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IGNITION PLUG AND METHOD FOR MANUFACTURING A CENTER ELECTRODE FOR THE SAME

Filed Nov. 14, 1968

FIG. 1

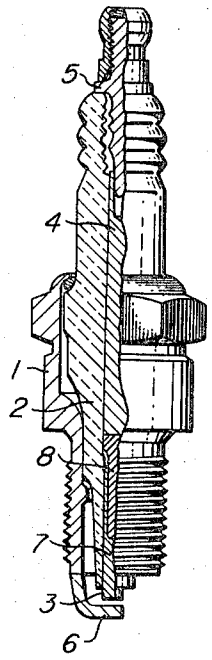



FIG. 3

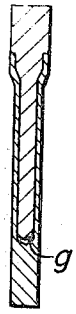
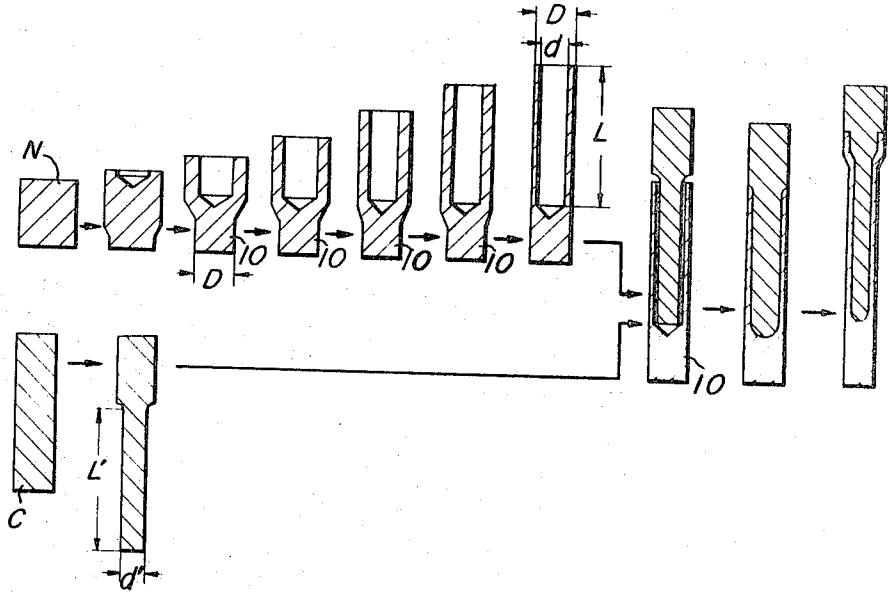



FIG. 2




INVENTORS
HISASHI URUSHIWARA
HIROSHI MORINO
HISAO SUZUKI

BY Craig & Antonelli
ATTORNEYS

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# IGNITION PLUG AND METHOD FOR MANUFACTURING A CENTER ELECTRODE FOR THE SAME

Hisashi Urushiwara, Hiroshi Morino, and Misao Suzuki, Hitachi-shi, Japan, assignors to Hitachi, Ltd., Tokyo-to, Japan

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## ABSTRACT OF THE DISCLOSURE

A method for manufacturing a center electrode for use in ignition plugs and of the type that a metal such as copper having a relatively higher heat-conductivity is inserted and buried in the closed end-tube portion of a corrosion-resistant metal such as nickel, said method comprising first subjecting two kinds of starting materials, i.e. a copper rod and a nickel rod, to cold working separately into shapes near to the desired dimensions, and thereafter assembling them together and subjecting this assembly to cold working into the required final dimensions.

## BACKGROUND OF THE INVENTION

### (a) Field of the invention

The present invention is concerned with a method for manufacturing a center electrode for use in ignition plugs, and more particularly, it relates to a center electrode manufacturing method in which a metal such as copper having a relatively higher heat conductivity is inserted and buried completely in the closed end-tube portion of a corrosion-resistant metal such as nickel.

### (b) Description of the prior art

In the past, center electrodes of the type that a metal having a relatively higher heat conductivity is inserted and buried in a corrosion-resistant metal have been manufactured by either of the following two kinds of manufacturing methods. According to one of them, a bore is formed in the closed end-tube of a corrision-resistant metal, and thereafter, a core metal having a relatively higher heat conductivity is inserted in this bore, and then these two metals are joined together by soldering. In another of the known methods, a piece of metal is superposed in another metal of a different kind in a cold extrusion mold, and utilizing the flow effect of these metals which takes place during their cold-working, the metal pieces are drawn together so that the core metal piece is enveloped by the corrosion-resistant metal piece.

