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JEAN H. L. DE BATS, OF EAST ORANGE, NEW JERSEY, ASSIGNOR TO DE BATS METALS COMPANY, OF BLOOMFIELD, NEW JERSEY, A CORPORATION OF NEW JERSEY.

METHOD OF MAKING ALLOYS.

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In a co-pending application Serial No. 688,303, filed Jan. 24, 1925 there is described an alloy of nickel and at least two metals of the chromium group, such as chromium and tungsten, which possesses in a marked degree certain desirable qualities as compared with an alloy, for example, of cobalt, chromium and tungsten. It is probable that hitherto the difficulties which have developed in the effort to make an alloy of nickel, chromium and tungsten have prevented the production of this alloy and the realization of its superior qualities, especially for the making of tools for the cutting of metal under heavy duty conditions, that is, at high speed and with deep cuts. At all events the production of an alloy of nickel and tungsten has been impracticable on account of the behavior of the metals when the attempt is made to combine them. Recognition of the probable value of an alloy containing nickel and tungsten as well as chromium has led to efforts to produce an alloy containing nickel as well as chromium and tungsten or their equivalents and a practical solution of the problem has been found in the present invention, one typical embodiment of which may be described as follows:

Into a suitable crucible, preferably of graphite and of the Number 3 size, for example, is put two pounds of shot nickel. On top of this in the crucible is placed a thorough mixture of four pounds of crushed chromium and four pounds of tungsten metal powder, this initial composition, as explained in said co-pending application, containing about 20% of nickel and about 40% each of chromium and tungsten. Thus charged the crucible is placed in a suitable furnace, preferably a high frequency electric induction furnace, whereby the heat is generated by induced currents in the material to be melted, so that the necessary high temperature is applied directly to the material and deterioration of the crucible and of the furnace lining is avoided. The heat due to the induced currents is generated chiefly in the nickel, which is quickly reduced to a molten condition and, being covered by the mixture of chromium and tungsten, superheats rapidly. At the same time the crucible itself and the mixture of chromium and tungsten become heated and the mixture of chromium and tungsten reaches a red heat especially near the molten nickel. When this condition has been attained the mixture of chromium and tungsten is rapidly stirred into the molten nickel, the stirring being effected by poking or thrusting a rod repeatedly and quickly down through the mixture of chromium and tungsten so that small portions of such fixture are successively poked down into the molten nickel. Through the continued contact of the small portions of the mixture with the molten nickel the chromium and tungsten are gradually alloyed with the nickel at a temperature far below the fusing point of tungsten. In this manner the whole or a large part of the powdered mixture is poked down into and enveloped by the molten nickel, forming therewith a pasty, semi-liquid mass.

This point in the method having been reached the cover is preferably placed on the crucible and the mass is allowed to heat for several minutes, at the end of which time it will be found to have become a fluid mass with a more or less heavy slag, comprising metallic oxides and unalloyed particles of tungsten, on top. The slag is removed in the usual manner and the molten mass is thoroughly stirred to float up any suspended slag and to bring about the liquefaction or perhaps solution of any tungsten or chromium which may have reached the bottom of the crucible without being liquefied. The crucible may then, if necessary, be covered and allowed to heat again to facilitate the removal of such slag as may have been held in suspension. Finally the molten mass is poured in an ingot mold, and later may be broken up for remelting.

Although the initial composition contains only chromium and tungsten, or other metals of the chromium group, and nickel, it may be desirable, under some conditions or for some special uses to add a relatively small quantity of some other metal or to add other substances to serve as purifiers, scavengers or fluxes. It is also possible that the alloy acquires from the crucible a small percentage of carbon and that the superior qualities of the finished alloy may be due in part to the formation of carbides of the metals of which the initial composition is composed.

Heretofore it has been found difficult or impracticable to combine tungsten alone with nickel. It has also been found difficult

or impracticable to combine chromium alone with nickel. By the method above described, however, in which the shot nickel is first reduced to a molten condition and the chromium and tungsten, mixed together in a finely divided condition, are placed on top of the nickel in the crucible and are thereby heated to a red heat during the melting of the nickel, also excluding atmospheric air from the points of contact of the mixture with the molten nickel, the alloying of the three principal components proceeds rapidly and thoroughly.

