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3,492,156

METHOD OF CHROMIZING ELECTROCONDUCTIVE ELEMENT

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2 Sheets-Sheet 1

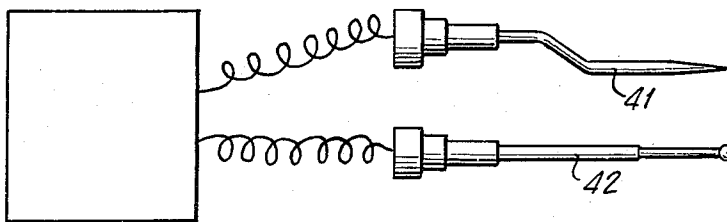
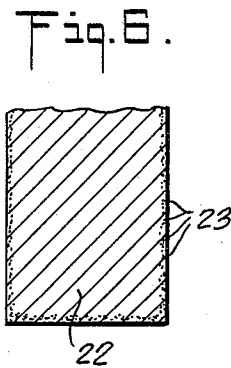
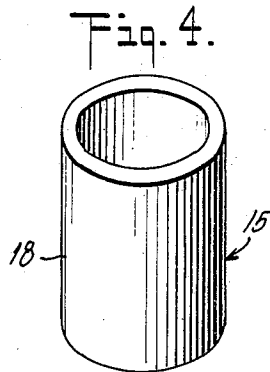
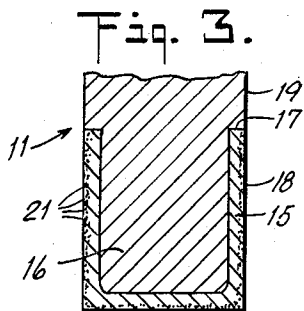
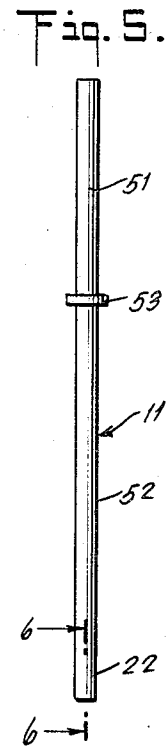
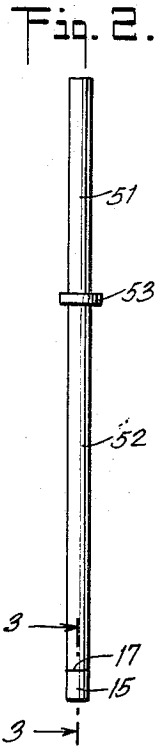
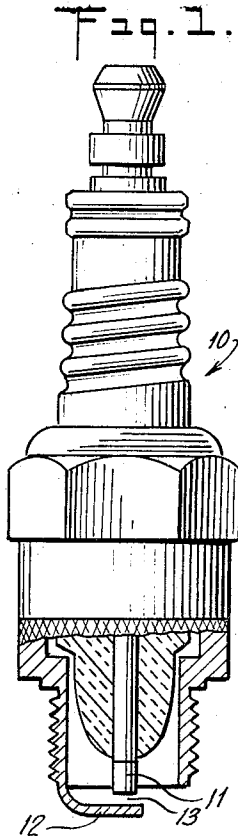


Fig. 8.

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2 Sheets-Sheet 2

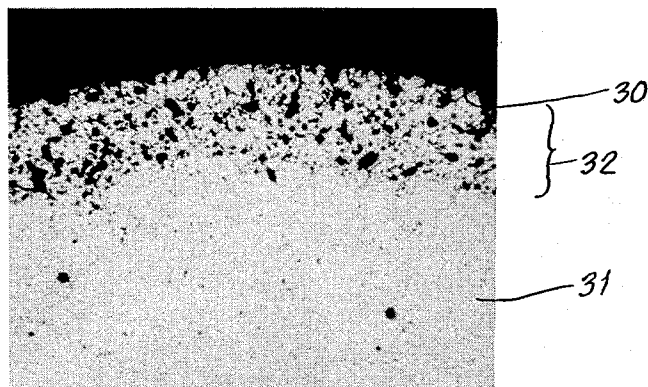


Fig. 7.

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METHOD OF CHROMIZING ELECTRO- CONDUCTIVE ELEMENT

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3 Claims

ABSTRACT OF THE DISCLOSURE

The invention provides an improved process of chromizing the surface of an electrically conductive electrode element to extend its useful life and to prevent erosion and deterioration. The steps of the process comprise embedding the electrode in a mix including chromium powder, iron powder, silicon and kaolin in principal amounts, and extremely small amounts such as .05% each of polyethylene film and ammonium carbonate; heating such mix gradually to about 350° F. to allow the ammonium carbonate to decompose; raising the temperature of such mix to about 900° F. and holding such temperature to allow for burn out of the polyethylene film; and then again raising the temperature of such mix to between 1850° F. and 1950° F. and maintaining such temperature for an extended period of time until the electrode has been chromized. The ammonium carbonate of the mix is broken down into nitrogen and hydrogen just prior to reaching the chromizing temperature.