While the former of these conventional methods is of the advantage on the one hand that the core metal can be worked into any desired shape, it has the drawbacks that the manufacture requires complicated procedure and a high cost and also that, accordingly, this prior method is not suitable for mass production.

The other of the conventional methods bears the advantage that it consists of fewer working steps and that the two kinds of metal pieces can be tightly joined together. However, this latter method or the prior art is so designed that the core metal is inserted in the envelope metal by utilizing the known phenomenon that when a workpiece is cold-extruded, the center portion of this workpiece is caused to advance beyond its peripheral portion which is in contact with the wall face of the die, owing to the friction resistance created between the wall face of the die and the workpiece contacting therewith, and accordingly there arise the following disadvantages



that the core metal cannot be worked and formed into the desired shape and clearance is formed between the top of the core metal and bottom of the bore that both the depth of the insertion and the shape of the inserted core will lack uniformity among the products thus manufactured even when cold working is carried out under the same conditions for all of these products.

In addition to the above inconveniences, this latter method has the following drawbacks that, in the stage of operation a little before the completion of the working, there occurs a loss of balance between the sustaining force of the corrosion-resistant metal and the pressure under which the core metal is inserted in this corrosion-resistant metal, and that this loss of balance will give rise to the slippage of the corrosion-resistant metal in the extrusion die, unavoidably causing portions of reduced diameters to develop in the bottom region of the core metal which is inserted in the envelope metal. These portions of reduced diameters will undesirably reduce the heat conductivity of the core metal.

In order to avoid the development of this portion of reduced diameter, it may be considered effective to insert the core metal piece to a shallow depth while increasing the pressure which is applied to the workpiece during its working. However, such an attempt will only lead to the breakage of the workpiece which is being worked. Therefore, the attempt of increasing the depth of insertion will bring about no desirable effect at all.

For the foregoing reasons, the adoption of the center electrodes which are processed according to this latter known method will only contribute to making the mass production of ignition plugs having a high and uniform heat value difficult.

There may be considered a method to process the workpiece by the hot working method, however this working method will encounter the problems such as the development of an oxide film on the surface of the workpiece during its working and the loss of precision in the products manufactured. Therefore, this hot working method is not applicable to practical purposes.

## SUMMARY OF THE INVENTION

It is, therefore, one of objects of the present invention to provide a method for manufacturing center electrodes which are suitable for being used in the production of ignition plugs having desired thermal values, in a manner satisfying the requirements of mass production system and at a low manufacturing cost.

Another object of the present invention is to provide a center electrode manufacturing method, which is capable of controlling the amount of the core metal to be inserted relative to the amount of the corrosion-resistant metal which serves as the envelope for the core metal and also of controlling the shape of the core metal to be inserted in said corrosion-resistant metal, to any desired amount and shape even where the working is performed on a mass production basis.

The distribution of the two kinds of metals which are located in the region of the center electrode which is worked according to the method of the present invention is desirably such that, in order to enhance the heat value of the ignition plug, the core metal having a relatively higher heat conductivity is inserted and buried deep in the corrosion-resistant hollow metal rod without any appreciable change in the diameter of the electrode throughout the length of this electrode in the portion which is inserted and buried in the corrosion-resistant envelope metal.

By the employment of the center electrode which is manufactured in such a way that both the insertion depth and the diameter of the core metal piece to be inserted

will assume constant values, it becomes possible to easily control the heat values of the ignition plugs to desired levels without causing any fluctuation in these values even where the ignition plugs are produced in large quantities.

The plane of contact between the two kinds of metal may be desirably such that the faces of these two kinds of metal are in the state of being connected firmly to each other, and this is so from the viewpoint of insuring the protection of the electrode from corrosion and firmly holding of the envelope metal.

## BRIEF DESCRIPTION OF THE DRAWING

FIG. 1 is a longitudinal sectional view of the ignition plug of having an improved center electrode according to the present invention;

FIG. 2 is an illustration, showing the respective stages in which the center electrode of the present invention for use in ignition plugs is worked; and

FIG. 3 is a fragmental illustration for the convenience of explanation of the steps of such working.

