Aug. 14, 1962 O. E. BOWLUS ETAL 3,049,644

IGNITION SYSTEM

Original Filed March 2, 1959

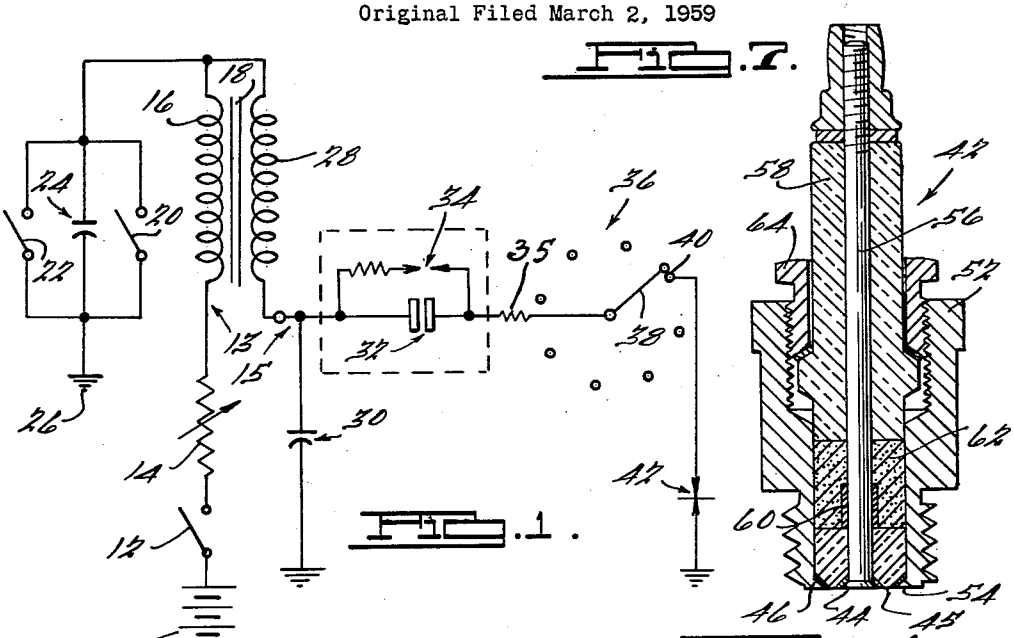

FIG. 1.

FIG. 4.

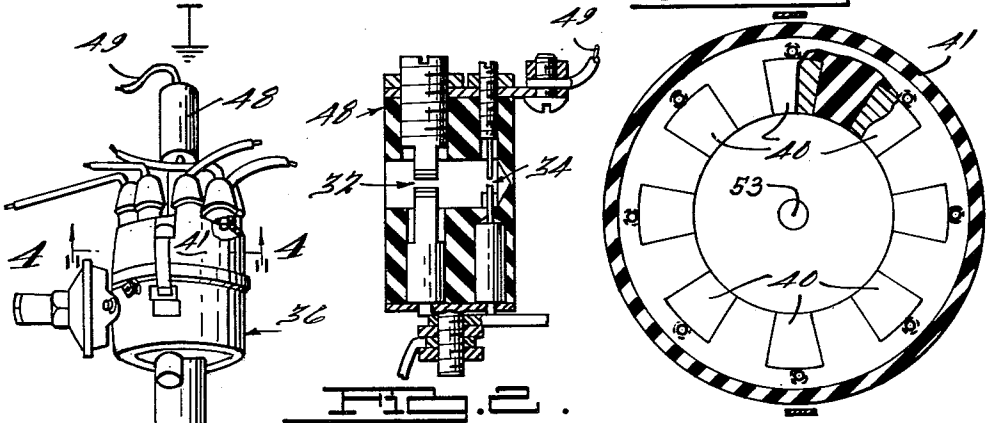

FIG. 2.

FIG. 3.

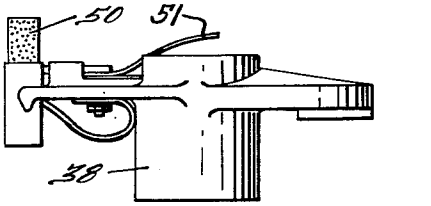

FIG. 5.

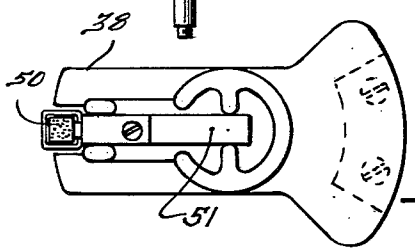

FIG. 6.

