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PULSE COUNTER IGNITION SYSTEM

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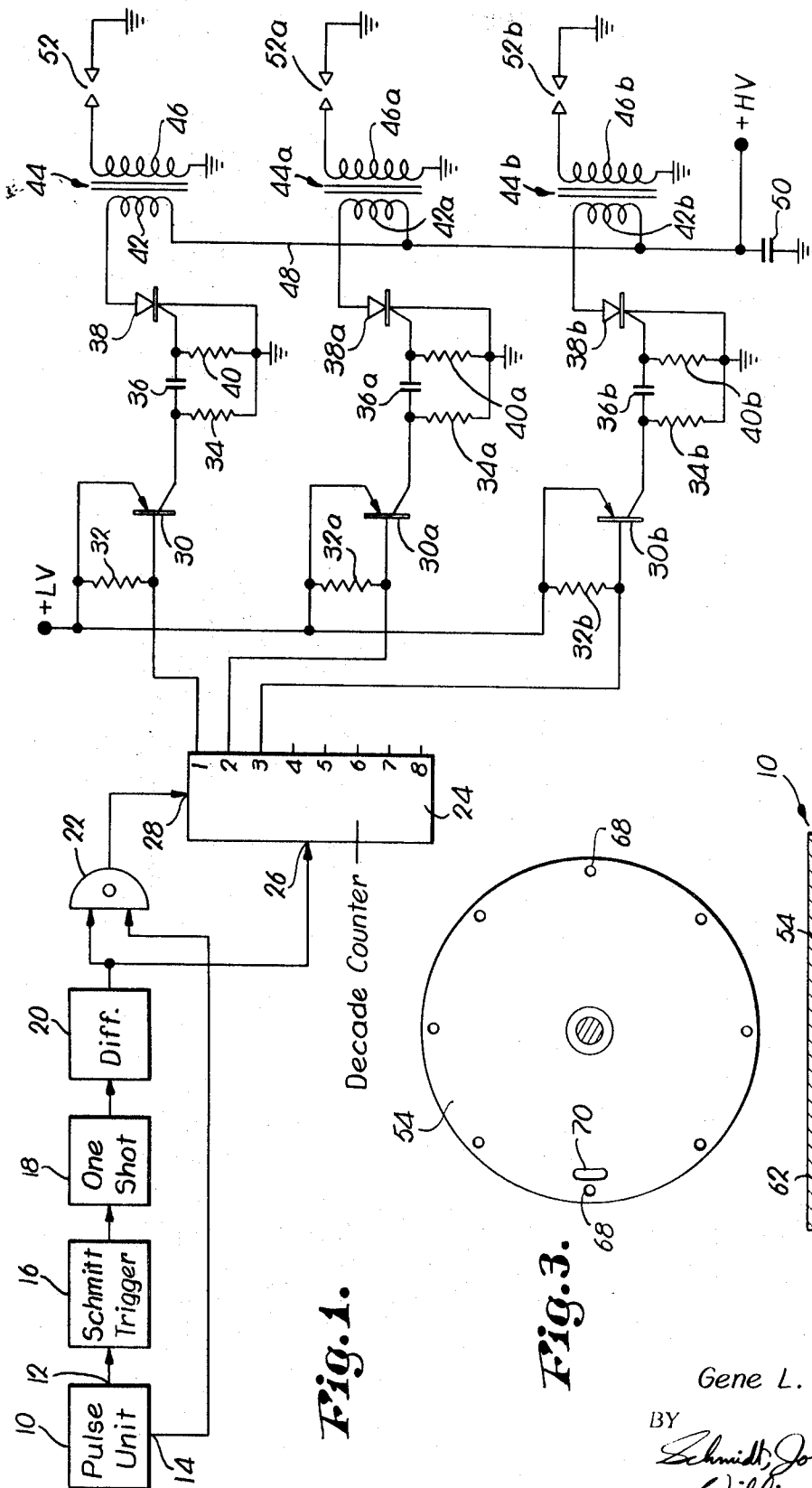


Fig. 1.

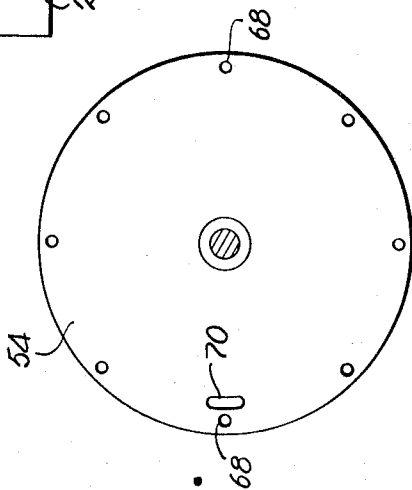


Fig. 3.

