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WORKABLE RUTHENIUM ALLOY AND PROCESS FOR PRODUCING THE SAME

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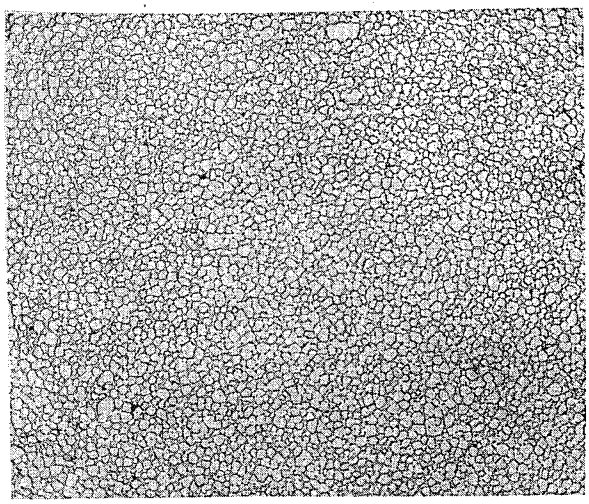

FIG. 1

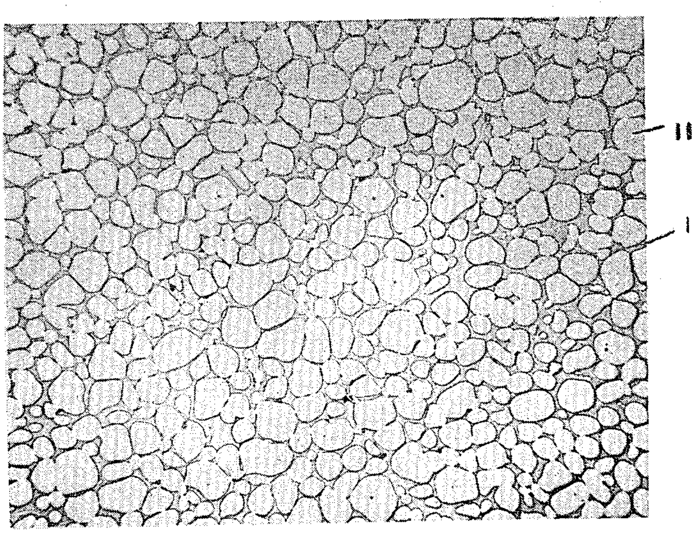

FIG. 2

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WORKABLE RUTHENIUM ALLOY AND PROCESS FOR PRODUCING THE SAME

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The present invention relates to a novel alloy and, more particularly, to a novel ruthenium-rich alloy and articles made therefrom by powder metallurgy techniques.

It is well known that for certain purposes in the electrical and electronic arts, ruthenium can have advantages not shared by most other metals. For example, the nobility, high melting point, and hardness which characterize ruthenium make it advantageous for an electrical contact material. As a practical matter, however, the working problems associated with ruthenium cause difficulties in making contacts for switch and other electronic and electrical components therefrom. Although attempts were made to overcome the foregoing difficulties and other difficulties, none, as far as we are aware, was entirely successful when carried into practice commercially on an industrial scale.

It has now been discovered that by means of a novel combination of metallic ingredients and by special processing techniques, workable ruthenium alloy articles can be provided which exhibit many of the advantages of massive metallic ruthenium.

It is an object of the present invention to provide means for the production of a workable ruthenium-rich alloy.

Another object of the invention is to provide a novel workable ruthenium-rich alloy.

It is a further object of the invention to provide a method for fabricating articles made of a cold-workable ruthenium-rich alloy.

Other objects and advantages of the invention will become apparent from the following description taken in conjunction with the accompanying drawing in which FIGURE 1 is a representation of the alloy structure of the present invention taken at 75 diameters and FIGURE 2 is a similar representation taken at 250 diameters.

Generally speaking, the present invention contemplates a novel liquid-phase sintered, duplex-structured ruthenium alloy containing, in weight percent, about 60% to about 90% ruthenium, about 5% to about 35% gold, and about 5% to about 35% palladium. In the duplex-structured alloy provided in accordance with the invention, the ruthenium essentially appears in the form of rounded grains dispersed in and metallurgically bonded to a continuous gold-palladium alloy matrix which matrix is believed to be substantially saturated with ruthenium. The grains of rutheinum are advantageously about 0.002 inch to about 0.0002 inch in diameter. The alloy can contain up to 10% in the aggregate of platinum, rhodium, iridium, molybdenum and tungsten, by weight, and can contain small amounts, e.g., up to 0.5%, of impurities unavoidably associated with gold, palladium and ruthenium.

