

[54] **ELECTRIC CIRCUIT FOR RAPIDLY IGNITING A DISCHARGE TUBE**

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[51] Int. Cl.....H05b 37/00

[58] Field of Search.....315/100, 100 U, 200, 219, 227, 315/258

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[57]

ABSTRACT

This invention discloses a circuit for rapidly and certainly igniting a discharge tube such as a fluorescent lamp, mercury-arc lamp, neon tube lamp or the like, which comprises a capacitor adapted to effect charge or discharge thereof at substantially the peak value of AC wave of power source by the action of a switching means, a transformer or ballast choke coil which is adapted to produce high voltage pulse in response to said charge or discharge of the capacitor, said high voltage pulse being applied to a discharge tube at its electrodes which are preliminarily heated thereby to ignite the discharge tube. According to this invention, simultaneously when a power source is closed, a high voltage is generated at substantially the peak value of positive and/or negative half cycle of the AC power source by the operation of a specific circuit, thereby enabling the discharge tube to be rapidly or instantaneously ignited. The present circuit is very useful for various commercial purposes.

17 Claims, 23 Drawing Figures

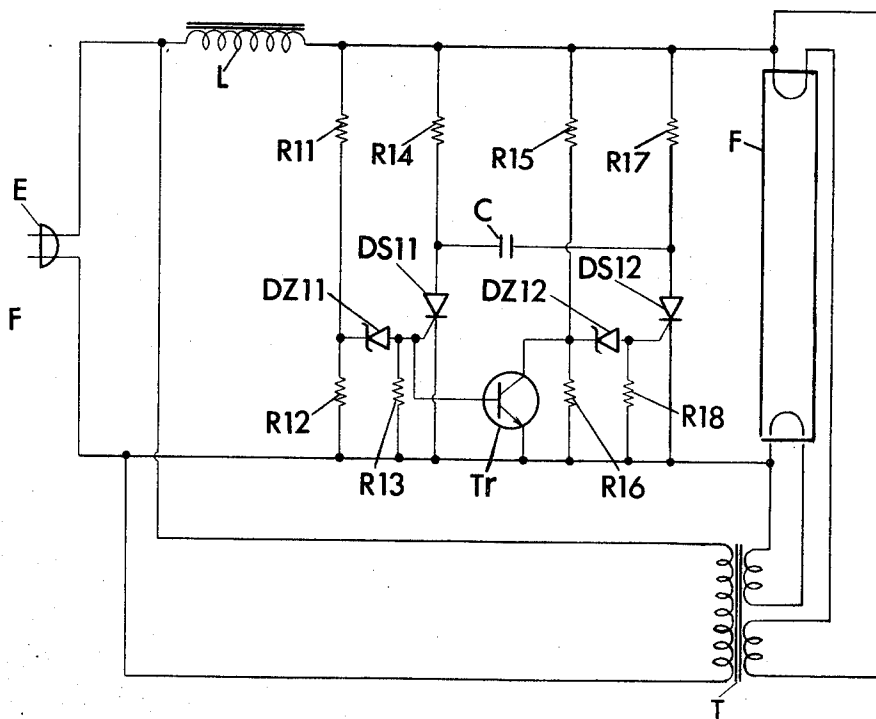


Fig. 1-B

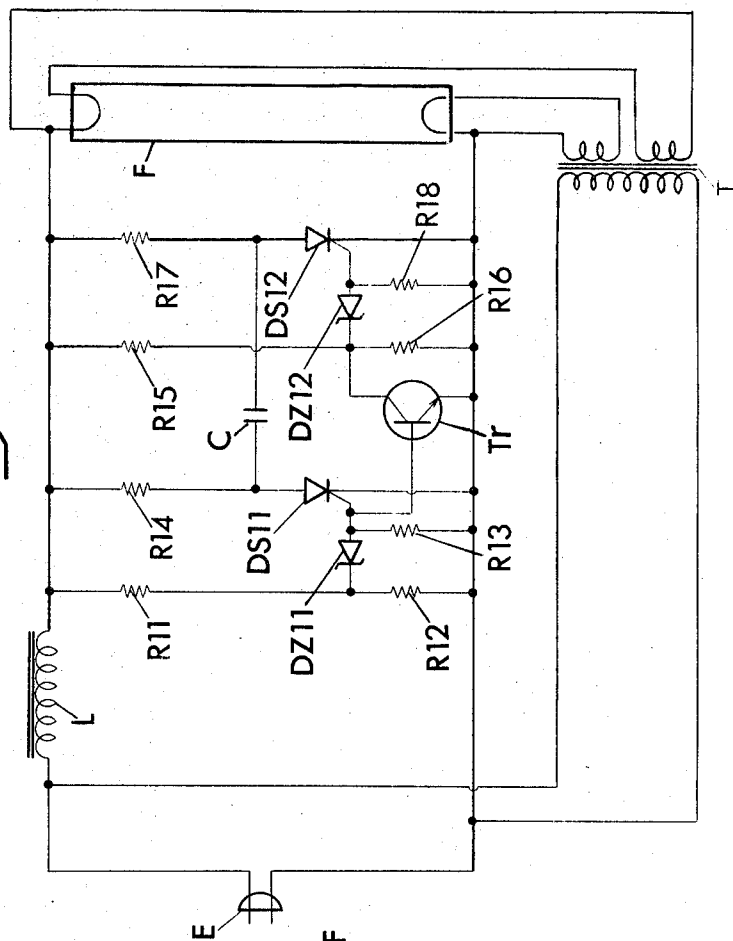
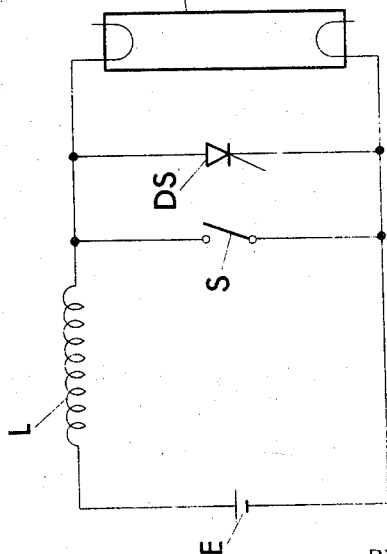


Fig. 1-A



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Fig. 2

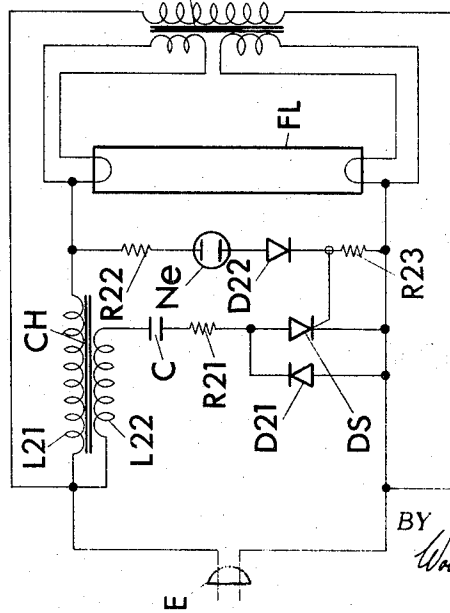
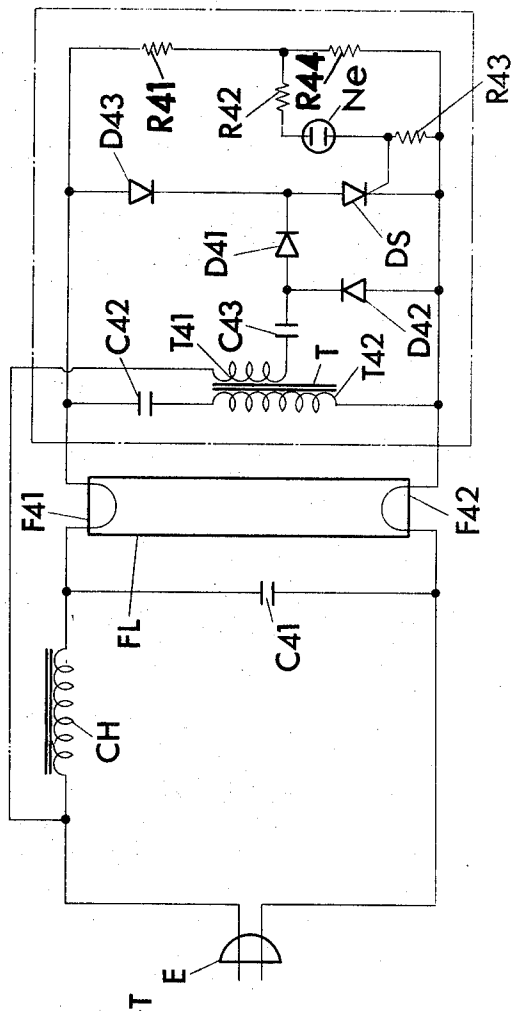
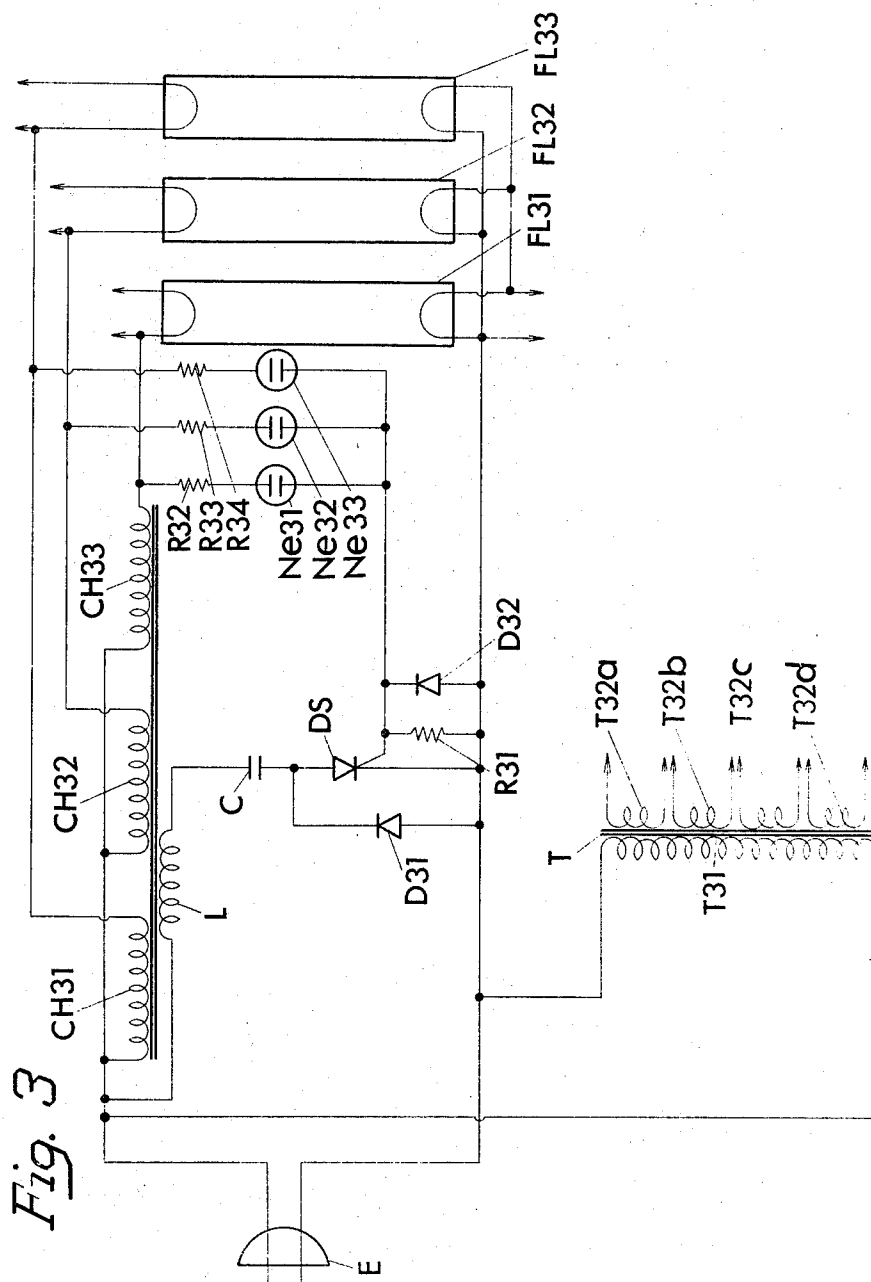


