

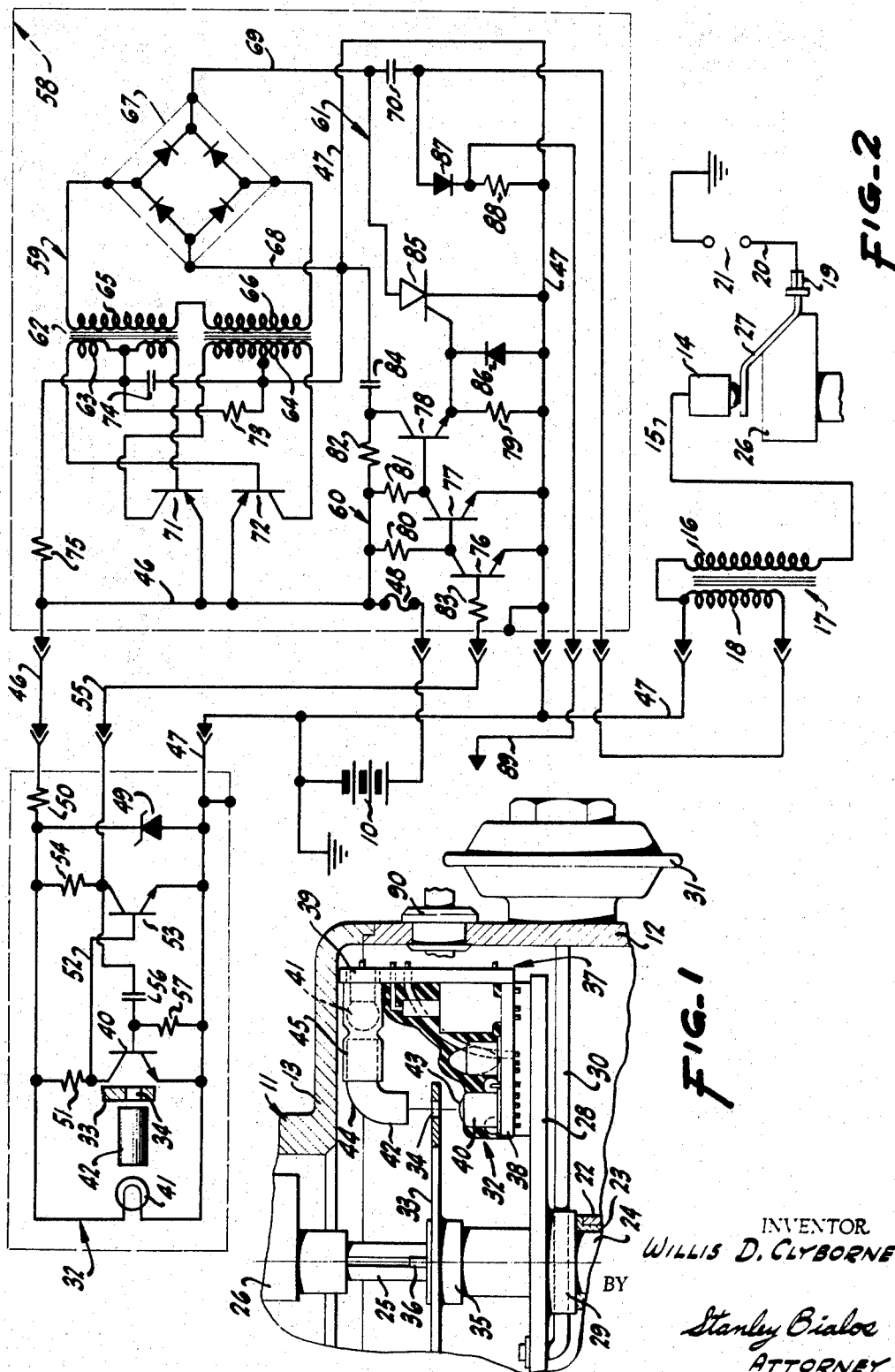
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ENGINE IGNITION SYSTEM