INVENTOR.
Omer E. Bowlus.
Kenneth H. Graham.
BY Harness & Harris
ATTORNEYS.

United States Patent Office 3,049,644 Patented Aug. 14, 1962

3,049,644
IGNITION SYSTEM

Omer E. Bowlus, Orchard Lake, and Kenneth A. Graham, Birmingham, Mich., assignors to Chrysler Corporation, Highland Park, Mich., a corporation of Delaware

Continuation of application Ser. No. 796,448, Mar. 2, 1959. This application May 2, 1960, Ser. No. 26,374
8 Claims. (Cl. 315—219)

The present invention relates to internal combustion engines and has particular reference to a new and improved ignition system therefor.

The present invention is an improvement over the ignition system of our Patent No. 2,819,428 and reference is also made to our copending application Serial No. 696,845, now Patent No. 2,984,760, filed November 15, 1957, relating to a surface gap spark plug which is described herein.

This application is a continuation of our application Serial No. 796,448 entitled Ignition System, filed March 2, 1959, now abandoned.

In the conventional ignition coil and magneto energized ignition systems for internal combustion engines wherein spark plugs are used having air gaps of a width within the range of 0.020 to 0.035 inch, the voltages necessary to electrically break down the air dielectric within these plug gaps fall within the range of 4 to 25 thousand volts. The high voltage spark is followed by a low current arc of relatively long duration which is effective in igniting cold and/or lean fuel mixtures but does not impinge upon carbon and lead fouling deposits which partially short the electrodes of these air gap plugs, nor contain the concentrated energy required to raise the temperature of the spark to a degree sufficient to burn away these deposits on the insulator surface should the spark actually contact these deposits by internal flash over.

This lack of concentrated energy in the spark is due in part to the characteristics of the ignition coil and magneto energy sources which are characteristically slow in releasing their electrical energy. Their slow release of energy is particularly disadvantageous to ignition when sufficient plug fouling exists to drain or shunt to ground a relatively large portion of the total energy supplied to the plug. Should fouling deposits of any substantial conductive capacity develop on the plugs the total energy dissipated by the shunting effect thereof may be sufficient to prevent the voltage from building up high enough to initiate a spark in the plug gaps.

Moreover, when using a conventional air gap plug of the type shown for example in Patent No. 2,269,067 with these ignition coil or magneto energizing systems, the spark plug actually has little opportunity to burn away its own fouling deposits since the spark does not occur in the immediate vicinity of these deposits which form on the insulator surface between the base of the center electrode and the metal shell or ground electrode of the plug. When these energizing systems on the other hand are used with surface gap plugs where a spark can be effective in burning away fouling deposits, the rate of release of energy to the plugs is not sufficient to burn away the fouling deposits and also perform its fuel ignition function.

A major object of this invention, therefore, is to provide a condenser discharge ignition system with surface gap spark plugs to eliminate spark plug fouling by causing the spark to occur in the immediate vicinity of the fouling deposits and be sufficiently hot to burn said deposits away.

Another object is to provide an improved ignition system characterized by its ability to produce a spark of sufficient duration and heat to insure proper ignition of cold, lean and other combustion mixtures, and combustion of the fouling deposits.

Another object of the invention is to provide an improved ignition system which operates at a high frequency

and low voltage compared to other systems known in the art.

A further object is to provide an ignition system capable of utilizing the residual energy of the ignition coil after the plug fires to maintain an arc having sufficient heat to aid in burning away fouling deposits and in igniting all fuel mixtures.

A still further object of the invention is to provide an improved ignition system which is characterized by its ease of operation and its relatively few number of parts.

Essentially the invention relates to an improved ignition system utilizing conventional circuitry on the primary side of the ignition coil which delivers a relatively low frequency and low voltage power. The secondary circuit of the ignition coil is loaded by a secondary or ignition condenser and is connected through a series spark gap to a brush type distributor. The absence of rectifiers in the present system is particularly noted and the reasons therefor are described below. The distributor is connected in the conventional manner to a plurality of surface gap spark plugs generally of the type disclosed in the aforementioned patent application and described below. By employing such a system the series gap breaks down at a predetermined relatively low voltage and the charge which has been built up on the secondary condenser discharges to the spark plug being fired to produce a spark of very short duration which is sufficiently hot to burn away fouling deposits. Moreover, the absence of rectifiers in the system allows the residual energy of the coil to be used to recharge the secondary condenser to a progressively diminishing degree or continue an arc across the series gap and plug for a period of time sufficient to insure complete fuel ignition. The resistor **48** helps prevent recharging of the secondary condenser and allows continuous arcing. The ionized condition of the series and spark plug gaps allows the flow of current in the secondary circuit to maintain the plug arc until the energy decays to a level which will no longer support the arc.

