April 18, 1944. L. BEEH 2,347,072

MAGNETIC SPARK PLUG

Filed April 9, 1942

Fig. 1.

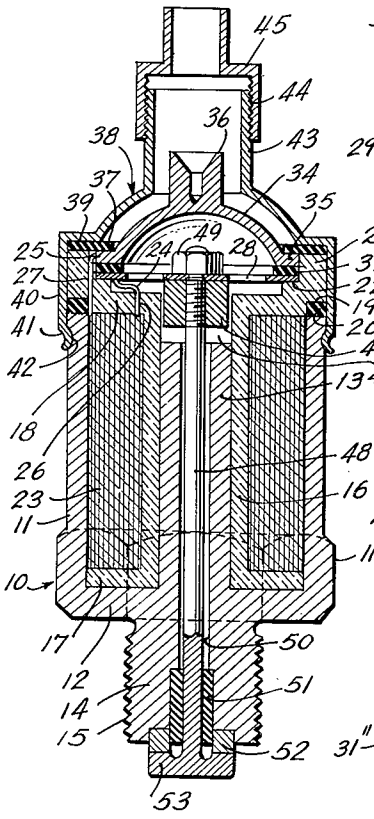


Fig. 2.

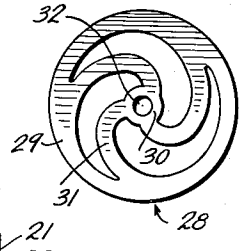


Fig. 2a.

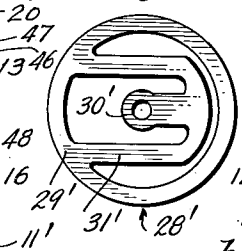


Fig. 2b.

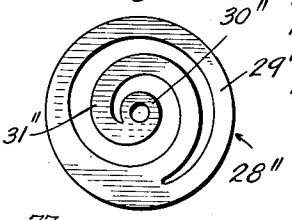


Fig. 3.

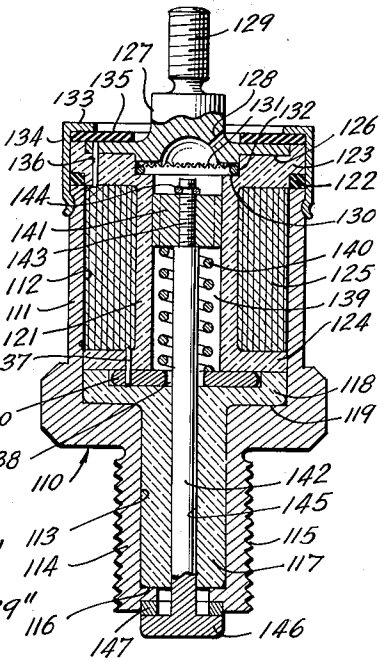
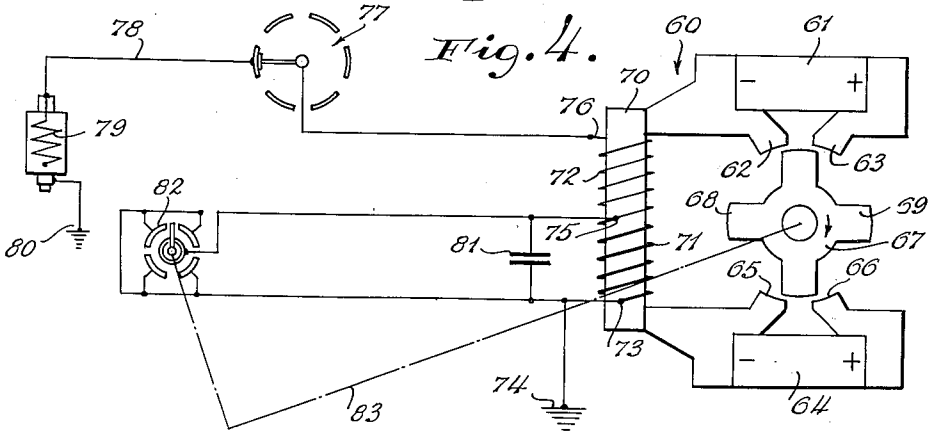


Fig. 4.