Two methods of manufacture can be employed in making the present alloys. In the first method, metal

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powders of the alloy ingredients having a particle size below 100 mesh are mixed thoroughly and pressed into a compact. The compacted mixture is then sintered at a sufficiently high temperature to liquefy and distribute the gold-palladium phase. The thus-produced alloy is then cooled. Advantageously, the ratio of gold to palladium is maintained at about 2:1 to about 1:1 in the alloy to render the alloy cold workable, for example, to the extent that the alloy can be reduced at least about 40% in section without annealing. In another suitable method of manufacture, ruthenium powder is compacted into a compact, is lightly sintered if desired, is then infiltrated with molten gold-palladium alloy, and is cooled to solidify the matrix phase. Advantageously, the ruthenium powder compact is subjected to a vacuum pretreatment at sintering temperatures prior to infiltration with gold-palladium alloy.

Both of the aforedescribed methods of manufacture result in a duplex alloy as depicted in FIGURES 1 and 2 of the accompanying drawing which depict, respectively, the microstructure taken at 75 diameters and at 250 diameters of Alloy No. 8 herein produced by the contact infiltration method. Referring now thereto, the drawing shows substantially rounded, isolated grains or islands of ruthenium **11** dispersed in and bonded to a continuous gold-palladium phase **12**. At the surface of the alloy, the more wear resistant ruthenium grains **11** stand out presenting in effect a substantially pure ruthenium surface. Deeper within the mass of the alloy, the ruthenium grains are surrounded by and metallurgically bonded to the matrix metal. By virtue of composition, the matrix metal and the ruthenium cooperate to produce a workable composite of substantial hardness, strength and significant ductility.

In carrying the invention into practice, it is advantageous with respect to alloy composition to maintain the amount of ruthenium within the range of about 60% to about 80%, to maintain the amount of gold within the range of about 5% to about 30%, and to maintain the amount of palladium within the range of about 5% to about 30%.

More advantageously, the gold and palladium contents are maintained between about 10% and 20%, by weight of the alloy and the gold:palladium ratio is maintained between about 2:1 and 1:1 to confer cold workability to the liquid-phase sintered alloy. Even more advantageously from the cold-workability standpoint, the gold:palladium ratio does not exceed about 1.5 to 1. Ruthenium contents below 60% result in sagging or distortion during sintering while ruthenium contents above 90% provide poor ductility in the resulting alloy articles. Gold contents below 5% (with palladium contents above 30% or 35%) result in excessive solution of ruthenium in the matrix phase with the result that the matrix phase becomes very hard and of limited workability. On the other hand, gold contents above 30% or 35% (with palladium contents below 5%) yield low workability and malleability in the resulting alloy articles. Alloys containing about 70% to about 75%, by weight, of ruthenium with the remainder being gold and palladium and with the ratio of gold to palladium being about 1.5 to 1 to about 1 to 1 are characterized by improved cold workability. Alloys containing only ruthenium and gold or only ruthenium and palladium have very poor malleability. In making the alloy of the present invention, the sintering temperature or the infiltrating temperature is at least sufficiently high to liquefy the gold-palladium matrix phase and is generally in the range of 1400° to 1600° C., e.g., about 1450° to about 1550° C.

For the purpose of giving those skilled in the art a better understanding of the invention and/or a better appreciation of the advantages of the invention, the illustrative examples of alloy compositions within the invention are set forth in the following Table I:

TABLE I

Alloy No.	Percent Gold	Percent Palladium	Percent Ruthenium
1	25	5	Balance.
2	20	10	Do.
3	15	15	Do.
4	20	20	Do.
5	17.5	17.5	Do.
6	15	10	Do.
7	10	10	Do.
8	14	11	Do.

Liquid-phase sintered alloys such as those set forth in Table I which are made by either infiltration or powder mixing techniques employing metal powders of about 325 mesh can exhibit ultimate tensile strengths (U.T.S.) in the range of about 60 to about 100 thousands of pounds per square inch (p.s.i.) and elongations of the order of 5% to about 10%. The alloys are readily workable and are substantially uniformly deformed during working. That is, both the matrix and the dispersed ruthenium particles deform under working conditions. As an indicatin of workability, sintered portions of Alloy No. 8 produced by contact infiltration could be cold rolled to effect a 45% reduction in thickness without developing edge cracks. When cold rolling, it is advisable to limit reductions to about 5% to 10% per pass. In contrast to the foregoing, it can be pointed out that commercially pure massive ruthenium cannot be reduced in section to any significant extent by cold working methods.

