United States Patent

[11] **3,626,200**

[72] Inventor **Takao Sasayama**
Hitachi-shi, Japan

[21] Appl. No. **862,327**
[22] Filed **Sept. 30, 1969**
[45] Patented **Dec. 7, 1971**

[73] Assignee **Hitachi, Ltd.**
Tokyo, Japan

[32] Priorities **Oct. 2, 1968**
[33] **Japan**
[31] **43/71122;**
Oct. 2, 1968, Japan, No. 43/71126; Oct. 2, 1968, Japan, No. 43/71131

[54] **ELECTRIC PULSE GENERATOR MEANS**
22 Claims, 11 Drawing Figs.

[52] **U.S. Cl.** .... **307/106,** 123/148 E, 307/108
[51] **Int. Cl.** **H03k 3/00,** F02p 1/00
[50] **Field of Search** .... 123/148 E; 307/106, 108

[56] **References Cited**
UNITED STATES PATENTS

3,496,921	2/1970	Boyer	123/148 E
3,291,110	12/1966	Peters	123/148 E
3,308,801	3/1967	Motto, Jr.	123/148 E
3,372,681	3/1968	Phillips et al.	123/148 E
3,399,658	9/1968	Gilbert	123/148 E
3,410,257	11/1968	Gilbert	123/148 E

Primary Examiner—William M. Shoop, Jr.
Attorney—Craig, Antonelli and Hill

ABSTRACT: A closed series circuit is composed of a plurality of circuit elements, i.e. a DC current source, an inductive reactor, a transistor. The conduction of the transistor is chosen to take place for a predetermined interval at a predetermined frequency. A capacitor is provided for being charged by a voltage induced across the inductive reactor at the time of the cutoff of the transistor. And the charge stored in the capacitor is discharged to a load simultaneously with the initiation of the conduction of the transistor.

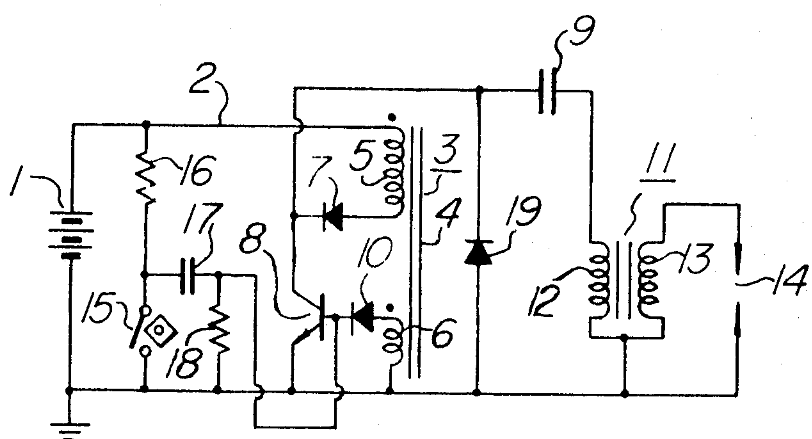


FIG. 1

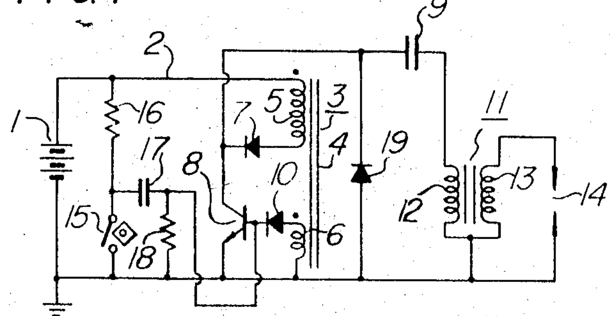


FIG. 3

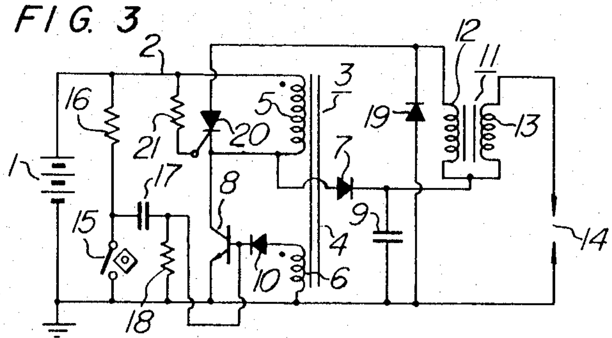
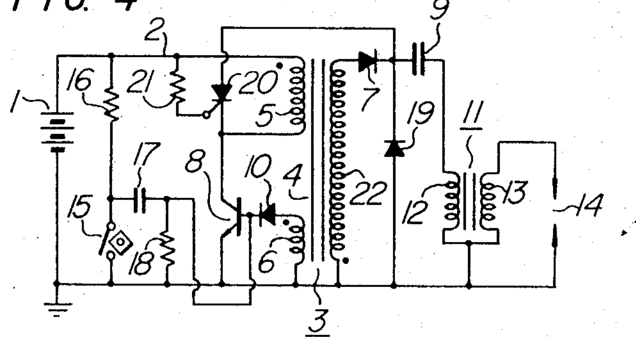


