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[54] **DENTAL ALLOY**

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[51] **Int. Cl.²** **A61C 13/22**

[58] **Field of Search** 75/171, 170; 148/32, 32.5; 32/1, 2, 5, 12

[56] **References Cited**

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[57] **ABSTRACT**

A base metal alloy is described comprised primarily of nickel and chromium with minor amounts of niobium, tin, molybdenum, boron, and silicon, which has outstanding physical properties with the melting temperature being low enough for the alloy to be used advantageously as a substitute for precious metals and metal alloys, generally and specifically, in the fabrication of a wide variety of dental prosthetic appliances.

9 Claims, No Drawings

DENTAL ALLOY

BACKGROUND OF THE INVENTION

The art and technology of constructing prosthetic dental appliances such as fixed bridgework and crowns, has traditionally employed alloys of precious metals. Technically, the alloys of gold are preferred in that gold exhibits many desirable physical characteristics, including having a relatively low melting point, being ductile and capable of forming an impact resistant porcelain to metal bond. Specifically, dental gold alloys have a relatively narrow range of coefficient of thermal expansion, bond well to porcelain, are easy to work, capable of being soldered, as well as being polished to a smooth, high-luster finish and being nearly devoid of any objectionable oxide formation or color. However, with the ever increasing cost of gold, less costly non-precious metal alloys, such as those set forth in U.S. Pat. No. 3,464,817 to Emil S. Griffiths, issued Sept. 2, **1969,** and U.S. Pat. No. 3,749,570 to Richard L. Lyon, issued July 31, 1973, have been developed for use as more economic alternatives than gold in fabricating prosthetic dental devices.

In order for a gold substitute to be suitable as an alternative alloy medium for construction of prosthetic dental devices, that alloy should exhibit many of the desirable physical properties and characteristics of gold identified herein and preferably contain no beryllium.

Technically, perhaps the most practical aforementioned physical properties of gold alloys to be closely duplicated in any non-precious alloy exhibiting the requisite ductility, tensile strength and elongation is a low melting point, together with the ability to form a durable impact resistant bond with porcelain.

It is desirable that the alloy be capable of being utilized with conventional equipment and techniques and that the alloy is relatively inert and exhibits minimal oxide formation. The latter requirement eliminates the need for special equipment and minimizes differences in techniques when using the alloy.

A predetermined coefficient of thermal expansion is also an essential physical characteristic of any alloy used with currently available dental porcelains. This is necessary to enhance the durability of any bond between porcelain and a dental prosthesis fabricated from the alloy composition.

It is quite important for any such alloy to be capable of being readily polished by conventional techniques to a smooth finish in order to minimize the formation, collection and retention of dental plaque on the exposed metal portions of the appliance.

The improved ductility of the alloy according to this invention and the superior impact resistance of the porcelain to metal bond formed with this alloy likewise permits the fabrication of prosthetic dental devices which are not subject to distortion or damage during normal fabrication or use. It is, of course, also desirable that any fabrication techniques can be performed with the conventional tools normally employed in working with alloys of gold.

The alloy of the present invention substantially fulfills the aforementioned attributes for a material which can successfully be employed in the fabrication of prosthetic dental devices in place of gold.

SUMMARY OF THE INVENTION

The present invention comprises a non-noble metal alloy and dental work produced therefrom, which metal alloy is designed to be a substitute for gold alloys in the fabrication of prosthetic dental appliances employing porcelain to metal bonds, which alloy is based on the combination of nickel and chromium with a lesser inclusion of other elements necessary to impart the desired properties heretofore described, including an acceptable level of tensile strength and the capacity of forming durable impact resistant bond with dental porcelain.

Polishing characteristics of alloys which are to be substituted for gold are important in order to provide a smooth fault-free surface which, in dentistry, is generally considered to be beneficial in retarding plaque formation.

