Jan. 25, 1949. F. I. McCARTHY ET AL 2,460,022

SPARK PLUG

Filed Oct. 23, 1944

Fig. 1.

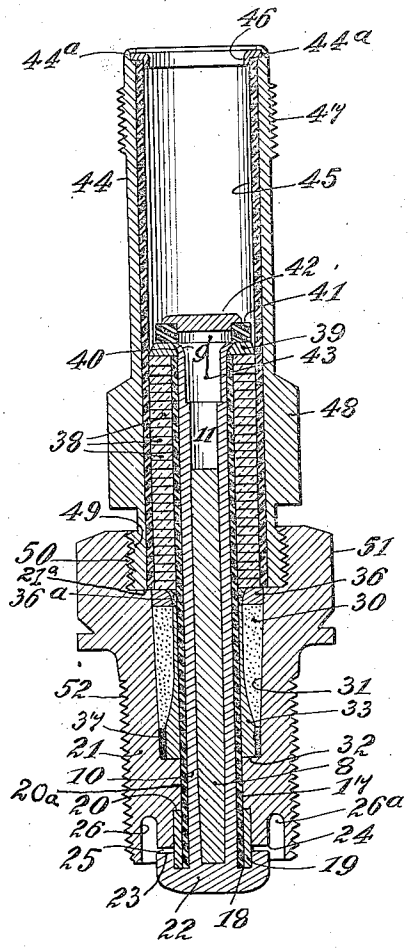


Fig. 2.

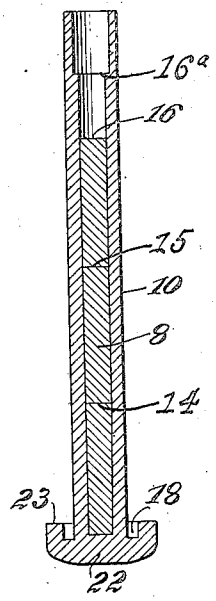


Fig. 3.

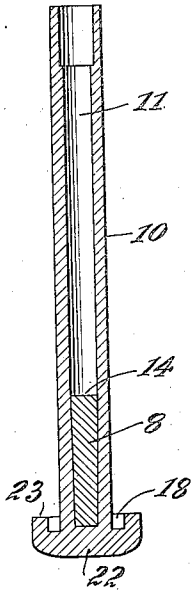


Fig. 4.

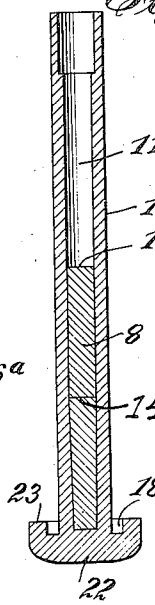


Fig. 6.

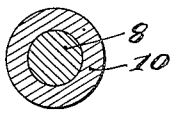


Fig. 5.

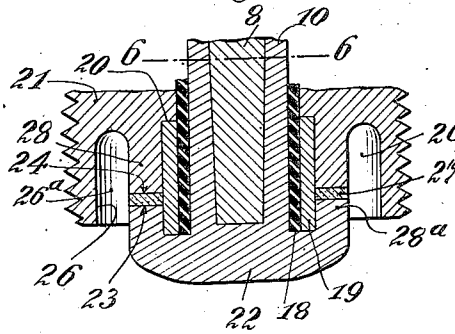
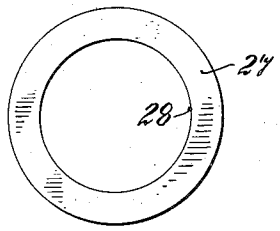


Fig. 7.



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SPARK PLUG

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4 Claims. (Cl. 123—169)

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This invention relates to spark plugs and more particularly to special means increasing the dissipation of heat from the electrode cap to the parts of the spark plug which dissipate the heat.

The immediate object is the provision of means giving the best possible efficiency of heat transfer with the provision of means giving the best possible efficiency of electrical conduction, without these functions conflicting with each other, or one diminishing the other.

For this purpose the invention consists of a spindle having a bore filled with a compact of compressed silver powder, the bore extending beyond a compact of powdered copper and silver located at about one half the length of the silver compact in the spindle, whereby the heat of the electrode cap is quickly transmitted to the copper and silver compact, and from there to the heat dissipators of the spark plug.

Also, the invention consists of a spacer washer in the spark gap to resist a closing of the spark gap when the copper and silver powder is being compacted, which washer is then removed after the spark plug is completed, the washer maintaining the proper dimension for the spark gap and preventing the breaking of a porcelain sleeve acting as an insulator.

The invention will be further described, embodiments thereof shown in the drawings, and will be finally pointed out in the claims.

