

UNITED STATES PATENT OFFICE.

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TREATMENT OF NICKEL-COPPER-ALUMINUM ALLOYS.

No Drawing.

Application filed March 17, 1924. Serial No. 699,894.

The present invention relates to alloys of nickel, copper and aluminum, in which the two former metals predominate.

Alloys consisting of about 60 to 75 parts of nickel and about 25 to 40 parts copper have been used in the industrial arts because of their resistance to corrosion, and good physical properties. For some purposes however the moderately low elastic limit of this type of alloy has been a serious handicap, particularly when these alloys have been used for the construction of devices subjected to severe mechanical strains and shocks, as for example for turbine buckets or similar rapidly rotating parts.

In accordance with the invention of Eric T. Asp an improved forgeable alloy of nickel, copper and aluminum has been produced which also is highly resistant to corrosion. As described and claimed by him in a co-pending application, Serial No. 699,895, filed March 17, 1924, this forgeable alloy is made by mixing about one-tenth of one per cent of magnesium with the molten ternary alloy prior to casting. The aluminum content preferably should be maintained between about 2.0 to 3.5 per cent to get best results although variations between about one-half per cent to five per cent are permissible. All of the proportions given herein are by weight. I have discovered that the alloy produced by Asp can be greatly improved by a deforming treatment below 1000° C. which together with the product constitutes my invention.

In accordance with my present invention, I have provided an improved alloy of nickel, copper and aluminum which has physical properties superior to the alloy produced by Asp, such as a higher tensile strength, high elastic limit and higher ductility. The alloy, when worked under the most favorable conditions, has a physical strength comparable to the alloy steels, while retaining the desirable corrosion-resisting properties of the nickel-copper alloys.

The carbon content ordinarily should be within the limits of .03 to 0.4 per cent. In general for the best results, when the aluminum content is high, the carbon content should be low, and conversely with an aluminum content of the lower values of the range above given, the carbon content may be higher. Excellent results have been ob-

tained with alloys having an aluminum content of about 3 to 3.5 per cent with a carbon content in the neighborhood of about .08 per cent; while equally good results have been obtained with alloys having an aluminum content of about 2 per cent and a carbon content of 0.14 to 0.16 per cent.

In order to produce the most desirable physical properties in the alloy the final deformation or working of the alloy must be carried on at a temperature below 900° C.

In carrying my invention into effect, an alloy of copper and nickel is prepared by the well known methods of the art. The nickel content may be varied considerably, but ordinarily should be as high as 50 per cent, the copper content being varied correspondingly, that is the copper content being increased as the nickel content is decreased. The nickel and copper may be alloyed with one another by simple fusion and the required amount of aluminum may be simply stirred into the molten nickel-copper alloy. Preferably about 1.5 parts by weight of manganese and about 2.5 parts by weight of iron are added to the melt prior to the addition of aluminum. As already indicated the carbon content desired depends upon the amount of aluminum present. In accordance with the invention of the above Asp application, about one-tenth of one per cent of magnesium by weight is stirred into the melt, and the alloy then is cast into an ingot mold. The cast ingots are workable, that is, capable of being wrought, as by forging or rolling. When the metal is forged at a temperature in the neighborhood of 1000° C. the physical properties of the product are in general similar to the physical properties of the corresponding nickel-copper alloy. When, however, in accordance with my invention, after some deformation has occurred, the deformation is continued at a lower temperature, the physical properties are improved to a radical degree, the improvement becoming more marked with the lowering of the final deformation temperature down to room temperature. However, below 600° C. but little additional change is produced in tensile strength.

For example, when ingots of an alloy of about 65 parts nickel, 35 parts copper and containing (by analysis) about 3.0 to 3.5 parts of aluminum and about 0.1 per cent of

carbon, which have been forged at about 1000° C. to reduce the diameter to about one-half the original value, are forged subsequently at 750° C. to a diameter of about one-fourth the original value, the tensile strength is increased from about 100,000 pounds to about 114,000 pounds, per sq. inch and the elastic limit is increased from 53,200 pounds to about 72,000 pounds without any corresponding decrease in ductility.

When the finishing temperature of forging is reduced to 600° C. the tensile strength is increased to about 172,000 pounds per sq. inch and the elastic limit is increased to 110,000 pounds per sq. inch with a retention of high ductility. When finishing at approximately room temperature a tensile strength of 175,000 pounds, and the remarkably high elastic limit of 131,000 pounds with high ductility are produced.

These excellent physical properties coupled with non-corrodibility render the alloy valuable for the manufacture of turbine buckets, springs and marine parts, such as propellers and condenser tubes.

What I claim as new and desire to secure by Letters Patent of the United States, is:—

1. The process of improving the physical properties of an alloy consisting largely of nickel and copper and a relatively small amount of aluminum which consists in deforming said alloy at a temperature of about 1000° C. and thereafter finishing the deformation at a temperature materially lower than 1000° C. but above 500° C.

2. The process of improving the physical properties of an alloy consisting largely of nickel and copper and containing a few per cent of aluminum which consists in initially deforming said alloy at a temperature below

1000° C. and continuing the deformation at temperatures approaching 600° C.

3. The process of improving the mechanical strength while retaining the ductility of an alloy consisting of at least about 50 parts nickel, about 25 to 40 parts copper about one-half to five parts aluminum, and a small amount of carbon having been rendered forgeable by treatment with magnesium, which consists in maintaining the carbon content of said alloy within the range of about 0.03 to 0.40 parts with respect to the aluminum content so that a higher aluminum content will be accompanied by a lower carbon content, deforming said alloy at a temperature of about 1000° C. and thereafter again deforming the alloy at a temperature materially below 1000° C. but above 500° C.

4. The process of improving the physical properties of an alloy comprising about 65 parts nickel, about 35 parts copper, about three parts of aluminum and a fractional part of carbon which consists in forging said alloy at temperatures within the range of 1000° to 600° C. the forging being begun in the upper part of said range and completed in the lower part of said range.

5. The process of improving the physical properties of an alloy consisting largely of copper and nickel, the nickel being in excess of the copper, and containing one half to five parts aluminum, which consists in deforming the alloy at a temperature of about 1,000° C. and again deforming the alloy at a temperature materially lower than 1000° C. but above 500° C.

In witness whereof, I have hereunto set my hand this 15th day of March, 1924.

TRUMAN S. FULLER.