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IGNITION DEVICE FOR INTERNAL COMBUSTION ENGINE

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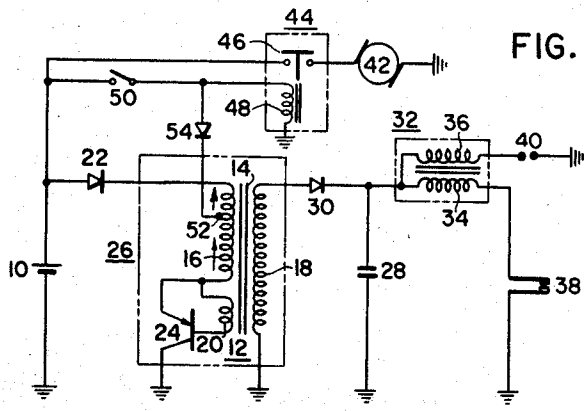


FIG. 1

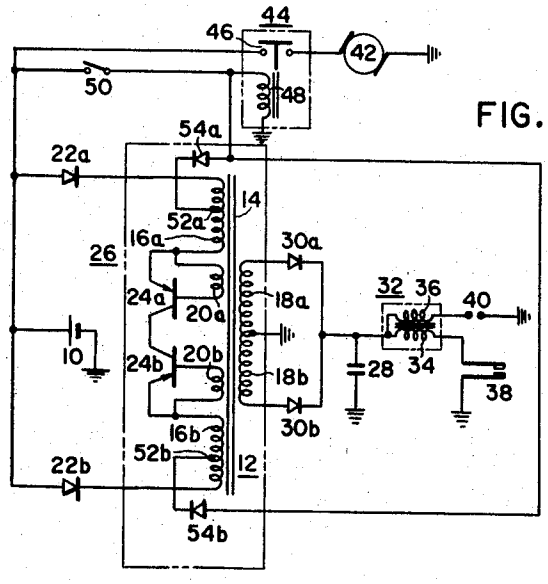


FIG. 2

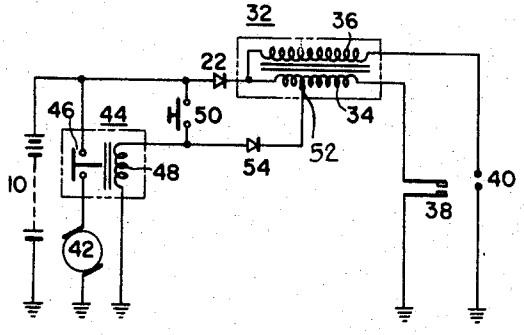


FIG. 3

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IGNITION DEVICE FOR INTERNAL COMBUSTION ENGINE

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6 Claims. (Cl. 123—179)

ABSTRACT OF THE DISCLOSURE

In order to compensate for a decrease in voltage across the battery upon starting an internal combustion engine, a transformer is included in an inverter of the blocking oscillator type or an ignition coil is provided on the primary winding with a tap connected to a junction of a starting switch and a starting relay winding through a semiconductor diode poled so as to permit a current to flow from the battery toward the tap. Thus, upon starting a starting motor, one portion of the primary winding is short-circuited. Also another semiconductor diode is connected between the battery and the primary winding and poled so as to permit a current to flow from the battery to the primary winding. The latter diode prevents a voltage induced across the one portion of the primary winding from causing a current to circulate through the closed starting switch.

This invention relates to improvements in an ignition device for use with an internal combustion engine.

As an ignition device for an intenral combustion engine, there have been heretofore proposed various types utilizing a transformer. For example, a transformer commonly called an ignition coil has been used in the type of ignition devices wherein a direct current from a source of direct current is periodically interrupted to ignite the fuel of an associated internal combustion engine. Alternatively a transformer has been used in the type of inverters for converting a direct current voltage to high voltage alternating current which, in turn, is utilized to ignite the fuel of the associated engine.