Other objects and advantages of the invention will become apparent from the following description and drawings, in which:

FIGURE 1 is a schematic illustration of the electrical circuitry of the invention;

FIGURE 2 is a sectional view of the spark gap assembly;

FIGURE 3 is an elevational view of a distributor used in the system;

FIGURE 4 is a view of the brush type distributor cap interior contact surface taken along the line 4—4 of FIGURE 3 in the direction of the arrows;

FIGURE 5 is a side elevational view of the brush type rotor;

FIGURE 6 is a top elevational view of the rotor of FIGURE 5; and

FIGURE 7 is a cross sectional view of the surface gap spark plug used in the present system.

Referring to the drawings and in particular to FIGURE 1, an ignition system is shown comprising a direct current power source **10** such as a battery or dynamo which is connected to ground and to an ignition switch **12** of the primary circuit **13**. This switch is connected through a variable ballast resistor **14** to the primary winding **16** of a transformer or ignition coil **18**. A pair of breaker switches **20** and **22** are connected in parallel with a spark suppressing and primary voltage build-up condenser **24** and are grounded at **26**. Switches **20** and **22** represent the equivalent of the conventional breaker point contacts of ignition systems such as are shown in the aforementioned patent and alternately are opened and closed to produce a pulsating direct current in winding **16**. Condenser **24** prevents excessive sparking at switches **20** and **22** and in

series with winding **16** causes a high voltage oscillation in the primary circuit.

The flux change linking both winding **16** and winding **28** and caused by the collapse of the primary current when the points **20** and **22** are opened induces an oscillatory current flow in the secondary circuit **15** comprised partially of the secondary winding **28** of coil **18** which on the first quarter wave of oscillation energizes the secondary or ignition condenser **30** to a voltage of approximately 2–5 kilovolts. This condenser has one plate connected to ground and the other plate connected to said secondary winding and to a parallel arrangement of a main series spark gap **32** and a teaser spark gap **34**. Teaser gap **34** is almost continuously ionized and tends to stabilize the voltage necessary to spark the main gap **32** at between 2,000 to 5,000 volts. The condenser **30** will charge up to the voltage necessary to spark gap series **32** and spark plug gap **42** which results in a high current flow in the secondary circuit to the plug.

As a result of this high current flow the arc between the electrodes **44** and **46** of the surface gap plugs is very hot and is maintained for a very short time of approximately one microsecond. This hot arc occurs directly across the face of the dielectric separator **45** on which the fouling deposits occur and is particularly effective in burning these fouling deposits from this face and also in igniting lean fuel mixtures.

Following the secondary condenser discharge is a low current arc maintained for approximately 250 microseconds by the residual energy of the coil **18**. This residual energy is derived from continued oscillation of current in the primary circuit, while the points are open, caused by the electrical resiliency of primary condenser **24** as it alternately attains charge and loses charge and also by the self-inductance of primary inductor winding **16**. This low current arc is especially suitable for igniting certain cold and moisture laden fuel mixtures and continues until the voltage induced by this residual energy cannot support the arc. By so utilizing this residual coil energy to supplement the energy of the condensers initial discharge the size of condenser **30** may be held to a capacitance of approximately 1000 micromicrofarads which reduces condenser cost and also reduces the degree of arc erosion of the plug electrodes.

In order to prevent overly rapid dissipation of energy through the spark plug, to help in igniting cold fuel mixtures, to aid in reducing radio interference, and to help reduce electrode arc erosion, resistance or inductance **35** may be placed in the circuit. This resistor or inductance **35** also assists in maintaining the arc at the spark plug after the initial discharge of condenser **30**.

The distributor **36** is provided with a brush type rotor **38** which in operation successively wipes across each high tension contact **40** at the moment that the required breakdown voltage of gap **32** is impressed across the secondary condenser **30**. As condenser **30** discharges in an arc across series gap **32**, the surface gap spark plug **42** (see FIGURE 7) connected to the made contact **40** arcs through the fuel mixture from the center electrode insert **44** to the ground electrode insert **46**. The gaps **32** and **34** are shown in their structural form in FIGURE 2 and are contained in a unit **48** which is connected to the power lead **49** of the distributor **36**. As shown in FIGURE 4, the contacts **40** are formed of conductive segments peripherally spaced around the cap **41** of distributor **36**. The distributor rotor **38** as shown in FIGURE 5 has a brush **50** for making sliding electrical contact with contacts **40**, and a spring arm **51** electrically connected to brush **50** and adapted to make electrical contact with power inlet terminal **53** of the distributor.

