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2,586,962

IGNITION CIRCUIT

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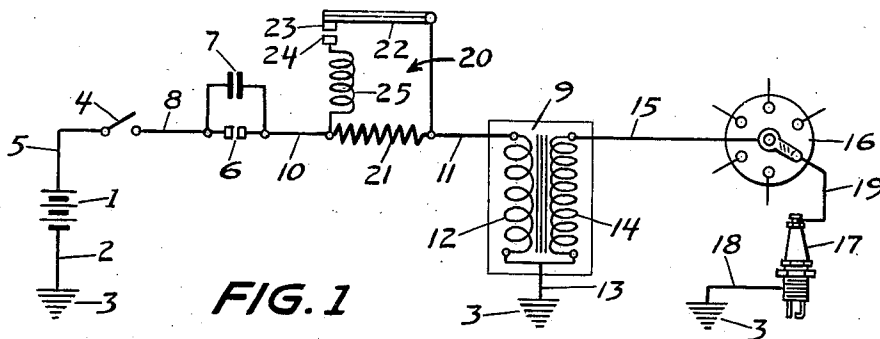


FIG. 1

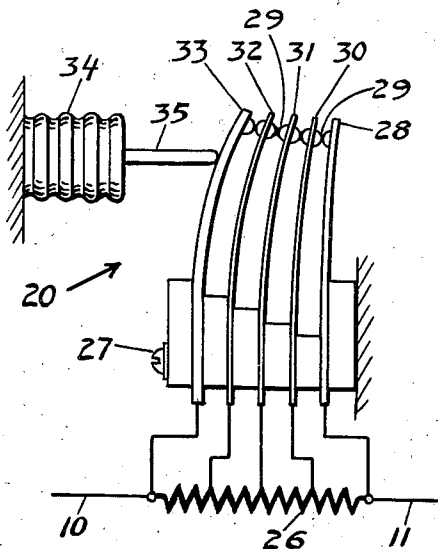


FIG. 2

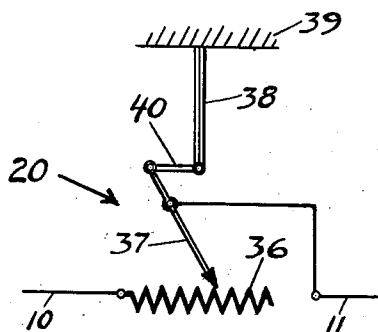


FIG. 3



FIG. 4

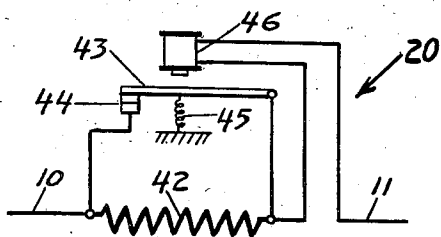


FIG. 5

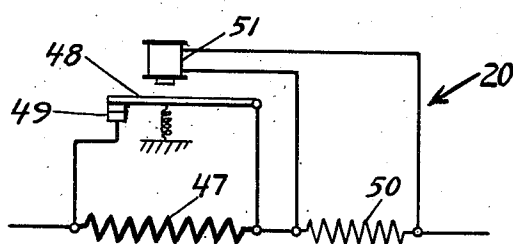


FIG. 6

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2,586,962

IGNITION CIRCUIT

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This invention relates to ignition systems particularly adapted for internal combustion engines.

One of the common difficulties encountered in the operation of automobiles particularly in cold climates is the difficulty in starting which may be due to various causes. The difficulty may be due to the type of fuel or an improper ratio of fuel to air. The lubricating oil which is used may be sufficiently viscous, because of its composition and the inclusion of wax, to render the engine difficult to crank or turn over. The conventional lead storage batteries have an inherent characteristic that the capacity or discharge rate decreases with a decrease in temperature causing the available starting power to be lowest at the time when the heaviest drain is placed on the battery.