On the other hand, the internal combustion engine is provided with a starting device such as a starting electric motor or the like. With an electrical starting device it is common practice to energize the starting device by the same source of electric power as does the abovementioned ignition device. In general, electrical starting devices require a flow of heavy current therethrough in operation. This leads to a substantial decrease in voltage across the source. Therefore, if a source of electric power is arranged to also energize the associated ignition device then an electric energy supplied from the source to the ignition device will decrease during operation of the starting device. This causes a decrease in ignition energy available at the associated ignition plug and hence in engine output. This decrease in energy supply to the ignition device becomes great particularly when starting of the engine is difficult and requires a great quantity of energy, for example in case the engine is to start in a cold state. Under these circumstances it may be impossible to start the engine.

In order to overcome the abovementioned difficulty, it has been previously proposed to temporarily shortcircuit one portion of a primary winding of a transformer associated with an ignition device. More specifically, a relay is provided to have a set of normally open contacts connected across that portion of the transformer primary winding and adapted to be energized to close the contacts only when the associated engine starts. The closure of the contacts effects shortcircuiting of that portion of the

primary winding shunting across the contacts thereby to decrease effectively the number of turns of the primary winding to increase effectively a ratio of transformation of the transformer resulting in an increase in output voltage from the latter.

However, the device just described is required to include an additional relay and accordingly increases in dimension. This renders such device unsuitable for use as an ignition device for an internal combustion engine carried by a vehicle because such an engine is required to be small. In addition the relay contacts involved progressively wear away during service leading to frequent failure of the device.

Accordingly it is a general object of the invention to eliminate the abovementioned disadvantages.

It is an object of the invention to provide an improved ignition device for use with an internal combustion engine capable of igniting the engine fuel with a sufficient energy to increase an output from the engine even upon starting the engine.

With the above cited objects in view, the invention resides in an ignition device for use with an internal combustion engine, comprising a source of direct current, means including transformer means having a primary winding adapted to be energized by the direct current source to generate an ignition voltage each time the engine is to be ignited, and a switch element connected to said source and operative to be closed to complete a circuit for energizing a starting electric motor by the source. The invention is characterized in that the abovementioned switch element is connected in parallel circuit relationship to one portion of the primary winding such that when closed the same is effective to shortcircuit the one portion of the primary winding and that a semiconductor diode is connected in the parallel circuit of the switch element and the one portion of the primary winding and so poled that a current is permitted to flow from the source through the closed switch element into the remaining portion of the primary winding whereas a current is prevented from flowing from the one portion of the primary winding to the starting electric motor.

In order to prevent a recirculation of current through the parallel circuit of the closed switch element and the one portion of the primary winding another semiconductor diode may be preferably connected between the source and the primary winding with the polarity that only a current is permitted to flow from the source to the primary winding.

The invention as to its organization and its mode of operation as well as other objects and advantages thereof will become more readily apparent from the following detailed description in conjunction with the accompanying drawings in which:

FIG. 1 is a circuit diagram of an ignition device constructed in accordance with the teachings of the invention;

FIG. 2 is a circuit diagram of a modification of the invention; and

FIG. 3 is a circuit diagram of another modification of the invention.

Referring now to FIG. 1 of the drawings, there is illustrated an ignition device constructed in accordance with the teachings of the invention. An arrangement illustrated comprises a source of direct current **10** such as a secondary battery carried by a vehicle, and a transformer generally designated by the reference numeral **12** including a magnetic core **14** and a primary winding **16**, a secondary winding **18** and an auxiliary winding **20** inductively disposed around the magnetic core **14**. In the embodiment illustrated, the source **10** is shown as having its negative terminal connected to the ground, and has its positive

terminal connected to one end of the primary winding **16** of the transformer **12** through a semiconductor diode **22** poled to permit a flow of current therethrough from the source to the primary winding. A pnp transistor **24** is operatively coupled to the auxiliary winding **20** with its emitter connected to the junction of the primary winding and the auxiliary winding, its base connected to the other end of the auxiliary winding and its collector connected to the ground. The transformer **12** and the transistor **24** form an inverter generally designated by the reference numeral **26** and serving to convert the direct current energy from the source **10** to an alternating current energy.

