

Aug. 4, 1970

TSUGUHITO HASHIMOTO
DISCHARGE LAMP STARTING DEVICE

3,522,475

Filed June 7, 1968

4 Sheets-Sheet 1

Fig. 1
(PRIOR ART)

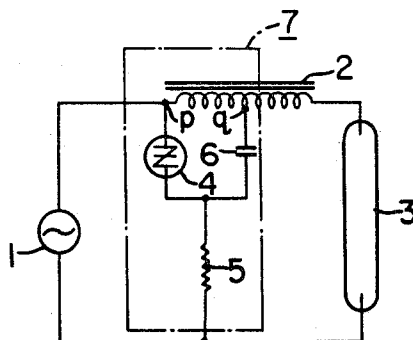


Fig. 2A

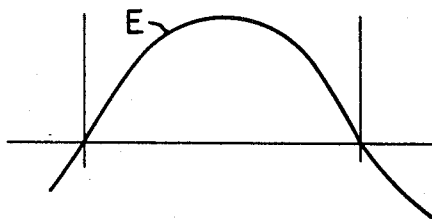


Fig. 2B

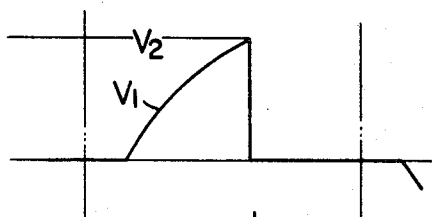
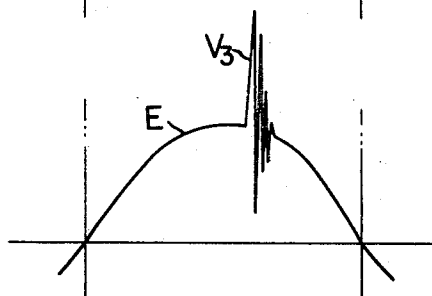


Fig. 2C



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Fig. 3
(PRIOR ART)

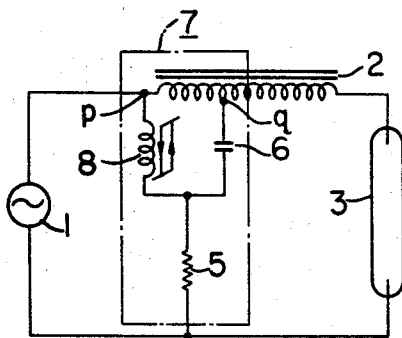


Fig. 4

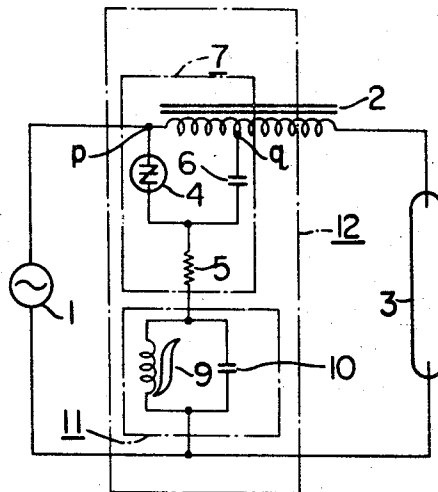


Fig. 6A

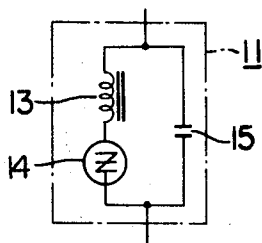


Fig. 6B

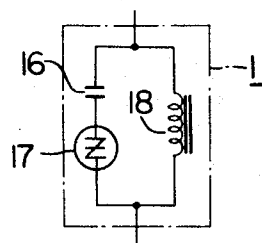


Fig. 6C

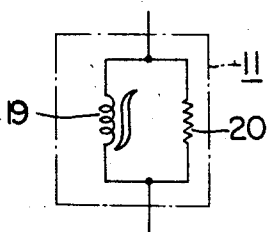
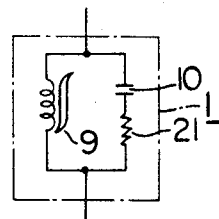