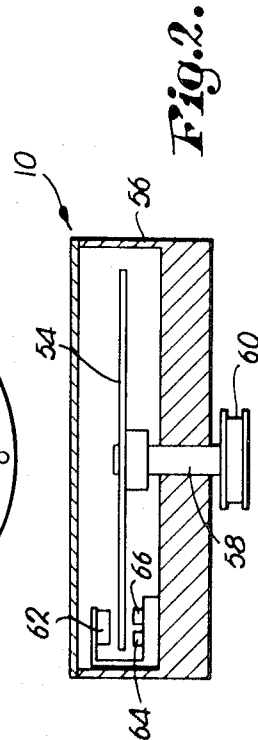


Fig. 2.

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PULSE COUNTER IGNITION SYSTEM

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5 Claims

ABSTRACT OF THE DISCLOSURE

An ignition system having a decade counter responsive to sequential timing pulses produced by an optical pulse generating unit driven by the timing shaft of the engine. The counter is reset following each firing cycle in response to a reset pulse produced by the pulse unit, such cycle comprising a count equal to the number of cylinders of the engine. Each counter output triggers a separate SCR that, in turn, activates an ignition transformer connected to a respective spark plug.

This invention relates to ignition systems for internal combustion engines and, more particularly, to an ignition system employing a pulse counter to control the cyclic firing of the cylinders.

Conventional ignition systems employing breaker points and a mechanical distributor inherently require frequent maintenance and adjustment. Periodic tune-ups are necessary to assure proper engine performance, and the usable life of such components as the breaker points and condenser is relatively short.

It is, therefore, the primary object of the present invention to provide an improved ignition system which is not subject to the above difficulties and disadvantages, and which is characterized by long life and dependability and provides accurate timing to the engine.

Another important object of the invention is to provide an ignition system as aforesaid having high operational flexibility in that it may be readily adapted to odd or even firing orders in accordance with the operating characteristics of a particular engine.

A further and important object of the invention is to provide an ignition system as aforesaid which makes maximum utilization of electrical components rather than mechanical, and which eliminates the need for a rotor type mechanical distributor through the use of a pulse counter that controls separate ignition circuits for the respective spark plugs of the engine.

Still another important aim of this invention is to provide an optical pulse generating unit responsive to engine speed which produces both timing and reset pulses for operating the pulse counter of the system.

In the drawing:

FIG. 1 is a block and electrical schematic diagram of the ignition system of the present invention;

FIG. 2 is a diagrammatic, cross-sectional view of the optical pulse generating unit; and

FIG. 3 is a view of one side of the timing disc of the unit showing the arrangement of the timing and reset windows.

Referring initially to FIG. 1, an optical pulse generating unit 10 has an output 12 from which timing pulses are delivered, and an output 14 from which a reset pulse is obtained at the commencement of each firing cycle of the engine. The details of construction of the pulse unit 10 will be described hereinafter with reference to FIGS. 2 and 3, it being sufficient at this juncture to understand that the timing pulses from the output 12 have a time spacing between successive pulses which is inversely proportional to the speed of the engine. The output 12 of pulse unit 10 is connected to the input of a Schmitt trigger 16 that, in turn, gets a monostable multi-

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vibrator or "one shot" 18. A differentiating network 20 is responsive to the output of the one shot 18 and is connected to one input of a two-input AND gate 22. The other input of the AND gate 22 is connected to the output 14 of the pulse unit 10.

A decade counter 24 has a counting input 26 connected to the output of the differentiating network 20, and is also provided with a reset input 28 connected to the output of the AND gate 22. The counter 24 has outputs designated "1" through "8" which are utilized in the present invention, the number of counter outputs corresponding to the number of cylinders of the engine with which the ignition system is employed. The exemplary arrangement of FIG. 1 illustrates the adaptation of the system to an eight-cylinder engine, the switching and ignition circuitry being fully shown for the three of the eight cylinders fired by the "1," "2," and "3" counter outputs.

A PNP transistor 30 has its base connected to the "1" output and its emitter connected to a source of operating voltage as represented by the terminal labeled +LV. A bias resistor 32 is connected across the base and the emitter, the collector of the transistor 30 being connected to circuit ground via a resistor 34. A capacitor 36 couples the collector to the gate of a silicon controlled rectifier 38, an input resistor 40 being connected across the gate and the cathode of the SCR 38. The cathode is at circuit ground, and the anode is connected to one end of the primary winding 42 of an ignition transformer 44, the latter having a high-voltage secondary winding 46. The opposite end of the primary winding 42 is connected by a lead 48 to one plate of a capacitor 50 to which positive high voltage is applied, as indicated by the terminal labeled +HV. The opposite plate for the capacitor 50 is at circuit ground.

