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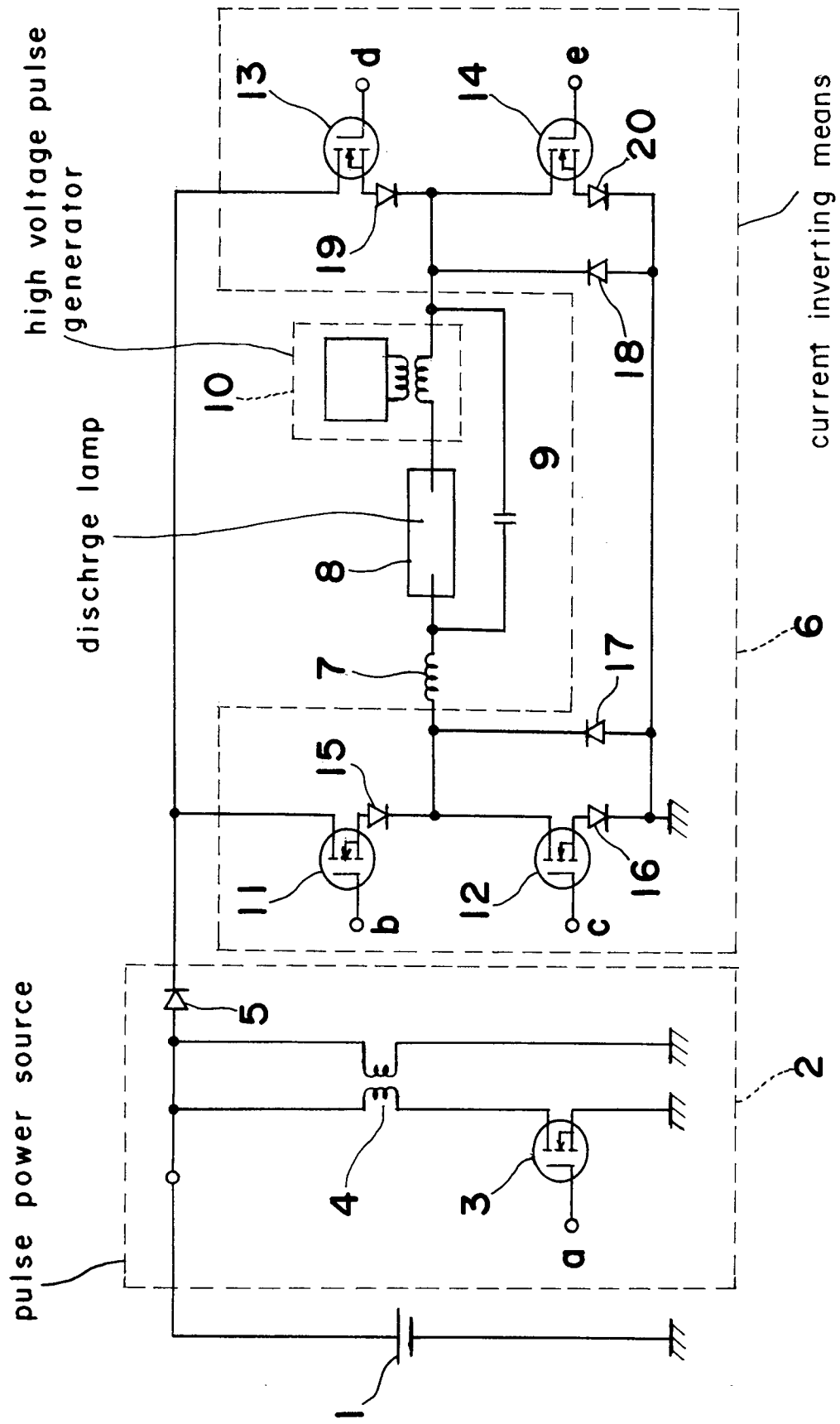
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(54) **Power apparatus.**

(57) A power apparatus for controlling the lighting of a discharge lamp (8) such as metal halide lamp or the like as a load, the switching circuits are reduced in number or smaller size of components are adapted to be used so as to make the power apparatus smaller in size and simpler in construction, wherein the pulse output is inverted with a frequency lower than the repetitive frequency of the pulse by a current inverting means (6), and is applied upon the discharge lamp (8) which is a load and the pulse is smoothed by a capacitor (9) provided in parallel to the discharge lamp (8), whereby the alternating current of the low frequency is flowed to the discharge lamp (8).

Fig. 1



BACKGROUND OF THE INVENTION

The present invention generally relates to a power apparatus for converting a direct current into an alternating current, and more particularly, to a power apparatus for controlling the lighting of discharge lamps such as metal halide lamp and so on as loads.

In the apparatus disclosed in Japanese Laid-Open Patent Application Tokkaihei No. 2-10697, comparatively high voltages are fed between a pair of electrodes of a discharge lamp so as to excite the excitable components charged in the discharge lamp so that the harmful electrophoresis and acoustic resonance function to be caused generally during the discharge lamp lighting operation may be reduced or substantially removed as a power apparatus for controlling the lighting of the discharge lamp when the discharge lamps such as metal halide lamp and so on as the loads are used. In order to retain the excitation thereafter, the rectangular wave current having the size within the given range and the given repetitive speed is fed to the above described one pair of electrodes, further the direction for feeding the above described rectangular wave current into the above described electrode is periodically changed alternately. This is to light the discharge lamp with the use of a power apparatus for outputting the alternating rectangular wave current.

An apparatus for employing the above described method is very complicated as disclosed in the open publication, thus being disadvantageous in practical use.

SUMMARY OF THE INVENTION

Accordingly, the present invention has been developed with a view to substantially eliminating the above discussed drawbacks inherent in the prior art, and has for its essential object to provide an improved power apparatus.

Another important object of the present invention is to provide an improved power apparatus which is less in switching circuit, and is capable of outputting the alternating current with simple construction.

In accomplishing these and other objects, according to one preferred embodiment of the present invention, there is provided a power apparatus which includes a direct current power supply, a pulse power supply which is driven by the direct current power supply so as to output the pulses, a current inverting means which is connected with the output of the output of the pulse power supply so as to inverse the output current, a load connected with the output of the current inverting means, a capacitor connected in parallel to the above described load, and which is characterized in that the output of the current inverting means is adapted to be inverted with the frequency lower than the frequency of the pulse to be outputted

by the above described pulse power supply.

Further, the pulse power supply is provided with a fly-back transformer. The pulse power supply is provided with a means which is adapted to vary the oscillation frequency or the duty ratio so as to control the current to flow into the load.

Further, a choke coil is provided between the current inverting means and the parallel circuit of the load and the capacitor.

Further, the current inverting means, which is a bridge inverter, is provided with a means for driving the above described switch element so that the inverter may be inverted with the frequency lower than the frequency of the pulse to be outputted by the pulse power supply with the diode being connected in opposite parallel to a pair of switch elements connected with the positive output side or the negative output side of the above described pulse power supply at least from among the switch elements for composing the bridge inverter.

Further, the parallel circuit of the load connected with the output end of the pulse power supply, and the capacity, a series circuit between a first choke coil and a first switch element for constituting the current inverting means, a series circuit between a second choke coil connected with the output end of the above described pulse power supply and a second switch element for constituting the current inverting means are provided. The current inverting means is provided with a means which is adapted to form a first closed loop circuit that flows into the load the accumulation energies of the above described first choke coil, when the pulse of the above described pulse power supply is off, the above described first switch element is on, the above described second switch element is off, to form a second closed loop circuit that flows into the load the accumulation energies of the above described second choke coil when the pulse of the above described pulse power supply is off, the above described first switch element is off, the above described second switch element is off so as to drive the above described first switch element and the second switch element for alternately turn on, off with a frequency lower than the frequency of the pulse to be outputted by the above described pulse power supply.

Further, the pulse power supply is provided with a reference output terminal, a pair of positive output terminals, negative output terminals for outputting the positive pulses, the negative pulses, the current inverting means is provided with two switch elements connected between the positive output terminal and the negative output terminal, with a parallel circuit of the load and the capacitor being connected between the reference output terminal and the connection points of the two switch elements, the above described current inverting means is provided with a means for driving the above described two switch elements so as to alternately turn on, off with a frequency

lower than the frequency of the pulse to be outputted by the pulse power supply.

Further, the pulse power supply is provided with a primary winding with the center tap being connected with one end of the above described direct current power supply, a pair of switching terminals which are connected between the other end of the above described alternate current power supply and both the ends of the primary winding of the above described transformer so as to alternately effect the intermittent high frequency switching operation, a series circuit of the switch circuit and the load to prevent the voltage from being caused in the secondary winding of the transformer, when one of the above described switching elements has been turned on in accordance with the control signal with the secondary winding of the above described transformer being connected, to flow the energies in the opposite direction to effect the positive, negative inverting operation, in accordance with the replacement of the intermittent high frequency switching operation, of the flowing direction when the magnetic energies are accumulated in the transformer to switch off.

Further, the current inverting means is provided with a control circuit for outputting an inverting signal when the pulse output of the pulse power supply is not provided.

The present invention has a direct current power supply provided with a reference output terminal, a pair of positive output terminal, negative output terminal for outputting the positive voltage, the negative voltage, a current inverting means provided with two switch elements connected between the positive output terminal and the negative output terminal, a series circuit of a parallel circuit of the load and the capacitor connected between the reference output terminal and the connection point of two switch elements, and the first choke coil. The above described current inverting means is provided with a means for driving the two switch elements so that one of two switch elements may be turned off, the other thereof may be put into the high frequency switching operation, and the switching operation may be alternately effected at a long period.

Also, the present invention is provided with a direct current power supply, an inverter connected with the output of the direct current power supply, a rectifying circuit having positive, negative rectifying outputting circuits, connected with the output of the inverter, having a switch element for stopping one of the positive, negative outputs with the control signal with the positive, negative output terminals being reversibly connected with respect to each other, a load connected with the output terminal of the rectifying circuit.

Further, the rectifying circuit is respectively a set of half-wave N times voltage rectifying circuit for the positive and the negative, being provided with a semi-

conductor switch element in series with the diode of the rectifying circuit.

Further, the load is a discharge lamp, with the inversion frequency of the current inverting means being made lower than the maximum frequency where the discharge lamp does not cause the acoustic resonance phenomenon.

Further, a lamp voltage detecting means, a frequency control means which is adapted to vary the frequency of the alternating current flowing into the discharging lamp in accordance with the output of the above described lamp voltage detecting means are provided, and also, the discharge lamp is connected with the current inverting means through inductances such as choke coil, transformer and so on.

Some current control means are provided with a sine wave signal circuit so as to effect the current control operation, synchronizing with the frequency of the current inverting means so that the alternating current output current may become the sine wave.

By the above described construction, the pulse is smoothed by a capacitor, is applied upon the load, and the alternating current is adapted to run with the pulse direction being inverted by the current inverting means, so that the alternating current may be flowed into the load by the simple circuit without provision of the special high frequency switching means.

Also, when the fly-back transformer is adopted in the pulse power supply, the pulse of the higher voltage may be obtained with the less turn ratio, with the high voltage may be obtained with a smaller sized circuit even with the low direct current voltage.

Also, the voltage and current of the load may be easily controlled by the variation of the oscillation frequency of the pulse power supply or the duty ratio.

A choke coil is provided between the current inverting means, and the parallel circuit of the load and the capacitor, so that the ripple of the voltage ; current of the load caused through inputting of the pulse may be reduced, and the noise may be restrained.

The diodes are connected in opposite parallel to a pair of switch elements connected onto the positive output side or the negative output side of, at least, the above described pulse power supply from among the switch elements constituting the bridge inverter so as to invert the inverter with the frequency lower than the frequency of the pulse to be outputted by the pulse power supply, so that the pulse is inputted to get one choke coil to effect a voltage lowering chopper operation, and thus, the rectangular wave voltage may be applied upon the load so as to make the circuit smaller in size.

The parallel circuit of the above described load connected with the output terminal of the pulse power supply, and the capacity, a series circuit between a first choke coil and a first switch element, a series circuit between a second choke coil connected with the

output end of the above described pulse power supply and a second switch element are provided. The current inverting means is adapted to form a first closed loop circuit that flows into the discharge lamp the accumulation energies of the above described first choke coil when the pulse of the above described pulse power supply is off, the above described first switch element is on, the above described second switch element is off, to form a second closed loop circuit that flows into the load the accumulation energies of the above described choke coil when the pulse of the above described pulse power supply is off, the above described first switch element is off, the above described second switch element is off so as to (easily drive the above described first switch element and the second switch element for) alternately on, off with frequency lower than the frequency of the pulse to be outputted by the above described pulse power supply, so that the number of the switch elements may be reduced in number, thus making it easier to effect the driving operation for simplifying the circuit.

Also, the pulse power supply is provided with a reference output terminal, a pair of positive output terminals, negative output terminals for outputting the positive pulses, the negative pulses, two switch elements are connected between the positive output terminal and the negative output terminal, with a parallel circuit of the above described load and the capacitor being connected between the reference output terminal and the connection point of the two switch elements, the alternate turning on, off operation is effected with a frequency lower than the frequency of the pulse to be outputted by the above described pulse power supply so that one choke coil will do and also, two switch elements will do, thus simplifying the circuit.

Also, the pulse power supply is provided with a transformer having a primary winding with the center tap being connected with one end of the above described direct current power supply, a pair of switching elements which are connected between the other end of the above described alternate current power supply and both the ends of the primary winding of the above described transformer so as to alternately effect the intermittent high frequency switching operation, a series circuit of the switch circuit and the load to prevent the voltage from being caused in the secondary winding of the transformer when one of the above described switching elements is on in accordance with the control signal with the secondary winding of the above described transformer being connected, to flow the energies in the opposite direction to effect the positive, negative inverting operation of the flowing direction in accordance with the replacement of the intermittent high frequency switching operation when the magnetic energies are accumulated in the transformer to switch off, the alternating current of the frequency lower than the high frequency switching

frequency is adapted to be flowed by the alternate operation of the intermittent high frequency switching operation of the switching element, so that the number of the switching elements may be reduced, thus making it easier to effect the driving operation, and simplifying the circuit.