Fig. 6D



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Fig. 5A

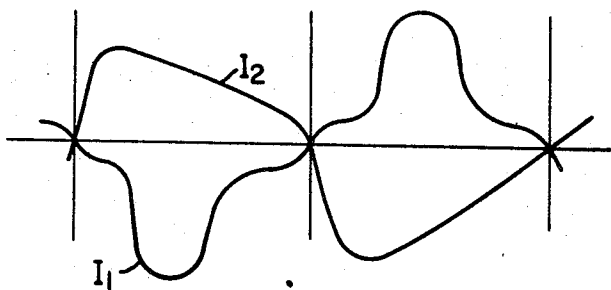


Fig. 5B

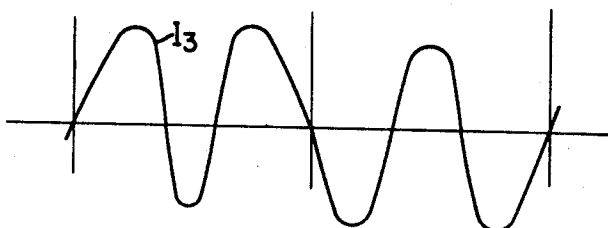


Fig. 5C

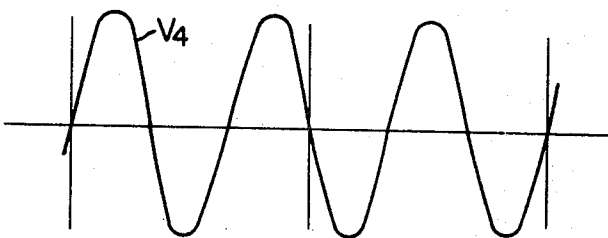


Fig. 5D

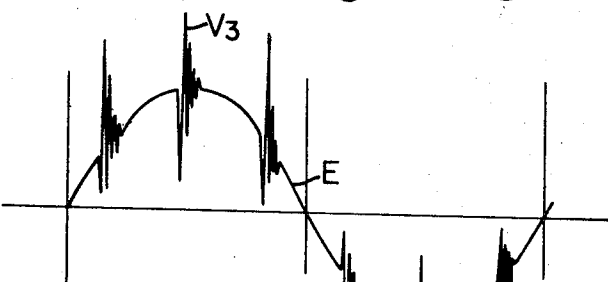
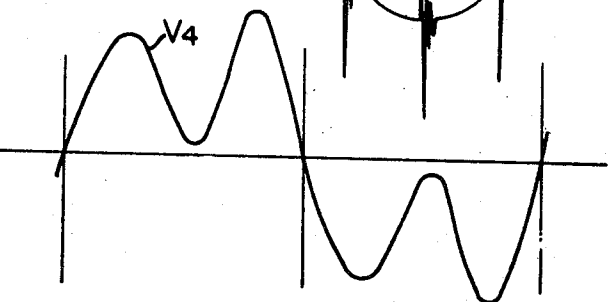


Fig. 5E



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Fig. 7A

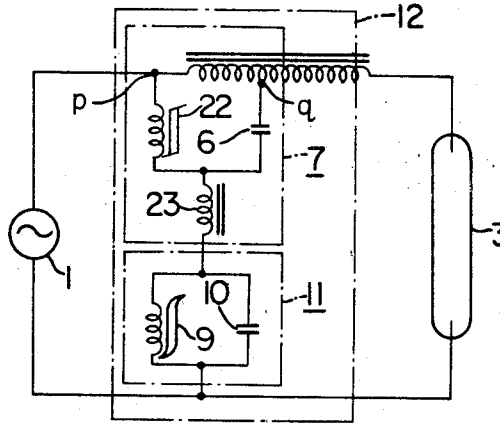


Fig. 7B

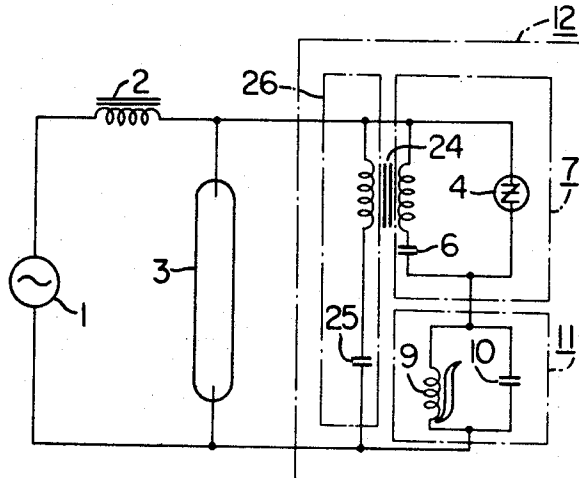
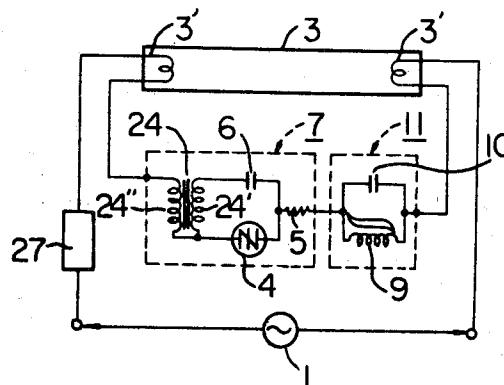


