Metals & Alloys in Dentistry

Prof. Dr. Mohammed T. AL-Khafagy

Metals

“An opaque lustrous chemical substance which is a good conductor of heat and electricity and when polished is a good reflector of light”.

This lec.....

- What are the main uses of metal and alloys in dentistry?
- What is the meaning of noble metal?
- What is the meaning of base metal?
- Gold and gold alloys, properties and its uses in dentistry.
- Co-cr alloy, properties and its uses in dentistry.
- Ni-cr alloy, properties and its uses in dentistry.
- Titanium and titanium alloys, properties and its uses in dentistry.
- Stainless steel alloy, properties and its uses in dentistry.

In dentistry most frequently used metals are:

1.Noble metals: This group of metals consists of mainly anticorrosive metals. like (gold, platinum, palladium, and silver; *however, in the oral cavity silver in not considered noble because of tarnish*).

In dentistry most frequently used metals are:

2- Base metal:

- These metals are prone to *oxide layer* formation which does not make them suitable for dental applications. *(why not suitable for dental applications???)*
- Once oxide layer is formed these metals lose their integrity and become dangerous for dental applications.
- To increase their anticorrosion behavior, they are used in combinations like (chromium, cobalt, nickel, iron, copper, manganese, etc…..).

Nobility is related to tarnish and corrosion resistance

What is the meaning of tarnish and corrosion?

What is main difference between them?

Tarnish: is loss of luster from the surface of metal or alloy due to the formation of a surface coating of metal oxide.

Corrosion: is the gradual destruction of materials (usually metals) by chemical or electric-chemical reaction with their environment.

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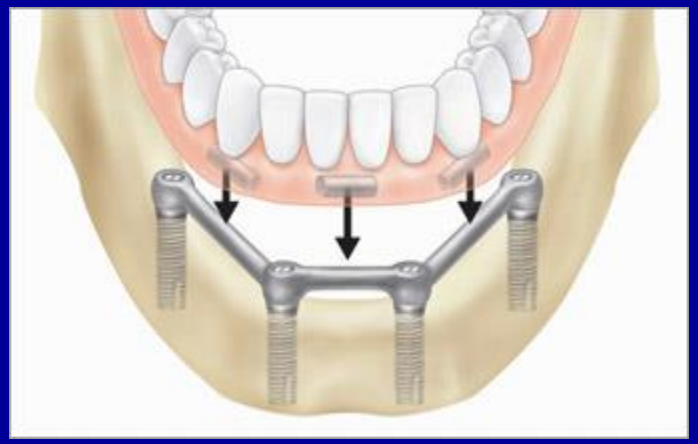
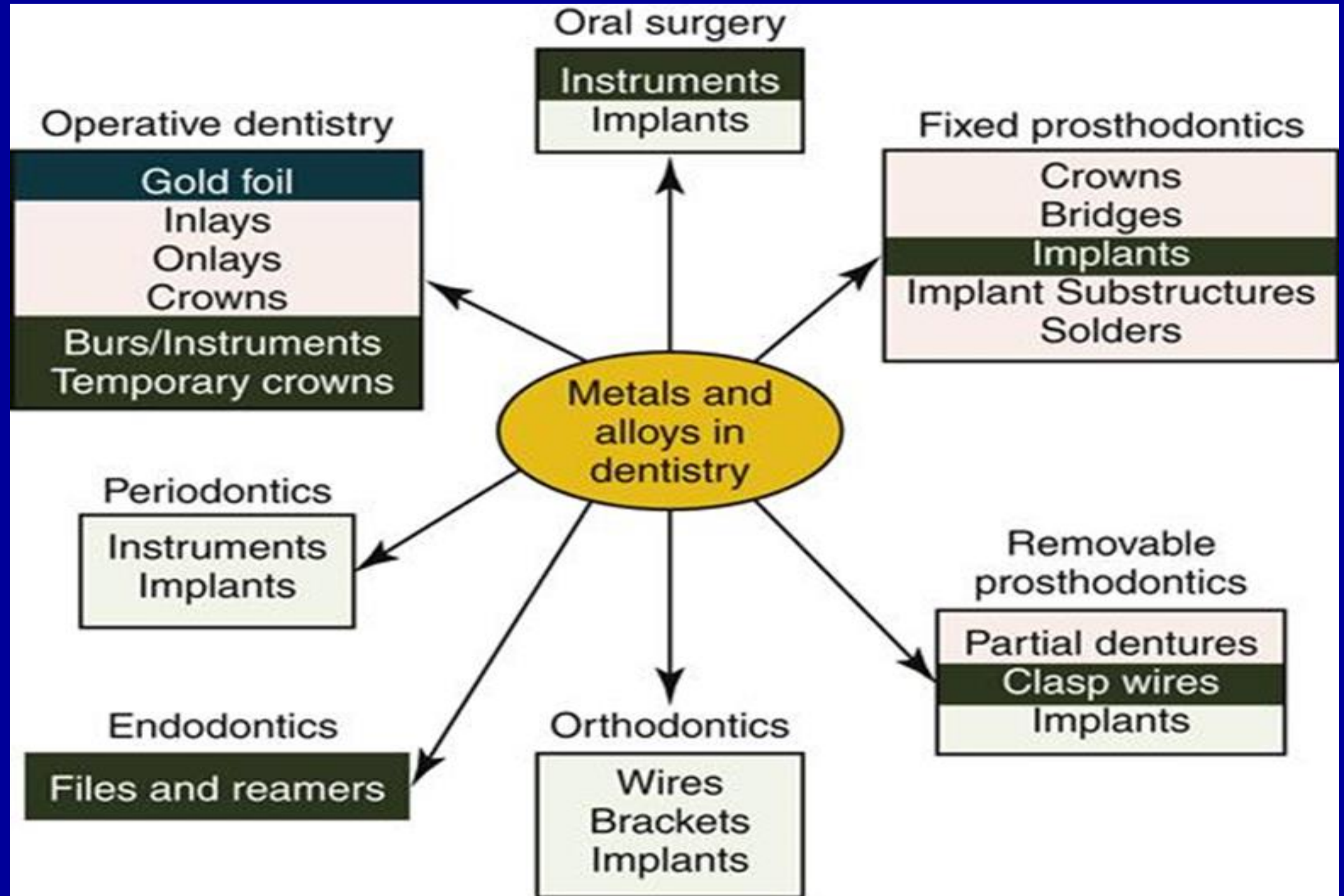
Alloys