The alloys of the invention are characterized by a high combination of nobility, melting point, hardness, workability, and ductility. These characteristics make alloys of the present invention particularly suitable in electrical and electronic applications, particularly in instances where mechanical wear is encountered. Thus, contacts includinge electrical contacts, welding contacts, etc., bearings for instruments, slip rings, etc., may be produced from the liquid-phase sintered alloys provided in accordance with the invention.

Although the present invention has been described in conjunction with preferred embodiments, it is to be understood that modifications and variations may be resorted to without departing from the spirit and scope of the invention, as those skilled in the art will readily understand. Such modifications and variations are considered to be within the purview and scope of the invention and appended claims.

We claim:

1. A liquid-phase sintered alloy containing, by weight, about 5% to about 35% gold, about 5% to 35% palladium and the balance essentially ruthenium, and with the ruthenium content being at least about 60% of the alloy, said alloy having a duplex structure consisting of rounded ruthenium grains dispersed in a gold-palladium alloy matrix.

2. A cold-workable, liquid-phase sintered alloy according to claim **1** wherein the ratio of gold to palladium is about 2:1 to about 1:1.

3. A cold-workable, liquid-phase sintered alloy according to claim **2** wherein the gold content is about 5% to 30% and the palladium content is at least about 5%.

4. A cold-workable, liquid-phase sintered alloy according to claim **2** wherein the gold content is about 10% to 20% and the palladium content is at least about 10%.

5. A cold-workable, liquid-phase sintered alloy according to claim **2** wherein the ratio of gold to palladium is about 1.5 to 1 to about 1 to 1.

6. An electrical contact made of a liquid-phase sintered alloy containing, by weight, about 5% to about 35% gold, about 5% to 35% palladium, and the balance essentially ruthenium, and with the ruthenium content being at least about 60% of the alloy, said alloy having a duplex structure consisting of rounded ruthenium grains dispersed in a gold-palladium alloy matrix.

7. A cold-worked electrical contact made of a liquid-phase sintered alloy containing, by weight, about 5% to about 35% gold, at least about 5% palladium, with the ratio of gold to palladium being about 2:1 to about 1:1, and the balance essentially ruthenium, and with the ruthenium content being at least about 60% of the alloy, said alloy having a duplex structure consisting of rounded ruthenium grains dispersed in a gold-palladium alloy matrix.

8. A cold-worked electrical contact according to claim **7** wherein the gold content is about 10% to 20% and the palladium content is at least about 10%.

9. A cold-worked electrical contact according to claim **8** wherein the ratio of gold to palladium is about 1.5 to 1 to about 1 to 1.

10. The method for producing a cold-workable ruthenium alloy which comprises compacting a mixture of metal powders comprising about 5% to about 35% gold, at least about 5% palladium, with the ratio of gold to palladium being about 2:1 to about 1:1, and the balance essentially ruthenium, and with the ruthenium content being at least about 60% of the alloy, sintering the compact at a temperature sufficiently high to form a molten gold-palladium alloy phase and to distribute said phase through the structure so as to produce in the resulting cooled alloy a duplex structure consisting of rounded ruthenium grains distributed through a gold-palladium alloy matrix.

11. The method for producing a cold-workable ruthenium alloy which comprises preparing a compact comprising ruthenium powder and distributing throughout said compact a molten gold-palladium alloy containing gold and palladium in the ratio of about 2:1 to about 1:1 to produce a final compact containing, by weight, about 5% to about 35% gold, at least about 5% palladium, and the balance essentially ruthenium, and with the ruthenium content being at least about 60% of the alloy, and having a duplex structure consisting of rounded ruthenium grains distributed through a gold-palladium alloy matrix.

12. The method according to claim **11** wherein the gold content of the final compact does not exceed about 30% by weight.

13. The method according to claim **11** wherein the gold content of the final compact is about 10% to about 20% and the palladium content is at least about 10%.

14. The method according to claim **11** wherein the gold:palladium ratio in the final compact is about 1.5 to 1 to about 1 to 1.

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