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FABRICATION OF METAL SHAPES

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This invention relates to the fabricating of shapes of pure refractory materials of predetermined composition.

Briefly according to the invention, there is provided a process of making shapes of desired contour of relatively pure refractory material, which comprises depositing selected material on a suitable master support by heating and accelerating particles of such material in a stream of selected gas flowing through an electric arc of the general type disclosed by Gage Patent No. 2,806,124, while maintaining the temperature of such master below its melting point. The resulting deposited layer has a characteristic microstructure in which microscopic lamellules or leaves of irregular shape are inter-locked one with another. The master and deposited layer are then separated from each other, providing a shape thereof having the desired contour and composition.

Tungsten tubes and other shapes are readily fabricated according to this invention by coating tungsten metal onto a pattern and then separating the pattern from the coating. Shapes of other refractory metals, such as molybdenum, niobium, chromium, tantalum, nickel, zirconium, and titanium, as well as compounds and mixtures thereof, can also be fabricated in this fashion.

Industry has need for refractory metals in various shapes. In particular tungsten metal is desired as relatively small hollow bodies for use as electron emitters in vacuum tubes in the radio and television field. Prior art tungsten electron emitters were fabricated with great difficulty, for example, by swaging or by wrapping tungsten wire around a pattern of the desired shape and then fusing in position. Such methods were all time-consuming and costly.

Tungsten carbide and similar refractory materials have been previously prepared in intricate shapes as dies by means of the detonation coating process covered in U.S. Patent No. 2,714,563. In such fabrication process of dies, which is covered in my copending application, Serial No. 648,265, filed March 25, 1957, now Patent No. 3,048,-060, which is a continuation-in-part of my now abandoned application Serial Number 377,030, filed August 28, 1953, a refractory material is coated onto the surface of a pattern. The coating is then covered by a substantial layer of supporting metal. The pattern is then removed to form a metal base containing an inner liner of refractory material. Such prior art process cannot be employed to fabricate tungsten or other pure metal shapes since the detonation reaction used in such process incorporates some carbon, carbides and/or foreign oxides in the final product coating.

I have found that a high-pressure arc coating process can be employed to produce adherent, dense, non-porous coatings of pure tungsten metal. No contaminants, such as carbides and foreign oxides, are present in the coating since inert gases, such as argon, helium, nitrogen, and hydrogen, are usually employed to protect the refractory metal during the coating process.

This novel process for preparing refractory metal shapes

comprises the steps of forming a pattern or master body having the desired shape of the finished product, depositing a coating of refractory metal or mixture thereof of desired thickness onto the pattern by means of the high-pressure arc torch process of Patent No. 3,016,447 and then separating the pattern from the coated shape.

The method of removal of the pattern after the coating step is complete depends upon the nature of the pattern. If it is aluminum, for example, it can be dissolved in sodium hydroxide solution. If it is brass, for example, it can be dissolved in nitric acid. A pattern of low melting point material can be easily removed by heating without affecting the solid coating. The pattern can also be formed of easily deformable material which can be forced from the refractory metal shape by mechanical means. The master material might also be removed physically by machining methods.

The following example of the fabrication of a tungsten metal shape is illustrative of the process. An aluminum tube ⅜ inch O.D., ¼ inch I.D., and 1¾ inches long was plated with a 0.010 inch thick coating of tungsten metal by means of the non-transferred arc torch process. The torch was operated by striking an arc of 45 volts (D.C.S.P.) and 125 amps. between an inner stick electrode and a nozzle electrode with 150 c.f.h. argon gas passing through the ⅛ inch I.D. torch nozzle. The tungsten powder passed down through the arc and out through the nozzle. The aluminum tube was rotated and traversed under the torch outlet which was maintained ⅞ inch from the aluminum tube. The resulting aluminum body coated with tungsten was placed in a 30 weight percent aqueous sodium hydroxide solution for about 4 hours. After this time the aluminum was completely dissolved. The remaining tungsten tube was 0.395 inch O.D., 0.375 inch I.D. and 1¾ inches long.

The above example employed the non-transferred arc torch coating process. The transferred arc torch process wherein the support is in the arc circuit could also be used provided an electrical conductor is employed as the pattern material.

This process has been employed to form hollow shapes of tungsten. The process is equally applicable to other refractory metals such as chromium, niobium, molybdenum, nickel, tantalum titanium, and zirconium, as well as to mixtures of refractory metals with emissive materials, such as the emissive metal oxides thoria or yttria, for example. In the latter case the present invention has a decided advantage over prior art methods. Pure tungsten can be shaped with difficulty into some forms by swaging, drawing and pressing which require some ductility in the metal. Tungsten-thoria mixtures on the other hand, are quite brittle and are almost impossible to fabricate in diverse shapes. This process is applicable to fabricating shapes of almost any refractory material which would be too brittle to work into shape. Laminated articles can be fabricated according to the invention by coating alternate layers of metal and compounds, such as emissive material, onto a pattern and then removing the pattern.

What is claimed is:

1. Process of making metal shapes of selected refractory material, which comprises applying refractory material selected from the class consisting of refractory metals such as tungsten, chromium, niobium, molyb-

denum, nickel, tantalum, titanium, and zirconium, as well as mixtures of refractory metals with emissive materials, such as the emissive metal oxides thoria or yttria to a temporary solid support by an electric arc-gas process which heats and accelerates particles of said selected refractory material in an arc effluent of inert gas to form a chemically unchanged coating of such selected material of desired shape on such support below the melting temperature of the latter to prevent intermingling, and then separating such coating and such support without changing such shape.