Fig. 4-A

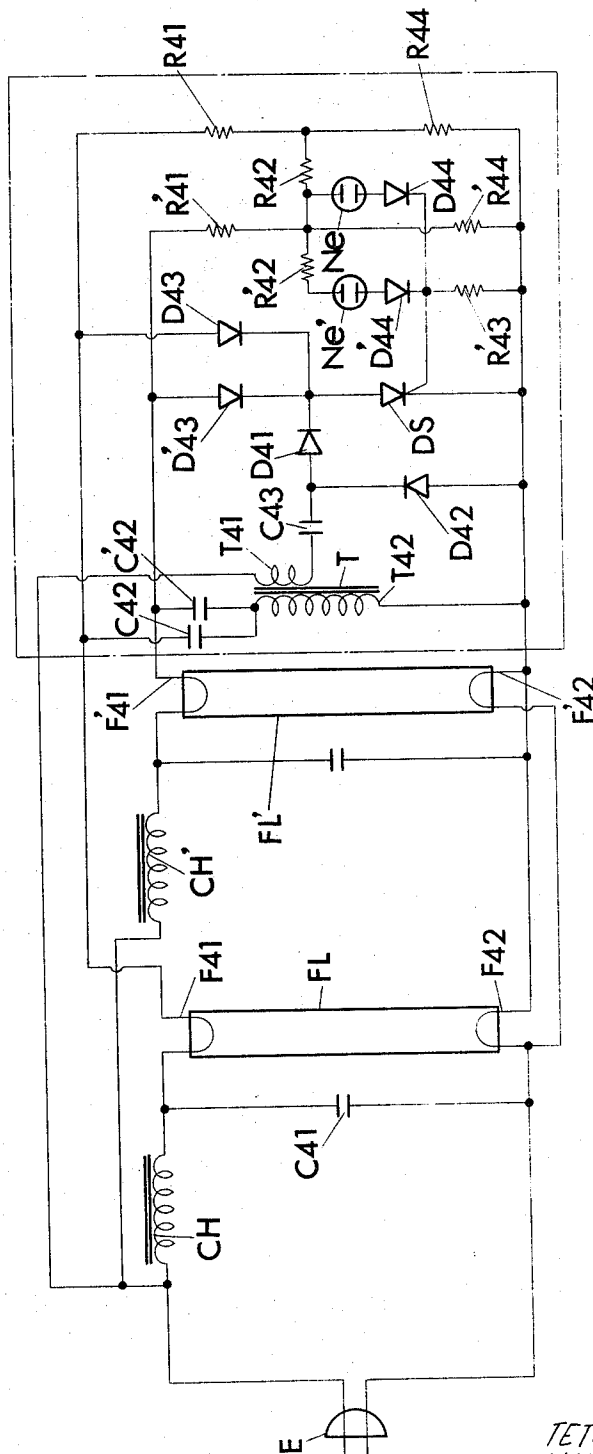


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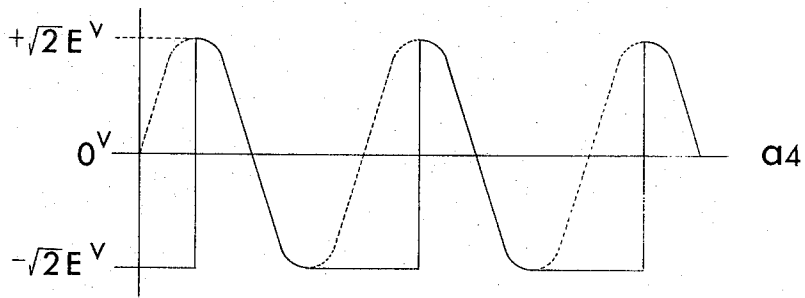
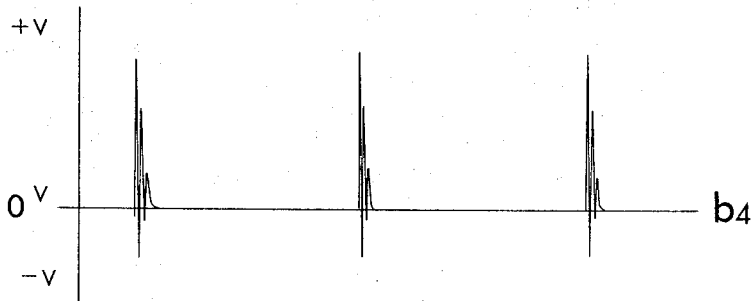
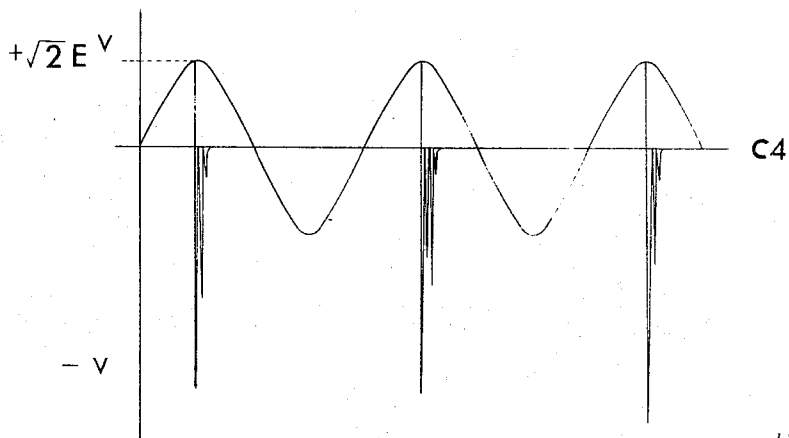
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Fig. 4-B



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Fig. 4-c



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Fig. 5-A

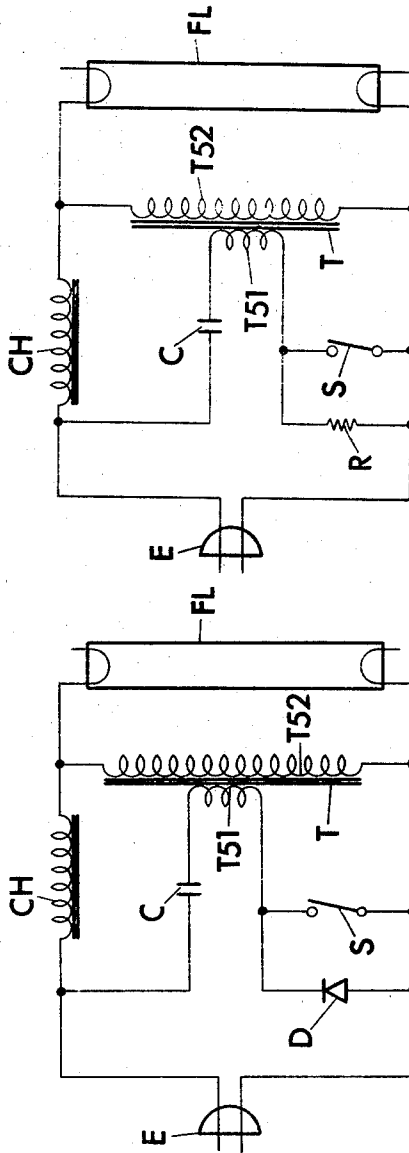


Fig. 5-B

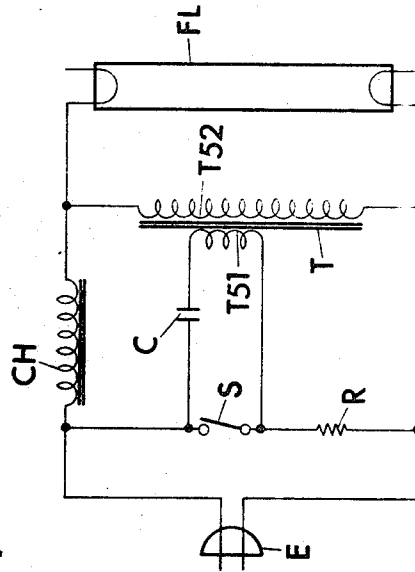


Fig. 5-E

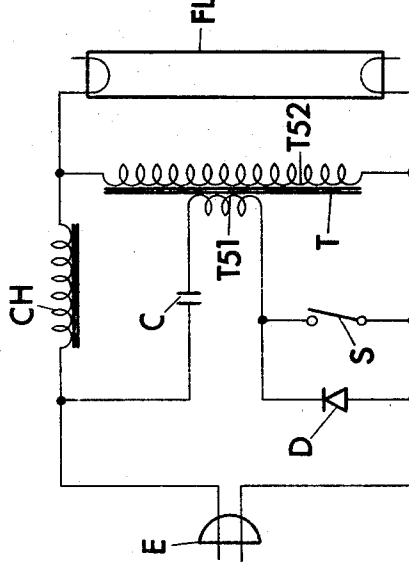
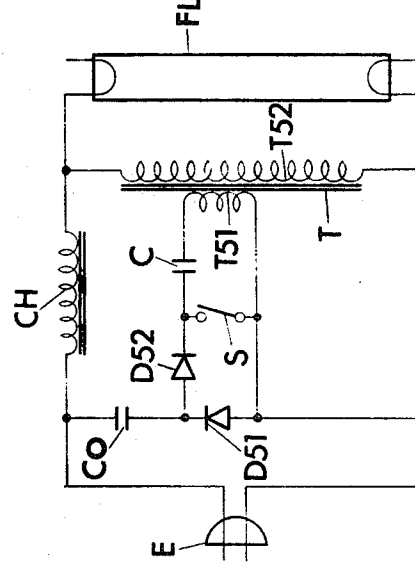


Fig. 5-F



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Fig. 5-D

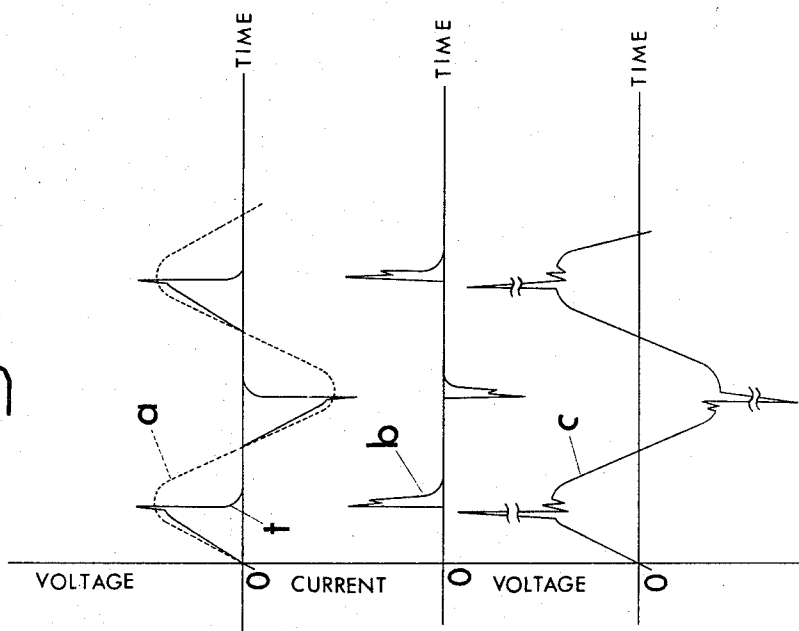
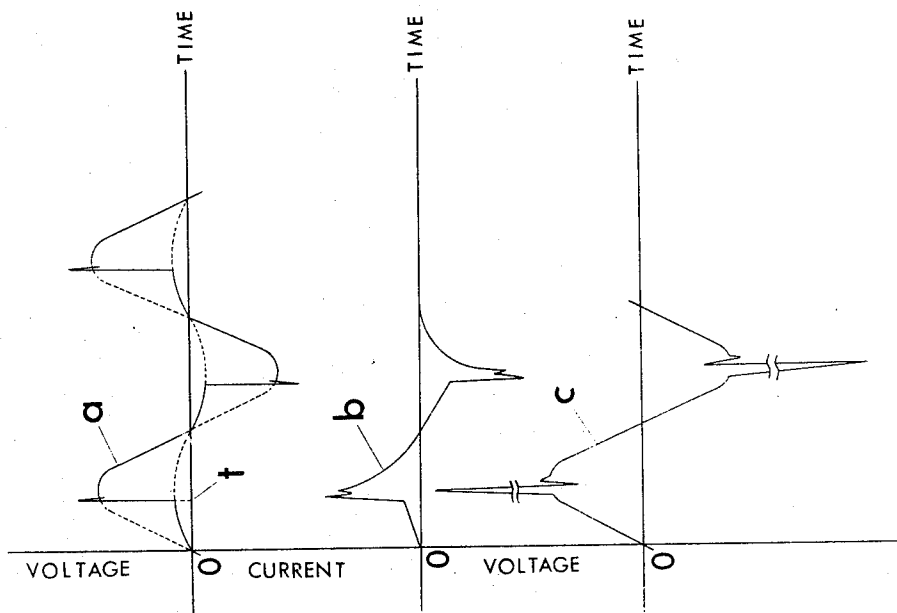


Fig. 5-C



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Fig. 5-H

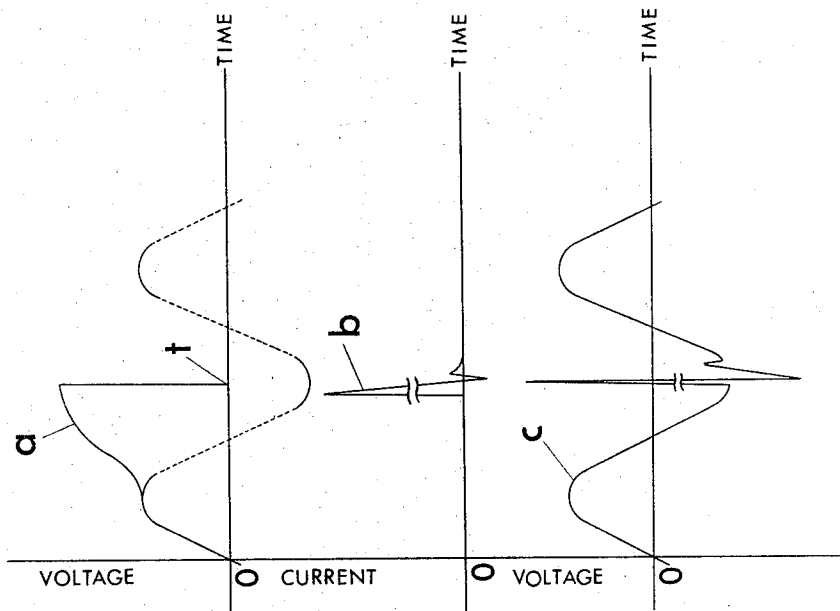
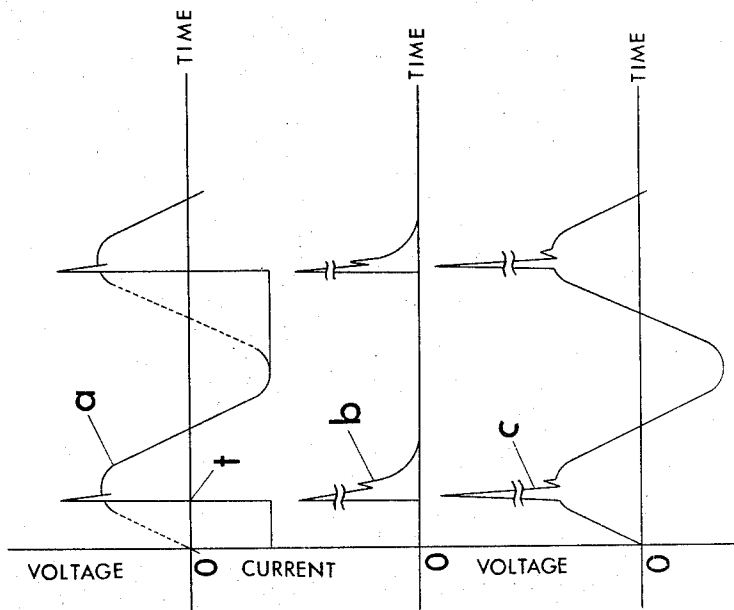


Fig. 5-G



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Fig. 6-A

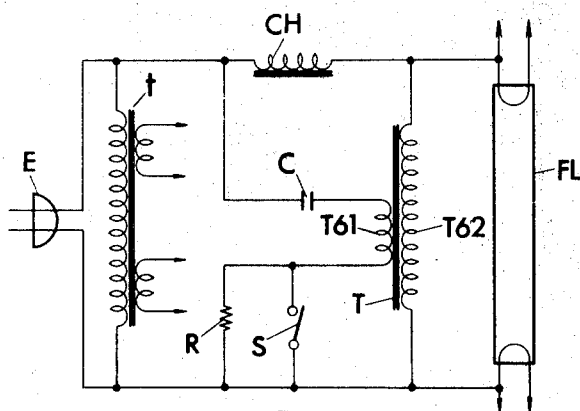


Fig. 6-C

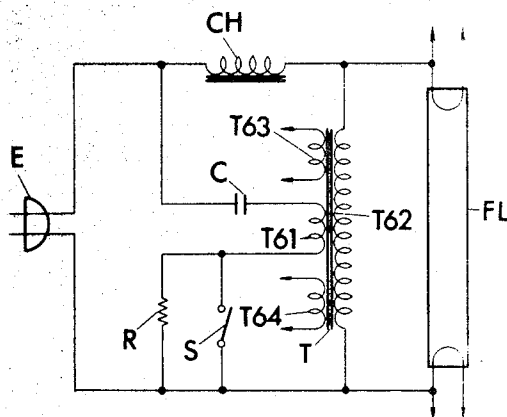


Fig. 6-B

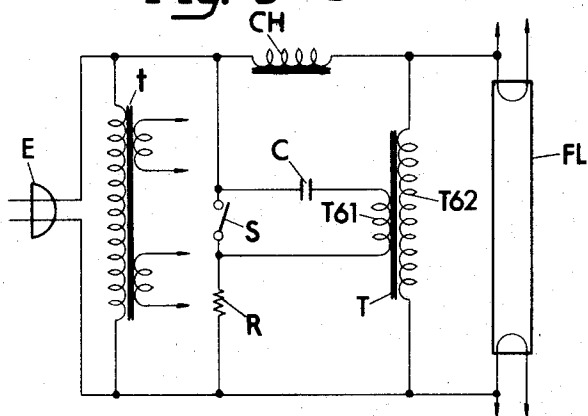
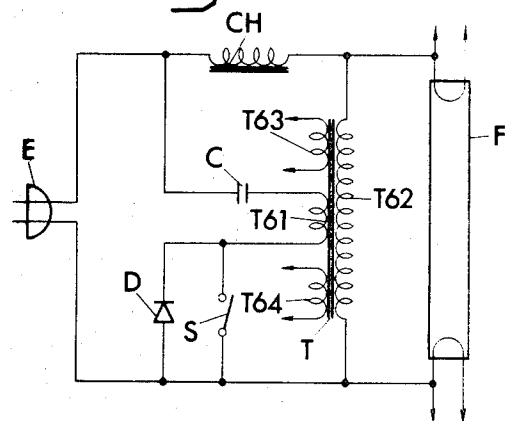