FIG. 4



INVENTOR

TAKAO SASAYAMA

BY Craig, Antonelli, Stewart & Hill

ATTORNEYS

FIG. 2a

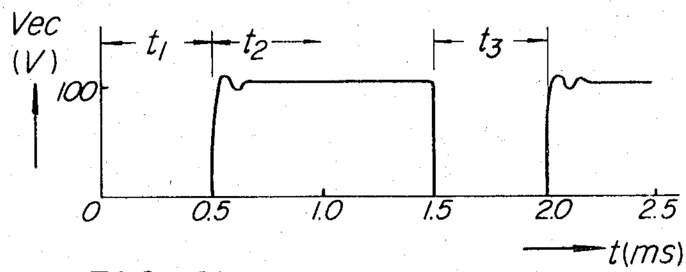


FIG. 2b

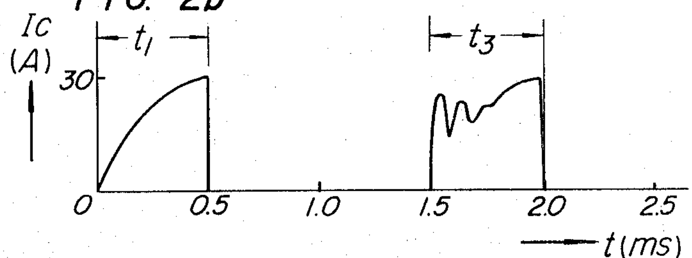


FIG. 2c

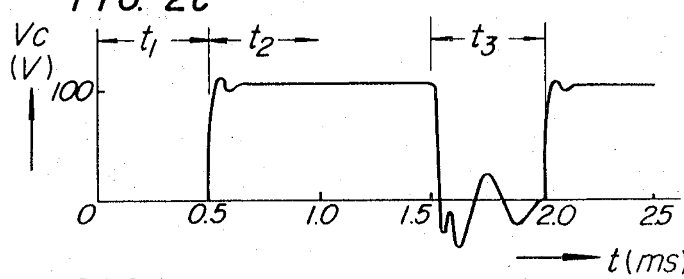
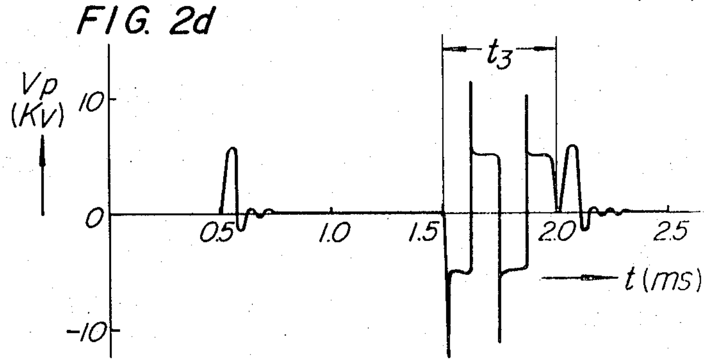


FIG. 2d



INVENTOR

TAKAO SASAYAMA

BY
Craig, Antonelli, Stewart & Hill
ATTORNEYS

FIG. 5

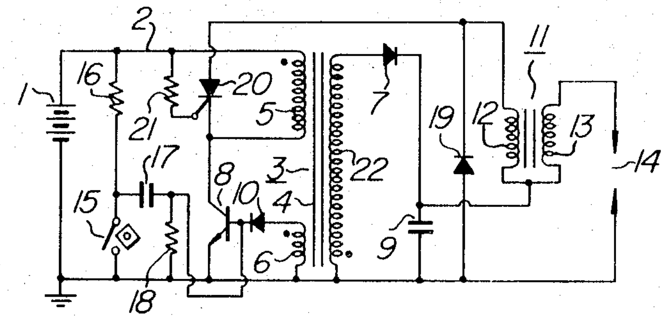
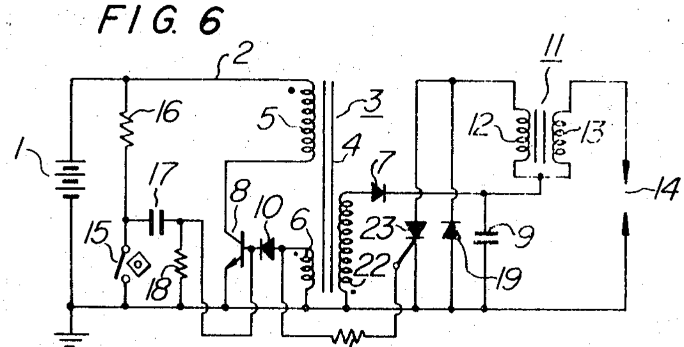


