

July 26, 1960

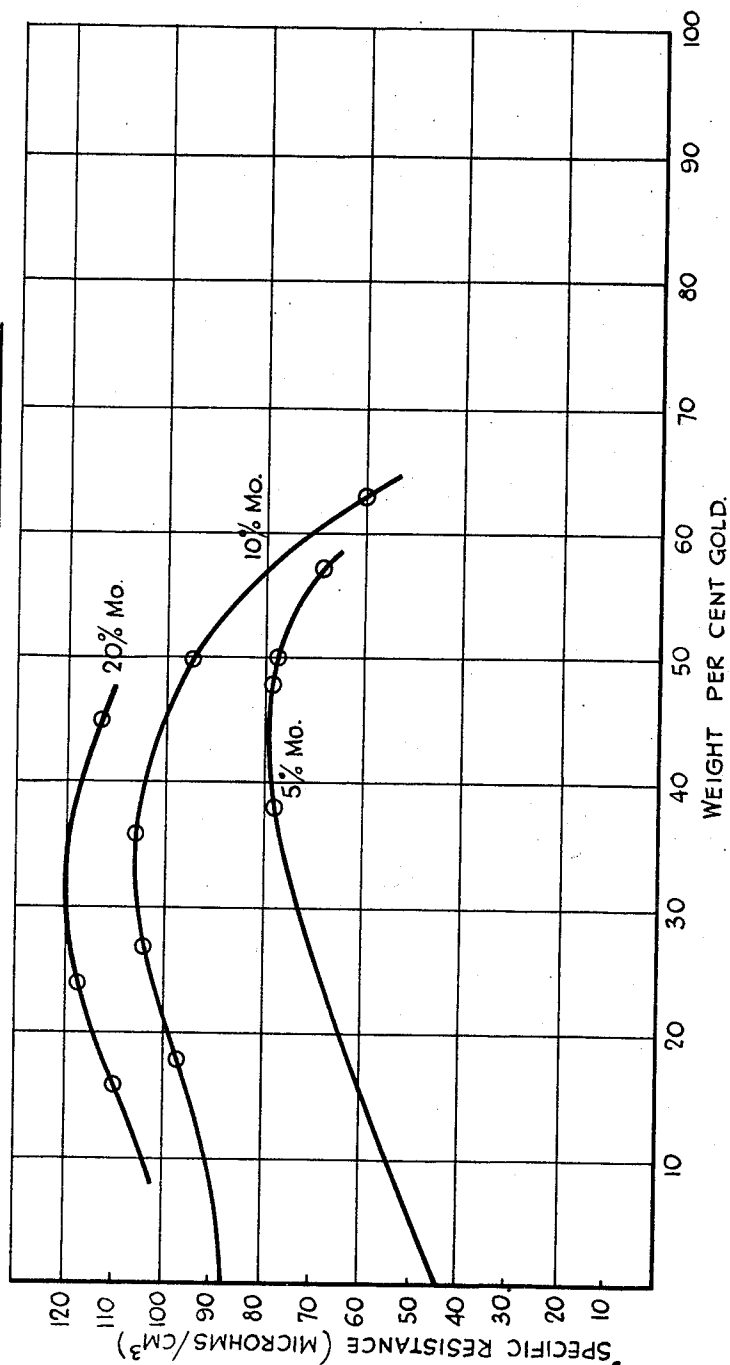
A. S. DARLING

2,946,679

DUCTILE ELECTRICAL RESISTANCE ALLOY

Filed July 29, 1959

SPECIFIC RESISTANCE OF
PALLADIUM - GOLD - MOLYBDENUM ALLOYS



Inventor:
Alan Sydney Darling,
By Pierce, Schiffman & Parker
his attorneys

1

2,946,679

DUCTILE ELECTRICAL RESISTANCE ALLOY

Alan Sydney Darling, Northwood, England, assignor to Johnson, Matthey & Company Limited, London, England, a British company

Filed July 29, 1959, Ser. No. 830,384

Claims priority, application Great Britain Aug. 6, 1958

7 Claims. (Cl. 75—134)

This invention relates to an improved alloy and more particularly to a high specific resistance alloy suitable for use in the fabrication of resistances for high precision electrical apparatus or equipment.

Resistance alloys for use in precision electrical apparatus are required to possess certain inherent characteristics. They should, for example, have an inherently high specific resistance, and a low temperature coefficient of resistance, be resistant to corrosion and abrasion and have adequate tensile strength, whilst at the same time they should be sufficiently ductile to enable them to be worked into wire.

Numerous alloy compositions consisting of base metals only, of base metals alloyed with noble metals, and compositions composed solely of noble metals are known for use as resistance alloys, but none of such alloy compositions as heretofore used or proposed possesses all the desirable characteristics required of a high resistivity alloy for precision electrical equipment. Consequently, manufacturers of high precision electrical equipment have always hitherto been faced with the necessity of compromising and of sacrificing one or other of the desirable characteristics in order to obtain the others.

For example, base metal resistance alloys, whilst possessing some of the desirable properties, such as high specific resistance and ductility, are susceptible to corrosion or to the formation of high resistivity surface oxide films, which render them quite unsuitable for use as slide wire elements in precision measuring and control equipment.

Many noble metal alloys, on the other hand, whilst being highly corrosion resistant, exhibit a relatively low specific resistance and have poor mechanical properties.