The upper end of the secondary winding 46 is connected to a spark plug 52 associated with one of the cylinders of the engine. The spark plug 52 comprises the spark generating component of the engine which must be periodically excited in proper timed relationship to the other spark plugs in order to effect proper operation of the engine.

The transistor 30 and its associated circuit elements form a polarity inversion stage which delivers a positive pulse to the gate of the SCR 38 in response to a negative count signal at the "1" output of the counter 24. The counter 24 is preferably an integrated circuit and may, for example, comprise an SN7441AN and SN7490N integrated circuit manufactured by Texas Instruments Incorporated of Dallas, Tex., which includes the AND gate 22. It should be appreciated that the Schmitt trigger 16, one shot 18, and differentiating network 20 may also comprise integrated circuits to further enhance the compactness and reliability of the system.

The switching and ignition circuits connected to the "2" and "3" outputs of the counter 24 are identical to the circuit just described above which connects the "1" output to the spark plug 52. Like components are designated by the same reference numerals with the addition of the *a* and *b* notation respectively. It should be noted that the ignition circuits to the spark plugs 52, 52a, and 52b are independent from one another and separately controlled by the counter outputs "1," "2," and "3" respectively.

The pulse unit 10 is illustrated in detail in FIGS. 2 and 3. An opaque, rotatable member in the nature of timing disc 54 is disposed within a housing 56 which shields the disc 54 from ambient light. The disc 54 is rigid with a rotatable shaft 58 that extends through a wall of the housing 56 and is provided with a pulley 60. The timing shaft (not shown) of the engine is coupled to the pulley 60 by a belt drive or, alternatively, a chain

and sprocket drive may be employed to form the drive connection between the engine timing shaft and the disc shaft 58.

A suitable light source 62, which may be of the infrared type, is mounted adjacent one side of the disc 54 near the circumferential periphery thereof. A pair of phototransistors 64 and 66 are disposed adjacent the opposite side of the disc 54 and are in general alignment with the light source 62. However, the disc 54 normally blocks passage of light rays from the source 62 to either of the phototransistors 64 or 66.

In order to periodically excite the phototransistor 64, the disc 54 is provided with a series of eight apertures 68 which present windows through which light rays from source 62 may pass. The apertures 68 are equally radially spaced from the rotative axis of the disc 54, and are also in equally angularly spaced relationship to one another with respect to such axis.

A slot 70 in the disc 54 is disposed adjacent one of the apertures 68 and forms a window through which light from source 62 may pass and be detected by the phototransistor 66. The slot 70 is spaced radially inwardly from the row of apertures 68, and the phototransistors 64 and 66 are radially spaced with respect to the axis of the disc 54 to coincide with the radial spacing of the apertures 68 and the slot 70 respectively. The central portion of the slot 70 is radially aligned with the adjacent aperture 68, thus both of the phototransistors 64 and 66 will be concurrently excited once during each revolution of the disc 54. Each of the phototransistors 64 or 66 is connected in a separate amplifier stage (not shown) which, in turn, delivers an amplified pulse at the outputs 12 or 14.

OPERATION

The windows formed by the apertures 68 and the window formed by the slot 70 provide two channels of information as the disc 54 is rotated by the engine. The apertures 68 constitute timing windows for effecting the firing of the cylinders in proper sequence, and the slot 70 constitutes a reset window which causes the counter 24 to reset following each firing cycle.

Timing pulses are initiated by the phototransistor 64 as the apertures 68 successively pass into alignment with the phototransistor 64 between the latter and the light source 62. The timing pulses are delivered at the output 12 and are each converted into a step voltage by the Schmitt trigger 16. Further pulse shaping is accomplished by the one shot 18, its output comprising a series of pulses of uniform duration and amplitude. The differentiating network 20 then shapes each one shot output pulse into a very narrow pulse for exciting both the AND gate 22 and the counting input 26 of the counter 24. The purpose of the pulse shaping arrangement is to prevent erroneous noise and secondary pulses from reaching the counting input 26. Noise could be the product of natural lighting or noise spikes produced by the ignition transformers or other circuits, and the secondary pulses could be produced by mechanical vibration or shock in the disc driving arrangement.