Fig. 6-D



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Fig. 6-E

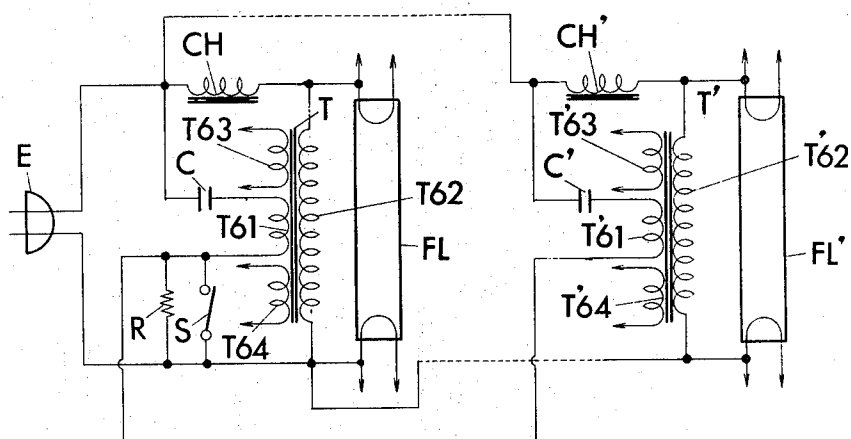
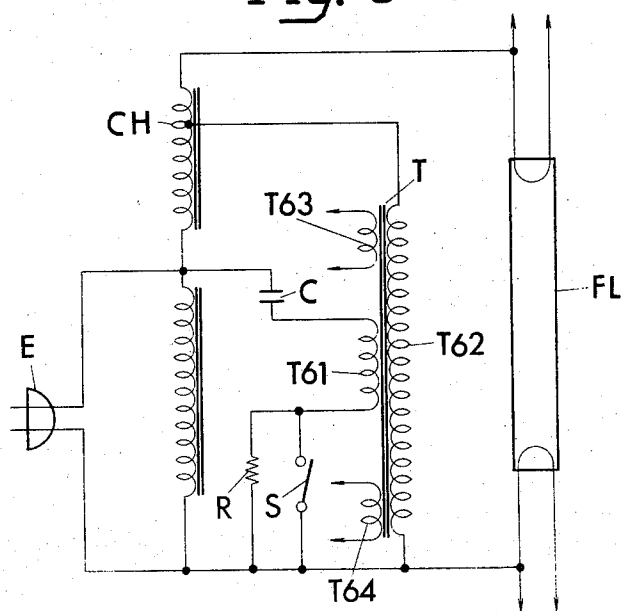
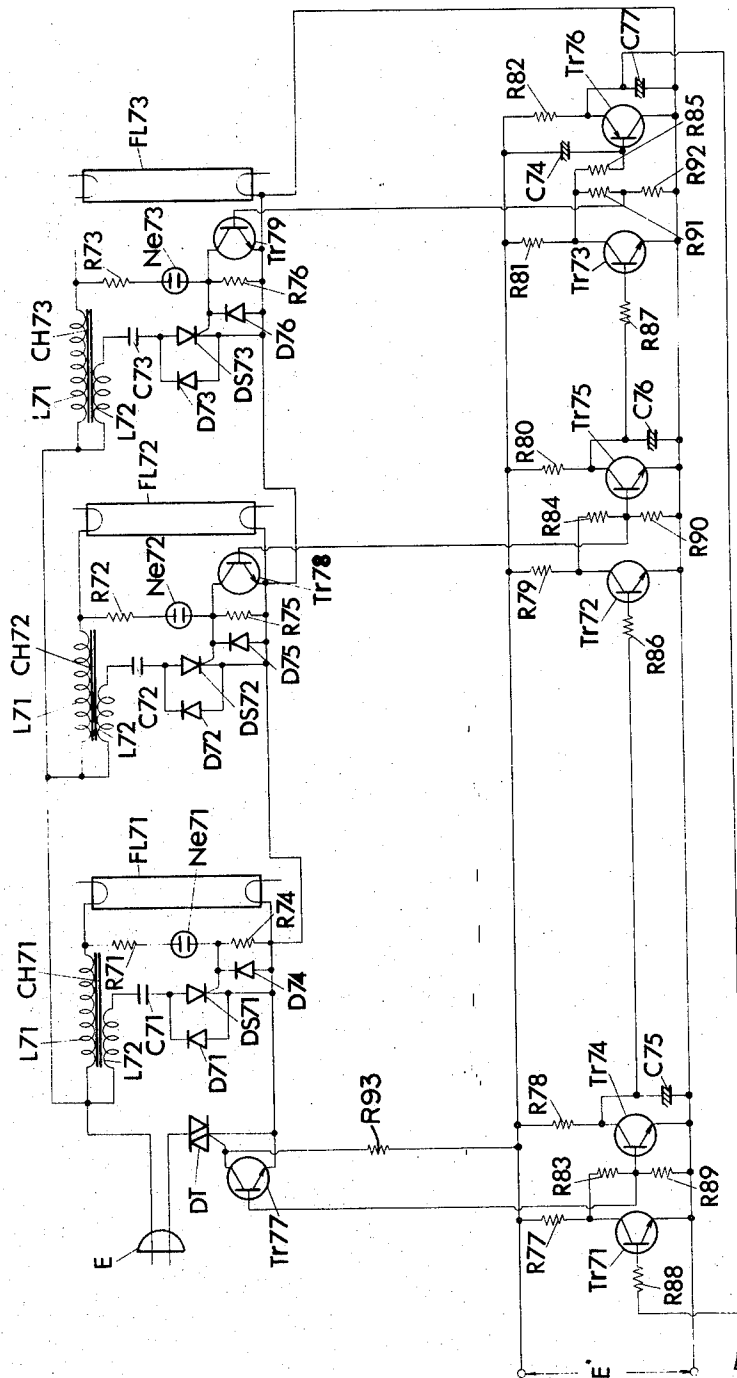


Fig. 6-F



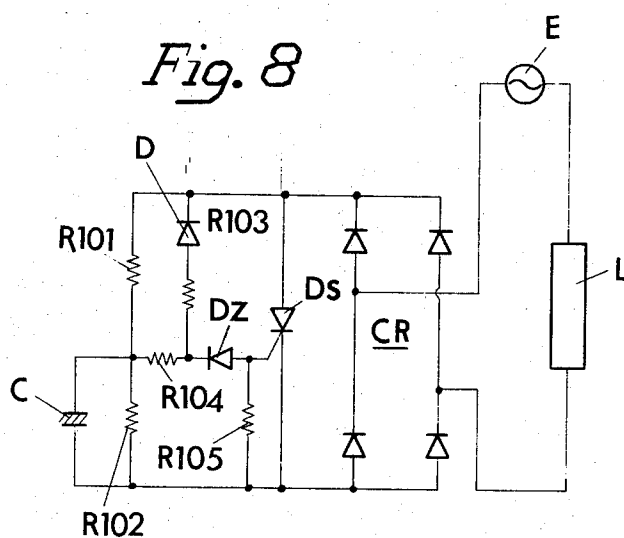
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Fig. 7



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Fig. 8



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ELECTRIC CIRCUIT FOR RAPIDLY IGNITING A DISCHARGE TUBE

This invention relates to circuit for rapidly igniting a discharge tube.

Conventionally there has been proposed various igniter circuits for a so-called rapid start type discharge tube or lamp such as fluorescent lamp, mercury-arc lamp, neon tube lamp or the like. In these conventional igniter circuits, however, there is generally used a leakage transformer having a secondary high voltage coil which is expensive. The use of such leakage transformer leads to such disadvantage that the apparatus employing a rapid start type discharge tube becomes, as a whole, much expensive.

An object of the present invention is to provide a circuit for rapidly or instantaneously igniting a discharge tube, which employs no leakage transformer and is simple in structure, leading to the considerable reduction of cost.

Another object of the present invention is to provide an igniter circuit for a discharge tube, which is provided with a pre-heater unit, that is, another circuit for preliminarily heating the electrodes of a discharge tube thereby to enable the discharge tube to be ignited in substantially simultaneity with the closure of electric power source, consequently being capable of effecting the ignition more rapidly than the conventional igniter circuit employing a leakage transformer.

Another object of the present invention is to provide an igniter circuit for a discharge tube, which repeatedly produces high voltage pulse of the same number with that of the frequency of power source until a discharge tube such as a fluorescent lamp or the like is ignited, thereby enabling the discharge tube to be discharged by the action of the subsequent high voltage pulse and consequently ignited even if the first discharge lamp fails to effect the ignition.

Another object of the present invention is to provide an igniter circuit for a discharge tube which, after the discharge tube has once been ignited, can continue to effect the ignition by the action of a conventional stabilizer, independently of a high voltage pulse producing circuit.

Another object of the present invention is to provide an igniter circuit which ignites a plurality of discharge tubes or lamps simultaneously.

Another object of the present invention is to provide an igniter circuit which ignites a plurality of discharge tubes with such certainty that even if one of said discharge tubes is in trouble the remaining discharge tubes can be ignited without any disorder.

Another object of the present invention is to provide an electric circuit for igniting discharge lamps which ensures the igniting operation; is made at low cost since a transformer for heating filaments is not used, and is compact and light in weight.

Another object of the present invention is to provide a discharge lamp igniting circuit in which a ballast choking coil and a secondary coil of a transformer are connected in series, and as a voltage to be applied to a discharge lamp, high voltage pulses generated on the ballast choking coil and the secondary coil of the transformer are used so that the resultant higher voltage can be applied to the discharge lamp, thereby rendering the ignition of the discharge lamp more certain.

Another object of the present invention is to provide a discharge lamp igniting circuit in which a diode is connected so as to generate high voltage pulse at every cycle of AC waveform, whereby larger electric current flows through a transformer when pulse is generated, thereby enabling the ignition of the discharge lamp to be more certain.

Another object of the present invention is to provide a discharge lamp igniting circuit in which a tertiary coil and a biquadratic coil for heating a filament are provided in a transformer so that a pulse voltage proportional to a pulse voltage of a primary coil is induced on the tertiary and biquadratic coils and an end-arc is generated at the electrode of a discharge lamp, thereby enabling the ignition of the discharge lamp to be more certain.

Another object of the present invention is to provide a discharge lamp igniting circuit in which a power required for preheating a filament is automatically reduced after the discharge lamp has once been ignited thereby rendering the life remarkably long, as compared with the conventional discharge lamps having a continually heating unit.

Another object of the present invention is to provide an electric circuit for sequentially igniting a fluorescent lamp most suitable to the advertisement etc. due to the fact that the fluorescent lamp is ignited simultaneously with the application of the power supply and also the fluorescent lamps can be sequentially turned on and are simultaneously turned off.

Another object of the present invention is to provide an electric circuit for igniting an AC load in which a diode is connected to a capacitor of time constant circuit to retain a holding current of SCR, and the capacitor discharges while the holding current is retained, so that the load can be kept as it is energized for a relatively prolonged period of time, and this makes energization of load distinguish from deenergization thereof.

The essential feature of the present invention consists in a circuit for rapidly and certainly igniting a discharge tube or lamp such as a fluorescent lamp, mercury-arc lamp, neon tube lamp or the like, which comprises a capacitor adapted to effect charge or discharge thereof at substantially the peak of AC wave of power source by the action of a switching means, a transformer or ballast choke coil which is adapted to produce high voltage pulse in response to said charge or discharge of the capacitor, said high voltage pulse being applied to a discharge tube at its electrodes which are preliminarily heated thereby to ignite the discharge tube.

It should particularly be noted that various embodiments including changes, omissions, additions, substitutions and/or other modifications may be made without departing from the scope of the invention. This invention itself, both as to its organization and manner of operation, together with further objects and advantages thereof, may be best understood by reference to the following description taken in connection with the accompanying drawings in which:

FIG. 1-A is a circuit diagram showing the principle of inducing a high voltage according to the present invention;

FIG. 1-B is a circuit diagram showing an embodiment of the present invention;

FIG. 2 is a circuit diagram showing another embodiment of the present invention;

FIG. 3 is a circuit diagram showing another embodiment;

FIG. 4-A is a circuit diagram showing another embodiment of the present invention;

FIG. 4-B is a circuit diagram showing another embodiment wherein the similar circuit to that of FIG. 4-A is used for igniting a plurality of discharge lamps;

FIG. 4-C a_1 , b_1 , and c_1 represent a series of waveforms useful in explaining the operations of the embodiments shown in FIGS. 4-A and 4-B, respectively;

FIG. 5-A and FIG. 5-B are circuit diagrams showing further embodiments of the present invention;

FIG. 5-C and FIG. 5-D represent a series of waveforms useful in explaining the operations of the embodiments shown in FIG. 5-A and FIG. 5-B, respectively;

FIG. 5-E and FIG. 5-F are circuit diagrams showing further embodiments of the present invention;

FIG. 5-G and FIG. 5-H represent a series of waveforms useful in explaining the operations of the embodiments shown in FIG. 5-E and FIG. 5-F, respectively;

FIG. 6-A and 6-B are circuit diagrams showing the principles of further embodiments of this invention;

FIG. 6-C, FIG. 6-D, FIG. 6-E and FIG. 6-F are circuit diagrams of the embodiments realizing the principles shown in FIG. 6-A and FIG. 6-B;

FIG. 7 is a diagram of a circuit for sequentially igniting a fluorescent lamp, in which a discharge tube igniting circuit embodying this invention is employed; and

FIG. 8 is a diagram of a circuit for igniting an AC load, in which a discharge tube igniting circuit embodying this invention is employed.

