

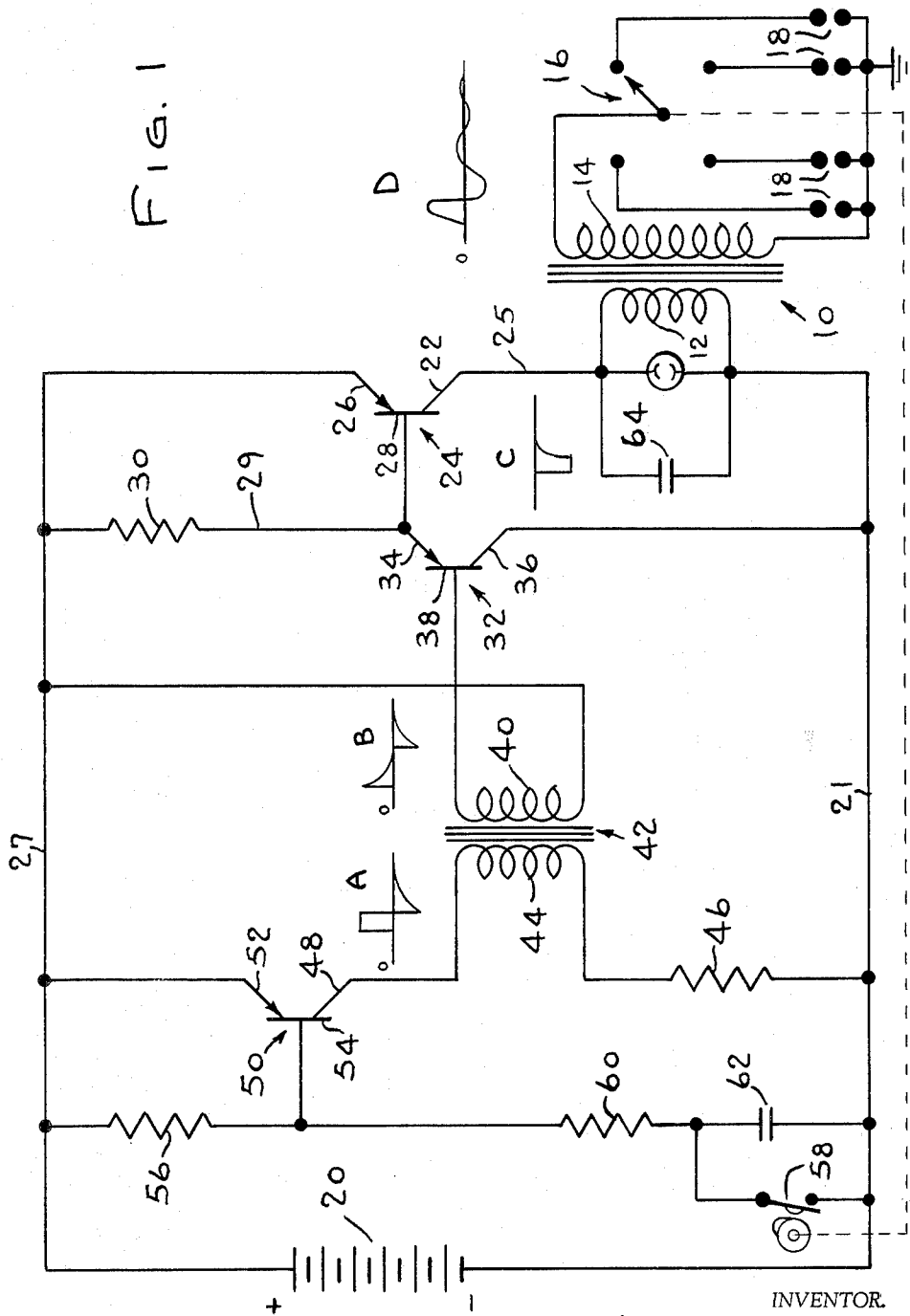
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PULSE AMPLIFICATION IGNITION SYSTEM

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PULSE AMPLIFICATION IGNITION SYSTEM
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This invention relates to transistorized ignition systems for internal combustion engines.

The limitations of the ignition coils for providing the energy for ignition are well known, such as maximum current limits, slow reaction and failure to build up maximum current at high speeds. Efforts to overcome these problems have been directed to the use of transistorized circuits to eliminate the necessity for using present types of ignition coils.

The primary object of this invention is to provide an improved transistorized ignition system which is simple in design and which provides sufficient current for ignition at any engine speed.

