

June 23, 1970

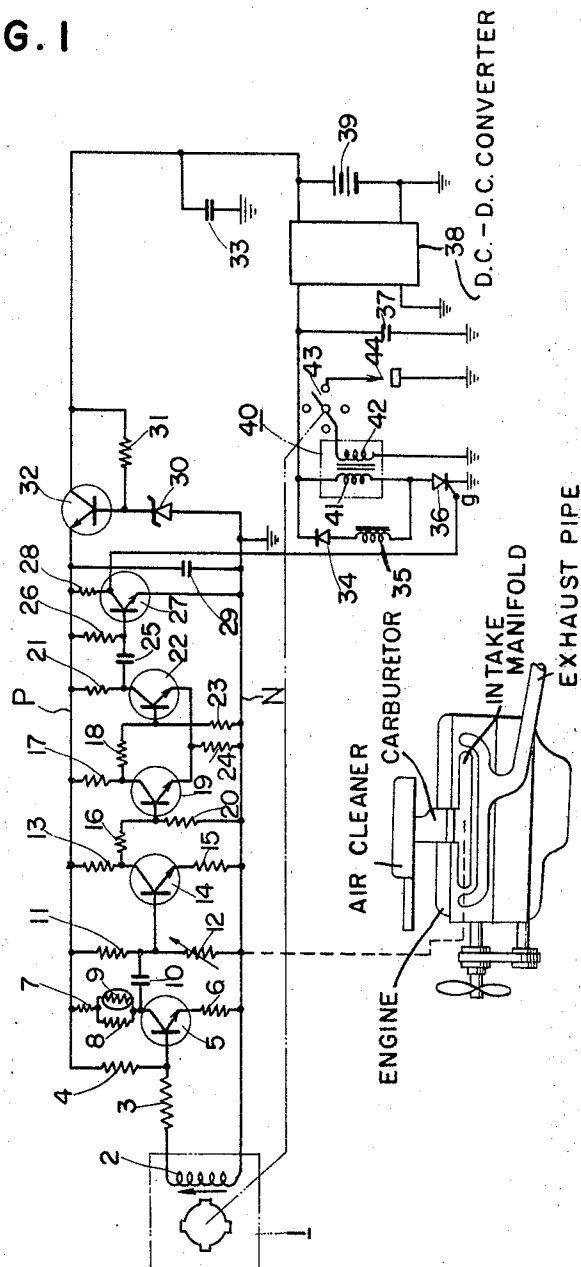
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TRANSISTORIZED CONDENSER DISCHARGE IGNITION SYSTEM
WITH A VACUUM REGULATOR

3,517,260

Filed Oct. 23, 1967

2 Sheets-Sheet 1

FIG. 1



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FIG. 2

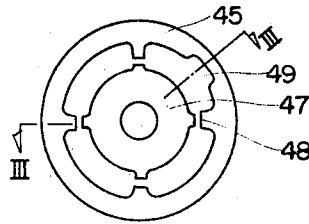


FIG. 3

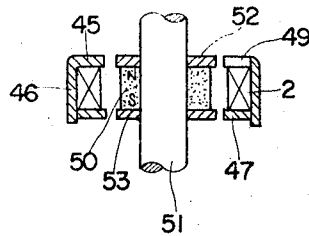
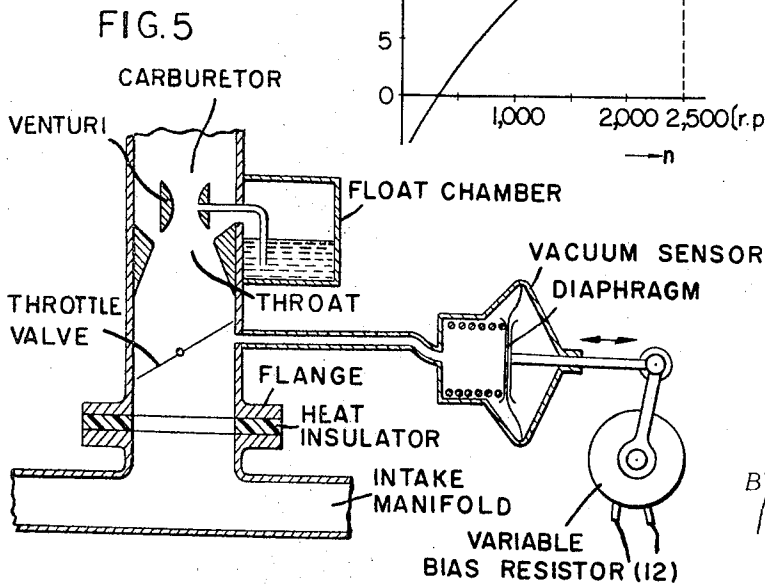
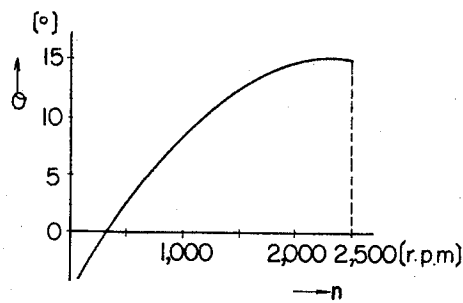