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3,472,216

ENGINE IGNITION SYSTEM

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ABSTRACT OF THE DISCLOSURE

Electro-optical circuit interrupter mechanism for use with the distributor of an internal combustion engine to replace the customary distributor points as the means for converting the steady-state D.C. battery current into a pulsating D.C. current enabling the primary winding of the ignition transformer to be energized thereby. The interrupter mechanism includes a sensor unit mounted as an integer within the distributor casing, and such unit is substantially encapsulated within an insulating material to protect its components from moisture and other adverse conditions of the ambient environment within the distributor casing. The sensor unit comprises a light source and a photoresponsive sensor energizable thereby and forming a part of a multivibrator circuit operative to provide a succession of voltage pulses in response to successive intermittent energization of the photoresponsive sensor; and the interrupter mechanism further includes an apertured-equipped interrupter disc rotatably driven by the distributor shaft and located between the photoresponsive sensor and light source so as to cyclically interrupt the transmission of light to the sensor and thereby effect such intermittent energization thereof. A capacitive discharge unit repetitively energizes the primary winding of the ignition coil in response to the succession of voltage pulses delivered thereto by the sensor unit.

This invention relates to an ignition system adapted for use with internal combustion engines and the like, and it relates more particularly to that portion of such ignition system through which the customarily provided, steady-state D.C. battery current is converted into a pulsating D.C. current to enable a high voltage to be developed from the low-value battery voltage in a step-up ignition transformer.

Conversion of the low value, direct current voltage (usually provided by a six or twelve volt storage battery) to the much higher value voltage necessary to create an arc across the spaced terminals of each spark plug or sparking device used in an internal combustion engine has long been accomplished by means of mechanical breaker points interposed in the primary circuit of a step-up transformer to repetitively complete and interrupt such circuit and thereby effectively change the steady-state battery current supplied thereto into a pulsating current effective to energize the secondary winding of the transformer. Conventionally, the breaker points are located within the distributor casing of such engine which enables a single engine-driven shaft to angularly displace the rotor member of the distributor (which rotor member successively connects in turn each of the various sparking devices to the secondary winding of the transformer) and to open and close the breaker points in timed relation therewith.

Such breaker points, which mechanically open and close the circuit therethrough, are subject to considerable wear and fatigue and, therefore, require frequent cleaning, adjusting and replacement. Moreover, since at least one of the breaker points is a movable component, the mechanical inertia inherent in the reciprocatory displacement thereof causes considerable inaccuracy in the timing of the ignition system, especially at higher engine speeds. Addi-

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tionally, there is a reactive bounce or rebound factor involved in the movable point or contact snapping closed against the stationary contact, which reactive bounce also interferes adversely with high quality engine performance especially at higher speeds.

As a consequence of these characteristic difficulties and limitations inherent in mechanical breaker points, efforts have been made to eliminate the same, and an exemplary instance thereof is *Berdine et al.* Patent No. 2,984,695 which shows that the mechanical breaker points can be replaced by an electro-optical system in which a beam of light is directed toward a photoelectric cell and the light beam repetitively interrupted to cyclically and alternately energize and de-energize the photoelectric cell, which alternate conditions thereof are used to complete and interrupt the circuit through the primary winding of a step-up transformer just as in the case of the mechanical breaker points.

The present invention constitutes an improved ignition system of the general type described in such Patent No. 2,984,695; and, in this respect, has a significantly greater life expectancy throughout which reliable and accurate performance is attained. Further, the system of the present invention affords rapid and accurate triggering of the ignition system; it has an exceedingly fast response time—in the nanosecond range (i.e., 10^{-9} second); it permits the spark gap of each engine spark plug or sparking device to be much greater than in the past with the result that a longer, flatter and hotter spark is provided which enables engine fuel to be burned more efficiently and thereby results in the development of greater engine horsepower; and it affords greater accuracy of control over the duration of each sparking period throughout the entire operating range of the engine. Additionally, the ignition system affords simplified installation in a vehicle because it includes an encapsulated sensor unit mountable as an integer within the distributor casing of the vehicle, and such sensor unit comprises a pulse-forming network of simplified character energized repetitively by the successive intermittent transmission of radiant energy from a source thereof provided by the sensor unit to an energy sensor also provided thereby.

An ignition system comprising the present invention includes a distributor which may be substantially conventional except that the usual mechanical breaker points are completely omitted and an electro-optical circuit interrupter mechanism substituted therefor. Such electro-optical mechanism includes a sensor unit located within the distributor casing and comprising a source of radiant energy which may be in the form of a light or electric lamp, a sensor responsive to the receipt of energy from such source, an energy conductor terminating at one end adjacent the energy source and terminating adjacent its other end in spaced relation with the sensor, and a pulse generating circuit including such sensor. Also mounted within the distributor casing intermediate the sensor and adjacent end of the energy conductor is an interrupter rotated by the engine-driven distributor shaft and operative alternately and repetitively to permit and then obstruct the transmission of radiant energy from the conductor thereof to the sensor. Responsive to the sensor unit and controlled thereby is an energizing circuit such as a capacitive discharge circuit operative to complete and interrupt cyclically the primary circuit of the ignition transformer in accordance with the cyclically alternate conditions of the sensor.