Alloys: an alloy is a metal containing two or more elements at least one of which is metal and all of which are mutually soluble in the molten state.



Metals & Alloys in Dentistry


Oral surgery
Instruments
Implants
Operative dentistry
Gold foil
Inlays
Onlays
Crowns
Burs/Instruments
Temporary crowns
Fixed prosthodontics
Crowns
Bridges
Implants
Implant Substructures
Solders
Metals and alloys in dentistry
Periodontics
Instruments
Implants
Removable prosthodontics
Partial dentures
Clasp wires
Implants
Endodontics
Files and reamers
Orthodontics
Wires
Brackets
Implants

Metals & Alloy are divided into:

1- Precious (Gold & Gold alloys).

2- Non-Precious (Stainless steel, Ni-Cr, Co-Cr).

Shaping the alloys

Alloys used in dentistry are either wrought alloy or casting alloy.

1-Wrought Alloys. Defined as alloys which are shaped without applying heat (room temperature) by hammering, drawn or bend into shape (cold working).

Stainless steel is a wrought alloy of iron, carbon, chromium, nickel and manganese. it is used for making dental instruments, burs, wires.

Shaping the alloys

Alloys used in dentistry are either wrought alloy or casting alloy.

2-Casting Alloy Defined as alloys which are shaped by heating the material until it becomes molten, when it can be forced into an investment mold which has been prepared from a wax pattern.

Requirements of casting alloys:

1. They must not tarnish or corrode in the mouth.

2. They must be sufficiently strong for intended purpose.

3. They must be biocompatible (nontoxic and no allergic).

4. They must be easy to melt, cast, cut, grind (easy to fabricate).

Requirements of casting alloys:

5. They must flow well and duplicate fine details during casting.

6. They must have minimum shrinkage on cooling after casting.

7. They must be easy to solder.

Classification of dental alloys:

A. According to number of elements:

1. Binary 2 elements.

2. Tertiary 3 elements.

3. Quaternary 4 elements.

Classification of dental alloys:

B. According to nobility:

1. High noble alloys: contain 40% gold or more & 60% noble metals or more.

2. Noble alloys: contain 25% noble metals or more.

3. Base metal alloys: contain less than 25% noble metals.

Classification of dental alloys:

C. According to major elements:

1. Gold alloy.

2. Silver alloy.

3. Palladium alloy.

4. Nickel alloy.

5. Cobalt alloy.

6. Titanium alloy.

.