FIG. 6



INVENTOR

TAKAO SASAYAMA

BY *Craig, Antonelli, Stewart & Hill*

ATTORNEYS

FIG. 7

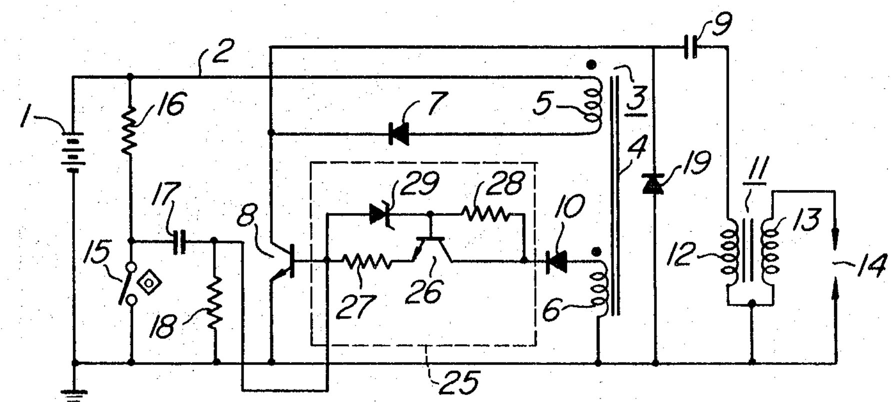
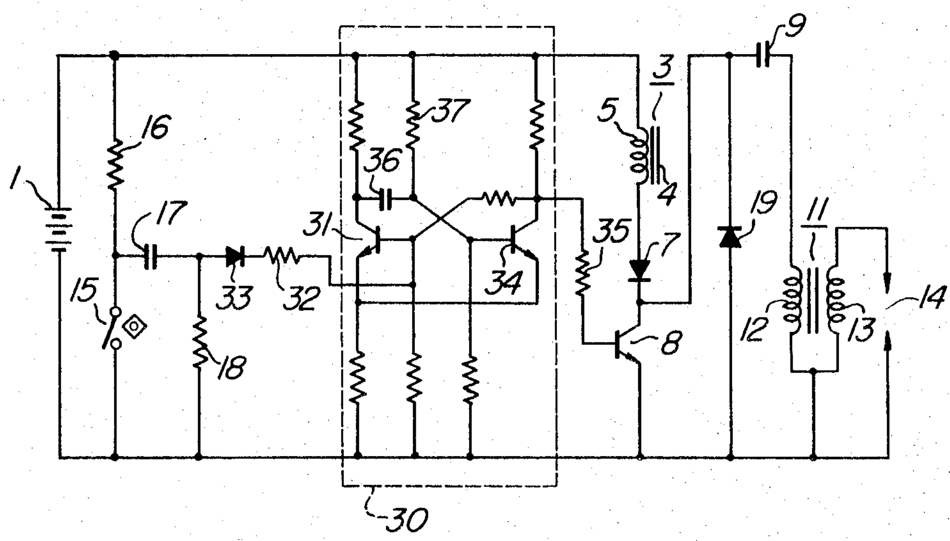


FIG. 8



INVENTOR

TAKAO SASAYAMA

BY Craig, Antonelli & Hill

ATTORNEYS

ELECTRIC PULSE GENERATOR MEANS

The present invention relates to an electric pulse generator means which finds its effective utility especially in apparatuses utilizing electric pulses for industrial purposes.

An ignition device used in an internal combustion engine will be discussed as an example of conventional devices. A voltage supplied from a battery is stepped up through a DC—DC converter so as to charge a capacitor. The electricity stored in the capacitor is discharged through the primary winding of an ignition coil. Consequently, due to induction phenomenon, a high voltage is developed across the secondary winding of the ignition coil. The high voltage thus induced is impressed between a spark gap to cause a spark discharge. This method is a conventionally used one. However, the DC—DC converter used in the conventional method usually includes a push-pull oscillator circuit having two transistors and a transformer, and a rectifier circuit comprising four diodes connected in a bridge circuit so as to rectify the output from the oscillator circuit. Thus, such a conventional method is disadvantageous because of its expensiveness. When the charge stored in the capacitor is passed through the thyristor connected between the output terminals of DC—DC converter, a short circuit is established between the output terminals of the DC—DC converter so that the DC—DC converter is in an over-loaded condition at this moment. Hence, some means have to be incorporated in the circuitry under question so as to prevent the DC—DC converter from being injured due to over-loading.