An embodiment of the invention is illustrated in the accompanying drawing in which:

FIGURE 1 is a broken vertical sectional view of an engine distributor embodying the present invention; and

FIGURE 2 is a schematic circuit diagram of an ignition system embodying the invention.

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The ignition system shown in the drawing is suitable for use with an internal combustion engine as, for example, the usual gasoline engine employed as the power plant in automobiles and other land vehicles, in marine and airborne vehicles, etc. The system to a great extent is conventional and includes the customary source of direct current electric power such as the storage battery 10 shown in FIGURE 2. As is well known, such battery ordinarily defines either a six or twelve source of D.C. potential, but as respects the present invention, any voltage value can be provided and the system adjusted therefor. The system further includes a distributor which is shown in part in FIGURE 1 and denoted in its entirety with the numeral 11. The distributor itself is in many respects conventional and includes a casing 12 having a removable cap 13. The cap is provided with a high voltage terminal 14 (FIGURE 2) connected by a conductor 15 to one side of the secondary winding 16 of a transformer 17. As in the usual case, the transformer 17 shown is an auto-transformer and, accordingly, the other end of the secondary winding 16 is grounded in common with one end of the primary winding 18.

The distributor 11 is also provided with a plurality of angularly spaced contacts 19 adapted to be connected by a plurality of respectively associated conductors 20 to conventional sparking devices or spark plugs 21. In FIGURE 2, only one such contact 19, conductor 20 and sparking device 21 are shown—it being understood that there will be a separate contact, conductor and sparking device for each cylinder of the engine, usually numbering 4, 6 or 8 in the automotive environment. As shown in FIGURE 2, one side of each sparking device 21 is grounded, usually through the engine and vehicle chassis.

The casing 12 is provided centrally along the bottom closure wall thereof with a hub or collar 22 that provides a mounting for a sleeve bearing 23. Extending upwardly through the bearing 23 is a hollow tubular shaft 24 coaxially and rotatably passing therethrough a distributor shaft 25 adapted to be driven by the engine through a suitable gear train (not shown). Adjacent its upper end, the distributor shaft 25 has a rotor 26 mounted thereon which rotates therewith, and relative angular displacements between the shaft and rotor are prevented in any suitable manner, as by means of flattened contiguous surface areas respectively provided by the shaft and rotor and which also serve as a polarizing means to cause the rotor to be mounted upon the shaft in a predetermined angular position with respect thereto. This latter feature is necessary since the rotor is removable and the timing of the engine would be destroyed if the precise angular relationship between the shaft and rotor were not maintained. As in the usual manner, the rotor 26 is formed of an insulated material but is equipped with a conductor or conductive strip 27, one end of which is in continuous engagement with the high voltage terminal 14 and the other end of which is adapted to selectively engage the successive contacts 19 as the rotor is angularly displaced by the shaft 25.

Located within the casing 12 is a timing plate 28 equipped with a hub or depending collar 29 circumjacent the hollow shaft 24 and pinned or otherwise secured thereto. The timing plate 28 is adapted to be angularly adjusted with respect to the axis of rotation of the distributor shaft 25 for the purpose of advancing the spark or time of spark occurrence as engine speed increases. Usually, such adjustment is accomplished automatically, as by connection of the plate 28 to an arm or lever 30 that extends through the casing 12 and into operative association with a conventional vacuum motor 31 adapted to be connected to the intake manifold of the associated engine.

Mounted within the distributor casing 12 upon the plate 28 is a sensor unit 32 forming a part of an interrupter system that further includes an interrupter 33 having therealong alternate areas adapted to pass or transmit

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energy therethrough and to obstruct or prevent the transmission of energy. In the form shown, the interrupter 33 is a circular disc formed of an opaque material, such as aluminum, and provided at angularly spaced locations therealong with a plurality of apertures 34. Thus, each aperture 34 defines an energy transmitting area and the portions of the disc 33 interposed between such apertures define the energy obstructing areas. The disc 33 is equipped with a collar 35 circumjacent the distributor shaft 25 and is secured thereby by a key or keyway composition 36 which causes the interrupter to rotate in enforced synchronism with the shaft. Evidently, there will be an aperture 34 for each contact 19 and therefore for each sparking device 21 of the associated engine.

