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METHOD OF MAKING STABLE INVAR

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This invention relates to alloys of high purity and especially to low-expansion alloys of iron and nickel having exceptional ductility and hot-working properties, and to a process of making the same.

In certain uses of Invar metal, it is desirable to employ a metal of high stability, that is, a metal which will not change its physical dimensions while in service. For example, the precision of base lines in surveys is severely restricted by the instability of most Invar tapes available for use. One cause of this instability is the presence of impurities of low solubility, such as nitrogen, oxygen, carbon and sulphur, in the metal from which the tape is made. Stable Invar can be obtained by producing a high purity alloy of iron and nickel with or without cobalt as one of the composition metals.

According to the present invention, low-expansion alloys of iron and nickel of exceptional purity having a low oxide and non-metallic inclusion content and a low sulphur content (that is, below 0.01%) and characterized by exceptionally good ductility and hot-working properties are produced. I have found that such a stable Invar may be prepared by first purifying the major component metals by heating the separate metals in the solid state, but at a temperature of above 1000° C., in an atmosphere of hydrogen gas from ten to forty-eight hours, and then compounding by melting the metals and alloying them in a molded state under conditions which prevent the material from oxidizing.

Electrolytic iron and nickel may be used to advantage since electrolysis removes elements of high solid solubility and particularly those that are harmful to the expansion properties of the metals. This is not essential, however, since good results can be obtained with other iron, nickel, and cobalt of a relatively high degree of purity such, for example, as those prepared by the carbonyl process. The metals should be in a finely divided state or in porous condition, as when electro-deposited, and are purified in the solid state by annealing in hyrogen gas at 1000° C. to 1300° C. for at least ten hours prior to melting and casting. I have found that heating at 1150° C. for twenty hours is quite effective. This treatment practically eliminates all the undesirable residual elements such as carbon, oxygen, nitrogen and sulphur from the electrolytically deposited base metal.

The iron and nickel so purified are melted together, preferably in an induction furnace, in an atmosphere of hydrogen, and solidified in the same atmosphere to avoid taking up oxygen. As a result, the solid metal is porous near the surface where there are blow holes caused by escaping gases but this is not injurious to the metal because, in the absence of oxides, the blow holes weld shut completely upon forging of the material.

Instead of melting and freezing the alloyed material under hydrogen after purification in the solid state, an alternate method of treatment may be employed. If the component metals have been annealed in an atmosphere of hydrogen, they may be then melted together in contact with air, preferably putting a slag on the metal when in a molten condition, and deoxidizing in the usual way with silicon, manganese, or aluminum, or any combination of these or other deoxidizing elements, after which the molten metal is poured into a mold. Alloys so prepared can be forged and fabricated with ease, chiefly because the sulphur content is low. The sulphur content provides a practical index of the purity of the alloy, and with the above-described process, is ordinarily below 0.01%.

A typical composition of Invar produced by the above-described method is: 36.85% nickel plus cobalt, 0.000% manganese, 0.011% silicon, 0.003% sulphur, 0.008% phosphorous, copper nil, the remainder of the material being iron. This process is equally applicable to other alloys where high purity is essential, such as iron, nickel and cobalt alloys, for sealing into hard glass and ferro-alloys for the deoxidation of steel.

I claim as my invention:

1. The method of preparing alloys of iron and nickel which consists in annealing electrolytic iron and nickel and other high purity products in an atmosphere of hydrogen gas at a temperature of about 1150° C. for twenty hours and then melting and freezing in an atmosphere of pure hydrogen.

2. The method of preparing a low-expansion alloy of iron, nickel and cobalt which consists in heating high purity components in an atmosphere of hydrogen gas at a temperature of between 1000° and 1300° C. for at least ten hours, and then melting and freezing in an atmosphere of pure hydrogen.

3. The method of preparing a low-expansion alloy of iron and nickel which consists in heating high purity components in an atmosphere of hydrogen gas at a temperature of between 1000° and 1300° C. for ten to forty-eight hours and in compounding by alloying and deoxidizing in the molten state.

4. The process of producing a non-porous stable Invar nickel iron alloy characterized by exceptionally good ductility and hot working properties, and a sulphur content below 0.01 per cent, which consists in annealing the component metals in an atmosphere of hydrogen gas at a temperature between 1000° and 1300° C. for at least ten hours and thereafter compounding the metals by melting.

5. The process of producing a stable Invar alloy of iron and nickel characterized by exceptionally good ductility and hot working properties and sulphur content below 0.01 per cent which consists in purifying in the solid state by annealing in hydrogen gas at between 1000° and 1300° C. for at least ten hours and thereafter melting and further deoxiding the metal.

6. The process of producing a stable Invar alloy of iron and nickel which consists in purifying in the solid state by annealing in hydrogen gas at a temperature between 1000° and 1300° C. for from ten to forty-eight hours, and thereafter further deoxidizing the material in the molten state.

7. The process of producing a non-porous stable Invar alloy of iron and nickel having a purity of 99.90 per cent or better and having low oxide and non-metallic inclusion content, which consists in purifying the major components in the solid state by annealing in hydrogen gas at a temperature over 1000° C. and in compounding by alloying in the molten state.

8. In the process of making iron-nickel alloys, the steps of heat treating iron in a finely divided solid state in a hydrogen atmosphere to produce a pure base metal, mixing the iron with the nickel and melting the mixed metals to compound them into an alloy.

9. In the process of making iron-nickel-cobalt alloys, the steps of heat treating iron, nickel and cobalt in a finely divided state in a hydrogen atmosphere to produce pure metals, mixing the iron with the nickel and cobalt and melting the mixed metals to compound them into an alloy.

10. In the process of making iron, nickel and/or cobalt alloys the steps of heat treating the iron, nickel and/or cobalt in a finely divided solid state at temperatures above 1000° C. in a hydrogen atmosphere to produce pure metals, mixing the iron with the nickel and/or cobalt and melting the purified mixed metals to compound them into an alloy.

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