The secondary winding **18** is connected at one end to a capacitor **28** through a semiconductor diode **30** poled to permit a current to flow from the secondary winding to the capacitor. The secondary winding **18** is connected at the other end to the ground as does the capacitor **28**. The secondary winding **18** also is operatively coupled to an ignition coil generally designated by the reference numeral **32**. Specifically the secondary winding **18** is connected through the semiconductor diode **30** to a primary winding **34** of the ignition coil **32**. The ignition coil **32** has a secondary winding **36**. The primary and secondary windings **34** and **36** are connected to the ground through normally open interrupter contact **38** and an ignition plug **40** respectively.

In order to start the engine (not shown) when required, the arrangement further comprises a starting electric motor **42** connected across the source **10** through a relay generally designated by the reference numeral **44**. More specifically, the motor **42** is connected at one terminal to the positive side of the source **10** through normally open contacts **46** and connected at the other terminal to the ground. The relay **44** has its operating winding **48** having one end connected to the positive side of the source **10** through a manually operated, normally open switch **50** and the other end connected to the ground.

The arrangement thus far described is operated as follows: When the transistor **24** becomes conductive between its emitter and collector electrodes as by leakage between the electrodes a current flows from the positive terminal of the source **10** through the semiconductor diode **22**, the primary winding **16** of the transformer **12** and the now conducting transistor **24** and back to the negative terminal of the source **10**. This flow of current establishes a magnetic flux within the magentic core **14** and also induces a voltage across the auxiliary winding **20** of the transformer **12** with such a polarity that the transistor turns on, resulting in an increase in flow of current through the primary winding **16**. As the flow of current through the primary winding **16** increases the magnetic flux within the magnetic core **14** will increase until the flux reaches its saturation magnitude beyond which the flux cannot increase in magnitude. At that time, the auxiliary winding **20** has produced thereacross a voltage of opposite polarity tending to turn off the transistor **24** resulting in a decrease in flow of current through the primary winding **16**.

The alternate increase and decrease in flow of current through the primary winding **16** as above described is accompanied by a secondary voltage being induced across the secondary winding **18**. The secondary voltage charges the capacitor **28** through the semiconductor diode **30**. When the capacitor **28** is in its charged state the closure of the interrupter contacts **38** permits the charge on the capacitor **28** to be discharged through the primary winding **34** of the ignition coil **32**. This causes a high ignition voltage to be induced across the secondary winding **36**. This high voltage causes discharge across the ignition plug **40**. The process just described is repeated to operate the associated engine. The repetition frequency of the inverter is greater than the ignition frequency. Therefore, ignition of an engine occurs when the capacitor **28** is fully charged and a large ignition energy can be obtained.

If the engine is desired to be started, the manually operated switch **50** can be manually closed to energize the operating winding **48** of the relay **44** to close its contacts **46**. The closure of the contacts **46** permits a heavy current to flow from the source **10** through the closed contact **46** into the starting motor **42**. When energized, the motor **42** starts the associated engine (not shown) in the conventional manner. It is to be noted that this load current flowing through the motor **42** is heavy particularly when the engine is difficult to be started and hence the motor bears a high load as in the case the engine is desired to be started in a cold state. This flow of heavy current decreases the voltage across the source **10** to a great extent with the result that the engine may be impossible to start.