Corresponding reference characters indicate corresponding parts throughout the figures of the drawings.

Referring now to FIG. 1-A, characters E and S designate a DC power source and a switch connected thereto in parallel, respectively. Character F indicates a discharge tube or lamp, for example, fluorescent lamp. A ballast choke coil L is connected between the positive electrode of the DC power source E and the switch S. In such circuit, when the filament of the lamp F is preliminarily heated and then the switch S is opened, the choke coil L will immediately produce a high electric voltage, thereby enabling the lamp F to be ignited. This principle is realized in the present invention as follows: a silicon controlled rectifier element Ds is employed for the switch S, which performs the same operation as the switch S in interrupting the gate current.

Referring now to FIG. 1-B, there is shown an embodiment of this invention. There is provided an ignition starting circuit for a discharge lamp such as fluorescent lamp, which comprises an initial stage SCR which is adapted to be turned on during a positive half cycle thereby to render a transistor conductive, a subsequent stage SCR adapted to be turned off by the interruption of the gate current, said initial stage SCR and said subsequent stage SCR being connected in parallel between the discharge lamp and AC power source, said interruption being caused by an inverse voltage which is applied between an anode and a cathode by the turn-on of said initial stage SCR, and a ballast choke coil adapted to apply a high-voltage counter electromotive force between the lamp and an electrode by the turnoff of said subsequent stage SCR and to effect a discharge, and connected in series between the lamp and the AC power source.

Characters E and T designate an AC power source and a transformer to pre-heat the filament of a discharge lamp F such as a fluorescent lamp, respectively. The primary side of said transformer is connected in parallel to said power source E, whereas the secondary side of said transformer is connected to the filament of the lamp F.

One terminal of the ballast choke L is connected to the primary side of the transformer T and the other terminal to the filament of the lamp F. To the junction point of the choke L and the filament of the lamp F, one terminal of each resistor R_{11} , R_{14} , R_{15} and R_{17} is connected. To the other terminal of the resistor r_{11} , a resistor R_{12} , of which the one terminal is connected to an electrode of the power source E, and a Zener diode DZ_{11} are connected. To the other terminal of the resistor R_{14} , the anode of the silicon controlled rectifier element DS_{11} (hereinafter referred to merely as SCR) and the capacitor C are connected. Furthermore, to the other terminal of the resistor R_{15} are connected the resistor R_{16} one terminal of which is connected to an electrode of the power source E, the collector of a transistor Tr and a Zener diode DZ_{12} . To the other terminal of the resistor R_{17} are connected the anode of SCR (DS_{12}) and the other terminal of said capacitor C.

The cathode of said SCR (DS_{11}) is connected to an electrode of the power source E, and the gate thereof is connected to the Zener diode (DZ_{11}) and the resistor R_{13} one terminal of which is connected to an electrode of the power source and the base of the transistor Tr. The emitter of the transistor Tr is connected to an electrode of the power source E.

The cathode of another SCR DS_{12} is connected to one electrode of the power source E and the gate thereof, is connected to the resistor R_{18} one terminal of which is connected to one electrode of the power source E and to the Zener diode DZ_{12} .

In operation, the filament of the lamp F is preheated by the transformer T. Taking the voltages of the Zener diode DZ_{11} and the Zener diode DZ_{12} as VDZ_{11} and VDZ_{12} , respectively and setting $VDZ_{11} > VDZ_{12}$, SCR (DS_{12}) is ignited, prior to DS_{11} during the positive half cycle at its portion corresponding to a small degree of angle. Since at this time SCR (DS_{11}) remains turned off, the capacitor C is charged positively on

the anode side of this SCR (DS_{11}) and negatively on the anode side of SCR (DS_{12}). When the terminal voltage of the resistor R_{12} reaches the Zener voltage VDZ_{11} of the Zener diode DZ_{11} , SCR (DS_{11}) is ignited during the positive half cycle at its portion corresponding to a larger angle than the other SCR (DS_{12}) and turned on. When this SCR (DS_{11}) is rendered conductive, the terminal (the anode side of SCR (DS_{11})) of the capacitor C which has been charged positively is immediately connected to the cathode side of SCR (DS_{12}). Between the anode and cathode of SCR (DS_{12}) is applied the inverse voltage of the capacitor C to turn off said SCR (DS_{12}). However, even when the inverse voltage of the capacitor C is applied to this SCR (DS_{12}) to turn off it, current flows to the gate during the whole range of the positive half cycle and said SCR (DS_{12}) is immediately turned on after once being turned off, which is undesirable. For this reason, the transistor Tr is provided to interrupt the gate current of SCR (DS_{12}) immediately on SCR (DS_{11}) being turned on. That is, simultaneously with the turn-on of SCR (DS_{11}) the Zener current of the Zener diode DZ_{11} flows through the base of the transistor Tr, which renders the transistor conductive and makes the potential of the gate of SCR (DS_{12}) equivalent to that of the cathode potential thereby to interrupt the gate current.

Thus, on SCR (DS_{12}) turned off, the current defined by the resistor R_{17} which has been flowed through the ballast choke L, immediately stops to flow. Accordingly, on the ballast choke is generated a counter electromotive force, which is then applied to the terminals of the lamp F to induce discharge and begin normal discharge. At this instance, however, if the filament of the lamp F has been not heated sufficiently, discharge is not carried out. Yet, as the high voltage is continuously generated during the positive half cycle while discharge is not carried out, discharge consequently comes to start as the filament becomes heated.

Once discharge begins, the voltage of the terminals of the lamp F is reduced to a discharge maintaining voltage of several tens volts. Because the circuit is so designed that the gates of SCR (DS_{11}) and (DS_{12}) do not operate below the discharge maintaining voltage, said SCR (DS_{11}) and (DS_{12}) remain turned off. Hence, this electronic circuit is brought into the condition separated from the lamp F. The ballast choke L merely operates to stabilize the lamp F.

As described, above, in this embodiment, at the same time a power source is closed, a high voltage is generated at substantially the peak of a positive half cycle of alternating current by the operation of an electronic circuit and the function of a ballast choke and if a lamp such as a fluorescent lamp has been preheated, discharge is carried out and the lamp is ignited as soon as a power source is closed. Accordingly, if this embodied circuit is utilized, for instance, for a flashing circuit of advertisement, the same function as that of an ordinary incandescent lamp can be obtained. After the lamp has been ignited, only the ballast choke operates as a stabilizer and the electronic circuit is not operated, thereby lengthening the life of said electronic circuit and achieving the intended object as well.

Referring now to FIG. 2 showing another embodiment of this invention, there is provided an electric circuit for producing pulse for igniting a fluorescent lamp comprising a ballast choke coil having a secondary coil; a capacitor; a thyristor and a neon tube lamp; said ballast choke coil and capacitor producing a high-voltage pulse at substantially the peak of positive half cycle of power source voltage in cooperation with said thyristor and neon tube thereby to discharge the fluorescent lamp, and said fluorescent lamp being kept as it is ignited by said ballast choke coil only.

In FIG. 2, reference E is an AC power source; T is a transformer for preheating a fluorescent lamp which is connected in parallel to said AC power source E and has the secondary side, terminals of which are connected to filaments of fluorescent lamp FL. One terminal of said fluorescent lamp FL is connected to one terminal of power source E and the other terminal thereof is connected to the other terminal of

power source E through the primary coil L_{21} of ballast choke coil CH. One terminal of secondary coil L_{22} of said ballast choke coil CH is connected to the other terminal of power source E and the other terminal thereof is connected to one terminal of power source through a capacitor C, resistor R_{21} and thyristor Ds in series connection. A diode D_{21} is connected to said thyristor Ds.

A resistor R_{22} , a neon tube lamp Ne, a diode D_{22} and a resistor R_{23} in series connection with each other are connected in parallel to said fluorescent lamp. A gate of thyristor Ds is connected to a junction point of diode D_{22} with the resistor R_{23} .

The thus connected electric circuit operates as follows.

The filaments of fluorescent lamp FL is preheated by the transformer. When the voltage of negative half cycle is applied by the power source E, the voltage is charged to the capacitor C, so that said capacitor bears the positive electrode at the side near to the resistor R_{21} , and the negative electrode at the side near to the secondary side of the ballast choke coil CH. The discharge current does not flow to the neon tube lamp Ne at the negative half cycle owing to the diode D_{22} connected thereto in the backward direction. Accordingly, the neon tube lamp is not yet ignited. The thyristor Ds is left as it is turned off, since the inverse voltage is applied to the thyristor Ds.

Subsequently, when the voltage of positive half cycle is applied to the capacitor and the voltage of said capacitor is raised to the voltage at which discharge of the neon tube lamp will start, the discharge current flows to said neon tube lamp, whereupon current flows to the gate of thyristor Ds to turn on said thyristor. Accordingly, the thyristor Ds is turned on at substantially the peak of positive half cycle, hence the appropriate oscillating voltage generates at both terminals of secondary coil L_{22} with the aid of the secondary coil L_{22} of ballast choke CH, the capacitor C and resistance of said secondary coil L_{22} . Said pulse oscillating voltage is more raised by the primary coil L_2 of ballast choke coil CH to produce the high-voltage pulse. Said HIGH-voltage pulse is impressed to the fluorescent lamp FL to excite the local discharge, and subsequently, normal discharge. Normally, the high-voltage pulse must be synchronized with the power source where the normal discharging is kept on, but in the present embodiment, the thyristor Ds is caused to trigger by utilizing the neon tube lamp Ne of which the discharge starting voltage is comparatively high.

Thus, the normal discharge is started, and the voltage at both terminals of fluorescent lamp FL drops below the discharge starting voltage of neon tube lamp Ne, so that the neon tube lamp Ne does not discharge at the subsequent positive half cycle and accordingly, current does not flow to the gate of thyristor Ds, hence said thyristor is kept as it is turned off. That is to say, the high-voltage pulse produced at the primary coil of ballast choke coil CH causes the fluorescent lamp FL to trigger to be ignited, and thereafter, the trigger circuit is separated from the main circuit.

As set forth in the foregoing, in the electric circuit of this embodiment, if the filaments of fluorescent lamp is preheated, the capacitor is charged at the negative half cycle in the waveform while the neon tube lamp discharges at the positive half cycle to turn on the thyristor at substantially the peak of said positive half cycle; the pulse oscillating voltage is produced with the aid of the secondary coil of ballast choke coil, said capacitor and resistance of said secondary coil; and the pulse voltage is further raised by the primary coil of choke coil, whereupon the fluorescent lamp starts discharging. Thus, the fluorescent lamp discharges immediately when the power source is closed. Accordingly, it is advantageous that in using the electric circuit as an igniting circuit in an advertising device, the fluorescent lamp which has been never applicable can be ignited likely to an incandescent lamp. The electric circuit has other advantages that the durability is greatly improved, since only the ballast choke is kept in operation as a stable unit after ignition of the lamp, while the trigger circuit becomes inoperative; and the circuit is manufactured at low cost and compact due to the simplicity in structure.

Referring now to FIG. 3, there is shown a further embodiment of this invention. This embodiment is an electric circuit for igniting a plurality of discharge lamps which comprises an electric circuit including a plurality of discharge lamps connected in parallel to a power source through respective ballast choke coils, and a capacitor adapted to be charged at a negative half cycle of power source voltage through a diode and discharge as well as be inversely charged by a semi-conductor controlled rectifier element such as a thyristor when said controlled rectifier element is turned on, thereby producing a high voltage pulse at an oscillation producing coil; and neon tube lamps connected between a gate of said controlled rectifier element and each of ballast choke coils causing said controlled rectifier element to turn on at substantially the peak of the positive half cycle; said ballast choke coils raising voltage of said high-voltage pulse to ignite respective discharge lamps.

Reference E is an AC power source; FL_{31} , FL_{32} and FL_{33} are discharge lamps such as a fluorescent lamp each of which has filaments connected at one terminal of one electrode thereof to one terminal of power source E and connected at one terminal of the other electrode to the other electrode of power source E through each of ballast choke coils CH_{31} , CH_{32} and CH_{33} . Reference T is a transformer for preheating filaments FL_{31} , FL_{32} and FL_{33} , which has a primary coil T_{31} connected to the power source E and secondary coils. One of secondary coils T_{32a} is connected to one electrode of each of filaments FL_{31} , FL_{32} and FL_{33} , and the other secondary coils T_{32b} , T_{32c} , and T_{32d} are connected to each of the other terminals of said filaments.

L is a coil for generating oscillation one terminal of which is connected to one electrode of power source at the side connected to the ballast choke coil CH_{31} , and the other terminal of which is connected to the other electrode of power source E through a capacitor C and thyristor Ds in series connection. The oscillation producing coil L and ballast choke coil CH_{31} - CH_{33} in combination constitute a transformer. A diode D_{31} is in the backward direction connected in parallel to the thyristor Ds. Between a gate of thyristor Ds and one electrode of the power source E, a resistor R_{31} and diode D_{32} are connected. The diode D_{32} is disposed for protecting the thyristor Ds.

The resistor R_{32} and neon tube lamp Ne_{31} , the resistor R_{33} and neon tube lamp Ne_{32} , and the resistor R_{34} and neon tube lamp Ne_{33} respectively in series connection are connected to a junction point of ballast choke coils CH_{31} - CH_{33} with filaments of discharge lamps FL_{31} - FL_{33} . The other terminal of respective neon tube lamps Ne_{31} , Ne_{32} or Ne_{33} is connected to the gate of thyristor Ds.

The operation of the thus connected circuit is as follows.

The discharge lamps FL_{31} - FL_{33} are preheated by the transformer for preheating T. When the negative half cycle of power source voltage is applied, the capacitor C is charged 30 through the diode D_{31} , positively at the side near to the thyristor Ds and negatively at the side near to the oscillation producing coil L. The capacitor C does not discharge if charging to said capacitor C completes and the time of discharging comes, since the thyristor Ds is left as it is turned off and the diode D_{31} is connected in the backward direction. At this time, the neon tube lamps Ne_{31} - Ne_{33} discharge at substantially the peak of the negative half cycle, but the thyristor Ds is kept as it is turned off since the positive current is not yet fed.

Subsequently, when the voltage of positive half cycle is applied and the voltage is raised to the voltage at which the neon tube lamps Ne_{31} - Ne_{33} start discharging, the discharging current flows to said neon tube lamps Ne_{31} - Ne_{33} , so that current flows to the gate of thyristor Ds to turn on said thyristor. Accordingly, the thyristor Ds is turned on at substantially the peak of the positive half cycle, and an appropriate oscillation voltage is produced at both terminals of oscillation producing coil L with the aid of the capacitor C, ballast choke coils CH_{31} - CH_{33} , and resistance of said ballast choke coils CH_{31} - CH_{33} . By this time, charging to the capacitor C is effected through the side near to the thyristor Ds, hence a high-voltage pulse oscillation voltage is produced at the oscillation producing

coil L by the discharging current of the capacitor which starts discharging at the same time when said thyristor Ds is turned on and the charging current flowing to the capacitor C through the positive side near to said oscillation producing coil L. Said pulse oscillating voltage is further raised by the ballast choke coils CH₃₁ - CH₃₃ to produce a high-voltage pulse. Said high-voltage pulse is impressed on the discharge lamps FL₃₁ - FL₃₃ to excite a local discharge, which is followed by the normal discharge. The high-voltage pulse must be synchronized with the power source voltage which maintains the discharge lamps in the normal discharging, and in this embodiment, the neon tube lamps Ne₃₁ - Ne₃₃ of which the discharge starting voltage is comparatively high are utilized to make the thyristor Ds trigger.

