Patented Aug. 12, 1941 2,252,421

UNITED STATES PATENT OFFICE

2,252,421

ALLOY

Philip T. Stroup, New Kensington, Pa., assignor to Aluminum Company of America, Pittsburgh, Pa., a corporation of Pennsylvania

No Drawing. Application August 2, 1939, Serial No. 288,032

3 Claims. (Cl. 75—138)

The present invention relates to a method of improving the electrical conductivity of relatively pure aluminum and the resultant product.

There are a number of applications in the electrical industry where aluminum can be used, for instance, in transmission lines, bus bars and cables. Since the electrical conductivity of aluminum varies with its chemical purity, it is usually necessary to employ metal of a higher purity than the commercial grade of aluminum which contains about 1.0 per cent total of impurities. Even aluminum of high purity sometimes contains very small amounts of certain impurities which have an appreciably adverse effect upon the electrical conductivity and may therefore render the aluminum unsuitable for high conductivity applications. Included in this group of impurities which have such a marked effect are such elements as chromium, titanium, vanadium, zirconium, and molybdenum. Very small amounts of these impurities may find their way into the aluminum from a variety of sources such as the ore, carbon materials in the reduction pots, furnace linings and accidental contamination during the process of reduction and fabrication.

When using aluminum for electrical conductors it is usually specified that the conductivity shall exceed a certain minimum value. To meet the nominal minimum electrical conductivity value which is generally accepted for conductor grade aluminum on a volume basis, the metal should reach at least 61 per cent of the conductivity of the international annealed copper standard which has a value of 100 per cent. It sometimes happens that the conductivity of the aluminum may fall slightly below this specified value because of the presence of traces of the impurities described above and yet the metal may be satisfactory in all other respects.

It is therefore an object of my invention to provide a method for improving the electrical conductivity of commercially pure aluminum containing chromium, titanium, vanadium, zirconium, or molybdenum as impurities. It is also an object of my invention to provide an aluminum conductor which although it contains the foregoing impurities yet has substantially the conductivity of the usual conductor grade of metal.

My invention is predicated on the discovery that when a relatively small amount of boron is added to aluminum containing more than 0.01 per cent of chromium, titanium, vanadium, zirconium, or molybdenum as impurities, in addition to the usual iron and silicon impurities, the electrical conductivity is restored to nearly the value that the metal would have if these impurities were not present. In referring to these elements as impurities, I mean that the total amount should not exceed about 1 per cent, although ordinarily not more than 0.10 per cent is found in aluminum used for electrical conductor purposes. The foregoing total amounts do not include the usual iron, silicon and copper impurities which are associated with aluminum. In conductor grade of aluminum these impurities are kept below a maximum total of about 0.45 per cent. The expressions "aluminum conductor metal," or "conductor metal," as herein employed refer to aluminum, having the aforementioned limit on iron, silicon and copper impurities, that is used for electrical conductor purposes.

I have found that in most instances not more than about 0.5 per cent of boron and not less than 0.005 per cent need be added to offset the deleterious effect of these impurities, and usually from 0.01 to 0.10 per cent boron is sufficient to improve the electrical conductivity the necessary amount. The amount of boron required to counteract the detrimental effect of chromium, titanium, zirconium, molybdenum, and vanadium impurities on the electrical conductivity of aluminum, of course, depends somewhat upon the amount of these impurities present. Although the solubility of these elements in aluminum is very small, yet the amount of impurity which is dissolved in the aluminum appears to be the portion which exerts the maximum effect on the conductivity.

In adding boron to aluminum containing the above-named impurities, I prefer to introduce the element into a melt of said aluminum in the form of an aluminum-boron alloy, or hardener. Another method that may be used for adding boron consists in adding a small amount of a boron compound, for instance, boric acid, to the aluminum melt. The compound is subsequently reduced, yielding metallic boron which goes into solution in the aluminum. Either of these methods give satisfactory results, but I recommend the former method, however, since the amount of boron introduced into the aluminum melt is more easily controlled. Metallic boron could be introduced directly into an aluminum melt but this usually involves the use of high temperature and other difficulties besides the added cost of metallic boron.

As an illustration of the beneficial effect of

boron in improving the electrical conductivity of aluminum containing chromium and titanium as impurities, the following test results may be cited. The test consisted of determining the electrical conductivity of sheet samples of conductor grade aluminum, aluminum containing chromium or titanium, and the same material to which boron had been added. The method employed for carrying out these tests consisted in melting aluminum of the grade usually used as conductor material, pouring an ingot of this metal, dividing the remainder of the aluminum into two portions, introducing a known amount of chromium and titanium, respectively, into each of the portions in the form of an aluminum base alloy, pouring small size sheet ingots from each melt, then adding boron in the form of an aluminum-boron alloy to the balance of the melts, and finally pouring additional ingots from each melt. The ingots were then rolled into sheet of 0.064 inch thickness in the usual manner and then tested for electrical conductivity in standard test apparatus. The amounts of chromium, titanium, and boron added to the aluminum are given in the table below, as well as the electrical conductivity values.

	Material	Electrical conductivity volume percent international annealed copper standard=100%
A	Aluminum conductor material containing no Cr, Ti, V, or B.	63.5
B	Aluminum conductor material containing 0.04% Ti.	59.1
C	Aluminum conductor material containing 0.04% Ti+0.03% B.	62.6
D	Aluminum conductor material containing 0.06% Cr.	58.2
E	Aluminum conductor material containing 0.06% Cr+0.1% B.	61.3

The improvements in the electrical conductivity of aluminum containing chromium or titanium by the addition of boron is at once apparent. The presence of boron has materially reduced the detrimental effect of chromium and titanium and restored the electrical conductivity to nearly that of the aluminum containing none of these impurities. Boron has a similar effect on aluminum conductor metal containing vanadium, zirconium, and molybdenum impurities. By adding boron to aluminum in this manner it is possible to use a grade of aluminum which heretofore has been impossible to accept for electrical conductor purposes.

Although this invention has been described with considerable detail, it is to be understood that the description is for the purpose of illustration only and is not definitive of the limits of the inventive idea.

I claim:

1. Aluminum conductor metal containing from 0.01 to 0.5 per cent of boron and from 0.01 to 1 per cent total of at least one of the group of impurities consisting of chromium, titanium, zirconium, vanadium, and molybdenum, said conductor metal being characterized by having an electrical conductivity greater than of the same metal devoid of boron.

2. Aluminum conductor metal containing from 0.03 to 0.07 per cent of boron and from 0.01 to 0.25 per cent total of at least one of the group of impurities consisting of chromium, titanium, zirconium, vanadium, and molybdenum, said conductor metal being characterized by an electrical conductivity of at least 61 per cent of that of international annealed copper standard on a volume basis.

3. An aluminum electrical conductor containing from 0.01 to 0.5 per cent of boron, from 0.01 to 1 per cent total of at least one of the group of impurities consisting of chromium, titanium, zirconium, vanadium, and molybdenum, and up to 0.45 per cent total of the usual iron, silicon, and copper impurities, the balance being aluminum.

PHILIP T. STROUP.