This object is accomplished by intermittently energizing a transistorized pulse generator in synchronism with the speed of the engine. The current from the pulse generator is shaped by a transformer and delivered to an emitter-follower transistor which serves to clip the wave form induced in the transformer. The clipped wave form from the emitter-follower transistor controls the operation of a transistorized class "B" amplifier that is connected to a step-up transformer. A high voltage is induced in the transformer and delivered to the ignition system. The base current for the pulse generator is used to control the operation of the system and can be controlled by a commutator, since it is so small, thereby saving the expense of a circuit breaker.

Other objects and advantages will be pointed out in or be apparent from the description and claims, as will obvious modifications of the embodiment shown in the single figure in the drawing which shows a circuit diagram for the ignition system.

The ignition system shown in the drawing includes a low inductance type step-up transformer 10 having a primary winding 12 and a secondary winding 14 connected to a distributor 16 which routes the current pulse induced in the secondary winding to sparking devices 18. Because of the relatively small number of turns, approximately 16, in the primary winding, the inductance of the primary winding is low. Current flow through the primary winding will therefore reach a maximum in a minimum of time inducing a voltage in the secondary winding instantly. The secondary winding has a relatively high number of turns, approximately 33,000, which will produce a spark across the sparking devices of sufficient magnitude to cause ignition in the engine. This type of transformer is well known and is shown in co-pending application Ser. No. 74,681, filed December 8, 1960.

The primary winding of the step-up transformer is connected to the negative terminal of a battery 20 through circuit 21 and to collector 22 of a class "B" transistor amplifier 24 through circuit 25. Emitter 26 of the amplifier is connected to the positive terminal of the battery through circuit 27. Base 28 is normally biased positive through circuit 29 and resistor 30. The amplifier is controlled by an emitter-follower type transistor 32 which has its emitter 34 connected to circuit 29. Collector 36 is connected to the negative terminal of the battery through circuit 21 and base 38 is connected to the positive terminal of the battery through secondary winding 40 of transformer 42 and circuit 27. Since the emitter and base of transistor 32 are both connected to the positive terminal of the battery, the transistor is normally non-conductive.

Primary winding 44 of the transformer 42 is connected

to the negative terminal of the battery through resistance 46 and circuit 21 and to collector 48 of pulse generator transistor 50. Emitter 52 of the pulse generator transistor is connected to the positive terminal of the battery through circuit 27 and base 54 is biased positive through resistor 56. Base 54 is biased negative when switch 58 is closed connecting the base to the negative terminal of the battery through resistance 60 and circuit 21. The shift to negative occurs through the voltage divider action of resistances 56 and 60. Capacitor 62 is connected in parallel with switch 58 to prevent arcing when the shift is made from positive to negative. Due to the low current controlled by switch 58 (on the order of 10 ma.) a simple commutator may be used in place of switch 58 thus eliminating point bounce and other inertia effects.

In operation, base 54 is normally biased positive and is shifted to negative when switch 58 is closed by the voltage divider action of resistances 56 and 60. The bias shift of the base causes the transistor to become fully conductive. The voltage at the collector rises to a value determined by resistance 46 and the resistance of the primary winding of transformer 42. When the switch is opened the collector swings negative beyond zero due to the inductive effect of the primary winding of the transformer and then rises exponentially to zero (as shown in diagram A).

Due to the poor low frequency response of transformer 42, the voltage induced in the secondary consists of a sharp rise in the positive direction when the points close and then decays exponentially to zero. When the switch is opened there is a sharp negative drop followed by an exponential decay to zero (as shown in diagram B).

If the secondary winding of the transformer were connected directly to the base of transistor amplifier 24, excessive loading of the transformer would result, changing the wave form from its desired shape (diagram B). To circumvent this problem, transistor 32 is used and is normally biased positive and thus non-conducting and, consequently, responds only to the negative portion of the wave form of the secondary winding that occurs when switch 58 is opened. The voltage at emitter 34 is essentially the same as at the base except that its peak is clipped (diagram C) due to the heavy base current of transistor 24 when it is driven into conduction. Since the emitter of transistor 32 is directly connected to the base of transistor 24, the output of the emitter-follower drives transistor 24 into full conduction causing a very large current to flow in the primary of transformer 10. This current flow causes a high voltage to be induced in the secondary winding of transformer 10. Capacitor 64 is connected in parallel with the primary winding of transformer 10 to produce a wave form that falls off sharply after the first cycle (diagram D).

The width of the pulse (diagram C) can be varied by varying resistance 46. The best efficiency has been obtained when the value of resistance 46 is chosen to provide a pulse width equal in time to the time of 1/2 cycle of the natural period of oscillation of the output transformer. As the resistance of resistance 46 is reduced, the collector current in transistor 24 will increase because of the increasing duty-cycle.

