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## REFRACTORY METAL ALLOY CASTINGS AND METHODS OF MAKING SAME

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The present invention relates to improved refractory metal alloy castings and methods of preparing the same.

In the past it has not been possible to produce forgeable castings of refractory metals such as molybdenum and tungsten. Consequently, the only method of producing metals of this type which could be hot worked has been to form bars of sintered, powdered material. While this method has been used extensively, particularly in the production of tungsten wire, it is impractical for the production of large forgings, because of the difficulty of making large bodies of sintered, powdered metal. Prior attempts to melt and cast such refractory metals have resulted in castings which were exceedingly brittle and which could not be hot worked.

Accordingly, it is the principal object of the present invention to provide a refractory metal in cast form which can be forged, swaged, rolled or drawn while hot.

Another object of the present invention is to provide a process of producing such castings.

In accordance with the present invention it is found that castings of refractory metals such as molybdenum and tungsten may be hot worked if they contain small quantities of carbon and the oxygen is reduced below an exceedingly minute quantity. Thus, an alloy containing carbon from 0.01 to 0.25 per cent, oxygen less than 0.005 per cent, and the balance molybdenum or tungsten or any alloy of both, may be forged. For this purpose a metal is considerable forgeable if its cross-sectional area may be reduced at least fifty per cent while hot. For best results the carbon content should lie between 0.03 and 0.10 per cent and the oxygen content should be less than 0.003 per cent. Within this preferred range, cast ingots which may be rolled into bars, rods, or sheet, and substantially reduced in cross-sectional area may be obtained.

At the present time so-called commercially pure refractory metals are obtainable as powders. It is found, however, that these metal powders contain small quantities of oxygen which must be removed in order to produce a forgeable casting. In accordance with the present invention, this oxygen is removed from the metal by the

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addition, at the time of melting or before, of calculated quantities of carbon and the melting operation is carried out under a high vacuum. For this purpose the pressure in the melting chamber must be less than 500 microns of mercury and preferably less than 100 microns. The amount of carbon which is added must exceed the calculated amount necessary to combine with the quantity of oxygen present in the material by an amount sufficient to produce residual carbon within the limits specified above. In this connection it is found that as the pressures approach the higher limit it is necessary to employ carbon in quantities correspondingly approaching the higher carbon limit. Accordingly, the quantity of oxygen in the raw material must be accurately measured. For this purpose the well-known vacuum fusion method of determining oxygen content may be employed.

While any suitable method of adding carbon to the metal and melting the mixture may be employed, the preferred method is to mix the powdered refractory metal with powdered carbon in the necessary proportions and compact the mixture by pressure into a bar or rod. This rod is then heated sufficiently, preferably by electric resistance heating, to sinter the powdered materials into a bar of sufficient strength to be used as an electrode in a vacuum arc melting furnace. This bar is then utilized as one electrode of the arc and consumed, the opposite electrode being preferably the bath of melted material. For this purpose it is preferred to use a water-cooled copper mold to collect the molten material. Any suitable means may be provided to support the consumable electrode in proper spaced relation to the bath of molten metal and maintain it in the spaced relation during the melting operation. At the start of the melting operation a small piece of the same refractory metal may be placed in the mold to act as the starting electrode pending formation of the molten bath.

The interior of the mold and the entire melting chamber is suitably enclosed and evacuated by conventional means.

It will be apparent to those skilled in the art that variations in the method of producing forgeable refractory metal castings in accordance