April 19, 1960 J. J. LOGAN 2,933,631

IGNITION APPARATUS

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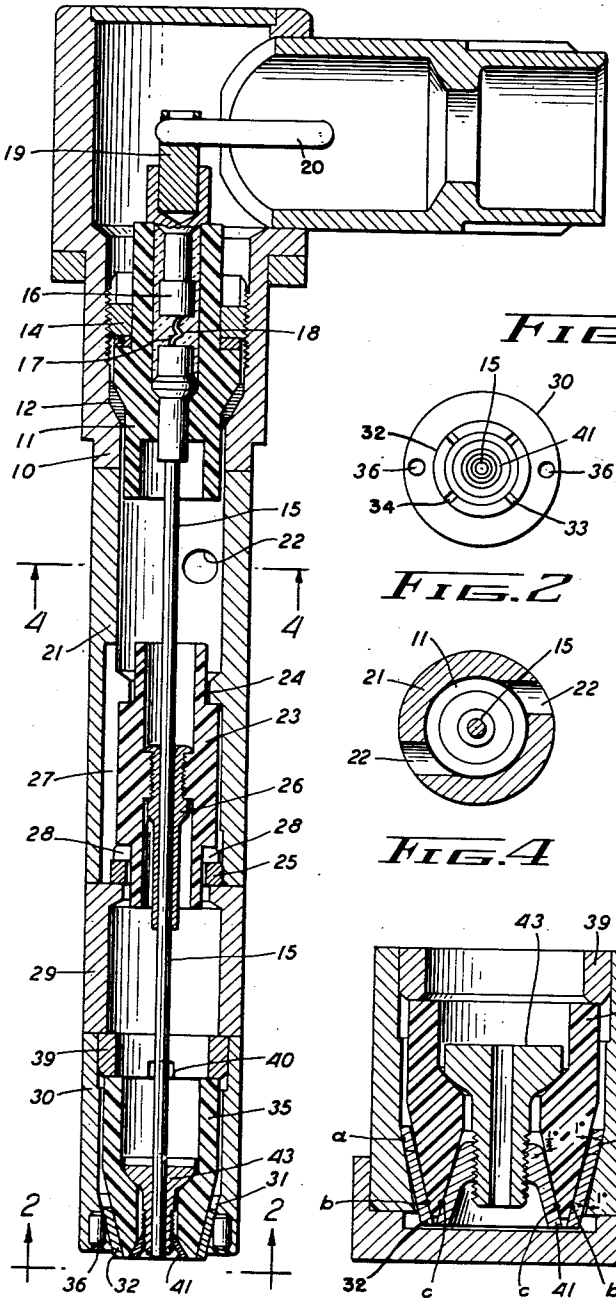


FIG. 1

FIG. 2

FIG. 4

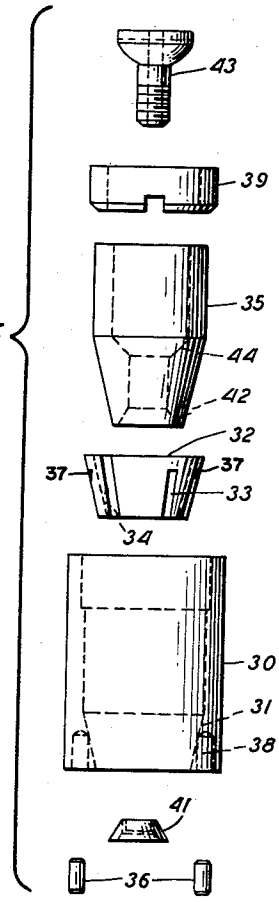


FIG. 3

FIG. 5

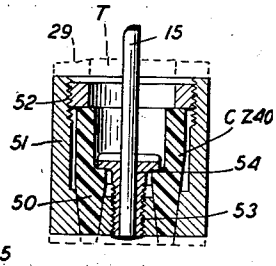


FIG. 6

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IGNITION APPARATUS

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This invention relates to electrical apparatus and more particularly to devices adapted for use in creating sparks, such as in ignition systems for combustion engines and the like.

One of the objects of the present invention is to provide a novelly constructed device of the above character embodying an annular spark gap.

Another object of the invention is to provide a novel spark gap construction which may be readily assembled into a rigid unit without damaging the relatively fragile insulation required.

Still another object of the invention is to provide a novel igniter plug of the long-reach type which is especially adapted for use in the ignition system of so-called jet or gas turbine type engines.

A further object is to provide a novel spark plug or igniter of the so-called shunted-surface gap type adapted to spark at relatively low voltages.