An ignition device furnished with such prevention means is reported in a periodical "ELEKTRONIK 16, 10, 1967 (pages 311–312).b" According to the device, a sufficient current is conducted through an electromagnetic coil when the contacts of a breaker are closed. Upon the opening of the contacts, a high voltage is generated due to induction, and the charge of a capacitor must be completed by the high voltage during the interval while the contacts are opening. However, the time of closure or opening will become shorter as the r.p.m. of the internal combustion engine is increased. Hence, there arises a technical difficulty from designing a device which can complete the desired operations during such short intervals as the closure and the opening of the breaker contacts operated at a high r.p.m. of the engine. Such a difficulty mainly results from the employment of a thyristor which is arranged to ignite simultaneously with the successive opening operation of the breaker contacts so as to conduct the charge stored in the capacitor through the primary winding of an ignition coil.

On the other hand, in accordance with a device disclosed in "S.A.E. paper No. 670116 (Jan. 9–13, 1967)," the thyristor which conducts the charge stored in the capacitor to the primary winding of the ignition coil forms a circuit different from that including the transistor which supplies the step-up transformer with actuating current. So, the ignition will be simultaneous with the operation of the transistor, but the turning off is not synchronized with it. Hence, various difficulties have to be overcome for effectively supplying the ignition coil with the electrical energy stored in the capacitor.

One object of the present invention is to provide a pulse generator means which can create a series of electric pulses capable of transporting sufficient energy even during a very short duration.

Another object of the invention is to provide a pulse generator means which can supply a capacitor to store the energy of electric pulses with sufficient energy.

A further object of the invention is to provide a device which can effectively convert the energy stored in the capacitor into electric pulse energy.

A still further object of the invention is to provide an electric pulse generator means possessed of an excellent property as an ignition device for use in an internal combustion engine.

Other objects and features of the invention will be apparent from the following detailed descriptions taken by way of the embodiments of the invention.

According to the present invention, a semiconductor element which is adapted to supply an electric energy stored in a capacitor for an output transformer is also used for conducting and interrupting a current which flows to an induction element from a low-voltage source so as to generate a middle voltage for charging the capacitor, and the semiconductor element is maintained in its conductive state from a desired instant coincident with the initiation of an arbitrary pulse during a desired interval.

In the following the present invention will be explained more precisely in conjunction with the accompanying drawings, in which

FIG. 1 is an electric coupling diagram of one embodiment of the present invention;

FIG. 2*a* is a graphic representation of a wave form showing the emitter-collector voltage of a switching transistor used in FIG. 1 circuit;

FIG. 2*b* is a graphic representation of a wave form showing the emitter-collector current of the switching transistor;

FIG. 2*c* is a graphic representation of a wave form showing the voltage developed across a capacitor used in FIG. 1 circuit;

FIG. 2*d* is a graphic representation of a wave form showing the terminal voltage across a spark plug in FIG. 1 circuit; and

FIGS. 3 to 8 are the electric circuit diagrams of other embodiments of the present invention.

FIG. 1 is a circuit diagram of an embodiment of the present invention as an ignition device for use in a car in which the negative electrode of the carried battery is grounded. In this figure a battery 1 has its negative electrode grounded and its positive electrode connected with a conductor 2. A transformer 3 has windings 5 and 6 wound around a magnetic core 4, the electric polarities of those windings 5 and 6 being indicated conventionally by dots in the figure. One end of the winding 5 is connected with the conductor 2, and the other end thereof is connected with the anode of a diode 7. An NPN-transistor 8 has its emitter electrode grounded, its collector electrode connected with the cathode of the diode 7 and further with one end of a capacitor 9, and its base electrode connected with the cathode of a diode 10. One end of the winding 6 of the transformer 3 is connected with the anode of the diode 10, and the other end of the winding 6 is grounded. An ignition coil 11 has a primary winding 12 and a secondary winding 13, one end of the primary winding 12 and one end of the secondary winding 13 being connected with each other and commonly grounded. The other end of the primary winding 12 is connected with the other end of the capacitor 9, and the other end of the primary winding 13 is connected with one terminal of a spark plug 14. Numeral 15 designates the contacts of an ordinary breaker, one of which is grounded, and the other of which is connected via a resistor 16 with the conductor 2 and also via a differentiating circuit composed of a capacitor 17 and a resistor 18 with the base electrode of the transistor 8. A diode 19 is connected between the emitter and collector electrodes of the transistor 8 in opposite polarity with respect thereto. An ignition switch may preferably be inserted in the conductor 2 but it is not shown in this figure.

