Aug. 25, 1964 J. J. LOGAN 3,146,301

SPARK DISCHARGE DEVICE

Original Filed April 21, 1958

Fig. 1

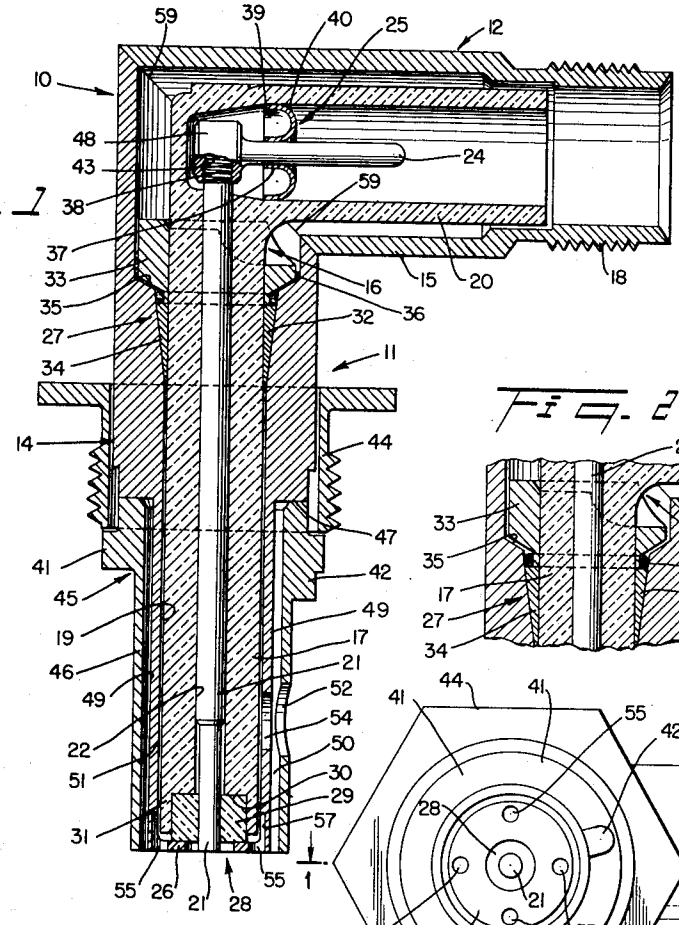


Fig. 2

Fig. 3

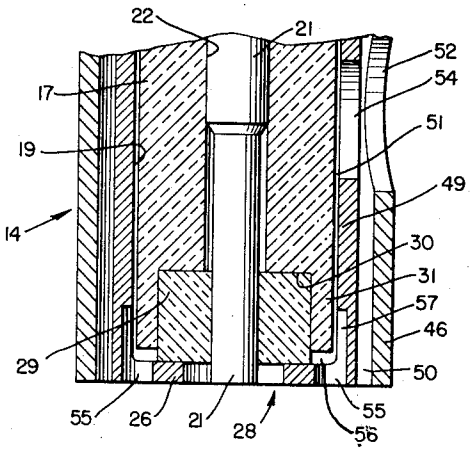


Fig. 4

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SPARK DISCHARGE DEVICE

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Original application Apr. 21, 1958, Ser. No. 729,598, now Patent No. 3,025,425, dated Mar. 13, 1962. Divided and this application Mar. 23, 1961, Ser. No. 97,959
4 Claims. (Cl. 174—152)

This invention relates to electrical apparatus, and more particularly relates to an improved spark discharge device.

The invention has among its objects the provision of an improved spark discharge device.

A further object of the invention resides in the provision of an improved spark discharge device of the angle type.

Another object of the invention lies in the provision, in an angle type spark discharge device, of an improved means for sealing the central conductor of such device to an electrically insulating ceramic sleeve which surrounds the conductor.

The above and further objects and novel features of the invention will more fully appear from the following 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.

This application is a division of application Serial No. 729,598, filed April 21, 1958, now Patent No. 3,025,425, granted March 13, 1962.

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

FIG. 1 is a view in axial section through an illustrative spark discharge device made in accordance with the invention, certain of the parts being shown in elevation;

FIG. 2 is a fragmentary view in section of a portion of the device of FIG. 1 in the condition it has prior to heating the shell of the device to effect a seal between the central insulator and the shell of the device;

FIG. 3 is a fragmentary view in bottom plan of the device of FIG. 1; and

FIG. 4 is an enlarged fragmentary view in axial section of the lower end of the device of FIG. 1, the central electrode being shown in elevation.