FIG. 4



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TRANSISTORIZED CONDENSER DISCHARGE IGNITION SYSTEM WITH A VACUUM REGULATOR

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Int. Cl. H05b 37/02, 39/04

U.S. Cl. 315—223

11 Claims

ABSTRACT OF THE DISCLOSURE

An output signal of a signal generator mounted in a distributor is amplified by at least one transistor amplifier, converted into a square-wave signal by a Schmitt trigger circuit, differentiated by a differentiator circuit and then applied to the gate of a controlled rectifier in the primary winding of an ignition coil. Temperature compensation of the transistor circuit is effected by inserting a temperature-dependent element into the output circuit of the transistor amplifier. The wave form of the output signal of the signal generator is adapted to the desired spark advance characteristics, by special formation of its stator.

SUMMARY OF THE INVENTION

The present application relates to an ignition apparatus for an internal combustion engine, and more particularly to an electronic circuit arrangement for generating ignition signals.

It is the principal object of the present invention to make the whole apparatus contactless, eliminating mechanical troubles due to movable components.

It is another object of the invention to provide an electrical spark advance circuit in place of a mechanical governor mechanism mounted in a distributor.

It is a further object of the invention to adapt the wave form of the output signal of a signal generator to the desired spark advance characteristics, by suitable construction of the signal generator.

It is another object of the invention to make the apparatus independent of variation in ambient temperature.

It is a further object of the invention to make the apparatus independent of variation in its supply voltage.

BRIEF DESCRIPTION OF THE DRAWINGS

Further objects and advantages of the present invention will be apparent from the following description, taken with the accompanying drawing, in which:

FIG. 1 is a schematic wiring diagram of a transistorized ignition circuit arrangement embodying the invention,

FIG. 2 is a plan view of a signal generator used in the circuit of FIG. 1,

FIG. 3 is a sectional view taken along line III—III in FIG. 2,

FIG. 4 is a diagram graphically explaining the operation of the circuit arrangement, and

FIG. 5 is the vacuum sensor for the variable bias resistor.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to FIG. 1, a permanent magnet signal generator 1, whose construction will be described below, has an armature winding 2 and a permanent magnet rotor rotatable in synchronism with an internal combustion engine (not shown). An end of the armature winding 2 is connected to the base of a first amplifier transistor

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5 through an input resistor 3, while the other end thereof is connected with a negative line N which is grounded. The emitter of the transistor 5 is grounded through an emitter resistor 6 while the collector thereof is connected to a positive line P through a collector resistor 7 and a temperature compensating circuit consisting of a fixed resistor 8 and a thermistor 9 in parallel to each other. A bias resistor 4 is connected between the base of the transistor 5 and the positive line P. The collector of the first transistor 5 is connected to the base of a second amplifier transistor 14 through a coupling capacitor 10. The base of transistor 14 is connected to the positive line P through a fixed bias resistor 11 while it is grounded through a variable bias resistor 12. The collector of the transistor 14 is connected to the positive line P through a collector resistor 13, and to the base of an input transistor 19 of a Schmitt trigger circuit through a coupling resistor 16. The collector of the input transistor 19 is coupled with the base of an output transistor 22 of the Schmitt trigger circuit through a resistor 18. The bases of both the transistors 19 and 22 are grounded through resistors 20 and 23, respectively while the collectors thereof are connected to the positive line P through collector resistors 17 and 21, respectively.

The emitters of the transistors 19 and 22 are connected commonly to an end of a resistor 24, the other end of which is grounded. A differentiator in parallel to the collector resistor 21 consists of a capacitor 25 and a resistor 26 whose junction point is connected with the base of an amplifier transistor 27. The emitter of this transistor 27 is grounded while its collector is connected to the positive line P through a collector resistor 28. 29 designates a smoothing capacitor connected between the positive line P and the negative line N. A voltage stabilizer transistor 32, whose emitter-collector path lies between the positive line P and the positive pole of a battery 39, is grounded at its base through a Zener diode 30. A bias resistor 31 is connected between the base and the collector of the transistor 32. 33 designates another smoothing capacitor in parallel to the battery 39. The negative pole of the battery 39 is grounded.