I have discovered a further cause for failure to start or a further difficulty in starting the engine which is not related to any of the aforementioned conditions. This difficulty is traceable to the ignition system and is a result of the formation of an adherent coating or film upon the working surfaces of the tungsten contact points in the ignition system. The exact nature or composition of the film is not known, but it may be an oxide or iron tungstate or a mixture of these compounds. It has been found that contacts which cause difficulty in starting or starting failures have, in general, a rough pocked operating surface, the positive contact surface presenting a blue or purplish-black appearance and the negative surface having a dark grey or black appearance. This condition of the contact faces is most prevalent in instances where the engine is operated at low temperatures for relatively short periods of time alternating with longer idle periods.

This invention is predicated upon and makes practical application of my discovery that the formation of the objectionable surface films frequently is caused by a high current flow in the primary circuit resulting from the decrease of the primary circuit resistance, particularly the decrease of the primary coil resistance which constitutes the major portion of the primary circuit resistance, attributable to low temperature conditions. These high currents are in excess of the peak or maximum current which may be carried and interrupted by tungsten contacts without formation of objectionable surface films.

The present invention contemplates the provision of means associated with the primary circuit to compensate for variations of resistance

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attributable to changes of the temperature of the primary circuit.

The compensating means may be continuously variable so as to effect a variation in the primary circuit resistance of the same order as the variation in resistance due to the temperature changes, or compensating means may be provided whereby the primary circuit resistance is varied by a fixed amount only after the temperature changes over a predetermined range. The purpose of varying the resistance to compensate for the variations due to the temperature changes of the primary circuit should be of such magnitude so as to prevent the passage of current through the primary circuit in excess of the peak current which may be carried and interrupted by the tungsten contact points without producing excessive surface films.

The application of my invention to an ignition circuit is illustrated in the accompanying drawings, wherein:

Fig. 1 is a schematic circuit diagram of an ignition system in which means are provided whereby the primary circuit resistance is varied by a fixed amount as the temperature changes over a predetermined range.

Fig. 2 is a diagrammatical illustration of means of varying the primary circuit resistance in increments over a predetermined temperature range.

Fig. 3 is a diagrammatical illustration of means of continuously varying the resistance included in the primary circuit dependent upon the temperature conditions.

Fig. 4 is a similar view illustrating a further type of means of continuously varying the resistance of the primary circuit with changes in temperatures.

Fig. 5 is a diagrammatical illustration of a further embodiment of the present invention.

Fig. 6 is a diagrammatical illustration of another modification of the present invention.

Numerous means and methods have been suggested and proposed whereby the current flowing in the primary circuit is increased at the time of starting and during the initial operating period which may vary from a few minutes to fifteen to twenty minutes. These prior art systems employ a current flow in the primary circuit in excess of the peak current which may be carried and interrupted by the tungsten contacts and thereby directly results in the formation of the excessive surface films on the operating faces of the contacts. The presence of the heavy films necessarily requires that a greater current be passed through the circuit to furnish the necessary

spark discharge for starting the engine and during the initial operating period.

I have found that if excessive film formation on the contact surfaces is prevented, it is not necessary to provide an increased current flow during the starting and the initial operating period. The present invention, therefore, is opposed to the prior art suggestions and provides means whereby it is unnecessary to increase the current flow in the primary circuit during starting and during the initial operating periods to provide the necessary spark discharge across the spark plugs. The limitation of the current flow as provided by my invention not only aids in starting the engine but also greatly reduces the wear on the contact points thereby substantially increasing their life.