Another object is to provide a sparking device which is novelly constructed to permit the circulation of air therethrough to cool the same.

A still further object is to provide a novel spark gap device which is so constructed and assembled as to permit the use of relatively fragile insulating material.

Another object is to provide a novel spark or igniter plug which has a relatively long and efficient operating life under the most severe operating conditions.

The above and further objects and novel features of the 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 purposes 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 a sectional side elevation view of one form of igniter or sparking plug embodying the present invention, the section being taken in a plane containing the longitudinal axis thereof;

Fig. 2 is a bottom view of the device of Fig. 1, the same being taken in the plane of line 2—2;

Fig. 3 is an exploded view of the nose or spark gap assembly of the device of Fig. 1;

Fig. 4 is a section taken on line 4—4 of Fig. 1;

Fig. 5 is an enlarged half sectional view showing parts of the nose assembly of Fig. 1 in loosely assembled relation; and,

Fig. 6 is a sectional view showing a modification of the nose or spark gap assembly.

The embodiment of the invention illustrated in Fig. 1 of the drawings, by way of example, is in the form of a long reach igniter or spark plug, for use in a jet or gas turbine type engine but the entire structure or features thereof may be adapted to other uses, such as in the ignition systems for reciprocating engines, oil burners, and the like. As shown, the upper or sealed section of the structure is constructed in a known manner to prevent the passage of gases therethrough. This section comprises a casing or shell 10 in which a tubular insulator 11 is seated on a gasket 12 and held in position by a nut 14 that operatively engages threads cut on the inner surface of shell section 10.

An enlarged head portion of a central conductor 15 is seated on a shoulder in insulator 11 and extends downwardly through the latter. An input terminal member 16 extends into the upper end of the insulator and is electrically connected to conductor 15 by a small wire 17. The remaining space within the insulator is preferably filled with an insulating mass 18 which functions as a gas seal and means for holding the parts in assembled relation. Several suitable sealing compounds are known to the art. One which has been successfully used consists of a mixture of lead oxide and "Pyrex" glass. If an elbow is required for connecting a power supply lead, the terminal member 16 may be supplemented by a plug 19 and pin 20. To properly position pin 20 in the housing elbow, a fixture is used. This is made possible by the telescopic relation of plug 19 in terminal 16 and the fact that pin 20 is longitudinally slidable in the transverse passage near the end of plug 19. When the parts are correctly positioned by the fixture (not shown) silver solder may be used for joining the parts 16, 19 and 20 of the terminal together.

A middle or guide section is provided for holding the elongated central conductor 15 against excessive vibration. This portion of the device comprises a shell section 21 which is arc welded or otherwise suitably secured to the lower end of shell section 10. In some installations this middle portion of the device passes through the air intake passage of the engine and one or more ports 22 are provided for receiving air to be utilized in a manner and for a purpose to hereinafter appear. The ports 22 are somewhat tangential as distinguished from radial, so that the stream of air entering the shell is given a whirling motion.

In the lower end of shell section 21 is a tubular insulator 23 which is seated upwardly against a flange 24 in the shell section and secured in position by a ring 25 having a press fit in said shell section. A tubular guide 26 made of metal or other suitable material is screw threaded in and rigidly supported by an internal flange in insulator 23 and closely surrounds conductor 15. Shell section 21 is provided with an internal groove 27 and the upper surface of ring 25 has a radial slot 28. The portion of insulator 23 which extends through ring 25 is of somewhat smaller diameter than the bore through said ring. Thus, air may pass downwardly through and from shell section 21 by way of groove 27, slot 28 and the bore through ring 25.

The end of shell section 21 and ring 25 are machined flush after assembly and a spacer shell section 29 is secured thereto, such as by arc welding. The wall thickness of section 29 is sufficient to overlap ring 25 and thus secure it in position.

The nose or spark gap assembly of the illustrated device is constructed in a novel manner and is similarly secured, such as by arc welding, to the lower end of shell section 29. In the form shown, the novel spark gap assembly which extends into the combustion chamber of the engine comprises a tubular shell section 30 having an end portion 31 of its bore tapered inwardly at a small angle toward the outer or lower end thereof. Seated on and firmly engaging tapered wall portion 31 is a tapered outer or ground electrode 32 which, for purposes to hereinafter appear, is in the form of a split ring having a plurality of axially extending slots 33. In one commercial embodiment ring 32 is longitudinally split at 34 (Fig. 3) and is provided with three slots 33.