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MAGNETIC SPARK PLUG

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8 Claims. (Cl. 123—147)

The present invention relates to spark plugs and more particularly to spark plugs for low tension ignition systems. The conventional high tension ignition systems operating with voltages as high as 25,000 volts had been developed as an improvement over the low tension systems used in the earlier years of internal combustion engines but abandoned because of the very high cost of the low voltage spark plugs used at that time, and which, furthermore, were not suited for engines operating with high compression. The high tension systems of present days, however, though satisfactorily operating at altitudes below about 25,000 feet frequently fail or break down at higher altitudes primarily due to the fact that the surface resistance of the conventional insulating materials vastly deteriorates with the decrease of the atmospheric pressure. The only remedy so far known against such failure of the insulation consists in an enlargement of the dimension whereby, however, other drawbacks, chiefly an increase in weight and cost, are involved.

The present invention contemplates to overcome the mentioned drawbacks by providing a spark plug which is reliable and efficient in a low tension ignition system in order to make such system useful for modern internal combustion engines and particularly for those of aircraft reaching high altitudes. By employing a low tension system operating at a voltage of, e. g., only 100 volts, all or at least most of the difficulties can be avoided which are encountered in the conventional high tension systems.

However, although I mentioned hereinbefore a voltage of 100 volts, it is to be understood that I do not want to limit myself to any definite value, and that the invention is equally well applicable no matter whether the voltage employed is above or below 100 volts, it being sufficient that the voltage is considerably lower than that mentioned with respect to high tension systems.

Another object of the invention is to provide a low tension spark plug having satisfactory insulating properties up to any altitude which may be practically reached or is intended to be reached by aircraft.

Another object of the invention is to provide a spark plug in which the spark gap is controlled by electromagnetic means.

Still another object is the provision of a low tension spark plug which may be readily radio shielded, and whose interior may be completely closed against explosive gases so as to protect the spark plug from being overheated.

The invention consists of a spark plug mainly comprising means to create a magnetic field, a member movable in response to the magnetic force of said field in one direction when said means is energized, and other means to restore said member to an original position when said first-mentioned means is de-energized, whereby a spark gap can be temporarily created between said movable member and a stationary spark plug body part which is exposed to the explosion gases when the spark plug is in use.

The invention further consists of a spark plug having a variable spark gap wherein one of the members between which the spark is created is movable in an axial direction and so formed similar to a valve as to prevent explosion gases from entering the interior of the spark plug body when the gap is closed.

Further objects and details of the invention will be apparent from the description given hereinafter and the accompanying drawing illustrating an embodiment thereof by way of example. In the drawing:

Fig. 1 is a longitudinal cross-section of a spark plug according to the invention.

Fig. 2 is a top plan view of a leaf spring constituting a part of the spark plug of Fig. 1.

Figs. 2*a* and 2*b* are similar views of modifications of the spring shown in Fig. 2.

Fig. 3 is a longitudinal cross-section of a modified spark plug, and

Fig. 4 is a digrammatical illustration of a low tension ignition circuit comprising a spark plug according to the invention and the means for energizing the same.

Referring now to the drawing, the spark plug of Fig. 1 comprises a body 10 of magnetizable metal substantially shaped as a hollow cylinder 11 with a bottom 12, an interior axial projection 13 and an exterior lower portion 14. Portion 14 is preferably so dimensioned and threaded at 15 that it can be screwed into the conventional or standard tapped spark plug hole of a cylinder of an internal combustion engine not shown by applying a wrench to the hexagonal portion 11' of the cylinder 11. An insulating spool 16, e. g., of ceramic material, is inserted into the cylinder 11 so as to surround the tubular projection 13 and to bear with a lower flange 17 on the cylinder bottom 12. Spool 16 is provided with an upper flange 18 forming the top cover of the cylinder 11 and being recessed at 19 to receive in said recess a gasket 20 which is interpositioned between the flange 18 and the top rim of the cylinder 11. For a purpose to be hereinafter explained, the flange 18 has an upwardly projecting rim 21 with an interior

