

UNITED STATES PATENT OFFICE

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PRODUCING METALLIC ARTICLES

No Drawing.

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This invention relates to metallic articles and has for its object the provision of a process for the production of articles of great hardness and heat resistance.

For example tungsten is a metal of highest fusing point now known, and the only feasible mode of production heretofore discovered has been to reduce its oxide by heating in contact with hydrogen whereby the metal is obtained in the form of a loose, non-adherent, sandy, powder. Owing to the difficulty of fusing it, and the even greater difficulty of casting it without contamination if fused, the customary modes of working this powder into such coherent forms as to be of practical value are either:

(a) The process described in U. S. Letters Patent of W. D. Coolidge No. 1,082,933, issued December 30, 1913, which consists of first sintering a block or rod of the powder at a high temperature approximating but not exceeding the melting point until it becomes coherent though porous and brittle and afterwards swaging and forging the metal at gradually decreasing temperatures, whereby its grain structure is broken up and it is converted into a substance having such malleability and ductility that it can be drawn into wire and rolled into sheets even when cold;

(b) The process described in my own Patent 1,359,353 dated November 16, 1920, by which the powdered tungsten is mixed with any one of numerous other metallic powders of lower melting point, compressed under high pressure to the shape desired, and afterwards subjected for a sufficient length of time to a temperature which is below the melting point at least of any substantial proportion of the ingredients, yet sufficiently high to allow molecular re-arrangement whereby the materials become integrated together into a hard and resistant mass but without any substantial change in shape or size of the article.

I have discovered, however, that metallic

masses produced according to the process last above described are susceptible of forging and mechanical working at a sufficient temperature and that such forging has exactly the opposite effect thereon that it has upon pure tungsten; that is to say: that whereas the forging of the pure tungsten serves to render the same softer, and more easily ductile and malleable, the forging of such mixtures of tungsten with other metals renders the same harder and more resistant.

As an example I will instance the behavior of a composition of tungsten and copper containing approximately 70 parts of tungsten and 30 parts of copper. The tungsten is produced in fine, granular form by reducing tungsten oxide by hydrogen in the usual way. The described proportion of finely divided copper is also taken, which may if desired be produced by heating copper oxide in the presence of hydrogen, or in any other desired manner. The two metals are mixed intimately together and compacted under considerable pressure. In my Patent 1,359,353 I suggested a pressure of 1000 to 4000 lbs. per square inch; such pressures are entirely feasible for small articles, and the larger the initial pressure the less the change in shape and size upon subsequent heat treatment; but in case the metal is to be forged as herein described it is permissible to employ lower compacting pressures, for example 500 lbs. per square inch. The resulting mixture is still susceptible of necessary handling if performed gently, but is sufficiently soft so as to be readily scratched or deformed. It is placed in a furnace and heated in a reducing atmosphere, preferably hydrogen, until the particles become adequately integrated together. To control the temperature I preferably place in the furnace on an insulating support close beside the article under construction, a tiny cone of pure copper (or other metal melting at a temperature at least not above that of the metal with which the tung-

sten is mixed) and raise the temperature of the furnace gradually until this test cone melts, whereupon I withdraw the mixed mass, and after allowing it to cool briefly so that no condition of "hot-shortness" can exist, I forge it by means of hammering, swaging, or pressing to produce the desired shape of article, re-heating from time to time if necessary. In such reheating care is exercised not to heat too hot, as by employing a copper or other telltale of such small size as to reach melting temperature before the larger mass. This shock-hardness produced by hammering may, in the case of tungsten and copper mixtures, increase the Brinell hardness by as much as from two to three, or even four times its Brinell hardness, depending upon the proportions of the ingredients. This proportion may vary all the way from about tungsten 99% and copper 1%, down to equal percentages of copper and tungsten. Even a small admixture of copper changes substantially the behavior of the tungsten, not by becoming alloyed therewith, since copper and tungsten are mutually insoluble, but apparently by coating the tungsten particles and thereby cementing them together. My theory is, although I do not limit myself thereto, that the result of the mechanical pressure upon the mixture is to squeeze aside the copper films between the adjacent tungsten particles, until the latter become braced so tightly together that further movement is impossible, thus producing a much higher compression strength. When the percentage of copper falls to a sufficiently small value, namely some fraction of one percent, the attributes of pure tungsten appear and the effect of forging is to soften the metal instead of hardening it; when the amount of tungsten becomes unduly small, namely somewhere less than 50% of the whole, it becomes impossible to force the tungsten particles into contact, and the hardness becomes essentially that of pure copper.

In general my improvements seem to be best utilized by employing one or more metals which melt above 2000° centigrade as the hard portion, together with one or more metals which melt at less than 2000° centigrade as the binder.

I do not limit myself to tungsten, since other high melting point metals can be employed, such for example as molybdenum and tantalum; neither do I limit myself to using these hard metals singly as mixtures of the same may be employed, neither do I limit myself to copper as a matrix metal since any other metal can be employed which exhibits the necessary properties of ductility, malleability and toughness, and, most important of all, does not dissolve in or alloy with the higher melting point substance, although it adheres closely to the external surfaces of the grains. Examples of such metals, other

than copper, are silver, gold and platinum, gold and platinum are, of course, unduly expensive for practical use, while tin and lead are too base, weak, and easily melted for most purposes, which leaves silver and copper as the most satisfactory for ordinary uses, although I do not limit myself thereto, nor do I limit myself to the use of pure metals, especially since certain alloys exhibit very valuable qualities for some purposes, such as silver and copper, silver and lead.

Also I do not limit myself to the temperatures employed, except that the same must be at least as high as the "critical temperature" of the matrix metal or alloy, namely, the lowest temperature at which molecular rearrangement of the material can occur, and must not be so high as to cause disintegration or collapse of the article, although in case the proportion of the matrix metal be small, (e. g. less than 10% by volume) the temperature can be raised above its melting point if the mass is carefully handled since its surface tension will preserve the space relations of the infusible particles, but it must be cooler than this for forging else the article will crumble.

Having thus described my invention what I claim is:

1. The process of producing a formed metallic article which consists in mixing intimately together powdered metal having a melting point above 2000° centigrade and a smaller amount of a second pulverized metal having a lower melting point, and of a nature not to dissolve in or become alloyed with the first metal; compacting said mixture, heating said mixture to a temperature which is above the critical temperature of the second metal, and afterwards forging the metal to the desired form at gradually decreasing temperatures.

2. The process of producing a formed metallic article which consists in compacting together a mixture of granular metals, containing predominantly one or more metals which melt above 2000° centigrade, and a subordinate quantity of one or more metals which melt at less than 2000° centigrade and which neither dissolve in nor alloy with the first metal or metals; heat-treating the compacted mixture at a temperature which is above the critical temperature of the lower melting point metal or metals until cohesion is secured; and afterwards forging the mass at a gradually decreasing temperature whereby its hardness is increased.

3. The process of producing a formed metallic article containing one or more metals having melting points above 2000° centigrade, combined with one or more metals lying adjacent to rubidium in the first group of Mendelejeff's Table of Elements, which contains the steps of first mixing the granulated or powdered ingredients intimately together,

the proportion of the high melting point
metal or metals being at least as great as that
of the remaining metal or metals; compacting
the mixture under great pressure; heating the
mixture to a temperature which is less than
the melting point of the predominating com-
ponent but higher than the critical point of
the lowest melting-point component; and sub-
sequently forging the mixture at a gradually
decreasing temperature.
In testimony whereof I hereunto affix my
signature.

CHARLES L. GEBAUER.