A D.C.-D.C. converter 38 of any known type serves to amplify the D.C. voltage across the battery 39. A storage capacitor 37 is connected across the output of the converter 38. The primary winding 41 of an ignition coil 40 is connected across the storage capacitor 37 through a controlled rectifier 36 while the secondary winding 42 is connected to ignition plugs 44 only one of which is shown, through a distributor 43. The series circuit of a diode 34 and a choke coil 35 is connected in parallel to the primary winding 41 in such a way that the polarity of the diode 34 is opposite to that of the battery 39. The gate g of the controlled rectifier 36 is connected to the collector of the amplifier transistor 27.

The structure of the signal generator 1 is shown in FIGS. 2 and 3. The stator of this signal generator consists of an upper annular pole plate 45 having a cylindrical yoke 46, a lower annular pole plate 47 and the armature winding 2 inserted therebetween. On the inner edge of the upper pole plate 45 there are formed inward projections 48 whose number corresponds to that of cylinders of the engine. Further the inner edge is notched at 49. The rotor consists of a cylindrical permanent magnet 50 mounted on the shaft 51 of the distributor 43, an upper pole plate 52 on the upper end face of the magnet 50 and a lower pole plate 53 on the lower end face thereof. The magnet 50 is axially magnetized.

The operation of the above ignition system will be described hereinafter: When the engine (not shown) begins to run, the distributor shaft 51 is rotated. A voltage

signal which is generated across the armature winding 2 causes a base current to flow through the resistor 3 and the base-emitter path of the first amplifier transistor 5. The current is amplified by means of this transistor 5 and the second amplifier transistor 14. A voltage signal occurring at the resistor 13 is applied to the base of the input transistor 19 in the Schmitt trigger circuit through the resistor 16. The Schmitt trigger circuit converts the input signal into a square-wave output signal. This square-wave output signal is differentiated by the differentiator 25, 26 and then amplified by means of the amplifier transistor 27. The amplified signal is then fed to the gate *g* of the controlled rectifier 36 to render it conductive. Electric energy, which has previously been stored in the storage capacitor 37 from the battery 39 through the D.C.-D.C. converter 38, is now discharged through the primary winding 41 of the ignition coil 40 and the then conducting rectifier 36. A high voltage induced in the secondary winding 42 is supplied to the ignition plugs 44 through the distributor 43 and causes them to spark. Upon completion of the discharge in the capacitor 37, electromagnetic energy stored in the primary winding 41 is then discharged through the choke coil 35 and the diode 34. Owing to the choke coil 35, this discharge, however, proceeds sufficiently slowly that a part of the electromagnetic energy charges the capacitor 37 to the opposite polarity through the still conducting rectifier 36. A voltage of opposite polarity which appears across the capacitor 37 serves to turn off the rectifier 36.

Spark advance by means of the above circuit arrangement will be described in the following:

The output signal voltage of the signal generator 1, after amplification by the amplifiers 14, 19, is applied to the Schmitt trigger circuit and triggers it at a trigger level which is predetermined by its circuit constant. With increase of the output signal voltage of the generator 1 in dependence upon the revolutions per minute of the distributor, the left-hand one of intersecting points of the signal voltage wave with the trigger level line moves towards the left foot of said signal wave. This means spark advance in response to increase in the r.p.m. of the engine.

The degree of spark advance can be determined either by the wave form of the output signal of the signal generator or by setting of bias levels at the amplifier circuits. Fine adjustment of the wave form of the output signal at the signal generator 1 can be attained by providing the notch 49 on the pole plate 45 as shown in FIG. 2. Setting of the bias voltage of the amplifier can be adjusted, for example, by means of the variable bias resistor 12. Further, spark advance in dependence upon the load of the engine can be attained by adjusting the resistance of the resistor 12 as a function of the negative pressure in the intake manifold of the engine.

In general the amplification factor of a transistor decreases with decreasing temperature. This may be compensated by increasing the apparent amplification factor, namely by increasing the voltage gain of an amplifier circuit comprising the transistor. It will be enough, for increasing the voltage gain, to increase the resistance of the load resistance of the amplifier transistor 5. For this purpose, the parallel circuit of the fixed resistor 8 and the thermistor 9 is provided in series with the collector resistor 7 of the transistor 5. Thus temperature compensation of the circuit arrangement can be attained.

