Aug. 6, 1957 TAKIZO KOBAYASHI 2,802,143

STARTING DEVICE FOR A PREHEATING TYPE FLUORESCENT LAMP

Filed Sept. 7, 1955

FIG. 1

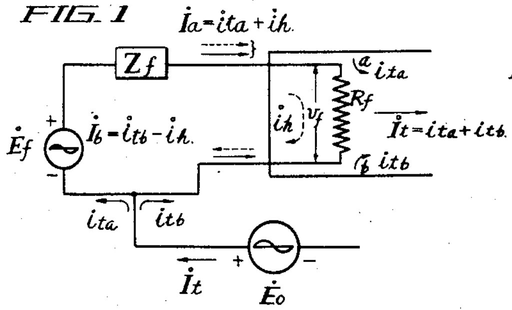


FIG. 3

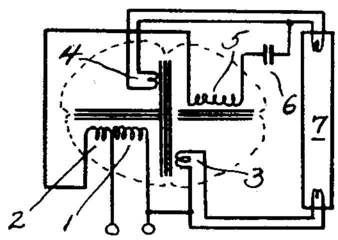


FIG. 2

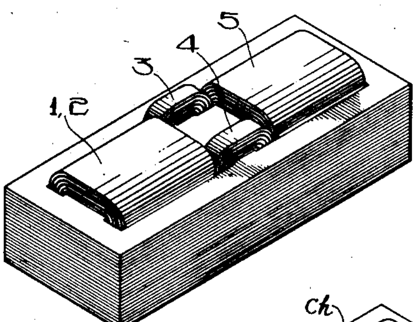


FIG. 5

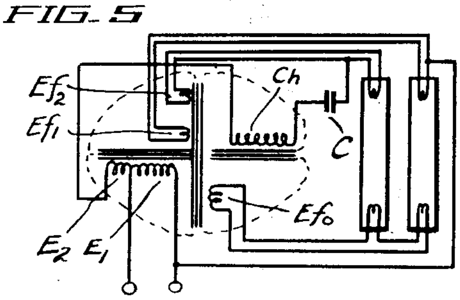


FIG. 4

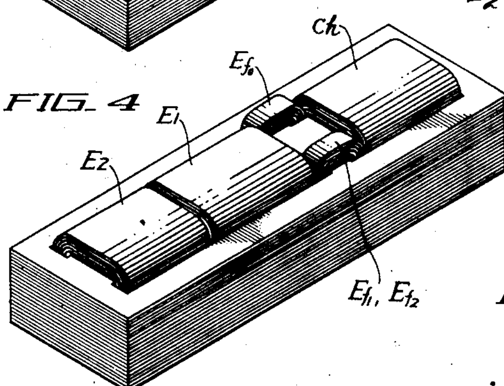
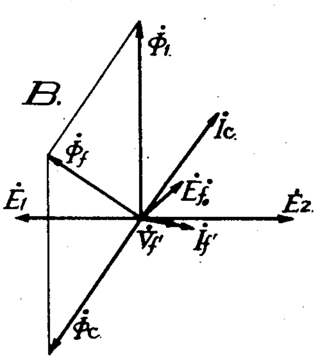
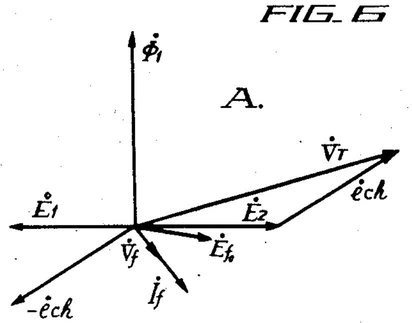


FIG. 6





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2,802,143

Patented Aug. 6, 1957

1

2,802,143

STARTING DEVICE FOR A PREHEATING TYPE FLUORESCENT LAMP

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Application September 7, 1955, Serial No. 532,994

4 Claims. (Cl. 315—98)

My invention relates to a starting device for a preheating type fluorescent lamp.

In a preheating type fluorescent lamp, it is necessary to preheat fully enough its cathode on starting, and to decrease the heating for cathode from the external circuit on lighting so as not to superheat it. For this object, a rapid start lighting ballast with a system to eliminate heating voltage for cathode by use of a filament transformer was devised. According to this system the cathode is to be preheated, on starting, by high heating voltage for cathode and, after lighting, the voltage is to be decreased to be kept low.