shoulder 22. An insulated coil 23 of relatively thick wire and a relatively small number of turns as compared to coils used in high tension systems is arranged on spool 16 in the chamber formed by the inner wall of the cylinder 11, and the spool 16 with its flanges 17 and 18. The ends 24 and 25 of the coil 23 are passed through holes 26 and 27 respectively in flange 18. The end 24 is connected to a leaf spring 28 which rests on the afore-mentioned rim shoulder 22. The spring as shown in Fig. 2 is preferably shaped with a peripheral ring portion 29 and a central portion 30 connected with each other by arm- or spoke-like portions 31 and provided with a hole 32. Springs of other shape, such as, e. g., illustrated in Figs. 2*a* and 2*b*, may be used instead of spring 28. The springs 28' and 28'' differ mainly in the manner in which the arms 31' and 31'' are arranged in relation to the respective rims 29' and 29'' and centers 30' and 30''.

On top of the peripheral portion of spring 28 a ring 33 is placed which is of insulating material as, for instance, of mica. A dome-shaped terminal member 34 bears with its flange 35 on the ring 33, and the arrangement is such that the upper face of flange 35 and the upper edge of rim 21 are substantially flush when the parts are assembled as shown in Fig. 1. The end 25 of coil 23 is connected to terminal member 34 which has a top projection 36 suitably shaped for the attachment of an ignition cable not shown. Another insulating ring or gasket 37 of greater width than 33 is placed on the top of rim 21 and flange 35, and a metal cap 38 bears with an interior shoulder 39 on ring 37 so as to hold the parts in assembled position. The cap 38 also serving as a radio shield has a lower cylindrical extension 40 which fits over the rim 21 and the top portion of the body cylinder 11 and is secured by its indented rim 41 engaging in a peripheral groove 42 of the cylinder 11. The top portion 43 of cap 38 is tubular and provided with a threading 44 for the attachment of a fixture 45 or the like for the afore-mentioned ignition cable.

It will be noticed that the tubular projection 13 does not extend upwardly all the way through the length of the spool 16, and that there is a free space 46 interiorly of said spool above the projection 13. In this space, a soft iron core 47 engages which is attached to the spring 28 by means of a pin 48 and nut 49 and which can move in axial direction as far as spring 28 allows. Pin 48 extends downwardly through the entire length of the spark plug body 10 in a central bore 50 of the latter, and has a diameter so much smaller than that of said bore 50 that no sparks can occur in the interior of the bore. The pin 48 is axially guided by a rather closely fitting bushing 51 of insulating material inserted in the lower projection 14 of body 10. A contact ring 52 of suitable material is inserted in the lower face of projection 14, and the lower end of pin 48 is provided with a head or flange 53 which bears on ring 52 when core 47 and pin 48 are in their topmost position under the action of spring 28 as shown in Fig. 1. Now it will be clear that the close fit between pin 48 and bushing 51 prevents explosion gases from entering the interior of the spark plug and that the parts 53 and 52 between which the ignition spark will occur in operation act like a valve or an additional means for withholding such gases from the interior of the spark plug when part 53 is urged against ring 52.

If the spark plug body is grounded by screwing it, e. g., in the spark plug hole of a cylinder of an internal combustion engine, and if, then, current is supplied from a source by a cable attached to the portion 36 of part 34, the current will flow through coil 23 from its end 25 to its end 24, through spring 28, core 47, pin 48, flange 53, ring 52, body projection 14 to ground. Thereby a magnetic field is set up with the effect that core 47 with pin 48 will be pulled downward against the restraint of spring 28. A gap will be created between flange 53 and ring 52 so that sparks will pass from the one to the other to ignite a surrounding explosive gas mixture. When the current is interrupted the magnetic flux will stop and the core 47 with pin 48 will be returned by spring 28 to their original position in which the parts 52 and 53 contact each other, so that a subsequent current impulse can rebuild the magnetic field and cause the occurrence of ignition sparks as hereinbefore described. It will be noticed that the spark plug according to the invention has certain self-adjusting qualities. On the one hand, the force of the magnetic field is a function of the current flowing through coil 23 from end 24 to 25. The greater the current flow, the deeper will core 47 be pulled into the spool and the larger will be the gap between the parts 52 and 53. The closer the core 47 is to the tubular projection 13, the greater will be the magnetic force—but at the same time, the greater will be the deflection of the spring 28, and the stronger will be its force resisting the downward movement of the core, and the larger the gap between ring 52 and 53, the larger will be the drop in current flow between these two parts with the effect that less of the total current is available to energize the magnetic field. Hence, the spark plug is operative within reasonably wide limits of variation of the voltage for which it is destined. Furthermore, it will be noticed that the magnetic force will be a maximum when the contact 53 is in its topmost position. At the same time the force of the spring is a minimum as the latter is not or only very little deflected. Hence, the difference of the two forces will also be a maximum. This maximum is helpful in overcoming the load on the contact 53 owing to the compression prevailing at the time of ignition in the motor cylinder to which the spark plug is applied. As soon as the gap is slightly opened the major portion of such compression load will disappear.