Description will now be made of the operation of the circuit just described. Assuming that the contacts 15 of the breaker are open when the ignition switch not shown in the figure is closed, it follows that a current flowing momentarily through the resistor 16, the capacitor 17 and the resistor 18 establishes a voltage across the resistor 18 which transiently serves as a forward-bias voltage between the base and emitter electrodes of the transistor 8. Accordingly, the transistor 8 enters its conductive state between the emitter and collector electrodes thereof so that a current flows through the primary winding 5 of the transformer 3. As the polarity of self-induction voltage then developed across the primary winding 6 is positive at the conductor 2, the polarity of an induced voltage developed across the secondary winding 6 is such that it forward-biases the transistor 8 between the base and emitter electrodes thereof via the diode 10. Consequently, the conductivity of the transistor 8 between the emitter and collector electrodes thereof is further increased until the collector current of the transistor **8** is increased, due to a positive feedback effect, to a value characteristic of the base current which is the addition of the current via the differentiating circuit and the current via the diode **10**. When the current flowing through the primary winding **5** reaches its maximum value or saturation, the voltage induced in the primary winding **6** decreases, causing the base current of the transistor **8** to decrease and accordingly the collector current to decrease. Accordingly, the voltage induced in the secondary winding **6** further decreases until the transistor **8** is rapidly driven into a nonconductive state between the emitter and collector electrodes thereof due to the positive feedback action. The wave forms representing the voltage Vec between the emitter and collector electrodes and the collector electrodes and the collector current Ic of the transistor **8** in the operation range just described are shown within the intervals t_1 of FIGS. *2a* and *2b*, respectively.

When the transistor **8** becomes nonconductive, a voltage in an amount of L(*di*/*dt*) is induced which charges the capacitor **9** via the diode **7**. The voltage Vec between the emitter and collector electrodes of the transistor **8**, the collector current Ic, the terminal voltage V*c* across the capacitor **9** and the voltage V*p* across the spark plug **14** in this stage of circuit operation assume the wave forms shown within the intervals t_2 of FIGS. *2a* to *2d*, respectively.

The voltage across the capacitor **9** reaches its maximum value and this value is maintained because the diode **7** and the nonconductive transistor **8** block the flow of the stored charge in the capacitor **9**. During the blockade the contacts **15** of the breaker resume their closed condition. When the contacts **15** are rendered open again at the time of next initiation of ignition, a forward-biasing current is supplied to the base electrode of the transistor **8** via the conductor **2**, the resistor **16** and the capacitor **17** so that the transistor **8** becomes conductive again. At this time of conduction of the transistor **8**, the conductive path between the emitter and collector electrodes of the transistor **8** is traversed by the flow of electric charge stored in the capacitor **9** into the primary winding **12** of the ignition coil **11** as well as by a current flowing through the conductor **2** and the primary winding **5** of the transformer **3**. The ignition coil **11** has an inductive property so that the discharge current from the capacitor **9** oscillates. The portion of the discharge current which is of opposite polarity, i.e. in an opposite direction with respect to the one-way conduction between the emitter and collector electrodes of the transistor **8** is to flow through the diode **19**. Due to the oscillator discharge current a very high voltage is induced in the secondary winding **13** of the ignition coil **11** through the step-up action as of transformer to cause the spark discharge of the spark plug **14**. The voltage V*ec* between the emitter and collector electrodes of the transistor **8**, the collector current I*c*, the terminal voltage V*c* across the capacitor **9** and the terminal voltage V*p* across the spark plug **14** during the spark discharge take wave forms indicated within the intervals t_3 of FIG. *2a* to *2d*, respectively. When the path between the emitter and collector electrodes of the transistor becomes nonconductive again, the capacitor **9** is charged with the current flowing through the primary winding **5** of the transformer **3** during the conduction of the transistor **8**.

Through the repetition of the operation just described a series of pulse voltages are applied to the spark plug **14**. In this operation the transistor **8** functions as a switching means. Namely, when the transistor **8** is nonconductive the capacitor **9** is charged, while the capacitor begins to discharge to energize the primary winding **12** of the ignition coil **11** as soon as the transistor **8** has become conductive. Therefore, the device whose circuit diagram is represented by that in FIG. **1** is especially excellent for use in a high speed internal combustion engine, as compared with other devices which use breakers for switching the charge and discharge of a capacitor. Not only is the period of conduction of the transistor **8** so chosen by suitably selecting the time constant of the positive feedback circuit that a sufficient energy may be drawn from the capacitor **9** to satisfactorily energize the ignition coil **11**, but also the remaining energy is restored in the capacitor **9** when the transistor **8** breaks the path of the discharge. By inserting a current regulator circuit into the base circuit of the transistor **8**, the current energy which is stored in the primary winding **5** of the transformer **3** when the transistor **8** becomes nonconductive can be rendered constant and, moreover, the power consumption by the transistor **8** can also be limited so that many difficulties inherent to the generation of heat can be eliminated. Namely, the effect of providing such a current regulator circuit in the base circuit will be apparent from the following brief description. The collector current of the transistor **8** will, therefore, be increased up to a value equal to the product of the base current and the current amplification factor of the transistor **8**. The collector current will saturate at this value and never exceed it.