The present invention relates to electro-conductive elements such as found in spark plugs, circuit breakers, electronic welding apparatus, and the like, wherein the electro-conductive element principally performs the function of emitting or passing electric or electronic impulses or sparks, with the result that it gradually deteriorates or erodes and thereby has its electrical effectiveness correspondingly reduced. More particularly, the present invention provides such an electro-conductive element which has an appreciably longer life and which does not deteriorate or erode under normal operating conditions for periods of time far in excess of those currently experienced.

According to the present invention these desirable results are obtained by chromizing electro-conductive elements or providing such electro-conductive elements with a chromized cap which is secured thereto. The present invention also provides a novel process of chromizing such elements or the caps for the same.

Heretofore various attempts have been made to prolong the life of electro-conductive elements so as to reduce their deterioration or erosion due to their constant passage of electric or electronic impulses or sparks. Also in unrelated fields it has been proposed to chromize various items by diffusion to gain the advantages which result from such surface diffusion coating. As far as I know, however, no one has heretofore suggested that the problem of electro-conductive element erosion or deterioration might be appreciably avoided by chromizing such electro-conductive element by a diffusion process, even though one such diffusion process was disclosed in U.S. Patent No. 2,536,774.

By experimentation, research and extensive tests I have found that the electro-conductive element of a spark plug for an automotive internal combustion engine, and electrodes for an electronic welding apparatus, when provided with a diffusion chromizing coating will have an appreciably increased useful life and will not suffer from rapid erosion and deterioration. In fact, I have found that with my chromized electro-conductive elements I have been able to double the useful life of spark plugs for automotive internal combustion engines and for electrodes for electronic welding apparatus.

I have also found that by the use of my improved chromizing process as herein disclosed, I have been able to attain a chromized diffusion coating on such electro-conductive elements more effectively and with greater penetration than heretofore attainable according to known processes.

For a better understanding of my invention reference will now be made to the accompanying drawing wherein:

FIG. 1 is an elevational view partly in section of an automotive internal combustion spark plug constructed according to the present invention.

FIG. 2 is a front elevational view of the electro-conductive, spark-emissive element of FIG. 1.

FIG. 3 is an enlarged cross-sectional view taken on the lines 3—3 of FIG. 2 and looking in the direction of the arrows.

FIG. 4 is a perspective view of a chromized cap for the spark-emissive, electro-conductive element of FIGS. 1 to 3 inclusive.

FIG. 5 is a vertical elevational view of an alternative form of electrode similar to FIG. 2 wherein the spark-emissive end of the electrode has been chromized instead of being provided with a cap.

FIG. 6 is an enlarged cross-sectional view of the spark-emissive end of the electrode of FIG. 5 taken on the lines 6—6 and viewed in the direction of the arrows.

FIG. 7 is a reproduction of a photomicrograph of the chromized coated surface of FIGS. 5 and 6 with the magnification being 100 times actual size.

FIG. 8 is a schematic illustration of two electrodes for an electronic welding apparatus.

Referring now to the drawings in detail it will be noted that FIG. 1 illustrates a conventional automotive internal combustion engine spark plug 10 having a central electrode 11 and an outer electrode 12 with a spark gap 13 therebetween. In conventional design the central electrode 11 is the spark-emissive electrode and hence is subject to erosion or deterioration with constant use.

In one form of the present invention the central electrode 11 as shown in FIGS. 2, 3 and 4 is provided with a chromized cap 15 at its spark-emissive end, such cap being suitably secured to a reduced end 16 of such electrode and preferably having abutting shoulders 17 and sidewalls 18 in alignment with the sidewalls 19 of the electrode 11. The opposite end of the electrode 11 is connected to a suitable source of electric current.

By the series of dots 21 shown on FIG. 3 it will be understood that the exterior surface of the cap 15 has been chromized according to the present invention, as will be hereinafter more fully described.

Referring now to FIGS. 5 and 6 of the drawings it will be noted that the central electrode 11 has had its

lower or spark-emissive end 22 similarly chromized as indicated by the dots 23 of FIG. 6 instead of utilizing a cap as shown in FIGS. 2, 3 and 4.

FIG. 7, which is a reproduction of a photomicrograph of a portion of an electrode corresponding to that shown in FIG. 6 and which has been magnified 100 times, shows the exterior arcuate surface 30 of such electrode, the base alloyed elements 31 of such electrode, and the chromium diffusion in the form of a band 32. From test reports the depth of penetration of the band 32 has been determined to have a minimum penetration of .00627 inch and a maximum penetration of .00739 inch.

Under normal automotive operating conditions with some spark plugs of conventional construction being used as a reference and other spark plugs constructed according to the present invention being subjected to comparative tests, it has been found that with 10,000 miles of travel the conventional spark plugs show appreciable erosion, pitting or scaling of the central electrode, whereas with central electrodes 11 as provided by the present invention there was no apparent erosion, pitting or scaling. Hence, it has been concluded that the normal life of an electro-conductive or spark-emissive electrode has been increased to at least double, if not more, its expected life.