Ductility of the alloy and impact resistance of porcelain-metal bond are also highly desirable physical properties in that a prosthetic dental device made of such an alloy may be shaped for fit, and yet be rigid enough to resist distortion or damage during normal fabrication procedures or when in use by a patient. Any substitute alloy should also be capable of being shaped with conventional tools of the type normally employed in working with alloys of gold.

The alloy composition of the present invention substantially fulfills the aforementioned attributes for a composition which would replace gold in the fabrication of dental prosthesis.

DETAILED DESCRIPTION OF THE INVENTION

The preferred alloy compositions of the present invention have the following range of constituents by weight:

	Percentages
Nickel	65 – 85
Chromium	8 – 25
Tin	0.5 – 5
Molybdenum	1 – 8
Silicon	0.5 – 3.5
Niobium	1 – 5
Boron	.05 – .75

The preferred compositions exhibiting most advantageously the properties heretofore described are selected from the foregoing alloys optionally containing between about 0.05 to 5.0% by weight aluminum whose melting points lie in the range of from about 2,100°F to about 2,500°F.

More specifically the most preferred alloy compositions are obtained from the following group of alloys containing by weight:

	Percentages
Nickel	65 – 80
Chromium	10 – 25
Tin	0.5 – 5.0
Molybdenum	1.0 – 8.0
Silicon	0.5 – 3.5
Niobium	1.0 – 5.0
Aluminum	.05 – 3.0
Boron	0.1 – 1.0

The foregoing compositions employ the well-known combination of nickel/chromium base metal compositions used previously for its superior corrosion resistance so important for any material subjected for pro-

longed periods to the environment of the human mouth.

It is the lesser components of these alloy compositions, however, in combination with the base nickel/-chromium components, which produce a finished alloy, exhibiting desirable features of the alloy of the present invention. All of the components interact in a complex fashion to give the resultant properties but certain elements have a particularly noticeable effect on certain properties. The molybdenum component accomplishes the dual purpose of adjusting the thermal expansion characteristic of the alloy so that such characteristic will be maintained within a relatively narrow range, and to assist in developing an aesthetically acceptable oxide on the finished devices. The inclusion of niobium also contributes to maintaining an acceptable coefficient of thermal expansion characteristic and, in addition, under certain conditions precipitation can strengthen the alloy.

The addition of boron increases the tensile strength characteristic of the alloy and lowers casting temperature somewhat. The inclusion of silicon enhances the nature of the oxide, lowers casting temperature and adjusts the thermal expansion. The inclusion of tin is for the purpose of bonding between the porcelain and metal and for lowering casting temperature. Aluminum is added as an agent for producing precipitation strengthening. The significantly increased elongation, ductility and bonding characteristics are resultant from the combined effect of the additions.

The alloy compositions herein disclosed characteristically have a melting range of from about about 2,100°F to about 2,500°F, a coefficient of thermal expansion ranging from about 13.0 × 10-6 in/in/°C to about 15.0 × 10-6 in/in/°C, an ultimate strength over 80,000 psi, a yield strength of over 52,000 psi, an elongation of over 5%, and a casting temperature within the capability of natural gas-oxygen torches.

The initial alloy preparation is typically carried under an argon cover employing an induction furnace, with the following order of addition of component elements. First, nickel in the form of chips, and chromium in the form of irregularly shaped granules are each weighed out in the appropriate amounts for the composition of alloy being prepared, and thereafter, placed in a crucible. The nickel and chromium components are then dispersed within a zirconia-lined crucible and melted to form a uniform aggregate mixture. An argon cover is maintained over the crucible throughout the melting.

It should be noted that the quality of all components is important in order to realize and maintain the ductility and elongation properties achievable with these particular alloy compositions. It should also be noted that the boron component is preferably added in the form of a nickel/boron pre-alloy having approximately 15–20% by weight of boron, and that compensation for the amount of nickel added with this pre-alloy must be made in determining the amount of nickel to be initially weighed out and melted with the chromium. Likewise aluminum is added as the nickel aluminide.