Fig. 8



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DISCHARGE LAMP STARTING DEVICE

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Int. Cl. H05b 41/14

U.S. Cl. 315—239

6 Claims

ABSTRACT OF THE DISCLOSURE

The present invention relates to a starting device for discharge lamps with an improved starting effect. The effect is produced by providing a distorted wave generating circuit connected in series with a starting pulse generating circuit. The distorted wave generating circuit is adapted so as to superpose a plurality of starting pulses on the source voltage during each half cycle thereof. The thus formed series circuit comprising the starting pulse generating circuit and the distorted wave generating circuit provides smooth and stable starting of the discharge lamp connected to both ends of said series circuit.

This invention relates to a discharge lamp starting device wherein a plurality of starting pulses are superposed on the source voltage during each half cycle thereof so that a discharge lamp may be positively started.

A discharge lamp starting device has recently been developed which is provided with a starting pulse generating device which will impress high voltage starting pulses on a discharge lamp in order to improve its startability.

An example of one conventional discharge lamp starting device provided with such a starting pulse generating device is shown in FIG. 1. A discharge lamp 3 is connected through a choke coil to both terminals of an alternating current source 1. A symmetrical silicon switch 4 (which shall be referred to as a 3-S element hereinafter) which is a thyristor for alternating currents and a current limiting resistance 5 are connected in series to both terminals of the alternating current source 1. In FIG. 1, *p* is a connecting point of the alternating current source 1 with the choke coil 2 and 3-S element 4 and *q* is an intermediate tap of the choke coil 2. A condenser 6 is inserted between the intermediate tap *q* and a connecting point of the 3-S element 4 and the current limiting resistance 5.

In such a circuit as FIG. 1, if a source voltage *E* is applied as in FIG. 2A, the condenser 6 will be charged as in FIG. 2B through a part of the choke coil 2, i.e., the part between the point *p* and the intermediate tap *q*, and the resistance 5. When the particular charging voltage *V*₁ of the condenser 6 has reached the breakdown voltage *V*₂ of the 3-S element 4, the 3-S element 4 will break down to conduct the current. Thus, the very large internal impedance of the element 4 will be almost shorted, and the electric charge accumulated in the condenser 6 will be instantaneously discharged into a closed circuit consisting of the choke coil 2 between the point *p* and the intermediate tap *q*, and of the 3-S element 4 in a conductive state, so that a steep pulse voltage will be generated between the point *p* and the intermediate tap *q* of the choke coil 2. The pulse voltage will be boosted at a boosting ratio determined by the position of the intermediate tap *q* of the choke coil 2, and a starting pulse *V*₃ of a wave form shown in FIG. 2C will be generated once in a half cycle, the starting pulse being superposed on the source voltage and being applied to both ends of the discharge

lamp 3 thereby contributing to the starting of the lamp.

While it is desirable to utilize a starting pulse having a larger height and a longer width in order to obtain better starting characteristics, there are inherent disadvantages in the conventional devices, examples of which are shown in FIG. 1, and in FIG. 3 wherein a magnetic switch 8 is used instead of the 3-S element 4. As a practical matter it is difficult to generate a plurality of starting pulses due to specific properties of the magnetic switch 8, setting of the operating voltage of the 3-S element, or the relationship of the other parameters, and thus, even if a sufficient wave height value is obtained for the starting pulse, the time of impressing it on the discharge lamp 3 will be so short that the desired object of smoothly starting the discharge lamp 3 will not be fully attainable in some cases. According to the present invention, the above mentioned disadvantages have been overcome by superposing a plurality of starting pulses on the source voltage during each of its half cycles.

An object of the present invention is to provide a discharge lamp starting device wherein the starter is formed by connecting a distorted wave generating circuit in series with a starting pulse generating circuit and is added into a discharge lamp starting circuit so that a plurality of starting pulses will be generated during each half cycle of the source voltage, thereby providing that the discharge lamp will be smoothly and positively started.