An insulator 35 is similarly provided at one end with

a tapered external wall which seats on the internal tapered wall of electrode member **32**. The lower or outer ends of insulator **35** and electrode **32** are preferably flush with or extend slightly beyond the lower end face of shell section **30**. Electrode **32** may be secured against movement relative to shell section **30** and insulator **35** by any suitable means such as pins **36** pressed into holes **38** in shell **30** to engage notches **37** (Fig. 3) in the electrode. The pins may be secured in holes **38** by staking. Insulator **35** is secured and electrode **32** is further secured in position in shell section **30** by a ring **39** which has a press fit in said section and engages the upper end of the insulator. Ring **39** and shell section **30** are machined flush and arc welded to shell section **29** which overlaps said ring and retains it in assembled position. The lower edge of ring **39** has one or more radial slots **40** through which air may pass from shell section **29** into the space around insulator **35** and thence through the passage formed between the ends (at **34**) of the split ring electrode **32**. If desired, the retaining ring **39** may be threaded into shell section **30**.

The center electrode of the spark gap comprises a ring **41** shaped like the frustrum of a cone to firmly engage a tapered portion **42** of the bore in the lower end of insulator **35**. Electrode ring **41** is internally threaded and the small diameter end thereof is operatively engaged by an externally threaded tubular member **43**, the enlarged head portion of which seats on a tapered shoulder **44** in insulator **35**. The surface of member **43** which engages seat **44** is preferably spherical to facilitate proper seating of electrode **41** on seat **42**. Conductor **15** extends through member **43** and is secured thereto at the end by any suitable means, such as by arc welding or silver solder. Electrode **41** may be similarly additionally secured to member **43**. The outer ends of electrodes **32** and **41** and of insulator **35** are preferably flush and the exposed end face of the insulator is coated with carbon or otherwise rendered semi-conductive. A so-called shunted surface type of spark gap is thus provided.

In preparing insulator **35** for assembly with the other parts the same may be coated with carbon or other conductive material in any suitable known manner. The insulator may, for example, be placed in an air-tight furnace at a temperature of about 1,375° F. while a liquified petroleum gas containing essentially the propane hydrocarbon is flowed through the furnace. Carbon may then be cleaned from surfaces on which it is not desired by grinding or vapor blasting. It is permissible and desirable to leave the carbon coating on the external and internal tapered surfaces engaged by electrodes **32** and **41** and on the wall of the reduced bore through which member **43** extends.

In order to insure adequate surface contact between the tapered parts of the spark gap assembly, the parts are novelly constructed in relation to each other and assembled under pressure in a novel manner. The relationship of the parts when loosely assembled and before the application of any pressure is illustrated in Fig. 5.

In assembling the nose or spark gap section, shell member **30** is placed in a fixture **45** (only partially shown) which, for the particular commerial embodiment here described, permits the electrode **32** to project a maximum of about .040 inch beyond the end of the shell. Electrode **32** is then dropped into place in shell **30** and the engaging tapered wall surfaces of the electrode and shell are such that initial contact occurs at *a* and said surface diverges downwardly at an angle of about 1°. The insulator **35** is then dropped into place and the engaging wall surfaces of electrode **32** and the insulator make initial contact at *b* and said surfaces diverge upwardly at an angle of about 1°. Ring **39** which has a .003" press fit in shell **30** is now pressed in and against insulator **35** with a pressure of about 1000 lbs. Electrode **32**, being capable of closing in by reason of slot **34**, moves downwardly with the insulator until it strikes the end wall of fixture **45**. Further downward movement of the insulator spreads or expands the slotted lower end of electrode **32** into firm and substantially full surface engagement with shell **30**. At the same time the tapered outer surface of the insulator moves into firm and substantially full surface engagement with the inner surface of electrode **32**. This desirable result is thus accomplished without over-stressing the insulator which is the most fragile of the parts.

The fixture is now removed, and center electrode parts **41** and **43** are put in place. Before substantial torque is applied, initial contact between insulator wall **42** and electrode **41** takes place at *c*, and the adjacent tapered surfaces diverge upwardly at an angle of about one-half degree. When a force of about 5 inch/pounds is applied to member **43**, the parts yield sufficiently to give good surface contact between electrode **41** and the insulator.

Following the assembly as above described, the holes **38** and notches **37** are drilled, and pins **36** are pressed into place. The outer ends of the holes may then be staked or pressed inwardly to hold the pins in position for locking electrode **32** against movement relative to shell **30**. The lower ends of electrodes **32** and **41** are then ground off to a plane which is flush with or within a maximum of about .003 inch below the plane of the exposed end face of insulator **35**. The upper end of shell **30** and ring **39** are machined flush, and the completed spark gap assembly is arc welded to shell section **29**.

