

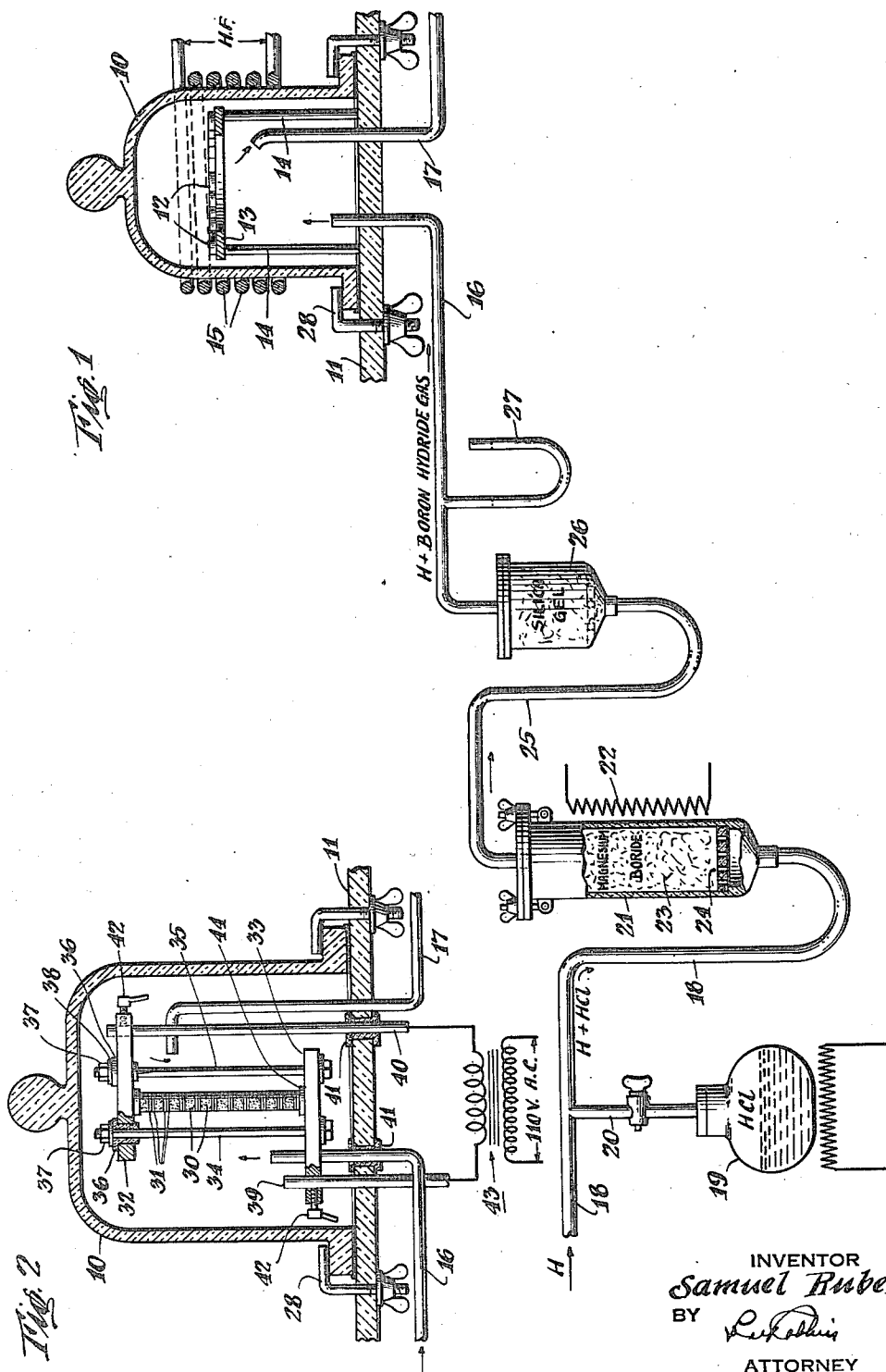
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S. RUBEN

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METHOD OF TREATING METAL COMPOSITION

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METHOD OF TREATING METAL
COMPOSITION

Samuel Ruben, New Rochelle, N. Y.

