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3,056,066

IGNITION SYSTEM FOR INTERNAL COMBUSTION ENGINES

Filed Dec. 21, 1959

2 Sheets-Sheet 1

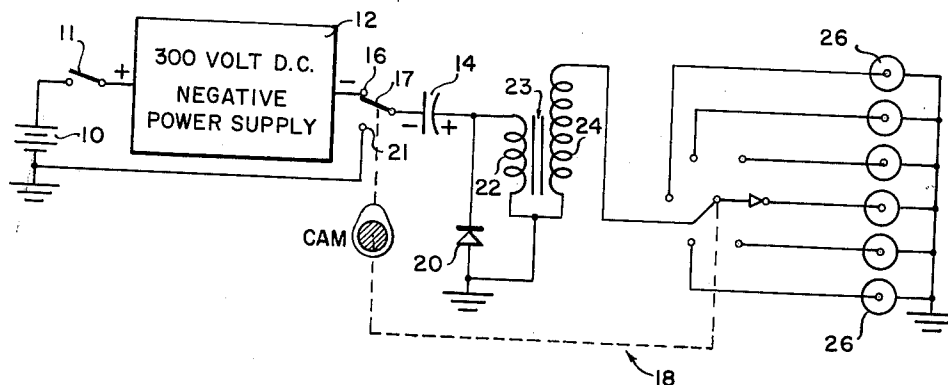


FIG. 1.

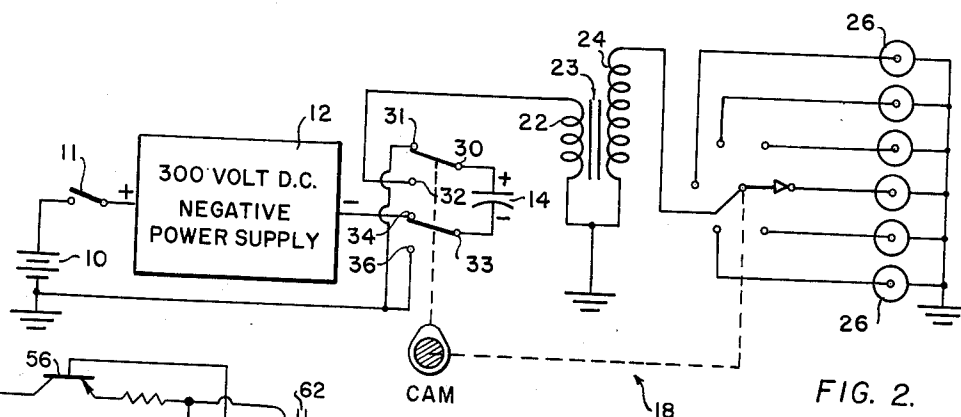


FIG. 2.

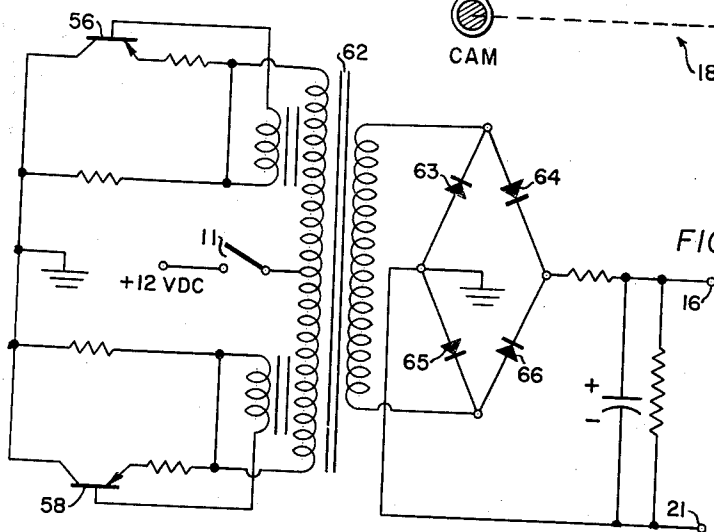


FIG. 5.

