

United States Patent

[11] 3,566,202

[72] Inventor **Sherman C. Carr**
Hartford, Wis.
[21] Appl. No. **734,006**
[22] Filed **June 3, 1968**
[45] Patented **Feb. 23, 1971**
[73] Assignee **Chrysler Corporation**
Highland Park, Mich.

2,995,685	8/1961	Lord.....	317/157.62X
605,174	6/1898	Bogart.....	317/157.62
3,202,950	8/1965	Penn.....	336/192
1,362,138	12/1920	Pratt.....	336/84
1,837,245	12/1931	Wheeler.....	336/84
3,195,020	7/1965	Willutzki.....	317/157.62

Primary Examiner—Lee T. Hix
Assistant Examiner—C. L. Yates
Attorney—Harness, Talburt and Baldwin

[54] **SELF RESONANT IGNITION COIL AND SYSTEM**
8 Claims, 3 Drawing Figs.

[52] U.S. Cl. 317/157.62,
336/84, 336/233

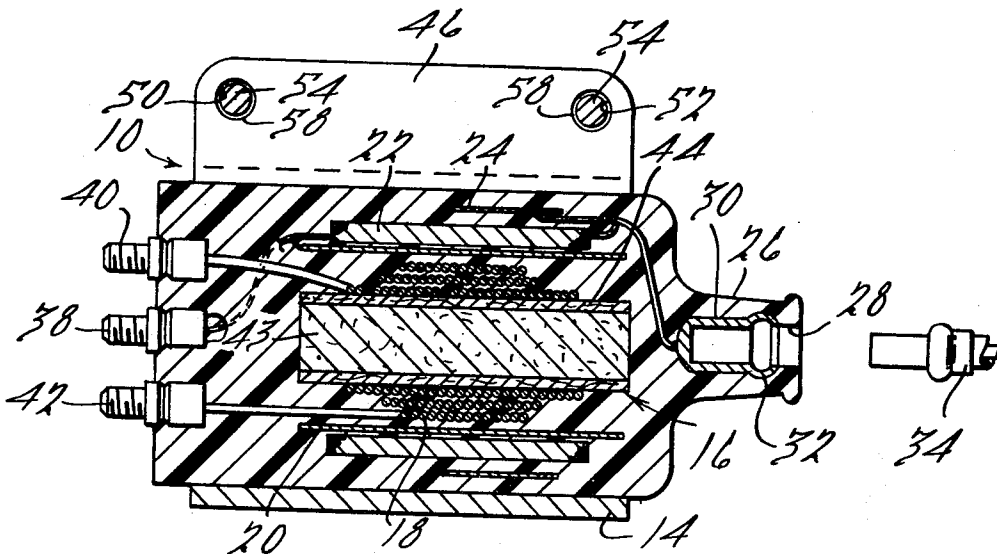
