March 28, 1950 F. I. McCARTHY ET AL 2,501,826

SPARK PLUG

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Fig. 1.

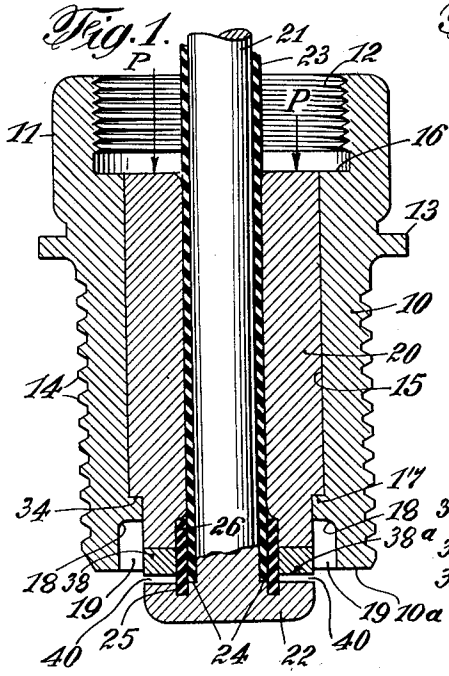

Fig. 2.

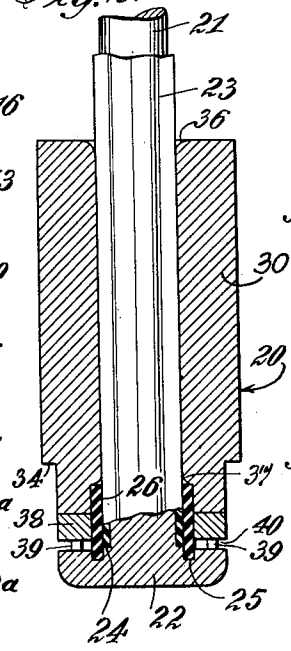

Fig. 3.

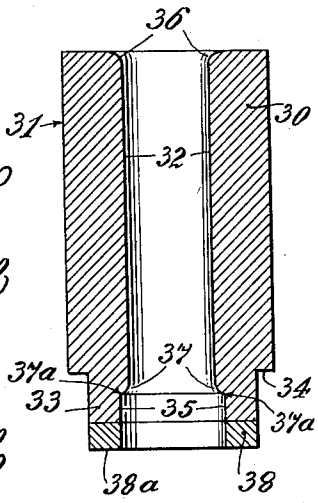

Fig. 4.

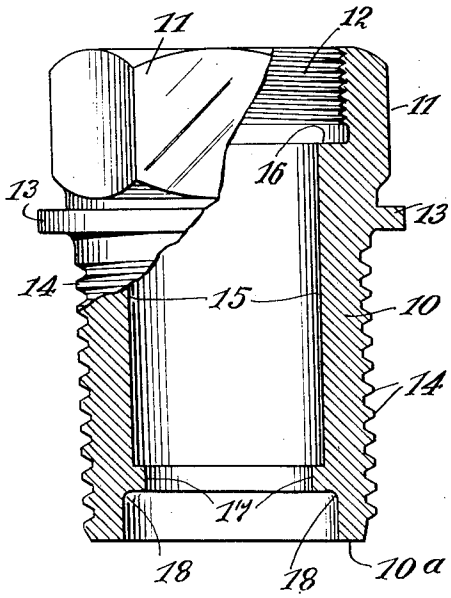

Fig. 5.

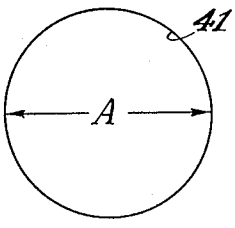

Fig. 6.

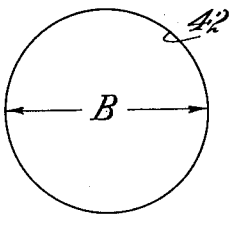

Fig. 7.

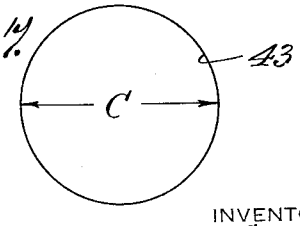

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Fig. 8.