But the ratio of this elimination of heating voltage for cathode is nearly proportional to the ratio of the impressed voltage between the terminals of the lamp, on starting, to the lamp voltage after lighting. So it is impossible to perfectly eliminate the preheating voltage for cathode except for a special case. In order to increase the ratio of elimination of the preheating voltage for cathode, it is necessary to raise the impressed voltage between both terminals of the lamp in the main discharge circuit. But, on the other hand, to eliminate the influence which will shorten the life of the lamp on starting, to keep the cost of the ballast low and to diminish its loss, the voltage of the main discharge circuit given, on starting, between both terminals of the lamp should be kept as low as possible by using a starting aid conductor plate or by applying dry film to the surface of the lamp.

Consequently, the main discharge circuit voltage is put down to the level required for lighting the lamp, the difference between the lamp voltage and the main discharge circuit voltage is diminished, and the ratio of the elimination of the preheating voltage for cathode is decreased. And it is also desirable to raise the preheating voltage for cathode as high as possible. Hence, the residual heating voltage for cathode cannot but have large value. In a preheating voltage for cathode eliminating starter heretofore in use, the heating current for cathode given by the residual heating voltage for cathode and the lamp current are superposed to promote the evaporation of oxide applied to the cathode by superheating its arc spot, lessening durability of the lamp.

The present invention started from the point of view quite different from other in order to overcome the defects. It is desirable indeed to keep the residual heating voltage for cathode as low as possible, but the essential problem for lengthening the life of the lamp is that the temperature of the cathode arc spot after lighting should be kept as low as possible and that the arc spot should be widely spread, not concentrated on one point. For instance, in a lamp having a supplying terminal only on one side, as in one with a switch-start system, its cathode acts with that one side overloaded. But, a lamp the cathode of which, though its residual heating voltage may be somewhat high, acts on its wide area of the cathode filaments is by far durable. Hence, when the temperature on arc spot is kept low and its action is spread on wider area by using effectively the heating current for cathode

2

flowing through the cathode filament circuit caused by the residual heating voltage for cathode, the lamp will stand longer use, which is experimentally proved, and in that lies the one purpose of the present invention.

Preferred embodiments of the invention are illustrated in the accompanying drawing, in which:

Fig. 1 is a diagram of a rapid start lighting type starting device with a filament transformer system while in lighting.

Fig. 2 is a perspective view of an embodiment of a one-lamp circuit according to the present invention.

Fig. 3 shows an electric circuit of Fig. 2.

Fig. 4 is a perspective view of an embodiment of a two-lamp circuit according to the present invention.

Fig. 5 shows an electric circuit of Fig. 4.

A and B of Fig. 6 shows vector diagrams.

In Fig. 1:

Ef . . . induced voltage of the heating coil for cathode.
Zf . . . series impedance of the heating circuit for cathode.
Rf . . . resistance of the cathode filament of the lamp.
Vf . . . residual heating voltage for cathode of the lamp.
ih . . . residual heating current for cathode of the lamp.
$\dot{I}t$ . . . electric current of the lamp.
ita, itb . . . shunt currents of the lamp current.

$$It = ita + itb \quad (1)$$

$\dot{I}a$ . . . resultant current of the shunt current ita of the lamp of the terminal a of the cathode filament of the lamp while in lighting and the residual heating current ih for cathode.

$$\dot{I}a = \dot{i}ta + \dot{i}h \quad (2)$$

$\dot{I}b$ . . . resultant current of the shunt current itb of the lamp of the terminal b of the cathode filament of the lamp while in lighting and the residual heating current ih for cathode.

$$\dot{I}b = \dot{i}tb - \dot{i}h \quad (3)$$

Where, when the series impedance $\dot{Z}f$ of the heating circuit for cathode is larger in comparison with the cathode filament resistance Rf, the lamp shunt current ita is much smaller than $\dot{i}tb$ and $ita \doteqdot O$, $\dot{I}t \doteqdot itb$. However, the phases of ih and itb are opposite to each other as shown in (3), so $ita \doteqdot O$ and they are opposite to the residual heating current ih for cathode at the terminal b of the cathode filament too. Though the residual voltage for cathode may be comparatively high, the cathode is not superheated by the superposed current of itb and $\dot{I}t$, and the cathode is kept at modest temperature so as to the lamp is much more durable.