Classification of dental alloys:

D. According to 3 major elements:

1. Gold-palladium-silver alloys.

2. Palladium- silver-tin alloys.

3. Nickel-chromium-molybdenum alloys.

4. Cobalt-chromium-molybdenum alloys.

5. Iron-nickel-chromium alloys.

6. Titanium-aluminum-vanadium alloys.

Gold

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Gold & Gold Alloys:

1- Pure Gold.

2- Casting Gold Alloy.

Gold foil filling (pure gold)

It is tarnish resistant and very malleable and ductile.

Gold foil is in the form of thin sheet or foil about 0.001 mm thickness.

It is condensed into the cavity and each layer of foil becomes welded to material already condensed.

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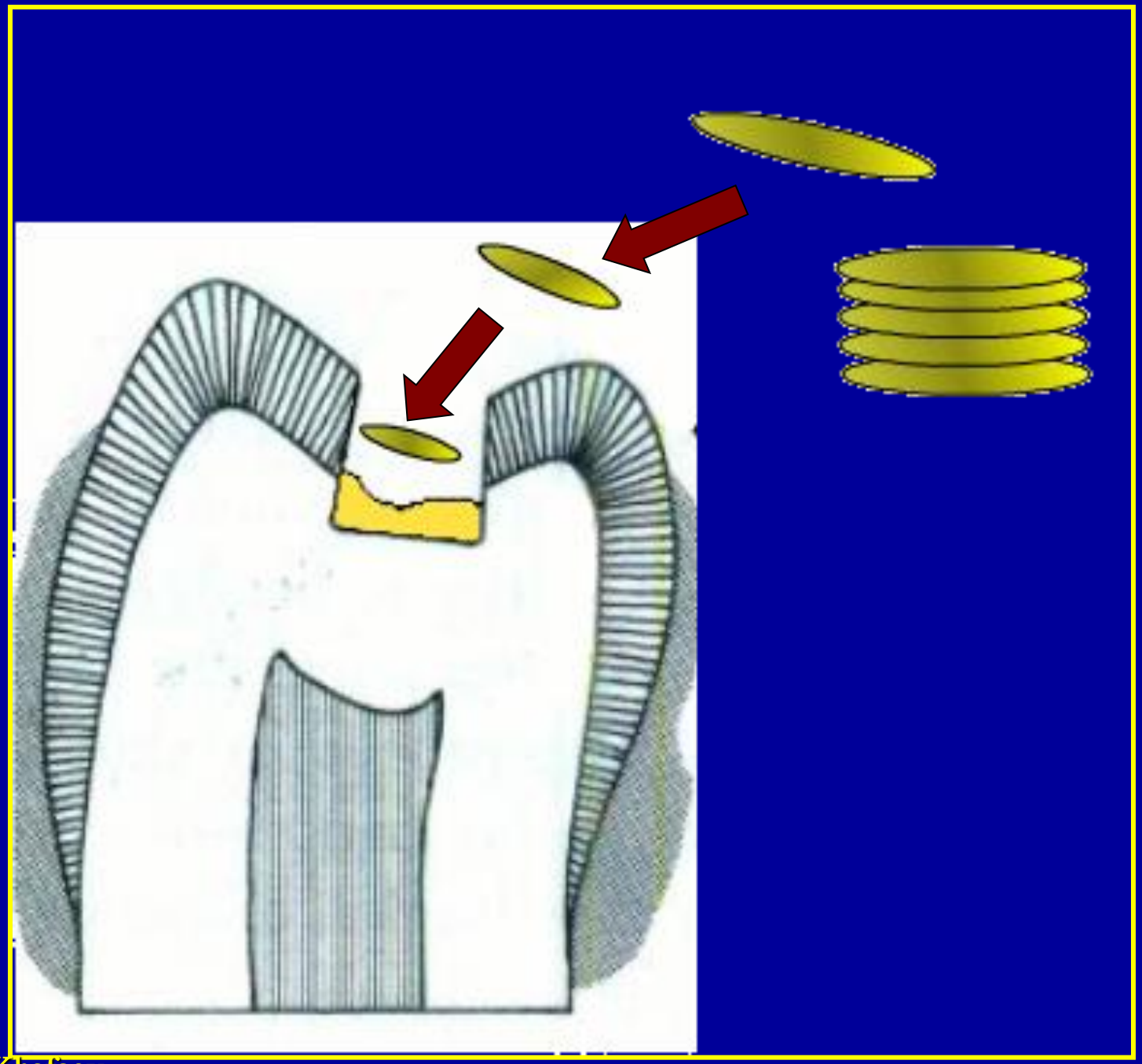