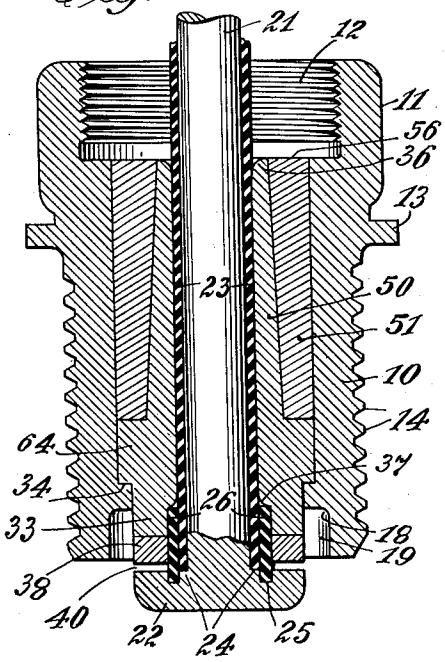


Fig. 9.

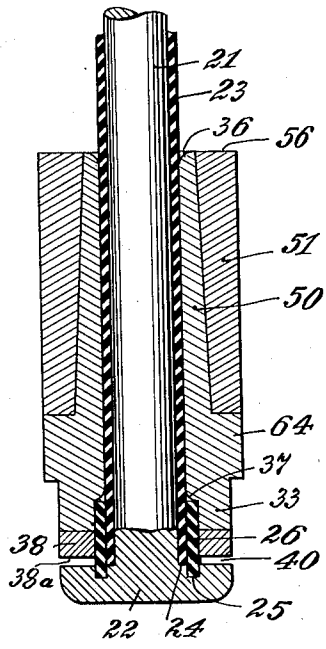


Fig. 10.

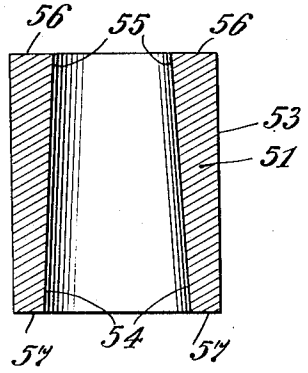
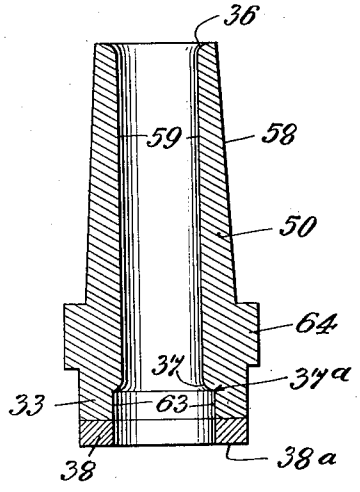


Fig. 11.



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UNITED STATES PATENT OFFICE

2,501,826

SPARK PLUG

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New York, N. Y.

Application April 6, 1945, Serial No. 586,972

1 Claim. (Cl. 123—169)

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This invention relates to spark plugs.

The object of the invention is to provide a spark plug with quick and efficient heat distribution, and leakage proof characteristics, and to provide its parts in a manner which lend themselves particularly to mass production.

The invention consists of a method in which a pre-shaped cartridge is formed by progressive pressures, which cartridge is then ready for insertion into a novel shell.

The invention consists in the combination of parts producing a novel result, in which a sleeve with an extension to a sparking terminal is provided with a direct heat transfer from the terminal to the body of the sleeve, and in which a spark gap extends beyond the end of the shell for ready access for cleaning, said shell having only one machined bore; and in which said sleeve is pressure shrunk on the lining covered spark terminal stem.

The invention consists in novel articles of manufacture, one consisting of the central spindle or stem having a spark plug tip in spaced relation to the inner cartridge having a pre-shaped heat conducting member which exerts a leakage proof pressure on the central stem; and the other consisting of a novel shell having the usual exterior hexagonal and screw threads, and having interior screw threads, as known, but having only one machined bore, thus simplifying the structure and reducing the cost of its making.

The invention will be more fully described hereinafter, embodiments thereof shown in the drawings, and the invention will be pointed out in the claim.

In the accompanying drawings,

Fig. 1 is a vertical central section of one embodiment of the improved spark plug, the parts shown being sufficient to explain the invention, co-related known parts being omitted.

Fig. 2 is a vertical central section of the improved pre-shaped cartridge, forming part of Fig. 1.