In FIG. 8 there is illustrated schematically an electric welding apparatus which is generally used by dentists, dental technicians and other specialists for autogenous and heterogeneous welding. Such a welding apparatus includes two electrodes 41, 42 which are usually of pure copper. Electrode 41 usually erodes or deteriorates very rapidly and requires frequent replacement. I have found that if the electrodes of such a welding apparatus are chromized according to the present invention their useful life is appreciably extended, and in fact more than doubled.

Referring again to the central electrode for a spark plug, such electrodes usually consist of an upper section 51 as seen in FIGS. 2 and 5 and a lower section 52 which is butt welded to the upper section as at 53.

In preparing a spark plug for an internal combustion engine according to the present invention it is the lower section 52 which is chromized as it is this section, and particularly its end, which is subjected to corrosion and erosion during normal use.

In preparing the spark plug electrode or the welding electrodes for chromizing according to the present invention, it is recommended that the surfaces first be thoroughly cleaned. This can be done first by high speed buffing, followed by immersion in a sonic cleaning bath containing an ammoniated cleaning solution. For completeness the electrode may be blotted dry with a clean towel, immersed in distilled water, and then thoroughly dried with a blast of air. These steps are recommended to be sure that the surface is free of all contaminants.

When thus cleaned the electrode is placed in a chromizing pack or mix preferably consisting of the following elements and in the following proportions:

	Percent
Chromium powder	40
Iron powder	25
Silicon	2.0
Polyethylene film	max. 0.05
Ammonium carbonate	max. 0.05
Kaolin, bal. to 100%.	

The electrodes are embedded in the chromizing mix in a suitably sealed retort and then placed in an oven where they are subjected to heat. The temperature is then elevated gradually to about 350° F. to allow the ammonium carbonate to decompose, and to expel atmospheric oxygen. The temperature then is gradually elevated to about 900° F. and held there for about 15 minutes to allow burnout of the polyethylene film. Just prior to the time when the chromizing temperature is reached (1850°

F. to 1950° F.) the ammonia released from the decomposition of the ammonium carbonate breaks down releasing nitrogen and hydrogen gas. The hydrogen gas thus provided produces a reducing atmosphere while the retort is maintained at the optimum chromizing temperature range.

According to the present invention the optimum chromizing temperature range is between 1850° F. and 1950° F. for a period of about 8 hours. For the copper electrodes of the welding apparatus shown in FIG. 8 the preferred chromizing temperature is about 1850° F. for the spark plug electrode shown in FIG. 5 the preferred chromizing temperature is about 1950° F.

The final step in chromizing is to allow the retort containing the chromizing mix and the electrodes to cool to room temperature, at which time the electrodes may be removed and are ready for use.

As part of the process of chromizing electrodes as above described I have found that by using relatively small quantities of polyethylene film and ammonium carbonate I obtain very desirable results. From this I conclude that the polyethylene film breaks down to carbon and hydrogen, and that the ammonium carbonate breaks down into carbon dioxide and ammonia which in turn gives rise to a reducing atmosphere of nitrogen and hydrogen. If the base metal of the electrode to be chromized contains carbon, a smaller quantity of polyethylene film should be used, as the carbon of the base metal will react in place of such film.

In a semi-quantitative spectrographic analysis of the chromized sparking end of a central electrode for a spark plug prepared according to the present invention, which was made with turnings taken from the first two mils of surface obtained by a machining operation, it was determined that the coated layer 32 had the following approximate composition:

	Percent
Nickel	80
Chromium	15
Iron	5
Manganese, silicon in quantities less than 1%.	

A further test using aqua-regia (50% concentrated nitric acid and 50% concentrated hydrochloric acid) showed a complete resistance to deterioration of the chromized surface of an electrode type element prepared according to the present invention; whereas, a duplicate electrode type element, not so chromized, dissolved completely in about 5 minutes. As aqua-regia is one of the most corrosive of known substances, it is believed that this test further substantiates the most unexpected results obtained according to the present invention.

What I claim is:

1. The process of chromizing the surface of an electrically conductive electrode element comprising the steps of embedding such electrode in a mix including chromium powder, iron powder, silicon, and kaolin in principal amounts, and polyethylene film and ammonium carbonate in minor amounts of approximately .05% each; heating such mix gradually to about 350° F. to allow the ammonium carbonate to decompose; raising the temperature of such mix to about 900° F. and holding such temperature to allow for burn out of the polyethylene film; and then again raising the temperature of such mix to between 1850° F. and 1950° F. and maintaining such temperature for an extended period of time until such electrode has been chromized.

2. The process according to claim 1 wherein the mix is in the following approximate proportions:

	Percent
Chromium powder	40
Iron powder	25
Silicon	2.0
Polyethylene film	0.05
Ammonium carbonate	0.05
Kaolin, balance to 100%.	

3. The process according to claim 1, wherein the ammonia released by the decomposition of the ammonium carbonate is broken down into nitrogen and hydrogen just prior to reaching the chromizing temperature.

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