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2 Sheets-Sheet 2

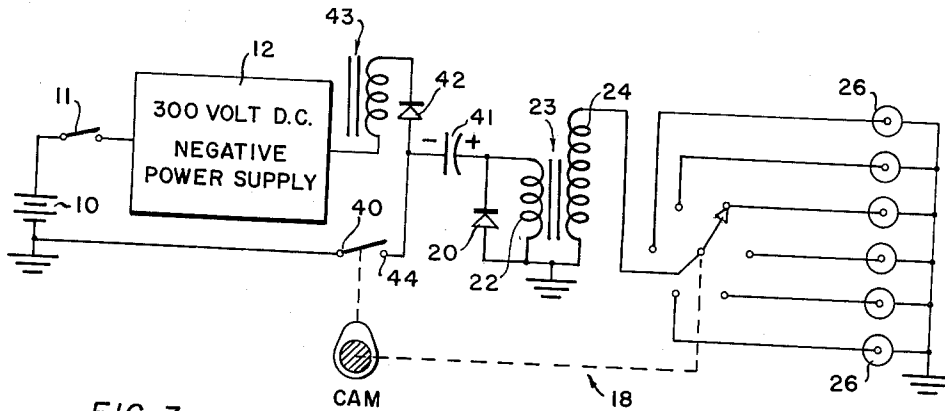


FIG. 3.

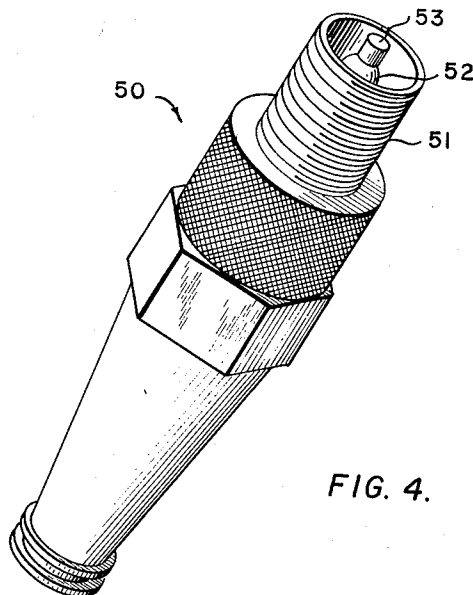


FIG. 4.

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IGNITION SYSTEM FOR INTERNAL COMBUSTION ENGINES

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8 Claims. (Cl. 315-223)

(Granted under Title 35, U.S. Code (1952), sec. 266)

The invention described herein may be manufactured and used by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

This invention relates to an improved ignition system for internal combustion engines which provides a high voltage, high energy spark for an internal combustion engine, particularly at very high engine speeds.

Conventional ignition systems generate a high voltage spark by interrupting a current from the storage battery through the ignition coil by the breaker arm contacts.

The arcing at the breaker arm contacts cannot be reduced to a point where damage to the contacts does not occur. As a result the contacts usually fail by burning, pitting and sticking.

During periods of engine starting the battery voltage falls to such a low value that the spark plugs must have small gap spacings to allow firing at the resulting reduced voltage in the ignition coil. This results in flooding, fouled plugs, and excessive burning of plug electrodes when voltage is normal.

The most serious limitation of this ignition system, however, is its inability to function efficiently at high engine speeds. This arises from the fact that the L/R time constant of the ignition coil primary between spark plug firings is so long that the flux field does not have time to build up to a value high enough to insure positive firing when the distributor breaker arm contacts open. Thus the spark plug gaps, which were already closely spaced to compensate for low starting voltage, must also be closely spaced to improve the firing reliability at high speeds.

In a typical ignition system the ignition coil primary inductance with the secondary open was 5 millihenrys and the resistance was 2 ohms. The L/R time constant was thus 2.5 milliseconds; at 6700 r.p.m. this time represents 100 degrees of crankshaft rotation. In an eight cylinder, four cycle engine the distributor breaker arm contacts open every 90° and must have an appreciable closing time; thus, although 300 to 500 degrees are required for the flux field to build up about the coil to approach the maximum output voltage, less than 90 degrees are available, and full firing voltage is not developed.

Gas tube, thyratron ignition systems have been proposed which are unreliable, difficult to de-ionize, and require complicated and expensive time delay circuits during starting.

A primary object of this invention is to overcome the limitations of conventional ignition systems during starting and at high r.p.m.

Another object of this invention is to disclose a novel spark plug for the improved ignition system which will handle high energy sparks without pitting or corrosion.