[51] Int. Cl. H01f 15/04,

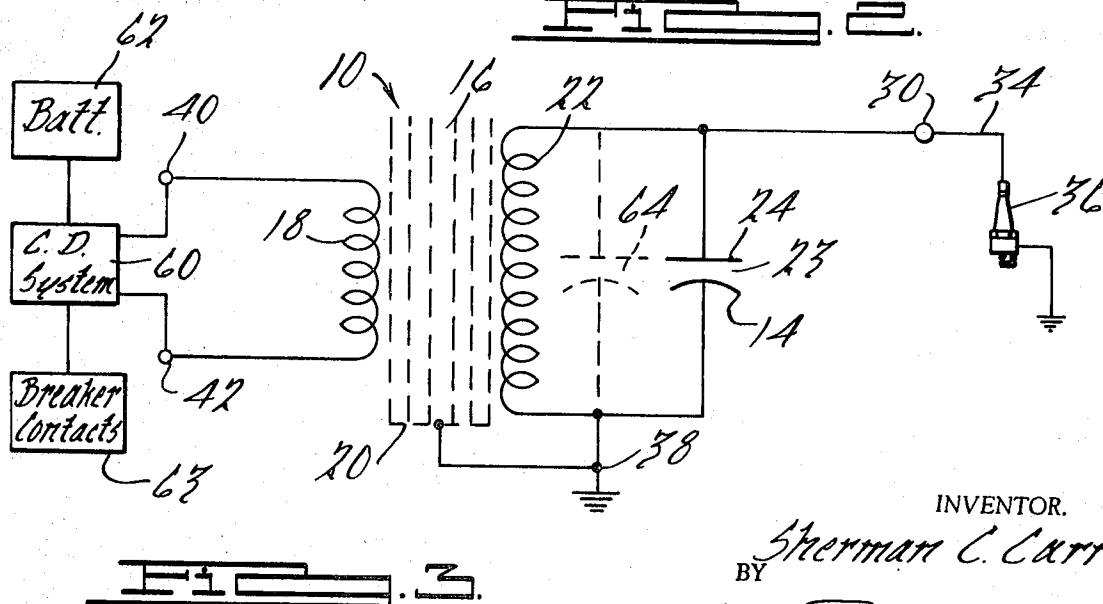
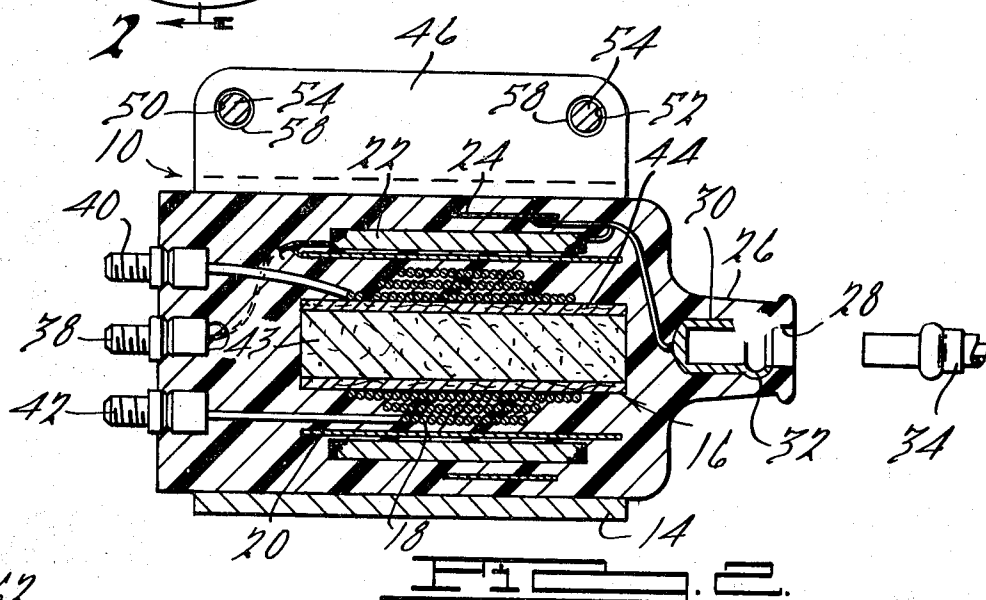
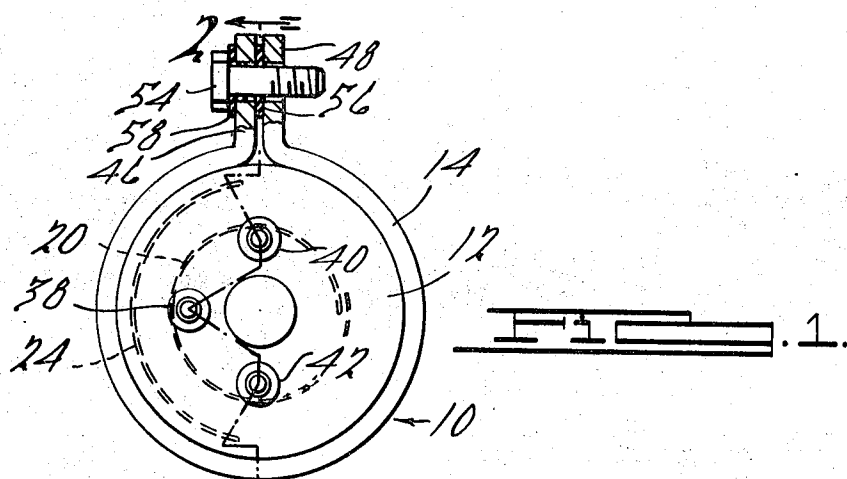
[50] Field of Search..... H01f 27/24, F02p 1/00
317/157.62;
336/233, 84

[56] **References Cited**
UNITED STATES PATENTS

2,081,979 6/1937 Bentley 336/84

ABSTRACT: An ignition coil of low internal impedance and high energy storage and transfer characteristics and having an electrostatic shield between the coil primary and the coil secondary surrounding the primary and additional capacity resonating the secondary to a high frequency providing improved operating efficiency and prolonged spark duration of a spark plug load connected thereto.