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3 Claims. (Cl. 148—10)

This invention relates to methods of preparing and treating metals and metal compositions particularly for electric contact purposes.

An object of the invention is to improve the methods of preparing metal compositions.

A further object is to improve electric contacts formed at least in part of refractory material.

Other objects of the invention will be apparent from the following description taken in connection with the appended claims.

The present invention comprises the combination of elements, methods of manufacture, and the product thereof brought out and exemplified in the disclosure hereinafter set forth, the scope of the invention being indicated in the appended claims.

While a preferred embodiment of the invention is described herein, it is contemplated that considerable variation may be made in the method of procedure and the combination of elements without departing from the spirit of the invention.

According to the present invention metal compositions and electric contacts formed therefrom are improved by a boriding treatment wherein the metal bodies are exposed to a boron-containing gas.

In the drawing:

Figure 1 illustrates one form of boriding apparatus embodying features of the invention; and Figure 2 shows a modification.

The introduction of boron into metal compositions is of advantage in many cases in improving the characteristics of the materials. For example, refractory metals such as tungsten and molybdenum are hardened and toughened by the introduction of a small percentage of boron. When such materials are used for electric contacts it is found that the performance is much better than that of ordinary tungsten and molybdenum materials. The boron appears to reduce the pressure resistance coefficient and to increase the P. A. R. rating of the contact operation.

Small percentages of boron are sufficient to accomplish the desired result and, in fact, it is generally preferred that the amount of boron be kept down to relatively small percentages. For most practical purposes .1 to .5% boron is preferred. The least critical and hence preferred, value appears to be about .25% boron.

The effect of the boron upon tungsten (and also on other refractory metals) is to make the tungsten tougher and harder, no doubt as a result of the formation of a certain amount of

tungsten boride associated with the tungsten. While this result is of great advantage in electric contacts and the like it has introduced considerable difficulty in fabricating contact discs and other contact shapes.

A commonly practiced method for making tungsten contacts consists in forming a rod of wrought or swaged tungsten (with or without further heat treatment) and then slicing the rod into contact discs using disc cutters of abrasive material. Where a borided tungsten rod is produced, however, the hardness and toughness of the material is such that the difficulty of cutting the discs is greatly increased. With a disc cutter of the type generally used it has heretofore been possible to cut 800 tungsten discs or more without difficulty whereas with the borided tungsten rods only 20 discs or so can be cut without excessive wear of the abrasive cutting wheels.

The present invention contemplates a method of making borided materials such as borided tungsten, while avoiding the difficulties in fabrication mentioned above. According to my improved method the material, such as tungsten contact discs which have previously been cut from pure tungsten rod, is heated in the presence of boron hydride gas.

Due to the decomposition of the boron hydride gas at high temperatures and their tendency to react with parts of a furnace, such as refractory furnace tubes, it is impracticable to carry on the reaction in a conventional furnace. Accordingly, a feature of my invention resides in the novel method and means which I have devised for carrying on the reaction, whereby only the parts intended to be reacted are heated. This will be made clearer by reference to the figures of the accompanying drawing.

In the drawing Figure 1 shows apparatus for boriding porous or non-porous discs of tungsten or other refractory metal. The reaction is carried on within a Pyrex glass bell jar 10 resting on a Pyrex glass plate 11, the two parts having a ground glass joint between them.

The refractory metal discs 12, to be borided, are supported within the bell jar upon a tungsten ring 13 standing on legs 14. The discs are arranged in a circle on top of the ring lying flat against the surface of the ring and making contact with each other and inductance coil 15 of heavy wire is supported outside the bell jar 10 encircling it in the region of the tungsten ring and contacts. The inductance coil 15 is arranged to be supplied with high frequency electric currents to thereby produce inductive heating of the

tungsten ring 13 and contacts 12. The ring 13 provides a closed circuit through which heavy induced currents will flow to heat the ring and associated contacts to the temperature required for boriding. The discs 12, being in contact with one another in a circle, also provide a conductive heating path. In addition, since the contacts are resting flat against the tungsten ring 13 a considerable proportion of the current flowing through the ring will pass up through the contacts.

