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SPARK PLUGS

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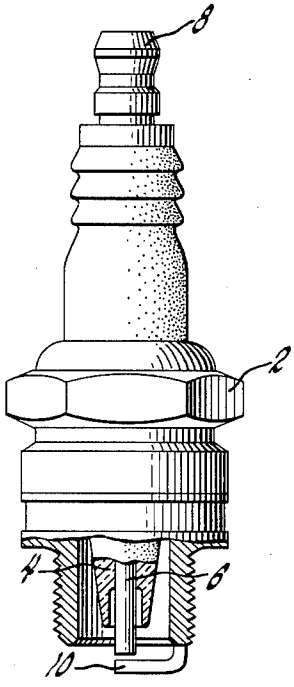


Fig. 1

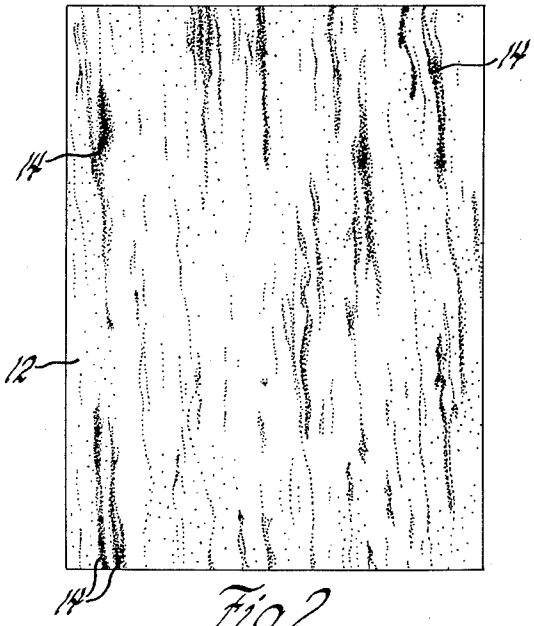


Fig. 2

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SPARK PLUGS

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This invention relates to spark plugs and has as one of its objects the provision of a spark plug with an improved electrode. More specifically, it is an object of the invention to provide a spark plug with an electrode formed of a material having high heat and erosion resistance as well as an exceptionally high heat conductivity. Another object is the provision of a method for making improved spark plug electrodes.

Principally because of its good heat and spark erosion resistance, the most commonly used material for present day spark plug electrodes is nickel. But with regard to one particular property, that of heat conductivity, nickel is far from ideal since for optimum electrode life a material having a much higher heat conductivity than that of nickel is desirable. Cobalt is somewhat similar to nickel with respect to its uility as a spark plug electrode material, though it is not widely used for this purpose, for one reason because of its higher cost.

In accordance with this invention, spark plug electrodes are made of a material consisting essentially of from about 5% to 30% (by weight) silver and the remainder substantially all either nickel or cobalt or an alloy of the two. Nickel is much desired over cobalt; the preferred electrode is about 10% silver and the remainder substantially all nickel.

The material is not a sliver alloy in the full sense since silver has a very low solubility in nickel and cobalt and thus occurs predominantly in its unalloyed state, preferably as elongated stringers which extend axially of the electrode, this as will be more specifically described hereinafter. We have found that the inclusion of the silver greatly improves the heat conductivity and is without detrimental effect on the high heat and spark erosion resistance of the nickel or cobalt. Thus the over-all result is an electrode having a much longer life under spark plug operating conditions than does nickel or cobalt alone. These and other aspects and advantages of the invention will appear more clearly from the following detailed description thereof made with reference to the appended drawing in which:

FIGURE 1 shows a side view in partial section of a spark plug embodying the invention; and

FIGURE 2 is an enlarged diagrammatic view of the metallurgical structure of the electrode in the spark plug shown in FIGURE 1.