Other objects and advantages of the present invention will become apparent from the following detailed description with reference to the accompanying drawings, in which:

FIG. 1 shows a conventional discharge lamp starting device.

FIGS. 2A, 2B and 2C show wave form diagrams in the essential parts of the device shown in FIG. 1.

FIG. 3 shows another embodiment of a conventional discharge lamp starting device.

FIG. 4 shows an embodiment of a discharge lamp starting device according to the present invention.

FIGS. 5A to 5E show wave form diagrams in the essential parts of the embodiment shown in FIG. 4.

FIGS. 6A to 6D show embodiments of distorted wave generating circuits to be used in the present invention.

FIGS. 7A and 7B show other embodiments of the present invention.

FIG. 8 shows still another embodiment of the present invention.

While the present invention will be described in connection with the certain preferred embodiments shown, it should be understood that it is not intended to limit the invention to these particular embodiments, but rather to cover all alternatives, modifications and equivalent arrangements included within the spirit and scope of the invention.

Referring now to the drawings, and more specifically to FIG. 4, 1 is an alternating current source, 2 is a choke coil, 3 is a discharge lamp, 4 is a 3-S element, 5 is a current limiting resistance and 6 is a condenser. A closed circuit comprising a part of the choke coil 2 between the point *p* and the intermediate tap *q*, the 3-S element 4 and condenser 6 is formed, and a starting pulse generating device 7 is formed by connecting one end of the current limiting resistance 5 to the connection point of the condenser 6 with the 3-S element 4. A starter 12 is formed by connecting a distorted wave generating circuit 11 in series with said starting pulse generating device 7, said distorted wave generating circuit 11 being formed by a parallel circuit of a saturable reactor 9 and a condenser 10.

In the discharge lamp starting circuit mentioned above, the operation of the distorted wave generating circuit 11 is

such that when a source voltage E is impressed on the circuit, a current will be fed to the starter 12. The current I_1 flowing through the inductive saturable reactor 9 will be of a very sharp pointed wave form, for example as shown in FIG. 5A, and will be of a phase opposite to the phase of a current I_2 flowing through the condenser 10. The resulting current I_3 , representing the sum of the currents I_1 , I_2 and flowing through the starter 12 will have peaks as shown in FIG. 5B. The condenser 6 in the starting pulse generating circuit 7 will be charged with current I_3 . In other words, the starting pulse generating circuit 7 of the starter 12 will be controlled by the current I_3 of distorted wave form having two peaks. This is equivalent to being operated by a distorted voltage V_4 of a frequency three times as high as of the source voltage E as shown in FIG. 5C. Therefore, the starting pulse generating circuit 7 will operate three times during a half cycle of the source voltage E. As shown in FIG. 5D, during a half cycle of the source voltage E, a starting pulse V_3 will be generated three times. Depending on the selection of the current I_3 flowing through the starter 12, the distorted voltage V_4 applied to the starting pulse generating circuit 7 may have two peaks while being of the same frequency as the source voltage E as shown in FIG. 5E. In some cases, the starting pulse will be generated twice during a half cycle of the source voltage E near the peaks of said distorted voltage V_4 .

The discharge lamp starting circuit according to the present invention is constructed and operates as indicated above. The starting pulse generating circuit 7 will operate a plurality of times during a half cycle of the source voltage E; a voltage on which a plurality of starting pulses V_3 are superposed during the half cycle will be impressed on the discharge lamp 3; and, therefore, the discharge lamp 3 will be smoothly started.

The distorted wave generating circuit 11 used in the present invention need not consist of a parallel circuit of the saturable reactor 9 and condenser 10, but may be any of a type generating distorted waves which will operate the starting pulse generating circuit 7 a plurality of times during a half cycle of the source voltage E.

For example, modification such as a circuit wherein a condenser 15 is added in parallel to the series circuit of a choke coil 13 and 3-S element 14 as shown in FIG. 6A; a circuit wherein a 3-S element 17 is connected in series with a condenser 16, and a choke coil 18 is provided in parallel with said series connection as shown in FIG. 6B; or a circuit wherein a saturable reactor 19 and resistance 20 are connected in parallel with each other as shown in FIG. 6C may be used.