The boron for the boriding operation is supplied as boron hydride gas which is introduced into the bell jar through glass tube 16, the glass tube 16 passing through a sealed aperture in the glass plate 11. The depleted gas is led off through a similarly mounted glass tube 17.

The apparatus for producing the boron hydride gas is shown at the left of the figure. Hydrogen gas enters the system through tube 18 at the extreme left and hydrochloric acid vapor is produced by heating hydrochloric acid in flask 19 and mixing it with the hydrogen gas through connecting tube 20. The mixed hydrogen and hydrochloric acid vapor pass on through tube 18 to the lower end of a reaction tower 21 heated by heating element 22. Lump magnesium boride produced by heating 2.25 parts of magnesium powder with one part of boric anhydride (B_2O_3) in a current of hydrogen gas is contained within reaction tower 21 and heated to 50 degrees C. by electric heating element 22. The hydrogen chloride gas reacts with the magnesium boride to produce magnesium chloride and boron hydride gas. When the warm hydrochloric acid vapor diluted with hydrogen passes through the reaction tower a reaction occurs producing boron hydride gas, such as B_2H_6 having a boiling point of 16 or 17 degrees C. This is carried on by the hydrogen stream through tube 25 leaving the top of the reaction tower. Tube 25 carries gas through a drying tower 26 containing a dryer such as silica gel. Tube 16 which introduces the gas into the bell jar is connected to the top of the drying tower 26. A manometer 27 is provided to indicate the gas pressure.

The boron hydride gas carried along with the hydrogen enters the chamber within bell jar 10 and comes in direct contact with the refractory metal discs 12 which are heated inductively by the high frequency coil 15 outside the jar. A suitable temperature for the metal during boriding is 1500 degrees C.

Figure 2 is a sectional elevation of apparatus for boriding porous tungsten or other refractory metal pellets or discs according to a modified procedure. In this modified apparatus the bell jar 10 resting on glass plate 11 is used as in the previous arrangement and the boron hydride gas is produced in a similar manner and introduced into glass tube 16 and the depleted gas allowed to pass off through gas exit tube 17 as before.

Porous pellets or discs 30 of tungsten or other refractory metal are produced by pressing finely divided tungsten or other refractory metal powder in a pilling machine or by other well-known methods under high pressures. The slugs or pellets 30 are formed into a stack with interposed non-porous punched tungsten discs 31 and the stack is clamped in a frame formed from two end plates 32 and 33 held together with a pair of tie rods 34 and 35. The plates 32 and 33 are made of substantial thickness and formed of highly conductive metal such as copper. Plate 32 is insulated from tie rods 34 and 35 by suitable heat

resistant insulating bushings 36 formed of lavite or similar material. The stack of slugs 30 and interposed discs 31 is clamped between plates 32 and 33, the clamping pressure being applied by nuts 37 which screw onto tie rods 34 and 35. Suitable spring washers 38 are provided underneath the nuts to provide yielding spring pressure which can take up expansion upon subsequent heating.

A pair of heavy copper rods 39 and 40 pass upward through glass plate 11 and are insulated therefrom by suitable refractory insulating bushings 41. Rod 39 passes through a suitable aperture in lower plate 33 and rod 40 passes through a similar aperture in plate 32, and the rods are clamped in intimate electric contact with the plate by butterfly set screws 42. The rods 39 and 40 are connected with any suitable high current capacity low voltage source such as the low voltage secondary winding of transformer 43 shown in the drawing. Thus a heavy current passes through the stack of pressed pellets and discs 30 and 31 from one copper plate to the other thereby heating them to a high temperature. Preferably reduced table-like projections 44 are provided on plates 32 and 33 at the point of contact with the stack to reduce the conduction of heat from the stack into the copper plates. However, it may nevertheless be necessary to discard the end pellets after boriding or to reinsert them in the middle of another stack during a subsequent boriding treatment. Here, as in the formerly described method the temperature of the material to be borided is raised to at least 1500 degrees C. and preferably to 2000 degrees C.