The sensor unit 32 includes support structure 37 comprising a pair of panels 38 and 39 disposed, in the form shown, at right angles with respect to each other. The panels 38 and 39 are printed wire panels (the term "printed" being used in a generic sense to cover conductor-equipped panels irrespective of the processing technique by which conductors are provided therealong) having conductors along at least one side thereof, and mounted upon the panel 38 is an energy sensor 40 characterized by being responsive to the receipt thereby of radiant energy. In the particular embodiment being considered the sensor is responsive to radiant energy in the visible spectrum such as that provided by a conventional incandescent lamp 41 supported by the panel 39 through a suitable socket provided therefor. The lamp 41 may be a conventional light bulb having, for example, a rating of 6 or 12 volts (usually depending upon the potential of the battery source).

As illustrated in FIGURE 1, the sensor 40 and energy source 41 are essentially disposed at right angles with respect to each other and energy is transmitted to the sensor 40 from the source 41 by means of a radiant energy conductor 42 in the form of an elongated rod terminating at one end adjacent the lamp or bulb 41 and terminating at its other end a spaced distance from the sensor 40 and in substantial alignment with the face or entrance aperture 43 thereof. The conductor or rod 42 in the apparatus being considered may be a lucite bar having all of the longitudinal surfaces thereof rounded since light energy has a tendency to escape along any sharp edges of such bar. The light-conductive bar or rod 42 has an arcuate section therealong, as shown at 44, so as to change the direction of the light energy transmitted therethrough from a path generally normal to the plane of the panel 39 to a path generally normal to the plane of the panel 38.

The conductor 42 is fixedly secured to the panel 39 by a releasable support 45 in the form of a hollow tube that telescopically receives therein at one end thereof the adjacent end portion of the conductor 42 which is affixed thereto in any convenient manner, such as by an adhesive connection therebetween, by a friction fit, or by solvent welding of the two components. The tubular support 45 is positioned circumjacent the lamp 41 and is releasably held in position by any conventional fastener arrangement such as by means of cap screws (not shown) extending through ears provided therefor by the tube and into the panel 39. The tubular support 45 is made removable so as to permit lamps 41 to be interchanged whenever necessary or desirable.

The entire sensor unit 32 may be removably secured to the timing plate 28 so that it is readily replaced should it be required, and it will be observed that the unit is oriented so that the interrupter 33 is disposed intermediate the face 43 of the sensor 40 and the facing end portion of the energy conductor 42. Therefore, the interrupter 33 is operative to position sequentially the successive apertures 34 between the conductor 42 and sensor 40 so as to permit the transmission of radiant energy therebetween.

The sensor unit comprises in addition to the sensor 40 and energy source 41, together with the associated com-

ponents heretofore described, circuitry that includes a voltage regulator and a pulse-forming network operative to produce voltage pulses in response to the successive intermittent energization of the sensor 40 as the interrupter 33 is rotated. The circuitry is illustrated in FIGURE 2, and referring thereto the sensor unit 32 is enclosed in broken lines (the interrupter 33 is also included therein) and leading thereto are voltage supply lines 46 and 47, the first of which is connected to the positive side of the battery 10 through a fuse 48, and the second of which is grounded in common with the negative side of the battery 10. Connected across the supply lines 46 and 47 through a voltage dropping resistance 50 in series with the positive supply line 46 is a voltage regulator 49 comprising, in the form shown, a zener diode.

Connected across the output of the regulator 49 is the pulse-forming network including as a part thereof the aforementioned sensor 40 which, in the circuit being considered, is a light activated silicon controlled switch (LASCS) having both an emitter gate and a collector gate, and by using the emitter gate as a base element and the collector gate as the collector element, the device functions as a light sensitive NPN transistor. The collector element of such photosensitive transistor 40 is connected to the positive side of the regulated supply through a load resistance 51 and its emitter is directly grounded through the line 47. The output signals appearing on the collector element are transmitted by a signal line 52 to the base of a transistor 53 which has a grounded emitter and a collector element connected to the positive side of the regulated supply through a load resistance 54. The signal output from the pulse-forming network appears on a signal line 55 connected to the collector element of the transistor 53, which collector element is also connected with the base of the sensor 40 through a feedback loop that includes a coupling capacitance 56 in series therebetween and a charging resistance 57 connected between ground and the base of the sensor 40.