2. Method of fabricating articles having internal surfaces of desired predetermined contour and of a predetermined material composition, which comprises providing a temporary solid master having an external surface complimentary in contour to said internal surface, providing a high thermal content effluent comprising a stream of selected gas heated by a high pressure arc; feeding to said effluent at a controlled rate a material of composition selected from the class consisting of refractory metals such as tungsten, chromium, niobium, molybdenum, nickel, tantalum, titanium, and zirconium, as well as mixtures of refractory metals with emissive materials such as the emissive metal oxides thoria or yttria which, when deposited on the master, forms a built up layer of said predetermined material composition, directing the resulting stream of material composition bearing effluent against the external surface of said temporary master until a built up chemically unaltered layer of said predetermined material composition of desired thickness is formed below the melting temperature of the master to prevent intermingling, and then removing said master to provide said article.

3. Process of making shapes of refractory metal, which comprises depositing refractory metal selected from the class consisting of molybdenum, niobium, chromium, tantalum, nickel, zirconium, and titanium, as well as compounds and mixtures thereof on a suitable solid supporting member by electric arc heating while maintaining the temperature of such supporting member below its melting point to prevent intermingling, and then removing the resulting shape composed of such refractory metal chemically unaltered from such supporting member.

4. Process of making desired shapes of tungsten metal, which comprises electric arc welding together particles of such metal on a temporary solid support of brass under a stream of inert gas selected from the class consisting of argon, helium, nitrogen and mixtures of argon and nitrogen, without melting said brass support to prevent intermingling and then separating the resulting shape of tungsten from such brass support by dissolving the latter in acid.

5. The method of making shapes of relatively pure material selected from the class consisting of niobium, chromium, molybdenum, nickel, tantalum, titanium, tungsten, zirconium and compounds and mixtures thereof, which comprises discharging a stream of selected inert gas against a local area of the surface of a temporary solid supporting member, drawing a high-pressure arc between a nonconsumable electrode and an annular nozzle, feeding and accelerating particles of powdered material selected from such class with such gas stream through said arc, heating such particles of powdered material in said arc, depositing and welding together the so heated particles of material on said local area as interlocking microscopic leaves of irregular shape built up to a thickness that is self-supporting when said temporary supporting member is separated therefrom, producing relative movement between said member and said inert gas stream and powdered material feed heated by an electric arc, so that the shape of such welded deposit of selected material corresponds to that of the surface of said supporting member; said deposition and welding being carried out below the melting temperature of said supporting member to prevent intermingling and then separating the resulting so deposited arc welded shape of selected material and said temporary supporting member from each other.

6. Process of fabricating members of pure refractory metal selected from the class consisting of molybdenum, niobium, chromium, tantalum, nickel, zirconium, and titanium, as well as compounds and mixtures thereof which comprises discharging a stream of inert gas from an electric arc torch provided with a non-consumable central electrode surrounded by a non-consumable annular electrode constituting the nozzle of such torch, establishing an electric arc between such electrodes, feeding a controlled flow of refractory metal particles into such gas stream for discharge from said nozzle with such arc heating said gas stream and refractory metal particles, applying the resulting hot effluent containing such gas and such heated and accelerated refractory metal particles to a local surface area of a solid support composed of material that can be removed by a chemical which does not remove the refractory metal, thereby depositing on such local surface area of the support a layer of welded microscopic lamellules of refractory metal particles, and relatively moving such effluent and support so as to coat a desired area of the support, such coating being accomplished below the melting temperature of the surface of said support to prevent intermingling and then removing the support by a suitable chemical, leaving the desired member composed of such pure refractory metal.

7. Process of fabricating electronic members composed of refractory metal selected from the class consisting of molybdenum, niobium, chromium, tantalum, nickel, zirconium, and titanium, as well as compounds and mixtures thereof and emissive material selected from the class consisting of thoria and yttria, which comprises simultaneously discharging a stream of inert gas and a mixture of refractory metal and emissive material particles as an extremely hot effluent from an electric arc torch in which a high pressure arc is drawn between the end of a central electrode and a nozzle electrode surrounding such central electrode applying such effluent to a solid support until there is built up thereon without intermingling therewith a composite composed of microscopic lamellules of such particles that are interlocking and welded one to another without any change in the original purity of the refractory metal and emissive material constituting such particles, and subsequently removing said support from said composite which thereupon constitutes the electronic member.

8. The process of fabricating electronic members which comprises depositing alternate layers of refractory metal selected from the class consisting of molybdenum, niobium, chromium, tantalum, nickel, zirconium, and titanium, as well as compounds and mixtures thereof and emissive material selected from the class consisting of thoria and yttria to a suitable solid support by alternately applying thereto without melting said support an extremely hot effluent comprising an inert gas stream and refractory metal particles, heated by an electric arc; and an extremely hot effluent comprising an inert gas stream and emissive material particles heated by an electric arc; and subsequently removing said support from the resulting composite of alternating layers of refractory metal and emissive material which composite thereupon constitutes the electronic member.

9. Process of fabricating shapes of refractory material selected from the class consisting of refractory metals such as tungsten, chromium, niobium, molybdenum, nickel, tantalum, titanium, and zirconium, as well as mixtures of refractory metals with emissive materials, such as the emissive metal oxides thoria or ytrria which comprises simultaneously discharging a stream of inert gas, a high pressure arc and refractory material particles as an extremely hot effluent from an electric arc torch in which such high pressure arc is drawn between the end of a torch electrode and a solid support, applying such effluent to such support until there is built up thereon without

intermingling therewith a composite composed of microscopic lamellules of such particles that are interlocking and welded one to another without any change in the original purity of the refractory material constituting such particles, and subsequently removing said support from said composite.

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