The current inverting means is provided with a control circuit for outputting the inverting signal when the pulse output of the pulse power supply is not provided so as to switch the direction of the current when the current is not flowed to the switching element of the inverting means, so that the loss of the switching elements may be reduced, and also, the damages may be prevented.

The present invention has a direct current power supply provided with a reference output terminal, a pair of positive output terminal, negative output terminal for outputting the positive voltage, the negative voltage, a current inverting means provided with two switch elements connected between the positive output terminal and the negative output terminal, a parallel circuit of the load and the capacitor connected is connected with a series circuit of a first choke coil between the reference output terminal and the connection point of two switch elements, the switching operation is alternately switched at a long period with one of the above described two switch elements being turned off, the other thereof being put into the high frequency switching operation, so that the driving operation of two switch elements connected in series may be effected with the high frequency, thus making it possible the driving circuit smaller in shape.

Also, a rectifying circuit having a positive, negative rectifying output circuit, connecting with the output of the inverter, having a switch element for stopping one of the positive, negative outputs by the control signal with the positive, negative output ends being oppositely connected with respect to each other, a load connected with the output end of the rectifying circuit are provided. The current flowing through the load by the control signal is inverted with a frequency lower than the oscillation frequency of the above described inverter, so that the rectangular wave alternating current voltage may be obtained with the less number of the switching elements, thus making it possible the apparatus smaller in size.

The rectifying circuit is two sets of half-wave N times voltage rectifying circuits. The semiconductor switch element is connected in series with the diode of the rectifying circuit so that the output voltage of the resonance circuit, the resonance current may be made lower, thus making the resonance circuit smaller in size.

The load is a discharge lamp, and the inversion frequency of the current inverting means is made a frequency lower than the maximum frequency where the discharge lamp does not cause the acoustic resonance phenomenon, the lamp is prevented from flick-

ering, turning off due to the acoustic resonance phenomenon caused when the discharge lamp has been turned on with the high frequency.

Also, a lamp voltage detecting means, a frequency control means which is adapted to vary the frequency of the alternating current flowing into the discharging lamp in accordance with the output of the above described lamp voltage detecting means are provided, and also, the discharge lamp is connected with the current inverting means through inductances such as choke coil, transformer and so on. When the lamp voltage is lower, the frequency of the alternating current flowing into the discharge lamp is made higher so as to make the impedance of the above described choke coil higher, so that the pulse voltage may be made not to become lower, thus preventing the lamp from tuning off when the lamp voltage is low at the starting time or the like of the lamp.

Also, a current control means is provided with a sine wave signal circuit so as to effect the current control operation, synchronizing with the frequency of the current inverting means so that the alternating current output current may become the sine wave. At the current inverting time, the current flowing into the switch element of the inverting circuit may be made smaller, the switching loss may be reduced, thus making the power supply apparatus smaller in size. When the input of the power supply apparatus is made an alternating current power supply, the input power-factor may be made higher, and the input higher harmonic current may be made smaller.

BRIEF DESCRIPTION OF THE DRAWINGS

These and other objects and features of the present invention will become apparent from the following description taken in conjunction with the preferred embodiment thereof with reference to the accompanying drawings, in which;

Fig. 1 is a circuit diagram showing the essential portions of a power apparatus in a first embodiment;

Fig. 2 is a circuit diagram showing one embodiment of a high voltage pulse generating circuit of the power apparatus of the present invention;

Fig. 3 is a wave form chart for illustrating of the operation of the pulse supply of the power apparatus of the present invention;

Fig. 4 is a circuit diagram showing the essential portions of a power apparatus in a second embodiment of the present invention;

Fig. 5 is a circuit diagram showing the essential portions of a power apparatus in a third embodiment of the present invention;

Fig. 6 is a circuit diagram showing the essential portions of a power apparatus in a fourth embodiment of the present invention;

Fig. 7 is a circuit diagram showing the essential

portions of the power apparatus in a fifth embodiment of the present invention;

Fig. 8 is a circuit diagram showing the essential portions of a power apparatus of a sixth embodiment of the present invention;

Fig. 9 is a wave form chart for illustrating the operation of the circuits in Fig. 1 and Fig. 4 through Fig. 8;

Fig. 10 is a circuit diagram showing the essential portions of a power apparatus in a seventh embodiment of the present invention;

Fig. 11 is a wave form chart for illustrating of the operations of the circuit in Fig. 10;

Fig. 12 is a circuit diagram showing the essential portions of a power apparatus in an eighth embodiment of the present invention;

Fig. 13 is a circuit diagram showing the essential portions of a power apparatus in a ninth embodiment of the present invention;

Fig. 14 is a circuit diagram showing the essential portions of a power apparatus in a tenth embodiment of the present invention;

Fig. 15 is a circuit diagram showing the other embodiment of a rectifying circuit of Fig. 14;

Fig. 16 is a circuit diagram showing the embodiment of a lamp voltage detecting means, a frequency control means of a power apparatus of the present invention; and

Fig. 17 is a circuit diagram showing the embodiment of a frequency control means of a power apparatus of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

Before the description of the present invention proceeds, it is to be noted that like parts are designated by like reference numerals throughout the accompanying drawings.

Referring now to the drawings, there is shown in Fig. 1, a circuit diagram showing the essential portions of a power apparatus according to a first embodiment of the present invention. Reference numeral 1 is a direct current power supply, a pulse power supply 2 is adapted to be driven by the direct current power supply 1 so as to output the pulse of the given frequency. The pulse power supply 2 is composed of a field effect transistor (hereinafter referred to as transistor) 3 which is a switch element, a fly-back transformer 4, a diode for output use 5. As a load circuit, a parallel circuit of a discharge lamp 8 as a load and a capacitor 9 is connected with a series circuit with respect to a first choke coil 7 through a current inverting means 6. Reference numeral 10 is a high voltage pulse generating circuit for starting use provided in series with the discharge lamp 8. The current inverting means 6 has transistors 11 through 14, which are switch elements, connected so as to constitute the bridge. Diodes 15, 16, 19, 20 are connected with the

respective transistors so as to become forward in direction with respect to the pulse, with diodes 17, 18 being connected in reverse parallel to the transistors 12, 14.

The transistors 11 through 14 are composed with 11 and 14 becoming one set, or 12 and 13 becoming one set by a driving circuit (not shown). They are given driving signals b through e so that they may be alternately inverted with the frequency lower than the frequency of the pulse to be outputted by the pulse power supply 2. An embodiment of a high voltage pulse generating circuit 10 is shown in Fig. 2. The high voltage pulse generating circuit 10, which is generally known, is composed of a direct current power supply 41, a series circuit of a resistor 42 connected with the output thereof, and a capacitor 43, a discharge gap 44, a pulse transformer 45, with the series circuit on the primary side of the discharge gap 44 and the pulse transformer 45 being connected in parallel to the capacitor 43. By such construction as described hereinabove, the load is stored in the capacitor 43 through the resistor 42 from the direct current power supply 41. When the voltage reaches the break over voltage of the discharge gap 44, the discharge gap 44 breaks down to flow the pulse current from the capacitor 43 onto the primary side of the pulse transformer 45, thus generating the high voltage pulse on the secondary side.

The operation by the above described construction will be described hereinafter. The operation wave form of the pulse power supply is shown in Fig. 3. Referring now to Fig. 3, reference character (a) is an input pulse signal a of a transistor 3, which is duty controlled, of approximately tens of KHz, reference character (b) is an output voltage wave form of a fly-back transformer 4, reference numeral (c) is an output current wave form of a fly-back transformer 4. When the direct current power supply 1 has been put to work, the pulse signal a, which is shown in Fig. 3 (a), duty controlled in approximately tens of KHz is inputted into the transistor 3 of the pulse power supply 2 so as to turn on, off the transistor 3 for flowing the pulse current onto the primary side of the fly-back transformer 4. Therefore, when the transistor 3 has been turned off, the pulse voltage shown in Fig. 3 (b) is generated in the forward direction of the diode 5 on the secondary side of the transformer 4. After the starting operation of the discharge lamp 8 by the high voltage pulse generating circuit 10, the current shown in Fig. 3 (c) flows into a transistor 11, a diode 15, a choke coil 7, a discharge lamp 8, a high voltage pulse generating circuit 10, a transistor 14, a diode 20 when the transistors 11, 14 are on with the output pulse voltage of the fly-back transformer 4. When the pulse current from the pulse power supply 2 runs out, the current flows through the closed loop of a discharge lamp 8, a high voltage pulse generating circuit 10, a transistor 14, a diode 20, a diode 17 by the accumulation ener-

gies of the choke coil 7 so as to retain the current of the discharge lamp. Further, the electric charge is stored by the current shunted into the capacitor 9 so that the current continuously flows into the discharge lamp 8. The pulse currents are inputted one after another so as to retain the lamp current. By the action of the choke coil 7, the capacitor 9, the diode 17, the pulse current continuously flows in one direction of the discharge lamp 8. Therefore, the ripples accompanied by the pulse currents may be made smaller.

After the pulse current has been flowed from the pulse power supply 2 for a plurality of times, the transistors 11, 14 are turned off, the transistors 12, 13 are turned on. The pulse current flows through a transistor 13, a diode 19, a high voltage pulse generating circuit 10, a discharge lamp 8, a choke coil 7, a transistor 12, a diode 16. Thus, the current flowing through the lamp is inverted, and also, continuously flows in one direction of the discharge lamp 8 by the action similar to that prior to the inversion. Further, the pulse current continuously flows in one direction of the discharge lamp 8 by the action of the choke coil 7, the capacitor 9, the diode 18. Therefore, the ripples accompanied by the pulse current may be made smaller.

In this manner, the pulse is inputted from the pulse power supply 2, the current direction is inverted by the current inverting means 6 so as to control the duty ratio of the pulse so that the current may become a constant value, so that an alternating current of a constant value of a low frequency lower than the frequency of the pulse, namely, a rectangular wave current of the low frequency may be flowed into the discharge lamp 8. Also, the ripples of the current may be made smaller by the choke coil 7, the capacitor 9 and so on.

The pulse generating circuit of Fig. 2 shows a basic circuit. It is needless to say that in addition to it, a circuit for stopping the pulses at the lamp lighting time, and so on are generally provided.

Also, the lighting control of the lamp may be effected with variation of the duty ratio of the pulse power supply 2, and of the oscillation frequency as in the present embodiment.

A circuit diagram of the essential portions of the power supply apparatus in a second embodiment of the present invention will be shown hereinafter in Fig. 4.

In the circuit of Fig. 4, the transistors 11, 13, the diodes 15, 19 are removed, and a second choke coil 7' is increased between the output end of the pulse power supply 2 and the transistor 12 through the comparison of the circuit of Fig. 1. The others are the same as in the embodiment of Fig. 1.

The operation of the construction of Fig. 4 will be described hereinafter. It is to be noted that the circuit portions the same as the circuit of Fig. 1 will be omitted in description thereof. After the starting operation of the discharge lamp 8 by the high voltage pulse

generating circuit 10, the current shown in Fig. 3 (c) flows into a choke coil 7, a discharge lamp 8, a high voltage pulse generating circuit 10, a transistor 14, a diode 20 through the diode 5 when the transistor 14 is on with the output pulse voltage of the fly-back transformer 4. When the pulse current from the pulse power supply 2 runs out, the current flows through the closed loop of a discharge lamp 8, a high voltage pulse generating circuit 10, a transistor 14, a diode 20, a diode 17, a choke coil 7' by the accumulation energies of the choke coil 7 so as to continue the current of the discharge lamp 8. Further, the electric charge is stored by the current shunted into the capacitor 9 so that the current continuously is flowed thereby into the discharge lamp 8. The pulse currents are inputted one after another so as to retain the lamp current. By the action of the choke coil 7, the capacitor 9, the diode 17, the pulse current continuously flows in one direction of the discharge lamp 8. Therefore, the ripples accompanied by the pulse currents may be made smaller.

After the pulse current has been flowed from the power supply 2 for a plurality of times, the transistor 14 is turned off, the transistor 12 is turned on. The pulse current flows through a choke coil 7', a transistor 12, a diode 16. When the pulse current from the pulse power supply 2 runs out, the current flows through the closed loop of a transistor 12, diodes 16, 18, a high voltage pulse generating circuit 10, a discharge lamp 8, a choke coil 7 by the accumulation energies of the choke coil 7' so as to flow the current of the reverse direction into the discharge lamp. Further, the electric charge is stored by the current shunted into the capacitor 9 so that the current continuously flows into the lamp. Thus, when the transistor 14 is on, the current flowing through the lamp is inverted, and also, continuously flows in one direction of the discharge lamp 8 by the action similar to that prior to the inversion. Further, the pulse current continuously flows in one direction of the discharge lamp 8 by the action of the choke coils 7, 7' the capacitor 9, the diode 18. Therefore, the ripples accompanied by the pulse current may be made smaller.

In this manner, the pulse is inputted from the pulse power supply 2, the current direction is inverted by the current inverting means 6 so as to control the duty ratio of the pulse so that the current may become a constant value, so that an alternating current of a constant value of a low frequency lower than the frequency of the pulse, namely, a rectangular wave current of the low frequency may be flowed into the discharge lamp 8. Also, the ripples of the current may be made smaller by the choke coil 7, the capacitor 9 and so on. Especially, in the embodiment of Fig. 4, by the action near the voltage lowering chopper by the pulse power supply 2, the transistor 14, the choke coil 7, the diode 17, and the action near the inversion chopper by the pulse power supply 2, the transistor

12, the choke coil 7', the diode 18, the rectangular wave current may be flowed into the discharge lamp 8, so that the discharge lamp 8 may be lighted in the rectangular wave by the transistor less as compared with in the first embodiment.

A circuit diagram of the essential portions of the power apparatus in a third embodiment of the present invention will be described hereinafter with reference to Fig. 5. In the circuit of Fig. 5, the transistors 11, 12, the diodes 15 through 20 are removed through the comparison of the circuit of Fig. 1. The secondary winding of the fly-back transformer 4' of the pulse power supply 2' becomes a winding with center tap attached to it, and the diodes 5 and 5' are connected with each other so that the positive, negative outputs may be provided, at both the ends of the winding, with respect to the center taps. The others are the same as in the embodiment of Fig. 1.