In the modification illustrated in Fig. 3, a coil spring is used instead of the leaf spring 28, and parts are differently shaped and arranged from the preferred embodiment shown in Fig. 1. In Fig. 3, the spark plug body 110 of magnetizable material comprises a hollow cylindrical portion 111 with a lower projection 114 provided with the external threading 115 whereby the plug can be secured to a cylinder of an engine. The projection 114 is hollow so that its interior space 113 constitutes a restricted continuation of the cylinder chamber 112. An interior ring-shaped shoulder 116 is provided in the lowest portion of projection 114. The space 113 is occupied by a tubular guide member 117 of insulating material, such as a ceramic, which bears on the shoulder 116 and has an upper flange 118 resting on the ring-shaped bottom surface 119 of cylinder 111. Member 117 has a circular recess in its upper face to receive therein a washer 120 of conductive material. On top of flange 118 and washer 120 rests a spool 121 similar as to purpose and shape to the spool 16 of Fig. 1; and a gasket ring 122 is provided between the upper flange 123 of the spool and the upper rim of the cylinder 111.

The spool 121 carries between its upper flange 123 and its lower flange 124 a wire coil 125 as described with respect to the coil 23 of Fig. 1. The upper flange 123 is recessed in its top surface at 126 so as to receive in said recess a terminal member 127 having a vent hole 128 and an upper extension 129 which constitutes a terminal for the attachment of a cable not shown. Between the member 127 and a shoulder 130 of spool 121, a screen 131 and a gasket ring 132 are inserted. An insulating ring 135 preferably of mica is placed on top of the flange 123 and part of the member 127 and held in position by the internally projecting flange 133 of a tubular metal member 134 which incloses the upper portion of cylinder 111 and is secured thereto in a manner similar to that applied in the connection of member 40 to cylinder 11 in Fig. 1. The two ends 136 and 137 of the spool 125 are passed through holes in the flanges 123 and 124 and connected to member 127 and washer 120 respectively. The central hole 138 of this washer 120 is smaller than the cross-section of the interior space 139 of spool 121 so that it constitutes an inwardly projecting rim which supports a coil spring 140 arranged in the space 139. The upper end of the spring bears against a soft iron core 141 axially movable within the upper portion of the space 139. A pin 142 is screwed into the core at 143 and secured in position by a split ring or the like 144. The pin extends through the spring 140 and an axial bore 145 of the member 117 in which it is axially movable with a close fit similar to pin 48 in bushing 51 of Fig. 1. The pin is provided at its lower end with a flange or head 146 bearing, under the action of spring 140, against a contact ring 147 inserted into the lower face of the body portion 114, similar to the arrangement of the parts 52 and 53 in Fig. 1.

Now, it will be clear that the modified spark plug operates in practically the same manner as that of Fig. 1. If the portion 114 is grounded, and a cable attached to the top projection 129 of member 127, current can pass from said member through coil end 136 into the coil 125 proper, from there through the end 137, washer 120, spring 140, core 141, pin 142, pin head 146, contact ring 147, and body portion 114 to ground. The current in coil 125 sets up a magnetic field which pulls the core 141 downward against the restraint of spring 140 thereby opening a spark gap between the pin head 146 and contact ring 147. When the current is interrupt spring 140 restores the core and pin to their original position.