The ignition circuits illustrated in the drawings include a battery 1, one side of which is grounded through conductor 2 to the vehicle frame 3. The other terminal of the battery is connected electrically to the usual ignition switch 4 by means of conductor 5. The tungsten contact points 6 and the bridging condenser 7 are mounted in the distributor in the usual manner and are connected to the switch 4 through conductor 8 and to the ignition coil 9 through conductor 10. One side of primary coil 12 is connected to the contact points through conductor 11, the other side being grounded to frame 3 by means of conductor 13. One side of secondary coil 14 is grounded to frame 3 by means of conductor 13 and the other side of the coil is connected to the conventional distributor 16 by means of conductor 15. The distributor is provided with a plurality of terminals each of which is connected to a spark plug mounted in the engine. For purposes of illustration, only one spark plug 17 is illustrated, one side of which is grounded by means of conductor 18, the other side being connected to the proper distributor terminal through conductor 19.

In Fig. 1 the current limiting unit 20 comprises a fixed resistor 21 included in the primary circuit between the contact points and the primary coil. Short circuiting means are provided around the resistor and comprise thermally responsive means, for example, a bi-metallic thermostat element 22, provided with a movable contact 23 and a fixed cooperating contact 24. The thermally responsive element is so arranged that the resistor 21 is short circuited during normal temperature conditions. Upon a decrease in the surrounding temperature, contacts 23 and 24 are opened and all current which flows through the primary circuit of the system must pass through resistor 21. The temperature at which the thermally responsive element opens the short circuit may be any desired temperature so long as the short circuit is opened before the decrease in primary resistance has been sufficient to cause an excess current flow in the primary circuit. For example, for conditions encountered in winter driving, the thermally responsive element may be so constructed and adjusted as to open the short circuit around resistor 21 when the temperature drops to about 10° F. above zero. The resistance of resistor 21 may be of such magnitude that it exactly compensates for the decrease of resistance of coil 12 and the primary circuit caused by a decrease in temperature from 70° or 80° F. to 10° F. below zero. The resistance of the resistor, however, should be of such magnitude that it prevents an excess current flow in the primary circuit at the low temperatures encountered. Upon an increase in the ambient

temperature, the thermally responsive element closes the short circuit around the resistor 21.

Conventional automotive ignition systems generally have a primary circuit resistance of between 0.8 ohm and about 2.0 ohms. I have found that compensating resistors having a resistance of between 0.2 ohm and 0.5 ohm are satisfactory for compensating resistance variations encountered in average winter driving conditions. The specific value of the compensating resistor is, of course, dependent upon the resistance of the primary circuit, the operating temperature range and the temperature coefficients of resistance of copper and the material of the resistor. The resistors may consist of wire-wound "Nichrome" resistance units or any other desired type; however, it is preferable to employ materials having a relatively low temperature coefficient of resistance.

The current limiting unit 20, or at least the thermally responsive element, is preferably mounted in close proximity to ignition coil 9 so that the temperature conditions of unit 20 and coil 9 are substantially identical. The unit may be mounted on the coil casing or the unit may be mounted within the coil casing, as desired. It is apparent that such mounting is desirable since substantially the entire resistance of the circuit consists of the resistance of coil 12.

In some instances, it may be desirable to include an inductance 25 in the short circuiting means around resistor 21. Such inductance has been found to aid in maintaining the working surfaces of contacts 23 and 24 clean and free from excessive films and in preventing other conditions which produce high contact resistance which might result from the interruption of the current flowing through the contacts at the instant the contacts are closed or separated.

It is obvious that although but one current limiting unit has been illustrated in the primary circuit, for certain extreme cases it may be desired to employ several such units. If several such units are employed, the thermally responsive element or elements are so constructed as to open the short circuit around the associated resistors at different temperatures. For example, in certain instances it may be desired to employ an additional unit which includes in the primary circuit an additional resistor when the temperature drops to about 15° F. below zero. In such instances, a single thermally responsive element may be employed to operate two or more pairs of contacts or short circuiting means, each pair of contacts or each short circuiting means being associated with a resistor.

