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ELECTRICAL APPARATUS

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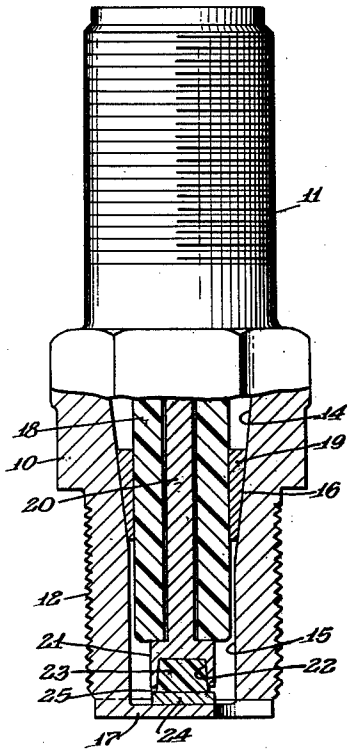


FIG. 1.

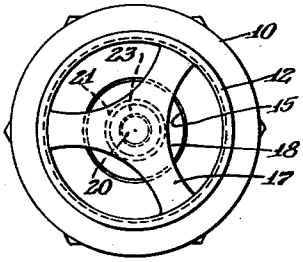


FIG. 2.

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ELECTRICAL APPARATUS

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This invention relates to electrical apparatus and more particularly to devices adapted for use in creating electrical spark discharges between spaced electrodes in an electrical circuit.

One of the objects of the present invention is to provide a novelly constructed spark or igniter plug or sparking device having spaced electrodes and adapted for use in electrical circuits, such as ignition circuits, at relatively low voltages for initiating the combustion of gaseous or other combustible charges, such as in the cylinders or other combustion chambers of reciprocating or so-called jet type engines or the like.

A further object of the invention is to provide a novel spark or igniter plug or device of the type wherein the spark or arc discharge between the spaced electrodes is preceded by the flow of a small electrical current along a high resistance or semi-conductive path connecting the electrodes for the purpose of ionizing the air gap between the electrodes.

Still another object is to provide a device of the above character which is constructed in a novel manner to insure accuracy in the initial spacing of the gap electrodes during manufacture.

A further object is to provide a sparking device wherein the electrodes are of novel construction and novelly combined.

A still further object is to provide novel apparatus of the above character which is so constructed that high energy sparks or arcs may be created at relatively low voltage across a comparatively wide gap.

Still another object is to provide a novel sparking device which is so constructed that breakage of the ceramic parts during operation in an engine is minimized.

The above and further objects and novel features of the present invention will more fully appear from the following detail description when the same is read in connection with the accompanying drawings. It is to be expressly understood, however, that the drawings are for the purpose of illustration only and are not intended as a definition of the limits of the invention.

In the drawings, wherein like reference characters refer to like parts throughout the several views,

Fig. 1 is an elevation view, partly in section, showing one form of spark gap device embodying the present invention; and

Fig. 2 is a bottom view of said device.

The single embodiment of the invention illustrated in the accompanying drawings, by way of example, is in the form of a spark gap or sparking device commonly known as an igniter plug or spark plug adapted for use in ignition systems for creating sparks to ignite combustible mixtures, such as in the combustion chambers of reciprocating engines or so-called jet type or direct expansion engines. Although the essential features of the invention may be embodied in many other types of spark gap devices, a radio-shielded type of spark plug or igniter plug now in common use has been chosen for illustration. Devices of the character contemplated by the present

invention are designed primarily for use in condenser discharge circuits or systems, wherein a storage condenser is charged and then permitted to discharge across the gap electrodes, but the same are nevertheless capable of satisfactory use in any electrical circuit wherein the electrical energy is created in the form of voltage pulses having relatively steep wave fronts. The construction is such, however, that the required maximum voltage is relatively low in comparison to the voltage required in most present-day engine ignition systems. By reason of the relatively low voltages required for reliable and satisfactory operation of the sparking devices contemplated by this invention, the difficulties involved in preventing radio interference or failures due to electrical breakdowns in the electrical circuit are reduced to a minimum. When the device is utilized for the creation of high energy sparks, such as result from the discharge of a high capacity condenser, the danger of ignition failures due to fouling at the spark gap is substantially eliminated and the efficient operating life of the device is increased.

The spark or igniter plug illustrated, by way of example, comprises a tubular shell **10** which may be made of steel or other suitable electrically conductive material. The upper end of shell **10** is externally threaded at **11** for the attachment of a well-known type of shielded connection from a source of electrical energy to the center electrode to be hereinafter described. The lower end of shell **10** is also externally threaded at **12** for engagement with a tapped opening in the cylinder or other combustion chamber wall of an engine or the like. Internally, shell **10** has an upper or larger bore **14** and a lower or smaller bore **15**, said bores being connected by a tapered bore portion **16**. Extending across the lower end of shell **10** is an electrode or electrode supporting web or bridge **17**. As shown, said bridge or spider includes a central portion connected to the shell by three spokes or arms (Fig. 2) which may be integral with or otherwise suitably secured to the shell.