As previously described, the invention contemplates to eliminate the abovementioned difficulty. To this end, the primary winding **16** of the transformer **12** is provided with a tap **52** connected through a semiconductor diode **54** to a point intermediate the manually operated switch **50** and the operating winding **48** of the relay **44**. Thus it will be seen that the switch **50** is connected in parallel circuit to one portion of the primary winding **16** disposed between the upper end or the end connected to the diode **22** and the tap **52**. The diode **54** is so poled that a current can flow from the source **10** through the closed switch **50** into the primary winding **16** and has the purpose of preventing the operating winding **48** of the relay **44** from being energized from the source **10** through the primary winding **16** of the transformer **12** during the associated engine being not in its starting state with the manually operated switch **50** open. Therefore the diode **54** serves to prevent any damage to the associated pinion and ring gear due to the operation of the starting motor when the engine is not in its starting state for example during the normal operation of the engine.

With the arrangement of the tap **52** on the primary winding **16** and the semiconductor diode **54**, the closure of the manually operated switch **50** also permits a current to flow from the source **10** through the closed switch **50** and the diode **54** into that portion of the primary winding **16** disposed between the tap **52** and the lower end of the latter. This means shortcircuiting one portion of the primary winding **16** disposed between the upper end or the end connected to the diode **22** and the tap **52**. This local shortcircuiting of the primary winding **16** decreases effectively the number of turns of the primary winding **16** and therefore a transformation ratio increases in view of the entire transformer resulting in an increase in voltage induced across the secondary winding **18** of the transformer **12**.

As well known an energy accumulated on a capacitor is expressed by $\frac{1}{2} CV^2$ where C is the capacitance thereof and V is a voltage to which the capacitor is charged and in this case, the voltage induced across the secondary winding **18**. Therefore it will be readily appreciated that the increase in the secondary voltage across the secondary winding **18** leads to an increase in energy accumulated on the capacitor **28**. Thus this increased in energy accumulated on the capacitor **28** compensate for a decrease in ignition energy causing from a decrease in voltage across the source **10** as previously described with the result that the engine is ignited with a sufficient energy.

The semiconductor diode **22** serves to prevent a current from flowing through the abovementioned one portion of the primary winding **16** which has shortcircuited by closure of the switch **50**, due to a voltage induced across that shortcircuited winding portion in the direction of the arrow shown in FIG. 1 and hence to prevent the flow of shortcircuiting current from interferring with a change in magnetic flux produced within the magnet core **14** of the transformer **12**.

Referring now to FIG. 2, there is a modification of the invention wherein the invterer **26** is of a push-pull type. As shown in FIG. 2, the transformer generally designated by the same reference numeral **12** as in FIG. 1 comprises primary, a secondary and auxiliary winding and the associated component in parts. Therefore those

windings and components are designated by the same reference numerals as those designating the corresponding parts illustrated in FIG. 1 with one section or the upper section as viewed in FIG. 2 of the push-pull inverted having the reference suffix character *a* while the lower section has the reference suffix character *b*. For example, the reference character **18***a* designates the secondary winding of the upper section and the reference character **52***b* designates a tap on the lower primary winding **16***b*. In addition to both the junction of two auxiliary windings **20***a* and **20***b* and a common tap on the secondary windings of the transformer **12** being connected to the ground it is to be noted that when the transistor **24***a* is in its conducting state a voltage induced across the auxiliary winding **20***a* tends to conduct the transistor **24***a* while a voltage induced across the auxiliary winding **20***b* tends to block the transistor **24***b* whereby the primary windings **16***a* and **16***b* have alternately a flow of current therethrough with the result that a capacitor **28** is charged alternately from the secondary windings **18***a* and **18***b* through the respective semiconductor diodes **30***a* and **30***b*. Other respects are substantially the same as in the arrangement illustrated in FIG. 1.

Referring now to FIG. 3 wherein the like reference numerals have been employed to identify the components corresponding to those illustrated in FIG. 1, a blocking oscillator **26** shown in FIG. 1 is omitted and instead a source of direct current **10** has its positive terminal connected directly to a primary winding **34** of an ignition coil **32** through a semiconductor diode **22** and provided with a tap **52**.