In the accompanying drawings,

Figure 1 is a central vertical section of a spark plug embodying the invention;

Figure 2 is a central vertical section of the improved electrode spindle, completely filled;

Figure 3 is a central vertical section of the improved spindle filled about one third;

Figure 4 is a central vertical section of the improved spindle filled about two thirds;

Figure 5 is an enlarged fragmentary section of the electrode cap and spark gap parts;

Figure 6 is a horizontal section taken on line 6—6 of Figure 5, and

Figure 7 is a plan view of the spacing washer.

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

Referring to the drawings, the spark plug shown in Figure 1, has the usual and known elements, with the improvement hereinafter claimed embodied therein.

The improvement consists in providing the spindle or stem 10 for the electrode with a bore 11 extending from the electrode cap 22 to the other end of the stem, and filling this bore 11 almost throughout its entire length with a tightly compacted metallic powder, such as silver, having the highest conductivity of heat. This powder is compacted very tightly by pressure and compression, so as to form substantially a solid 8. As

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such a powder is flocculent and thus takes up a considerable volume before its compression to the extent necessary, the present day method is to compact it in three stages. In Figure 3, is shown the first stage indicated to height shown generally by 14. The second stage is shown in Figure 4, indicated by the height shown by 15, and the final stage is shown in Figure 2, indicated by the height shown by 16. The compression top indicated by 14 in Figure 4 disappears when the next stage is added. Likewise, the line 15 disappears in Figure 2. These lines are shown for clarity, though a merger of the charges takes place. There may be, however, a slight variation in compactness, the top of one charge and the adjacent botom of the next upper charge as compacting of metal powder depends on forces applied and their reactions. For practical purposes, the charges of Figure 2 act as one integral piece. The compression is such as to avoid all air spaces in the compressed material and between it and the walls forming the bore. The compacted inlay is of silver, and the surrounding hollow spindle and cap 22 is made of stainless steel.

Surrounding the spindle is a closely fitting cylinder 17 of insulating material, preferably mica sheets wound spirally around the spindle, which extends from the cap 22 or lower end of the spindle to the upper end of the same to below a bent over outwardly flaring portion of the upper end of the spindle as at 9. The cap 22 of the spindle has a circular recess 18 for the entrance of the lower end of this insulating cylinder 17. For electrical purposes it is important that this insulating cylindrical sleeve be firmly seated in the recess 18, and be tightly wound with the edges tightly abutting, to prevent electrical leakage. The recess 18 is sufficiently wide in the embodiment shown, to accommodate also a cylindrical sleeve 19 of porcelain or the like, insulating material which has its lower end seated in the recess 18, and which extends upwardly to seat against a shoulder 20 in the exteriorly screwthreaded member 21. This porcelain sleeve 19 is used as a spacer for the spark plug and as a protector placed at the inner end of the spark plug, to guard the exterior of the mica cylinder 17 from spotting. The spacer action is now less important in view of the following.

The cap 22 has a plane circumferential surface 23, which is parallel with a plane circumferential surface 24, of the member 21, and these surfaces are spaced from each other to form a spark gap 25. The member 21 has a circumferential recess 26, the depth and width of this recess determining the temperature of the circumferential space 25*a*, to maintain the proper heat balance.

Another improvement is the provision of a

spacing disc 27, as shown in plan in Figure 7, the interior opening 28 of which has substantially the same diameter as the external diameter of the cylinder 19, and the exterior perimeter of which has the same diameter as the external diameter of the cap 22 and of the extension 28 of the member 21, which are in alignment. The thickness of the disc 27 is slightly larger than or equal to the space of the spark gap 25. This disc 27 is made of cellulose acetate, and it may be readily dissolved by a suitable and known solvent such as acetone, and when so dissolved, the spark gap is free from any intervening material. At the same time, the surfaces 23 and 24 are clean.

The washer 27 acts as resistor to the closing of the spark gap, which has been found to take place when the metal power is pounded and compacted to the inlay 30. The presence of the washer prevents this closing of the gap. Heretofore, a closing of the gap broke the ceramic cylinder 19. The use of the washer 27 prevents any compression upon the ceramic cylinder 19, if used. Heretofore, the ceramic cylinder determined the width of the spark gap, but now the washer assures the exact width of the spark plug within tolerances.

Above the spark gap region, the member 21 is provided with a shoulder 32, which forms the bottom of a conically shaped bore 31 of the member 21, which bore 31 extends to an upper shoulder 21*a*. After the spindle with its surrounding mica insulator has been inserted into the member 21, a conical sleeve 33 of metal is slipped down over the mica covered spindle. Powdered metal, such as a mixture of copper and silver is then charged into the remaining space between the exterior of the sleeve 33 and bore 31. To prevent the powdered metal from being forced between the shoulder 32 and the bottom of the sleeve 33, there is first inserted a small charge of mica powder and this is tightly stamped and compressed and forced into the space 37. Part of this may be forced to the mica sleeve 17, and thus form an efficient protector for the sleeve and prevent any metal powder from entering the mica sleeve and cause electrical leakage or a short. The mica filled space 37 prevents any metal powder from falling between the mica cylinder 17 and the bore 29*a*, and into the ceramic cylinder and into the spark gap.