The operation of the construction of Fig. 5 will be described hereinafter. It is to be noted that the circuit portions the same as the circuit of Fig. 1 will be omitted in description thereof. The signal a shown in Fig. 3 (a) is inputted, and the transistor 3 turns on, off. The pulse power supply 2' outputs the positive, negative pulses with respect to the center tap through the diodes 5, 5'. The transistors 13, 14 alternately turns on, off with the frequency lower than the generated pulse of the pulse power supply 2'. After the starting operation of the discharge lamp 8 by the high voltage pulse generating circuit 10, the current shown in Fig. 3 (c) flows into a transistor 13, a high voltage pulse generating circuit 10, a discharge lamp 8, a choke coil 7 through a diode 5 when the transistor 13 is on with the output of the pulse power supply 2'. When the pulse current from the pulse power supply 2' runs out, the current flows through the closed loop of a secondary winding of a transformer 4', a diode 5, a transistor 13, a high voltage pulse generating circuit 10, a discharge lamp 8 by the accumulation energies of the choke coil 7 so as to continue the current of the discharge lamp 8. Further, the electric charge is stored by the current shunted into the capacitor 9 so that the current continuously is flowed thereby into the discharge lamp 8. The pulse currents are inputted one after another so as to retain the lamp current. By the action of the choke coil 7, the capacitor 9, the pulse current continuously flows in one direction of the discharge lamp 8. Therefore, the ripples accompanied by the pulse currents may be made smaller.

After the pulse current has been flowed from the power supply 2' for a plurality of times, the transistor 13 is turned off and the transistor 14 is turned on. The pulse current flows through a choke coil 7, a discharge lamp 8, a high voltage pulse generating circuit 10, a transistor 14, a diode 5' from the center tap of the fly-back transformer 4'. Thus, the current flowing through the lamp is inverted, and also, continuously flows in one direction of the lamp as before the inversion.

Further, the pulse current continuously flows in one direction of the lamp by the actions of the choke coil 7, the capacitor 9. Therefore, the ripples accompanied by the pulse current may be made smaller.

In this manner, the pulse is inputted from the pulse power supply 2', the current direction is inverted by the current inverting means 6 so as to control the duty ratio of the pulse so that the current may become a constant value, with a result that an alternating current of a constant value of a frequency lower than the frequency of the pulse, namely, a rectangular wave current of the low frequency may be flowed into the discharge lamp 8. Also, the ripples of the current may be made smaller by the choke coil 7, the capacitor 9 and so on.

A circuit diagram of the essential portions of the power apparatus in a fourth embodiment of the present invention will be described hereinafter in Fig. 6. In the circuit of Fig. 6, there are differences through the comparison with the circuit of Fig. 5 in that the secondary winding of the transformer 4'' of the pulse power supply 2'' is different in polarity, the diodes 21, 22 are connected in parallel to the output end with the polarity being set. The others are the same as in the embodiment of Fig. 5.

The operation of the construction of Fig. 6 will be described hereinafter. It is to be noted that the description will be omitted about the circuit portions the same as in the circuit of Fig. 5. By the change in the polarity of the transformer 4'' and also, the provision of the diodes 21, 22 in this manner, the pulse current is adapted to flow through the diodes 5, 5' at the on of the transistor 3. When the pulse current from the pulse power supply 2'' has run out at the off of the transistor 3, the current is adapted to flow through the closed loop of the transistors 13, 14, the high voltage pulse generating circuit 10, the discharge lamp 8 through the diodes 21, 22 without flowing of the accumulated energies of the choke coil 7 through the secondary winding of the transformer 4'', the diodes 5, 5'. Thus, the lamp current is retained, so that the ripple current may be made smaller. Also, the loss at the transformer 4'' may be prevented as it does not pass through the transformer 4''.

The circuit diagram of the essential portions of the power apparatus in a fifth embodiment of the present invention will be described hereinafter. In the circuit of Fig. 7, there are differences through the comparison with the circuit of Fig. 6 in that both the primary, secondary windings of the transformer 26 of the pulse power supply 23 are attached with a center tap, push-pull operation may be effected with transistors 24, 25 being connected on the primary side, the full waves are rectified with the diodes 27 through 30 being connected onto the secondary side. The others are the same as in the embodiment of Fig. 6.

The operation of the construction of Fig. 7 will be described hereinafter. The description is omitted

about the circuit portions the same as in the circuit of Fig. 6. By the push-pull operation of the transformer 26, and also, the full wave rectification including the center tap of the transformer 26 with the diodes 27 through 30 being connected, the pulse current flows through the diodes 27 through 30 when the either of the transistors 24, 25 is on. When the pulse current from the pulse power supply 23 has run out at the off in both the transistors 24, 25, the accumulated energies of the choke coil 7 are adapted to flow through the closed loop of the transistors 13, 14, the high voltage pulse generating circuit 10, the discharge lamp 8 through the secondary winding of the transformer 26, the diodes 27 through 30. Thus, the lamp current is maintained so that the ripple current may be made smaller.

The circuit diagram of the essential portions of the power apparatus of a sixth embodiment of the present invention will be described hereinafter in Fig. 8. In the circuit of Fig. 8, there are differences through comparison of the circuit of Fig. 1 in that the transistors 11, 13, the diodes 5, 15, 19, the choke coil 7 are removed, the transistor 3' is increased, the primary winding of the fly-back transformer 4A of the pulse power supply 2A is attached with a center tap, the output end of the direct current power supply 1 is connected with the center tap, the transistors 3, 3' are connected with both the ends of the primary winding of the fly-back transformer 4A. The others are the same as in the embodiment of Fig. 1.

The operation of the construction of Fig. 8 will be described hereinafter. It is to be noted that the description is omitted about the circuit portions the same as in the circuit of Fig. 1. The pulse voltage generating operation by the fly-back transistor 4A of the circuit of Fig. 8 is similar to that of the circuit of Fig. 1. When one of the transistors 3, 3' is put into the high frequency switching operation with the other being off, the current flows to one of the primary windings N1, N1' of the fly-back transformer 4A. When the transistor 3 is put into the high frequency switching operation, the transistor 12 is turned on, and the transistor 14 is turned off. When the transistor 3' is put into the high frequency switching operation, the transistor 14 is turned on, and the transistor 12 is turned off. When the transistor 3 is put into the high frequency switching operation, the pulse voltage is generated in the secondary winding in the forward direction of the transistor 12. When the transistor 3' is put into the high frequency switching operation, the pulse voltage is generated in the secondary winding in the forward direction of the transistor 14. When these transistors 3, 3' alternately effects the high frequency switching operation intermittently so as to intermittently generate the pulse voltage in the direction reverse to each other in accordance with these operations, the voltage to be inputted into the discharge lamp 8 is inverted, so that the current in the direction reverse to each other flows

to the discharge lamp 8. The electric charge is accumulated by the current shunted into the capacitor 9 is accumulated. Also, the current continuously flows to the discharge lamp 8 by the inductance of the pulse transformer of the high voltage pulse generating circuit 10. As the intermittent high frequency switching operation of the transistors 3, 3' is effected alternately with the low frequency in this manner, the discharge lamp 8 may be lighted with the low frequency alternating current.

In this manner, the pulse is inputted from the pulse power supply 2A, the current direction is inverted by the current inverting means 6 so as to control the duty ratio of the pulse so that the current may become a constant value, so that an alternating current of a constant value of a frequency lower than the frequency of the pulse, namely, a rectangular wave current of the low frequency may be flowed into the discharge lamp 8. Also, the ripples of the current may be made smaller by the capacitor 9 and so on.

The wave form chart for illustrating the operation of the circuits in a first embodiment through a sixth embodiment of the present invention will be described in Fig. 9. In Fig. 9, reference characters (i), (j) respectively show currents flowing to transistors, in a direction different from each other, of the inverting means. In this manner, the pulse current flows to the load in a direction opposite to each other, is smoothed by a capacitor provided in parallel to the load, a choke coil provided in series, and so on, and becomes such an alternating current wave form as shown in the (k). The timing of the alternating inversion of Fig. 9 (k), namely, the inversion of the current inverting means is effected when the pulse is not generated as in the i1, i2 or the output is small if it is generated, so that the switching loss of the inverting circuit may be made smaller.

The circuit diagram of the essential portions of the power apparatus in a seventh embodiment of the present invention will be shown hereinafter in Fig. 10. In the circuit of Fig. 10, there are differences through the comparison with the circuit of Fig. 5 in that the direct current power supply 31 has the positive, negative outputs with capacitors 32, 33 being provided in the output of the pulse power supply 2', diodes 34, 35 are provided in reverse parallel to the transistors 13, 14. The others are the same as in the embodiment of Fig. 5.

The operation of the construction of Fig. 10 will be described hereinafter. It is to be noted that the description is omitted about the circuit portion the same as in the circuit of Fig. 5. As the direct current power supply 31 is constructed like this, the output becomes the positive, negative direct current voltage. When it is alternately replaced at a long period with one being turned on, off with the high frequency pulse, the other being turned off as shown in Fig. 11 (f), (g), such rectangular wave current shown as in Fig. 11 (h) flows to the discharge lamp 8 through the choke coil 7, the

high voltage pulse generating circuit 10. When the transistors 13, 14 are off, the current flows from the choke coil 7 into the discharge lamp 8 through the capacitors 32, 33, the diodes 34, 35 so as to continue the lamp current. By this way, the driving operation of the transistors 13, 14 may be effected with the high frequency, and the drive transformer may be made smaller in shape.

The circuit diagram of the essential portions of the power apparatus of an eighth embodiment of the present invention will be described hereinafter in Fig. 12. In the circuit of Fig. 12, a forward type of direct current power supply 36, instead of the direct current power supply 31 of the circuit of Fig. 10, is provided. Also, the circuit diagram of the essential portions of the power apparatus in a ninth embodiment of the present invention will be described in Fig. 13. In the circuit of Fig. 13, a push-pull type of direct current power supply 37 using a transformer 26', instead of the direct current power supply 31 of the circuit of Fig. 10, is provided. The same effect is provided if the positive, negative direct current outputs are obtained.

The circuit diagram of the essential portions of the power apparatus in a tenth embodiment of the present invention will be shown hereinafter in Fig. 14. In the circuit of Fig. 14, there are differences through the comparison with the circuit of Fig. 1 in that the inverter, instead of a pulse power supply 2, is provided as an alternating power supply having the positive, negative alternating outputs, a rectifying circuit, instead of a current inverting means, connected with the output of the inverter, having the positive, negative rectifying output circuit, and having a switch element where one of the positive, negative outputs is stopped with a control signal with the positive, negative output ends being reversibly connected with respect to each other. The others are the same as in the embodiment of Fig. 5 except for the absence of the choke coil 7. In Fig. 14, reference numeral 100 is a series resonance type of inverter, which is driven by the direct current power supply 1 so as to output the resonance voltage of the high frequency. The series resonance type inverter 100 is composed of a series circuit of transistors 11, 12 connected with the output of the direct current power supply 1, a series circuit of the choke coil 101 and the capacitor 102 connected in parallel with the transistor 12, with the capacitor 102 becoming the output end. Also, reference numeral 103 is a rectifying circuit, which is composed of a voltage doubler circuit of the negative output composed of a capacitor 104, diodes 105, 106, a transistor 13 which is a switch element for stopping the negative output, a voltage doubler circuit of the positive output composed of a capacitor 107, diodes 108, 109, a transistor 14 which is a switch element for stopping the positive output. The inputs of the respective voltage doubler circuit are common, the outputs are connected to become reverse in positive and negative, and the transistors

13, 14 are respectively connected in the forward direction with the diodes 105, 108.

The operation of the construction of Fig. 14 will be described hereinafter. It is to be noted that the description is omitted about the circuit portions the same as in the circuit of Fig. 5. The series resonance type of inverter 100 is driven by the direct current power supply 1 and the transistors 11, 12 are put into the high frequency switching operation so as to output the resonance voltage of the high frequency into the capacitor 102 by the series resonance of the choke coil 101 and the capacitor 102. When the transistor 103 is on, and the transistor 14 is off at this time, the negative voltage is outputted into the capacitor 9 through the capacitor 104, the diodes 105, 106. Although the current flows through the diode 109 to the capacitor 107 as the transistor 108 is off, the current does not flow any more when the electric charge is stored, so that the positive output into the capacitor 9 is not provided. Therefore, only the negative voltage is outputted to the capacitor 9 from the rectifying circuit 103. Similarly, when the transistor 13 is off, the transistor 14 is on, only the positive voltage is outputted to the capacitor 9 from the rectifying circuit 103. In this manner, the transistors 13, 14 are alternately turned on, off, so that the positive, negative voltages may be outputted to the capacitor 9, the capacitor lamp 8 may be lighted with the alternating current.

By the frequency control or the PWM control of the inverter so that the output current of the inverter may become a constant value, the alternating current of the given constant value of the low frequency lower than the oscillation frequency of the inverter, namely, the rectangular wave current of the low frequency may be flowed to the discharge lamp 8. The circuit may be made smaller in size by the use of the inverter of the high frequency in this manner. Also, the inversion of the current flowing into the discharging lamp may be effected by two transistors, thus resulting in simplified circuit. Although a series resonance type of inverter is provided by way of example as an inverter, it is needless to say that the other inverters such as one stone of inverter, push-pull inverter, half bridge inverter, bridge inverter and so on in addition to it may be used.

The circuit diagram in the other embodiment of the rectifying circuit in an embodiment of Fig. 14 of the present invention will be shown hereinafter in Fig. 15. In the circuit of Fig. 15, there are difference through the comparison with the circuit of Fig. 14 in that a rectifying circuit has the positive, negative four times voltage rectifying output circuit with capacitors 104', 107', 9', diodes 105', 106', 108', 109', transistors 13', 14' being increased, has a switching element for stopping one of the positive, negative outputs with a control signal, with the positive, negative output ends being oppositely connected with respect to each other. The others are the same as in the embodiment of Fig. 5. Therefore, except for a fact that the output becomes

twice as much, the negative voltage is outputted to the capacitors 9, 9' when the transistors 13, 13' are on, the transistors 14, 14' are off as in the embodiment of Fig. 5, the positive voltage is outputted to the capacitors 9, 9' when the transistors 14, 14' are on, the transistors 13, 13' off. Although the above description shows that the positive, negative rectifying circuit is the examples of double voltage, four times voltage, the circuit will do if it is a rectifying circuit for outputting the positive, negative voltages through inputting of the alternating current voltages respectively by the positive and the negative. In addition, the circuit may be, needless to say, the positive, negative N times rectifying circuit.