Referring now to FIGURE 1, the spark plug shown comprises a conventional metal shell **2** in which there is tightly secured a generally tubular shaped ceramic insulator **4**. A center electrode **6**, which is secured within the insulator, is electrically connected to the terminal **8** and has a lower tip portion which extends into spaced, spark gap relationship with the ground electrode **10** which is secured by welding to the bottom of the spark plug shell. The present invention relates to the material for both of the electrodes **6** and **10**, but finds particular utility in connection with the center electrode.

In accordance with the invention the center electrode **6** consists essentially of from 5% to 30%, preferably 10%, silver and the remainder either nickel or cobalt or alloys thereof, but preferably nickel. It will be understood, of course, that the nickel used to make the electrode need not be pure nickel but may in some instances be in the form of a nickel base alloy. Hence, the nickel

may contain minor additions, totaling not more than about 5% by weight, of alloying constituents as are frequently used in conventional nickel spark plug electrodes, for example minor amounts of manganese, chromium and the like and also perhaps a small amount of barium which is sometimes used in nickel spark plug electrodes to improve certain of the electrical characteristics. Where cobalt is used it may likewise contain such minor amounts of alloying additives. The precise metallurgical structure of the electrode will be best understood from the following description of our preferred method for its manufacture.

A quantity of from 100 to 325 mesh nickel powder is mixed with a quantity of from 100 to 325 mesh, preferably about 250 mesh, silver powder, the proportions used being such as to provide the exact percentage of silver desired. After thorough mixing the powder batch is pressed into a bar-shaped billet at about 40,000 pounds per square inch pressure and the billet then sintered in a reducing atmosphere such as hydrogen at about 2000° F. In accordance with conventional practice a small amount of a suitable lubricant such as hydrogenated cottonseed oil may be included in the raw powder batch to facilitate the pressing operation. After sintering, the bar should preferably be repressed again at about 40,000 pounds per square inch to increase the density and decrease the porosity thereof, and then annealed at 1750° F. in a reducing atmosphere. Since silver is relatively insoluble in nickel, there is very little alloying during these operations and thus the silver remains as dispersed particles in the sintered product. Subsequently the bar may be swaged cold to a diameter of about $\frac{1}{10}$ inch through a series of dies, the material thereby becoming more dense and nonporous. Frequent anneals may be given between swaging passes at temperatures of about 1550° F., the lower temperatures being desirable here to prevent sweating of the silver from the wire as it becomes more dense. After the swaging operation the silver remains as a separate constituent in the wire, it being present now in the form of elongated stringers or fibers which extend longitudinally of the wire. This is shown in FIGURE 2, the nickel being the matrix material **12** and the silver stringers being shown at **14**. These stringers **14** serve as network of very high heat conductivity cores. Thus the wire itself exhibits a high heat conductivity from one end to the other thereof along its longitudinal axis.

The exact mesh sizes used in the raw powder batch are not critical though the above-specified sizes are desirable in order to obtain the best network of silver stringers in the final product. Where cobalt or cobalt-nickel alloys are used in place of nickel the temperatures and pressures used may be substantially the same as those above, though with pure cobalt somewhat higher temperatures for the sintering operation may be used to advantage. It will be understood that the method is not limited to the use of nickel or cobalt since other hard, high heat-resistant metals in which silver is substantially insoluble may be used, reference being made, for example, to copending application United States Serial No. 826,007 filed July 9, 1959, in the names of Karl Schwartzwalder and Raymond E. Schwyn, and assigned to the assignee of the present invention and which is now U.S. Patent No. 2,992,353, granted July 11, 1961.

The wire can be subsequently cut to the desired length or otherwise shaped as necessary to form the spark plug center electrodes. If desired, the wire may be used for the spark plug ground electrode **10** though such is generally not necessary since in most types of spark plugs the ground electrode has a very short heat path to the metal shell, and hence an exceptionally high heat con-

ductivity in the ground electrode will serve to no great advantage.