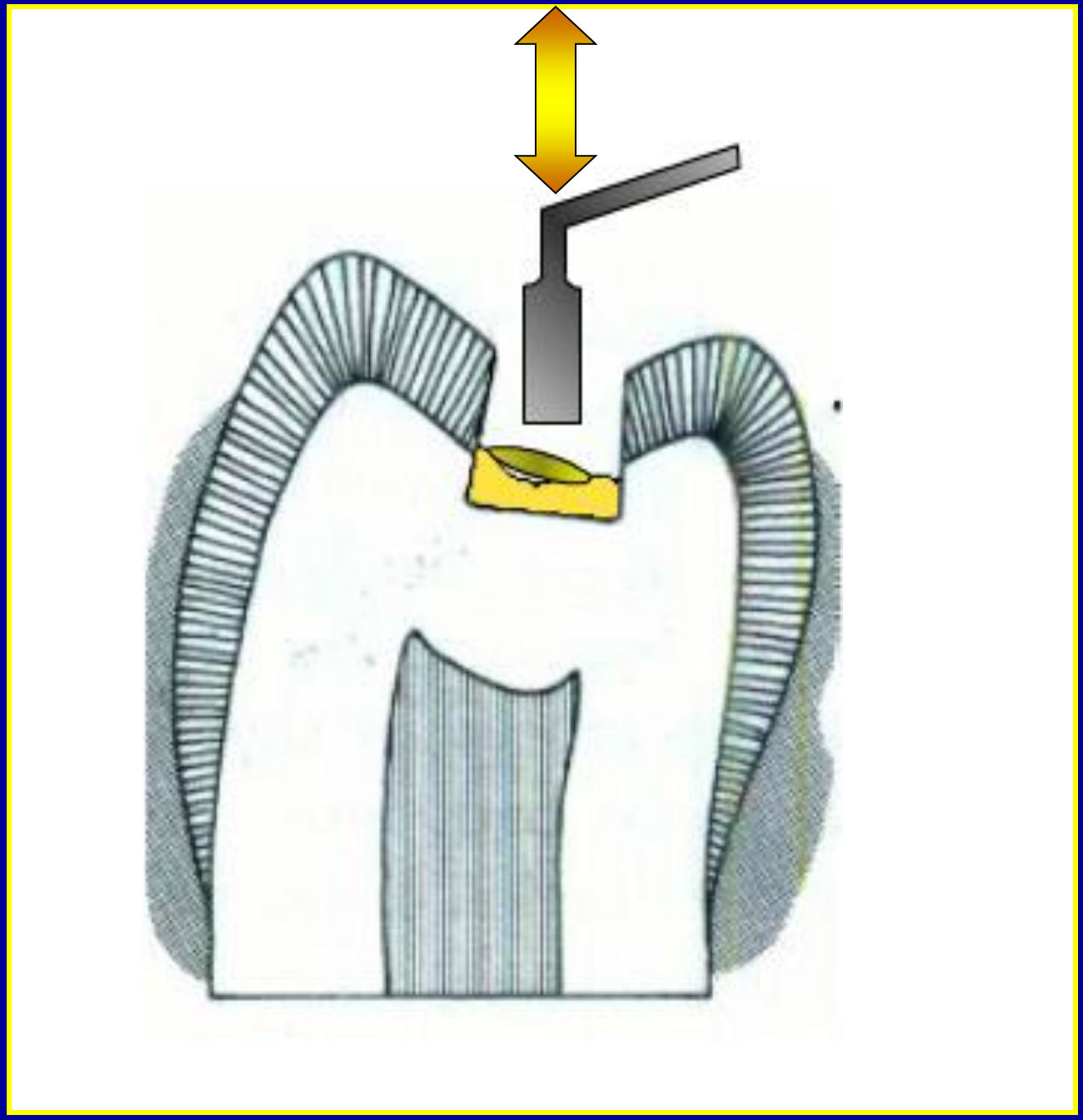

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Gold foil filling (pure gold)