Then, the transistor **8** becomes nonconductive so that the energy stored in the primary winding **5** of the transformer **3** will be the same every time. The transition of the transistor **8** into its nonconductive state is performed automatically at this time, and the power consumption of the transistor **8** itself will not be increased even though the switching time of the breaker is retarded. Here, the current regulator circuit may be one of ordinary types as used in a conventional electric circuit.

With reference to FIG. **7**, block **25**, enclosed by dotted lines, represents the constant current control circuit which is connected between the base of transistor **8** and the cathode of diode **10**. The constant current control circuit **25** comprises an NPN-transistor **26**, a resistor connected between the base of transistor **8** and the emitter of transistor **26**, a resistor **28** connected between the base and the collector of transistor **26** and a Zener diode **29** connected between the base of transistor **26** and the base of transistor **8**. In the constant current control circuit just described, control for maintaining the current constant is performed by a voltage across the resistor **27** which is developed as a result of the current flowing therethrough degeneratively acting between the base and the emitter of transistor **26**. As the operation of the negative feedback circuitry is well known, no explanation thereof has been given.

Next, description will be made of another embodiment shown in FIG. **3**. Hereinafter, throughout the drawings similar reference numerals indicate corresponding circuit elements as in FIG. **1**. As for such an ignition device utilizing the capacitor discharge as shown in FIG. **3**, the charging voltage for the capacitor **9** is sometimes chosen to be 200 V or so from the standpoint of circuit design. As this voltage is impressed between the emitter and collector electrodes of the transistor **8** when it is nonconductive, the breakdown voltage between the emitter and the collector must be higher than this charging voltage. However, the employment in the ignition device of a transistor which has such a high breakdown voltage will cause a rise in the production cost of the ignition device. So, that is not economically favorable. The circuit shown in FIG. **3** is designed to overcome such drawbacks.

In FIG. **3**, the junction of the primary winding **5** of the transformer **3** and the collector electrode of the transistor **8** is connected through a diode **7** with one end of a capacitor **9** and also with a common terminal to which one end of the winding **12** and one end of winding **13** are coupled together. The other end of the capacitor **9** is grounded. The other end of the primary winding **12** of the ignition coil **11** is connected with the anode of a silicon controlled rectifier (hereinafter referred to as SCR) **20**, of which the cathode is connected with the collector electrode of the transistor **8**. The gate electrode of the SCR **20** is connected via a resistor **21** with a conductor **2**. A diode **19** is connected between the anode of the SCR **20** and the emitter electrode of the transistor **8** in such a manner that the polarity of the diode **19** is in opposite relationship with respect to the series circuit of the SCR **20** and the transistor **8**.

In accordance with this circuit arrangement just described, the SCR **20** as well as the diode **7** blocks the terminal voltage across the capacitor **9** so that the voltage between the emitter and collector electrodes of the transistor **8** is very small. Nevertheless, the potential at the collector of the transistor **8** rises transiently when the capacitor **9** is charged. The momentary rise in the impressed voltage, however, is not a matter of consideration so long as the breakdown voltage is concerned. Because the breakdown voltage between the emitter and collector of the transistor **8** is rendered higher during the charge of the capacitor **9** due to the application of a reverse-biasing voltage induced in the primary winding **6** to the base of the transistor **8**. Let the case be considered that the charge stored in the capacitor **9** is drawn into the primary winding **12** of the ignition coil **11**. When the transistor turns conductive between the emitter and collector electrodes thereof, the potential at the cathode of the SCR **20** falls. Accordingly, a current flows through the gate electrode of the SCR via the conductor **2** and the resistor **21** so that the SCR **20** begins firing to form a path for the discharge of the capacitor **9**. The transistor **8** maintains its conductive state for a predetermined internal and thereafter turns nonconductive. When the transistor becomes nonconductive, the SCR **20** is forcibly rendered nonconductive even if it is conducting a current. Therefore, when the voltage across the capacitor **9** becomes high after the capacitor **9** finishes charging again, the SCR **20** blocks the high voltage and prevents it from being impressed between the emitter and collector electrodes of the transistor **8**.

If it is desired to further increase the voltage to charge the capacitor **9** or to electrically separate the charging circuit from the remaining circuit, then the transformer **3** has to be provided with a tertiary winding **22** as shown in FIGS. **4** and **5**. By means of this tertiary winding **22** a high voltage can be obtained through the step-up action of the transformer.

In FIG. **4** circuit the primary winding **12** of the ignition coil **11** is inserted in series in the charging circuit of the capacitor **9**. In FIG. **5** circuit the winding **12** of the ignition coil **11** is inserted only in the discharge circuit of the capacitor **9**.

In FIG. **6** circuit wherein a gate turnoff thyristor (hereinafter referred to as GTO) is used in place of the SCR **20**, the transistor **8** is separated from the charging circuit of the capacitor **9**, and the primary winding **12** of the ignition coil **11** has one end thereof connected with the anode of a GTO **23**, of which the cathode is grounded and of which the gate electrode is connected via a resistor **24** with the secondary winding **6** of the transformer **3**.