The circuit diagram in the embodiment of a frequency control means of a current inverting means of the power apparatus of the present invention will be shown hereinafter in Fig. 16. In the circuit of Fig. 16, reference numeral 8 is a discharge lamp, reference numeral 110 is a lamp voltage detecting means, reference numeral 111 is a frequency control means. The lamp voltage detecting means 110, which is composed of a resistor, a diode, a capacitor, is connected with both the ends of the discharge lamp 8 so as to input the lamp voltage and output a signal corresponding to the lamp voltage. The frequency control means 111 is composed of an inversion amplifying circuit 112, a constant-current circuit 113, a switching regular control IC114, a capacitor 115. As the inversion amplifying circuit 112 receives the output of the lamp voltage detecting means 110, further inputs the negative bias voltage VA, the positive high voltage is outputted when the lamp voltage is low and the output becomes lower as the lamp voltage becomes higher. The constant-current circuit 113 inputs the output voltage of the inversion amplifying circuit 112 so as to draw larger current by the output transistor when the lamp voltage is lower, and to draw the smaller current as the lamp voltage becomes higher. As the switching regular control IC114 is larger in suction current when the lamp voltage is low in accordance with the increase, decrease in the suction current of the constant-current circuit 113, the charging current of the timing capacitor 115 for determining the oscillation frequency increases to make the oscillation frequency higher. As the suction current becomes smaller as the lamp voltage becomes higher, the charging current of the timing capacitor 115 for determining the oscillation frequency decreases so as to make the oscillation frequency lower.

In this manner, the oscillation frequency, namely, the inversion frequency of the current inverting means may be changed in accordance with the lamp voltage. By this fact, when the lamp voltage is low, the frequency of the alternating current flowing to the discharge lamp is made higher so as to increase the impedance of the inductance for the choke coil, the transfer and so on provided in series with the dis-

charge lamp so as not to lower the output voltage of the power supply. When the lamp voltage is low at the starting time of the discharge lamp, the discharge lamp may be prevented from being turned off. As the inductance of the pulse transformer functions as in the choke coil, it is needless to say that it may be substituted.

The circuit diagram in the embodiment of a current control means of the power apparatus of the present invention will be shown hereinafter in Fig. 17. In the circuit of Fig. 17, reference numeral 120 is a sine wave signal circuit, reference numeral 121 is a resistor connected with the output of a sine wave signal circuit 120, reference numeral 122 is a photo coupler connected with the sine waver signal circuit through a resistor 121, reference numeral 123 is a resistor for receiving the output of the photo coupler 122 so as to generate a signal with the sine wave signal being rectified in the full wave, reference numeral 124 is a pulse generating circuit for receiving a signal generated by the resistor 123 so as to generate the pulse signal larger in duty ratio as the amplitude thereof is larger, reference numeral 125 is a comparator which is adapted to receive the output of the sine wave signal circuit 120 so as to output a signal of positive when the output is positive, a signal of 0 when the output is negative, reference numeral 126 is an inverter which is adapted to receive the output of the comparator 125 so as to invert the signals of the positive and 0.

The operation of the current control means will be described hereinafter. When the current flows to the photo coupler 122 thorough the resistor 121 by the output of the sine waver signal signal circuit 120, the current flows to the output transistor so as to generate the voltage, which has made the full-wave rectification of the sine wave, in the resistor 123. After receiving the voltage, the pulse generating circuit 124 outputs the pulse a. At this time, the pulse a to be generated becomes a pulse which becomes larger in duty ratio as the voltage is higher in accordance with the height of the voltage of the resistor 123. The comparator 125 outputs pulse signals b', e' which become positive only at the time of the positive in the sine wave. The inverter 126 outputs the inverted signals c', d' of the signals. When these signals a, b', c', d' e' are inputted to the a, b, c, d, e in the embodiment of, or example, Fig. 1, the current inverting means operates so that the positive, the negative may be inverted at the timing of 0 of the sine wave signal circuit output. On the other hand, as the a becomes the widest pulse at the peak of the sine wave of the sine wave signals circuit, the output of the pulse power supply becomes wider and the pulse of the voltage becomes higher. Therefore, the current flowing to the load also becomes peak at the same time, and becomes the least current at the inversion time of the current inverting means. Thus, the current flowing to the load also becomes closer to the approximately sine wave. In order to

strictly make the current flowing to the load the sine waver, there is a method of detecting the current flowing to the load, comparing the signal with the signal of the sine wave signal circuit, and controlling the duty ratio of the pulse by the comparison of the current amount with the signal. The current flowing to the load is made the sine waver in this manner, so that the switching loss of the switching element of the current inverting means at the current inversion time may be reduced, so that the power supply apparatus may be made smaller in size. In order to drive the power apparatus with the direct current power supply for rectifying, operating the alternating power supply, effect the smoothing operation with the use of the capacitor of small capacity at the location of the direct current power supply with the load current being made sine wave, and the input power-factor from the alternating power supply may be increased, and also, the input higher harmonic current may be reduced.

In the above described pulse power supply, the current ripple may be reduced if the choke coil is not provided for the inductance of the transformer itself in the case of the fly-back shape. In the shape of the push-pull shape, it is needless to say that the inductance operation may be provided by the use of the transformer of the leakage shape, and the circuit may be simplified. Also, a chopper circuit such as boosting type chopper, inverting type chopper or the like may be used as the pulse power supply. In this case, the size may be made smaller as the transformer is not used. Also, the inductance may be provided for the high voltage pulse transformer. Also, it is needles to say that the rectifying current may be rectified, or further smoothed in the direct current power supply.

Although a field effect transistor is used by example as a switch element, the other switch element with control terminal attached to it such as a bipolar transistor, SI transistor or the like may be used.

Although a discharge lamp was used as the load in the embodiment, the other load such as resistor or the like in addition to it may be used. Also, it may be connected with a condenser of small capacity with which the output of pulse source becomes a kind of pulse output.

As is clear from the foregoing description, according to the arrangement of the present invention, the rectangular wave current may be flowed to the load, especially the lamp in a simple circuit, the voltage . current of the load may be easily controlled by the variation in the pulse power supply oscillation frequency or the duty ratio. Also, the voltage . current of the load, especially the discharge lamp may be reduced in ripple, and the acoustic resonance phenomenon of the lamp and the noises may be prevented. In addition, the number of the switching elements may be reduced, and the driving circuit for driving the switching element may be constructed smaller in size.

Although the present invention has been fully described by way of example with reference to the accompanying drawings, it is to be noted here that various changes and modifications will be apparent to those skilled in the art. Therefore, unless otherwise such changes and modifications depart from the scope of the present invention, they should be construed as included therein.

Claims

(1) A power apparatus comprising a direct current power supply, a pulse power supply which is driven by the direct current power supply so as to output pulses, a current inverting means which is connected with the output of the output of the pulse power supply so as to inverse the output current, a load connected with the output of the current inverting means, a capacitor connected in parallel to the above described load, characterized in that the output of the current inverting means is adapted to be inverted with the frequency lower than the frequency of the pulse to be outputted by the above described pulse power supply.

(2) A power apparatus described in accordance with the claim 1, where a pulse power supply is provided with a fly-back transformer.

(3) A power apparatus described in accordance with the claim 1, where a pulse power supply is provided with a means which is adapted to vary an oscillation frequency or a duty ratio so as to control the current to flow into a load.

(4) A power apparatus described in accordance with the claim 1, where a choke coil is provided between a current inverting means and a parallel circuit of a load and a capacitor.

(5) A power apparatus described in accordance with the claim 1, where the current inverting means is a bridge inverter, which is provided with a means for driving the above described switch element so that the inverter may be inverted with a frequency lower than a frequency of the pulse to be outputted by the above described pulse power supply with the diodes being connected in opposite parallel to a pair of switch elements connected with the positive output side or the negative output side of the pulse power supply at least from among the switch elements for composing the bridge inverter.

(6) A power apparatus described in accordance with the claim 1, where the current inverting means is provided with a first switch element connected with the output end of the pulse power supply through a parallel circuit of the load and the capacitor, and a series circuit with respect to a first choke coil, a second switch element to be connected with the output end of the above described pulse power supply through a second choke coil, a means which is adapted to form a first closed loop circuit that flows into the

load the accumulation energies of the above described first choke coil when the pulse of the above described pulse power supply is off, the above described first switch element is on, the above described second switch element is off, to form a second closed loop circuit that flows into the load the accumulation energies of the above described choke coil when the pulse of the above described pulse power supply is off, the above described first switch element is off, the above described second switch element is off so as to drive the above described first switch element and second switch element for alternately turning on, off with a frequency lower than the frequency of the pulse outputted by the above described pulse power supply.

(7) A power apparatus described in accordance with the claim 1, where the pulse power supply is provided with a reference output terminal, a pair of positive output terminal, negative output terminal for outputting the positive pulses, the negative pulses, a current inverting means is provided with two switch elements connected between the positive output terminal and the negative output terminal, with a parallel circuit of the load and the capacitor being connected between the reference output terminal and the connection point of the two switch elements, the above described current inverting means is provided with a means for driving the above described two switch elements so as to alternately turn on, off with a frequency lower than the frequency of the pulse to be outputted by the pulse power supply.

(8) A power apparatus described in accordance with the claim 1, where the pulse power supply is provided with a primary winding with the center tap being connected with one end of the above described direct current power supply, a pair of switching elements which are connected between the other end of the above described alternating current power supply and both the ends of the primary winding of the above described transformer so as to alternately effect the intermittent high frequency switching operation, a series circuit of the switch circuit and the load to prevent the voltage from being caused in the secondary winding of the transformer when one of the above described switching elements has been turned on in accordance with the control signal with the secondary winding of the above described transformer being connected, to flow the energies in the opposite direction, when the magnetic energies are accumulated in the transformer to twitch off, to effect the positive, negative inverting operation of the flowing direction in accordance with the replacement of the intermittent frequency switching operation, the alternating current of a frequency lower than the high frequency switching frequency is adapted to flow by the alternate operation of the intermittent high frequency switching action of the switching element.

(9) A power apparatus described in accordance with the claim 1, where the current inverting means is

provided with a control circuit for outputting an inverting signal when the pulse output of the pulse power supply is not provided or is small.

(10) A power apparatus comprising a direct current power supply provided with a reference output terminal, a pair of positive output terminal, negative output terminal for outputting the positive voltage, the negative voltage, a current inverting means provided with two switch elements connected between the positive output terminal and the negative output terminal, a series circuit of a parallel circuit of the load and the capacitor connected between the reference output terminal and the connection point of two switch elements, and a first choke coil, the above described current inverting means is provided with a means for driving the two switch elements so that one of two switch elements may be turned off, the other is put into the high frequency switching operation, and the switching operation may be alternately effected at a long period.

(11) A power apparatus comprising a direct current power supply, an inverter connected with the output of the direct current power supply, a rectifying circuit having positive, negative rectification outputting circuit with the output of the inverter being connected, a switch element for stopping one of the positive, negative outputs with the control signal with the positive, negative output terminals being reversibly connected with respect to each other, a means for driving the above described switch element so that the current flowing to the load by the control signal may be inverted with a frequency lower than the oscillation frequency of the above described inverter.

(12) A power apparatus described in accordance with the claim 11, where the rectifying circuit is respectively a unit of positive, negative half-wave N times voltage rectifying circuits for the positive, the negative, a semiconductor switch element is connected in series with the diode of the rectifying circuit.

(13) A power apparatus described in accordance with the claim 12, where the load is a discharge lamp, with the inversion frequency of the current inverting means is made a frequency lower than the maximum frequency where the discharge lamp does not cause the acoustic resonance phenomenon.

(14) A power apparatus described in accordance with the claim 13, where a lamp voltage detecting means, a frequency control means which is adapted to vary the frequency of the alternating current flowing into the discharging lamp in accordance with the output of the above described lamp voltage detecting means are provided, the discharge lamp is connected with the current inverting means through inductances such as choke coil, transformer and so on, the frequency of the alternating current flowing to the discharge lamp is made higher when the lamp voltage is low so as to raise the impedance of the above described choke coil.

(15) A power apparatus described in accordance with the claim 14, where a current control means is provided with a sine wave signal circuit so as to effect the current control operation, synchronizing with the frequency of the current inverting means so that the alternating current output current may become the sine wave.