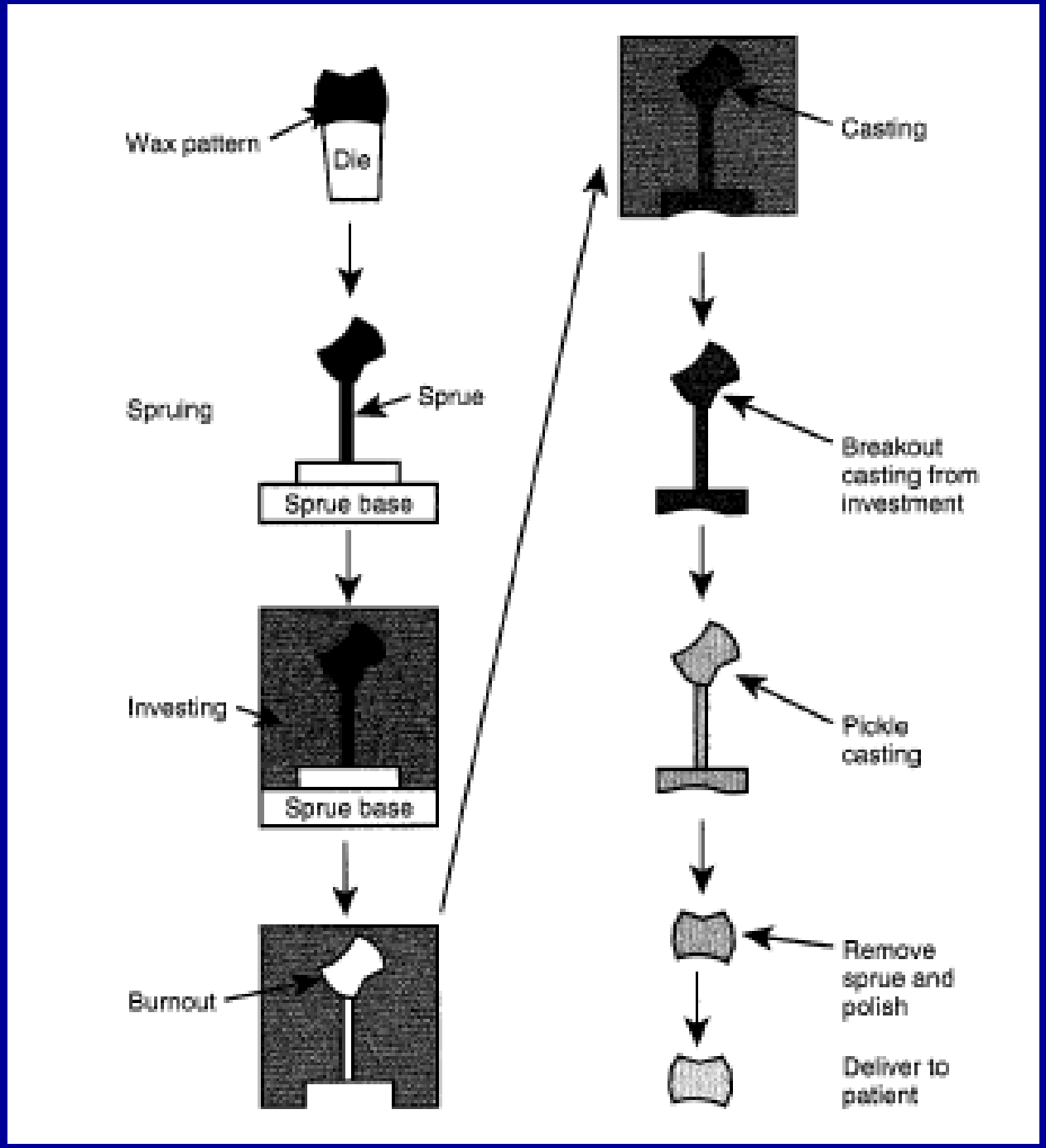
Advantages of gold foil filling:

- Perfect corrosion resistance.
- Adequate mechanical properties.
- Very durable.