Interrupter contacts **38** are operative to periodically interrupt a flow of current through the primary winding **34** of the ignition coil **32** in the conventional manner to induce across the secondary winding **36** an ignition voltage. Upon energizing a starting motor **42** to start the associated engine, a manually operated switch **50** is closed to energize the motor and simultaneously to shortcircuit one portion of the primary winding **34** in the manner as previously described in conjunction with FIG. 1. Likely numbered semiconductor diodes **22** and **54** perform the same functions as the semiconductor diodes **22** and **54** previously described in conjunction with FIG. 1.

From the foregoing it will be appreciated that the objects of the invention have been accomplished by the provision of an ignition device including a transformer whose primary winding has one portion adapted to be shortcircuited upon starting the associated internal combustion engine. Further since a semiconductor diode is used to effect such shortcircuiting the resulting device is not only simple in construction but also substantially free from any damage to a starting device and the like due to power supply to the latter when the engine is not in its starting state.

While the invention has been illustrated and described in conjunction with certain preferred embodiments thereof it is to be understood that various changes and modifications may be made without departing from the spirit and scope of the invention. For example, instead of the manually operated switch **50**, the relay contacts **46** may be utilized to shortcircuit one portion of the primary winding **16** or **34** as the case may be.

What I claim is:

1. An ignition device for use with an internal combustion engine having an electric starting motor, said device comprising a soure of direct current, transformer means having a primary winding energized by said source and a secondary winding, an ignition voltage generator means connected to said transformer for generating an ignition voltage each time the engine is to be ignited through utilization of a secondary voltage across said secondary winding of said transformer means, a normally open switch element connected to said source and capable of being closed during starting of said starting electric motor to complete a circuit for energizing said starting electric motor, said switch element being connected in parallel circuit to one portion of said primary winding of said transformer means, and a semiconductor diode connected in said parallel circuit of said switch element and said one portion of said primary winding and so poled that a current is permitted to flow from said source through said closed switch element into the remaining portion of said primary winding whereas a current is prevented from flowing from said source through said one portion of said primary winding to said starting electric motor, the improvement which comprises another semiconductor diode connected in said parallel circuit of said switch element and said one portion of said primary winding and so poled that a current is permitted to flow from said source into said one portion of said primary winding whereas a voltage induced across said one portion of said primary winding is prevented from causing a current to circulate through said parallel circuit.

2. An ignition device for use with an internal combustion engine having an electric starting motor, said device comprising a source of direct current, inverter means including transformer means having a primary winding energized by said source to convert a direct current energy from said source to an alternating current energy, ignition voltage generator means connected to said transformer for generating an ignition voltage each time the engine is to be ignited through utilization of an output from said inverter means, a normally open switch element connected to said source and capable of being closed during starting of said starting electric motor to complete a circuit for energizing said starting electric motor, said switch element being connected in parallel circuit to one portion of said primary winding of said transformer means, and a semiconductor diode connected in said parallel circuit of said switch element and said one portion of said primary winding and so poled that a current is permitted to flow from said source through said closed switch element into the remaining portion of said primary winding whereas a current is prevented from flowing from said source through said one portion of said primary winding to said starting electric motor, the improvement which comprises another semiconductor diode connected in said parallel circuit of said switch element and said one portion of said primary winding and so poled that a current is permitted to flow from said source into said one portion of said primary winding whereas a voltage induced across said one portion of said primary winding is prevented from causing a current to circulate through said parallel circuit.

3. An ignition device for use with an internal combustion engine having an electric starting motor, said device comprising a source of direct current, ignition coil means having a primary winding energized by said source and a secondary winding connected in operation to an ignition plug of said engine, switching means for interrupting a flow of current through said primary winding each time the engine is to be ignited thereby to produce an ignition voltage across said secondary winding of said ignition coil means, a normally open switch element connected to said source and capable of being closed during starting of said starting electric motor to complete a circuit for energizing said starting electric motor, said switch element being connected in parallel circuit to one portion of said primary winding of said ignition coil means, and a semiconductor diode connected in said parallel circuit of said switch element and said one portion of said primary winding and so poled that a current is permitted to flow from said source through said closed switch element into the remaining portion of said primary winding whereas a current is prevented from flowing from said source through said one portion of said primary winding to said starting electric motor, the improvement which comprises another semiconductor diode connected in said parallel circuit of said switch element and said one portion of said primary winding and so poled that a current is permitted to flow from said source into said one portion of said primary winding whereas a voltage induced across said one portion of said

primary winding is prevented from causing a current to circulate through said parallel circuit.