INVENTOR.

Sherman C. Carr

BY

Harness, Talburt & Ballwin
ATTORNEYS.

SELF RESONANT IGNITION COIL AND SYSTEM

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to ignition coils and, more particularly, to self resonant ignition coils.

2. Prior Art

Conventional ignition systems employing customary forms of ignition coils are at a serious disadvantage in internal combustion engines particularly under cold starting conditions, wide open throttle and full load operating conditions, or partially hot or cold fouled spark plug conditions. The energy supplied by the conventional ignition coil does not attain its peak intensity sufficiently rapidly for cold starting firing of partially fouled plugs, the coil frequency being too low to provide the fast rise time required of the pulse energy to initiate combustion under these conditions.

Such coils are also characterized by high internal impedance and resistance, which severely limit the energy delivered to the plug, while the laminated iron core normally employed in these coils constitutes an additional source of power loss due to eddy current and hysteresis or molecular friction effects therein. Fouled or eroded electrode conditions change the impedance of the plug and affect the energy transferred thereto from the coil, which is incapable of adjusting its voltage output in accordance with the plug electrode conditions. Nor are such coils capable of providing the high current demand of the spark gap for ignition of all common fuels in engines which operate with various forms of such fuels.

Accordingly, the present invention has for its object to provide an ignition coil device that will provide improved operation as a source of ignition energy for an internal combustion engine under severe starting and operating conditions with consequent resulting improvement of engine combustion efficiency, operation and performance.

Another object is to provide an improved ignition coil for a source of ignition energy having a rapid voltage rise time to gap break down characteristic and providing maximum peak energy for severe starting conditions of an internal combustion engine.

A related object is to provide an improved ignition coil self resonating at a high frequency providing a rapid rate of rise of the pulse energy supplied therefrom and promoting burn-off or self cleaning of fouling deposits on the plug electrodes.

Another object is to provide an improved ignition coil for an ignition energy storage source capable of providing energy over a sufficient period of time to a spark plug load to ensure combustion under high turbulence, high temperature, full load, high engine r.p.m. and full load throttle conditions.

Another object is to provide an improved ignition energy source whose output voltage will adjust to spark plug gap growth without loss of energy to the plug and which will provide high spark plug gap current in proportion to gap current demand for ignition of various fuels commonly employed in internal combustion engines.

SUMMARY OF THE INVENTION

Towards accomplishment of the foregoing and related objects, the present invention provides an improved ignition coil of high energy storage capacity and of low internal impedance and resistance characteristics. The coil is designed with additional lumped capacity therein to provide high current delivery therefrom and to parallel resonate the secondary inductance to an internal impedance to operate into the external load for maximum energy transfer thereto. Energy is supplied from the coil at a rate or frequency providing a rapid rise to gap breakdown time characteristic for firing under cold starting or fouled plug conditions and is sustained for a period sufficient to ensure complete combustion when the engine is operating under high temperature, high turbulence, full throttle, full load conditions.

The structure and operation of the invention will be explained with reference to the accompanying drawings first briefly described below.

DESCRIPTION OF THE DRAWINGS

FIG. 1 is an elevation view of one end of an ignition coil constructed in accordance with the present invention;

FIG. 2 is a sectional view taken in the direction 2-2 of the coil of FIG. 1; and

FIG. 3 is an electrical schematic circuit diagram illustrating the connections of the subject coil in an ignition circuit supplying energy to a spark plug connected as an electrical load.

DESCRIPTION OF THE PREFERRED EMBODIMENT

As illustrated in FIGS. 1 and 2 of the drawings, the coil 10 is of elongated cylindrical formation comprising a shell or body portion 12 circumferentially surrounded over the major portion of its axial length by a split cylindrical mounting clamp or strap 14. Interiorly, the coil comprises an axially extending central core structure 16, a primary transformer winding 18, an electrostatic shield 20, a high tension secondary winding 22, and a foil segment 24 forming an element of a capacitor 23, the other element of which is formed by the mounting clamp 14.

The body portion 16 is composed of a high dielectric insulating material such as a cast epoxy in which the foregoing elements 18-24 are potted or embedded. One end of the body portion extends axially forwardly or beyond the mounting strap 14 and includes a diametrically reduced, truncated conical portion 26 having a short axially extending, outwardly opening bore 28 centrally formed therein. Molded in the bore is a generally cup-shaped, brass terminal connector 30 the open end of which has a radially outwardly expanded annular ferrule 32 formed thereon for detachably receiving a high tension cable 34 exteriorly connected to the spark plug 36, as shown in FIG. 3.