In accordance with the circuit arrangement, when the transistor **8** is forward-biased to turn conductive, a positive voltage appears at the gate electrode of the GTO **23** to fire the GTO **23** into conduction, while when the transistor **8** is reverse-biased to turn nonconductive, a negative voltage in turn appears at the gate electrode of the GTO **23** to forcibly render the GTO **23** nonconductive.

In the explanation of the above mentioned embodiment, a positive feedback circuit is provided in the base circuit of the transistor **8** in order to maintain the transistor **8** in its conductive state for a certain constant period. The same effect can be obtained by employing instead of such feedback circuit a control circuit such as an ordinary timer circuit. A monostable multivibrator will be a preferable timer circuit which is arranged to be triggered by a signal voltage available via the differentiating circuit composed of a capacitor **17** and a resistor **18** and which in turn serves to apply a forward-biasing voltage to the base electrode of the transistor **8** for a predetermined period.

With reference to FIG. **8**, block **30**, enclosed by dotted lines, designates a monostable multivibrator. The base of a normally nonconductive NPN-transistor **31** is connected with capacitor **17** via a series circuit of resistor **32** and diode **33**. The collector of a normally conductive NPN-transistor **34** is connected to the base of a transistor **8** by way of resistor **35**. Accordingly, when breaker **15** is opened, a forward current flows into the base of transistor **31** through the circuit consisting of resistor **16**-capacitor **17**-diode **33**-resistor **32**, so that the monostable multivibrator **30** shifts into its quasi-stable state. In the quasi-stable state, transistor **34** is nonconductive and the transistor **8** becomes conductive, so that electric charges stored in the capacitor **9** are released, providing a current flow through the inductive winding **5**. The time during which the monostable multivibrator **30** is in its quasi-stable state depends upon the time constant determined by the capacitor **36** and resistor **37**. After this monostable time, i.e., the completion of the quasi-stable state, the monostable multivibrator **30** assumes its stable state. Then, the transistor **34** becomes conductive and transistor **8** becomes nonconductive, so that energy stored in the inductive winding **5** is transferred to capacitor **9**. If the time of the quasi-stable state of the monostable multivibrator has been set equal to the time of saturation of the energy stored in the inductive winding **5**, the charge of the capacitor **9** can be accomplished with only a slight loss of power, as is the case when a feedback winding is employed.

What is claimed is:

1. An electric pulse generator wherein a capacitor is charged by a voltage induced in an induction winding due to the rapid interruption of the current flowing through the winding so that the charged electricity may be discharged through a load at a predetermined instant characterized by a series circuit composed of a DC supply source, an induction winding and a semiconductor switching element; a capacitor to be charged by a voltage induced in one of said induction winding and another winding electromagnetically coupled to said induction winding due to interrupting the current through said induction winding; a closed circuit for the discharge of said capacitor composed of said semiconductor switching element, said capacitor and a load; and a control circuit comprising a feedback winding which is electromagnetically coupled to said induction winding and which is so connected as to render said semiconductor switching element conductive when the magnetic flux passing through said inductive winding is increasing and a bias means to temporarily actuate said semiconductor switching element into a conductive state.

An electric pulse generator as defined in claim **1**, characterized in that said semiconductor switching element is a transistor, the base of which is connected with a series circuit of a current regulator circuit and a feedback winding electromagnetically coupled to said induction winding.

3. An electric pulse generator wherein a capacitor is charged by a voltage induced in an induction winding due to the rapid interruption of the current flowing through the winding so that the charged electricity may be discharged through a load at a predetermined instant characterized by a series circuit composed of a DC supply source, an induction winding and a transistor; a capacitor to be charged by a voltage induced in one of said induction winding and another winding electromagnetically coupled to said induction winding, due to interrupting the current through said induction winding; a closed circuit for the discharge of said capacitor, constituted by connecting a series circuit composed of said capacitor, a load and a thyristor between the emitter and collector electrodes of said transistor; a means for connecting the gate electrode of said thyristor with the positive terminal of said DC supply source; and a control circuit to supply a forward-biasing current for the base electrode of said transistor from a predetermined instant for a predetermined period.

4. An electric pulse generator as defined in claim **3**, characterized in that the primary winding of an ignition coil for use in an internal combustion engine is connected as a load with a capacitor.