On the contrary, in a filament transformer type rapid start lighting ballast heretofore in use, in which the series impedance Zf is extremely small, $ith \doteqdot o$, $ita \doteqdot \dot{I}t$, and, the residual heating current ih for cathode being superposed to the lamp shunt current $ita = It$, $Ia = ita + ih = It + ih$, to the lamp shunt current $ita \doteqdot \dot{I}t$, $\dot{I}a \doteqdot \dot{i}ta + \dot{i}h \doteqdot \dot{I}t + ih$, with the cathode temperature being extraordinarily superheated and the life of the lamp being much shortened. So, it has been tried to keep the residual heating voltage for cathode as low as possible after lighting and thus lessen the residual heating current for cathode, so that the lamp may not suffer less durability caused by that high temperature on its cathode which the superposing of the lamp currents $\dot{I}t \doteqdot ita$ brings. But, as the main discharge circuit voltage is required to be kept as low as possible, it is difficult to drop the residual preheating voltage for cathode. And, though it is most ideal to let the heating coil for cathode itself have a comparatively large Zf as an internal impedance, yet any of rapid start lighting type starting devices with filament transformers heretofore in use cannot meet this requirement, its internal impedance of the heating coil for cathode being very small. In order to settle the problem, the present invention investigated in addition the following question: a ballast of a leading discharge circuit type with a series condenser as a type of a high power factor ballast may be thinkable? But in a ballast of a leading discharge circuit type, if it has only a series condenser, electric wave form of the lamp will be much disordered within the limits of commercial frequency. In order to prevent it, a choke may be provided in series. And, when the ratio of C (ohm value) to L (ohm value) has some proper value, experimentally about 2.35, an electric wave form as satisfactory as that of L ballast can be acquired. When a secondary coil, as in a leakage transformer, acts also as a series choke L, and on starting, its induced voltage becomes a necessary voltage for start, added to the primary voltage and, after lighting, becomes a reactor, then, although the ballast can be very small. In a leading discharge electric circuit, the leakage flux according to the leading lamp current, after lighting, having the phase of intensifying the magnetism with the main flux, the flux under the secondary coil is very decreased in reactance value owing to the characteristic of magnetism saturation, and the electric wave form of the lamp is obstructed. So, in a ballast of a leading discharge circuit type, it was profitable to use separately an external choke rather than that of a leakage transformer. The device of the present invention was devised to remedy this defect of a leakage transformer type, and the device is made by winding coils for reversing magnetic flux round the parallel joint part of the magnetic iron core of the primary and secondary coils and the magnetic iron core of the choke coil acting also as the secondary coil. And the part of this coil for reversing magnetic flux, in its application to a heating type fluorescent lamp, is played by the heating coil for cathode, which thus is used effectively as an eliminator of the heating voltage for cathode. The method to wind separately the cathode heating coil, which also acts as the reversing magnetic flux coil, so as to form two separate magnetic circuits, together with the above mentioned method to lower the cathode temperature by raising the internal impedance of the coil for heating cathode, was synthetically investigated to give birth to the present invention. Now to explain the detailed structure and acting system of the device of the present invention, in the drawing **1** is the primary coil, **2** the secondary coil, **3, 4** the cathode heating coil, **5** the choke coil for stabilizing the leading discharge circuit, **6** the series condenser and **7** the fluorescent lamp. In this starting device, the cathode of the fluorescent lamp **7** is preheated by the induced voltage of the cathode heating coil **3, 4**, when the power source is closed. Owing to this cathode preheating load, the leakage magnetic flux is induced in the magnetic circuit of the choke coil for stabilization **5**. The voltage induced by the leakage magnetic flux in the choke coil for stabilization induces positive voltage on the secondary coil voltage, and thus the impressed voltage between the lamp terminals is so much raised. When the starting discharge voltage is dropped, which is caused by the lamp preheating the cathode, the fluorescent lamp **7** comes to lighting. When the lamp is lighted, the lamp current running down the choke coil for stabilization **5** produces magnetic flux Φc in the magnetic circuit of the choke coil for stabilization, and this magnetic flux Φc and the main magnetic flux Φ_1 caused by the primary coil **1** are combined into the resultant magnetic flux $\Phi_1+\Phi c$, which becomes acutely interlinkage magnetic flux of the cathode heating coil **3, 4**, and this acutely interlinkage resultant magnetic flux, vectorially combined with each other, diminishes extremely. So the voltage of the cathode heating coil **3, 4** is dropped on lighting, the residual heating voltage for cathode being so much decreased. The choke coil for stabilization **5**, as is above mentioned, acts also as the secondary coil on starting by the close of the circuit when the cathode is preheated by cathode heating coil **3, 4** the part of which plays additionally the reversing coil for magnetic flux, but, after lighting acts as a choke element of the leading discharge circuit to keep the electric wave form of the lamp good.

In Fig. 2.A:

E_1 . . . primary voltage.

E_2 . . . secondary voltage (secondary no load current of main discharge circuit of the ballast).

ech . . . voltage in the choke coil for stabilization, induced by close of the cathode heating circuit.