While the uniform aggregate mixture of nickel and chromium is molten in a homogeneous liquid dispersion, the appropriate weights of molybdenum, silicon, niobium, and boron (in the form of a nickel/boron pre-alloy) are prepared for addition to the nickel/-chromium melt. The molybdenum may be added in sheet form or irregular shaped granules with no noticeable difference in resultant alloy properties. The silicon is preferably added in granular form, and the niobium and nickel/boron pre-alloy are added in whatever appropriate forms are available. This second batch of components is introduced to the crucible within the furnace containing the nickel/chromium homogeneous liquid melt dispersion to form a six or seven component homogeneous liquid melt mass.

The appropriate amount of tin, in elemental or pre-alloyed form is weighed out and added last to the melt. The tin is allowed to disperse as a liquid component within the liquid melt alloy mass to form the homogeneous alloy composition of the present invention. This melt is then cast directly into investment molds or into convenient size ingots and thereafter is ready for re-melting for casting and fabricating prosthetic dental devices.

It is important in the preparation of this alloy that oxidation of the tin and silicon components be minimized in order to adequately control the compositions of the melt. For this reason, initial preparation of the alloy composition is conducted under an argon cover, thereby reducing oxidation and consequent slag formation which would have undesirable effects on the alloy. However, once compounding of the alloy composition is completed, and ingots cast therefrom, re-melting of the ingot alloy form of the present invention may be accomplished with the proper use of standard dental laboratory thermal equipment, such as the natural gas-/oxygen torch, or an electrical induction heating source without fear of adversely affecting the beneficial properties of the alloy, or the danger of excessive oxidation or slag formation.

Likewise, it is important that control of the carbon content of the alloys of the present invention be exercised during use of the alloy. For example, techniques which tend to introduce objectionable amounts of carbon into the alloy will degrade some of the desired properties. Preferably the alloy should not contain more than 0.1% by weight carbon.

Utilization of the alloy of the present invention in place of gold or gold alloys should not require any additional or different investment materials, casting equipment, or any significant change in technique other than that which is currently employed in a reasonably well equipped dental laboratory as used and carried out by a reasonably skilled and competent dental technician. Likewise, no special handling is required in the use of the alloy of the present invention as such might be required in the use of an alloy which contained Beryllium.

The following examples illustrate alloy compositions and their percentages, by weight, of the total composition when made in accordance with the method set forth hereinbefore:

EXAMPLE 1

	Percentages
Nickel	76.5
Chromium	12.0
Tin	3.0
Molybdenum	3.0
Silicon	2.0
Niobium	3.0
Boron	0.2

EXAMPLE 2

Nickel	76.7
Chromium	12.0

EXAMPLE 2 – Continued

	Percentages
Tin	3.0
Molybdenum	3.0
Silicon	2.0
Niobium	3.0
Boron	0.3

EXAMPLE 3

	Percentages
Nickel	74.8
Chromium	14.0
Tin	3.0
Molybdenum	3.0
Silicon	2.0
Niobium	3.0
Boron	0.2

EXAMPLE 4

Nickel	78.5
Chromium	15.0
Tin	2.5
Molybdenum	0.5
Silicon	2.0
Aluminum	1.0
Boron	0.5

As previously indicated, and set forth in Examples 1 – 4, alloy compositions made in accordance with the method described above are suitable for use in fabricating and constructing prosthetic dental devices, such as bridges and crowns, and exhibit the improved properties and characteristics as set forth hereinbefore.

The following table, showing Examples **5** through **25,** is typical of the kinds of alloy compositions prepared as described in Examples 1 – 4, which will exhibit the characteristics described herein as desirable and necessary for a base metal substitute for gold or gold alloys in the fabrication of dental prosthetic devices.