The spark discharge device of the invention may be used to advantage as a spark plug in various types of engines. Among such engines are those of the jet or ram jet type. The spark gap providing end of the spark discharge device is mounted within the combustion chamber of the engine, and is thus subjected to high temperatures during use. The device of the invention is designed to make efficient use in a novel manner of the cooler gases, removed from the immediate combustion zone in the engine chamber, in cooling the spark gap providing end of the device.

Turning now to the drawings, the spark discharge device, which is shown as a spark plug generally designated **10**, has a first, spark gap portion **11** and a second, connector portion **12** disposed at a right angle to portion **11**. The device **10** has an integrally connected outer metal shell or housing, made, for example, of heat resistant nickel alloy, which protects and supports the parts therewithin, and also shields the device from transmitting radio-interferring electromagnetic disturbances. The portion of the shell which is disposed vertically in FIG. 1 is designated **14**, and the portion of the shell which is disposed horizontally is designated **15**. The lower or inner end of shell **14** is of a somewhat reduced diameter.

Within the shell there is disposed an integral, right-angular hollow, dense, impervious ceramic insulator **16**, made, for example, of alumina. The vertical leg **17** of

insulator **16** fits with a small clearance within the passage **19** in portion **14** of the shell. The horizontal leg **20** of insulator **16** is hollow, and is disposed coaxially of leg **15** of the shell, being spaced appreciably from the shell in the portion thereof adjoining vertical leg **14** of the shell and lying closer thereto but still spaced therefrom at the outer end of insulator leg **20** where shell portion **15** is necked in, as shown. The outer end of shell leg **15** is threaded at **18**, to receive the retaining nut of a second connector part (not shown) which carries a socket receiving the connector pin **24**.

The insulator **16** serves to support and locate a central electrode **21**, the main, upper portion of which is snugly received in a central passage **22** through leg **17** of the insulator **16**, and to support and locate a connector pin **24** connected to the upper end of the central electrode. Electrode rod **21** and pin **24** are thus electrically connected and constitute angularly disposed legs of a central conductor. The connector pin **24**, which is located within leg **20** of the insulator, and coaxially thereof, is sealed to such leg by a flexible annular diaphragm generally designated **25**.

The insulator **16** is maintained in place within the shell of the device by a flange **26** projecting radially inwardly from the lower end of leg **14** of the shell, and by an annular wedge and solder means, generally designated **27**, interposed between the vertical leg **17** of insulator **16** and the portion **14** of the shell adjacent the upper end of such leg. The flange **26**, as will appear, forms an outer annular electrode for the discharge device, the other electrode being formed by the lower end of central electrode **21**, which terminates flush with the lower surface of flange **26**. An electrically semi-conductive annular body **29** tightly embraces the lower end of the central electrode **21** and overlies flange **26**, so as to form a semi-conductive shunt across the annular gap **28** between the electrodes. Body **29** is received in an annular central recess **30** in the lower end of leg **17** of insulator **16**, and is preferably bonded thereto in a manner to be described. A depending flange **31** bounding recess **30** terminates somewhat short of the lower surface of insert **29**.

The arrangement **27** is made up of an annular member **32**, made of a metal such as copper, the outer wall of which is slanted to converge downwardly toward the inner wall, and a rigid upper compression ring **33**, made of a metal such as stainless steel. The inner surface of shell portion **14** confronting the outer surface of member **32** is similarly frusto-conical at **34**. Above zone **34** the inner surface of shell portion **14** is formed with a second shallow frusto-conical zone or seat **35**, which receives the similarly shaped lower surface of compression ring **33**. Members **32** and **33** are held in place by a layer of hard solder **36** which was assembled as a solder ring **36'** (FIG. 2) between members **32** and **33** and, after members **32** and **33** had been pressed strongly in a downward direction, was melted to bond the members to each other and to the portion **14** of the shell.

The upper end of central electrode **21** is threaded at **38**, and is threaded into a passage **43** in an enlargement **48** on the inner end of pin **24**. Preferably the central electrode and the connector pin are also brazed together, in a manner to be explained. The diaphragm **25**, which may be made, for example, of a heat resistant nickel iron alloy, is bonded to the pin **24** by having its inner flange **37** brazed thereto, and by having its outer flange **39** soldered or brazed to the metallized inner wall surface **40** of the insulator portion **20**.