Other objects and many of the attendant advantages of this invention will be readily appreciated as the same becomes better understood by reference to the following detailed description when considered in connection with the accompanying drawings wherein:

FIG. 1 is a schematic diagram of a preferred embodiment of the invention using a diode for high speed capacitor charging;

FIG. 2 is a schematic diagram of another embodiment

of the invention using switches for high speed capacitor charging;

FIG. 3 is a schematic diagram of another embodiment of the invention using a charging choke;

FIG. 4 is a perspective view of a novel spark plug for use with the improved ignition system; and

FIG. 5 is a schematic circuit diagram of a 300 volt D.C. negative power supply suitable for use in the circuits of FIGS. 1-3.

Referring now to the drawings, there is shown in FIG. 1 a battery 10, ignition switch 11, and power supply 12. Power supply 12 is a semi-conductor type power supply using an 800 cycle transistor blocking oscillator-rectifier circuit which requires no warm-up time.

In an operating ignition system a Model 2D12 power supply made by Automatic Communications Equipment, Kansas City, Mo., was used. Supply 12 delivers 300 volts at 100 milliamps normally and over 200 volts during engine starting periods, or the supply may be regulated to deliver a constant 300 volts.

When the ignition switch 11 is closed power supply 12 rises to normal voltage in a few milliseconds and charges capacitor 14 through contact 16 and arm 17 of the distributor 18 and through charging diode 20. As the engine begins cranking arm 17 opens contact 16 and closes ground contact 21. Diode 20 now appears as a very high resistance and capacitor 14 quickly discharges through primary winding 22 of ignition coil 23. This discharge generates a high voltage in the secondary winding 24 of 15,000 volts or more that is sufficient to fire the spark plugs 26 at full gap setting.

After a plug has fired, arm 17 opens contact 21 and closes contact 16 again charging capacitor 14 in readiness for the next firing cycle. The charge time of capacitor 14 through diode 20 is very short as diode 20 has a very low resistance in the forward direction; therefore, engine speed is not limited by the charging time of the system. Engine speed is limited only by the discharge time of capacitor 14 through the primary winding 22. In order to obtain maximum energy in the firing arc capacitor 14 should be chosen as large as possible consistent with the highest engine speed expected. For a 10,000 r.p.m., 8 cylinder engine, a value of .5 μ f. is sufficient. Storage capacitor 14 should have a voltage rating of QE_t , where Q is the figure of merit of the series resonant circuit composed of capacitor 14 and the primary winding 22, and E_t is the voltage appearing across winding 22 in the non-resonant condition. The microfarad value of capacitor 14 (.5 μ f.) should be such that it resonates with primary winding 46 at a frequency high enough to allow spark plug firing at the highest desired engine speed. Diode 20 is a semi-conductor diode formed by putting two M500 diodes by Sarnes Tarzian, Inc., Bloomington, Ind., in series having forward and reverse voltage ratings equal to the voltage rating of capacitor 14. The peak current rating of diode 20 should be high enough to handle the initial charging current of capacitor 14. Coil 23 is a conventional ignition coil having a 5 mh. inductance primary winding 22 which may be of the type shown or of the auto-transformer type.

In addition to greatly prolonging spark plug life the proposed system can eliminate point wear due to burning and pitting as encountered in conventional systems. In the conventional system this wear occurs because switching takes place when circuit current is at maximum. This causes large voltages to appear at the switching points or contacts and arcing develops. In the proposed system proper timing of the contact arm 17 of distributor 18 will cause all switching to occur at times when the circuit currents are zero or very nearly zero.

FIG. 2 shows an alternate arrangement which does

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not make use of any electron devices except in the power supply. In this configuration the charging diode 20 is replaced by another switch 30 with contacts 31 and 32. In this case contacts 33—34 and 30—31 charge capacitor 14 and contacts 33—36 and 30—32 discharge capacitor 14 through primary winding 22. The circuit operation is the same as with the charging diode.

FIG. 3 shows another arrangement which when used with engines such as are found in most motor vehicles is superior to any other configurations because of its large stored energy and reliability. All switching is done by the breaker arm 40 of the distributor 18 which connects contact 44 to ground to discharge capacitor 41 through primary winding 22. Storage capacitor 41 is at all times connected to the power supply 12 through hold-off diode 42 and choke 43, which resonantly charges capacitor 41 to 600 volts or twice the supply voltage.