As soon as the discharge lamps FL₃₁ - FL₃₃ begin to effect the normal discharge, the voltage at both terminals of discharge lamps FL₃₁ - FL₃₃ drops below the voltage at which the neon tube lamps Ne₃₁ - Ne₃₃ will start discharging, hence the neon tube lamps Ne₃₁ - Ne₃₃ do not discharge at the subsequently the subsequent positive half cycle of power source voltage. Accordingly, current does not flow to the gate of thyristor Ds, so that the thyristor is left as it is turned off. In other words, the high-voltage pulse produced by the ballast choke coils CH₃₁ - CH₃₃ causes the discharge lamps FL₃₁ - FL₃₃ to trigger, and thereafter, the trigger circuit is automatically separated from the main circuit.

Thus, all of discharge lamps FL₃₁ - FL₃₃ are simultaneously ignited. In case one or more of plural discharge lamps fails to be ignited, any of neon tube lamps connected to the discharge lamp which remains not ignited is ignited at the subsequent positive half cycle. Consequently, the thyristor Ds is turned on by the circuit operation as set forth in the foregoing, and said discharge lamp is ignited with high-voltage pulse oscillating voltage.

In the the electric circuit of this embodiment, the ballast choke coils CH₃₁ - CH₃₃ and the oscillation producing coil L are combined into a unitary transformer, and alternatively the oscillation producing coil may be connected to each of ballast choke coils. In this embodiment, three discharge lamps are connected, and the number of discharge lamps may be increased according to necessity, with increase in the number of neon tube lamps and ballast choke coils.

As described herein above, the electric circuit of this embodiment is so adapted that filaments of discharge lamps such as a fluorescent lamp are preheated; the capacitor is charged at the negative half cycle of power source through the diode; and the neon tube lamps discharge at the positive half cycle to turn on the semiconductor controlled rectifier element such as thyristor, so that the high-voltage pulse is produced at the oscillation producing coil, thereby igniting the discharge lamps through the ballast choke coils. The thus connected electric circuit has such advantages that its application is versatile, for example, it is useful as a flashing circuit for advertising purpose, since all discharge lamps are simultaneously ignited instantly when the power source is closed; the ignition operation is ensured since charging to the capacitor at the negative half cycle is effected through the diode, transfer of electric charge in said capacitor is increased which takes place synchronously when the semiconductor controlled rectifier element is turned on, hence the signal of high-voltage pulse is applied sufficiently to ignite discharge lamps; the circuit is economical since ignition of a plurality of discharge lamps is effected by a single trigger pulse including a controlled rectifier element; and the durability of circuit is greatly prolonged, since the ballast choke coils serve as a stable element after the ignition of discharge lamps, while the trigger circuit becomes inoperative.

Referring now to FIGS. 4-A, 4-B and 4-C, there are illustrated further embodiments of this invention. There are shown:

An electric circuit for igniting a discharge lamp which comprises an electric circuit for preheating filaments including a controlled rectifier element such as a thyristor adapted to turn

on at substantially the peak of positive half cycle of a power source voltage and connected between filaments of said discharge lamp; and a high-voltage pulse generating circuit consisting of a capacitor and transformer connected in common to said controlled rectifier element; said filaments of discharge lamp being preheated through the controlled rectifier element adapted to turn on at substantially the peak of positive half cycle, said capacitor being charged at the negative half cycle of power source voltage and inversely rapidly charged at substantially the peak of the positive half cycle, whereupon said charging current produces an oscillating pulse at a primary side of transformer, said pulse is raised to excite a high-voltage oscillating pulse at a secondary side thereof, and the high-voltage oscillating pulse of the negative direction is impressed on said filaments, thereby igniting the discharge lamp; and

An electric circuit for igniting a plurality of discharge lamps which comprises a filament preheating circuit connected to filaments of a plurality of discharge lamps and adapted to preheat the respective filaments through said controlled rectifier circuit; and a high-voltage pulse generating circuit including a capacitor and transformer connected in common to said controlled rectifier circuit; said filament preheating electric circuit including a controlled rectifier element connected between respective filaments of discharge lamps and adapted to turn on at substantially the peak of positive half cycle of an AC power source and a gate current controlling circuit including neon lamps and connected to the respective filaments, said gate current controlling circuit feeding current to a gate of said controlled rectifier element to turn on said controlled rectifier element; said capacitor being charged at the negative half cycle of power source voltage and inversely rapidly charged at substantially the peak of the positive half cycle, whereupon said charging current produces an oscillating pulse at a primary side of transformer, and said pulse is raised to excite a high-voltage oscillating pulse at a secondary side thereof, and the high-voltage oscillating pulse of the negative direction is impressed on said filaments, thereby igniting said plurality of discharge lamps.

In FIG. 4-A, reference E is a 100 or 200V. AC power source; CH is a ballast choke coil, one terminal of which is connected to said power source E; C₄₁ is a capacitor for noise regulation which is connected to one polarity of power source E and the other terminal of said choke coil CH; FL is a discharge lamp such as a fluorescent lamp having filaments F₄₁ and F₄₂ each of which is connected at one terminal to the power source E. If a discharge lamp of 32W or below is used, the discharge lamp is connected to the 100V power source, while if a discharge lamp of 40W and more is used, the discharge lamp is connected to the 200V power source E. T is a transformer having a secondary coil T₄₂ one terminal of which is connected to a filament F₄₁ of discharge lamp FL through a capacitor C₄₂ and the other terminal of which is connected to the filament F₄₂ of discharge lamp FL, and a primary coil T₄₁ one terminal of which is connected to the power source E at the side near to choke coil and the other terminal of which is connected to a capacitor C₄₃. The other terminal of capacitor C₄₃ is connected to the anode of semiconductor controlled rectifier element Ds such as a thyristor through a diode D₄₁ in the forward direction and to the filament F₄₂ of discharge lamp FL through a diode D₄₂ in the backward direction. The anode of controlled rectifier element Ds is connected to the filament F₄₁ of discharge lamp FL through a diode D₄₃, and the cathode thereof is connected to the filament F₄₂ of discharge lamp FL. A gate of said SCR is connected to a connection point of a resistor R₄₃ having one terminal connected to the filament F₄₂ and a neon tube lamp Ne having one terminal connected to the filament F₄₁ of discharge lamp FL through resistors R₄₁ and R₄₂. R₄₄ is a resistor one terminal of which is connected to a connection point between the resistors R₄₁ and R₄₂ and the other terminal of which is connected to the filament F₄₂.

The electric circuit having such electric connection operates as follows.

If the power source E is closed, preheating current flows to the filaments F_{41} and F_{42} of discharge lamp FL through the diode D_{43} only when the controlled rectifier element Ds is turned on. When the positive half cycle of power source voltage is applied to said controlled rectifier element Ds and the voltage thereof is raised to the voltage at which the neon tube lamp Ne starts discharging, discharge current flows to said neon tube lamp Ne, so that current flows to the gate of rectifier element to turn on said rectifier element Ds. The neon tube lamp Ne used in this circuit is of the type which discharges at substantially the peak of positive half cycle, and therefore the controlled rectifier element Ds is turned on at substantially the peak of positive half cycle.

Now the explanation will be made on the case where the filaments F_{41} and F_{42} of discharge lamp FL are sufficiently preheated with current determined by the choke coil CH, diode D_{43} and controlled rectifier element Ds. The capacitor C_{43} is charged negatively at the negative half cycle through the diode D_{42} , and said negative voltage is retained until the controlled rectifier element Ds is turned on at substantially the peak of positive half cycle. This is shown in FIG. 4 - C, a_4 . When the controlled rectifier element Ds is turned on, the capacitor C_{43} is rapidly charged to the substantially the peak of positive half cycle through the diode D_{41} , so that the extremely large amplitude of discharging current flows to the primary side T_{41} of transformer T, thus the electromotive force generates as shown in FIG. 4 - C, b_4 . This produces a high-voltage oscillating pulse at the secondary side T_{42} of transformer T. Said high-voltage oscillating pulse has a phase which is inverted by 180° at a phase angle with respect to that of the high-voltage oscillating pulse generated at the primary side T_{41} thereof. Said high-voltage oscillating pulse voltage as seen in FIG. 4-C, c_4 is impressed on filaments F_{41} and F_{42} of fluorescent lamp FL through the capacitor C_{42} . The negative high-voltage pulse is impressed between filaments F_{41} and F_{42} synchronously at substantially the peak of positive half cycle of the power source voltage. The filaments F_{41} and F_{42} are cut off in relation to pulse of the positive direction at the positive half cycle, but not cut off in relation to the negative pulse of the negative direction, hence the negative pulse is impressed on filaments F_{41} and F_{42} to excite a local discharge. Since the filaments F_{41} and F_{42} are already preheated to a certain degree, the local discharge is accelerated to cause these filaments to normally discharge, thereby igniting the discharge lamp. Reference D_{43} is a diode for separating the preheating circuit from the high-voltage generating circuit.

When the discharge lamp FL is ignited, the voltage at both terminals of said discharge lamp FL drops to the discharge retaining voltage, so that the neon tube lamp Ne stops discharging, and therefore, the controlled rectifier element Ds is left as it is turned off. Accordingly, the operation of the preheating circuit and high-voltage generating circuit are caused to stop. Thus, the trigger circuit shown with the one-dotted line in FIG. 4-A becomes independent of the electric circuit including a discharge lamp.

The electric circuit as shown in FIG. 4-A is used either to ignite a discharge lamp FL of 6W, 15W, 20W, 30W or 32W with respect to the 100V power source, or to ignite a discharge lamp of more than 40W in relation to the 200V power source. In the meantime, in order to ignite a more than 40W discharge lamp using the 100V power source, a leakage transformer is connected in parallel to the power source, so that the discharge lamp can be ignited in the same way as set forth in the foregoing example.

FIG. 4-B shows an electric circuit for igniting a plurality of discharge lamp. In this example, two discharge lamps are connected. Said electric circuit of FIG. 4-B comprises an additional electric circuit including a discharge lamp FL', a ballast choke coil CH', a capacitor for noise regulation C_{41}' , a capacitor C_{42}' connected between a filament F_{41}' of discharge lamp FL' and secondary side T_{42} of transformer T, a diode D_{43}' connected between a filament F_{41}' of discharge lamp FL' and the anode of controlled rectifier circuit Ds, resistors $R_{41}' - R_{44}'$ and a neon tube lamp Ne', said another circuit being con-

nected in parallel to said electric circuit of one lamp type as shown in FIG. 4-A. Diodes D_{44} and D_{44}' are connected to prevent the gate circuits of neon tube lamps Ne, Ne' from being interacted with each other.

The operation is as follows.

Likely to said electric circuit of one lamp type, the preheating current flows to the filaments F_{41} , F_{42} and F_{41}' , F_{42}' of the respective discharge lamps FL and FL' through the controlled rectifier element Ds which is turned on by neon tube lamps Ne and Ne' discharging at substantially the peak of positive half cycle, thereby preheating said filaments. With the charging current rapidly flowing to the capacitor C_{43} , an oscillating pulse voltage is produced at the primary coil which is proportional to a differential value of charging current. Said pulse voltage is inverted to the secondary coil and raised to excite a high-voltage oscillating pulse of high frequency. Said high-voltage oscillating pulse is impressed on the discharge lamps FL and FL' through the capacitors C_{42} and C_{42}' , thereby igniting the discharge lamps.

In the above embodiment, the discharge lamps FL and FL' of 6, 10, 15, 20, 30 or 32W are connected to the 100V power source, and the more than 40W discharge lamps FL and FL' are connected to the 200V power source. In order to connect more than 40W discharge lamps to the 100V power source, a leakage transformer is connected to each of discharge lamps FL and FL', so that said discharge lamps can be ignited.

The two-lamp type of electric circuit is exemplified, and needless to say, the number of discharge lamps may be increased according to application, with increase in the number of additional circuits connected thereto.

As set forth in the foregoing, the electric circuit of this embodiment is so adapted that the filaments of discharge lamp is preheated through a controlled rectifier element such as a thyristor, and a negative oscillating pulse is impressed on said filaments at substantially the peak of positive half cycle of the AC power source by the circuit consisting of the capacitor and transformer connected in common to said controlled rectifier element and providing a high voltage pulse, thereby igniting the discharge lamps. Hence, the electric circuit has such advantages that ignition of any type of discharge lamp, either a normal discharge lamp or a rapid-starting type of discharge lamp, can be positively and rapidly effected; and, that if plural discharge lamps are connected to said circuit, the respective discharge lamps can be exactly ignited independently of other lamps, since these lamps are connected in parallel.

Referring now to FIGS. 5 - A, 5 - B, 5 - C, 5 - D, 5 - E, 5 - F, 5 - G and 5 - H, there are illustrated further embodiments of the present invention. These embodiments are:

a discharge lamp igniting circuit which is characterized in that a discharge lamp and a secondary coil of a transformer is connected in parallel to AC power source through the medium of a ballast choke coil, a circuit in which a primary coil of said transformer, a capacitor and a resistor are connected in series, is connected in parallel to AC power source, a switch which operates at substantially the peak of both positive and negative half cycles of a power source voltage is connected in relation to a circuit including said primary coil of the transformer, said capacitor and said resistor, said secondary coil producing a high voltage pulse, utilizing transient phenomena caused by charge and discharge of said capacitor which are caused by the operation of said switch, whereupon the thus produced high voltage pulse operates as a power source to produce a counter electromotive force on the ballast choke coil and then said high voltage pulse, counter electromotive force and power source voltage are applied to the discharge lamp; and

A discharge lamp igniting circuit which is characterized in that a discharge lamp and a secondary coil of a transformer are connected in parallel to AC power source through the medium of a ballast choke coil, a circuit in which a primary coil of said transformer, a capacitor and a diode for making approximately twice a charging or discharging current of said capacitor and applying it every cycle of AC voltage are con-

nected is connected in parallel to AC power source, a switch which operates at substantially the peak of either positive or negative half cycle of power source voltage is connected in relation to a circuit including said primary coil of the transformer, capacitor and diode, said secondary coil producing a high voltage pulse, utilizing transient phenomena caused every cycle by charge and discharge of said condenser which are caused by the operation of said switch whereupon the thus produced high voltage pulse operates as a power source to produce a counter electromotive force on the ballast choke coil and then said high voltage pulse, counter electromotive force and power source voltage are applied to the discharge lamp.