A modification of the nose or spark gap assembly is illustrated in Fig. 6. This structure differs from the embodiment of Fig. 1 primarily in the fact that the shell is utilized as the ground electrode. As shown, a tubular insulator **50** is seated on a tapered wall portion of the bore of a shell member **51** and is secured in position by a retaining ring **52**. The latter may be threaded into shell **51**, as shown, or may have a press fit therein. The center electrode comprises an externally tapered nut electrode **53** which fits a tapered bore portion of the insulator and operatively engages a tubular, headed stud **54** through which central conductor **15** extends. The lower ends of shell **51**, electrode **53** and stud **54** are ground off approximately flush with the end face of insulator **50**, and parts **15**, **53** and **54** are secured at their ends by arc welding or the like. At least the exposed end face of the insulator is semi-conductive or coated with carbon or similar conductive material.

In operation, input terminal **20** is connected to a source of electrical energy which preferably but not necessarily includes facilities for high energy, low voltage discharges from a condenser. The energy flows through central conductor **15** to center electrode **41**, **43**, creating a voltage differential between the latter and ground electrode **32**. If the voltage provided is insufficient to bridge the gap between the electrodes, an initial small current passes through the semi-conductive or carbon coated face of insulator **35**, thereby ionizing the gases in the vicinity and reducing the resistance to sparking so that a high energy spark is created between the electrodes. Sparking may thus be insured at a relatively wide gap by a relatively low source of voltage, a phenomenon which is already known in the art. If the end face of the insulator is burned away excessively, the device may be reconditioned by merely grinding down the ends of electrodes **32** and **41**.

Although only a limited number of embodiments or modifications of the present invention have been illustrated in the accompanying drawings and described in the foregoing specification, it is to be expressly understood that the invention is not limited thereto. For example, the air cooling feature is not essential in some installations and may be eliminated. In such installations, the split **34** in electrode ring **32** may be retained or not, as desired. Where shorter structures are required, the middle or guide section for conductor **15** may be dispensed with and shell section **30** attached directly to an extension of shell section **10**. Although electrodes **32** and **41** are shown as having substantially uniform wall

thickness, either or both may have internal tapers which are greater or less than the external tapers thereof. Various other changes may also be made in the design and arrangement of the parts illustrated 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. An electrical spark gap device comprising a tubular shell having a tapered bore portion, a tubular insulator having an external wall portion tapered in the same direction as said tapered bore portion, a ring-like outer electrode wedged between said tapered portions of the shell and insulator, a center electrode in said insulator, the adjacent ends of said electrodes being in spark gap relation across the annular end face of said insulator, and means for securing said shell, electrodes and insulator in assembled relation.

2. A spark gap device as defined in claim 1 wherein said outer electrode is expandable.

3. A spark gap device as defined in claim 1 wherein said outer electrode consists of a split ring, thereby rendering the same expandable.

4. A spark gap device as defined in claim 1 wherein said outer electrode has at least one axially extending slot therein to render the same expandable.

5. A spark gap device as defined in claim 1 wherein the center electrode comprises a cone-like member having the outer end thereof converging toward the outer end of said outer electrode.

6. A spark gap device as defined in claim 5 comprising a member supported in the bore of said insulator and having threaded engagement with said cone-like center electrode member.

7. A spark gap device as defined in claim 1 comprising means for securing said outer electrode against movement relative to said shell.

8. An electrical spark gap device comprising a tubular shell having a tapered bore portion, a tubular insulator having an external wall portion tapered in the same direction as said tapered bore portion, a cone-like outer electrode wedged between said tapered portions of the shell and insulator, a center electrode in the insulator having spark gap relation with said outer electrode and at least one dowel extending axially in the wall of said shell and engaging said outer electrode to hold said outer electrode and shell against relative movement.

9. In electrical apparatus, such as a spark plug, a hollow shell having adjacent sections extending at an angle to each other, a first conductor centrally disposed in one section and insulated therefrom, said first conductor having a recess in the end thereof, a second conductor extending into said recess and having a transverse opening therein extending in the direction of the axis of the other section, and a third conductor extending through said transverse opening and along the axis of said other section, whereby said second conductor may be secured by soldering in said first conductor at a desired position and said third conductor may be secured by soldering to said second conductor in a desired position.

10. Apparatus as defined in claim 9 wherein a cover is provided in an opening in said shell to afford access to joints between said conductors to permit adjustment and securing thereof.