In the other or rearwardly facing end of the body portion are molded three brass terminal post connectors 38, 40 and 42, having reduced and threaded ends for grounding of the core and external connections to an excitation source therefor. The terminals are shown located at the same radial distance from the axis of the coil structure with the terminal 38 equidistantly located between the oppositely diametrically disposed terminals 40 and 42.

The core structure 16 comprises a ferrite rod 42 of relatively high magnetic permeability constant in the order of 2000 to 2500 Oersted per Gauss, and is formed of compressed powdered iron particles in a suitable binder. The rod is contained within an elongated fiber tube 44 upon which is wound the primary winding 18 of the coil.

The primary winding 18 is comprised of approximately 75 turns of 016 A.W.G. enameled magnet wire and is wound about a portion of the length of the tube in three tiered layers. It will be appreciated that the resistance of the primary of the coil is considerably less than that of an ignition coil whose primary is wound about the secondary and therefore requires a greater lineal length of wire by reason of the increased diameter thereof. As indicated in FIG. 2, the starting end of the primary winding is interiorly electrically connected to input terminal post 40, while its other or finish end is connected to input terminal post 42.

The secondary winding 22 is spaced radially outwardly of and from the primary winding about which it is concentrically wound with approximately 4500 turns of 036 gauge magnet wire distributed in a plurality of layers insulated from each other by intervening paper insulating material.

The electrostatic or Faraday shield 20, which is located between the primary and the secondary windings, comprises a thin strip of copper foil material disposed concentrically of and physically insulated from the coil windings. The wrapped ends of the foil extending paraxially of the coil assembly are disposed in overlapping but slightly separated relation, as in-

indicated in FIG. 1, and are spaced apart by intervening insulating material therebetween. The electrostatic shield and the starting or low potential end of the secondary winding are connected interiorly to the terminal post 38, which is externally connected to electrical ground.

The foil element 24 forming one side or electrode of the capacitor structure 23 provided within the coil is a thin strip of copper having an area of approximately one and a half square inches in the constructed embodiment of the invention. As illustrated in dashed outline in FIG. 1 the foil is of semicircular extent and is spaced radially outwardly from the secondary winding and inwardly of the inner surface of the mounting strap 14 which cooperates electrically therewith to form the other side, plate or electrode of the capacitor.

The mounting strap 14 may be bonded as by cementing to the periphery of the body portion 16 and is composed of electrically conducting material, as aluminum. As indicated in FIG. 1, the mounting strap is shaped in the form of a split ring or circular clamplike structure and has a pair of radially outwardly extending bracket or ear portions 46, 48. Each of the ear portions has a pair of laterally spaced apart apertures 50, 52 therein for attachment of the coil assembly by the mounting bracket with threaded screws or bolts, one of which is shown at 54, to a support or mounting base structure not shown. The inwardly facing surfaces of the ear portions are spaced apart by phenolic washers of suitable insulating material 56 interposed therebetween to prevent the circulation of currents induced in the conducting strap from changes in the coil field. Likewise, suitable grommets as 58 formed of insulating material are inserted in the aligned mounting apertures in the strap ear portions to insulate the head and body of the attachment bolts from the strap structure and prevent completing a continuous electrically conducting path therethrough. The ends of the electrostatic shield 20 are spaced apart for the same reason, i.e. to avoid power losses therein that would otherwise result from the short circuited turn effect of a continuous conducting medium exposed to a changing electromagnetic field.

In FIG. 3, the subject coil is represented in electrical schematic form as employed in an engine ignition system and connected between an excitation source 60 and the spark plug 34. The excitation source 60 is energized from a storage battery 62 and supplies a high current, short duration energy pulse therefrom as obtained from a condenser discharge system, for example. As employed in engine ignition applications, such condenser discharge systems include a DC to AC inverter device that inverts the low DC output voltage of the storage battery to an AC voltage in the order of 300 volts, a rectifier device connected in charging circuit relation with an energy storage condenser of say to 1—2 ufd. capacity, and a discharge control circuit connecting the condenser in discharge circuit relation with the primary side of the ignition coil. The discharge controlling circuit comprises the engine actuated breaker or interrupter contacts 63 connected directly or through an intermediate electronic triggering circuit to the gate control element of a controlled switch, as an SCR device. The latter is connected in discharge controlling circuit relation with the charged energy storage condenser to discharge the condenser through the coil load device in timed relation with the operation of the breaker contacts.

