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GOLD ALLOY COMPOSITION

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ABSTRACT OF THE DISCLOSURE

The present invention relates to a gold alloy composition containing, based on weight percent, from 1 to 25% of at least two members of the group consisting of iron, vanadium and nickel, the balance being gold, preferably such composition wherein the gold comprises at least 75% thereof. Particularly desirable are compositions containing 5 to 15% of at least two members of the group consisting of iron, vanadium and nickel, and 85% to 95% gold. The aforesaid composition is particularly suitable for use as a wire composition in various applications, such as bridge or ignition wires in electro-explosive devices, wire wound potentiometers or resistors, etc.

BACKGROUND OF THE INVENTION

For a wide variety of applications, an alloy composition which offers high resistivity coupled with high tensile strength ductility and corrosion resistance, as well as a controllable temperature coefficient of resistance, is extremely desirable. Such wires are used in potentiometers, electro-explosive devices, precision resistors and a wide variety of other applications.

It has now been found that an alloy composition comprising a major portion of gold, coupled with minor portions of at least two members of the group consisting of vanadium, iron and nickel is an excellent composition for the manufacture of wires for a wide variety of uses due to its extremely high resistance, good tensile strength, ductility and controllable low temperature coefficient of resistance, as well as offering a variety of other desirable properties. The present compositions comprise 1 to 25 wt. percent, preferably 5–15 wt. percent of at least two members of the group consisting of iron, vanadium and nickel, with the balance (75%, preferably 85 wt. percent and greater) being gold. Particularly desirable are compositions wherein the gold comprises at least 85 wt. percent of the composition and the composition contains 0.1 to 10 wt. percent, especially 2 to 8% vanadium, along with 1 to 10 wt. percent of either iron and/or nickel, i.e., gold-vanadium alloys with minor amounts of iron and/or nickel. A particularly desirable composition because of its high resistivity contains 7% vanadium, 5% iron and 88% gold.

It has been found that the above alloy and alloys of similar composition are capable of producing wire offering the following significant advantages:

1. High resistivities, e.g., typically 800 ohms/c.m.f. and higher. Particularly desirable and unusual are resistivities in the range of 850 to 1,200 ohms/c.m.f. The term "ohms/c.m.f." refers to the resistance of one foot of wire at 0.001 inch diameter and is a well-known expression used in the wire industry to denote resistivity. In contrast, pure gold has a resistivity of about 15 ohms/c.m.f.

2. A wide range of resistivities are possible by minor changes in the composition of the alloy. By way of example, resistivities within the range of about 750 ohms/c.m.f. to 1,130 ohms/c.m.f. are obtained by varying the composition from 2% vanadium, 5% iron, 1% nickel, 92% gold to 8% vanadium, 5% iron and 87% gold.

3. High tensile strengths, e.g., in the range of approximately 150,000 p.s.i. and above in the stress-relieved condition are obtainable, thereby making for ease in handling. Typically, the present wire compositions have tensile strengths in the range of 135,000 to 200,000 p.s.i. in the form of a stress relieved 0.005 inch diameter wire.

4. High corrosion resistance. Typically, the aforesaid compositions have almost an infinite shelf life, particularly with the gold content over 80%, e.g., 88%. This makes possible the ability to produce potentiometers and the like having an exceptionally low "noise" level.

5. Very satisfactory wear conditions. By way of example, test runs showed execptionally low noise value as a wire would potentiometer element over 500,000 cycles in life tests. In this respect, this wire is at least equal to other materials generally known in the trade, if not superior to many.

6. Alloys having temperature coefficients of resistance approaching zero can be produced. Typically, temperature coefficients of resistance of less than 65 (positive or negative), preferably less than 40, and most desirably under 20, are obtainable in accordance with the present invention.

This is an unusual quality, particularly desirable in applications wherein a large change of temperature is to be faced without significantly varying the resistance of the wire element in its circuit.

Alloys of high electrical resistivity have the practical advantage of giving either high resistance values of the potentiometer winding in which they are incorporated or permit the use of smaller elements of the same resistance value. Similarly, in other uses such as bridge wire, or ignition wire in electro-explosive devices such as blasting caps, the high resistivity means that a larger diameter wire may be used resulting in greater strength for the same resistance/unit strength, or a greater resistance obtained with the same diameter wire.

All of the aforesaid properties indicate some of the advantages of the present alloys compositions in the manufacture of wires for a wide variety of uses.

Typically, the alloy composition is made into wires by standard procedures, such as vacuum melting the alloy and pouring it into wire ingots, typically about ¾ inch in diameter. The composition is sufficient ductile so that with suitable annealings it may be cold worked into small sizes of wire which is the form in which it is normally used. Generally, the wire is a relatively thin size, i.e., in the range of 0.0004 inch to 0.03 inch diameter. Typical, but not limiting, as to uses for such wire includes potentiometers, fixed or variable resistors, precision resistors, electro-explosive devices and the like.

It is to be noted that while alloys of gold with vanadium are known (U.S. Pat. No. 1,107,180), it is necessary to have a high concentration of gold, e.g., at least 75% and preferably 85% or more in order for the composition to be ductile and capable of fabrication into wire. By way of example, compositions containing 30% gold, 40% iron and 30% vanadium cannot be fabricated into wire form and are normally merely products of powder metallurgy or cast ingots. Therefore, their resistivity as a wire element is irrelevant, and in any case cannot be readily measured. Such compositions falling outside the present invention will not offer the advantages or find the applications of the present alloys. While such compositions may be suitable for other purposes e.g., coins, they are not suitable for manufacture into useful ductile wire products.