11. An electrical spark gap device comprising a tubular shell, an elongated central conductor means in said shell, means surrounding said conductor means at one end of the shell for insulating the shell from the conductor means, for fixedly holding the conductor means relative to the shell, and for forming a gas-tight seal between the shell and the conductor means, an electrode assembly mounted in the other end of said shell, and means mounted in said shell intermediate the ends thereof for centering said conductor means, said shell having an opening therein between said centering means and said first-named means and said centering means and said electrode assembly having passages for permitting flow of gases longitudinally through said shell.

12. A spark gap device comprising a tubular shell, an elongated substantially inextensible conductor means in said shell, means surrounding said conductor means at one end of said shell for insulating the shell from the conductor means and forming a gas-tight seal therebetween, an electrode assembly comprising electrodes in spark gap relation mounted in the other end of said shell, and means mounted in said shell intermediate the ends thereof for centering said conductor means in the shell, said shell comprising a plurality of sections joined together in end-to-end relation, and said electrode assembly and each of said second-named and third named means being mounted in different sections of the shell.

13. A spark device comprising a tubular outer electrode having a tapered inner wall portion, a tubular insulator having an external tapered wall engaging said tapered wall portion and an oppositely tapered inner wall, and a center electrode in said insulator comprising a support member and an electrode member having an external tapered surface engaging said inner wall of the insulator, said support member and said electrode member having cooperating threaded engagement to wedge the latter into said insulator.

14. A spark gap device as defined in claim 13 comprising means for securing said insulator and outer electrode in assembled relation.

15. Electrical apparatus comprising a tubular shell having a tapered bore portion adjacent one end thereof, a ring electrode seated on said tapered bore portion, said ring elctrode being internally and externally tapered, a tubular insulator having a tapered external wall seated in said ring electrode, said insulator having a bore portion within the tapered external wall thereof which is oppositely tapered, thereby providing the insulator with a narrow annular end face, a tapered center electrode seated in said tapered bore portion of the insulator, the adjacent end surfaces of said electrodes and said end face of said insulator being in approximately the same plane, means for securing said insulator and ring electrode in said shell, and means for securing said center electrode in the insulator.

16. A spark gap device comprising an outer electrode having a tapered internal wall, a tubular insulator having oppositely tapered external and internal walls at one end thereof to provide a narrow annular end face at said one end of the insulator, the tapered external wall of said insulator being seated against the tapered internal wall of said outer electrode, a center electrode having a tapered external wall portion seated against the tapered internal wall of the insulator, whereby the end faces of said electrodes are separated by said annular end face of said insulator, and means for securing said electrodes and insulator in assembled relation.

17. An electrical spark gap device comprising a tubular shell, an elongated conductor means passing through and centered in said shell, means surrounding said conductor means at one end of said shell for centering said conductor means in the shell, for holding it fixed with respect thereto, and for insulating the shell from the conductor and forming a gas-tight seal therebetween, and electrode assembly having opposed electrodes fixedly held with respect to each other and fixedly secured to the other end of said conductor means and to the other end of said shell, an insulating centering means mounted in said shell and contacting a portion of said conductor means intermediate the ends thereof, said shell having an opening therein between said centering means and said gas-tight seal, said centering means and said electrode assembly having passages therein for permitting the flow of gases longitudinally through said shell.

18. In a spark gap device as defined in claim 17 wherein said shell comprises a plurality of sections joined

together in end-to-end relation, and wherein the gas-tight seal, the centering means and the electrode assembly are each mounted in different sections of the shell.

19. The method of making a spark gap device which comprises making a tubular shell having a tapered internal wall portion, placing therein a tapered ring-like electrode having at least the smaller end thereof expansible, the taper of the external wall of said electrode being such that the small end thereof diverges at a small angle from said tapered wall portion of the shell, placing a tubular insulator in said shell and electrode, said insulator having oppositely tapering inner and outer wall portions, said tapered outer wall portion of the insulator diverging at a small angle from the inner wall of said electrode at the larger end thereof, and pressing said insulator into said electrode to expand the latter into firm surface engagement with said shell and effect firm surface engagement between said electrode and insulator.

20. The method defined in claim 19 wherein the axial

movement of said electrode relative to said shell is limited by a fixture while assembly pressure is applied to said insulator.

21. A method as defined in claim 19 comprising inserting a tapered center electrode in the end of said insulator, the tapered outer wall of said center electrode being divergent with the inner tapered wall of the insulator at a small angle toward the small diameter end thereof, and applying force to said center electrode to press it into the tapered bore of the insulator.

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