In Fig. 2 there is shown such a combination in which a tapped resistor 26 and a switch stack assembly 27 adapted to short circuit the resistor at the normal and higher temperatures of operation of the primary circuit are included between conductors 10 and 11. The tapped resistor is, of course, equivalent to a plurality of individual resistors. The switch stack assembly includes a plurality of spring blades mounted between insulating spacer bars or strips and is secured to a rigid support. Switch blades 30, 31 and 32 are of the usual leaf spring construction. For mechanical reasons, switch blade 28 may be somewhat more rigid to insure a desired pressure between contacts 29 mounted on the switch blades. Switch blade 33 is preferably more rigid than the other switch blades to insure the required force to deflect the switch blades into closed position as illustrated. The switch stack is constructed

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with dielectric spacer bars of sufficient thickness so that in the normal position of the switch blades the contacts 29 of adjacent blades are in open position. Each switch blade is connected electrically to one tap of the resistor 26.

A thermally responsive element, such as a bellows 34 containing a suitable fluid having a high thermal coefficient of expansion, is secured to a rigid support, for example, to the primary coil casing. A link or bar 35 is rigidly secured at one end to bellows 34 and at the other end to switch blade 33. The thermally responsive element and the switch stack are so arranged that at and above normal operating temperatures the free ends of the switch blades are deflected into a closed position of the contacts whereby the short circuit around resistor 26 is closed. As the ambient temperature decreases, bellows 34 contracts and first opens the short circuit between switch blades 28 and 30 whereby all current flowing in the circuit must pass through the corresponding portion of the resistor 26. Further decreases in ambient temperature cause an opening of the short circuit between succeeding pairs of switch blades.

In the control unit 20 illustrated in Fig. 3, a continuously variable compensation is provided for the variations of primary circuit resistance caused by changes of temperature. This unit is placed in the primary circuit between conductors 10 and 11. The unit consists of a resistor 36 provided with a suitable contactor or slider 37, the position of which determines the portion of the resistor 36 which is included in the primary circuit. Thermally responsive element 38 such as a bi-metallic element, is fixed to a suitable support 39 at one end. The free end of the bi-metallic element is connected with the slider 37 through a link 40 so that movement of the free end of the bi-metallic element due to temperature changes will be transmitted to the slider. The bi-metallic element and slider are connected mechanically in such a manner that substantially no part of the resistor is included in the circuit at and above a predetermined or normal temperature of operation. As the ambient temperature decreases, the movement of the free end of the bi-metallic element is adapted to include in the primary circuit various portions of the resistor. The resistor and bi-metallic element are so designed that the resistance introduced into or removed from the circuit upon changes of temperature is substantially the same as the decrease or increase of resistance of the balance of the circuit due to the temperature changes.

In each of the foregoing types of compensating means, certain moving parts are included. In many instances, it may be desirable to avoid the use of units which embody moving parts and avoid difficulties and disadvantages which necessarily accompany such elements.

The compensating unit 20 illustrated in Fig. 4, consists of a resistor 41 which is characterized by a negative temperature coefficient of resistance. The resistance of such resistors increases with a decrease in temperature and decreases with an increase in temperature. This unit may be selected so that its resistance at normal temperatures and its negative temperature coefficient of resistance compensate exactly for the positive temperature coefficient of resistance of the balance of the elements in the primary circuit.

There are numerous types of such resistors available at the present time. Certain of these types comprise a sintered mass of metallic oxides.

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The particular element selected will be based upon the characteristics of the primary circuit of the ignition system in which it is to be incorporated. A further type of resistance having the desired characteristics may comprise a filament mounted within a sealed tube or chamber with a certain definite type of atmosphere, the diameter of the tube being relatively large as compared to the filament or heater element. It is known that a hot filament loses heat more rapidly by conduction as the pressure of the atmosphere within the tube or chamber increases. The pressure of the gas, as is well-known, within a chamber or tube is directly proportional to the ambient temperature. If the sealed tube contains a vapor of a liquid and a small quantity of the liquid, the pressure of the atmosphere within the tube will vary directly with the ambient temperature. For the purposes of the present invention water and water vapor furnish a satisfactory atmosphere for such a unit. In this type of resistance unit, a filament is provided which will glow during operation of the ignition circuit and the filament and atmosphere may be so selected and proportioned that a negative temperature coefficient of resistance is obtained which will closely compensate for the positive coefficient of resistance of the balance of the primary circuit of the ignition system.