As shown in FIGURE 2, the sensor 40 is energized by light transmitted thereto from the lamp or energy source 41 whenever one of the apertures 34 in the interrupter 33 is in alignment with the light-receptive entrance aperture 43 in the sensor and adjacent end portion of the conductor tube 42. The sensor 40, transistor 53 and associated circuitry define a one-shot or monostable multivibrator conditioned to operate such that when the interrupter 33 prevents the transmission of light from the lamp 41 to the sensor or light-sensitive transistor 40, it is cut off because in the absence of energizing light incident thereon it functions analogously with any standard reversely biased NPN transistor. In the non-conductive state of the sensor 40, the transistor 53 will conduct because of the positive potential then applied to the base thereof, thereby causing ground potential to appear at the collector element of such transistor and on the output signal line 55.

Whenever the interrupter 33 positions an aperture 34 in alignment with the sensor 40, the light sensitive junction thereof is energized and the transistor begins to conduct. The flow of current through the sensor 40 will cause the transistor 53 to cut off because of the negative going potential then applied to the base thereof with the result that the potential on the collector of such transistor will rise toward the potential of the regulated supply. This positive going pulse on the collector of the transistor 53 is coupled back to the base of the sensor 40 by the capacitance 56 and will drive the sensor 40 into a state of full current conduction. The result thereof is that the collector element of the sensor 40 and base element of the transistor 53 connected therewith will approximate ground potential, thereby causing the transistor 53 to cut off. As a consequence, the potential on the output signal line 55, and collector of the transistor 53, will assume its maximum positive value which, by way of example, might be 5 volts in a particular circuit embodiment in which the applied voltage across the lines 46 and 47 (i.e., the battery voltage) may vary between about 9 to 15 volts and is reduced by the resistance

50 and regulated by the regulator 49 to such 5-volt value.

The sensor 40 will remain in the conductive state thereof until the interrupter disc 33 has displaced one of its light-interrupting areas in front of the sensor at which time the sensor will start to cut off. This change in condition of the sensor 40 will cause the transistor 53 to begin to conduct, whereupon the potential of the collector element thereof will become negative going. This negative going signal appearing on the collector element of the transistor 53 will be coupled back to the base of the sensor 40 through the coupling capacitance 56 causing the sensor to completely cut off, whereupon the potential of the signal on the output line 55 will closely approximate ground potential.

Thus, the stable state of the multivibrator is that in which the sensor 40 is cut off and the transistor 53 is conducting; and the successive intermittent energizations of the sensor 40 as a consequence of the rotational displacement of the interrupter 33 will result in a chain of positive voltage pulses appearing on the output signal line 55, one such pulse for each aperture 34 moved into alignment with the sensor. Each such signal will rise toward its highest positive voltage value whenever the sensor 40 is energized, and it will recede toward its minimum value whenever the sensor is de-energized. In a typical circuit embodiment, the time required for the multivibrator to change its condition from minimum to maximum voltage, and vice versa, is in the range of about 5 to 10 nanoseconds.

The remainder of the circuitry illustrated in FIGURE 2 constitutes a capacitive discharge unit, enclosed within broken lines and generally denoted 58, operative to repetitively energize the primary winding 18 of the ignition transformer 17 in response to the output pulses on the signal line 55. The unit 58 is conveniently divisible into a D.C. to D.C. converter, a pulse generator and a discharge circuit and such components are respectively denoted in general with the numerals 59, 60 and 61. The D.C. to D.C. converter 59 is substantially conventional and includes a transformer 62 having two sets of primary windings 63 and 64 and respectively corresponding secondary windings 65 and 66 serially connected across the two opposite input terminals of a diode bridge rectifier 67. The high voltage D.C. output from the rectifier 67 is used to energize the primary winding 18 of the ignition transformer 17, and such output of the rectifier is provided across conductors 68 and 69 respectively connected to the output terminals of the bridge rectifier. The conductor 68 defines ground potential for the capacitive discharge unit 58; and the conductor 69 is connected to one side of a capacitor 70 (forming a part of the discharge circuit 61), the charging and discharging of which determines energization of the transformer 17, as explained hereinafter.

The primary winding 63 of the transformer 62 may comprise two serially related windings as illustrated, and the opposite sides thereof are respectively connected to the base elements of a pair of transistors 71 and 72. The primary winding 64 of the transformer 62 has the opposite ends thereof respectively connected to the collector elements of the transistors 71 and 72. The primary windings 63 and 64 are effectively provided with taps connected to each other through a shunt-related resistance 73 and capacitance 74 which are connected in common with the tap of the winding 64 to the ground conductor 68, and in common with the tap of the winding 63 to the supply line 46 through a resistance 75. The emitter elements of the transistors 71 and 72 are connected to the positive side of the battery 10 or, specifically, to the aforementioned supply line 46.