In the coil generally designated at 10 in FIG. 3, the electrostatic shield is represented at 20. The shield serves to minimize the internal capacitive coupling between the coil primary and secondary windings and effectively presents a low impedance path to ground for high frequency currents which are generated in the spark plug arc and resonate at the natural frequency of the secondary lead wires and components external to the coil secondary. The shield prevents this energy from being coupled back into the primary of the coil and developing a voltage thereacross that could damage the voltage sensitive electronic components, including the semiconductor devices of the condenser discharge system, connected thereto. By isolating these currents from the primary, the shield

prevents them from being dissipated as power losses in the coil and, instead, converts and utilizes such energy appearing in the secondary to maintain the oscillations of the coil for sustaining spark plug ignition.

5 The lumped capacitor formed by the foil wrap 24 and mounting clamp 14 is shown schematically at 23 in parallel with both the secondary winding 22 and the inherent distributed capacity effect 64 of the secondary winding and serves to parallel resonate the secondary to a frequency providing a rapid rate of rise to the energy supplied from the coil to break down the plug gap under cold starting conditions.

10 In addition to increasing the energy storage capacity of the coil as a source of energy, the additional capacity provided by the lumped circuit capacitor 23 enables delivery of sufficiently high currents from the coil to satisfy the gap current demand of the plug for operation of the engine with all commonly available fuels therefor. The additional capacitance parallel resonates the secondary and effectively reduces the internal impedance of the coil to adequately or more closely match that of the plug load for maximum transfer of energy thereto.

15 The coil thus effectively constitutes a constant current source or generator that will deliver energy to a variable impedance load and will adjust its output voltage characteristic in relation to the voltage requirements of the load for gap breakdown thereof while supplying the high current level demands and energy requirements of the load. In distinction to the high impedance, low current transfer characteristic of the conventional ignition coil, the reduction of the internal resistance and somewhat lowered primary inductance of the subject ignition coil renders the primary thereof a low impedance, high current energy transfer link circuit to the secondary. The capacitance 23 resonates the secondary as a high Q oscillatory tank circuit supplying energy therefrom of sufficient intensity and duration providing successive or multiple firings to insure combustion under adverse operating conditions of the engine.

20 The energy attains a sufficient intensity and is released at such a rapid rate as to effectively burn off fouling deposits on the plug electrodes, thereby improving combustion efficiency, delaying the formation of combustion chamber deposits and reducing the content of unspent combustion products exhausted from the engine.

I claim:

45 1. An ignition coil comprising a core; a primary winding around said core; an open-circuited electrostatic shield in the form of an electrically conducting sheet of material spaced from and wrapped about the primary winding with the starting and finishing ends of the wrapped sheet in overlapping but slightly spaced apart relation to one another; a secondary winding surrounding said electrostatic shield and having an electrical connection thereto; and an additional capacitance electrically connected across the secondary winding to increase the energy storage and current delivery capability of the coil and to decrease the internal impedance thereof.

50 2. An ignition coil according to claim 1 wherein said additional capacitance comprises an electrically conducting foil element spaced from said secondary winding.

55 3. An ignition coil according to claim 2 including:
a body portion enclosing said windings, shield and foil element; and
a mounting clamp surrounding said body portion and electrically cooperating with said foil element to form the other element of said additional capacitance.

60 4. An ignition coil assembly according to claim 3 wherein, said mounting clamp is of split, discontinuous formation at the adjacent ends thereof which are insulatingly spaced apart in open circuit electrical relation.

65 5. An ignition coil assembly according to claim 4 and wherein said coil includes a ferrite material central core.

70 6. An ignition coil assembly according to claim 6 wherein said body portion is composed of a high dielectric material completely surrounding said core, windings, shield and foil element.

5

6

7. An ignition coil assembly according to claim 6 wherein said body portion is comprised of an epoxy material cast about said core, windings, shield and foil element all of which are insulatingly spaced apart by the material of the body portion.

8. An ignition coil assembly according to claim 8 wherein said coil further includes:

first and second low voltage terminals extending through one end of the body portion and connected electrically to

the opposite ends of the primary winding;
a high voltage terminal extending through another end of said body portion and electrically connected to one end of the secondary winding; and
a ground terminal extending through said one end of the body portion and electrically connected to the other end of said secondary winding and to said electrostatic shield.

10

15

20

25

30

35

40

45

50

55

60

65

70

75