A low tension ignition circuit suitable to supply adequate low tension current to spark plugs of the type described will be explained with reference to the diagram of Fig. 4. In this figure, a magneto 60 comprises a first permanent magnet 61 with pole shoes 62 and 63 and a second permanent magnet 64 with pole shoes 65 and 66. A cross shaped rotor 67 of soft iron can rotate between the four pole shoes, and the latter are so arranged that when an arm of the rotor cross is in front of one of the shoes of one magnet the diametrically opposite arm is also in front of that shoe of the other magnet which has the opposite polarity; e. g., if upon rotation of the rotor the arm 68 is in front of the shoe 62 which has negative polarity, the arm 69 will be in front of the shoe 65 which is a positive pole. The magneto further comprises a soft iron core 70 bridging one of the poles of the one magnet and the pole of the same polarity of the other magnet. Thus, in Fig. 4 the core 70 bridges the two negative magnet poles 62 and 65. Hence, when the rotor is in a position as hereinbefore mentioned, in which rotor cross arm 68 is in front of pole shoe 62 a magnetic flux will take place from the positive pole of magnet 64 through rotor cross arms 69 and 68, polepiece 62, core 70 and to the negative side of magnet 64. If, however, upon further rotation a pair of opposite rotor arms is in front of the pole shoes 63 and 65 the magnetic flux through the core 70 goes in the other direction, reversal taking place whenever the rotor cross is in the position of Fig. 4 in relation to the pole shoes 62, 63, 65 and 66. Core 70 is provided with a primary winding 71 of relatively thick wire and small number of turns and a secondary winding 72 of thinner wire and a greater number of turns. The one end 73 of the primary winding is grounded at 74 and its other end is connected at 75 with one end of the secondary winding 72. The free end 76 of the latter is connected via a distributor 77 by a wire 78 to the coil 79 of a spark plug according to the invention, coil 79 corresponding to coil 23 in Fig. 1 or 125 in Fig. 3, and being grounded at 80 through the spark plug body as hereinbefore described. The distributor 77 is of a type conventional in the ignition system of a multi-cylinder engine. A condenser 81 and a breaker 82 are connected in parallel to the primary winding 71 and, hence, also in parallel to the circuit comprising the secondary winding 76, the distributor 77 and the spark plug coil 79. The breaker 82 is so connected to the rotor 67 by mechanical means indicated by the dot and dash line 83 that the current through the primary winding 71 will be shortly broken each time and at exactly the moment when the magnetic flux is reversed.

The system operates as follows: When the soft iron rotor 67 is rotated in the magnetic field, the magnetic flux flowing through the soft iron core 70 will induce a current in the windings 71 and 72. At the moment of the flux reversal as hereinbefore described, the current flowing in the primary winding 71 is interrupted by the contact breaker 82. This reversal and break raises the induction in the secondary winding 72 to its maximum. Since the end 76 of the secondary winding is connected to the spark plug, in fact to the member 34 in Fig. 1 or to member 127 in Fig. 3, the secondary current flows through the spark plug coil 79 (i. e., 23 in Fig. 1 or 125 in Fig. 3) where it induces the magnetic field formed by the spark plug body and attracts the iron core 47 of Fig. 1 or 141 of Fig. 3, thereby causing a break between the head of the contact pin and the contact material mounted on the spark plug body. This break creates an arc or spark which is of an oscillatory nature and high in heat value due to the fact that the condenser 81 of the system is connected parallel to the secondary winding 72 and coil 79 in series as well as to the primary winding 71.

The system has the following advantages over the conventional high tension system. The low voltage current is easily insulated on the magneto and distributor for high altitude flying. It permits proper insulation of the spark plug which at present is limited to about 30,000 feet altitude. The low voltage system is more easily manufactured because of the elimination of high voltage difficulties in production. All its elements including the spark plugs are more easily radio shielded than those of a high voltage system. The interior of the spark plug according to the

invention is completely closed against explosion gases, thereby eliminating overheating. The elements of the low voltage system are lower in production cost and labor, and the magneto required in the low voltage system is not in excess of the outside dimensions and weight compared with the high tension magneto, and the distribution and timing of the spark does not involve other than conventional elements. The low voltage system and particularly the spark plug according to the invention is less sensitive in operation than the corresponding elements of the conventional high voltage system.

It will be understood that various changes in the specific form of my novel spark plug may be made without departing from my invention which is not limited by the particular disclosure of the embodiments thereof illustrated and described hereinabove but by the scope of the appended claims.