The spark advance characteristics must be held constant independently of voltage variation in the power source 39. For this purpose there is provided the voltage stabilizer circuit consisting of the transistor 32, the resistor 31 and the Zener diode 30.

From the foregoing description, it will be seen that the circuit arrangement in accordance with the invention offers important advantages. The stable spark advance characteristics can be attained for variation in ambient temperature as well as in a supply voltage. The spark advance characteristics can also be adapted easily to a de-

sired one either by providing a notch 49 on the stator of the signal generator 1 or by adjusting the resistance of the bias resistor 12. It is also possible to construct the circuit arrangement with a relatively small number of circuit elements.

A test of the circuit arrangement of FIG. 1 has been made using the following elements, and the result thereof is shown in FIG. 4 wherein the abscissa represents the number of revolutions *n* of the distributor while the ordinate represents the advance angle θ of the distributor, the permanent magnet 50: made of ferrite

the outer diameter of the stator 45, 46, 47: 56 mm.

the diameter of the rotor 50, 52, 53 at its projections: 30 mm.

the air gap between the projections of the rotor and the stator: 0.3 mm.

the number of turns of the armature coil 2: 1000

the resistor 3: 2.2K Ω

the bias resistor 12: 5K Ω in maximum.

What is claimed is:

1. An ignition apparatus, for an internal combustion engine having a source of potential and a distributor including a distributor shaft, said ignition apparatus comprising, in combination, a signal generator including a rotor driven by said distributor shaft and a stator; at least one transistor amplifier circuit connected to said signal generator and amplifying the output signal thereof; a Schmitt trigger circuit connected to the output of said amplifier circuit and converting the amplifier circuit output signal into a square wave signal; a differentiation circuit connected to said Schmitt trigger circuit and differentiating the output of said Schmitt trigger circuit; voltage stabilizer means connected to said source of potential and to said circuits and stabilizing the supply voltage of said circuits; an ignition coil having a secondary winding, connected to said distributor, and having a primary winding; a storage capacitor connected to said source of potential and to said primary winding and supplying ignition energy to said primary winding; a controlled rectifier connected in series with said primary winding; and means connecting said differentiation circuit to the control electrode of said controlled rectifier for feeding the differentiated signal to said control electrode.

2. An ignition apparatus, as claimed in claim 1 wherein said stator of said signal generator includes an annular pole plate having a notch in its periphery for adapting the wave form of the output of said signal generator to the desired spark advance characteristic.

3. An ignition apparatus, as claimed in claim 1, in which the load resistance in said transistor amplifier circuit includes a temperature compensating resistance element.

4. An ignition apparatus, as claimed in claim 3, wherein said temperature compensating resistance element comprises a thermistor.

5. An ignition apparatus, as claimed in claim 3, in which said transistor amplifier circuit includes a variable bias resistor.

6. An ignition apparatus, as claimed in claim 5, in which said internal combustion engine includes an inlet manifold; and means operatively connecting said inlet manifold to said variable bias resistor and varying the bias of said resistor in accordance with the negative pressure in said inlet manifold.

7. An ignition apparatus, as claimed in claim 1, in which said voltage stabilizer circuit comprises a transistor having its emitter-collector circuit connected to one terminal of said source of potential, a Zener diode connected in series between the base of said transistor and the other terminal of said source of potential, and a resistor connecting the base of said transistor to the collector thereof and to such one terminal of said source of potential.

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8. An ignition apparatus, as claimed in claim 1, in which said ignition coil includes a diode and a choke coil connected in a series circuit which is connected in parallel with said primary winding to discharge electromagnetic energy in said ignition coil.

9. An ignition apparatus, as claimed in claim 1, including a D.C.-D.C. converter connected between said source of potential and said storage capacitor.

10. An ignition apparatus, as claimed in claim 1, in which said signal generator includes a shaft rotating in synchronization with the engine; said rotor comprising a cylindrical, axially magnetized magnet on said shaft, and a circular annular pole piece rotatable with said magnet; said stator comprising a stationary annular magnetic pole having a channel-shaped cross section with an axially extending web and a flange substantially aligned with said rotating pole piece.

11. An ignition apparatus, as claimed in claim 1, in which the facing annular peripheries of said rotary and stationary magnetic poles are formed with the same num-

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ber of equiangularly spaced radial projections, the number of projections corresponding to the number of cylinders of the engine; whereby, when said projections are radially aligned, there is a relatively small air gap between facing projections so that the reluctance of the magnetic circuit is varied with rotation of said shaft.

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