Fig. 3 is a vertical central section of the moldable member used in the cartridge shown in Fig. 2.

Fig. 4 is a vertical central section, partly in elevation of the improved shell.

Figs. 5, 6 and 7 are diagrammatic plans of the circumferential bores of progressive dies used in pre-shaping the improved cartridge shown in Fig. 2.

Fig. 8 is a vertical central section of another embodiment of the invention, showing a complete

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spark plug to the extent necessary to explain the invention.

Fig. 9 is a vertical central section of the pre-shaped cartridge used in the spark plug shown in Fig. 8.

Fig. 10 is a vertical central section of the hard wedge used to form the pre-shaped cartridge shown in Fig. 9, and

Fig. 11 is a vertical central section of the softer and moldable material used in the cartridge shown in Fig. 9.

Similar characters of reference indicate corresponding parts throughout the various views.

Referring to the drawings, and more particularly to Figures 1 to 7, the complete spark plug in accordance to the invention consists of two independent parts, the outer shell 10, shown separately in Fig. 4, and the pre-shaped cartridge 20 shown separately in Fig. 2. All that is necessary in the assembly operation is to insert against frictional pressure, the pre-shaped cartridge 20 into the shell 10, and then apply a bringing home pressure P to the cartridge 20 in order that its exterior circumferential surface merges into the interior circumferential surface of the main bore of the shell, upon which the spark plug shown is ready for use, when assembled with its known environmental parts, shown in our co-pending application Serial No. 559,880, filed October 23, 1944, issued to Patent No. 2,460,-022 on January 25, 1949, to which reference is herewith made.

The novel shell 10 is provided with the known hexagonal 11, with its interior screw threads 12, circular rim 13, and known exterior screw threads 14. The main bore 15 is of subcaliber to the diameter of the interior threads 12, and a circular shoulder 16 is formed at the juncture of these parts. The main bore 15 terminates near the bottom of the shell 10 at a shoulder 17, and that portion of the shell has a curved cutout 18 forming an air space 19 with the end of the cartridge 20.

The pre-shaped cartridge 20 has the stem or spindle 21 provided with a spark plug tip 22 integrally therewith, and the stem is made of stainless steel. Surrounding the stem 21 is a wrapped layer consisting of a plurality of sheets of mica forming a sleeve 23, which extends along the length of the stem, and seats on the inner surface 24 of the sparking tip 22. This surface 24 is provided with a circular recess 25 into which a cylinder 26 of ceramic material is seated. Surrounding the sleeve covered stem 21 is a hollow cylinder 30 of soft moldable material such

as copper. This cylinder 30 is shown separately in Figure 3. It has a substantial length for extending along the stem. It has an exterior circumferential surface 31, somewhat larger in diameter than the diameter of the main bore 15 of the shell 10. It has an interior bore 32 of the same diameter throughout, about the diameter of the external diameter of the mica sleeve 23. It has a constricted extension 33 forming an exterior shoulder 34, and an internal bore 35 of larger diameter than the diameter of the bore 32. A curved portion 36 is provided at one end of the bore 32 and a curved portion 37 at the other end of the bore 32. To the extension 33 is secured by brazing or welding, a circular disc 38 of nickel alloy, having an exterior and interior diameter equal to those of the extension 33.

The mica sleeve 23 is wrapped around the stem 21, in the manner well known. Then the ceramic sleeve 26 is placed into the recess 25. Then the cylinder 30 is passed over the mica covered stem 21, until the curved shoulder 37*a* of the cylinder 30 rests about on the ceramic sleeve 26. A removable spacer 39 may also be used to space the terminal ring or disc 38 from the tip 22 to form the spark gap 40.

With the cartridge parts just described assembled as described, the so formed cartridge is placed in a circular bore of a die having a diameter A, only the internal circumference 41 being shown in Figure 5, as such dies are well known. The moldable cylinder 30 of copper is subjected to pressure and the distribution of this pressure exerts a confining effect upon the cylinder 30 radially inwardly and against the mica sleeve 23. The object of the curved portions 36 and 37 is to provide a diminution of pressure at these points, so as to prevent puncturing the mica sleeve, all of the pressure applied radially inwards against the remaining portion of the mica sleeve being substantially equal and thus not likely to puncture the sleeve.