The spark discharge device **10** is designed to be mounted in an opening through the side wall (not shown) of an engine housing. A flange **41**, at the upper end of the reduced diameter portion of leg **14** of the shell, is adapted to be received in a counterbore at the outer end

of such opening in the housing. A key or lug 42 projecting from the housing portion 14 below flange 41 is adapted to be received in a device locating recess in the engine housing. A nut 44, rotatable on shell 14 above flange 41, is designed to engage the internally threaded outer end of the opening in the engine housing, the nut engaging flange 41 to retain device 10 in the opening in the engine housing.

The spark discharge device is so constructed and arranged as to provide access for gases within the engine housing to the outer surface of the leg 17 of insulator 16 throughout the major portion of the length thereof inwardly of the spark gap, thereby to prevent the undue progressive build-up of temperature in the insulator, and the consequent damage thereof. Further, the lower end of the wall of shell portion 14 is circumferentially divided for a substantial length upwardly from the spark gap, so as to allow engine gases also effectively to cool the lower end of the shell.

As shown in FIGS. 1 and 4, the outer portion of the leg 14 of the shell from the lower end thereof to a level somewhat above flange 41 is initially formed as a separate tube-like member 45 having a relatively thin wall 46 below flange 41. Intermediate the ends of the leg 14 the main body of the shell has a shoulder 47 below which the main body is markedly reduced in diameter to form an inner wall 49 having a thickness about equal to that of outer wall 46. Member 45 is integrally connected to the main body of the shell at shoulder 47, as by welding in a manner to be described.

As shown, the circular cylindrical outer and inner walls 46 and 49, respectively, which terminate flush with the bottom of flange 26, are coaxial, and are spaced to form an annular space 50 between them. The inner diameter of wall 49 is such as to provide a relatively radially thin annular space between the inner surface of wall 49 and the outer surface of portion 17 of insulator 16. To provide access for the engine gases to spaces 50 and 51, the walls 46 and 49 are each provided with a lateral opening therethrough. Such openings, which are designated 52 and 54, respectively, are aligned; opening 52 somewhat exceeds opening 54 in diameter.

The above described flange 26 is integral with the inner wall 49 at the lower end of leg 14 of the shell. A free opening is thus provided at the lower end of the outer annular space 50. To provide bottom openings into the inner annular space 51, the flange 26 has passages 55 (four shown) therethrough which underlie annular space 51. In the embodiment shown, the passages 55 are symmetrically arranged as regards the inner and outer boundaries of the space 51 (FIG. 4). The space 56 between the lower end of flange 31 on insulator portion 17 and the upper surface of flange 26 allows the gases to flow more freely through pasages 55. Further to aid such gas flow, the lower end of the inner surface of the inner wall 49 is relieved at 57 to form a further annular space overlying passages 55.

It will be understood that during operation of the device the inner end of leg 14 thereof adjacent the spark gap is positioned close to the flame in the engine, and becomes highly heated. The device of the invention prevents the progressive build-up of the temperature of such portion of the device to degrees which would seriously shorten the operating life of the parts of the device, including the insulator and the shell. The gases in the combustion chamber which are spaced from the flame or immediate zone of combustion are cooler than those at the tip or spark gap end of the device. Such cooler gases are allowed to flow through the annular spaces 50 and 51. In a jet-type engine such cooler gases are, in the main, led into spaces 50 and 51 through openings 52 and 54, and discharged therefrom through passages 55. Such cooler gases abstract heat from the parts of the device, and thus keep their temperature within safe operating limits. It will be understood that in some engines, particularly those operating with varying combustion chamber pressures in different parts of the operating cycle, the flow of gas through spaces 50 and 51 may be, in the main, in the reverse direction from that above described, or that such direction of gas flow may reverse once or several times in each operating cycle.

The seal 25 is advantageous in that it is readily installed and is economical of manufacture. Further, seal 25 is of such construction and is so disposed in the assembly that it may yield somewhat as required, as by expansion and contraction of the various parts, while maintaining a positive, secure seal at all times. Because of its yieldability, seal 25 does not subject any of the parts of the assembly to undue stress, even though some of the parts may change in size relative to the others. Thus, for example, a lengthening of central rod 21 will merely raise pin 24 somewhat, the diaphragm seal 25 yielding to permit such action without either injuring the seal or placing an undue stress upon ceramic insulator 20.

A preferred manner in which the described spark discharge device may be assembled is as follows:

The inner surface 40 of leg 20 of insulator 16 is metallized in a conventional manner. A silver paste is applied to threads 38 on central electrode 21 and to the threads in passage 43 in enlargement 48 on contact pin 24. Such silver paste may be composed of precipitated silver powder in a suitable vehicle such as 1:5 solution of pyroxalin and anyl acetate. The contact pin and the electrode are placed in the proper position in insulator 16, and the electrode is screwed into enlargement 48 on the contact pin to engage approximately one half of the threads.

