core of a first predetermined volume, first and second wire wound coil means associated with said core to provide a choke coil having a second predetermined volume, said wire of said first and second windings having a third predetermined volume, and container means disposed about said choke coil and said core having a cross-section load greater than 8α volt-amperes per square centimeter and a fourth predetermined inner volume, said device comprising a pair of first and second serially connected coils, said first coils of said pair being disposed about first and second different portions, respectively, of said core and said second coils of said pair being disposed a common portion of said core to provide an α of said load factor equal to 1/12000 of the product of a, i, b and B, in which:

a=the ratio of said third volume to said second volume,

i=the average current density in amperes per square millimeter,

b=the ratio of said first volume to the difference of said fourth and second volumes, and

B=the magnetic flux density in gauses in said core,

said first and second coils of one of said pair comprising said first wire wound coil means, and said first and second coils of the other of said pair comprising said second wire wound coil means.

2. A ballast device according to claim 1, wherein each of said first and second coils of said pair have a cylindrical cross section, said second coils being concentrically disposed with respect to each other on said common portion of said core.

3. A ballast device according to claim 1 further comprising yoke means associated with said choke coil, said yoke means having a plurality of laminations, each of said laminations being substantially disposed at right angles to the plane formed by the longitudinal axes of said core and of the respective lamination.

4. A ballast device according to claim 1, wherein said first wire wound coil means is serially connected to said gas tube for series connection to said source, and said second wire wound coil means is shunted across said tube.

5. A ballast device according to claim 1, wherein said second wire wound coil is adapted for series connection with a capacitor for parallel connection across said tube.

6. A ballast device for a gas discharge tube supplied by a source of alternating current, comprising a capacitive reactance element, a choke coil connected in series therewith comprising a magnetic core of predetermined volume, first and second coils disposed thereon, each of said coils comprising first and second serially connected coil elements, the first coil elements of each of said first and second coils occupying a common portion of said core, and the second coil element of each of said first and second coils being arranged on non-contiguous portions of said core, and container means of predetermined volume housing said choke coil.

7. A ballast device for a gas discharge tube having a pair of electrodes and supplied by a source of alternating current comprising a capacitor, a choke coil connected in series therewith and in series with said source of alternating current and said electrodes, said choke coil comprising a magnetic core of predetermined volume, first and second inductively coupled coils disposed thereon, said first and second coils being serially connected by means of one of said electrodes, each of said coils comprising first and second serially connected coil elements, the first coil element of each of said first and second coils occupying a common portion of said core, and the second coil element of each of said first and second coils being arranged on separate portions of said core on either side of said common portion, and container

means of predetermined volume housing said choke coil.

8. A ballast device for a gas discharge tube having first and second electrodes and supplied by a source of alternating current comprising, in series circuit arrangement, a choke coil having a main coil and an auxiliary coil, said main coil being serially connected between one terminal of said alternating current source and said first electrode, a capacitor connected in series with said auxiliary winding, said series combination of capacitor and auxiliary winding being connected across said tube in series with said first and second electrodes, said second electrode being connected to the other terminal of said alternating current source, said choke coil further comprising a magnetic core of predetermined volume on which said main and auxiliary coils are disposed in inductive coupling arrangement, each of said coils comprising first and second serially connected coil elements, the first coil element of each of said main and auxiliary coils occupying a common portion of said core and being closely coupled to counteract one another, and the second coil element of each of said main and auxiliary coils being arranged on separate portions of said core on either side of said common portion, yoke means disposed about said windings and having a plurality of laminations, each of said laminations being disposed substantially at right angles to the plane formed by the longitudinal axes of said core and of the respective lamination, and container means of predetermined volume housing said choke coil.

9. A ballast device for a gas or vapour discharge tube having first and second thermionic electrodes and supplied by a source of alternating current, comprising a container of a given cross-section, inductance means comprising a magnetic core of predetermined volume mounted in said container, said inductance means further comprising first and second windings disposed on said core, each of said winding comprising first and second serially connected coil elements, said first coil element of each of said winidngs being arranged on a common portion of said core to provide close mutual coupling therebetween, said second coil element of each of said windings being arranged on non-contiguous portions of said core, said first coil elements being wound on said core in a sense so as to substantially neutralize one another in the non-ignited condition of said tube, a capacitor, and means connecting said capacitor, said first and second windings, said electrodes and said current source in a series circuit.

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