The D.C. to D.C. converter 59 operates in a substantially standard manner with the forward bias for the transistors 71 and 72 being developed across the resistances 73 and 75 which are connected between ground and the supply line 46. The bias potentials are connected to the taps of the primary windings 63 and 64 constituting the

bias windings of the transformer 62, which windings are respectively connected to the base elements and to the collector elements of the transistors 71 and 72. This configuration of the primary windings and transistors results in high-voltage square-wave output from the secondary windings of the transformer 62, and the square wave voltage output is rectified in the bridge 67 to provide a high voltage D.C. output on the conductor 69. In certain embodiments of the invention, such voltage may approximate a value of 300 volts.

The pulse generator 60 includes a plurality of transistors 76, 77 and 78, the emitters of the first two of which are directly connected to the ground line 47, and the emitter of the latter being grounded through a resistance 79. Load resistances 80, 81 and 82 are respectively provided in the collector circuits of the transistors 76, 77 and 78 to connect the same with the supply line 46. The output signal from the sensor unit 32 is delivered to the base of the transistor 76 through a resistance 83, and the amplified replica of such signal appearing on the collector of the transistor 76 is transmitted therefrom to the base of the transistor 77.

Evidently, the signals delivered from the unit 32 via the line 55 are successively inverted by the transistors 76 and 77 so that each signal delivered to the base of the transistor 78 from the collector of the transistor 77 is a positive going pulse whenever the signal appearing on the line 55 is positive. Whenever the signal appearing on the base of the transistor 78 changes from a substantially zero to a positive value, the transistor conducts which causes a sharp output pulse to be generated across the emitter resistance 79. Such pulse persists until a capacitance 84 in the collector circuit of the transistor 78 discharges as a consequence of the reduced voltage on the collector during such periods of conduction. Whenever the signal delivered to the base of the transistor 78 returns to a zero value, the transistor is cut off and the capacitance 84 charges to the higher positive potential of the supply voltage through the resistance 82. The RC circuit defined by the resistance 82 and capacitance 84 causes an output pulse to be generated only when the output signal on the line 55 from the sensor unit 32 changes from zero to a positive potential, and it should be noted that there is a sufficient interval between successive pulses for the capacitance to be recharged.

The discharge circuit 61 includes the aforementioned charging capacitance 70 connected in the line 69 from the rectifier 67 to the primary winding 18 of the transformer 17, and it further includes a gating circuit defined by a gating diode 85 having the anode thereof connected to the signal line 69 on the rectifier or positive side of the capacitance 70 and its cathode connected to the ground line 47. The gate element of the diode 85 is connected to one side of a diode 86 in shunt with the resistance 79 and operative to make certain that any negative pulses that may be present at the gating circuit are shorted to ground. A diode 87 having its anode connected to the capacitance 70 on the transformer or negative side thereof and its cathode connected to ground through a resistance 88 forms an unidirectional charging path from ground for the capacitance 70.

In the static state of the discharge circuit 61, which corresponds to no light being incident on the sensor 40, the capacitance 70 has a high voltage charge thereacross because of the action of the D.C. to D.C. converter 59 in producing such high voltage and the application thereof to one side of the capacitance. However, upon a positive pulse being generated by the sensor unit 32 on the output signal line 55 thereof, the diode 85 will have a positive pulse applied to its gate and the diode then will conduct, thereby allowing the capacitance 70 to discharge from its negative side through the primary winding 18 to ground and from ground through the diode 85 to the positive side of the capacitance (i.e., the side thereof connected to the rectifier

67). Whenever the capacitance 70 has completely discharged, the diode 85 will cease to conduct, thereby allowing the converter 59 to recharge the capacitance 70 through the series path provided by the resistance 88 and diode 87. At the time that the capacitance 70 starts to recharge, any attempt of the primary winding 18 to conduct in the opposite direction will be effectively shorted out by the low impedance path defined by the resistance 88 and diode 87.

If desired, the voltage developed across the resistance 88 during the interval that the capacitance 70 is recharged can be made available via a signal line 89 for use in auxiliary equipment such as a tachometer. In a conventional manner, the secondary winding 16 of the transformer 17 is energized by the current flow through the primary winding 18 to develop the high voltage delivered via the conductor 15, terminal 14 and conductive strip 27 of the rotor 26 to the appropriate contact 19 and sparking device 21 associated therewith.