The metallized area 40 of the insulator is coated with nickel oxide paint. The diaphragm 25 is inserted and pressed into place. The electrode 21 is now screwed into its final position with respect to insulator 16. Nickel oxide paint is applied to the joint between flange 37 of the diaphragm and contact pin 24, and that between flange 39 of the diaphragm and metallized surface 40 of insulator 16. A thin wire ring of silver of the correct size is then placed in position at such joints, excess nickel oxide paint, if any, is removed from insulator 16, and the assembly is then heated in a dry hydrogen atmosphere to melt the silver rings and to reduce the nickel oxide to form gas impermeable joints. Preferably in the last step the assembly is positioned with the pin 24 vertical and with the free end of the pin up.

The bushing 32 is now cleaned of all traces of grease and oil by using a suitable solvent. After cleaning, the bushing 32 is coated with a suitable liquid flux and allowed to dry. The outer cooling shell 45 is assembled onto the leg 14 of the main shell body in the manner shown and is arc welded thereto along the junction between the upper end of the cooling shell and shoulder 47 on the main shell body. Preferably a suitable jig is employed to hold the parts accurately during the welding operation. The retaining nut 44 is then assembled over the end of leg 20 of insulator 16 so as to lie upon flange 41.

The semi-conductive body 29 is inserted in recess 30 at the lower end of portion 17 of insulator 16, the contacting surfaces of body 29 and recess 30 being first coated with a refractory cement. The above described assembly of insulator 16, central electrode 21, and contact pin 24, a copper bushing 32, a silver solder ring 36' (FIG. 2), and a compression ring 33 are then assembled into a leg portion 14 of the shell as above prepared.

The assembly is mounted in a suitable fixture which locates the insulator 16 in the proper relationship and maintains spark gap 28 concentric. The fixture is mounted under the ram of a hydraulic press, and a load is slowly applied to compression ring 33 until 1400 lbs. is applied on bushing 32. While such load is maintained, the area of the outer wall of the shell portion 14 adjacent bushing 32 is heated, as by a four flame gas burner with burners set 90° apart, to a dull red heat. The heat source is removed

from the assembly, and the assembly is allowed to cool appreciably before the applied load is removed.

The leg portion **12** of the shell is now assembled upon leg **14**. As shown, legs **12** and **14** are so formed as to meet an annular junction **59** lying in a plane at 45° with respect to the axes of legs **12** and **14**. The assembled shell is held in a suitable fixture which holds the internal diameter of leg **12** of the shell concentric with the outer diameter of insulator portion **20**. The legs **12** and **14** of the shell are now welded, as by heliarc welding, along their outer surfaces at junction **59**.

Although only one embodiment of the invention has been illustrated in the accompanying drawings and described in the foregoing specification, it is to be expressly understood that various changes, such as in the relative dimensions of the parts, materials used, and the like, as well as the suggested manner of use of the apparatus of the invention, may be made therein without departing from the spirit and scope of the invention as will now be apparent to those skilled in the art.

What is claimed is:

1. In a spark discharge device, a metal shell provided with two legs disposed generally at an angle with respect to each other, a central conductor disposed within the shell and having two intersecting substantially rigid rod-like legs, each within the respective leg of the shell, extending generally at said angle with respect to each other, means positioning one leg of the conductor with respect to its respective leg of the shell and insulating it therefrom, a ceramic insulating sleeve within the other leg of the shell and generally coaxially surrounding the other leg of the conductor, and means for positioning the other leg of the conductor with respect to the ceramic sleeve and for sealing it thereto, said last-named means comprising a flexible gas impermeable diaphragm sealed at its central portion to the other leg of the conductor and sealed at its periphery to the ceramic sleeve.

2. A spark discharge device as defined in claim 1, wherein the flexible diaphragm is located close to the intersection of the rod-like members forming the conductor.

3. A device as claimed in claim 1, comprising means for rigidly connecting said first-named positioning means to and sealing it to the one leg of the shell.

4. A device as defined in claim 1, wherein the sealing diaphragm has a portion in the form of the shell of a part of a torus, the diaphragm having a radially outer flange extending along the inner surface of said ceramic sleeve and bonded thereto, and a radially inner flange extending along the other leg of the conductor and bonded thereto.

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