Short circuiting of power supply 12 by the low impedance of arm 40 and contact 44 is prevented by charging choke 43. During charging time (between plug firings) choke 43 presents a low impedance to the charging current; whereas, during firing time choke 43 appears as a high impedance to the firing pulse, thus isolating the power supply 12. The inductance of choke 43 (200 mh. for capacitor 41=.5 μ f.) is chosen to perform these functions at the highest r.p.m. expected.

One drawback to this configuration is the fact that the battery 10 will be discharged if the ignition is advertently left on and the breaker arm 40 happens to stop in the discharge position when the motor is stopped. This is only a minor drawback, but could be eliminated if desired by the inclusion of a normally closed, open for overload relay. Generally speaking this is considered an unnecessary refinement, especially in view of the fact that the semi-conductor type power supplies recommended for use in the proposed systems are short-circuit protected.

Referring to FIG. 4, a perspective view of a spark plug 50 suitable for use with the improved ignition system is shown having a grounded outer circular electrode 51, a central insulator 52 inside electrode 51, and a central electrode 53 inside insulator 52 and extending therefrom to provide a large surface area for the arc.

Full gap setting in a conventional plug results when the grounded electrode of the plug is removed altogether and the arc is allowed to develop between the central electrode and the outer circular electrode of the plug. This arrangement, which is possible only with the improved ignition systems of FIGS. 1—3, has several advantages. The wide gap eliminates engine flooding and plug fouling. Due to the nature of the arc to rotate away from the point of previous firing, local erosion will be greatly reduced. The large amount of electrode material available indicates that the spark plugs may well outlast the engine. And the wide arc produced will result in more efficient fuel combustion. In recent tests of this configuration, the system performed satisfactorily at 10,000 r.p.m. with an eight-cylinder distributor.

Referring to FIG. 5 a schematic circuit diagram of the power supply 12 is shown, having an inverter including transistors 56 and 58 for converting the D.C. potential from the battery to A.C. voltage. This A.C. voltage is stepped up by transformer 62 and rectified by diodes 63, 64, 65 and 66 to provide the desired output at terminals 16 and 21.

Obviously many modifications and variations of the present invention are possible in the light of the above teachings. It is therefore to be understood that within the scope of the appended claims the invention may be practiced otherwise than as specifically described.

I claim:

1. An improved ignition system for high speed internal combustion engines comprising: a high voltage power

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supply, a storage means for storing power, a spark coil, means connected to said spark coil for igniting the fuel in an internal combustion engine, and control means connected between said power supply, storage means and spark coil for energizing said storage means from said power supply and for discharging said storage means into said spark coil, said control means including a means for providing a low impedance path between said power supply and said storage means when said storage means is being charged and for providing high impedance path between said power supply and said storage means when said storage means is discharged into said spark coil.

2. An improved ignition system according to claim 1, and further characterized by said fuel igniting means additionally comprising a spark plug having a central electrode, insulating means around said spark plug, and an outer circular electrode mounted around said insulating means and spaced a relatively large distance from said central electrode whereby fouling may be eliminated.

3. An improved ignition system according to claim 1 and further characterized by said power supply including a conventional storage battery and a transistor type, direct current voltage step-up means for generating a high voltage direct current.

4. An improved ignition system according to claim 3 and further characterized by said voltage step-up means additionally comprising means for short circuit protection against large transient currents.

5. An improved ignition system according to claim 1 and further characterized by said control means additionally including a distributor cam operator switch for maximum reliability.

6. An improved ignition system for high speed internal combustion engines comprising a high voltage power supply, a storage means for storing power, a spark coil, means connected to said spark coil for igniting the fuel in an internal combustion engine, control means connected between said power supply, storage means and spark coil for energizing said storage means from said power supply and discharging said storage means into said spark coil without high speed charging limitations, and a diode connected across said spark coil whereby fast charging of said storage means may be obtained at a high engine r.p.m.

7. An improved ignition system for high speed internal combustion engines comprising a high voltage power supply, a storage means for storing power, a spark coil, means connected to said spark coil for igniting the fuel in an internal combustion engine, control means connected between said power supply, storage means and spark coil for energizing said storage means from said power supply and discharging said storage means into said spark coil without high speed charging limitations and a charging inductance connected between said power supply and said control means to provide high speed resonant charging of said storage means and to provide isolation of said power supply during a fuel ignition period.

8. An improved ignition system according to claim 7 and further characterized by a hold-off diode connected between said inductance and control means whereby said storage means may be charged to twice the supply of voltage.

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