The cartridge is then removed from die 41, and placed in a die 42, Figure 6, which has a slightly smaller internal diameter B and pressure is again applied, all as described in connection with Figure 5; and all this is repeated with die 43 of Figure 7, which has its diameter C again slightly smaller.

Thus, the external diameter of the cylinder 30 becomes progressively smaller.

The respective pressures are about 2000 pounds each and these successive and progressively smaller diameter pressures shape the cartridge into semi-final shape, such as to justify the appelation of a pre-formed or pre-shaped cartridge. Such a cartridge is shown in Figure 2, and is ready to insert into the shell 10 of Figure 4, after which insertion, a final pressure P is applied and the spark plug of Figure 1 results.

The method described includes subjecting a moldable cylinder to radially inwards pressures against a central sleeve of mica to secure it in leakage proof condition or seal against the sparking tip stem under progressively smaller diameters, and then subjecting the cylinder of moldable material to a pressure distributed radially outwards against the bore of the shell to provide a leakage proof seal therebetween, and obtain a heat transfer action between the cylinder and shell, due to the absence of air between these parts.

The surface 38*a* of the nickel sparking terminal 38 extends slightly beyond a plane passing through the surface 10*a* of the shell 10, and consequently the spark gap 40 is beyond the end of the shell 10, and thus may be readily cleaned by simple means and without taking the parts of the plug apart. At the same time the space 19 serves the function of an air chamber in close proximity to the spark gap 40. The nickel disc 38 and the extension 33 of the cylinder 30 are arranged in the manner described to provide a direct path of heat flow from the spark gap to the body of the cylinder 30, from which the heat is transmitted directly to the shell.

The method described and the combination of the cylinder extension with its nickel disc extending slightly beyond the end of the shell for ready access for cleaning, combined with the direct heat transmission by a unitary structure, may be applied to a spark plug made by the use of a wedge 51 of beryllium copper, a metal or alloy much harder than the softer moldable sleeve 50, as shown in Figures 8 to 11.

Reference is here made to our copending application Serial No. 584,800, filed March 26, 1945, issued to Patent No. 2,471,070 on May 24, 1949, and the method therein described may be used, by forcing in the beryllium copper sleeve 51 from its draft initial position to its final position, and the novel combination of the extended sparking gap and direct heat transmission availed of; or, the method described in connection with the progressively smaller dies may be used.

The beryllium copper sleeve 51 is shown separately in Figure 10, and has an external diameter slightly larger than its external diameter when finally in use, as in Figure 8, that is after the radially inward pressures of the progressive dies have been applied. The exterior surface 53 is cylindrical and about the circumference of the main bore of the shell (Fig. 10) but its outer diamter is larger than the inner bore diameter. The inner bore 54 of the sleeve 51 is frustoconical, with the apex 55 of the cone forming a larger base portion 56 of the wedge, than the apex end 57 of the wedge 53. The contacting surfaces may be cylindrical.

Or, the moldable sleeve 50 is also largely of frusto-conical shape with its exterior surface 58 inclined at an angle of about 2°, which inclination is that of the inner bore 54. The outer sleeve 51 may be either in draft to the inner sleeve 50 and the parts brought home, or the inner surfaces can be co-extensive initially as in Fig. 9. In accordance with the present invention, in either case, the outer diameter of the sleeve 51 is larger than the main bore 15 diameter, and the cartridge is subjected to the successive and progressive pressures of the dies 41, 42 and 43, to bring the outer diameter of the sleeve 51 to equal that of the bore 15, after which insertion of the cartridge into the shell takes place and the pressure P is applied to the cartridge in order to distribute it to the peripheral surface of the sleeve 51 and merge it into the bore 15 surface to obtain a leakage proof fit and a good heat transfer contact. The length of the exterior inclined portion 58 is equal to that of the inner bore 54 of the sleeve 51. The inner bore 59 of the sleeve 50 extends beyond the length of the exterior portion 58, and terminates at one end in a curved enlargement 36 and at the other end in a similar curved enlargement 37; the enlargement 37 forming a shoulder 37*a* at the end of a bore 63 of larger diameter than the bore 59. An external shoulder 64 is provided having an external diameter substantially that of the main bore of the shell 10.

A nickel disc 38 is applied to the end of the sleeve 50. Thus, from the parts described the sleeve 50 has an extension 33, which acts as a direct transmitter of heat.