Of the noble metal resistance alloys, those based on, or containing, palladium have, in general, higher resistivities than platinum alloys. Examples of palladium alloys, known for use as resistance alloys are the binary palladium-tungsten, palladium-chromium, and palladium-gold alloys.

Palladium-tungsten alloys containing up to 20% tungsten, have an inherently high specific resistance, but are not sufficiently ductile to be easily workable.

Palladium-chromium alloys also exhibit a high specific resistance, but develop on the surface a thick oxide skin which renders them unsuitable for use as slide-wire material.

The binary palladium-gold alloy, containing 40–60% palladium is known to have a stable resistance. The alloy, however, possesses only a moderately low temperature coefficient of resistance, has poor mechanical properties and is not resistant to abrasion. The specific resistance of this alloy, moreover, is too low for precision instrument purposes.

More recently, a ternary palladium-gold-iron alloy composed of 20–62% Pd, 28–70% Au and 4–18% iron has been proposed for use as a potentiometer wire. This alloy, whilst having the desirable property of high spe-

2

cific resistance together with resistance to corrosion and high tensile strength and ductility, suffers from the disadvantage that carefully controlled heat-treatment of the alloy is necessary in order to develop the optimum electrical properties.

The principal object of this invention is to provide an improved resistance alloy for use in precision electrical apparatus or equipment.

Another object of the invention is to provide a ductile, stable resistance alloy having high specific resistance, high tensile strength and resistance to corrosion.

A further object of the invention is to provide a noble metal resistance alloy suitable for use in precision electrical equipment and apparatus, which does not require heat-treatment in order to develop its optimum electrical properties.

According to this invention, a ductile stable high resistance alloy is composed of 16–90% palladium, 5–64% gold and 2.5–20% molybdenum, apart from impurities.

An alloy embodying the invention and which will be found to be efficient in use is composed of 63% palladium, 27% gold and 10% molybdenum, apart from impurities. This alloy has a specific resistance 95.2 microhms per cm.³ as drawn and annealed and a positive temperature coefficient of 0.00026 per ° C.

Another alloy embodying the invention, which has a specific resistance of 77.5 microhms/cm.³ as drawn and annealed and a positive temperature coefficient of 0.00013 per ° C. and is, therefore, slightly less efficient than the 63% Pd, 27% Au and 10% Mo alloy, is composed of 45% Pd, 50% Au and 5% Mo apart from impurities.

The single figure of the accompanying drawing shows graphically the specific resistance of various alloys in the as-cast condition embodying the invention, the specific resistance in microhms/cm.³ having been plotted against varying content of gold in weight percent and in respect of molybdenum contents of 5% Mo, 10% Mo and 20% Mo.

In a modification of the invention the specific resistance of my improved alloy may be further increased without detrimentally affecting the workability of the alloy by inclusion of up to 4% of iron in the alloy.

For example, a particularly suitable alloy may be composed of 41.5% Pd, 50% Au, 5% Mo and 3.5% Fe, which will be found to have in the hard drawn condition a specific resistance of 102 microhms per cm.³. The characteristics of this alloy are given in the following table.

Table

Alloy	41.5% Pd, 50% Au, 5% Mo, 3.5% Fe.
Specific resistance, microhms/cm. ³	Worked 102, annealed 99.6
Mean temperature coefficient between 0 and 100° C.	+0.00012 per ° C.
Thermal E.M.F. against copper	—1.82 per ° C.
Density	14.11 gms./cm. ³ .
Ultimate tensile strength:	
Annealed	42.6 tons/sq. in.
Hard drawn	69.7 tons/sq. in.

The high degree of stability of this alloy is demonstrated by the fact that, after annealing at 105° C. for ½ hour, the resistivity of the alloy decreased only to 99.6 microhms per cm.³.

My improved alloy will be found to have a specific resistance within the range of 22–125 microhms per cm.³, to remain stable over long periods and to possess adequate tensile strength and ductility combined with corrosion resistance, which renders it eminently suitable

3

for use as resistance material for precision resistance electrical apparatus or equipment. Moreover, the alloy does not require heat-treatment in order to develop its maximum electrical properties.

What I claim is:

1. A ductile stable high resistance alloy composed of 16-90% palladium, 5-64% gold and 2.5-20% molybdenum apart from impurities.

2. A ductile stable high resistance alloy composed of 63% palladium, 27% gold and 10% molybdenum.

3. A ductile stable high resistance alloy composed of 45% palladium, 50% gold and 5% molybdenum.

4. A ductile stable high resistance alloy composed of 16-90% palladium, 5-64% gold, 2.5-20% molybdenum and up to 4% iron, apart from impurities.

5. A ductile stable high resistance alloy composed of

4

41.5% palladium, 50% gold, 5% molybdenum and 3.5% iron.

6. Resistance material for precision resistance electrical apparatus or equipment, made of the alloy as claimed in claim 1.

7. Resistance material for precision resistance electrical apparatus or equipment made of the alloy claimed in claim 4.

References Cited in the file of this patent

UNITED STATES PATENTS

2,001,017	Feussner et al. -----	May 14, 1935
2,780,543	Schneider et al. -----	Feb. 5, 1957

FOREIGN PATENTS

454,019	Canada -----	Jan. 11, 1949
---------	--------------	---------------