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SUPERCONDUCTIVE ALLOY OF NIOBIUM-ZIRCONIUM-TIN

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4 Claims. (Cl. 148—32)

The present invention relates to an improved superconductive alloy and more particularly to a superconductive alloy of niobium-zirconium-tin.

Niobium-zirconium alloys containing 20–80% by weight of niobium are already known. These alloys are suited for the production of so-called hard superconductors, that is, such superconductors the maximum current density of which in the range of superconductivity is only little influenced by exterior magnetic fields even up to high field strengths. It furthermore is known to produce bands or wires from such superconductive alloys by cold deformation of a casting by rolling or drawing.

It further more is known that a heat treatment can be given to the alloy before or after its deformation in order that the critical current density be increased. Insofar as the critical current density could be increased by such a heat treatment this was considered to be due to an increase in the inner stresses caused by the heat treatment. Nevertheless, it was not possible to ascertain from previous investigations, in which manner the optimum properties could be achieved with alloys of different compositions. It has finally been accepted that superconductors which consist of the intermetallic compound Nb_3Sn can take up a high current density when they have a lamellar like, or a so-called filament structure. In such case the thickness of the lamallae should be less than the depth of penetration and be noteworthily less than 100 A.

According to the invention, it was found that the maximum current density of niobium-zirconium superconductive alloys of this type can be substantially improved if they contain tin as a further component in a quantity between 0.1 and 10%, preferably between 0.5 and 3% by weight. With the alloy addition according to the invention the transition temperature is simultaneously advantageously raised.

The superconductive alloy according to the invention can be shaped to bands or wires by the known methods of rolling or drawing.

Expediently the alloy according to the invention is given an intermediate anneal between the individual deformation stages employed to produce superconductive bands or wires therefrom.

The bands and wires of the hard superconductive alloys of niobium, zirconium and tin according to the invention reach the optimal properties when such bands or wires exhibit a lamellar like structure. This lamellar like structure can be attained by providing a suitable heat treatment between the individual deformation operations, in any event before the last cold deformation.

The temperature and duration of the heat treatment differs depending upon the composition of the alloy within the ranges given. It, however, is easy to ascertain the temperature and duration of the heat treatment or anneal as well as the degree of deformation which must be employed to obtain the lamellar like structure by simple preliminary tests. The degree of deformation is only of significance in that it should be over 40% if possible whereas the temperature and duration of the heat treatment must be exactly adjusted with respect to each other so that no phase of granular character is formed. For

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this reason, care must be taken above all that the temperature of the heat treatment is not too high as at higher temperatures there is a greater tendency for the formation of granular phases. If the temperature selected is too low, a longer heat treatment is required which for practical reasons is not generally desired, but this does not in general stand in the way of the production of the desired lamellar like structuer after the cold deformation. The minimum temperature employed for the heat treatment, of course, must be sufficiently high to suffice for the necessary softening of the alloy for further cold working.

The intermediate anneals are so adjusted with regard to temperature and duration that the lamellar like structure extends in the longitudinal direction of the bands and wires and in addition runs as parallel as possible to the surfaces so that it is interrupted as little as possible. The lamellae therefore should run parallel to the surface as in slate formations and should as much as possible be without interruptions worth mentioning. This, for example, is achieved by selecting a temperature for the anneal which is only so high that any grain structure which may be present which is suited for the formation of long plate shaped lamellae does not break down into individual round grains. The phases after the heat treatment should be present in as flat a form as possible.

A lamellar like structure in which the lamellae run parallel to the surface is best achieved in the production of wires, in that, as many deformations to round calibers as possible are carried out. In this way the lamellae are to a far-reaching degree oriented parallel to the surface and deformed to the desired degree. The thickness of the lamellae in general should be between 0.01 and 1μ and preferably to about 0.1μ.

The intermediate anneal for alloys according to the invention with 20 to 80%, preferably 60 to 80%, by weight of niobium, 0.1 to 10% by weight of tin and the remainder zirconium is best carried out at a temperature range between 750 and 950° C., preferably between 800 and 850° C., for a duration of about 5–30 minutes, preferably, about 15 minutes. Raising the temperature above 850° C. would have the disadvantage that the duration of the anneal would have to be very short and therefore difficult to control as the above-mentioned undesired round granular agglomerations occur in the structure which substantially impede the formation of the desired lamellar like structure. Lower temperatures than 750° C. can be used for the anneal but the duration thereof must be longer. Expediently a temperature below 600° C. should not be used, as then, through the formation of α-zirconium at the long annealing periods necessary for the deformation, the production of the lamellar like structure is rendered considerably more difficult.

The number of deformations and the degree of deformation depend upon the size of the casting. It is, in itself, possible with small castings to employ only one intermediate anneal prior to the final deformation. In general, however, a number of deformation stages with intermediate anneals between each stage usually are necessary.

The superconductive alloys according to the invention can also, for example, be converted to a fine grained starting material for the deformation by converting them to the corresponding hydrides, comminution, pressing and then heat treating under vacuum.

The invention is illustrated by the following example.

Example

A casting 10 mm. in diameter of an alloy of 75% by weight of niobium, 0.5% by weight of tin and the remainder zirconium was cold worked over 99% by rolling and drawing to a wire 0.3 mm. in diameter. After a heat treatment for 15 minutes at 800° C. a further cold working to a diameter of 0.2 mm. was effected. The resulting wire possessed a lamellar like structure with a lamellae thickness of 0.1μ. At 5° K. and a period of measuring of 20μ seconds a maximum critical current density of 45.10^4A./cm.^{2} was measured for such alloy.

The same alloy without the tin addition according to the invention produced in the same manner and having a lamellar like structure only exhibited a maximum critical current density of 20.10^4A./cm.^{2} under the same conditions of measurement. The transition temperature of the tin containing alloy according to the invention was 12° K. whereas that of the alloy devoid of tin was 11.5° K.

I claim:

1. An elongated body of a cold worked superconductive alloy of 60 to 80% by weight of niobium, 0.5 to 3% by weight of tin and the remainder zirconium having surfaces parallel to the longitudinal axis thereof and having a lamellar structure with the lamellae substantially parallel to the longitudinal axis, the average thickness of the lamellae being between 0.01 and 1.0μ.

2. An elongated body of a cold worked superconductive alloy of 60 to 80% by weight of niobium, 0.5 to 3% by weight of tin and the remainder zirconium having surfaces parallel to the longitudinal axis thereof and having a lamellar structure with the lamellae substantially parallel to the longitudinal axis, the average thickness of the lamellae being between 0.01 and 1.0μ.

3. An elongated body of a cold worked superconductive alloy of 20 to 80% by weight of niobium, 0.1 to 10% by weight of tin and the remainder zirconium having surfaces parallel to the longitudinal axis thereof and having a lamellar structure with the lamellae substantially parallel to the longitudinal axis, the average thickness of the lamellae being between 0.01 and 1.0μ.

4. An elongated body of a cold worked superconductive alloy of 20 to 80% by weight of niobium, 0.1 to 10% by weight of tin and the remainder zirconium having surfaces parallel to the longitudinal axis thereof and having a lamellar structure with the lamellae substantially parallel to the longitudinal axis, the average thickness of the lamellae being about 0.1μ.

References Cited by the Examiner

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