4. An ignition device for use with an internal combustion engine having an electric starting motor, said device comprising a source of direct current, transformer means having a primary winding energized by said source and a secondary winding, an ignition voltage generator means connected to said transformer for generating an ignition voltage each time the engine is to be ignited, through utilization of a secondary voltage across said secondary winding of said transformer means, a normally open switch element connected to said source and operative to be closed when the engine is started, said switch element being connected in parallel circuit to one portion of said primary winding of said transformer means, actuating means responsive to closure of said switch element to complete an energizing circuit extending from said source through the closed switch element to said starting electric motor, and a semiconductor diode connected in said parallel circuit of said switch element and said one portion of said primary winding and so poled that a current is permitted to flow from said source through said closed switch element into the remaining portion of said primary winding whereas a current is prevented from flowing from said source through said one portion of said primary winding to said actuating means, the improvement which comprises another semiconductor diode connected in said parallel circuit of said switch element and said one portion of said primary winding and so poled that a current is permitted to flow from said source into said one portion of said primary winding whereas a voltage induced across said one portion of said primary winding is prevented from causing a current to circulate through said parallel circuit.

5. An ignition device for use with an internal combustion engine having an electric starting motor, said device comprising a source of direct current, an inverter means including transformer means having a primary winding energized by said source to convert a direct current energy from said source to an alternating current energy, ignition voltage generator means connected to said transformer for generating an ignition voltage at each time the engine is to be ignited, through utilization of an output from said inverter means, a normally open switch element connected to said source and capable of being closed when the engine is started, said switch element being connected in parallel circuit to one portion of said primary winding of said transformer means actuating means responsive to closure of said switch element to complete an energizing circuit extending from said source through the closed switch element to said electric starting motor, and a semiconductor diode connected in said parallel circuit of said switch element and said one portion of said primary winding and so poled that a current is permitted to flow from said source through said closed switch element into the remaining portion of said primary winding whereas a current is prevented from flowing from said source through said one portion of said primary winding to said actuating means, the improvement which comprises another semiconductor diode connected in said parallel circuit of said switch element and said one portion of said primary winding and so poled that a current is permitted to flow from said source into said one portion of said primary winding whereas a voltage induced across said one portion of said primary winding is prevented from causing a current to circulate through said parallel circuit.

6. An ignition device for use with an internal combustion engine having an electric starting motor, said device comprising a source of direct current, ignition coil means having a primary winding energized by said source and a secondary winding connected to an ignition plug of said engine, switching means for interrupting a flow of current through said primary winding each time the engine is to be ignited thereby to produce an ignition voltage across said secondary winding of said ignition coil means, a normally open switch element connected to said source and capable of being closed when the engine is started, said switch element being connected in parallel circuit to one portion of said primary winding of said ignition coil means, actuating means responsive to closure of said switch element to complete an energizing circuit extending from said source through the closed switch element to said starting electric motor, and a semiconductor diode connected in said parallel circuit of said switch element and said one portion of said primary winding and so poled that a current is permitted to flow from said source through said closed switch element into the remaining portion of said primary winding whereas a current is prevented from flowing from said source through said one portion of said primary winding to said actuating means, the improvement which comprises another semiconductor diode connected in said parallel circuit of said switch element and said one portion of said primary winding and so poled that a current is permitted to flow from said source into said one portion of said primary winding whereas a voltage induced across said one portion of said primary winding is prevented from causing a current to circulate through said parallel circuit.

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