In addition to increasing the heat conductivity, the silver also increases to some extent the electrical conductivity of the wire. The silver has no adverse effect on the high spark erosion resisitance and good wear characteristics of the nickel or cobalt. Thus the invention provides a spark plug having an electrode of higher heat conductivity without any sacrifice in other desirable properties.

It will be understood that while the invention has been described with reference to a particular embodiment thereof, changes and modifications may be made, all within the full and intended scope of the claims which follow.

We claim:

1. In a spark plug, the improvement which comprises an electrode consisting essentially of about 10% by weight silver and the remainder substantially all nickel, at least a major portion of said silver being unalloyed and present as a network of elongated stringers which extend generally parallel to the longitudinal axis of the electrode.

2. In a spark plug, the improvement which comprises an electrode consisting essentially of about 5% to 30% by weight silver and the remainder substantially all a metal selected from the group consisting of nickel, cobalt and nickel-cobalt alloys, at least a major portion of said silver being unalloyed and present as a network of elongated stringers which extend generally parallel to the longitudinal axis of the electrode.

3. In a spark plug, the improvement which comprises an electrode consisting essentially of about 5% to 30% by weight silver and the remainder substantially all nickel, at least a major portion of said silver being unalloyed and present as a network of elongated stringers which extend generally parallel to the longitudinal axis of the electrode.

4. In a method for making a spark plug electrode, the steps of forming a uniform mixture of about 5% to 30% by weight silver powder and the remainder a powder of a hard, high heat-resistant metal in which the silver is substantially insoluble, pressing and sintering said mixture to form a compact coherent body wherein the silver occurs as discrete particles in its unalloyed state, and then drawing said body to cause an elongation and a reduction in the cross section thereof and to simultaneously form the silver into a network of elongated stringers which extend generally parallel with the longitudinal axis of the drawn body.

5. In a method for making a spark plug electrode, the steps of forming a uniform mixture of about 5% to 30% by weight silver powder and the remainder a powder of a hard, high heat-resistant metal in which the silver is substantially insoluble, pressing and sintering said mixture to form a compact coherent body wherein the silver occurs as discrete particles in its unalloyed state, pressing said body to reduce the porosity and increase the density thereof, and then drawing said body to cause an elongation and a reduction in the cross section thereof and to simultaneously form the silver into a network of elongated stringers which extend generally parallel with the longitudinal axis of the drawn body.

6. In a method for making a spark plug electrode, the steps of forming a uniform mixture of about 5% to 30% by weight silver powder and the remainder a powder of a hard, high heat-resistant metal in which the silver is substantially insoluble, pressing and sintering said mixture to form a compact coherent body wherein the silver occurs as discrete particles in its unalloyed state, pressing said body to reduce the porosity and increase the density thereof, annealing said body, drawing said body to cause an elongation and a reduction in the cross section thereof and to simultaneously form the silver into a network f elongated stringers which extend generally parallel with the longitudinal axis of the drawn body, and again annealing said body, this time at a temperature lower than that of the previous anneal in order to prevent separation of the silver from the other metal in the drawn body.

7. In a method for making a spark plug electrode, the steps of forming a uniform mixture of about 5% to 30% by weight silver powder and the remainder nickel powder, pressing and then sintering said mixture at about 2000° F. to form a compact coherent body wherein the silver occurs as discrete particles in its unalloyed state, pressing said body to reduce the porosity and increase the density thereof and then drawing said body to cause an elongation and a reduction in the cross section thereof and to simultaneously form the silver into a network of elongated stringers which extend generally parallel with the longitudinal axis of the drawn body.

8. A spark plug comprising a metal shell, a ceramic insulator in said shell having a centerbore therethrough and an electrode in said centerbore, said electrode consisting essentially of about 5% to 30% by weight silver and the remainder a hard heat resistant metal in which said silver is substantially insoluble, at least a major portion of said silver being unalloyed and present as a network of elongated stringers which extend generally parallel to the longitudinal axis of the electrode.

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