UNITED STATES PATENT OFFICE.

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ALLOY FOR ELECTRICAL RESISTANCES.

961,217. Specification of Letters Patent. Patented June 14, 1910.

No Drawing. Application filed February 28, 1906. Serial No. 303,554.

To all whom it may concern:

Be it known that I, WILBUR B. DRIVER, a citizen of the United States of America, and a resident of East Orange, State of New Jersey, have invented a new and useful Improvement in Alloys for Electrical Resistances, which improvement is fully set forth in the following specification.

My invention relates to alloys intended primarily for electrical resistances, and is based upon my discovery that a substantial amount of aluminum added to alloys produces a marked effect upon their electrical resistances. This is particularly true of alloys composed mainly of copper and alloys composed mainly of iron.

As is generally known, the specific resistance of aluminum is very low; so that the natural expectation would be that the addition of aluminum to alloys would not suffice to raise the specific resistance to any extent, and would not be of any particular benefit. While small amounts of aluminum have been used in the manufacture of steel, and in alloys of copper, it has been for the purpose of a flux (in order to produce sound castings) or for hardening; but so far as I know, no use has been made of it for its electrical effect. When used for a flux, the aluminum usually passes off in the melting, and frequently its presence cannot be detected at all upon analysis of the alloy.

It has been supposed that substantial amounts of aluminum serve only to harden an alloy and to make it brittle, accomplishing no beneficial results electrically. I have found, however, that while this may be the case in some instances, yet quantities of aluminum varying from about one per cent. (1%) to about nine per cent. (9%) can be added to alloys of copper and nickel, of copper and manganese, and of copper and nickel and manganese, and (within the limits explained below) to alloys of iron and nickel, with marked benefit by way of increasing the electrical resistances of such alloys, while often improving their mechanical properties in the way of ductility, etc., and the aluminum likewise tends to "fix" the electrical properties of the alloys containing manganese (in this respect behaving similarly to nickel, as noted in my pending application filed February 9, 1906, S. N. 300,281). Aluminum has the advantage of nickel, however, in that it does not cause the increase in the thermo-electric effect against copper. Alloys of copper and nickel have been used to a considerable extent during recent years; but with a nickel content of about 42%, these alloys attain their maximum resistance. An addition of 2% to 8% of aluminum to copper-nickel alloys causes an increase in resistance; but where the nickel is in high percentage, the aluminum must be kept relatively low, so as to avoid brittleness. The resistances of copper-nickel-manganese alloys are also increased by aluminum additions. When to alloys of copper and manganese, sufficient nickel is added to fix the electrical properties, the "thermo-electric effect against copper", is raised, sometimes to its detriment. A "substantial amount of aluminum" added to this copper-nickel-manganese alloy, not only increases the resistance, but it also serves to reduce the "thermo-electric effect" referred to.

Alloys of copper and aluminum, containing up to 10% of aluminum, termed "aluminum bronze," have been employed for mechanical purposes, but these binary alloys do not possess any value for high resistance. I have found that at least one other ingredient, in substantial quantity, is essential, for the purpose indicated. The quantity of aluminum which can be used, without rendering the alloy too hard and brittle to enable it to be worked, varies in proportion to the quantity of copper present; other things being equal, the more copper there is in the alloy, the more aluminum can be used,— but the amount of aluminum should not be less than about one or two per cent. 1—2%), by weight, and not more than about eight or nine per cent. (8%—9%), by weight, according to the amount of copper present. Smaller amounts are not sufficient to produce marked effects, and larger amounts tend to make the alloys brittle. I have found the greatest power to be around five per cent. (5%).

Iron, alone, with a substantial amount of aluminum, seems to be in almost all cases too brittle. Iron-nickel-aluminum alloys are found too hard and unworkable when containing a small percentage of nickel, and are then usable only where the composition does not need to be rolled, hammered, or drawn. However, as twenty per cent. (20%) of nickel is approached, iron-nickel-aluminum alloys, containing substantial amounts of aluminum, have been found to give very satisfactory results; the aluminum

serves to increase the specific electrical resistance, and does not prevent the manipulation of the alloy, in fact, it often improves its ductility. For instance: nickel 25% and iron 75%, gives a specific resistance of about 80 microhms per cubic centimeter; whereas nickel 25% and iron 71½%, with aluminum 3½%, gives a specific resistance of about 104 microhms per cc.,—a gain of 30% in specific resistance. Again, nickel 30% and iron 70%, gives a specific resistance of about 84 microhms per cc.; whereas nickel 30% and iron 65%, with 5% of aluminum, gives a specific resistance of about 110 microhms per cc.,—also a gain of 30% in specific resistance. Moreover, the alloys produced by these formulæ are ductile and otherwise mechanically suitable for electrical resistances.