I claim:

1. A spark plug comprising a body of magnetizable metal including a hollow cylindrical upper portion and an exteriorly threaded lower portion provided with an axial bore in continuation of the interior of said cylindrical portion, a first contact element in connection with the bottom face of said lower portion, an insulated coil in said cylindrical portion, a core member in coaxial arrangement with the coil and movable in one axial direction with respect thereto when the coil is energized, a second movable contact element so arranged and constructed as to cover the bottom entrance of said bore when contacting said first contact element and including an axial pin connecting said second element to said core through said bore, a spring insulatedly secured to said cylindrical portion and conductively connected to the one end of said coil, said spring being in engagement with said core and tending to move it in the opposite direction so as to hold said elements engaged, and means to connect the other end of said coil to an external current source.

2. A spark plug as claimed in claim 1, wherein said first contact element is a ring attached to the bottom face of said lower bottom portion, and said second contact element is constituted by a substantially flange-shaped head of the lower end of said pin.

3. A spark plug comprising a body of magnetizable material including a hollow cylindrical upper portion open at its top, a tubular projection interiorly of said cylinder and extending axially upward from the cylinder bottom, and a lower exteriorly threaded portion with an axial bore in continuation of that of said tubular projection, a spool of insulating material interiorly of said cylinder and encompassing said projection, said spool having a top flange covering said cylinder, a spring attached to said flange, a coil on said spool, a core carried by said spring in an axial space of said spool above said projection, a first contact element attached to the bottom face of said lower portion, a second contact element including a pin passed through said bore and connected to said core, and insulating and sealing means between said pin and the wall of said bore, whereby gases are substantially prevented from entering said body.

4. A spark plug as claimed in claim 3, wherein said spring is substantially wheel-shaped including a fellow-like rim portion supported by said spool flange, a hub-like center portion to which said core is attached, and spoke-like portions connecting said rim to said center portion.

5. A spark plug comprising a body of magnetizable material including an upper portion and a lower portion, said portions constituting communicating cylindrical chambers, each with an interior annular shoulder at its bottom, said lower portion and chamber being narrower than the upper and being exteriorly threaded, a tubular insulating member including a top flange interiorly of said lower chamber and with said flange covering the shoulder of said upper chamber, an insulating spool interiorly of said upper chamber, said spool including a lower and an upper flange and being provided with an axial hollow space, said lower flange being arranged above said flange of said member and said upper flange on top of the rim of said upper portion, a coil on said spool, a helical spring interiorly of said spool and conductively connected to the one end of said coil, a core interiorly of said spool and bearing on said spring, means for connecting an external current source to the other end of said coil, a contact means in connection with the bottom face of said lower portion, and a movable contact in cooperative relation to said contact means and connected to said core so as to respond to the movement of the core owing to magnetic attraction and the restraint of said spring, said movable contact including a portion slidingly fitting in said tubular member so as to substantially prevent gases from entering said body.

6. A spark plug comprising a body including a hollow cylindrical upper portion and a lower portion adapted to be connected to the combustion chamber of an internal combustion engine, a coil interiorly of said body and provided with an axial hollow space, a core projecting into said space from the top so as to be attracted by a magnetic force in axial direction when said coil is energized, a spring in engagement with said core and tending to raise it, a first stationary contact element attached to the bottom face of said lower portion, a second contact element movable with respect to said first element and including a pin-like member in connection with said core and in axial arrangement with respect to said cylindrical portion, and means for guiding said pin substantially gas tight in said lower portion.

7. A spark plug as claimed in claim 6, wherein said first contact element is ring-shaped and said second element is shaped as a bottom flange of said pin so that the two elements, in valve-like manner, prevent gases from entering the interior of the spark plug when the elements contact each other.

8. A magnetic spark plug comprising a hollow body having an axial bore through its lower portion, an electric coil and a movable core interiorly of said body, a stationary contact at the bottom of and coaxial with said bore, a bushing of insulating material in the lower portion of said bore, a movable contact member slidably fitting in said bushing so as to substantially prevent the entrance of gases into said body from below, said member being responsive to the core movement and including a lower enlarged portion fitting on said stationary contact so as to cover the lower end of said bore when said movable contact, in an end position, engages said stationary contact.

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