The spacing discs 31 permit ready separation of the parts after the boriding process. They may be of refractory metal or metal compounds such as tungsten, molybdenum, tantalum or the carbides, silicides or borides thereof.

The penetration of the boron into the metal is increased by prolonging the time of exposure or by increasing the temperature of the metal. This also results in an increase in the percentage of boron at the surface of the metal. The degree of penetration will also depend upon the character and porosity of the metal as well as the concentration of the boron hydride in the gas mixture.

With tungsten discs tungsten boride is formed on the contact surface and the boron apparently penetrates to some extent and reacts with the underlying tungsten. The formation of the tungsten boride apparently begins at the grain boundaries of the tungsten material.

For some uses only a superficial boride layer is sufficient to show a marked improvement in contact operation. Oxidation, carburizing and pitting are materially reduced and a more consistent operating life is observed under high current operation.

While the process is of great advantage when applied to dense non-porous materials such as wrought or swaged tungsten rod and discs cut therefrom, a possibly still more important application of the process resides in its use in boriding the porous metal bodies produced as described from pressed powders. Such materials are readily penetrated by the boron hydride gas and hence the boriding takes effect throughout the metal body.

After sufficient boride content is added in this way the material can be further treated, for example, by heating the boride material to a temperature of 2000 to 3000 degrees C. in hydrogen or other inert atmosphere. This may suitably

be done in the apparatus already described by heating in hydrogen for a sufficient time to sinter the granules together.

The porous refractory slugs, containing tungsten or molybdenum, which have been borided as just described, are not useful as such, but require impregnation with a lower melting point metal, such as copper or silver or their alloys. This is effected by heating the porous borided body in contact with the copper or silver or other lower melting point metal until the latter becomes melted and is absorbed into the porous refractory body by capillary absorption.

By boriding the refractory metal prior to melting-in of the lower melting point metal, a much harder and stronger refractory metal framework is obtained than with the prior art method in which the refractory material is pressed together and sintered but not otherwise treated prior to the admission of the copper or silver. Also the presence of the boride on all areas of the tungsten or molybdenum with which the silver or copper come into contact facilitates the impregnation of these latter materials and prevents their oxidation. The resultant product is much stronger and less oxidizable than the composite metal structure of the prior art and is superior for such uses as resistance welding electrodes, contactors, and other electrical applications.

Mixtures of refractory metals may also be treated by processes described herein. For example, mixtures of tungsten and molybdenum are amenable to such treatment.

It will be obvious that other methods of producing the boron hydride gas may be used and that the temperature, time of exposure, gas concentration and other factors may be adjusted to obtain the results desired.

While a preferred embodiment of the invention is described herein, it is contemplated that considerable variation may be made in the method of procedure and the construction of parts without departing from the spirit of the invention.

In the following description and in the claims, parts will be identified by specific names for convenience, but they are intended to be as generic in their application to similar parts as the art will permit.

What is claimed is:

1. The method of boriding refractory metal bodies which comprises placing said bodies in a closed chamber, electrically heating said bodies to a temperature of at least 1500° C. therein without correspondingly heating the walls of said chamber, and introducing boron hydride gas through a passage into said chamber to produce boriding of said bodies without wasteful decomposition of said gas adjacent the walls of said chamber or deleterious reaction of said gas with said walls.

2. The method of boriding refractory metal bodies which comprises placing said bodies in heat exchange relation with a short-circuited winding in a closed chamber of insulating material, electrically heating said bodies to a temperature of at least 1500° C. by passing high frequency currents through an inductive winding outside said chamber inductively coupled to said short-circuited winding, whereby the walls of said chamber are not correspondingly heated, and passing boron hydride gas continuously through said chamber during said heating period to produce boriding of said bodies.

3. The method of boriding refractory metal contact discs which comprises placing said discs on a flat metal ring supported on insulated supports in a closed chamber of insulating material, electrically heating said bodies to a temperature of at least 1500° C. by passing high frequency alternating currents through an inductive winding inductively coupled to said ring, whereby the walls of said chamber are not correspondingly heated, and passing boron hydride gas continuously through said chamber during said heating period to produce boriding of said bodies.

SAMUEL RUBEN.