In FIG. 5 - A, character E is a power source, T is a transformer, the primary coil T_{51} of which is connected in parallel to the power source E through the medium of a capacitor C and a resistor R, and the secondary coil T_{52} of which is connected in parallel to the power source E through the medium of a ballast choking coil CH. Reference character FL is a discharge lamp, such as a fluorescent lamp of which the filaments are connected at their ends to the secondary coil T_{52} of the transformer T. S is a switch connected in parallel to said resistor R and adapted to be closed at substantially the peak of both positive and negative half cycles in AC wave form. The filament (not shown) of said discharge lamp FL is connected to a filament heating transformer. With reference to FIG. 5 - C, explanation will be made on a transient phenomena caused by the charge of the circuit which includes the capacitor C, the primary coil T_{51} of the transformer T, the resistor R and the switch S synchronizing with substantially the peak of either positive or negative half cycle in AC waveform. The charging voltage of the capacitor varies, as shown in the curve *a*, depending on a time constant of the resistor R. If the switch S is closed at the time period *t* of substantially the peak of the positive half cycle in AC waveform, the resistor R is short-circuited by the switch S. Accordingly, the capacitor C is soon charged rapidly as shown in the curve *a*, hence the electric charge of the capacitor C shifts rapidly and an extremely large current curve *b* flows through the capacitor C. Since the current flows through the inductance of the primary coil T_{51} of the transformer T, counter electromotive force is generated on the primary coil T_{51} in pulses. The counter electromotive force generated on the primary coil T_{51} is boosted and induced thereby to be of high voltage pulse, which is applied to the discharge lamp FL. The high voltage pulse generated on the secondary coil T_{52} is applied to the closed loop looking toward left from the ends of the secondary coil T_{52} and consisting of the ballast choke coil, the capacitor C, the primary coil T_{51} , the resistor R or the switch S, and as a result, a transient current flows, so that counter electromotive force is generated by the inductance of the ballast choke coil CH, and then applied to the discharge lamp FL. Thus, the high voltage pulse is generated on the secondary coil T_{52} of the transformer and on the ballast choke coil CH, and the thus generated high voltage pulses are added to AC waveform to produce the voltage as shown in the curve *c*, which is then applied to the discharge lamp FL thereby to facilitate the ignition. The above explanation was made for the case the switch S is closed at substantially the peak value of the positive half cycle. Yet, in case the switch S is closed at substantially the peak of the negative half cycle or in case the positions of the capacitor C and the switch S are interchanged, also, high voltage pulse is generated.

Referring now to FIG. 5 - B, the switch S is, in the above-mentioned circuit of the transformer T through the medium of the capacitor C connected in parallel with the primary coil T_{51} . With reference to FIG. 5 - D, the explanation will be made on the circuit being charged to the condenser C by the time constant of the resistor R. If the switch S is closed at the time period *t* of substantially the peak of the positive half cycle in AC waveform, the electric charge which has been charged to the capacitor C begins to be discharged rapidly as shown in the curve *a*, through the primary coil T_{51} of the transformer T. Accordingly, the electric charge of the capacitor C shifts very

rapidly and an extremely large current (the current *b*) flows through the capacitor C. Since the current flows through the inductance of the primary coil T_{51} of the transformer, counter electromotive force is generated on said primary coil T_{51} in pulses. The counter electromotive force generated on the primary coil T_{51} is boosted and induced. The subsequent operation is the same as that of the circuit of FIG. 5 - A. Consequently, such induced high voltage pulses and the peak of AC waveform shown in the curve *c* is applied to the discharge lamp FL. In this case, the closed loop as seen toward left from the ends of the secondary coil T_{52} is formed of the ballast choke coil CH, the switch S, and the resistor R. This embodiment is concerned with the case the switch S is closed at substantially the peak of the positive half cycle in the AC waveform. Yet, even when the switch S is closed at substantially the peak of the negative half cycle, high voltage pulse is generated.

In the circuit of FIG. 5 - E, the diode D is connected in place of the resistor R in the circuit of FIG. 5 - A. The anode side of the diode D and the cathode side thereof are connected to the power source E and to the primary coil T_{51} of the transformer T, respectively. The operation will be explained hereinbelow with reference to FIG. 5 - G. If the voltage of the negative half cycle of AC waveform from the power source E is applied to the circuit, the capacitor C is charged positively on the side of the primary coil T_{51} of the transformer T and negatively on the side of the ballast choke coil CH through the diode D. The capacitor C does not start to discharge, even when the charge has been completed and the time for discharge has come. This is so because the switch is kept open and the diode D is connected inversely. Then, when the voltage of the positive half cycle is applied and the switch S is closed at the time period *t* of substantially the peak in the curve *a*, the charging current of the capacitor C which has been charged as shown in the curve *b* and the charging current to be charged negatively on the side of the ballast choke coil CH flow through the inductance of the primary coil T_{51} of the transformer T, resulting in counter electromotive force being generated on the primary coil T_{51} in pulses. Comparing this circuit with the above-described circuit of FIG. 5 - A, in the latter circuit, on closing the switch S either charging or discharging current from the capacitor C flows through the primary coil T_{51} during positive or negative half cycle of AC waveform, whereas in the circuit of FIG. 5 - G, both charging and discharging currents flow simultaneously. Accordingly, the high voltage pulse boosted and induced on the secondary coil T_{52} is twice or thrice as high as that of FIG. 5 - A. This high voltage pulse is added to the AC waveform as shown in the curve *c* and then applied to the discharge lamp FL. This embodiment is carried out by connecting the anode side of the diode D to the side of the power source E. The same result is also obtained by connecting the cathode side to the side of the power source E and by designing so that the switch S is closed at substantially the peak of the negative half cycle.

Referring to the circuit of FIG. 5 - F, the capacitor C_0 and the diode D_{51} which are connected in series are connected in parallel to the power source E and furthermore the switch S and the primary coil T_{51} of the transformer T are connected in parallel to said diode D_{51} through the medium of the diode D_{52} and the capacitor C, respectively. In the circuit, on the other hand, the secondary coil T_{52} of the transformer T is connected in parallel to the power source E through the medium of the ballast choke coil CH. The explanation of the operation will be made with reference to FIG. 5 - H. When the voltage of the positive half cycle of the AC waveform from the power source E is applied to the circuit, the capacitor C_0 is charged positively on the side of said diode D_{51} through the diode D_{51} . When the voltage of the negative half cycle is then applied, the electric charge which has been charged to the capacitor C_0 and the AC voltage are simultaneously charged to the capacitor C, so that the voltage up to about twice the voltage charged to the capacitor C_0 is charged by the time period *t*. When the switch S is closed at the time period *t*, the discharging current of the

capacitor C flows through the inductance of the primary coil T_{s1} of the transformer T as shown in the curve *b*, so that counter electromotive force generated on said primary coil T_{s1} is brought to have high voltage pulse about twice the one in the circuit of FIG. 5 - B. Then high voltage pulse as same as that of the circuit of FIG. 5 - F is obtained even if said diodes D_{s1} and D_{s2} are designed to be connected inversely and the switch S closed at substantially the peak of the positive half cycle.

It is to be noted that, according to this embodiment, charge and discharge is controlled by a switch which operates at substantially the peaks of both positive and negative half cycles in AC waveform of a power source voltage, high voltage pulse is induced by applying a charging or discharging current to a transformer and the thus induced voltage of a secondary coil of the transformer is further boosted by counter electromotive force caused by the inductance of a ballast choking coil, that the voltage adding high voltage pulse to a power source voltage is applied to a discharge lamp thereby to enable the ignition of said discharge lamp to be effected with certainty and rapidity. Moreover, it is to be noted that a diode is connected in the circuit and charge and discharge of a capacitor are carried out every cycle so that the charging and discharging currents which flow through the transformer becomes further larger, thereby enabling not only the ignition of the discharge lamp to be more certain but also the intended objects to be achieved as well.

Referring to FIGS. 6-A, 6-B, 6-C, 6-D, 6-E and 6-F, there are shown further embodiments, the essential feature of which consists in a discharge lamp igniting electric circuit wherein said electric circuit comprises a discharge lamp and a transformer connected in parallel to an AC power source through a ballast choke coil, primary coil of said transformer, a capacitor, a resistor or diode, and a switch adapted to synchronize with substantially the peak of AC, which comprises tertiary and biquadratic coils of said transformer for preheating filaments of discharge lamp which are combined into a unitary coil; a secondary coil producing a high-voltage pulse, utilizing a transient phenomena caused by charging and discharging of a capacitor, whereupon the thus produced high-voltage pulse produces a counter electromotive force at the ballast-choke coil; and said tertiary and biquadratic coil producing a pulse voltage proportional to that of the primary coil.

In FIG. 6-A showing a theoretical circuit, E is a power source, T is a transformer, the primary coil T_{s1} of which is connected in parallel to the power source E through the medium of a capacitor C and a resistor R, and the secondary coil T_{s2} of which is also connected in parallel to the power source E through a ballast choke coil CH, FL is a discharge lamp, such as fluorescent lamp, which has filaments connected at one terminal to the secondary coil T_{s2} of the transformer T, and S is a switch which is connected in parallel to said resistor R, and closed at substantially the peak of either positive or negative half cycle in AC waveform. The filaments of the said discharge lamp FL are connected to the heating transformer T connected in parallel to the power source E. Describing the transient phenomena caused by the charging to this circuit, the capacitor is charged with the voltage determined by the time constant of the resistor R. The discharge lamp FL is to be preheated by the filament heating transformer T. If the switch S is now closed at substantially the peak of the positive half cycle in AC waveform, the resistor R is short-circuited by the switch, and therefore the capacitor is rapidly inversely charged, resulting in the immediate transfer of the electric charge of the capacitor C and extremely large flow of the current through the capacitor. Since the current flows through the inductance of the primary coil T_{s1} of the transformer T, counter electromotive force by this current is generated in a pulse form on the primary coil T_{s1} . The counter electromotive force generated on the primary coil T_{s1} is boosted and induced by the secondary coil T_{s2} which becomes of high voltage pulse and applied to the discharge lamp FL. At this time, the high voltage pulse generated on the secondary coil T_{s2} is applied to

the closed loop as seen toward the left from the ends of the secondary coil T_{s2} consisting of the ballast choke coil CH, the capacitor C, the primary coil T_{s1} and the resistor R or the switch S, so that the transient current flows therethrough and the counter electromotive force is generated by the inductance of the ballast choking coil CH and is further applied to the discharge lamp FL. Then, the high voltage pulse is generated on the secondary coil T_{s2} of the transformer T and the ballast choke coil CH, and superposed to AC waveform to be applied to the discharge lamp FL, facilitating ignition of lamps. The above description is concerned to the case where the switch is closed at substantially the peak of the positive half cycle, but if the switch is closed at substantially the peak of the negative half cycle, the high voltage pulse is generated with the positions of the capacitor C and the switch S exchanged.

As illustrated in the theoretical circuit of FIG. 6-B, the switch S in the above-mentioned circuit of FIG. 6-A is now connected in parallel to the primary coil T_{s1} of the transformer through the medium of the capacitor C. Describing the circuit in which the capacitor C is being charged by the time constant of the resistor R, when the switch S is closed at substantially the peak of the positive half cycle, the electric charge of the capacitor C which has been charged begins to be discharged rapidly through the primary coil T_{s1} of the transformer T and the electric charge of the capacitor C transfers immediately, so that extremely large current flows through the capacitor C. Since this current flows through the inductance of the primary coil T_{s1} of the transformer T, the counter electromotive force generated on the primary coil T_{s1} is boosted and induced by the secondary coil T_{s2} . The succeeding operation is the same as in the circuit of FIG. 6-A, and the high voltage pulse is superposed on the peak of the AC waveform and applied to the discharge lamp FL. At this time, the closed loop, as seen toward the left from the ends of the secondary coil T_{s2} , consists of the ballast choke coil CH, the switch S and the resistor R. The embodiment described above is concerned to the case the switch is closed at substantially the peak of the positive half cycle in AC waveform, but in the case the switch is closed at substantially the peak of the negative half cycle, the high voltage pulse is also generated.

Referring to the circuit of FIG. 6-C, the which the tertiary and biquadratic coils for filament heating are combined into a unitary form on the transformer T as shown in FIG. 6-A.

Describing the transient phenomena caused by the charging to the capacitor C, when the power source E is put on and the switch S is closed at substantially the peak value of either positive or negative half cycle, the alternating current on which the high voltage pulse is superposed is applied to the discharge lamp FL. At this time, the voltage applied to the secondary coil T_{s2} of the transformer T is the value which is obtained by the impedance drop of the ballast choke coil CH from the power source voltage, and generally, when the impedance of the ballast choke coil CH is relatively low, most voltage is applied to the secondary coil T_{s2} . Accordingly the transformer T is excited by the secondary coil T_{s2} , so that the voltage directly proportional to the voltage applied to the secondary coil T_{s2} which is a primary coil for the tertiary and biquadratic coils is induced on the tertiary coil T_{s3} and the biquadratic coil T_{s4} , and heats the filament of the discharge lamp. After the power source E is closed, when the filament is heated and electrons required for the discharge of the discharge lamp FL is emitted from the cathode, as described above, the voltage on which the high voltage pulse is superposed is applied to the discharge lamp FL, so that the normal discharge immediately begins. At the same time, in the alternating current induced on the tertiary and biquadratic coils T_{s3} and T_{s4} , the pulse voltage proportional to the pulse voltage of the primary coil T_{s1} is induced, by which so called end-arc is generated at the electrode of the filament, facilitating ignition of the discharge lamp furthermore.

On the other hand once the discharge lamp FL is ignited, the voltage at the tube end of the discharge lamp FL is

reduced to the discharge maintaining voltage and the current to excite the secondary coil T_{62} does not flow, so that on the tertiary and biquadratic coils T_{63} and T_{64} the voltage is hardly induced. Accordingly the filament is not yet heated. Thus, the transformer T generates the high voltage pulse until the lamp is ignited. The tertiary and biquadratic coils are used as the power source for heating the filaments, but after the discharge lamp has been ignited, the power required for the preheating is automatically reduced, and therefore the high voltage pulse is not generated, resulting in the longer span of the discharge lamp than the one of constant heating system. The switch is opened properly after the ignition of the discharge lamp. The above-mentioned embodiment is concerned to the transient phenomena caused by the charge of the capacitor, while the same operation can be expected by the transient phenomena caused by the discharge in the circuit of FIG. 6-B.

Referring to FIG. 6-D where the resistor in FIG. 6-C is replaced by the diode D, when the voltage of the negative half cycle in AC waveform from the power source E is applied to the circuit, the capacitor is charged positively on the side of the primary coil T_{61} of the transformer T and negatively on the side of the ballast choke coil CH through the medium of the diode D. After the charging has been completed and the time for discharge has come, the switch remains opened and the diode is connected inversely so that the capacitor does not begin to discharge. If a positive half cycle is then applied and the switch S is closed at substantially the peak value, the electric charge of the capacitor which has been charged is inversely rapidly charged so that the electric charge of the capacitor C is rapidly transferred thereby to flow the large current. Since the current flows through the inductance of the primary coil T_{61} of the transformer T, the counter electromotive force is generated on the primary coil T_{61} in pulse. The high voltage pulse is superposed onto the AC waveform and is applied to the discharge lamp FL. As in the circuit of FIG. 6-C, on the tertiary and biquadratic coils T_{63} and T_{64} of the transformer T is induced the voltage proportional to the voltage applied to the secondary coil T_{62} , which heats the filament of the discharge lamp FL. At the same time, on the alternating current induced on the tertiary and biquadratic coils T_{63} and T_{64} , the pulse voltage proportional to the pulse voltage of primary coil T_{61} is induced, resulting in the end-arc at the electrode of the filament. When the direction of the diode of the above-mentioned embodiment is inversed and the switch S is closed at substantially the peak value of the negative half cycle, the same result is obtained. In case there is utilized the transient phenomena caused by the discharge effected by connecting the diode in the fundamental circuit of FIG. 6-B, the same operation is perceived.