In the particular modification wherein the distorted wave generating circuit 11 consisting of the parallel circuit of the saturable reactor 9 and condenser 10 is used, the phases of the current I_2 flowing through the condenser 10 and of the current I_1 flowing through the saturable reactor 9 are opposite each other and a current flows through the saturable reactor 9 for only a substantially short period of time, and thus, this particular circuit 11 will be useful in obtaining greatly distorted waves, thereby stably obtaining a plurality of starting pulses and consequently more smoothly starting the discharge lamp 3. Further, when the saturable reactor 9 is connected in parallel with a series circuit of a condenser 10 and resistance 21 as shown in FIG. 6D, thereby adjusting the phase of the current from the condenser 10, permitting the wave form of the distorted wave to be freely varied, thereby permitting free selection of the starting pulse generating position. Therefore, stable discharge of the discharge lamp 3 can be continued by generating starting pulses near the rise of the lamp voltage while the discharge lamp 3 is operated. Further inasmuch as the generation of distorted waves varies depending on the magnitude of the source voltage E, the number of generations of starting pulses will be varied depending on the fluctuation of the source voltage E.

The starting pulse generating circuit 7 used in the present invention may be such as will automatically operate depending on the instantaneous value of the voltage applied to it, irrespective of the manner of transmitting starting pulses to the discharge lamp 3. For example, as shown in FIG. 7A, a magnetic switch 22 may be used instead of the 3-S element 4 in the embodiment shown in FIG. 4, and a current limiting choke coil 23 may be used instead of the current limiting resistance 5 also shown in FIG. 4. Further, as shown in FIG. 7B, the starter 12 may be formed by making the pulse generating circuit 7 independent of the choke coil by, inserting a pulse transformer 24, removing the current limiting resistance 5, by forming the pulse generating circuit 7 of a closed circuit consisting of the primary side of the pulse transformer 24, condenser 6 and 3-S element by connecting the distorted wave generating circuit 11 to the circuit 7 in series, connecting both the circuits 7 and 11 to both ends of the discharge lamp 3 and, at the same time, by providing a pulse transmitting circuit consisting of a series circuit of the secondary side of the pulse transmitter 24 and a condenser 25 in parallel with the series circuit of the starting pulse generating circuit 7 and distorted wave generating circuit 11.

FIG. 8 shows still another embodiment of the present invention as applied to a filament preheating type discharge lamp. In FIG. 8, 3 is a discharge lamp, 3' is a filament and 7 is a starting pulse generating device formed of a 3-S element 4, current limiting resistance 5, condenser 6 and the primary winding 24' and secondary winding 24'' of a pulse transformer 24. A distorted wave generating circuit 11 formed of a saturable reactor 9 and a condenser 10. A stabilizer 27 is included. Upon application of a source voltage to this device, current flows through the stabilizer 27, filament 3', secondary winding 24'' and primary winding 24' of the pulse transformer, condenser 6, current limiting resistance 5, distorted wave generating circuit 11 and filament 3', and the condenser 6 becomes charged. When the condenser 6 has been charged to a fixed voltage, the 3-S element 4 will be in a conductive state, thereby starting pulses and the device will then operate in the same manner as in the devices previously described.

What is claimed is:

1. A discharge lamp starting device comprising the combination of a discharge lamp, a voltage source for supplying power to said discharge lamp, a distorted wave generating circuit operatively connected to said voltage source and including means for producing distorted waves having a plurality of peaks during each half cycle of said source voltage and a starting pulse generating circuit connected in series with said distorted wave generating circuit and responsive to said plurality of peaks in said distorted waves for producing a plurality of starting pulses for said discharge lamp during each half cycle of said source voltage, said discharge lamp being connected to both ends of said series connection of said starting pulse generating circuit and distorted wave generating circuit.
2. The discharge lamp starting device according to claim 1, wherein said distorted wave generating circuit is formed of a parallel circuit of a saturable reactor and condenser.
3. The discharge lamp starting device according to claim 1, wherein said distorted wave generating circuit is formed by connecting a condenser in parallel with a series circuit of a choke coil and symmetrical silicon switch.
4. The discharge lamp starting device according to claim 1, wherein said distorted wave generating circuit is formed by connecting a choke coil in parallel with a series circuit of a condenser and symmetrical silicon switch.
5. The discharge lamp starting device according to claim 1, wherein said distorted wave generating circuit

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is a parallel circuit of a saturable reactor and resistance.

6. The discharge lamp starting device according to claim 1, wherein said distorted wave generating circuit is formed by connecting a saturable reactor in parallel with a series circuit of a condenser and resistance.

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