For purposes of presenting a specific example of component values in typically illustrative circuits, the following may be considered:

Sensor unit

Transistor 40	GE LASCS
Light 41	CM7685
Zener diode 49	1ZF52T10
Resistances:	
50	ohms 47
51	megohms 1.0
Transistor 53	HEP50
Resistance 54	100K
Capacitance 56	picofarads 10
Resistance 57	megohms 4.7

D.C. to D.C. converter

Transformer 62	TY79
Rectifier diodes 67	FWA400
Transistors:	
71	2N2078
72	2N2078
Resistance 73	ohms 200
Capacitance 74	microfarads 5.0
Resistance 75	ohms 10

Pulse generators

Transistors:	
76	HEP50
77	2N706
78	2N706
Resistances:	
79	ohms 22
80	ohms 14K
81	do 1.0K
82	do 100K
83	do 47K
Capacitance 84	microfarads 0.01
Diode 86	1N536

Discharge circuit

Capacitance 70	microfarads 1.0
Diodes:	
85	2N3525
87	1N2071
Resistance 88	ohms 10

Voltages

In the above-identified exemplified circuitry, the following voltages are typical:

	Volts D.C.
Voltage of battery 10	12
Voltage across the diode regulator 40	5
Maximum positive voltage on signal line 55	5
Output voltage of rectifier 67	300

It should be appreciated that the specific circuit and voltage values set forth imply no criticality and can be varied greatly depending upon internal and external parameters, the choice of transistors, specific environmental settings, etc.

As explained hereinbefore, the sensing unit 32 is mounted as an integer within the distributor casing 12 and has substantially all of its components encapsuated within a suitable potting material. The electrical connections with the sensor unit 32 may be established by wire conductors that extend through an opening provided therefor in the casing 12, which opening in the usual case will have an insulating grommet 90 positioned there-within to protect such conductors passing therethrough. It will be observed in FIGURE 2 that the sensor unit 32, the transformer 17, and the capacitive discharge unit 58 are shown to be separate components interconnected one with the others by means of conventional plugs or connector devices diagrammatically depicted in this figure.

The battery 10 ordinarily comprises the wet cell storage battery on the vehicle with which the ignition system is used and, accordingly, the usual ignition switch for such vehicle will be connected with the ignition system as, for example, in series between the positive side of such battery and the fuse 48 so that the entire circuit is de-energized when such ignition switch is in its "off" position. In the illustration of FIGURE 2, the switch has been omitted since it is not pertinent to an understanding of the present invention.

In accordance with the battery 10 being the storage battery of the associated vehicle, the output voltage provided thereby usually will vary somewhat between maximum and minimum values respectively corresponding to the running and starting conditions of the vehicle. Accordingly, the voltage regulator, including the Zener diode 49 and resistance 50, is operative to provide a relatively constant supply voltage for the circuit irrespective of any such variation in the output voltage of the battery 10.

While in the foregoing specification an embodiment of the invention has been set forth in considerable detail for purposes of making a complete disclosure thereof, it will be apparent to those skilled in the art that numerous changes may be made in such details without departing from the spirit and principles of the invention.

What is claimed is:

1. In an ignition system for internal combustion engines and the like including a distributor having a casing and a shaft extending thereinto adapted to be rotatably driven by such engine, an interrupter system for developing a pulsating current effective to energize said ignition system and comprising a sensor unit mounted within said casing and including a source of radiant energy and a sensor spaced therefrom and responsive to the energy output thereof, an interrupter located within said casing and being provided with energy-transmitting means effective to permit the transmission of radiant energy from said source to said sensor and also being provided with energy-obstructing means effective to prevent such transmission of radiant energy to said sensor, said interrupter connected with said shaft so as to be driven thereby to cyclically disposed said energy-transmitting means in energy-transmitting disposition relative to said source and sensor in timed relation with the rotational movement of said shaft to repetitively energize said sensor, said sensor unit further including support panel structure providing a mounting for both said source of radiant energy and said sensor, a pulse-forming circuit mounted upon said support structure and including said sensor as a component thereof, and said circuit being encapsulated in an insulating material to protect the components thereof from the ambient environment within said distributor casing.

2. The ignition system of claim 1 in which said support

structure comprises a printed circuit panel having various conductors formed therealong to interconnect components of said circuit one with another.