Assuming, for example, that spark plug 52 has been fired, the next pulse from the output of network 20 causes a count signal to appear at the "2" output of the counter 24. Such count signal is in the form of a negative potential and will place transistor 30a in conduction. This, in turn, delivers a momentary positive pulse through capacitor 36a to the gate of SCR 38a. With the SCR 38a in conduction, the upper end of the primary 42a is connected to ground, thereby placing the primary 42a directly in parallel with the capacitor 50 which recharged after previously exciting spark plug 52. Therefore, the capacitor 50 now discharges through primary 42a to cause the secondary 46a of the transformer 44a to deliver a high-voltage ignition pulse to the spark plug 52a. The ringing action of inductive feedback then reverse biases the SCR 38a to place the latter in its nonconducting state.

As each count signal of a series of eight count signals

is delivered at the respective counter output, the associated switching and ignition circuit is activated as above. Thus, the eight cylinders of the engine are successively fired in a predetermined order.

Once a count signal has been delivered at the "8" output of the counter, it may be appreciated that the count must not proceed to higher digits; instead, resetting of the counter 24 is necessary in order to repeat the firing cycle. To this end, the reset window provided by the slot 70 and the timing window provided by the adjacent aperture 68 always cause a count signal to be delivered at the "1" output of the counter 24. The timing pulse and the reset pulse are coincident and after the timing pulse is shaped are both fed to the inputs of the AND gate 22. Therefore, the AND gate 22 delivers a reset signal at its output which is received by the reset input 28 of the counter 24 to cause the counter to return its "1" output state. Thus, the next count signal will be delivered at the "2" output, and so on through the "8" output, whereupon resetting is again effected by the coincident presence of the timing and reset pulses.

Having thus described the invention, what is claimed as new and desired to be secured by Letters Patent is:

1. In an ignition system for an internal combustion engine having a predetermined number (N) of cylinders each provided with a corresponding spark producing means:

timing pulse generating means adapted to be mechanically coupled with and driven by said engine for producing a first electrical output comprising a continuing series of sequential electrical timing pulses occurring at successive intervals dependent upon the speed of said engine;

reset pulse generating means adapted to be mechanically coupled with and driven by said engine for producing a second electrical output comprising a continuing series of sequential electrical reset pulses respectively occurring substantially coincidentally with every Nth one of said timing pulses of said first electrical output;

an ignition voltage generating means for each of said spark producing means respectively and each adapted for coupling with a corresponding one of the latter, each of said ignition generating means being operable responsive to application of a control signal thereto for actuating the corresponding spark producing means;

electrical pulse counting means having a timing pulse input terminal, a reset pulse input terminal, and a plurality numbering at least N of signal output terminals, said counting means being operable responsive to application of a series of electrical timing pulses to said timing pulse input terminal thereof to count said timing pulses and to provide in correlation with said count a control signal initially at a first control signal output terminal then successively at different remaining ones of said control signal output terminals in a predetermined order, said counting means further being operable responsive to application to each electrical reset pulse to said reset pulse terminal thereof to restore said counting means to a reset condition for next providing said control signal at said first of said control signal output terminals in response to the next timing pulse applied to said timing pulse input terminal;

first circuit means for coupling said timing pulse generating means with said timing pulse input terminal of said counting means for applying said first electrical output to the latter;

second circuit means for coupling said reset pulse generating means with said reset pulse input terminal of said counting means for applying said second electrical output to the latter; and

third circuit means for coupling a different predetermined one of said ignition voltage generating means with each of the first N of said control signal output

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terminals to be provided with said control signal during said predetermined order of counting and control signal providing operation of said counting means.

2. The ignition system as claimed in claim 1, said timing pulse generating means including a rotatable, light blocking member having timing windows therein equal in number to said spark producing means, said windows being substantially equally radially spaced from the axis of rotation of said member and being equally angularly spaced thereabout, said timing pulse producing means further including a light source and a photoelectric element on opposite sides of said member with the element disposed in alignment with each of said windows as the same pass between the element and the source, and a drive coupling for mechanically connecting said member with said engine, said element producing said timing pulses upon rotation of said member.
3. The ignition system as claimed in claim 2, said reset pulse generating means including a reset window in said member at a different radial distance from said axis than said timing windows, said reset pulse generating means being provided with a second photoelectric element for producing a reset pulse with each revolution of said member, said second element being on the same side of the member as the first mentioned element and disposed in alignment with said reset window as the latter

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passes between said second element and said source.

4. The ignition system as claimed in claim 3, said reset window being radially aligned with one of said timing windows.

5. The ignition system as claimed in claim 1, said second circuit means including an AND gate having an input coupled with said timing pulse generating means for receiving said timing pulses from the latter, an input coupled with said reset pulse generating means for receiving said pulses from the latter, and an AND gated output coupled with said reset pulse input terminal.

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