The collector current of transistor 24 increases linearly with speed and may be used as tachometer information with a suitably calibrated ammeter. It should be obvious that the circuit described will provide sufficient current at the sparking devices for ignition at all speeds of the engine. Due to the low current controlled by switch 58 it is possible to use a commutator in place of the usual breaker points, thus eliminating point bounce and other inertia effects. This will provide a distributor life that is greater than that of the engine without attention.

Although but one embodiment of the present invention has been illustrated and described, it will be apparent to those skilled in the art that various changes and modifications may be made therein without departing from the spirit of the invention or from the scope of the appended claims.

I claim:

1. An ignition system for an internal combustion engine having a number of spark ignition devices comprising,
 - a first transformer having a primary winding and a secondary winding connected with said spark ignition devices,
 - a unidirectional voltage power supply,
 - a first transistor having its emitter connected to the positive terminal of the power supply and its collector to one end of said primary winding,
 - the other end of said primary winding being connected to the negative terminal of the power supply,
 - and control means connected across the power supply and to the base of said first transistor to control the operation of the first transistor, said control means including pulse-generating means energized in synchronism with the engine including a second transistor having its emitter connected to the positive terminal of the power supply and its collector to a pulse-shaping means and also including voltage divider means connected across said power supply and to the base of said second transistor positive, switch means connecting the voltage divider means in circuit with the power supply and selectively operable to change the bias on the base of said second transistor to render said second transistor conductive, pulse-shaping means connected in circuit with said pulse-generating means and operative to shape said electrical pulse in response to energization and de-energization of said pulse-generating means and in synchronism with said generating means, and pulse clipping means connected in circuit with said pulse-shaping means and said first transistor to control the operation of the first transistor whereby a shaped and clipped pulse is applied to and renders said first transistor conductive to energize said first transformer and produce a spark at said spark ignition devices.
2. An ignition system according to claim 1 wherein said pulse shaping means comprises a second transformer having its primary winding arranged with one terminal connected to the collector of said second transistor and the other terminal to the negative terminal of said power supply.
3. An ignition system according to claim 2 wherein said pulse clipping means comprises a third transistor having its emitter connected to the base of the first transistor, its collector connected to the negative terminal of said power supply, and its base to one side of the secondary winding of the second transformer.
4. An ignition system according to claim 3 including a resistance member connected in circuit with the primary winding of the second transformer to control the width of the electrical pulse transmitted to the first transistor.
5. An ignition system for an internal combustion engine having a number of spark ignition devices comprising,
 - a step-up transformer having a primary winding and a secondary winding,
 - the secondary winding being connected to energize the spark ignition devices,
 - a unidirectional voltage power supply,

- a transistor class "B" amplifier having its emitter connected to the positive terminal of the power supply and its collector to one end of the primary winding, the other end of the primary winding being connected to the negative terminal of the power supply,
- a pulse-generating transistor connected across the power supply,
- switch means activated in synchronism with the engine and connected in circuit with and operative when activated to energize said pulse-generating transistor,
- and pulse shaping and clipping means including (a) an emitter-follower transistor having its emitter connected to the base of the transistor amplifier and its collector to the negative side of the battery so that said transistor amplifier is conductive when said emitter-follower is conductive; and (b) a second transformer having its primary winding connected to the collector of the pulse-generating transistor and to the negative terminal of the power supply and its secondary winding connected to the positive side of the power supply and to the base of the emitter-follower transistor so that current induced in the secondary when said switch means is opened causes the emitter-follower to become fully conductive.
6. An ignition system according to claim 5 including a first resistance in the primary winding circuit of the second transformer to limit the duration of conductivity of the emitter-follower transistor to a predetermined interval.
7. An ignition system for an internal combustion engine having a number of spark ignition devices comprising,
 - a first transformer having its secondary connected to energize said ignition devices,
 - a source of unidirectional current connected to supply current to the primary of said transformer,
 - a first normally nonconductive transistor in circuit with and controlling current flow to said primary winding,
 - a second normally nonconducting pulse generating transistor connected across said unidirectional source, means connected with the base of said second transistor and said engine and operative selectively to change the bias on the base of said second transistor to render it conductive,
 - a second transformer connected to receive the pulse from said second transistor and shape the pulse to provide an alternating output,
 - and a third transistor connected across said power supply and to the base of said first transistor, the base of said third transistor being connected to receive the the output of said second transformer so that said third transistor is rendered conductive on a $\frac{1}{2}$ cycle of the output of said second transformer and correspondingly renders said first transistor conductive.
8. The ignition system of claim 7 wherein the emitter of said third transistor is connected to the base of said first transistor to clip the pulse transmitted to said first transistor to render it conductive.

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