The conical shaped sleeve 33 extends upwardly in tapering form to the upper part of the bore 31, and the internal bore of which sleeve hugs the exterior of the insulating sleeve 17. Between the exterior of the sleeve 33, and the bore 31, the intervening space is filled with a metallic power such as silver and copper in preferably equal proportions, tightly compacted by pressure to remove all possibility of air spaces between the particles of the powder and to form a solid of the metal. The metal inlay also prevents air between it and the wall of the bore 31. The sleeve 33 is pressed tightly against the mica sleeve 17 when the copper and silver is compacted. The sleeve is preferably of copper or copper and silver alloy. In place of a tapering sleeve, the sleeve 33 may be of cylindrical shape, as it is largely a protector for the exterior of the mica sleeve, which mica cannot resist sufficiently the high compacting pressures applied to the powder.

The compacted metal 30 is then capped with a washer 36 of copper or of copper and silver alloy, which has preferably a curved portion,

forming a space 36*a* with the exterior of the insulating sleeve 17, which space is filled with a suitable cement.

A plurality of mica washers 38 are piled upon the copper washer 36, which extend upwardly to the upper end of the mica sleeve 17, both of which are capped by a washer 39 of brass, which has a curved inner contour 40, over which the upper end of the spindle 10 is bent and outwardly flared as at 9. Above the washer 39, is a washer 41 of insulating material, the circular opening of which has a corklike top piece 42 of brass, fitting therein. The chamber 43 acts as a spark gap for the spark passage from the bent end 9 to the top piece 42. The interior of the upper part of the spindle is provided with a thinning 11*a* which forms a shoulder, and which thinning enables the bending and flaring to be carried out as at 9.

The action of this sparking is described in U. S. Letters Patent No. 2,357,602 of September 5, 1944, issued to Melville F. Peters and Fred I. McCarthy.

Within the limitation of electrical conductivity, the difficult problem is the removal of heat and the prevention of leakage of gases. Air being a bad conductor of heat, must be removed from the path of heat flow; and the passage of heat from the heated electrode cap 22 is the second criterion. To carry out these concepts the metal 30 is so compacted as to remove all air pockets, and the compacting of the metal powders of silver and copper in the bore of the member 21, brings about reactions of compression between the rather solid, and therefore pressure resisting walls of the member 21, and the exterior of the thin sleeve 33. This is rather thin and the pressure is readily transmitted to the mica insulating sleeve and to the exterior of the spindle 10, and through the spindle walls to the inlay 8 of compacted silver. This inlay by the high pressures applied is also free from air pockets. As the bore of the spindle 10 is filled to about the level 16, the pressure applied very slightly expands the walls of stainless steel spindle, but not sufficient to interfere with the assembly of parts as described and as shown in Figure 1, or sufficient to provide a wavylike exterior to the spindle.

The foregoing actions have been emphasized to bring out intimate contacts under forces of pressure, which aid the flow of heat from the silver inlay 8 to the compacted metal 20 and to the member 21 and shell 44, which latter dissipate the heat. The heat flow is subject to the heat resistance of the mica sleeve which is made as thin as possible, yet assuring a proper insulation for the electric conductivity of the spark plug.

Surrounding the mica washers 38 and the parts just described is a sleeve 45 of mica, which extends from the copper washer 36, and the shoulder 21*a* upon which it rests, to the uppermost end of the shell 44 of the spark plug. A circular recess 44*a* in the shell 44 seats an angular annulus 46, capping the end of the mica sleeve 45. The shell 44 is exteriorly screwthreaded at 47, and has an enlargement of hexagonal shape at 48, and has an exterior screwthreaded portion 49, which engages interior screwthreads 50 of the member 21. The member 21 is provided with an enlargement 51 of hexagonal shape and has screwthreads 52 to enter the screwthreads of the motor cylinder.