This type of control or compensating unit has the advantages that it is fixed, it requires no adjustment and it does not include moving parts. The specific compensating resistor employed in an ignition circuit must be selected to match the characteristics of the ignition system. For example, in an ignition system having a primary circuit resistance of about 1.12 ohms at normal temperature, 23° C., a compensating resistor having a resistance of about 0.40 ohm at the same temperature and a negative temperature coefficient of resistance of about 0.015 per centigrade degree has been found to be entirely satisfactory in compensating for variations of the primary circuit resistance attributable to temperature changes. This primary circuit, without the compensating resistor, when operated over an extreme temperature range of from 23° C. to about -54° C., decreased in resistance to about 0.80 ohm, equivalent to a resistance variation of about 28%. The inclusion in the primary circuit of the compensating resistor resulted in a decrease of resistance over the same temperature range from about 1.52 ohms at 23° C., to about 1.36 ohms at -54° C., equivalent to a resistance variation of about 11%. This degree of compensation is sufficient to prevent the passage of current in excess of the peak current for tungsten ignition contacts.

The control unit illustrated in Fig 5 is dependent for its operation upon the amount of current flowing in the primary circuit. The unit comprises a resistor 42 adapted to be short circuited through a spring lever 43 and contacts 44. The spring lever 43 is constantly urged by spring 45 into a position in which contacts 44 are closed. The current sensitive relay coil 46 is connected in series with resistor 42 and the short circulating means between conductors 10 and 11. Under normal operating conditions resistor 42 is short circuited by means of a lever 43 and contact points 44 and the current in the primary circuit flows through the resistor and short circuiting means and through coil 46. The characteristics of coil are such that current flowing through coil 46 will not effect an opening of contacts 44 until the current exceeds a predetermined value, which

value is preferably slightly below the peak current permissible for the breaker contacts. When the primary circuit resistance decreases sufficiently to cause an excessive current flow in the primary circuit, contacts 44 are opened and all current flowing in the primary circuit passes through resistor 42.

In the device illustrated in Fig. 6, the control means is operated by a voltage sensitive relay. A resistor 47 and a short circuiting means consisting of a spring lever 48 and contacts 49 similar to those described in Fig. 5 is employed to include in and remove from the primary circuit the compensating resistor. A second relatively fixed resistor 50 is inserted in series with the resistor 47 and short circuiting means in the primary circuit between conductors 10 and 11. The coil 51 of the voltage sensitive relay is connected electrically across the fixed resistor 50. As the resistance of resistor 50 remains approximately constant, the voltage across the resistor and across coil 51 will vary with changes in the current flowing through the primary circuit of the ignition system. An increase in the current flowing through the primary circuit caused by a decrease of the primary circuit resistance or an increase in voltage applied to the primary circuit increases the voltage drop across resistor 50 sufficiently to actuate spring lever 48 and all current flowing in the primary circuit passes through resistor 47. The particular characteristics of resistor 47, resistor 50 and coil 51 will be dependent entirely upon the characteristics of the circuit in which the control unit is to be employed.

In the control units illustrated in Figs. 2, 5 and 6, an inductance unit similar to that illustrated in Fig. 1 may be employed to aid in maintaining the contact points 34 and 39 in a clean condition.

It is apparent that the specific examples set forth herein are merely illustrative of the application of my invention and it is to be understood that these illustrations are not intended as limitations of the invention. The methods of computing the values of specific elements of the control units illustrated will be obvious to those skilled in the art. Although I have illustrated my invention as applied to automotive ignition systems, it is obvious that it is equally effective and applicable to ignition systems for use in aircraft, stationary engines, and all engines employing an ignition system.