5. An electric pulse generator wherein a capacitor is charged by a voltage induced in an inductive winding due to the rapid interruption of the current flowing through the winding so that the charged electricity may be discharged through a load at a predetermined instant comprising a series circuit composed of a DC supply source, an induction winding and a transistor; a capacitor to be charged by a voltage induced in one of said induction winding and another winding electromagnetically coupled to said induction winding, due to said transistor interrupting the current through said induction winding; a thyristor constituting together with said load and

said capacitor a closed circuit for the discharge of said capacitor; and a control circuit comprising a feedback winding which is electromagnetically coupled with said induction winding and which is so connected as to render said transistor and thyristor conductive when the magnetic flux passing through said inductive winding is increasing and a bias means to temporarily actuate the transistor into its conductive state.

6. An electric pulse generator wherein a capacitor is charged by a voltage induced in an induction winding due to the rapid interruption of the current flowing through the winding so that the charged electricity may be discharged through a load at a predetermined instant, characterized by a series circuit composed of a DC supply source, an induction winding and a semiconductor switching element; a capacitor to be charged by a voltage induced in one of said induction winding and another winding electromagnetically coupled to said induction winding due to interrupting the current through said induction winding; a discharge circuit for the discharge of said capacitor composed of said semiconductor switching element, said capacitor and a load; an electric timer to which the control electrode of said semiconductor switching element is connected and which can actuate said semiconductor switching element into a conductive state at a predetermined instant and maintain the conductive state until the energy stored in said induction winding is saturated.

7. An electric pulse generator as defined in claim **6**, characterized in that said semiconductor switching element is a transistor of which the base current is controlled by a monostable multivibrator capable of being actuated at a predetermined instant to a quasi-stable state.

8. An electric pulse generator as defined in claim **1**, characterized in that the primary winding of an ignition coil for use in an internal combustion engine is connected as a load with a capacitor.

9. An electric pulse generator as defined in claim **5**, characterized in that the primary winding of an ignition coil for use in an internal combustion engine is connected as a load with a capacitor.

10. An electric pulse generator as defined in claim **6**, characterized in that the primary winding of an ignition coil for use in an internal combustion engine is connected as a load with a capacitor.

11. An electric pulse generator as defined in claim **8**, characterized in that the primary winding of an ignition coil for use in an internal combustion engine is connected as a load with a capacitor.

12. An electric pulse generator for supplying pulses through a load inductive winding to a load coupled therewith, comprising:

a capacitor connected switchably in parallel with said load inductive winding;

a DC supply source;

first means, intermittently connected with said DC supply source for switchably connecting said capacitor in parallel with said load winding, said first means including a second inductive winding and a semiconductor switching element connected in series with said DC supply source;

second means, electromagnetically coupled with said second inductive winding for controlling the conductivity of said semiconductor switching element, so as to effect the charging and discharging of said capacitor; and

third means, coupled to said DC supply source and said semiconductor switching element, for intermittently connecting said first means with said DC supply source;

whereby pulses are intermittently supplied to said load inductive winding through the charging and discharging of said capacitor.

13. A pulse generator in accordance with claim **12**, wherein said semiconductor switching element comprises a transistor, the collector of which is connected to said capacitor, the emitter of which is connected to one side of said DC supply source, and the base of which is coupled to said second means and said third means.

14. A pulse generator in accordance with claim **13**, wherein said second means comprises a third inductive winding, electromagnetically coupled with said second inductive winding, and having one end thereof connected to the base of said transistor through a first diode.

15. A pulse generator in accordance with claim **14**, wherein said third means comprises a differentiating circuit coupled to said DC supply source through a resistor and having an intermittent switching element connected in parallel therewith, the output of said differentiating circuit being connected to the base of said transistor.

16. A pulse generator in accordance with claim **15**, further including a second diode connected between one end of said load inductive winding and the side of said capacitor which is connected to said transistor.

17. A pulse in accordance with claim **12**, wherein said first means further includes a controlled rectifier switching element connected between said load inductive winding and said semiconductor switching element, and wherein the control terminal of said controlled rectifier switching element is connected to said DC supply source.

18. A pulse generator in accordance with claim **17**, wherein said semiconductor switching element comprises a transistor, the collector of which is coupled to said capacitor through a coupling diode, the emitter of which is connected to one side of said DC supply source, and the base of which is coupled to said second and third means.

19. A pulse generator in accordance with claim **18**, wherein said second inductive winding is connected to said coupling diode and the cathode of said controlled rectifier switching element.

20. A pulse generator in accordance with claim **18**, wherein said resistor is coupled to said capacitor through a fourth inductive winding electromagnetically coupled with said second and third windings and connected in series with said coupling diode.

21. A pulse generator in accordance with claim **12**, wherein said semiconductor switching element comprises a transistor, the collector of which is connected to said inductive winding, the emitter of which is connected to one side of said DC power source, and the base of which is coupled to said second means and said third means.

22. A pulse generator in accordance with claim **21**, wherein said first means includes a controlled rectifier switching element connected in parallel with said capacitor and said load inductive winding, the control terminal of which is coupled to a third inductive winding electromagnetically coupled with said second inductive winding and to the base of said transistor.

* * * * *