Fig. 1

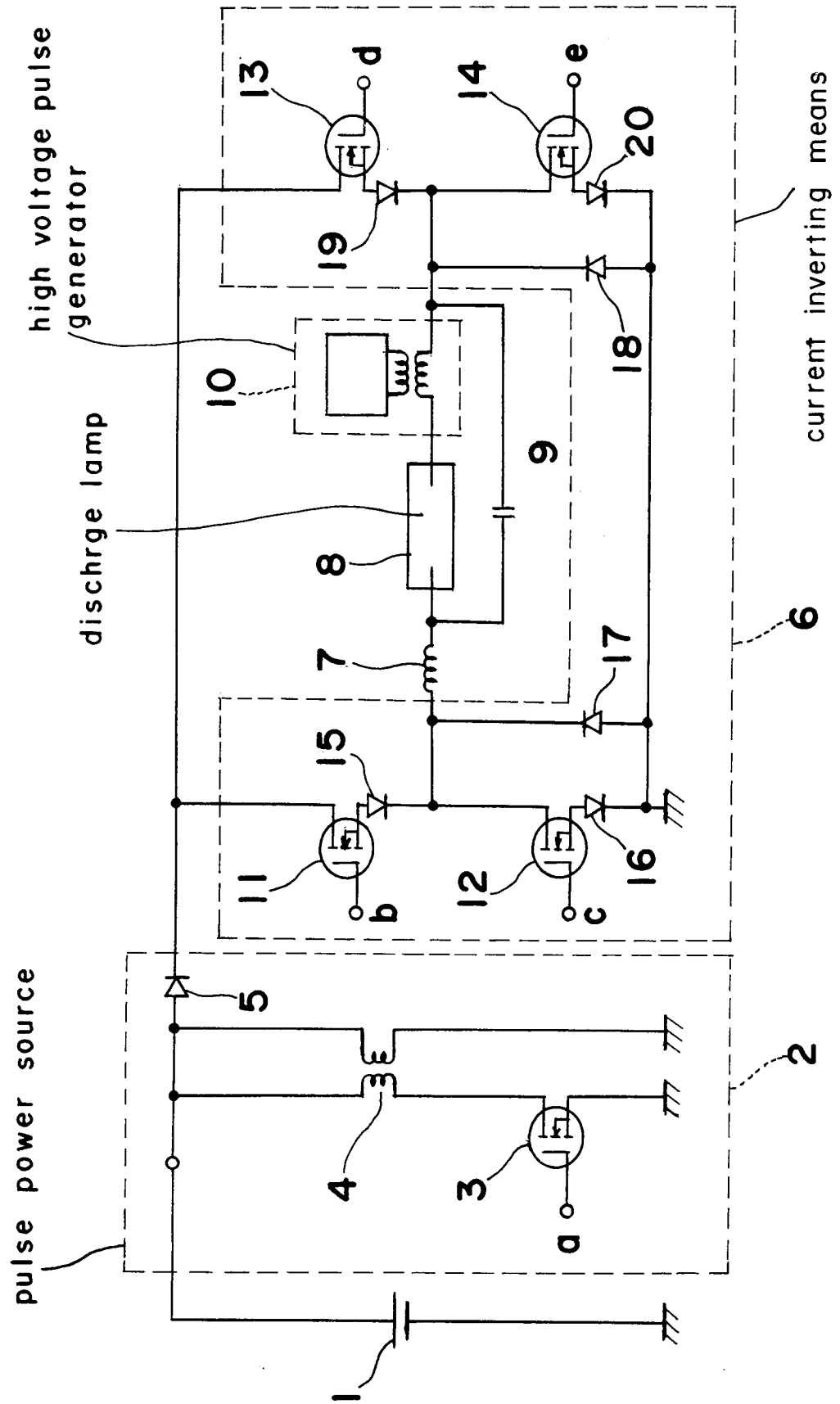


Fig. 2

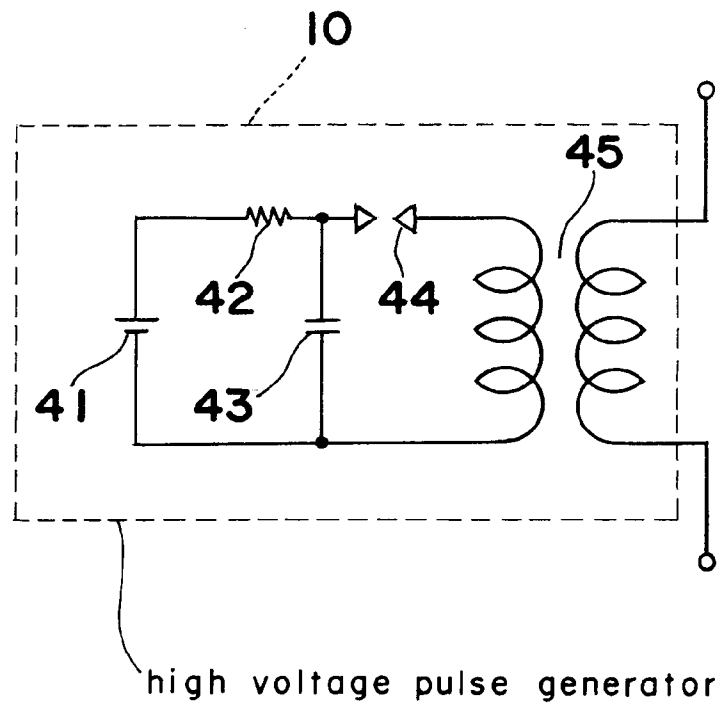


Fig. 3

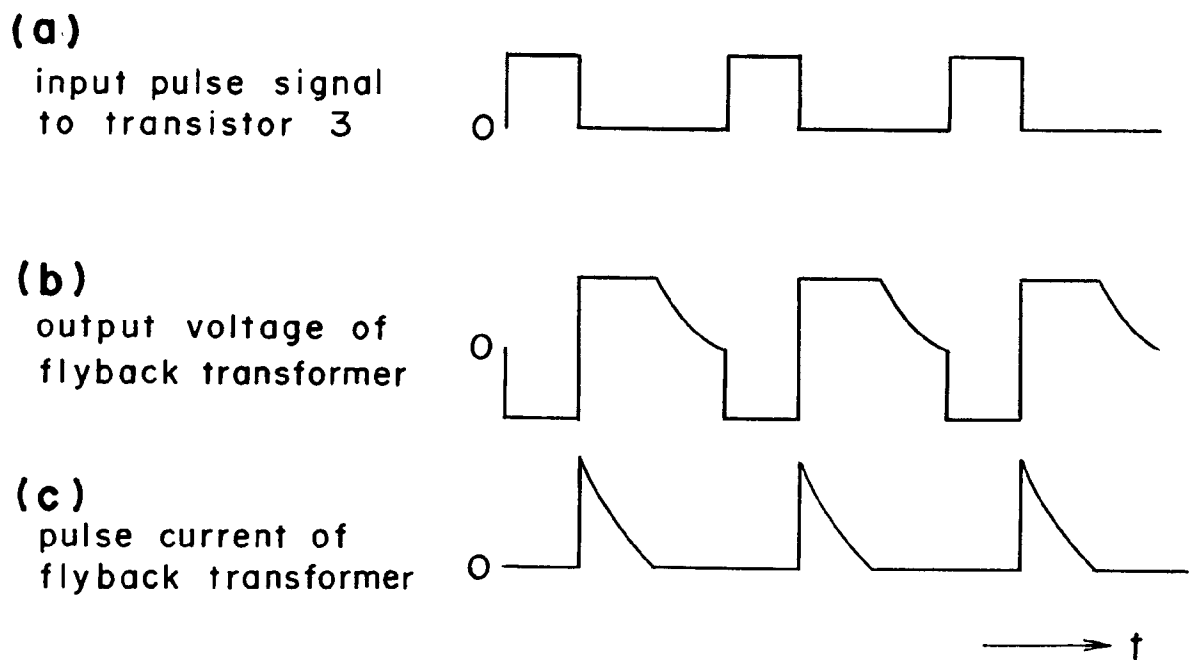


Fig. 4

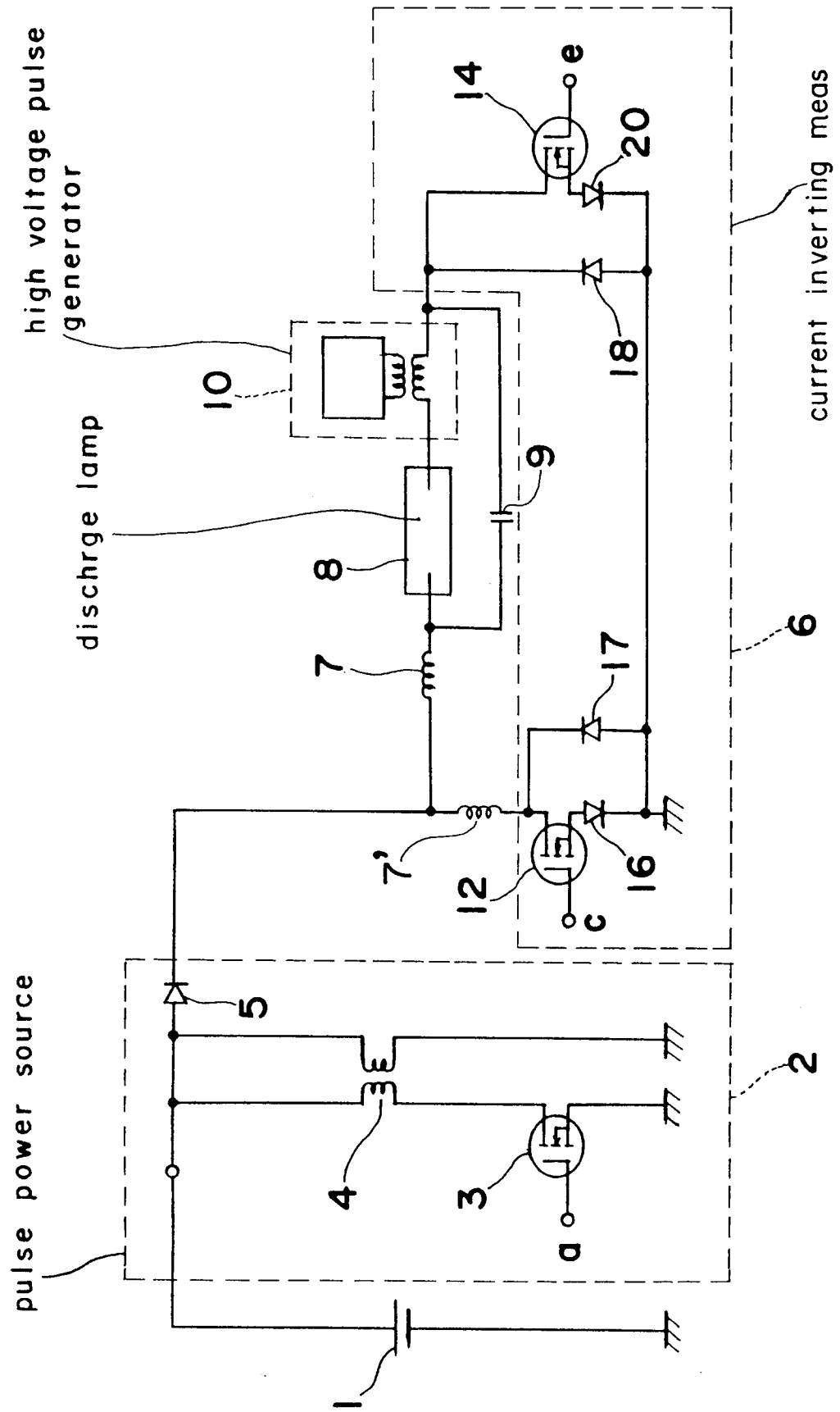


Fig. 5

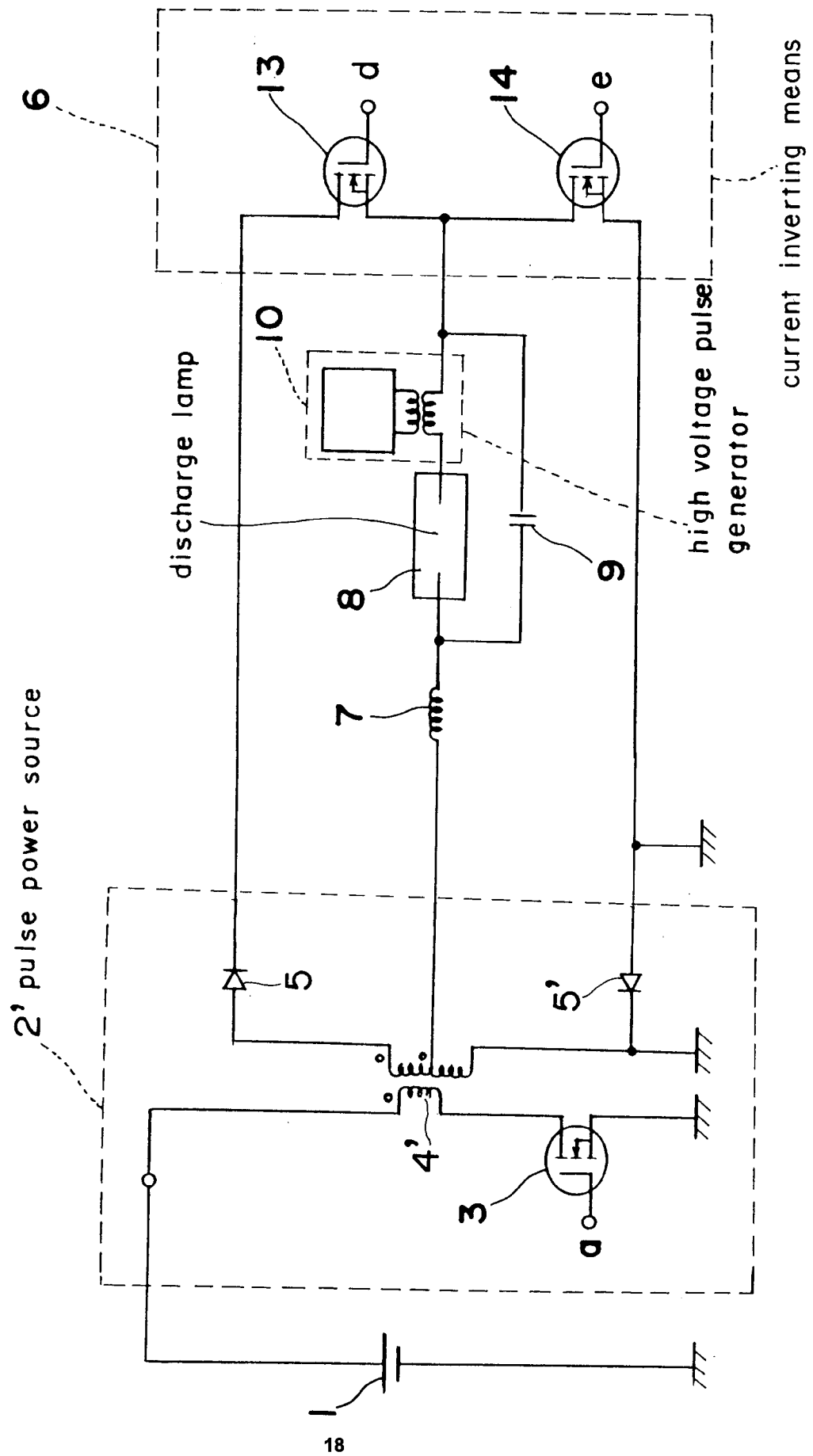