3. The ignition system of claim 1 and further including a longitudinally-extending energy conductor for transmitting such radiant energy longitudinally therethrough and at one end terminating adjacent said source of energy and at its other end terminating a spaced distance from said sensor.

4. The ignition system of claim 3 in which said support structure includes a pair of panel segments angularly oriented with respect to each other with said sensor being supported by one such segment and said source of radiant energy being supported by the other such segment, and in which said energy conductor has an arcuate section therealong to effect the aforesaid transmission of radiant energy from said source to said sensor.

5. The ignition system of claim 1 in which said sensor unit is a unitary member mounted as an integer within said casing.

6. The ignition system of claim 1 in which said interrupter is interposed between said sensor and source of radiant energy and is rotatably driven by said shaft, said energy-transmitting means comprising a group of angularly-spaced energy-transmitting areas provided along said interrupter and said energy-obstructing means comprising a group of angularly-spaced energy-obstructing areas provided by said interrupter and alternately related with said energy-transmitting areas, whereby rotation of said interrupter successively advances in turn each of said energy-transmitting areas into energy-transmitting alignment with the energy path to said sensor.

7. The ignition system of claim 6 and further including a longitudinally-extending energy conductor for transmitting such radiant energy longitudinally therethrough and at one end terminating adjacent said source of energy and at its other end terminating a spaced distance from said sensor.

8. The ignition system of claim 7 in which said support structure includes a pair of panel segments angularly oriented with respect to each other with said sensor being supported by one such segment and said source of radiant energy being supported by the other such segment, and in which said energy conductor has an arcuate section therealong to effect the aforesaid transmission of radiant energy from said source to said sensor.

9. The ignition system of claim 8 in which each of said panel segments comprises a printed circuit panel having various conductors formed therealong to interconnect components of said circuit one with another.

10. The ignition system of claim 9 in which said sensor unit is a unitary member mounted as an integer within said casing.

11. The ignition system of claim 10 in which said source of energy is an electric light, and further including a hollow support tube circumjacent the energy-transmitting portion of said source and telescopically receiving an end portion of said energy conductor therein for supporting the same with such one end thereof adjacent said source.

12. In an ignition system for internal combustion engines and the like including a D.C. voltage source, a shaft adapted to be rotatably driven by such engine, and an interrupter provided with a group of angularly-spaced energy-transmitting areas and a group of angularly-spaced energy-obstructing areas alternately related with said energy-transmitting areas and being connected with said shaft so as to be rotatably driven thereby to successively advance in turn each of said energy-transmitting areas into energy-transmitting disposition relative to a light source and a photosensitive transistor so as to repetitively energize the latter in timed relation with the rotational movement of said shaft, a sensor unit comprising a voltage regulator and a monostable multivibrator circuit operative to produce output signal pulses in

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response to energizations thereof, said circuit including a pair of conductors connected across said voltage source so as to have the potential thereof applied thereto, said voltage regulator being connected with said conductors to provide a substantially constant potential thereon of known value irrespective of variations in the potential supplied by said voltage source, an electric light connected to said conductors so as to be energized thereby, and said multivibrator including as one stage thereof a normally non-conductive photosensitive transistor adapted to be energized by said electric light and including as another stage thereof a normally conductive transistor amplifier, each of said transistors having emitter, base and collector elements and being respectively connected emitter to collector across said conductors, the base of each transistor being connected with the collector of the other transistor, and the collector of said transistor amplifier providing said output signal pulses, said photosensitive transistor being energized by light energy transmitted thereto from said light whenever any one of said energy-transmitting areas is in energy transmitting disposition with said light and photosensitive transistor whereupon said transistor amplifier then becomes non-conductive to provide such signal pulse on the collector thereof.

13. The ignition system of claim 12 and further including a capacitive discharge unit connected with said

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sensor unit and responsive to each such output pulse thereof to produce a high voltage current pulse effective to energize the ignition transformer of such engine.

14. The ignition system of claim 13 in which said capacitive discharge unit comprises a D.C. to D.C. converter to produce a high value voltage from the low value voltage supplied by said voltage source, a pulse generator responsive to each output pulse from said sensor unit to control energization of such ignition transformer, and a discharge unit to convert such high value voltage produced by said D.C. to D.C. converter into such current pulses under the control of said pulse generator.

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3,418,989	12/1968	Silverman	123—148

LAURENCE M. GOODRIDGE, Primary Examiner

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