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ALLOYS

Johann Simon Streicher, Newark, N. J., assignor to American Platinum Works, Newark, N. J., a corporation of New Jersey

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My invention relates to alloys which are adapted as substitutes for the well known gold-palladium alloys, now used for the manufacture of pins, washers and other auxiliary elements in the dental industry.

The object of the invention is to provide a new alloy composed of the precious metals palladium, platinum and gold, the palladium preferably being present in greater proportion than the platinum, and the gold in lesser proportion than the platinum.

An alloy containing substantially 60% palladium, 30% of platinum and 10% of gold has been found particularly satisfactory.

The well-known gold-palladium alloys are used as a substitute for gold. Palladium is added to the gold regularly in amounts from 30 to 40%; the resulting alloys melt around 1400° C.

When these gold-palladium alloys are shaped into thin wires, ribbons and the like, they behave, mechanically, much the same as pure palladium in that the alloys smear and are very hard on the rolls and dies, necessitating the cleaning of the rolls and dies within short working periods. When these alloys are shaped into dental pins or washers on the well known automatic machines they are always obtained with rough edges, because these alloys drag considerably from the tools and the minute punches and dies used in the machines have to be changed and cleaned every few hours.

Although these gold palladium alloys are harder than pure palladium they preserve all of the mechanical properties so characteristic of the pure palladium metals even when alloyed with about 60 to 70 parts of gold. The addition of small amounts of rhodium or iridium does not favorably change the property of these alloys, but on the other hand increases the hardness of these alloys with the result that the mechanical difficulties are accordingly increased.

It has been found that all these purely mechanical difficulties can be overcome and these alloys can be improved in many other directions when the regularly predominating gold content of these alloys is greatly reduced, and when platinum is added in such proportion that palladium and platinum together become the main constituents of the alloys. Special tests have shown that the most favorable change in the mechanical properties of the gold-palladium alloys takes place as soon as the gold content is reduced to less than 25%, and when these alloys contain at least 15% platinum. In other words, the most favorable results are obtained with alloys comprising as constituents:

	Percent
Platinum	15–50
Gold	5–20
Palladium	Remainder

The ternary alloys resulting from these combinations, especially those with gold contents not higher than 5 to 15% are extremely easy to work. They show nearly the same mechanical properties as platinum (high ductility); and when shaped into wires, sheets, ribbons, pins, etc. they have the same color and high brillliancy as platinum, but never the dullness which is so characteristic of the gold-palladium or palladium-gold alloys. My new alloys melt nearly all around 1500° C.; they are, therefore, especially adapted to be used as auxiliary metal elements in the manufactrue of artificial teeth, especially, since they preserve a very high tensile strength up to 1400° C., and, as tests have shown, adhere excellently to the porcelain, when baked together with the porcelain used for the manufacture of artificial teeth.

These ternary alloys may contain also some of the other metals of the platinum group, such as rhodium, iridium, ruthenium and osmium, singly or collectively in minor amounts, (about 0.5–2%; these platinum group by-metals are often present in these amounts in the commercial grades of platinum and palladium). These minute amounts (.5% to 2%) of the metals of the platinum group will increase the tensile strength of these ternary alloys to a high degree as well as the corrosion resistance thereof without changing the good mechanical properties mentioned above.

I have found that the presence of rhodium and/or iridium is especially advantageous; these by-metals of the platinum group practically volatilize in these alloys only in a very minor degree when the alloys are used at temperatures above 1100° C. Similarly, the mechanical properties of these alloys are not essentially changed when small amounts of the metals of the iron group (iron, cobalt, nickel) are present in these alloys alone or together with minor amounts of the metals of the platinum group (rhodium, iridium, ruthenium, osmium). These metals of the iron group can be present, singly or in combinations, in amounts up to approximately 3%. The metals of the platinum group, as well as the metals of the iron group, do not change the general character of these alloys, since all of these metals, when they are added singly or in combination in

the amounts specified, are able to form solid solutions with the constituents of the above named ternary alloys. All of these alloys, with or without the addition of the metals of the platinum group (rhodium, iridium, ruthenium, osmium) and/or the metals of the iron group can be forged in the hot state, up to the gold content of about 15 to 20% and up to a platinum content of about 35%. The other combinations are best worked in the cold state, with intermediate annealings, and by quenching them in water after such annealings.