Fig. 6

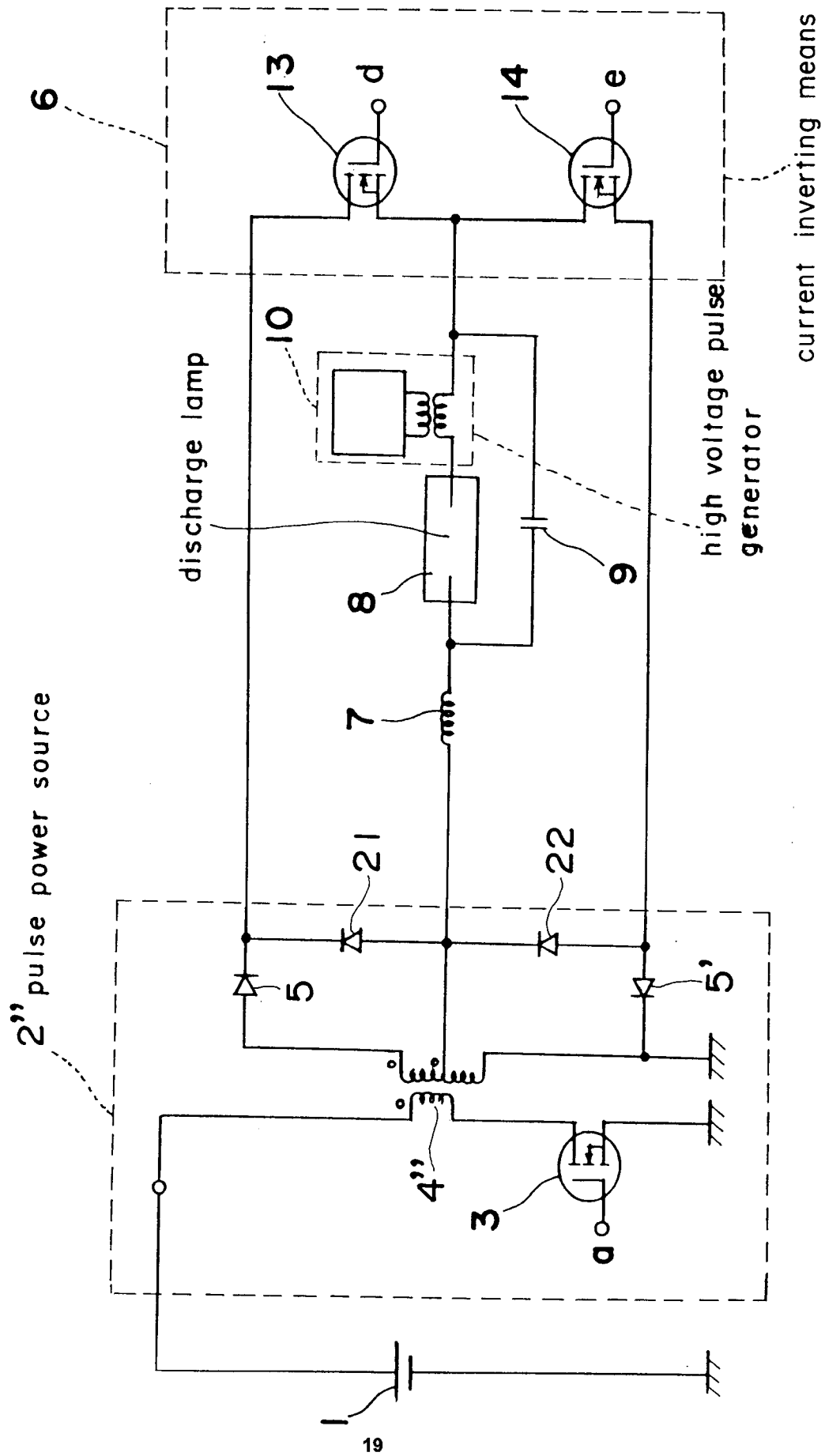


Fig. 7

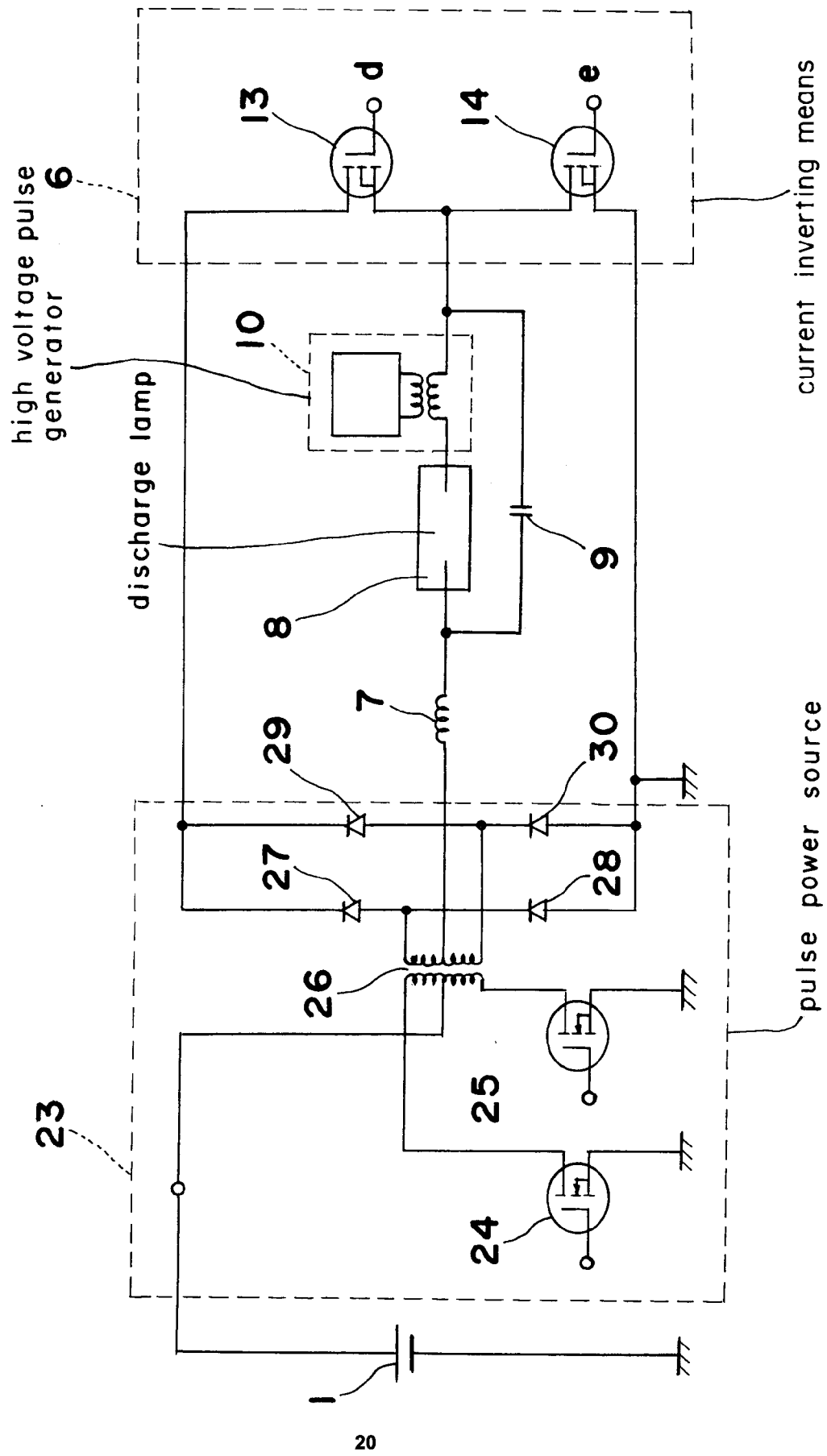


Fig. 8

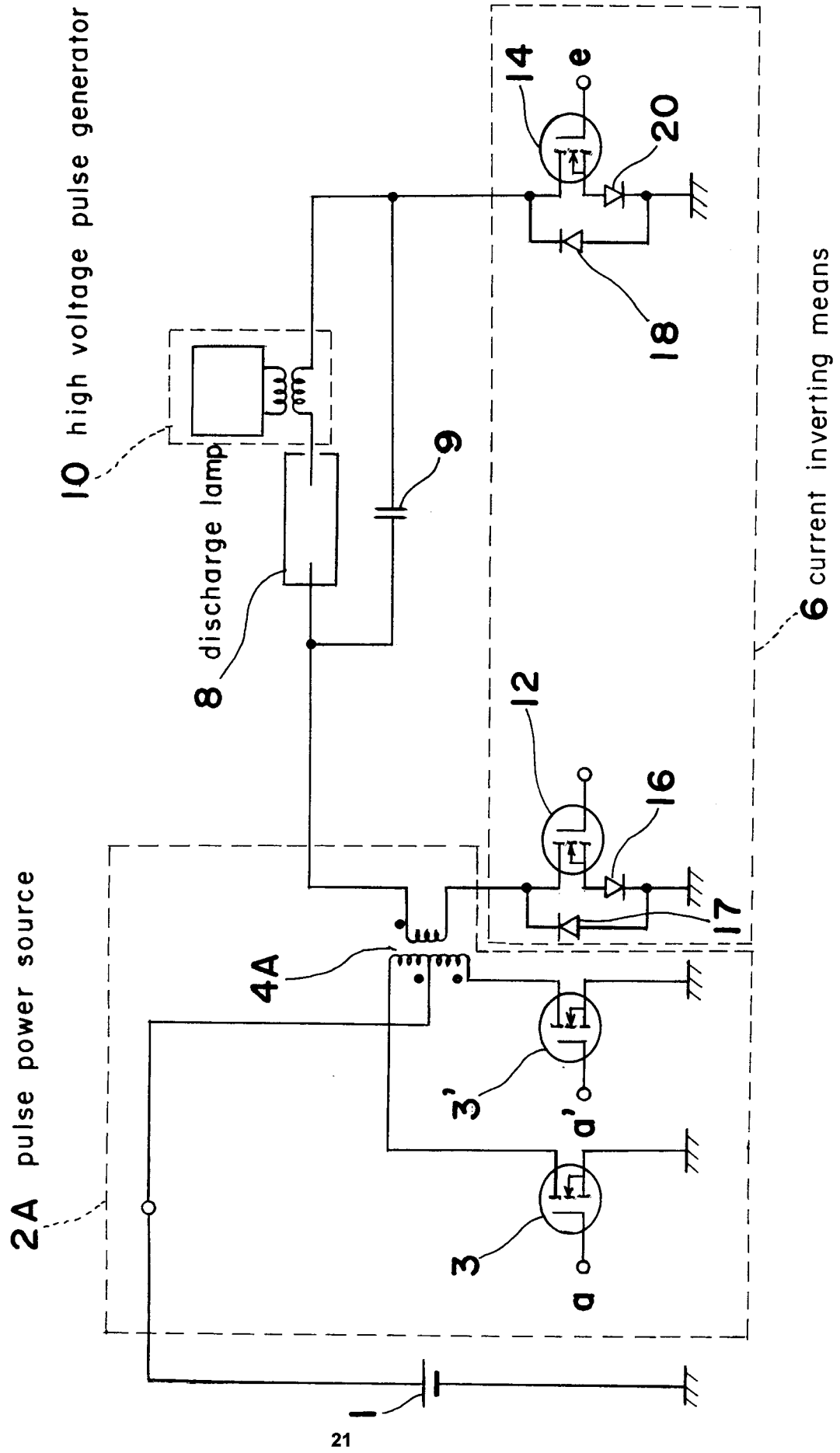


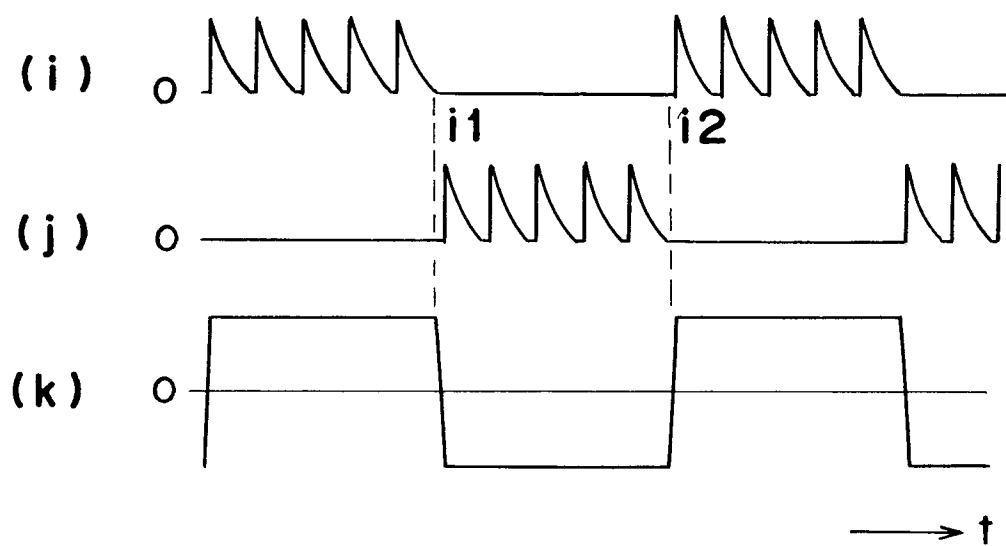
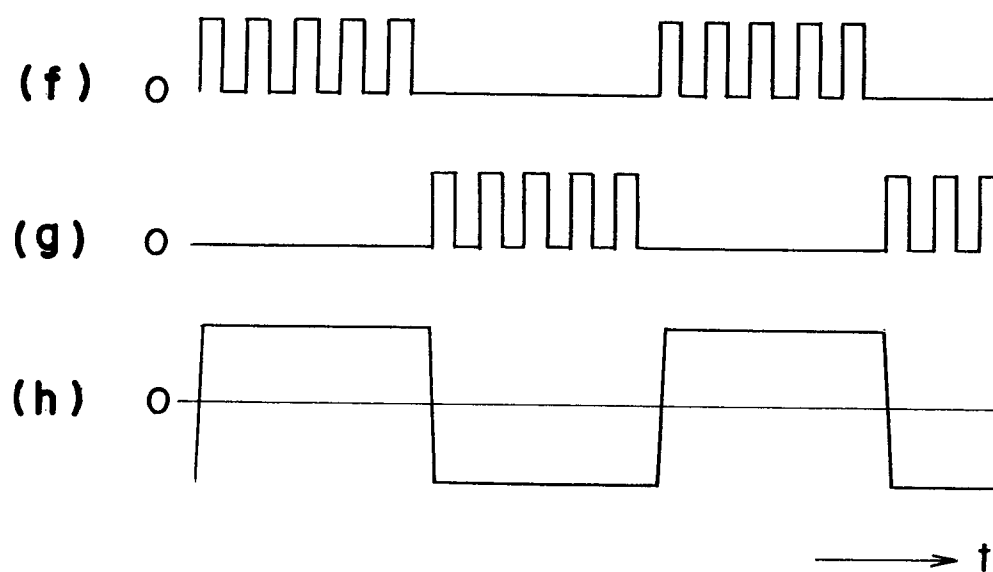
Fig. 9**Fig. 11**