Ex.	Ni	Cr	Si	Mo	Nb	Sn	B
5	65.0	22.8	2.0	3.0	4.0	3.0	0.2
6	83.8	10.0	1.0	1.5	1.5	2.0	0.2
7	83.0	10.0	0.8	2.0	2.0	2.0	0.2
8	67.0	25.0	1.0	2.0	2.0	2.7	0.3
9	85.0	10.0	0.5	1.0	1.0	2.0	0.5
10	65.8	19.0	1.5	8.0	2.5	3.0	0.2
11	75.9	12.0	3.5	2.5	3.0	3.0	0.1
12	77.0	12.0	3.5	2.5	2.0	3.0	0
13	78.0	12.0	0.5	3.0	3.0	3.0	0.5
14	76.8	13.0	2.0	1.0	4.0	3.0	0.2
15	76.8	11.0	1.0	8.0	1.0	2.0	0.2
16	75.8	12.0	2.0	2.0	5.0	3.0	0.2
17	72.7	14.0	2.0	3.0	5.0	3.0	0.3
18	76.4	12.0	2.5	3.0	3.0	3.0	0.1
19	76.5	13.0	0.5	3.0	3.0	3.0	1.0
20	76.2	14.0	1.8	3.0	3.0	1.0	1.0
21	77.9	14.0	2.0	2.5	2.5	0.5	0.6
22	78.7	12.0	2.0	3.0	3.0	0.5	0.8
23	75.7	15.0	3.0	2.5	2.5	1.0	0.3
24	71.9	14.0	3.0	3.0	3.0	5.0	0.1
25	77.7	11.0	2.0	2.0	2.0	5.0	0.3

This invention has been described with reference to the preferred embodiments of the invention; however the contemplated breadth of the composition and its application should be interpreted in light of the specification and claims to include further embodiments which employ equivalent materials for their stated function in the melt and finished alloy.

We claim:

1. A dental alloy consisting essentially of (by weight):

	Percentages
Nickel	65% – 85%
Chromium	10 – 25
Tin	0.5 – 5.0
Molybdenum	1.0 – 8.0
Silicon	0.5 – 3.5
Niobium	1.0 – 5.0
Boron	0.1 – 1.0

wherein said alloy exhibits tensile strength and elongation properties suitable for use in the fabrication of dental prosthetics.

2. The alloy of claim **1** containing additionally between about 0.5 to 5.0% aluminum.

3. A nickel-chromium alloy having a melting point in the range of from about 2,100°F to 2,500°F, an ultimate strength of over about 80,000 psi, a yield strength of at least 50,000 psi, and a coefficient of thermal expansion in the range of from about 13.0 × 10-6 in/in/°C to about 15.0 × 10-6 in/in/°C and consisting essentially of (by weight): from about 8 to 25% chromium, from about 0.5 to 3.5% silicon, from about 0.1 to 1.0% boron and further comprising from about 0.5 to about 5% each of tin and molybdenum, with or without 0.5% to 5.0° niobium.

4. The alloy of claim **3** comprising from about 10 to 16% chromium, from about 73 to 85% nickel, from about 0.5 to 3.0% silicon, from about 0.1 to 1.0% boron and from about 0.5 to 5% each of tin, molybdenum and niobium.

5. The alloy of claim **4** containing additionally between about 0.5 and 3.0% aluminum.

6. The alloy of claim **4** containing additionally about 1.0% aluminum.

7. An alloy suitable for use in the fabrication of dental prosthetics consisting of essentially (by weight) at least 76.6% nickel, 12% chromium, 3% tin, 3% molybdenum, 2% silicon, 3% niobium, 0.3% boron and less than 0.1% carbon.

8. Dental work containing dental porcelain fused to a metal casting, said casting consisting essentially of (by weight): an alloy of 65 – 85% nickel, 10 – 25% chromium, 0.5 – 5.0% tin, 1.0 – 8.0% molybdenum, 0.5 – 3.5% silicon, 1.0 – 5.0% niobium and 0.1 – 1.0% boron.

9. The dental work of claim **8** wherein said alloy contains additionally between about 0.5 to 5.0% aluminum.

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