## DESCRIPTION OF THE PREFERRED EMBODIMENT

The present invention will hereunder be described in further detail by referring to the drawing.

In FIG. 1, reference numeral **1** represents a shell made of anticorrosive metal; **2** represents a refractory insulator; **3** represents a center electrode; **4** represents a central rod; **5** represents a terminal stud; and **6** represents an outer electrode. The central electrode **3** is made with a hollow member **7** which consists of a corrosion-resistant metal and with a core member **8** which consists of a metal having a relatively higher heat conductivity. This center electrode **3** is of a structure such that the lowermost end edge of the hollow member **7** forms a discharge face, with a clearance being interposed from the inner face of the grounding electrode **6**, while on the other hand, the core member is connected to a central rod **4** which also consists of a heat conductive metal such as copper and iron. The term "cold working and cold extrusion" is used in the specification and claims to cover extrusion at a room temperature and above, but considerably below the fusion temperature of electrode materials.

The center electrode **3** is processed in the manner and the order as illustrated in FIG. 2.

To begin with, a starting material N consisting of nickel which is in the form of a round rod—which will be used as the corrosion-resistant metal—is subjected to two successive cold-extrusion workings to form it into a hollow body provided with a stem portion **10** having a diameter D. In the next four successive cold drawing processes, this hollow body is worked only in its hollow portion, leaving the stem portion **10** to remain in its form as it was initially shaped, until the whole hollow body will bear a straight external configuration which is represented by a uniform external diameter D, and also till it bears a uniform internal diameter *d* and a depth L of the bore of the hollow section.

Along with this working of the corrosion-resistant metal, a material C consisting of a round rod of copper which is of relatively higher heat conductivity and which will serve as the core metal is worked by cold extruding technique and is shaped into a core body which is of the structure that its smaller diameter portion is of a length L′ which is slightly greater than the depth L of the bore of the hollow member and that the external diameter *d′* of this core body is slightly smaller than the internal diameter *d* of the bore of the hollow member.

In the subsequent press-in step, the core member **8** is placed in the bore of the hollow member **7** in the mold, and this assembly of the two metal pieces is pressed



only slightly, with the result that these two members are united to each other to form an integral body. This working operation is performed in such a way that the core member **8** is first collapsed in the bore of the hollow member **7** owing to the pressure force which is applied thereto, till the core member conforms to the internal configuration of the bore of the hollow member. After this, the two members as an integral body are pressed together in the die. It is to be noted that the amount of this working which is performed is very small.

It should be noted also that, if arrangement is not provided in this press-in step to first collapse the core member in the bore of the hollow member, there will arise the following inconvenience.

Specifically, in case the core member and the hollow member are of a substantially corresponding diametrical dimension prior to the press-in operation, that is to say, in case there exists, prior to the press-in operation, a substantial clearance between the external circumference of the reduced diameter portion of the core member and the internal peripheral wall face of the bore of the hollow member, the pressure force of the press-in operation which is applied to the assembly of the two members will be sustained only by the upper edge of the hollow member and by the stepped portion of the core member, and accordingly, the portion of the body of the core member which is located within the bore of the hollow member will not be subjected to the force which will cause the entire face of said body portion of the core member to be connected uniformly with the internal peripheral wall face of the bore of the hollow member, with the result that the pressing of the assembly of these two members will end in an incomplete coherence between these two members as is represented by the clearance left therebetween.

The hollow member **7** and the core member **8** which have been united together in the form of an integral body in the above-described press-in step is then subjected to a heat diffusion step in order to adhere and connect metallurgically.

Omission of this hot diffusion step will unavoidably lead to the formation of the clearance *g* as shown in FIG. 3 in the subsequent cold extrusion step.

This space *g* is produced because, as is commonly known that a workpiece having a smaller diameter is harder to flow during its extrusion, only the hollow member **7** is pressed with a much greater force than that which is applied to the core member being accommodated therein.

In case there exists a space *g* between the hollow member and the core member or in case there is lack of perfect and complete cohesion between the two members, in the stage of operation before or after the hot diffusion step, there would undesirably develop corrosion in the interface of these two members **7** and **8** owing to the high temperature gas which is produced in said space *g* during the use of the ignition plug, causing the corrosion of the core member **8** and resulting in a marked reduction in the desired property of the ignition plug as a whole.