While it is not necessary to attempt to explain what takes place either when it is attempted to alloy tungsten alone with nickel or in the practice of the method above described, it is believed that the action which takes place when it is attempted to alloy tungsten alone with nickel is due to the rapid oxidation of the tungsten, which does not appear to take place when the tungsten is associated in a more or less finely divided condition with the chromium. It may be supposed that as the heat of the mixture increases toward the point of oxidation of the tungsten, the particles of chromium, which has a comparatively low fusing point, sinter themselves together and seal up the particles of tungsten from the air until the mixture is submerged below the surface of the molten nickel and where air cannot reach it. It may also be supposed that when the sintered chromium is liquefied through contact with the molten nickel, the tungsten particles are thereupon released in a comparatively pure metallic state in which the tungsten also can be liquefied readily through contact with the molten nickel. At all events it is known that tungsten is peculiarly subject to oxidation at high temperatures, and that a slight degree of oxidation makes exceedingly difficult the fusing together of metals, so that the absence of phenomena due to oxidation leads to the supposition that oxidation is prevented in the manner described.

The liability of tungsten to oxidation makes it desirable that the poking down or stirring of the chromium-tungsten mixture into the molten nickel should be performed carefully and rapidly. It has been found that when the nickel has just reached the molten condition the lower zone of the chromium-tungsten mixture is at a bright red heat and that the temperature of the mixture gradually reduces toward the top of the mass, where the temperature of the mixture is below the oxidation point of tungsten. If the temperature is allowed to run too high the chromium-tungsten mixture will become heated throughout and at the top, where the mixture is exposed to the air, the tungsten will begin to oxidize and burn off and a considerable percentage of the tungsten will be lost in the final alloy with a consequent variation in the character of the alloy. It is therefore desirable that the poking down or stirring in of the mixture shall take place before the temperature reaches such an objectionably high degree and while the lower portions of the mixture are protected by the upper portion from any considerable oxidation. On the other hand, if the mixture is poked down before the nickel has been heated to a degree sufficient to bring about the liquefaction of the chromium-tungsten mixture, some part of the mixture may drop to the bottom of the crucible in a solid state and it is impracticable to get any substantial proportion of such sunken tungsten into alloy for the reason that the molten mass cannot be stirred too vigorously and the specific gravity of the unliquefied tungsten at the bottom is so much greater than that of the molten mass that it is very difficult to float up the solid particles and incorporate them with the molten mass. As a result, therefore, the final alloy would be either deficient in the desired percentage of tungsten or would contain lumps of solid tungsten made up of particles sintered or cemented together.

For similar reasons it is desirable that the commercial chromium employed shall be sufficiently fine to pass through a thirty mesh screen, lest lumps of the chromium should drop to the bottom of the crucible in an unmelted condition and the function of the chromium in protecting the tungsten from oxidation is lost.

Because of the possible losses of chromium or tungsten due to variations in the practice of the invention, it is desirable to define the percentages of the several components by reference to the initial composition rather than by reference to the chemical analysis of the finished alloy. It will be understood, also, that the proportions of the components will be varied more or less in accordance with the particular qualities which it is desired that the alloy shall have.

It is desirable that the tungsten employed be relatively pure, lest the oxidation of the tungsten be increased by the evolution of oxygen by dissociation of contained salts, at the high temperatures attained.

While particular reference has been made to the superimposing in the crucible of a mixture of chromium and tungsten on the nickel in the bottom of the crucible, which is first brought to a molten condition, it is possible that the mixture of chromium and tungsten might be introduced into the nickel by enveloping a portion or portions of the mixture in an envelope of nickel and placing such enveloped portions of the mixture in the crucible with a covering of a suitable flux, or that portions of the mixture, in suitable containers, might be plunged into the

body of molten nickel. It will be understood, therefore, that the invention, except as pointed out in the claims, is not limited to the precise method herein described in detail, although the same has been found to give satisfactory results. It will also be understood that although the described method has been developed with particular reference to the alloying of the metals named, it may be employed to advantage in the alloying of other metals at least one of which, like the nickel, has a relatively low melting point, while another or others, like the tungsten, has or have a relatively high melting point.

I claim as my invention:

1. The method of alloying nickel with metals of the chromium group which consists in superposing a mixture of metals of the chromium group in finely divided condition upon a body of nickel in unmelted condition, heating the nickel to a temperature above its melting point but not above the melting point of any of the metals of the chromium group and mechanically mixing the superposed finely divided mixture of metals of the chromium group with the molten nickel.

2. The method of alloying nickel with chromium and tungsten which consists in superposing a mixture of chromium and tungsten in finely divided condition upon a body of nickel in unmelted condition in a quantity sufficient to exclude air from the surface of the nickel, heating the nickel to a temperature above its melting point but not above the melting point of the chromium, and mechanically mixing the finely divided chromium and tungsten with the molten nickel.

This specification signed this 19th day of January, A. D. 1924.

JEAN H. L. DE BATS.