I claim:

1. An ignition system for internal combustion engines including an ignition coil having a low voltage primary winding and a high voltage secondary winding comprising a primary circuit including the primary winding of the ignition coil, a source of low voltage connected electrically to the primary winding through a pair of tungsten contacts arranged to periodically open and close the primary circuit, the primary circuit including components having a positive temperature coefficient of resistance whereby the current flow through the tungsten contacts varies inversely with ambient temperature changes, a secondary circuit including the high voltage winding of the ignition coil and thermally responsive-variable resistance means in the primary circuit for varying the effective resistance of the variable resistance means inversely with ambient temperature changes thereby maintaining the total resistance of the primary circuit and the current flow through the tungsten contacts substantially constant with ambient temperature changes and eliminating film formation on the faces of the tungsten contacts.

2. An ignition system for internal combustion engines including an ignition coil having a low voltage primary winding and a high voltage secondary winding comprising a primary circuit including the primary winding of the ignition coil, a source of low voltage connected electrically to the primary winding through a pair of tungsten contacts arranged to periodically open and close the primary circuit, the primary circuit including components having a positive temperature coefficient of resistance whereby the current flow through the tungsten contacts varies inversely with ambient temperature changes, a secondary circuit including the high voltage winding of the ignition coil and thermally responsive-variable resistance means in the primary circuit consisting of a resistor characterized by having a negative temperature coefficient of resistance thereby maintaining the total resistance of the primary circuit and the current flow through the tungsten contacts substantially constant with ambient temperature changes and eliminating film formation on the faces of the tungsten contacts.

3. An ignition system for internal combustion engines including an ignition coil having a low voltage primary winding and a high voltage secondary winding comprising a primary circuit including the primary winding of the ignition coil, a source of low voltage connected electrically to the primary winding through a pair of tungsten contacts arranged to periodically open and close the primary circuit, the primary circuit including components having a positive temperature coefficient of resistance whereby the current flow through the tungsten contacts varies inversely with ambient temperature changes, a secondary circuit including the high voltage winding of the ignition coil and thermally responsive-variable resistance means in the primary circuit consisting of a resistor characterized by having a resistance and a negative temperature coefficient of resistance of such magnitudes so as to maintain the total resistance of the primary circuit and the current flow through the tungsten contacts substantially constant with ambient temperature changes and eliminate film formation on the faces of the tungsten contacts.

4. An ignition system as claimed in claim 1 wherein the thermally responsive-variable resistance means comprises a resistor in the primary circuit and thermally responsive means arranged to short-circuit the resistor at a predetermined normal ambient temperature and to open the short-circuit around the resistor at a predetermined decrease from the normal ambient temperature.

5. An ignition system as claimed in claim 1 wherein the thermally responsive-variable resistance means comprises a resistor in the primary circuit and a bi-metallic thermostatic element arranged to short-circuit the resistor at a predetermined normal ambient temperature and to open the short-circuit around the resistor at a predetermined decrease from the normal ambient temperature.

6. An ignition system as claimed in claim 1 wherein the thermally responsive-variable resistance means comprises a tapped resistor in the primary circuit, a switch stack connected electrically to the tapped resistor, and a thermally responsive element; the switch stack and the thermally responsive element being arranged to short-circuit the resistor at a predetermined normal ambient temperature and to open in succeeding order the short-circuit around the tapped

portions of the tapped resistor at predetermined decrease from the normal ambient temperature.

7. An ignition system as claimed in claim 1 wherein the thermally responsive-variable resistance means comprises a continuously variable resistor in the primary circuit and a thermally responsive element arranged to vary the resistance of the variable resistor included in the primary circuit inversely with ambient temperature changes.

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