In the cold extrusion step following the aforesaid hot diffusion step, the assembly of the two members is processed to obtain predetermined dimensions.

Since, prior to the arrival of this assembly in said cold extrusion step, both of the hollow member **7** and the core member **8** have already been worked separately into a state in which these two have dimensions which are close to the final dimensions, it will be understood that the amount of working which is required in this cold extrusion step is only trivial and also that there will occur no separation of the connected faces of the walls of these two members in their inter-face.

The resulting composite assembly may, if required, be given a further heat diffusion process. In the manner as has been described, it is possible to insert and bury the core member which consists of a metal having relatively higher heat conductivity in the hollow member which

consists of a corrosion-resistant metal up to a desired depth and with a uniform diameter of the core member throughout the length of its inserted portion. In addition, these two members can be united together firmly to form a perfectly integral single body of a composite structure.

Hereunder will be described an example in which a good result was obtained by carrying out the following workings in accordance with the method of the present invention.

## EXAMPLE

A nickel rod (external diameter of 4.5 mm. x length of 6.1 mm.) was processed, by drawing the same 6 times, into a hollow body having the following dimensions, i.e. external diameter D of 3.4 mm. x length of 1.6 mm.; bore diameter *d* of 2.4 mm. x depth L of 12.0 mm. Along with this, a copper rod (external diameter of 3.3 mm. x length of 16.0 mm.) was worked in one drawing process into the following dimensions, i.e. diameter of the large diameter portion of 3.45 mm., diameter of the reduced diameter portion *d'* of 2.35 mm. x depth L' of 13.0 mm. The resulting copper rod was placed in the bore of the hollow nickel body, and this assembly was subjected to pressing to form an integral body having the following dimensions, i.e. external diameter D of 3.4 mm. x length of 25.0 mm. This integral body was then placed, for 1.5 hours, in a vacuum furnace which was held at the vacuum magnitude of $10^{-4}$ mm. Hg and at the temperature of 960° C. to thereby effect the diffusion of both metals into each other. Thereafter, the resulting integral assembly was placed in a mold and was extruded therefrom, with the result that the assembly was shaped into the desired shape of product having the following dimensions, i.e. diameter of the large diameter portion of 3.5 mm., diameter of the reduced diameter portion of 2.9 mm., overall length of 30.0 mm., length of the reduced diameter portion of 17.2 mm., and the depth of the core metal in the portion of the reduced diameter inserted in the envelope metal of 12.0 mm. x diameter of the reduced diameter of this latter portion of 1.9 mm. The core member inserted in the envelope member had a diameter of 1.9 mm., uniformly throughout the whole length up to the portion close to its foremost tip which is adjacent to the stepped part. Both of these two kinds of metals were noted to have been connected integrally throughout the inter-face of these metals.

By the employment of the central electrode thus formed, there can be manufactured an ignition plug having a desired thermal value.

The working steps in the method of the present invention are all performed in the form of cold work with the only exception of the heat diffusion step. However, the amount of working which is performed on the workpiece in each step is limited, and accordingly, the amount of the pressure which is applied to the workpiece during each working step is also small. Thus, it becomes possible to perform the working of the workpiece by the use of an ordinary working apparatus.

Also, in each of the various cold working steps, there may be employed a single working apparatus which is so designed as to perform several steps simultaneously. In such an instance, the overall pressure applied to the workpiece in the working performance will not amount to an undesirably high level.

The core member which can be employed in the method of the present invention may consist of a material which has been already worked into a hollow shape having an external diameter which is slightly smaller than the internal diameter of the bore of the hollow member and having been cut into an appropriate length.

Known ignition plugs include the type wherein the copper portion of the center electrode **3** is coupled, by welding or like means, to the copper rod which serves as the terminal stud **5**. For the manufacture of ignition plugs of this type, it is quite advantageous if the method of the present invention is employed. As has been clearly understood from the foregoing description, according to the method of the present invention, the amount of working a starting material into the large diameter portion of the core member is small or rather it may be said that the shape of the material will hardly undergo any substantial change till it is worked into the large diameter portion of the core member. Furthermore, the amount of force which is applied to the material in order to form the reduced diameter portion is also small. It is, therefore, possible to form the core member in the form of having the terminal stud portion integrally therewith by cutting the material rod into a length sufficient for including the length of the terminal stud portion also. By conducting the working in this way, the step of welding the core member to the central rod will become unnecessary.