Mounted within shell **10** is a novel center electrode assembly comprising a tubular insulator **18** of molded ceramic, aluminum oxide or other suitable insulating material. Said assembly is retained in the shell by an annular wedge-shaped ring **19** of soft copper or the like pressed between insulator **18** and tapered bore portion **16** in a manner well understood in the art. Any other suitable known means may be provided for securing and centering the electrode assembly in the shell.

The novel center electrode comprehended by the invention for conducting electrical current from a source through insulator **18** comprises a spindle **20** having a close fit within the bore of the insulator and an enlarged cylindrical head portion **21** which engages the end of the insulator. Head portion **21** is hollowed out or recessed to provide a cavity **22** which is preferably nearly cylindrical and centrally disposed for receiving a button or disk **23** of high heat resistant material that is electrically non-conductive, such as a ceramic, aluminum oxide, or the like. The outer wall of disk **23** may be slightly tapered or cone-shaped, and the inner wall of cavity **22** may be correspondingly shaped to facilitate pressing the disk, small diameter end first, tightly into the cavity. The portion of disk **23** which projects from the cavity **22** may be accurately machined before installation of the center electrode assembly in shell **10** to thereby accurately determine the extent of the projection and hence, the width of the annular spark gap **25** to be next described. Center electrode **20, 21** may be made of a heat resistant metal, such as a nickel alloy, an example of which is nichrome, or other suitable metals adapted to resist erosion due to high temperatures and electrical sparks.

The novel ground electrode which cooperates with

electrode **21** to form the annular spark gap **25** comprises a disk **24** secured to bridge or spider **17**, such as by soldering, welding or other known means. Electrode disk **24** is preferably made of coined silver consisting of about 90% silver and 10% copper, but other equivalent conductive materials may be used, such as pure silver and other silver alloys which include tungsten, molybdenum and the like. The center electrode assembly described above rests on electrode disk **24**, the latter being in face-to-face engagement with ceramic disk **23**. The diameter of electrode disk **24** is at least as large as the diameter of the projecting end of ceramic disk **23** and preferably as great as the outer diameter of center electrode head **21**, as shown. The spacing of the annular electrodes **21** and **24** to form gap **25** is thus accurately determined by the extent to which ceramic disk **23** projects from cavity **22**, a distance which as pointed out above is accurately determined by machining the ceramic disk before the center electrode assembly is installed in shell **10**. The disk **23** bridges the inner periphery of spark gap **25** and there is ample space in shell **10** around the gap to permit satisfactory scavenging of the gap area after each operation of the device so as to permit a fresh charge of the combustible mixture to occupy said area when the next spark occurs. It will be seen also that pressures to which a ceramic disk **23** is subjected during use, particularly those which result from expansion and contraction of the assembled parts upon being subjected to temperature variations, will be compressive pressures only and hence, not apt to damage the ceramic disk.

The illustrated device is sealed against gas leakage around insulator **18** by the wedging ring **19**. Any suitable known means may be provided for sealing the bore through insulator **18** against the leakage of gases therethrough. By way of example, one suitable means for this latter purpose is shown in Tognola et al. U. S. Patent No. 2,482,884.

The width of spark gap **25** may vary depending upon the circuit in which it is to be used, but for internal combustion engine ignition systems, this distance in a new device may be between .005 inch and .025 inch. This range of gap sizes corresponds to a break-down voltage of from 500 to 1500 volts peak at a bomb pressure of about 200 lbs. per square inch in carbon dioxide. In one condenser discharge ignition system wherein the storage condenser connected across the electrode was charged to a voltage of about 2500 volts, an initial gap distance of about .015 inch or less was found suitable. This gap distance is exaggerated in the drawing in the interest of clarity.

When the illustrated spark plug has been assembled as above described and shown in the drawing, and before it is installed in an engine for operation, the same is presparked at atmospheric or other suitable pressure for about five minutes. A suitable voltage for this purpose when the gap is of the order last above mentioned is about 1500 volts. The sparks thus created will sputter small quantities of silver from electrode disk **24** onto the surface of the insulator **23** which bridges the inner periphery of the spark gap. The spark will move around the annular gap during the pre-sparking operation, jumping from one place to another as the silver is eroded from the electrode disk to increase the gap distance wherever the spark occurs. When the conditioned device is now put into an engine cylinder or combustion chamber for firing under pressure conditions present in the cylinder and at a voltage which would not normally jump the gap at the pressure present, a small current flows through the sputtered silver on the surface of insulator disk **23**. This current, though small, is believed to ionize the gases between the electrodes **21** and **24** and thereby permit a rapid discharge of the condenser through the ionized gas to create an arc or spark discharge between the electrodes. A high-energy arc may thus be obtained from a relatively low-voltage, high-capacity condenser. In modern-day reciprocating engines, a pre-sparked device of the above character having the gap dimensions above referred to will break down at a voltage of about 1000 to 1500 volts in the engine cylinder under normal pressures present therein.