Vt . . . voltage impressed between the lamp terminals on starting, that is, preheating the cathode.

$$Vt=E_2+ech$$

Efo . . no load voltage of the cathode heating coil.

If . . . preheating current for cathode.

Vf . . . preheating voltage for cathode filament of the lamp.

Φ_1 . . . main magnetic flux.

In Fig. 6.B:

E_1 . . . primary voltage.

E_2 . . . secondary voltage.

$\dot{I}c$ . . . lamp current.

Φ_1 . . . main magnetic flux.

Φc . . . magnetic flux in the magnetic circuit of the choke coil for stabilization, produced by the lamp current Ic.

Φf . . . acately interlinkage resultant magnetic flux of the cathode heating coil.

$$\dot{\Phi}=\dot{\Phi}_1+\dot{\Phi}c$$

Efo . . induced voltage of the cathode heating coil, produced by the combined magnetic flux $\dot{I}f$ interlink at an acute angle.

Vfi . . residual heating voltage for cathode while in lighting.

If^1 . . . residual heating current for cathode while in lighting.

Any ballast of a preheating voltage for cathode elimination type heretofore in use needs extra electric loading and magnetic loading in order to decrease the preheating voltage for cathode, but the present invention adopts the most efficient and most reasonable stabilizing system of a magnetic flux reversing type, in applying a leakage transformer system to the leading discharge circuit. As the necessary result, the stabilizer of the present invention, becoming a cathode preheating voltage eliminating type, comes to be light and cheap and may well be said the most efficient cathode preheating voltage elimination type stabilizer.

The other characteristic of the device of the present invention is in its structure dividing the heating coil for cathode **3, 4** into two parts. Hence, as the main magnetic flux Φ_1 coming from the primary coil which joins to the heating coil for cathode at an acute angle becomes ½, the cathode heating coil requires twice as many turns in order to get the desirable voltage. This enables the internal impedance of the cathode heating coil to be raised up respectively to 4 times as much and is equivalent to increasing the value of the cathode heating circuit internal impedance Zf. Thus, for the above mentioned reason, the arc spot on the lamp cathode is properly spread not to be superheated on one point and the lamp can get out of the influence to shorten its life. The device of the present invention has such desirable characteristics as above and, moreover, has good features as below in addition;

(1) As the internal impedance of the cathode heating coil increases, the no load voltage of the cathode heating coil is raised when the prescribed heating current for cathode running along it. Hence, the lamp gets rid of its base pin or socket contact resistance being damaged.

Though the size of the cathode filament of the lamp may become somewhat different, the device of the present invention can remain a constant current circuit, so the heating current for cathode is hardly affected. Whether it is in a standard fluorescent lamp or in a rapid starter type fluorescent lamp, not only it is of no harm to use the device of the present invention but it gives desirable effect to use this device made for the standard fluorescent lamp in a rapid starter type fluorescent lamp.

(2) In the device of the present invention, when the heating circuit for cathode is not closed, the impressed voltage between the terminals of the lamp is not raised, so the lighting is difficult or impossible. Hence, it cannot be that when the heating cathode circuit is opened on account of a defective socket or the like as in high speed starting ballast heretofore in use, that the lamp is lighted on the instant to suffer lessening of its life. The fact is very profitable for protecting the lamp.

(3) As the internal impedance of the heating coil for cathode, or the internal inductance is high, the residual preheating current for cathode, the ballast becomes highly efficient and the ballast capacity diminishes. The fact not only keeps the loss of the ballast low but makes the cost low.

What is claimed is:

1. For use with a preheating type of fluorescent lamp, a starting device comprising a magnetic core, a primary coil and a secondary coil coupled to a first flux path on said core, a choke coil coupled to a second flux path on said core, a cathode heating coil for said lamp coupled to both said paths, means responsive to energization of said heating coil from said primary coil during preheating of said cathode for creating a leakage flux in said choke coil to induce a voltage thereacross additive with respect to the voltage across said secondary coil, means for applying the combined choke coil and secondary coil voltages to said lamp to light it, and means for shifting the phase of the flux in said choke coil upon lighting of the lamp to oppose the flux in said heating coil produced by said primary coil to reduce the residual cathode heating voltage.

2. The device of claim 1, said cathode heating coil having two parts each coupled to half the flux produced by said primary coil, each of said parts having a high impedance with respect to the impedance of the cathode heaters to which they are connected.

3. The device of claim 1, said secondary coil being connected in a series circuit with said choke coil and said lamp, said phase shifting means comprising a condenser in said series circuit.

4. The device of claim 3, said secondary coil and said primary coil forming an autotransformer.

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