As used in the examples and specification:

(1) "Resistivity" is expressed in ohms per circular mil foot, (ohms/c.m.f.).

(2) "Temperature coefficient of resistance" is expressed as ohms/ohm/degree centigrade based on parts per million. This characteristic is determined by ASTM B84–65 test method.

The various aspects and modifications of the present invention will be made more clearly apparent by reference to the following examples and accompanying description.

TABLE 1

	Resistivity (in ohms per circular-mil foot	Temperature coefficient of resistance, −50° C. to +150° C. (ohms/ohm/° C. expressed in parts per million)	Tensile strength in (nominal .005" diameter)	Chemical composition, weight percent			
				Au	V	Fe	Ni
Sample codes:							
659	372.8	+42.3	179,000	90	3	-----	75
669	758.5	+65.0	145,600	92	2	5	1
672	819.0	−36.0	156,800	91	2.45	5	1.5
670	833.3	+33.2	165,800	91.5	2.5	5	1
668	895.7	−2.1	168,000	91	3	4.5	1.5
660	928.1	−16.0	165,700	92	3	5	------
644	948.8	−73.6	190,400	90	------	5	5
651	1,055	−48.2	135,000	92.5	5	2.5	------
646	1,073	−54.7	168,000	90	5	5	------
650	1,130	−63.0	190,400	87	8	5	------
Controls:							
664	502.2	+392	95,200	95	0	5	0
634	1,114	−128.4	185,000	93	7	0	0

EXAMPLE 1

22 ounces of Gold 99.99% pure, 1.75 ounces of Vanadium 99.9% pure, and 1.25 ounces of Iron 99.9% pure were weighed, making a total of 25 troy ounces. This gave an alloy of 7% Vanadium, 5% Iron and 88% Gold (weight percent). It was vacuum melted using a vacuum of 1×10^{-3}mm. of Mercury, or better and poured into a ¾" diameter ingot while still in vacuum.

The ¾" diameter ingot was then annealed at 1450° F., swaged to about half its diameter, and again annealed at the same temperature. The wire was then rolled and subsequently drawn through diamond wire drawing dies. From about ⅜" diameter it was annealed at about every sixty percent diameter reduction, or whenever necessary at temperatures from 1100 to 1300° F. in an argon or hydrogen atmosphere, as is quite typical in accordance with normal good wire drawing practice. Its ultimate diameter was 0.005 inch. The particular alloys of the present invention require no unusual precautions or care in the fabrication steps used, and conventional fabrication techniques are employed.

The alloy wire of the aforesaid composition was then tested for its electrical resistivity by use of a Wheatstone Bridge, and its resistivity found to be 1,100 ohms/c.m.f. The tensile strength of the wire was 150,000 p.s.i., and its temperature coefficient of resistance was −55 ohms/-ohm/degree centigrade.

Such a wire composition would be particularly suitable for use as a bridge or ignition wire or as a potentiometer element.

EXAMPLES 2–11

A series of gold alloys were fabricated using the same fabrication techniques. For consistency, all alloys were fabricated into 0.005 inch diameter wires. It is recognized in the art that the ultimate tensile strength increases with reduction of wire diameter. For example, it has been found that by reducing the diameter from 0.005 to 0.001 inches, an increase of 20° in tensile strength is obtained.

The resistivity, temperature coefficient of resistance and tensile strength of the resulting wire alloys is set for Table 1.

As shown in Table 1, the compositions of the present invention give an excellent combination of high resistivity, high tensile strength, and temperature coefficients of resistivity approaching zero. More particularly, resistivities above 800, coupled with tensile strengths of above 150,000 p.s.i. and temperature coefficient of resistance of less than 65 are obtained in Samples 672, 670, 668, 660, 646 and 650.

As compared to compositions containing no Vanadium (Sample 664), the desirability of incorporating 0.1 to 10 Vanadium is indicated. Similarly, Sample 634 shows that an alloy of gold/Vanadium alone gives high negative temperature coefficients of resistivity.

Further, the following data extracted from Table I shows the controlled variation of resistivity with composition obtained in accordance with the present invention.

TABLE 2

	Gold	Vanadium	Nickel	Iron	Resistivity of wire, ohms/c.m.f.
Sample:					
669	92	2	1	5	758.5
651	92.5	5	0	2.5	1,155
650	87	8	0	5	1,130

Various modifications may be made to the present invention. For example, the wire compositions obtainable by the present alloy compositions will find application in a very wide variety of fields wherever wire of high resistivity, high tensile strength, control of temperature coefficient of resistance and good corrosion resistance are desired. Various other modifications to the invention as described will suggest themselves to those skilled in the art.

Having described the invention, that which is sought to be protected is set forth in the following claims.

What is claimed is:

1. An alloy composition consisting essentially of on a weight percentage basis: 7 to 8% vanadium, 5% iron and the balance of said composition being gold.

2. The alloy composition of claim 1 which is 7% vanadium, 5% iron and 88% gold.

3. The alloy composition of claim 1 which is in the form of a ductile wire of less than 0.03 inch diameter.

4. A wire wound potentiometer element having the composition of claim 1.

5. A resistor element having the composition of claim 1.

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