Even silver and copper, and also such metals as zinc, cadmium, tin, manganese, rhenium, chromium, etc. can be present in these alloys in minor amounts up to 3% without impairing the original properties of these alloys. The presence of the metals with low melting points, (such as zinc, cadmium, tin, silver, copper) in such minor amounts does not even change substantially the melting points and the corrosion resistance of these alloys. The tensile strength of these alloys is, however, increased and in a similar way as with the addition of the metals of the platinum group (rhodium, iridium, osmium, ruthenium) or those of the iron group. These alloys are best worked in the cold state and with intermediate annealings and by quenching them in water after such annealing.

In case these alloys shall be used for dental casts of small dimensions and these casts are not to be worked mechanically afterwards, but just fashioned to the purpose intended, there can be produced with these alloys excellent combinations in which the melting point of the liquid alloys is decreased; the liquidity is increased by adding to the melts of from 1 to 4% of phosphorous. Since these alloys absorb rather large amounts of oxygen when in the liquid state, the phosphorous practically to be added has to be in excess of this amount, since part of it acts as a dioxidizer.

The alloys of the specified system do not show an essential improvement when submitted to the well-known heat-treatment processes; they represent systems in which the constituents are in complete solid solution.

The palladium-platinum alloys, with the constituents specified above, are of great technical value because they have a high melting point, high tensile strength up to highest temperatures used in the dental industry, and because they possess the brilliancy and color of platinum and all the other excellent mechanical properties outlined above. They are besides very highly corrosion resistant. Palladium is very readily soluble in boiling nitric acid and also are most of the palladium alloys with a high palladium content. The new alloys resist boiling concentrated as well as diluted nitric acid and also boiling concentrated hydrochloric acid. These alloys are, therefore, not only of great use in the dental industry but they can also be used with great advantage, for the manufacture of pens for fountain pens, instead of gold alloys, and in the chemical industry. Last but not least, these new alloys offer a great economical advantage. As long as the price of gold is higher than the price of platinum or equal thereto, these alloys are much cheaper than the regularly used gold alloys with gold as a predominant constituent. Likewise are always of special advantage the alloys with 50% palladium and more; especially since all the alloys with such high palladium content do not exceed in their specific gravities the value of 15 essentially, which specific gravity is far below the values attained with alloys containing gold and platinum as predominating constituents.

Examples

(1) The alloy consisting of 60% palladium, 30% platinum, 10% gold has the following properties:

Melting point: 1506° C.
Specific gravity: 15.25.
Tensility: hard (75% reduced) 74 kilograms per square millimeter.
soft (annealed 1 hour at 1400° C.) 27.3 kilograms per square millimeter.
Rockwell hardness ($\frac{1}{16}$'' ball, 100 kg.):
soft 67.3.
reannealed 67.5.
Corrosion: Loss per square centimeter: one hour
Boiling conc. HCl .005 milligram.
Boiling conc. HNO_3 .010 milligram.

(2) The alloy consisting of 59% palladium, 30% platinum, 10% gold, and 1% rhodium has the following properties:

Melting point: 1515° C.
Specific gravity: 15.20.
Tensility: hard (75% reduced) 79 kg./per square millimeter.
soft (annealed 1 hour at 1400° C.) 27.6 kilograms per square millimeter.
Corrosion: Loss per square centimeter—one hour
Boiling conc. HCl .14 milligram.
Boiling conc. HNO_3 .021 milligram.

(3) The alloy consisting of 58% palladium, 30% platinum, 10% gold, 1% rhodium, and 1% iridium has the following properties:

Melting point: 1538° C.
Specific gravity: 15.30.
Tensility: hard (75% reduced) 78.3 kilograms per square millimeter.
soft (annealed 1 hour at 1400° C.) 34.4 kilograms per square millimeter.
Corrosion: Loss per square centimeter—one hour
Boiling conc. HCl .008 milligram.
Boiling conc. HNO_3 .012 milligram.