Fig. 10

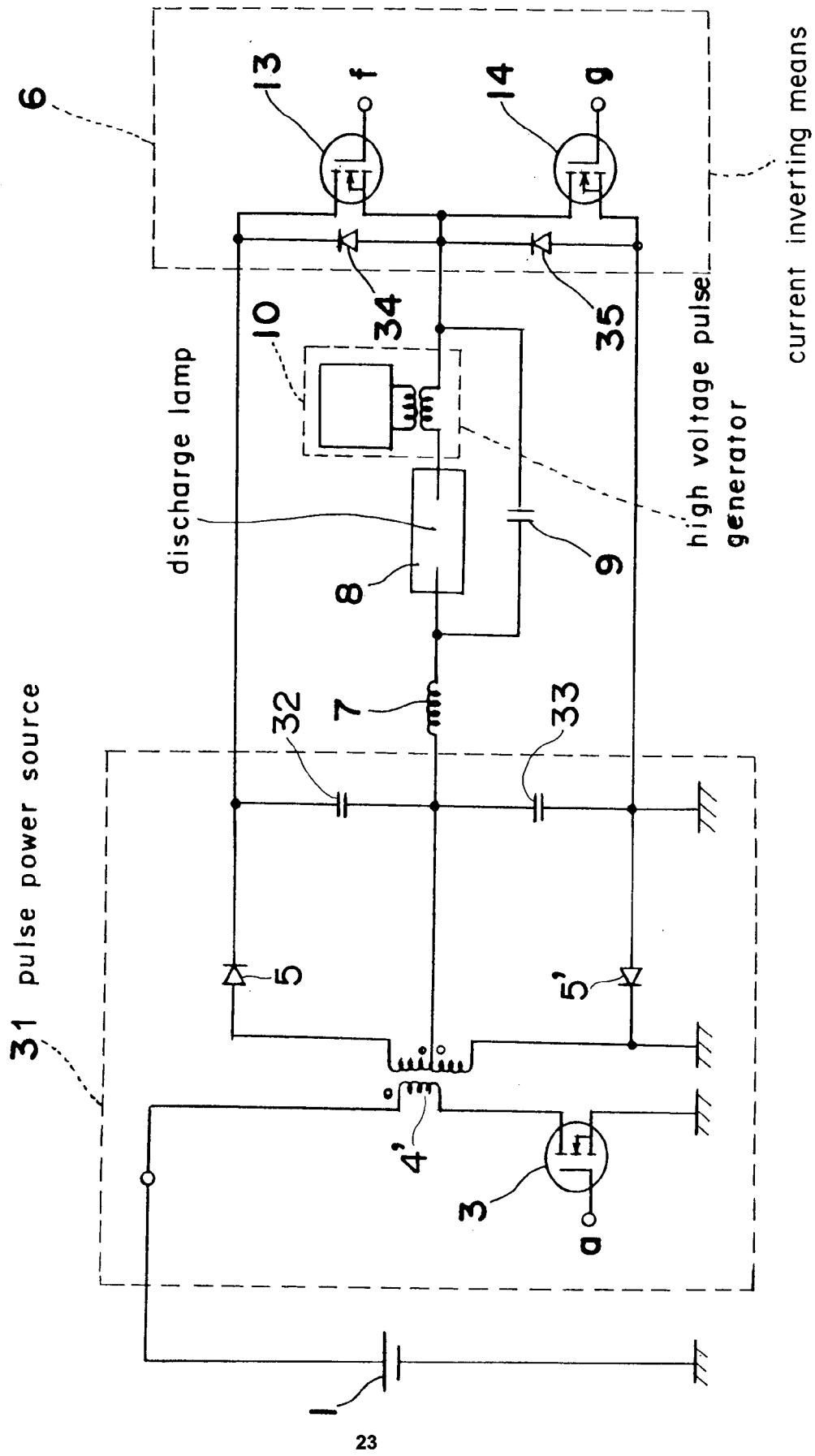


Fig. 12

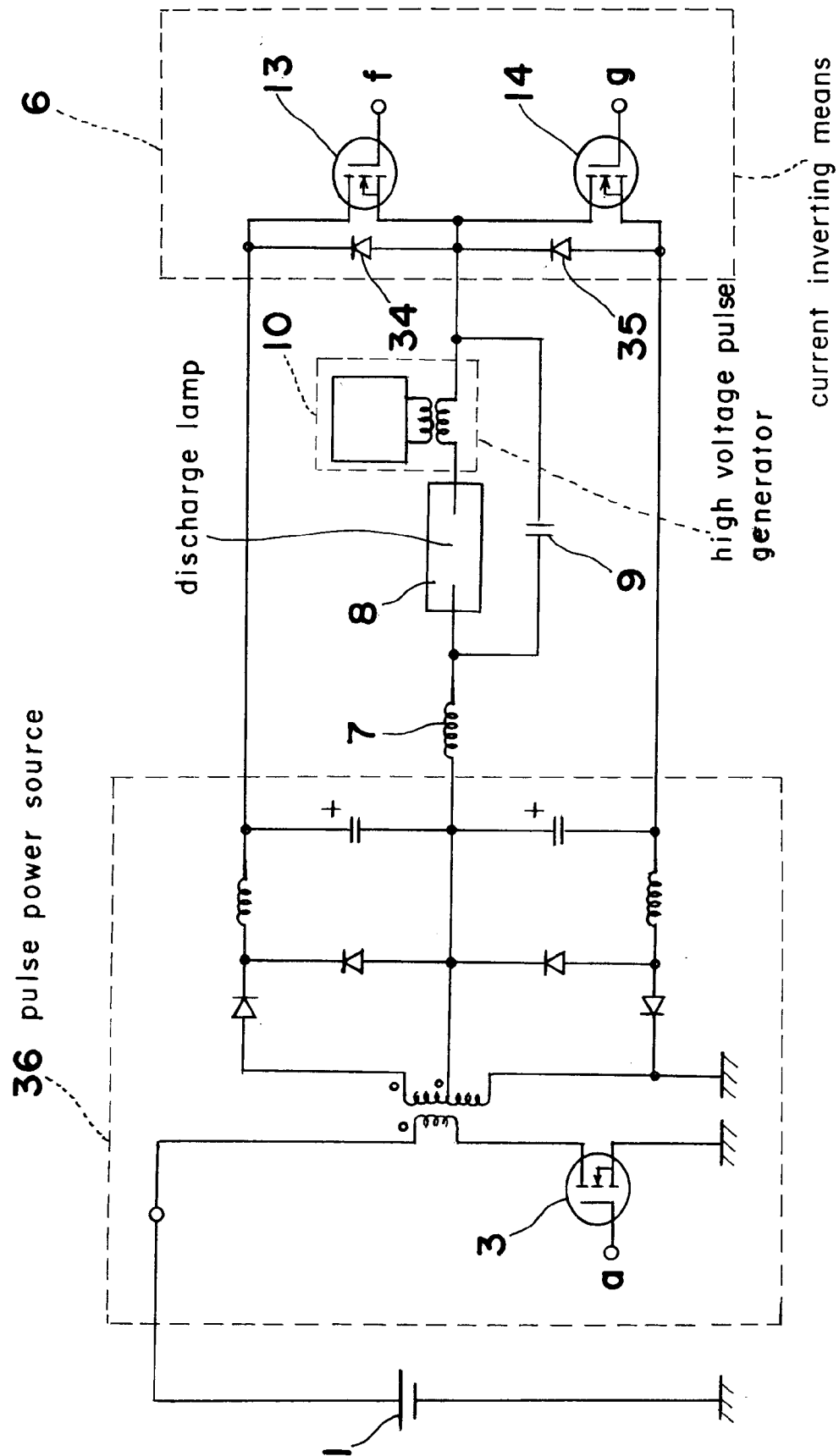


Fig. 13

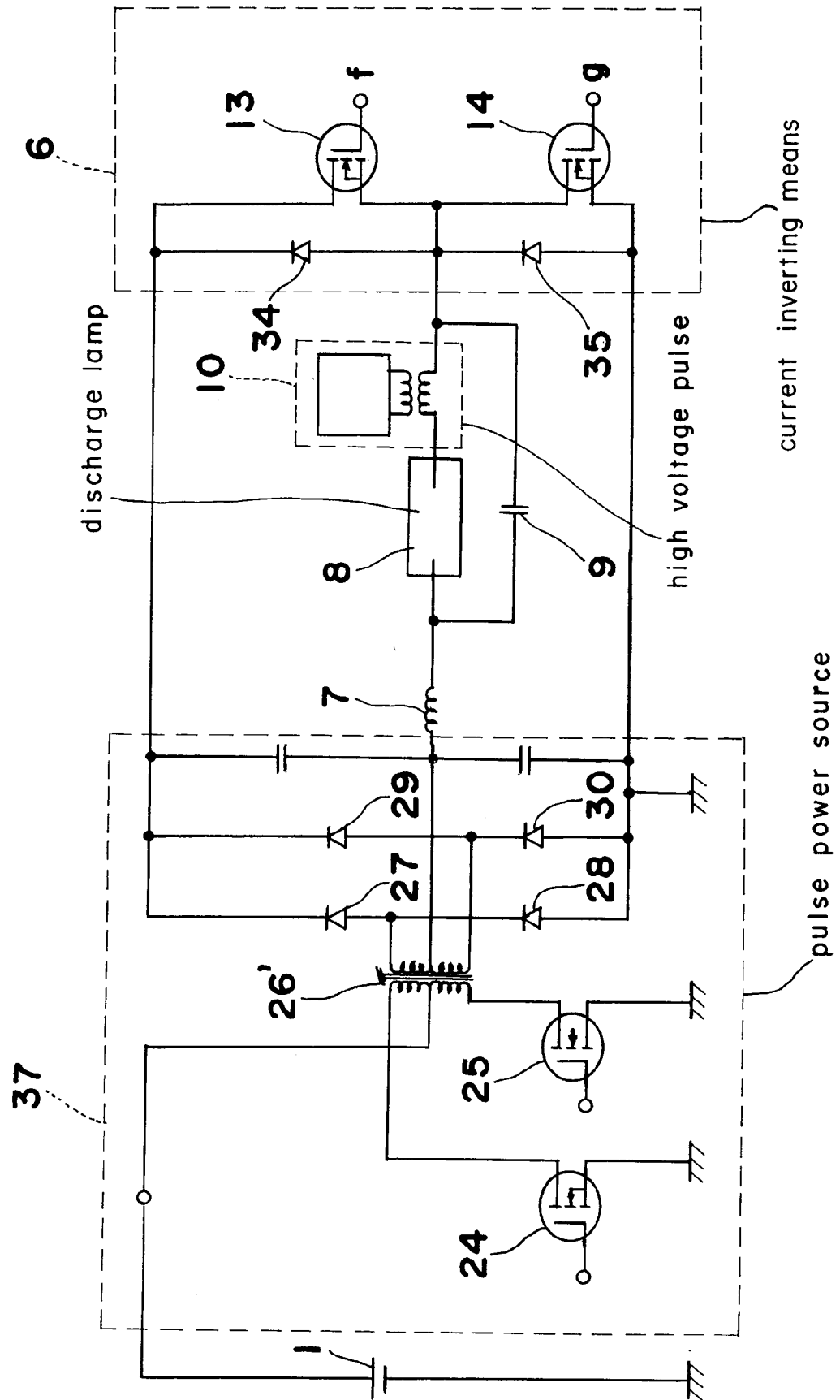


Fig. 14

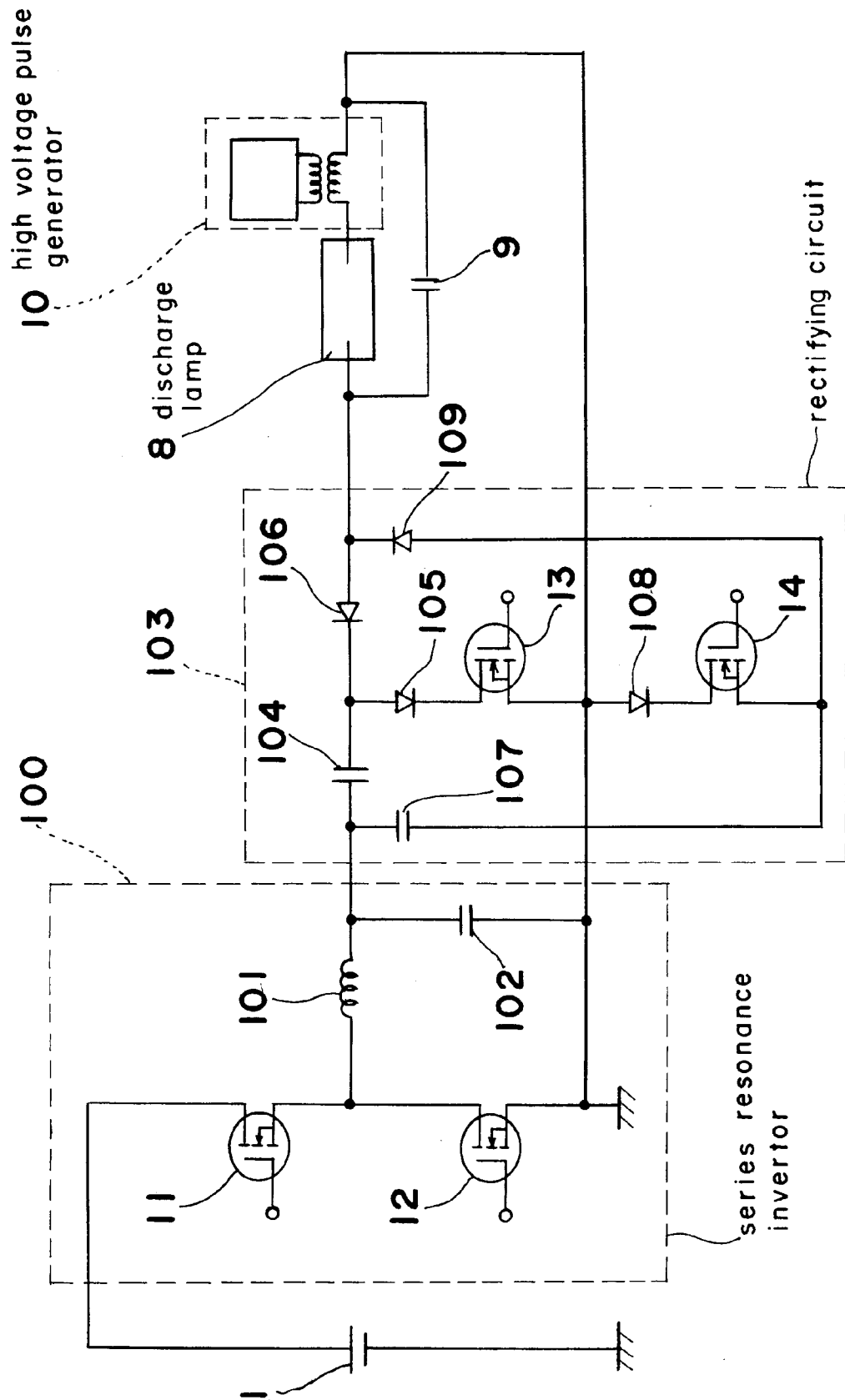


Fig. 15

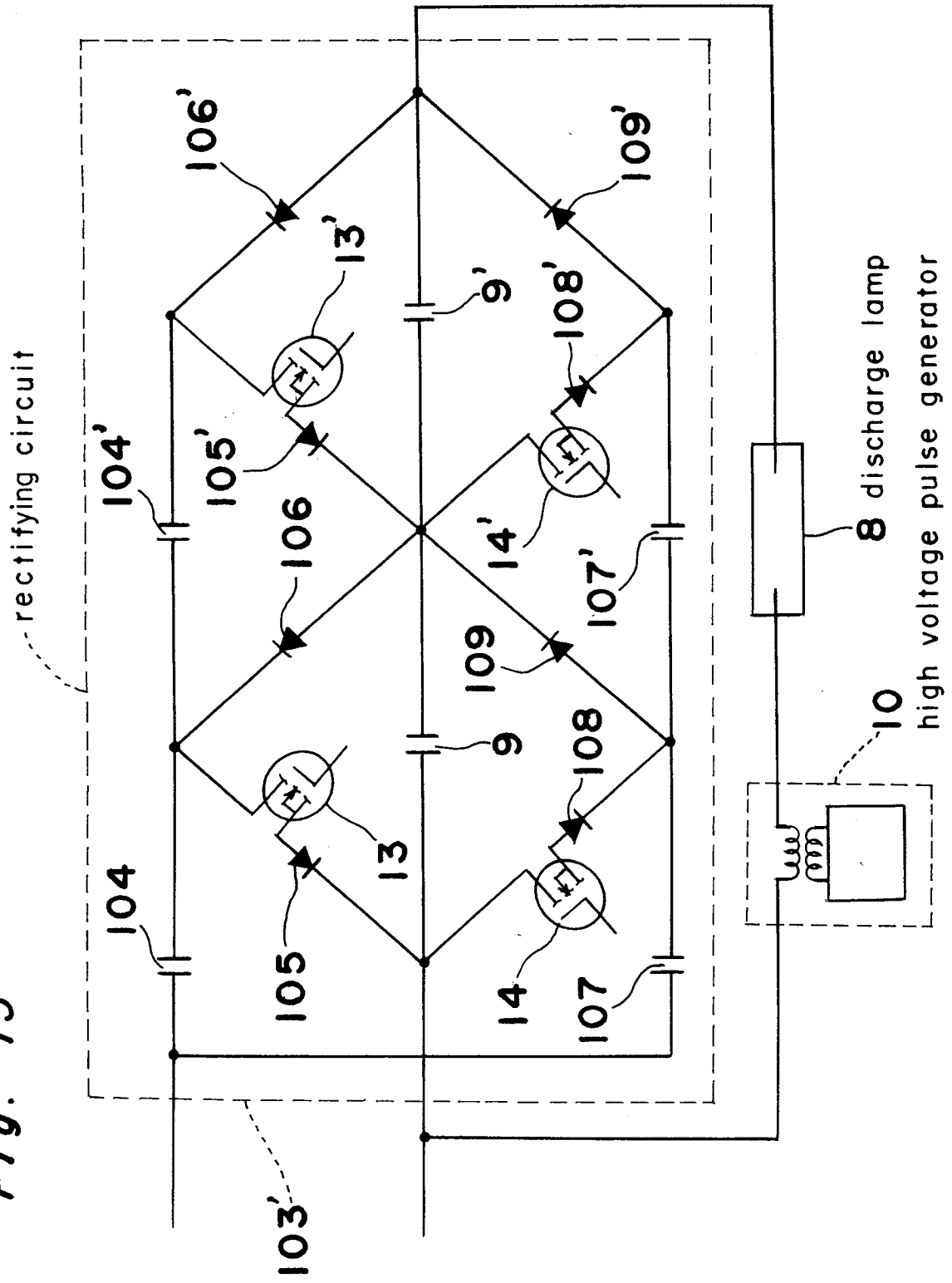


Fig. 16

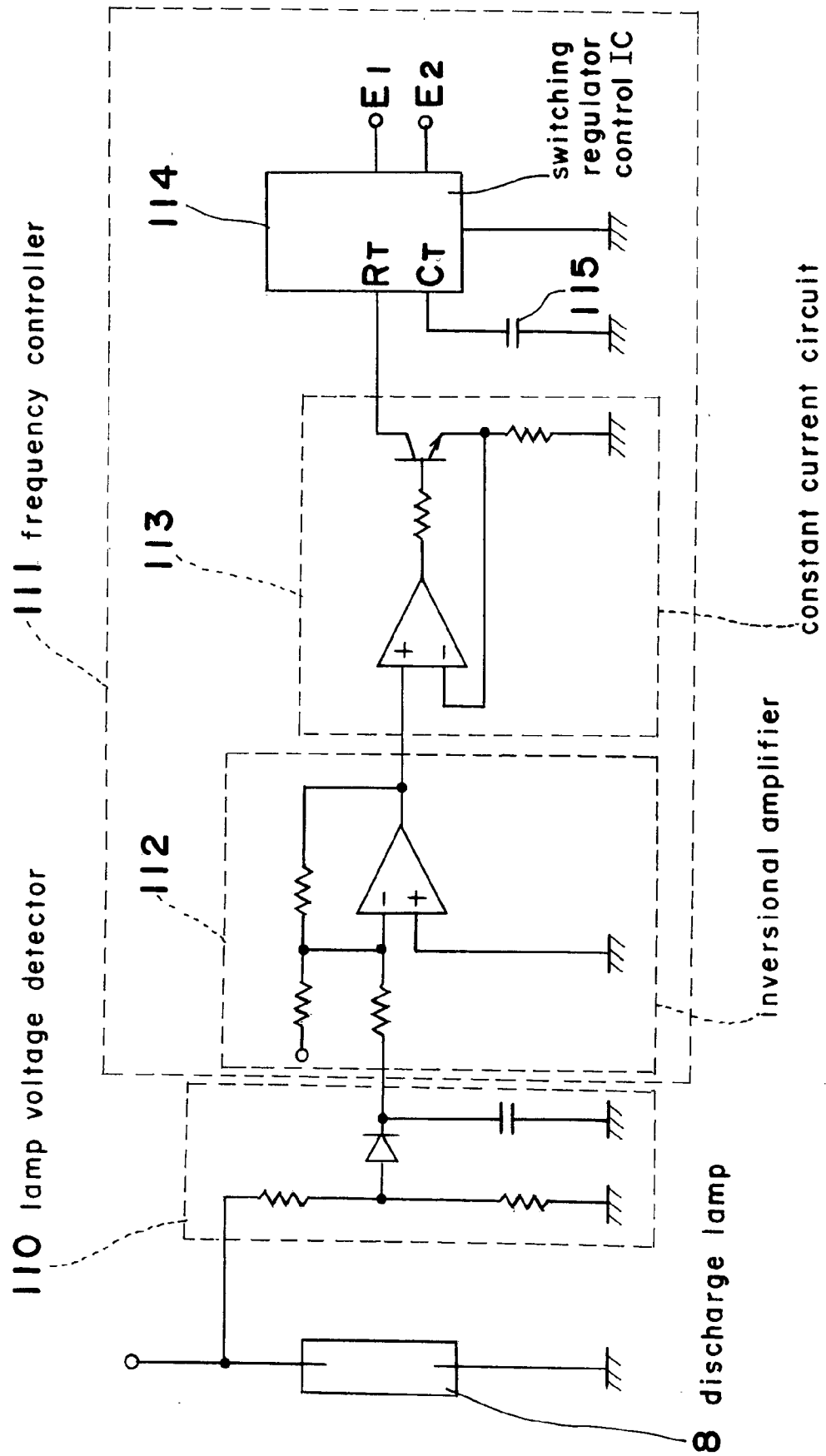
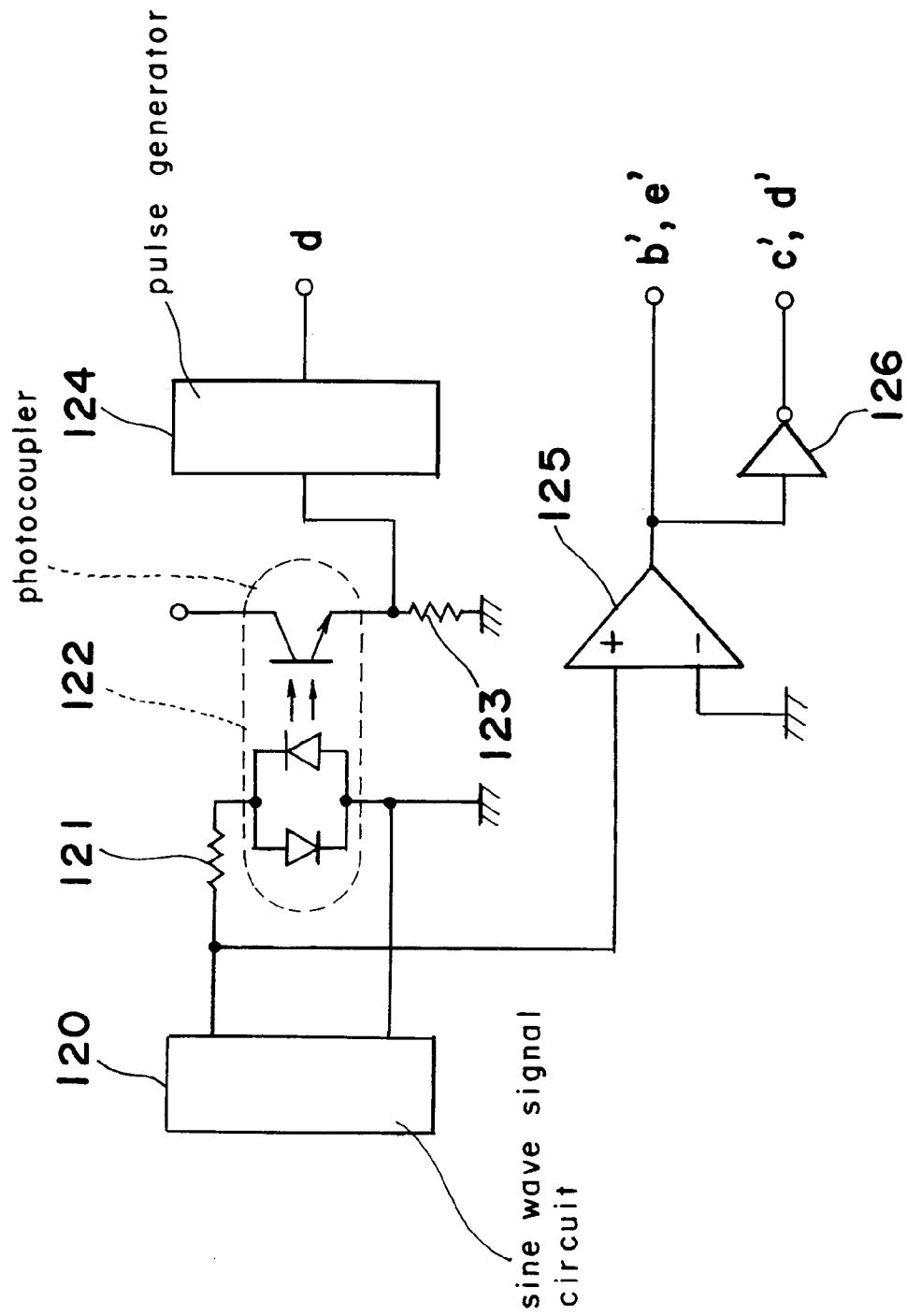


Fig. 17





European Patent
Office

EUROPEAN SEARCH REPORT

Application Number

DOCUMENTS CONSIDERED TO BE RELEVANT			EP 91114707.2
Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
A	<u>EP - A - 0 075 176</u> (OY HELVAR) * Abstract; fig. 1 * --	1,4-7, 10,11	H 05 B 41/29
A	<u>GB - A - 2 030 800</u> (ESQUIRE) * Abstract; fig. 1 * --	1,4-7, 10	
A	<u>DE - A - 3 623 306</u> (MATSUSHITA) * Abstract; fig. 1 * --	1,4-7, 10	
D,A	<u>DE - A - 3 905 715</u> (GENERAL ELECTRIC) * Abstract; fig. 2,6 * -----	1	
			TECHNICAL FIELDS SEARCHED (Int. Cl.5)
			H 05 B 41/00
The present search report has been drawn up for all claims			
Place of search VIENNA		Date of completion of the search 11-12-1991	Examiner TSILIDIS
CATEGORY OF CITED DOCUMENTS X : particularly relevant if taken alone Y : particularly relevant if combined with another document of the same category A : technological background O : non-written disclosure P : intermediate document T : theory or principle underlying the invention E : earlier patent document, but published on, or after the filing date D : document cited in the application L : document cited for other reasons & : member of the same patent family, corresponding document			

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