It is important to conduct the heat quickly

from the cap 22 to the locality of the inlay 8. For this purpose, the bore extends down to as low a part of the interior of the cap as manufacturing conditions permit. The silver inlay has a quick conductivity of heat and the heat quickly passes to a position in the inlay opposite to the metal compact 30, which being of copper and silver has a quick heat transmission factor. The thin stainless steel spindle transmits heat quickly in a direction transverse thereto. However, the spindle does not transmit heat longitudinally as quickly as the inlay does. So, the new function is the quicker transmission of heat within the bore of the stem or spindle, than that of the hollow spindle itself or a spindle made solid. The extension of the inlay above the locality of the compact 30 is to act to conduct the heat beyond the locality, from which upper part the heat is also withdrawn. Furthermore, the co-relationship of conductivities of heat and electrical current, facilitates the electric flow to the upper end of the spindle in proximity to the positive lead-in conductor at 42.

The electrical conductivity of silver and copper at 0° C., with silver as a standard is 100% for silver, and 99.9% for copper. Silver and copper have the smallest resistance for a given volume. As the electrical conductivity of metals is diminished by an increase in temperature it is important to dispose of the heat, and this is availed of by reason of the subtraction of heat from the spindle at the locality of the part 30.

The heat conductivity of the stainless steel spindle is less than that of the silver. The steel of the lower shell is preferably of carbon steel of about 1045, which emits heat quickly.

As is known, the electrical pole of one polarity is connected with the lower shell or member 21, which by the screwthreads 50 is connected with the upper shell 44. The pole of opposite polarity is connected with piece 42, which is in electrical connection through the sparking chamber 43, with the spindle 10, and cap 22. These polarities must be separated in all events and electrical leakage prevented, and this is carried out by the longitudinally extending mica cylinder 17, which is intermediate the spindle 10 and the parts 21 and 44, augmented by the mica cylinder 45 and washers 38.

Gas leakage is prevented by the actions of forces in a lateral, or in respect to Figure 1 horizontal direction, with the tightly compressed portion of the mica cylinder 17 between compacted metal 30, and the compacted inlay 8.

Heat transfer is obtained from the heated cap 22 immediately to the silver inlay, to the region or zone of the compacted metal 30, and to the members 21 and 44, through the laterally thin spindle wall 10, laterally thin mica layer, and laterally thin sleeve 33. Mica is a poor heat conductor, but an excellent electrical insulator, but whatever heat is passed is immediately conducted to the metal 30, the silver and copper of which provides a quick transfer of heat to the shell.

Spark plugs of the kind shown in Figure 1, have given a very high rating of 381 (IMEP test).

In the drawings, the silver inlay has been shown to about the line 16, but the inlay may be extended to the shoulder 16*a*, or above, if the shoulder be raised.

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 claims.

We claim:

1. In a spark plug, the combination of an exterior heat dissipating shell having a central bore and a larger diametered bore concentric thereto, and having an electrode for one polarity, a spindle extending through the central bore of the shell having an electrode for another polarity at one end, and having a hollow bore extending from the electrode to its other end, and an insulator between the spindle and the central bore, insulating the opposite polarities, said electrodes being disposed at spark gap distance from each other, said larger bore of the shell being filled with compacted and compressed powder containing silver forming a solid without air spaces and free from air spaces between the solid and the larger bore and between the solid and the insulator, and a compact of compressed silver powder in the bore of the spindle, extending from its electrode to beyond the compact of the shell bore, whereby a heat exchange action takes place through both compacts from the spindle electrode to the shell.

2. The structure of claim 1, and a washer surrounding the insulator, with a curved inner part above the compacted powder in the shell bore, and an insulating filling between the curved inner part and the insulator.

3. The structure of claim 1, and a metallic sleeve interposed between the metal powder compact in the shell bore and the insulator, and a filling of insulating material between the sleeve and the wall of the bore of the larger shell.

4. In a spark plug having an exterior heat dissipating steel shell having coxial bores each with a vertical wall, one bore having a larger diameter than the other, said shell having a sparking tip for one polarity, a spindle extending through the bore of the shell having at one end a sparking tip for another polarity, and an insulator around the spindle between it and the wall of the smaller bore, the diameter of the spindle and its insulator being substantially equal to the diameter of the smaller bore for insulating the opposite polarities, the wall of the larger bore being spaced from the spindle with its insulator, said sparking tips being disposed at spark gap distance from each other, a conical metal sleeve having its base rest on the bottom wall of the shell forming the larger bore and having its inner bore diameter substantially equal to the outer diameter of the insulator, and surrounding the insulator, and a metal filling between said sleeve and the vertical wall of the larger bore, the combination of a cylindrical outer wall at the lower end of said sleeve, and a ring of insulating material between said cylindrical outer wall and the vertical wall of the larger bore, and resting on the bottom wall of the shell.

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CHARLES SCHANDLER.

REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
2,139,793	Benton	Dec. 13, 1938
2,186,038	Peters	Jan. 9, 1940
2,280,972	Paulson	Apr. 28, 1942
2,357,602	Peters et al	Sept. 5, 1944
2,377,481	Christie	June 5, 1945