Referring to the circuit of FIG. 6-E, a transformer T' and a discharge lamp FL' are connected to the power source E through the medium of a ballast choke coil CH' and the capacitor is also connected to a primary coil T_{61}' of the transformer T'. In this second stage circuit both the resistor R and the switch S are not connected and they are common to the first stage. This operation is the same as the circuit of FIG. 6-C. The embodiment is concerned to the one having two stages but in the one having several stages also the same result can be obtained. Occasionally, the above-mentioned unitary unit is employed in combination.

In FIG. 6-F, to the leakage auto-transformer type discharge lamp igniting circuit is connected a transformer T in which the tertiary and biquadratic coils T_{63} and T_{64} are integrally formed. In this case also, the pulse voltage proportional to the primary coil T_{61} is superposed on the AC heating voltage in the tertiary and biquadratic coils T_{63} and T_{64} and accordingly the end-arc is generated at the electrode of the filaments of the discharge lamp FL.

As described above, in this embodiment, charge or discharge of a capacitor is controlled by a switch which operates at substantially the peak value of both positive and negative half cycles in AC waveform of the power source voltage, the charging or discharging current of the capacitor is

made to flow through the transformer to induce the high voltage pulse and tertiary and biquadratic coils for heating the filaments of the discharge lamp are integrally formed in the transformer of a circuit in which the induced voltage of the secondary coil of the transformer is boosted by counter electromotive force caused by the inductance of a ballast choke coil, so that the pulse voltage proportional to the primary coil is generated on said tertiary and biquadratic coils and superposed on the heating power source thereby to produce end-arc on the filament electrodes of the discharge lamp, thus facilitating the ignition and reducing the electric power needed for preheating after the discharge lamp is once ignited. Accordingly, the life of the present discharge lamp is remarkably improved as compared with that of the conventional one employing a continually heating unit.

Referring now to FIG. 7, there is shown a further embodiment, which is a circuit for sequentially igniting a plurality of fluorescent lamps which comprises a plurality of stages each comprising a lamp circuit including a ballast choke coil having a secondary coil, a capacitor, a thyristor and a neon tube, said ballast choke coil and capacitor producing a high voltage pulse at substantially the peak of positive half cycle of power source voltage in cooperation with said thyristor and neon tube thereby to ignite the fluorescent lamp, and connected to one another, a transistor connected to said lamp circuit and adapted to render said lamp circuit inoperative when said transistor is rendered conductive, and a control circuit for controlling said transistor to be rendered conductive or non-conductive which is connected to said transistor and includes a transistor circuit having two transistors and a time constant circuit, the control circuits of said stages being connected so as to ignite fluorescent lamps sequentially and extinguish them all at once after being ignited.

In FIG. 7, CH_{71} , CH_{72} and CH_{73} designate ballast choke coils each having a primary coil L_{71} and a secondary coil L_{72} , one terminal of which is connected to one electrode of AC power supply E. The other terminals of said primary coils L_{71} are connected to filaments of fluorescent lamps FL_{71} , FL_{72} and FL_{73} , respectively, and also connected to resistors R_{71} , R_{72} and R_{73} , respectively. While the other terminals of said secondary coils are connected to the anode sides of thyristors DS_{72} , DS_{72} and DS_{73} through capacitors C_{71} , C_{72} and C_{73} . To said thyristors DS_{71} - DS_{73} are connected diodes D_{71} , D_{72} and D_{73} in parallel. To gates of said thyristors are connected cathode sides of diodes D_{74} , D_{75} , and D_{76} , respectively and are also connected resistors R_{74} , R_{75} and R_{76} as well as neon tubes NE_{71} , NE_{72} and NE_{73} which are connected to the other sides of said resistors R_{71} , R_{72} and R_{73} , respectively. Each cathode side of said thyristors DS_{71} - DS_{73} , the respective other side of said resistors R_{74} to R_{76} and the respective other terminal of fluorescent lamps FL_{71} - FL_{73} are connected to the other electrode of the power supply E via a triac DT. Filaments (not shown) of said fluorescent lamps FL_{71} - FL_{73} are connected to the power supply via a transformer so that these filaments can be preheated. These elements are composed of a trigger circuit; in short, said trigger circuit comprises the secondary coil L_{72} of the ballast choke coil CH_{71} , capacitor C_{71} , diodes D_{71} and D_{74} , thyristor DS_{71} , resistors R_{71} and R_{74} and neon tube NE_{71} . The circuits of second and third stages have the similar construction.

Controlling circuits for controlling said lamp circuit are provided, E' designates a B side of DC power supply, which is connected to resistors R_{77} , R_{78} , R_{79} , R_{80} , R_{81} and R_{82} and a capacitor C_{74} . To one side of each resistor R_{77} , R_{79} and R_{81} are connected collectors of NPN type transistors Tr_{71} , Tr_{72} and Tr_{73} and resistors R_{83} , R_{84} and R_{85} . To one end of each resistor R_{78} , R_{80} and R_{82} are connected collectors of NPN type transistors Tr_{74} , Tr_{75} and emitter of PNP type transistor Tr_{76} , capacitors C_{75} , C_{76} , C_{77} and resistors R_{86} , R_{87} , R_{88} . The other ends said resistors R_{83} - R_{85} are connected to bases of transistors Tr_{74} to Tr_{76} , resistors R_{89} , R_{90} and the other end of said capacitor C_{74} . One end of each resistor R_{86} - R_{88} is connected to bases of transistors Tr_{72} , Tr_{73} , Tr_{71} . To the other end

of said resistor R_{81} is connected resistor R_{91} to which resistor R_{92} is connected in series. Emitters of transistors Tr_{71} to Tr_{75} , and collector of Tr_{76} , resistors R_{89} , R_{90} , R_{92} and capacitors C_{75} to C_{77} are grounded.

The base of transistor Tr_{74} is connected to the base of NPN type transistor Tr_{77} , the collector of which is connected to the gate of triac DT and the emitter of which is connected to one terminal of said triac. The gate of said triac DT is connected to the line B of DC power supply E' via a resistor 93

The base of transistor Tr_{75} is connected to the base of NPN type transistor Tr_{78} , the collector of which is connected to a junction point of the neon tube Ne_{72} and the resistor R_{75} , and the emitter of which is connected to one end of said triac DT. A junction point of resistors R_{91} and R_{92} is connected to the base of the NPN type transistor Tr_{79} , the collector of which is connected to a junction point of the neon tube Ne_{73} and the resistor R_{76} , and the emitter of which is connected to one end of said triac DT.

The thus connected electric circuit operates as follows. Referring to the first stage of lamp circuit, said circuit is kept under the condition that the filaments of fluorescent lamp FL_{71} are preheated and the triac DT is turned on. When a voltage of a negative half cycle from the power supply E is applied, the capacitor C_{71} is charged positively on the side near to the thyristor and negatively on the side near to the secondary coil L_{72} of ballast choke coil. With the voltage of the negative half cycle the neon tube Ne_{71} discharges and is ignited, so that the thyristor remains turned on because an inverse voltage is applied to the gate thereof.

When the voltage of the positive half cycle is applied and said voltage is boosted to the voltage at which the neon tube Ne_{71} starts discharging, the discharging current flows to said neon tube Ne_{71} and the current flows to the gate of thyristor DS_{71} to turn on said thyristor. Accordingly, the thyristor DS_{71} is turned on at substantially the peak of the positive half cycle, and the appropriate oscillation voltage is generated at both terminals of the secondary coil L_{72} by means of the secondary coil L_{72} of ballast choke CH_{71} , capacitor C_{71} and the resistance proportion of said secondary coil L_{72} . The pulse oscillating voltage is further boosted by means of the primary coil L_{71} of the ballast choke coil CH_{71} to become a high voltage pulse. Said high voltage pulse is impressed on the fluorescent lamp FL_{71} to excite a local discharge, leading to a normal discharge. While the high voltage pulse must be synchronized with the power supply by which the normal discharge is kept on, the electric circuit of this embodiment utilized the neon tube Ne_{71} with a comparatively high discharge starting voltage to trigger the thyristor DS_{71} . When the fluorescent lamp FL_{71} starts the normal discharge, the voltage at both terminals of fluorescent lamp FL_{71} drops below the discharge, starting voltage so that discharge of the neon tube Ne_{71} does not take place at the subsequent positive half cycle. Accordingly the current does not flow to the gate of thyristor DS_{71} , hence said thyristor remains turned off. Thus with the high voltage pulse produced on the primary coil of ballast choke coil CH_{71} , the fluorescent lamp FL_{71} is triggered to ignition and thereafter, this trigger circuit is automatically separated from the lamp circuit.

In the same manner the lamp circuits at the second and third stages are operated to ignite fluorescent lamps FL_{72} and FL_{73} .

Referring to the operation throughout the circuit, when the AC power supply E and DC power supply E' are closed, the current flows through resistors R_{77} and R_{83} to the base of transistor Tr_{77} to render and transistor conductive.

Accordingly, the current does not flow to the gate of triac DT to remain said triac turned off. At the same time the current flows to the base of transistor Tr_{74} to render said transistor conductive, so that the capacitor C_{75} starts discharging. Likely, transistor Tr_{76} and Tr_{78} become conductive with current flowing to the bases thereof through respective resistors R_{79} , R_{84} and R_{81} , R_{91} , so that thyristors DS_{72} and DS_{73} are not triggered. That is to say, left as they all the lamps are in the turn-off state. Current flows to the base of transistor Tr_{75}

through resistors R_{79} and R_{84} to render said transistors conductive and, accordingly the capacitor C_{76} starts discharging.

The transistor Tr_{76} is of PNP type, and therefore is left non-conductive upon closing the DC power supply E' , hence, capacitor C_{77} is charged through the resistor R_{82} . When the charged voltage is raised to exceed the voltage predetermined by the time constant of the resistor R_{82} and the capacitor C_{77} , the current flows to the base of transistor Tr_{71} to render said transistor conductive. With the transistor Tr_{71} becoming conductive, the current does not flow to the bases of transistors Tr_{74} and Tr_{77} to render said transistors Tr_{74} and Tr_{77} nonconductive. Consequently, the current flows to the gate of triac DT through the resistor R_{83} to turn on said triac thereby rendering the lamp circuit conductive. By the reason given in the foregoing, the fluorescent lamp FL_{71} is instantly ignited at the positive half cycle and at the same time the trigger circuit is electrically cut off from the main circuit.

When the transistor Tr_{74} becomes nonconductive, the capacitor C_{75} is charged through the resistor R_{78} . When the charged voltage is raised to the voltage determined by the time constant of the resistor and capacitor, the transistor Tr_{72} is rendered conductive. When the transistor Tr_{72} becomes conductive, the transistors Tr_{75} and Tr_{73} become nonconductive, so that the thyristor DS_{72} is turned on at substantially the peak of the positive half cycle, thereby igniting the fluorescent lamp FL_{72} .

The same operation is repeated in the succeeding circuits; that is, when capacitor C_{76} is charged as a result of the transistor Tr_{75} becoming nonconductive and the charged voltage is raised to reach a certain value predetermined by a time constant, the transistor Tr_{73} is rendered conductive. Accordingly, the transistor Tr_{76} becomes nonconductive and the fluorescent lamp FL_{73} is ignited, whereby the ignition of all lamps is completed.

On the other hand, the capacitor C_{74} is charged through the medium of the resistor R_{85} and when the charged voltage reaches a certain value, the transistor Tr_{76} becomes conductive. When the transistor Tr_{76} becomes conductive, the transistor Tr_{71} is rendered nonconductive and the transistors Tr_{74} and Tr_{77} are rendered conductive. Then, as a result of the transistor Tr_{77} becoming conductive, current flowing to the gate of the triac DT is cut off to turn off said triac so that the lamp circuit is interrupted and the fluorescent lamps FL_{71} - FL_{73} extinguished all at once. As a result of the transistor Tr_{74} becoming conductive, the capacitor C_{75} begins to discharge to prepare for next cycle. The above-mentioned operation is further repeated, that is, as a result of the transistor Tr_{74} becoming conductive, the transistor Tr_{72} is rendered nonconductive and the transistors Tr_{75} and Tr_{78} conductive. Subsequently, the circuit between the gate of the thyristor DS_{72} and the cathode is turned off, as a result of the transistor Tr_{78} becoming conductive.

Furthermore, as a result of the transistor Tr_{75} becoming conductive, the transistor Tr_{73} is rendered nonconductive and the transistor Tr_{76} conductive. Accordingly, a circuit between the gate of the thyristor DS_{73} and the cathode is turned off. At the same time, the transistor Tr_{76} is rendered nonconductive. Thus, the one cyclical operation of the controlling circuit is completed.

Thus, the capacitor C_{77} begins to be charged and the prescribed operation is repeated. The lag in ignition of time from fluorescent lamp FL_{71} to FL_{72} and FL_{72} to FL_{73} is determined by the time constant of the resistor R_{78} to the capacitor C_{75} and the resistor R_{80} to the capacitor C_{76} respectively. The time all lamps are to be ignited is determined by the resistor R_{85} and the capacitor C_{74} and the time all lamps to be extinguished is by the resistor R_{82} and the capacitor C_{77} .

In the above embodiment, three fluorescent lamps are installed, though of course the fluorescent lamps can be increased by increasing the lamp circuits and the control circuit if desired.

According to this embodiment, as set forth, a lamp circuit adapted to ignite a fluorescent lamp at substantially the peak

of the positive half cycle and trigger ignition is made possible by the extremely slight external AC or a pulse signal. Accordingly, excellent adaptation and stable operation can be secured and the circuit also can be realized in a small size. It also enables the fluorescent lamps to be ignited sequentially by the control circuit and after all lamps have been ignited, to be extinguished all at once, which is absolutely suitable for advertisements. And because noncontact circuits are employed, mechanical troubles are completely eliminated, so that stable operation and longer durability can be secured.

Referring now to FIG. 8, there is shown a further embodiment, which is an electric circuit for flashing an AC load which comprises a rectifier circuit connected to an AC power source through an AC load; a time constant circuit including a resistor and capacitor; an SCR adapted to be turned on with current flowing to a gate thereof when the charging voltage of capacitor of said time constant circuit is raised to exceed the Zener voltage of Zener diode thereby to cause the capacitor of time constant circuit to discharge; a diode for maintaining a holding current of SCR for a predetermined period of time thereby to energize the load; said time constant circuit, said SCR and said diode being connected to the rectifier circuit.