During the operation of the spark plug in the cylinder of an engine for initiating the combustion of a gaseous charge, the surface of insulator disk **23**, which bridges the inner periphery of the spark gap between the electrodes, will become coated with carbon or similar conductive particles which will carry the ionizing current that was originally carried by the sputtered silver. Thus, the carbon deposits which have heretofore created a fouling condition which was detrimental in devices of this character are utilized as an asset in the present device to initiate a spark discharge at a lower voltage than has been heretofore normally used for creating a spark at a gap of the same dimensions. Excessive carbon deposits are burned or blasted off the electrode and insulator surfaces by the high energy sparks which occur upon discharge of the condenser across the electrodes. By designing the electrode gap to break down initially at about 1000 to 1500 volts in the engine cylinder for use in a circuit in which a voltage of about 2500 volts is available, the gap may be very considerably enlarged by erosion of the silver electrode disk **24** or otherwise before the device will cease to operate satisfactorily and efficiently.

There is thus provided a novel sparking device which is particularly adapted for use in circuits embodying means for producing voltage pulses having steep wave fronts, such as produced by a discharging condenser. The device comprehended is especially useful where high energy sparks or arcs are required and where low voltages are desirable, such as at high altitudes, and where radio interference is a hazard. The novel construction provided is also structurally and electrically durable and operates efficiently under severe adverse conditions for long periods of time. The spark gap construction embodied in the device is self-cleaning to a desirable degree by reason of the high energy sparks created and hence, will not become fouled to the point of failure. The simplified structure of the device makes the manufacturing costs relatively low and makes increased production possible without increasing production facilities.

Although only a limited number of embodiments or modifications of the invention have been illustrated in the drawings and mentioned and described in the foregoing specification, it is to be expressly understood that the invention is not limited thereto. For example, the disk **23** may be so constructed and compounded that at least the gap bridging surface thereof may be a high resistance which is capable of carrying sufficient current to ionize the gap **25**. If desired, either one or both of the electrodes **21** and **24** may have the outer periphery thereof flush with the periphery of the extending portion of disk **23**. The electrode disk **24** may be eliminated and the disk **23** caused to directly engage the bridge **17** which would then alone constitute the ground electrode. It would be feasible also to make the ground or shell-connected electrode of an erosion-resistant metal and the active edge of electrode **21** of a silver alloy or other equivalent metal. In some cases it may be desirable to pre-spark or condition the spark gap under pressure or in a vacuum rather than at atmospheric pressure. It will be understood also that the spark gap structure per se may be embodied in other types of devices for other uses. Various other changes, including changes in the materials suggested, and in the relative sizes, electrical values, design and arrangement of the parts illustrated may be made without departing from the spirit and scope of the invention, as will now be understood by those skilled in the art.

What is claimed is:

1. A sparking device comprising a tubular metallic shell, a tubular insulator supported in said shell, a center

electrode supported in said insulator and projecting from one end thereof, said electrode having a centrally disposed recess in the projecting end thereof, a second electrode supported by an extending transversely of said shell adjacent an end thereof, said electrodes cooperating to form an annular spark gap, and a rigid block fitted into said recess and extending beyond said projecting end into end surface engagement with said second electrode, whereby said block bridges said gap, the engaging faces of said second electrode and said block being plane flat surfaces, and the width of said gap being equal to the distance said block projects from said recess.

2. A sparking device as defined in claim 1 wherein said block is made of insulating material.

3. A sparking device as defined in claim 2 wherein at least one of said electrodes is made of a metal which will sputter onto the gap bridging portion of said block when electrical sparks are impressed across said gap.

4. A sparking device as defined in claim 1 wherein said second electrode includes a disk in contact with said block and supported on a web across the bore of said shell.

5. A sparking device as defined in claim 4 wherein said disk is made of a metal which will react to electrical sparks impressed across the spark gap in substantially the same manner that silver reacts.

6. A sparking device as defined in claim 1 wherein said block is highly resistant but slightly conductive to the flow of electrical current in the vicinity of said gap.

7. A sparking device comprising an electrode having a centrally disposed recess in one end thereof, a rigid block fitted in and projecting from said recess a distance of less than about .025 inch, and a second electrode engaging face to face the flat end surface of the projecting portion of said block, whereby said electrodes form a spark gap around said projecting end of the block, the width of said gap being equal to the distance said block projects from said recess.

8. A sparking device as defined in claim 7 wherein said block is an insulator and at least one of said electrodes is made of a metal which will be sputtered onto the gap bridging portion of said block in response to arcing across said gap.

9. A sparking device as defined in claim 7 wherein said block is semi-conductive in the vicinity of said spark gap.

10. A sparking device comprising a tubular metallic shell having a web across the bore thereof, a tubular insulator supported in said shell, a center electrode supported in said insulator and projecting from one end thereof, said electrode having a centrally disposed recess in the projecting end thereof, a second electrode comprising a disk supported on said web and extending transversely of said shell, said electrodes cooperating to form an annular spark gap, and a rigid block fitted into said recess and extending beyond said projecting end into end surface engagement with said disk, whereby said block bridges said gap, the engaging faces of said disk and said block being plane flat surfaces.

11. A sparking device as defined in claim 10, wherein said disk is made of a metal which will react to electrical sparks impressed across the spark gap in substantially the same manner that silver reacts.

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