In the working method of the prior art which was performed by utilizing the welding technique, not only was it necessary to shape the welded part of the workpiece after the welding process, but also it was quite difficult to align the center axes of both the terminal stud and the center electrode in one straight line, so that there was encountered a great difficulty in putting the integral assembly of this core member and said terminal stud in place in the insulating member **2**. According to the method of the present invention, however, there is no such inconvenience whatsoever that is encountered.

We claim:

**1.** A method for manufacturing a center electrode for use in ignition plugs by inserting a metal having a relatively higher heat conductivity into a corrosion-resistant metal and then shaping the resulting assembly into the electrode, said method comprising shaping, by several cold-workings, a first starting material consisting of a corrosion-resistant metal into an initial hollow member having dimensions near to the dimensions of the final hollow member required for forming the complete center electrode, while on the other hand shaping a second starting material consisting of a metal having a relatively higher heat conductivity into a core member and working the same into a shape conforming to the bore of said initial hollow member and placing said core member into said bore of the initial hollow member, lightly pressing the resulting assembly of said two members to form an integral body, thereafter connecting these two metal members of said assembly to each other by a heat diffusion process, and subjecting the resulting connected assembly to final cold working.

**2.** A method for manufacturing a center electrode for use in ignition plugs by first inserting a metal having a relatively higher heat conductivity into a corrosion-resistant metal and then shaping the resulting assembly into the electrode, said method comprising shaping, by several cold-workings, a first starting material consisting of a corrosion-resistant metal into an initial hollow member having dimensions near to the dimensions of the final hollow member required for forming the complete center electrode, while on the other hand shaping a second starting material consisting of a metal having a relatively higher heat conductivity into a core member and subjecting the same to cold working till the core member thus formed has a reduced diameter portion having an external diameter slightly smaller than the internal diameter of the bore of said initial hollow member and a length slightly greater than the depth of the bore of said initial hollow member, placing said core member into said bore of said initial hollow member, lightly pressing the resulting assembly of said two members to form an integral body, thereafter connecting these two metal members of said assembly to each other by a heat diffusion process, and subjecting the resulting connected assembly to cold working.

**3.** A method for manufacturing a center electrode for use in ignition plugs by first inserting a metal having a relatively higher heat conductivity into a corrosion-resist-

ant metal and then shaping the resulting assembly into the electrode, said method comprising shaping, by several cold-workings, a first starting material consisting of a corrosion-resistant metal into an initial hollow member having dimensions near to the dimensions of the final hollow member required for forming the complete central electrode; cutting, into a piece of a length for use as a core member, a second starting material consisting of a metal having a relatively higher heat conductivity and having an external diameter slightly smaller than the internal diameter of the bore of said initial hollow member, placing said core member into said bore of said initial hollow member, lightly pressing the resulting assembly of said two members to form an integral body, thereafter connecting these two metal members of said assembly to each other by a heat diffusion process, and subjecting the resulting connected assembly to final cold working.

4. A method according to claim 2, wherein said material consisting of a metal having a relatively higher heat conductivity is cut into a piece of a length including the length of said core member and also the length of a terminal stud, thereafter subjecting the portion of said piece which will serve as the core member to a cold working to form it into a reduced diameter portion having an external diameter slightly smaller than the internal diameter of the bore of said initial hollow member and a length slightly greater than the depth of said bore of the initial hollow member.

5. A method according to claim 1, wherein said material consisting of a metal having a relatively higher heat conductivity is cut into a piece of a length including the length of said core member and also the length of a terminal stud, thereafter subjecting the portion of said piece which will serve as the core member to a cold-working to form it into a reduced diameter portion conforming to the bore of said initial hollow member.

6. A method for manufacturing a center electrode for use in ignition plugs according to claim 1, wherein said final cold working is followed by a further heat diffusion process.




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JOHN F. CAMPBELL, Primary Examiner

R. B. LAZARUS, Assistant Examiner

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