In this embodiment, the AC load such as a fluorescent lamp, an incandescent lamp, a motor and a transformer is energized and deenergized repeatedly with the aid of any one of electric circuit as described with reference to FIGS. 1 to 6.

Reference E is an AC power source, CR is a diode bridge rectifier circuit for rectifying said AC power source, and L is an AC load such as a fluorescent lamp, an incandescent lamp, a motor and a transformer which is connected in series between the AC power source and the rectifier circuit CR.

Reference Ds is a silicon controlled rectifier element connected in parallel to the rectifier circuit CR; Dz is a Zener diode connected between a gate of said SCR, Ds and a resistor R_{104} ; and D is a diode connected to a resistor R_{103} and the positive line of DC. The other terminal of said resistor R_{103} is connected to a junction point of Zener diode DZ with the resistor R_{104} . A resistor R_{101} has one terminal connected to the positive line of DC and the other terminal connected to the resistor R_{104} , the resistor R_{102} one terminal of which is connected to the negative line and one terminal of capacitor C. The resistor R_{105} is connected between the gate of SCR, Ds and the negative line of DC.

Operation is as follows.

If the AC power source E is closed, charging to the capacitor C starts through the resistor R_{101} . When the charging voltage thereof is raised to exceed the Zener voltage of Zener diode DZ, the Zener current flows to the gate of SCR (Ds) through the Zener diode to turn on said SCR, thereby energizing the load L. At the same time when said SCR, Ds is turned on, the charging voltage of the capacitor C is discharged through the diode D while retaining the holding current of SCR (Ds). Hence, said SCR (Ds) is kept as it is turned on to continuously energize the load L.

While, the gate current is cut off simultaneously when the capacitor C starts discharging, but since the diode D retains the holding current of SCR, Ds, the load L is kept as it is energized if the gate current does not flow.

When the electric charge of capacitor C is discharged too much to maintain the holding current of SCR (Ds), said SCR (Ds) is turned off to deenergize the load L.

This is one cycle of operation, and the load L is again energized in the same way as set forth in the foregoing, and deenergized at a predetermined interval of time after the energization thereof.

The electric circuit of this embodiment has such advantages that the energizing period of load can be prolonged, with no relation to the flow of gate current of SCR, since the diode controls discharging through the time constant circuit and maintains the holding current of SCR to turn on said SCR thereby energizing the load, if the gate current is not flowed; that the circuit is made at low cost because of its simplicity in structure; and that its operation is positively ensured.

What is claimed is:

1. A circuit for rapidly and certainly igniting a discharge lamp, comprising in combination: a power source having a fluctuating output voltage amplitude, means energizable from said source for preliminarily heating the electrodes of said discharge lamp, a capacitor, switching means actuable for rapidly changing the charge condition of said capacitor and including a switch, means for connecting said capacitor to said switching means, actuating means connected to said power source and switching means responsive to the phase of said power source for actuating said switching means at substantially the peak value of said output voltage of said power source, inductor means for producing a high voltage pulse in response to said change of said charge condition of said capacitor, means for connecting said inductor means to said capacitor and said switching means, and means applying said high voltage pulse to said discharge lamp at said electrodes.

2. An ignition starting circuit for a discharge lamp, comprising in combination: an A.C. power source, a transistor having a control electrode, an initial stage SCR having a gate, means connecting the gate of said initial SCR with said power source for turning on said initial SCR during a positive half cycle of said source, means interconnecting the gate of said initial SCR and the control electrode of said transistor for rendering said transistor conductive upon conduction of said initial SCR, a subsequent stage SCR having a gate, means connected to the gate of said subsequent SCR for turning on said subsequent SCR prior to conduction of said initial SCR, and means connecting said transistor to the gate of said subsequent SCR for interrupting gate current thereof on conduction of said transistor to prevent further conduction of said subsequent SCR, said initial stage SCR and said subsequent stage SCR having further electrodes and at said further electrodes being connected in parallel and with the same polarity across each of the discharge lamp and A.C. power source, a ballast choke coil and means connecting same in series with said source and lamp and to said subsequent SCR for applying a high-voltage counter electromotive force to said lamp in response to the turn-off of said subsequent stage SCR so as to effect a discharge through said lamp, said subsequent SCR flowing current through said coil from said source when turned on.

3. An electric circuit for producing a pulse for igniting a fluorescent lamp, comprising in combination: an A.C. power source, a ballast choke coil in circuit with said lamp and source, a thyristor and a neon tube lamp and means connecting said neon tube lamp to the gate of said thyristor and to said A.C. source for enabling said thyristor for conduction substantially at a voltage peak of said A.C. supply, a further coil, a capacitor and means connecting said further coil and capacitor in series with said thyristor across said source for producing a pulse in said further coil substantially at said peak in response to discharge of said capacitor through said thyristor and source and further coil, and means inductively coupling said further coil to said lamp for substantially simultaneously applying a high voltage to said lamp to initiate discharge of said lamp, said fluorescent lamp being kept ignited by current flow thereto from said source through said ballast choke coil.

4. An electric circuit for igniting a plurality of discharge lamps, comprising in combination: a plurality of ballast choke coils, a power source, means connecting said plurality of discharge lamps in parallel to said power source through respective ones of said ballast choke coils, a diode and a capacitor and means connecting said diode and capacitor in series with said source for charging said capacitor during a negative half cycle of power source voltage through said diode, a semiconductor controlled rectifier element, an oscillation producing coil and means connecting said controlled rectifier element and oscillation coil to said capacitor for causing said capacitor to discharge as well as be inversely charged by said controlled rectifier element when said controlled rectifier element is turned on, thereby producing a high-voltage pulse in said oscillation producing coil usable for igniting said plurality of discharge lamps, and a plurality of neon tube lamps and means connecting each said neon tube lamp between a gate of said controlled rectifier element and a

respective one of said ballast choke coils for causing said controlled rectifier element to turn on at substantially the peak of the positive half cycle of said power source.

5. An electric circuit for igniting a discharge lamp, comprising in combination:

a power source;

means for preheating the filaments of said discharge lamp including a controlled rectifier element adapted to turn on at substantially the peak of positive half cycle of the power source voltage and connected between filaments of said discharge lamp; and

a high-voltage pulse generating circuit comprising a capacitor and means connecting said capacitor to said source for charging said capacitor at the negative half cycle of power source voltage, a transformer, means connecting the secondary side of said transformer to said lamp, and means connecting said capacitor and the primary side of said transformer to said controlled rectifier element for rapidly inversely charging said capacitor at substantially the peak of the positive half cycle of said power source in a manner that said charging current produces an oscillating pulse at the primary side of said transformer, said pulse is raised to excite a high-voltage oscillating pulse at the secondary side thereof, and said high-voltage oscillating pulse is impressed on said filaments to ignite said discharge lamp.

6. An electric circuit for igniting a plurality of discharge lamps, comprising in combination:

an A.C. power source;

a controlled rectifier circuit including a controlled rectifier element;

a filament preheating circuit including means connecting said controlled rectifier element in circuit with the filaments of said discharge lamps and said source for preheating the respective filaments by conduction through said controlled rectifier element;

a high-voltage pulse generating circuit including a capacitor, means connecting said capacitor to said source for charging said capacitor during the negative half cycle of said source voltage, a transformer, means connecting the secondary side of said transformer to said lamps, and means connecting the primary side of said transformer and said capacitor in common to said controlled rectifier circuit and responsive to conduction of said controlled rectifier element for rapidly inversely charging said capacitor at substantially the peak of the positive half cycle of said source voltage in a manner that the capacitor inverse charging current produces an oscillating pulse at the primary side of said transformer, said pulse is raised in voltage to provide a high-voltage oscillating pulse at the secondary side of said transformer and the high-voltage oscillating pulse is impressed on said filaments to ignite said plurality of discharge lamps and

a gate current controlling circuit including neon lamps and means connecting said neon lamps to the filaments of respective ones of said discharge lamps, said gate current controlling circuit feeding current to a gate of said controlled rectifier element to turn on said controlled rectifier element at substantially the peak of the positive half cycle of said source.

7. A discharge lamp igniting circuit, comprising in combination: an A.C. power source, a discharge lamp, a transformer having a secondary coil and a primary coil, means connecting said secondary coil across said lamp, a ballast choking coil, means connecting said secondary coil across said A.C. power source through said ballast choking coil, a capacitor, a resistor, means connecting said primary coil of said transformer and said capacitor and said resistor in a series circuit across said A.C. power source, a switch operable at substantially the peak of both positive and negative half cycles of the power source voltage and means connecting said switch across a portion of said series circuit for causing said secondary coil to produce a high voltage pulse utilizing transient phenomena caused by charge and discharge of said capacitor upon opera-

tion of said switch, whereupon the thus produced high voltage pulse produces a counter electromotive force on the ballast choke coil and then said high-voltage pulse, counter electromotive force and power source voltage are applied to the discharge lamp.

8. A discharge lamp igniting circuit, comprising in combination: an A.C. power source, a discharge lamp, a transformer having a secondary coil and a primary coil, means connecting said secondary coil across said lamp, a ballast choke coil, means connecting said secondary coil in parallel to said A.C. power source through said ballast choke coil, a series circuit connected across said A.C. power source and including said primary coil of said transformer as well as a capacitor and a diode for making approximately twice charging or discharging current of said capacitor and applying it every cycle of A.C. voltage, a switch which operates at substantially the peak of the positive or negative half cycles of the power source voltage and means connecting said switch across a portion of said series circuit for causing said secondary coil to produce a high voltage pulse utilizing transient phenomena caused every cycle by charging and discharging of said capacitor whereupon the thus produced high voltage pulse produces a counter electromotive force on the ballast choke coil and then said high voltage pulse, counter electromotive force and power source voltage are applied to the discharge lamp.

9. A discharge lamp igniting electric circuit, comprising in combination: an A.C. power source, a ballast choke coil, a discharge lamp and a transformer having a secondary coil connected in parallel to said A.C. power source through said ballast choke coil, a series circuit connected across said A.C. source and comprising a primary coil of said transformer as well as a capacitor and a current flow control device of a type capable of continuously passing D.C. current in at least one direction, a switch connected across a portion of said series circuit and adapted to synchronize with substantially the peak voltage of said A.C. source, tertiary and biquadratic coils and means inductively energizing same from said A.C. source for preheating filaments of said discharge lamp, said tertiary and biquadratic coils being combined into a unitary coil, the secondary coil being inductively coupled at least to said primary coil for producing a high-voltage pulse utilizing a transient phenomena caused by charging and discharging of said capacitor, whereupon the thus produced high-voltage pulse produces a counter-electromotive force at the ballast choke coil, said tertiary and biquadratic coil producing a pulse voltage proportional to that of the primary coil.

10. A circuit for sequentially igniting a plurality of fluorescent lamps, comprising in combination:

a power source;

lamp circuits each including a ballast choke coil connected between said source and a corresponding lamp, said ballast choke coil having a secondary coil, a capacitor chargeable from said source, a thyristor, a neon tube, means connecting said neon tube to said source and thyristor for turning said thyristor on at substantially the peak of the power source voltage, and means connecting said capacitor to said secondary coil and thyristor for causing discharge of said capacitor therethrough to produce a high voltage pulse in the ballast choke coil for igniting the corresponding one of said lamps, said lamp circuits being interconnected;

a plurality of transistors and means connecting each said transistor to a corresponding one of said lamp circuits for rendering each said lamp circuit inoperative when the corresponding one of said transistors is rendered conductive; and

control circuit means for controlling the conductive state of said transistors and connected to said transistors, said control circuit means including a transistor circuit for each said transistor, each said transistor circuit having two further transistors connected to a time constant circuit, and further including means interconnecting said transistor circuits for igniting said fluorescent lamps

sequentially and for extinguishing said fluorescent lamps all at once after being ignited.

11. An electric circuit for flashing an A.C. load, comprising in combination:

an A.C. power source;
a rectifier circuit having an A.C. side and a D.C. side, said A.C. side being connected to said A.C. power source through said A.C. load;

a time constant circuit connected across the D.C. side of said rectifier circuit and including a resistor and capacitor;

an SCR connected across said D.C. side of said rectifier circuit;

means including a Zener diode connecting said capacitor to a gate of said SCR for turning on said SCR with current flowing to said gate thereof when the charging voltage of said capacitor of said time constant circuit is raised to exceed the Zener voltage of said Zener diode thereby to cause said capacitor of said time constant circuit to discharge;

a diode and means connecting said diode from a point between said capacitor and Zener to a point between said SCR and said rectifier circuit for maintaining conduction of said scr for a predetermined period of time thereby to energize the load.

12. The circuit of claim 3 in which said further coil is inductively coupled to said ballast coil so that said pulse in said further coil induces a high voltage pulse in said ballast coil, said ballast coil applying said further high voltage pulse to said fluorescent lamp for discharging same substantially at said peak of said source.

13. The circuit of claim 3 including a still further coil and means connecting same in series with said fluorescent lamp, said still further coil being inductively coupled to said further coil for discharging said fluorescent lamp upon appearance of said pulse.

14. The circuit of claim 14 including a diode in series with said thyristor and means connecting said source, said ballast choke coil, said diode and thyristor in series loop with the electrodes of said fluorescent lamp for preheating said electrodes when said thyristor conducts.

15. The circuit of claim 4 in which said oscillation coil is inductively coupled to each of said ballast coils so that said high voltage pulse in said oscillation coil produces higher voltage pulses in each of said ballast coils, said ballast coils applying said higher voltage pulses to respective ones of said discharge lamps for igniting same.

16. The circuit of claim 4 including a further coil inductively coupled with said oscillation coil, and means connecting said further coil in series with each of said discharge lamps for igniting said discharge lamps upon appearance of said high voltage pulse.

17. The circuit of claim 4 including means for connecting each of said neon tube lamps in parallel with the corresponding one of said discharge lamps for causing ignition of said discharge lamps to prevent further actuation of said controlled rectifier element by the corresponding ones of said neon tube lamps and upon failure of one of said discharge lamps to ignite allowing the corresponding one of said neon tube lamps to subsequently turn on said controlled rectifier element.

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UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3 676 734

Dated July 11, 1972

Inventor(s) Tetsuji Shimizu and Makoto Iwakura

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 1, under the heading entitled "Foreign Application

Priority Data" and following "November 15, 1968

Japan.....43/83232" add:

---Nov. 26, 1968 Japan.....43/102457

Jan. 13, 1969 Japan.....44/2042

Feb. 7, 1969 Japan.....44/10175

Feb. 24, 1969 Japan.....44/15472

March 28, 1969 Japan.....44/23055

April 2, 1969 Japan.....44/29427

June 5, 1969 Japan.....44/43552---

Column 23, line 24; change "scr" to ---SCR---.

Column 24, line 6; change "claim 14" to ---claim 3---.

Signed and sealed this 23rd day of January 1973.

(SEAL)
Attest:

EDWARD M. FLETCHER, JR.
Attesting Officer

ROBERT GOTTSCHALK
Commissioner of Patents