(4) The alloy consisting of 58% palladium, 30% platinum, 10% gold and 2% silver has the following properties:

Melting point: 1498° C.
Specific gravity: 15.08.
Tensility: hard (75% reduced) 94.4 kilograms per square millimeter.
soft (annealed 1 hour at 1400° C.) 28.2 kilograms per square millimeter.
Corrosion: Loss per square centimeter—one hour
Boiling conc. HCl .008 milligram.
Boiling conc. HNO_3 .011 milligram.

(5) The alloy consisting of 60% palladium, 27% platinum, 10% gold, 3% nickel has the following properties:

Melting point 1463° C.
Specific gravity: 14.68.
Tensility: hard (75% reduced) 105.3 kilograms per square millimeter.
soft (annealed 1 hour at 1400° C.) 35.7 kilograms per square millimeter.
Rockwell hardness ($\frac{1}{16}$'' ball, 100 kg.)
soft 73.8.
reannealed 75.2.
Corrosion: Loss per square centimeter—one hour
Boiling conc. HCl .020 milligram.
Boiling conc. HNO_3 .029 milligram.

(6) The alloy consisting of 60% palladium, 27% platinum, 10% gold, 3% zinc, has the following properties:

Melting point: 1485° C.
Specific gravity: 14.69.
Tensility: hard (75% reduced) 99.7 kilograms per square millimeter.
soft (annealed 1 hour at 1400° C.) 26.7 kilograms per square millimeter.
Rockwell hardness ($\frac{1}{16}$'' ball, 100 kg.)
soft 70.8.
reannealed 78.0.
Corrosion: Loss per square centimeter—one hour.
Boiling conc. HCl .041 milligram.
Boiling conc. HNO_3 .084 milligram.

As the examples show, the new alloys include mostly alloys with a melting point nearly as high as that of pure palladium (1555° C.). Compared with pure palladium these new alloys are, however, much more corrosion resistant than palladium. Palladium is, like silver, very readily soluble in diluted nitric acid. The alloys have not the dullness of palladium but the brilliancy of platinum and also all the other good mechanical properties of platinum, but combined with a greater natural hardness and a greater tensile strength than platinum or palladium. They therefore, excel in every manner palladium and also the much used gold-palladium alloys.

In the appended claims where the expressions "commercial platinum" and "commercial palladium" and "commercial gold" are used, it is understood that these terms refer to platinum and palladium and gold as these metals are available on the open market for every day commercial use or when taken from the various stages of the refining processes. Commercial palladium and commercial platinum, as is well known to persons skilled in the art, may contain up to 2% other metals of the platinum group (iridium, rhodium, osmium, ruthenium), minor amounts of the metals of the iron group (which are, to a certain degree related to the metals of the platinum group); minor amounts of silver and copper (which are similar to gold) and also minor amounts of such substances as zinc, cadmium or tin may be present in various grades of the commercially used gold. The presence of such elements (altogether not more than up to 6%) does not materially change the character of the described and specified palladium/platinum/gold alloys; but they do, when present, improve slightly these alloys as to their natural hardness.

Having thus described my invention, what I claim as new and desire to secure by Letters Patent, is:

1. An alloy consisting of 60% of palladium, 30% of platinum and 10% of gold.

2. A dental element in the form of a shaped member coinformable to a dental condition, said member being made from an alloy consisting of 60 percent of palladium, 30 per cent of platinum, and 10 per cent of gold.

3. An alloy consisting of 15 to 50% platinum, 5 to 20% gold, the remainer of the alloy being palladium.

4. A dental element in the form of a shaped member conformable to a dental condition, said shaped member being made from an alloy consisting of 15 to 50% platinum, 5 to 20% gold, the remainder of the alloy being pallidium.

JOHANN SIMON STREICHER.