My invention is not limited to the precise formulæ or ingredients given. The spirit of my invention is based upon the discovery that aluminum taken in substantial amounts increases the electrical resistance and often improves the mechanical properties of alloys containing copper and some other ingredient (or ingredients), and of alloys containing iron with about 20% or more of nickel. By "a substantial amount" of aluminum, I mean as the minimum about one or two per cent. (1%—2%), by weight. Owing to the comparative lightness of aluminum, one per cent. by weight of this metal will be of far larger bulk than one per cent. of an ordinary metal such as iron or copper.

In the present application I do not claim specifically the conductor composed of iron alloys containing a substantial amount of aluminum, for the reason that I am specifically claiming herein copper alloys, and am advised that specific claims to such iron alloys may not be presented in this application.

Having thus described my invention, I claim:

1. An electrical-resistance-element, consisting of an alloy containing a substantial amount of aluminum with at least two other ingredients.

2. An electrical-resistance-element, consisting of a ductile alloy containing a substantial amount of aluminum with at least two other ingredients.

3. An electrical-resistance-element, consisting of an alloy containing from one per cent. to nine per cent. (1% to 9%), by weight, of aluminum, with at least two other ingredients.

4. An electrical-resistance-element, consisting of an alloy containing from two per cent. to eight per cent. (2% to 8%), by weight, of aluminum, with at least two other ingredients.

5. An electrical-resistance-element, consisting of an alloy containing from three per cent. to seven per cent. (3% to 7%), by weight, of aluminum, with at least two other ingredients.

6. An electrical-resistance-element, consisting of an alloy containing from four per cent. to six per cent. (4% to 6%), by weight, of aluminum, with at least two other ingredients.

7. An electrical-resistance-element, consisting of an alloy containing five per cent. (5%), by weight, of aluminum, with at least two other ingredients.

8. An electrical-resistance-element, consisting of a copper alloy containing another ingredient besides copper, and a substantial amount of aluminum.

9. An electrical-resistance-element, consisting of a copper alloy containing another ingredient besides copper, and from one per cent. to nine per cent. (1% to 9%), by weight, of aluminum.

10. An electrical-resistance-element, consisting of a copper alloy containing another ingredient besides copper, and from two per cent. to eight per cent. (2% to 8%), by weight, of aluminum.

11. An electrical-resistance-element, consisting of a copper alloy containing another ingredient besides copper, and from three per cent. to seven per cent. (3% to 7%), by weight, of aluminum.

12. An electrical-resistance-element, consisting of a copper alloy containing another ingredient besides copper, and from four per cent. to six per cent. (4% to 6%), by weight, of aluminum.

13. An electrical-resistance-element, consisting of a copper alloy containing another ingredient besides copper, and five per cent. (5%), by weight of aluminum.

14. An electrical-resistance-element, consisting of an alloy containing copper and manganese with a substantial amount of aluminum.

15. An electrical-resistance-element, consisting of an alloy containing copper and manganese, and from one per cent. to nine per cent. (1% to 9%), by weight, of aluminum.

16. An electrical-resistance-element, consisting of an alloy containing copper and manganese, and from two per cent. to eight per cent. (2% to 8%), by weight, of aluminum.

17. An electrical-resistance-element, consisting of an alloy containing copper and manganese, and from three per cent. to seven per cent. (3% to 7%), by weight, of aluminum.

18. An electrical-resistance-element, consisting of an alloy containing copper and manganese, and from four per cent. to six per cent. (4% to 6%), by weight, of aluminum.

19. An electrical-resistance-element, con-

sisting of an alloy containing copper and manganese, and five per cent. (5%), by weight, of aluminum.

20. An electrical-resistance-element, consisting of an alloy containing copper and nickel and manganese, with a substantial amount of aluminum.

21. An electrical-resistance-element, consisting of an alloy containing copper and nickel and manganese, and from one per cent. to nine per cent. (1% to 9%), by weight, of aluminum.

22. An electrical-resistance-element, consisting of an alloy containing copper and nickel and manganese, and from two per cent. to eight per cent. (2% to 8%), by weight, of aluminum.

23. An electrical-resistance-element, consisting of an alloy containing copper and nickel and manganese, and from three per cent. to seven per cent. (3% to 7%), by weight, of aluminum.

24. An electrical-resistance-element, consisting of an alloy containing copper and nickel and manganese, and from four per cent. to six per cent. (4% to 6%), by weight, of aluminum.

25. An electrical-resistance-element, consisting of an alloy containing copper and nickel and manganese, and five per cent. (5%), by weight, of aluminum.

In testimony whereof I have signed this specification in the presence of two subscribing witnesses.

WILBUR B. DRIVER.

Witnesses:
C. A. L. MASSIE,
R. L. SCOTT.