Plug **42** is disclosed in further detail in applicants' copending application Serial No. 696,845 and comprises an outer shell or ground electrode **52** of conductive material which is swaged or otherwise formed over at the end

54 to retain the inserts **44**, **46** of molybdenum or other high temperature resistant metal and the dielectric insulator **45** which may be of porcelain or other insulative material known to the art. A center or power electrode **56** is spaced from the outer shell by insulator **58** and is provided with a collar **60** which holds dielectric insert **45** in place. Powdered insulator material **62** is compressed by the action of the assembly lock nut **64** to thereby properly position and maintain the plug parts in such position. As stated above, the voltage necessary to initiate the spark in the plug gap is approximately 2,000 volts which is considerably less than that required to arc a conventional air gap spark plug.

We claim:

1. In an ignition system for an internal combustion engine, a surface gap spark plug and gap means in an operative electrical circuit, a condenser arranged in said circuit to discharge through said plug and gap means in series when the latter is conductive, said gap means requiring a predetermined comparatively high breakdown potential to initiate its conduction and being adapted to conduct thereafter at a comparatively low conducting potential until said conducting potential sustains a predetermined interruption, electrical power supply means arranged in said circuit to charge said condenser to said breakdown potential to effect a sudden current surge across said gap means and plug upon the discharge of said condenser, and resistance means in said circuit for retarding the rate of discharge of said condenser appreciably as the potential of the latter approaches said conduction potential, said power supply means being also effective to supply electrical power to said gap means at said conducting potential for an extensive time interval with respect to the duration of said current surge, thereby to effect a trailing current of extensive duration across said gap means and plug following said initial current surge.

2. In an ignition system for an internal combustion engine, a surface gap spark plug and gap means in an operative electrical circuit, a condenser arranged in said circuit to discharge through said plug and gap means in series when the latter is conductive, said gap means requiring a predetermined comparatively high breakdown potential to initiate its conduction and being adapted to conduct thereafter at a comparatively low conducting potential until said conducting potential sustains a predetermined interruption, electrical power supply means arranged in said circuit to charge said condenser to said breakdown potential to effect a sudden current surge across said gap means and plug upon the discharge of said condenser, and resistance means in said circuit for retarding the rate of discharge of said condenser sufficiently as the potential of the latter approaches said conduction potential to prevent said predetermined interruption of said conducting potential, said power supply means being also effective to supply electrical power to said gap means at said conducting potential for an extensive time interval with respect to the duration of said current surge, thereby to effect a trailing current of extensive duration across said gap means and plug following said initial current surge.

3. In an operative ignition circuit for an internal combustion engine, surface gap means requiring a predetermined high breakdown potential to initiate conduction of electric current and being thereafter susceptible of conduction at a low conducting potential until the latter potential sustains a predetermined interruption, a surface gap spark plug arranged to receive the current conducted by said spark gap means, a condenser arranged to discharge through said plug and gap means when the latter is conductive, electrical power supply means for charging said condenser to said breakdown potential to effect a sudden current surge across said gap means and plug upon the discharge of said condenser, and resistance means

for retarding the rate of discharge of said condenser sufficiently as the potential of the latter approaches said conducting potential to prevent said predetermined interruption of said conducting potential by resisting oscillation of said condenser potential about said conducting potential, said power supply means having a high internal impedance compared to the impedance to charging said condenser and being effective to supply electrical power to said gap means at said conducting potential for an extensive time interval with respect to the duration of said current surge to effect a trailing current of extensive duration across said gap means and plug following said current surge.

4. In an operative ignition circuit for an internal combustion engine, surface gap means requiring a predetermined high breakdown potential to initiate conduction of electric current and being thereafter susceptible of conduction at a low conducting potential until the latter potential sustains a predetermined interruption, a surface gap spark plug arranged to receive the current conducted by said spark gap means, a condenser arranged to discharge through said plug and gap means when the latter is conductive, electrical power supply means including a voltage step-up transformer having secondary windings connected with said condenser to charge the same to said breakdown potential to effect a sudden current surge across said gap means and plug upon the discharge of said condenser, and resistance means for retarding the rate of discharge of said condenser sufficiently as the potential of the latter approaches said conducting potential to prevent said predetermined interruption of said conducting potential by damping oscillation of said condenser potential about said conducting potential, said power supply means being effective to supply electrical power to said gap means at said conducting potential for an extensive time interval with respect to the duration of said current surge to effect a trailing current of extensive duration across said gap means and plug following said current surge.