The new result obtained is the accessibility of the spark gap for cleaning; and the direct transmittal of heat, by the arrangement of the parts described as part of the spark plugs shown in Figures 1 and 8.

The novel method is the subjection of the moldable member to progressive radially inward pressures to assure the compacting of the mica layers against the stem and against each other to secure a leakage proof seal, and the subjection of the cartridge to pressure applied vertically and transmitted and distributed radially outwards to obtain a leakage proof air seal and intimate molecular contact for heat transmission between the cartridge and the shell.

The novel shell requires only the machining necessary for its main bore, and the novel cartridge differs from a cartridge having a draft like that shown in our Patent No. 2,460,022 in that the cartridge is pre-shaped to almost final condition before its entrance into the bore of the shell. Thus the simple shell and the pre-shaped cartridge provide a most simple manner of assemblage capable of utilizing relatively unskilled labor.

The tip 22 is of stainless steel, the ring 38 of nickel and the ring is of some depth for wear and tear; the inner sleeve 50 is of softer copper than the harder copper of the sleeve 51 using in the preferred form an admixture of beryllium; the sleeve 30 is of copper which is moldable or compressible under the radially inwards pressure applied, and preferably is such as not to flow too easily and beyond the surface 16 of the shell, and we have obtained good results by using a beryllium copper sleeve 30, which while hard has still its modulus of elasticity or compressibility under the pressures applied radially inwards. Carbon steel is used for the shell 10.

When the successive and progressive radially inward pressure method is used, all the compression work is done on the cartridge outside of the shell, and thus the shell is safeguarded against the possibility of springing open, or from being subjected to excessive strains and stresses, which may affect its heat conductivity or its inherent resiliency.

Spark plugs made under the disclosure of our Patent No. 2,471,070 have given excellent ratings of over 400 and passed the endurance tests; and it is believed that spark plugs made in accordance with this disclosure will be of higher rating and also present improvements in production and assembly.

Spark terminals extending outside of the shell are known, but the improvement of this part of the spark plug is to extend the parallel surface spark gap outside of the shell enabling a cleaning tool to be inserted between the parallel surfaces of the kind disclosed in U. S. Letters Patent No. 2,357,602 of September 5, 1944 to Melville F. Peters and Fred I. McCarthy.

It will be noted that the spark gap terminal is made a part of the sleeve extension 33, this having heretofore been part of the shell; and thus a much quicker heat transfer takes place. It will also be noted that the moldable sleeve action is direct on the covered stem, without any intermediate parts. The stem may be provided with a silver or part silver core to increase the heat conductivity of the stem and dissipate the heat of the sparking tip.

The improved spark plug is specially intended for high altitude flights (30,000 feet) where the motor gets hot and thus the sparking terminals expand and somewhat reduce the gap which is advantageous. The ring 38 is responsive to the extension 33 expansion, and the tip 22 to the tip and stem expansion.

When the cartridge is about to be inserted in the shell the pressure P is applied to the cartridge which pressure is about 5000 pds. to bring home the cartridge in the shell.

The initial diameter is reduced about .004 with each radial compression.

In the finished spark plug, the spaces formed by the rounded portions 36 and 37, are filled with cement, in the known manner.

We have described several forms of our invention, but obviously various changes may be made in the details disclosed without departing from the spirit of the invention as set out in the following claim:

We claim:

In a spark plug having a central stem one end of which forms a spark tip, an insulating layer around the main portion of said stem, a compression member surrounding the insulating layer having a flat surface forming a spark tip, and having a circumferential cylindrical cutout with a curved surface at its inner end, and a shell enclosing the compression member and in electrical connection therewith, said spark tips extending outside of the shell, the combination of a circular shoulder on the spark tip end of the stem abutting against an end of the insulating layer, a circular groove in said spark tip end exterior to said shoulder, a flat surface circumferentially and radially disposed around said circular groove and parallel with said flat surface of the compression member, and spaced therefrom to form a spark gap, and a porcelain cylinder seated at one end in the circular groove and huggingly surrounding the end portion of the insulating member on the shoulder, and forming the inner wall of the spark gap, the other end of the porcelain cylinder being in said cut out and seated against its curved surface.

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CHARLES SCHANDLER.

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