5. In an operative ignition circuit for an internal combustion engine, surface gap means requiring a predetermined high breakdown potential to initiate conduction of electric current and being thereafter susceptible of conduction at a low conducting potential until the latter potential sustains a predetermined interruption, a surface gap spark plug arranged to receive the current conducted by said spark gap means, a condenser arranged to discharge through said plug and gap means when the latter is conductive, electrical power supply means for charging said condenser to said breakdown potential to effect a sudden current surge across said gap means and plug upon the discharge of said condenser, said power supply means including a battery, a transformer having primary windings connected with said battery to be energized thereby and also having secondary windings connected with said condenser to charge the same, and breaker points for interrupting the energizing of said primary windings to effect a condenser charging potential across said secondary windings, and resistance means for retarding the rate of discharge of said condenser sufficiently as the potential of the latter approaches said conducting potential to prevent said predetermined interruption of said conducting potential by damping oscillation of said condenser potential about said conducting potential, said power supply means being effective to supply electrical power to said gap means at said conducting potential for an extensive time interval with respect to the duration of said current surge to effect a trailing current of extensive duration across said gap means and plug following said current surge.

6. In an operative ignition circuit for an internal combustion engine, surface gap means requiring a predetermined high breakdown potential to initiate conduction of electric current and being thereafter susceptible of conduction at a low conducting potential until the latter potential sustains a predetermined interruption, a surface gap spark plug arranged in series with said spark gap means, a condenser arranged to discharge through said plug and gap means when the latter is conductive, electrical power supply means for charging said condenser to said breakdown potential to effect a sudden current surge across said gap means and plug upon the discharge of said condenser, and resistance means arranged between said gap means and plug in series therewith for retarding the rate of discharge of said condenser sufficiently as the potential of the latter approaches said conducting potential to prevent said predetermined interruption of said conducting potential by resisting oscillation of said condenser potential about said conducting potential, said power supply means being effective to supply electrical power to said gap means at said conducting potential for an extensive time interval with respect to the duration of said current surge to effect a trailing current of extensive duration across said gap means and plug following said current surge.

7. In an operative ignition circuit for an internal combustion engine, surface gap means requiring a predetermined high breakdown potential to initiate conduction of electric current and being thereafter susceptible of conduction at a low conducting potential until the latter potential sustains a predetermined interruption, a surface gap spark plug arranged in series with said spark gap means, a condenser arranged to discharge through said plug and gap means when the latter is conductive, electrical power supply means including a voltage step-up transformer having secondary windings connected with said condenser to charge the same to said breakdown potential to effect a sudden current surge across said gap means and plug upon the discharge of said condenser, and resistance means arranged between said gap means and plug in series therewith for retarding the rate of discharge of said condenser sufficiently as the potential of the latter approaches said conducting potential to prevent said predetermined interruption of said conducting potential by resisting oscillation of said condenser potential about said conducting potential, said gap means being arranged between and in series with said resistance means and the connection between said condenser and secondary windings, said power supply means being effective to supply electrical power to said gap means at said conducting potential for an extensive time interval with respect to the duration of said current surge to effect a trailing current of extensive duration across said gap means and plug following said current surge.

8. In an operative ignition circuit for an internal combustion engine, surface gap means requiring a predetermined high breakdown potential to initiate conduction of electric current and being thereafter susceptible of conduction at a low conducting potential until the latter potential sustains a predetermined interruption, a surface gap spark plug arranged in series with said spark gap means, a condenser arranged to discharge through said plug and gap means when the latter is conductive, electrical power supply means for charging said condenser to said breakdown potential to effect a sudden current surge across said gap means and plug upon the discharge of said condenser, said power supply means including a battery, a transformer having primary windings connected with said battery to be energized thereby and also having secondary windings connected with said condenser to charge the same, and breaker points for interrupting the energizing of said primary windings to effect a condenser charging potential across said secondary windings, and resistance means arranged between said gap means and plug in series therewith for retarding the rate of discharge of said condenser sufficiently as the potential of the latter approaches said conducting potential to prevent said predetermined interruption of said conducting potential by damping oscillation of said condenser potential about said

conducting potential, said gap means being arranged between and in series with said resistance means and the connection between said condenser and secondary windings, said power supply means being effective to supply electrical power to said gap means at said conducting potential for an extensive time interval with respect to the duration of said current surge to effect a trailing current of extensive duration across said gap means and plug following said current surge.

References Cited in the file of this patent

UNITED STATES PATENTS

2,819,428 Bowlus et al. ---------- Jan. 7, 1958
2,833,963 Tognola ---------- May 6, 1958