Disadvantages of gold foil filling

- Highly expensive.
- Not esthetic.
- The technique is time consuming and depends on the skill of operator

Casting Gold Alloys



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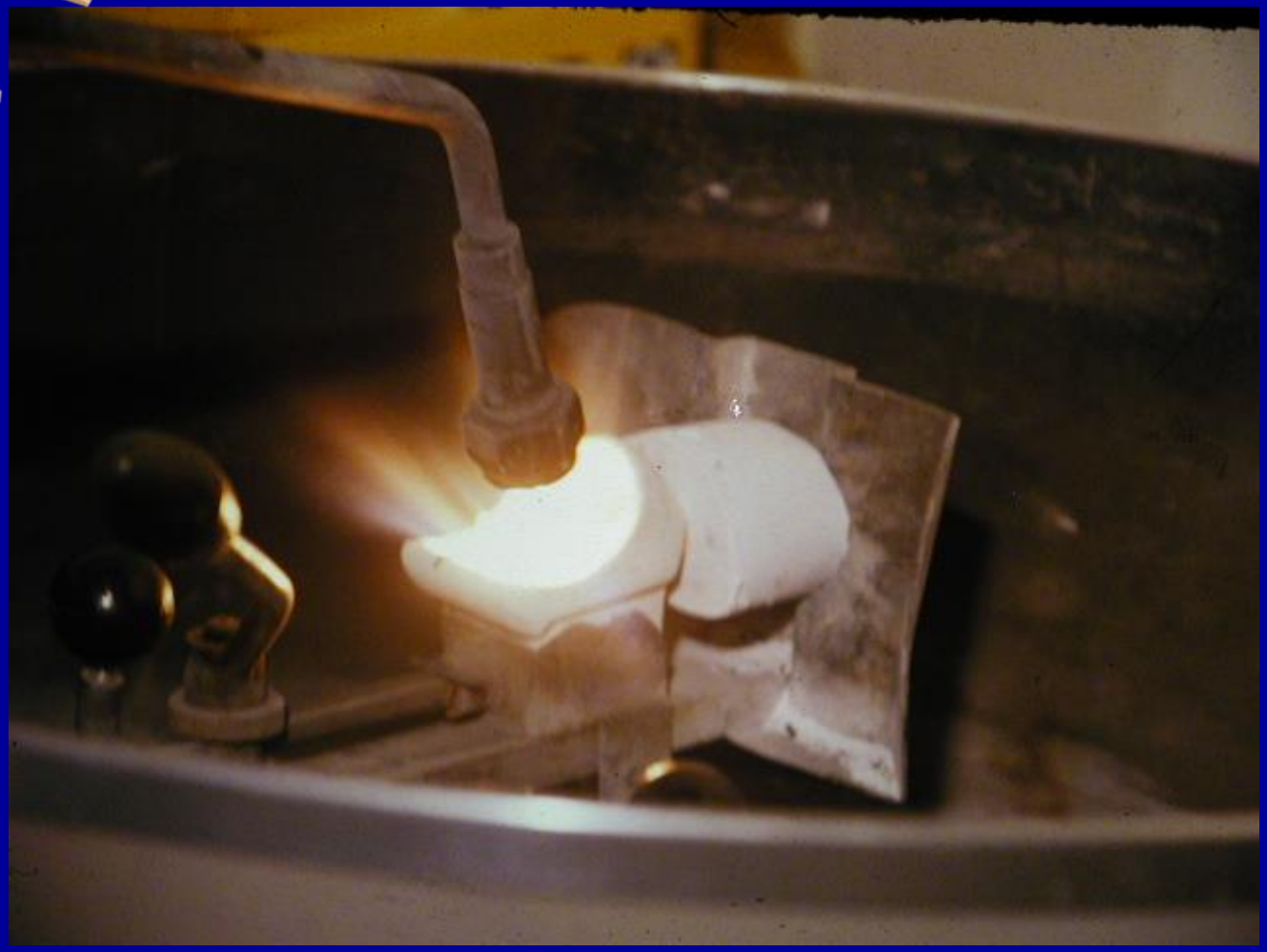

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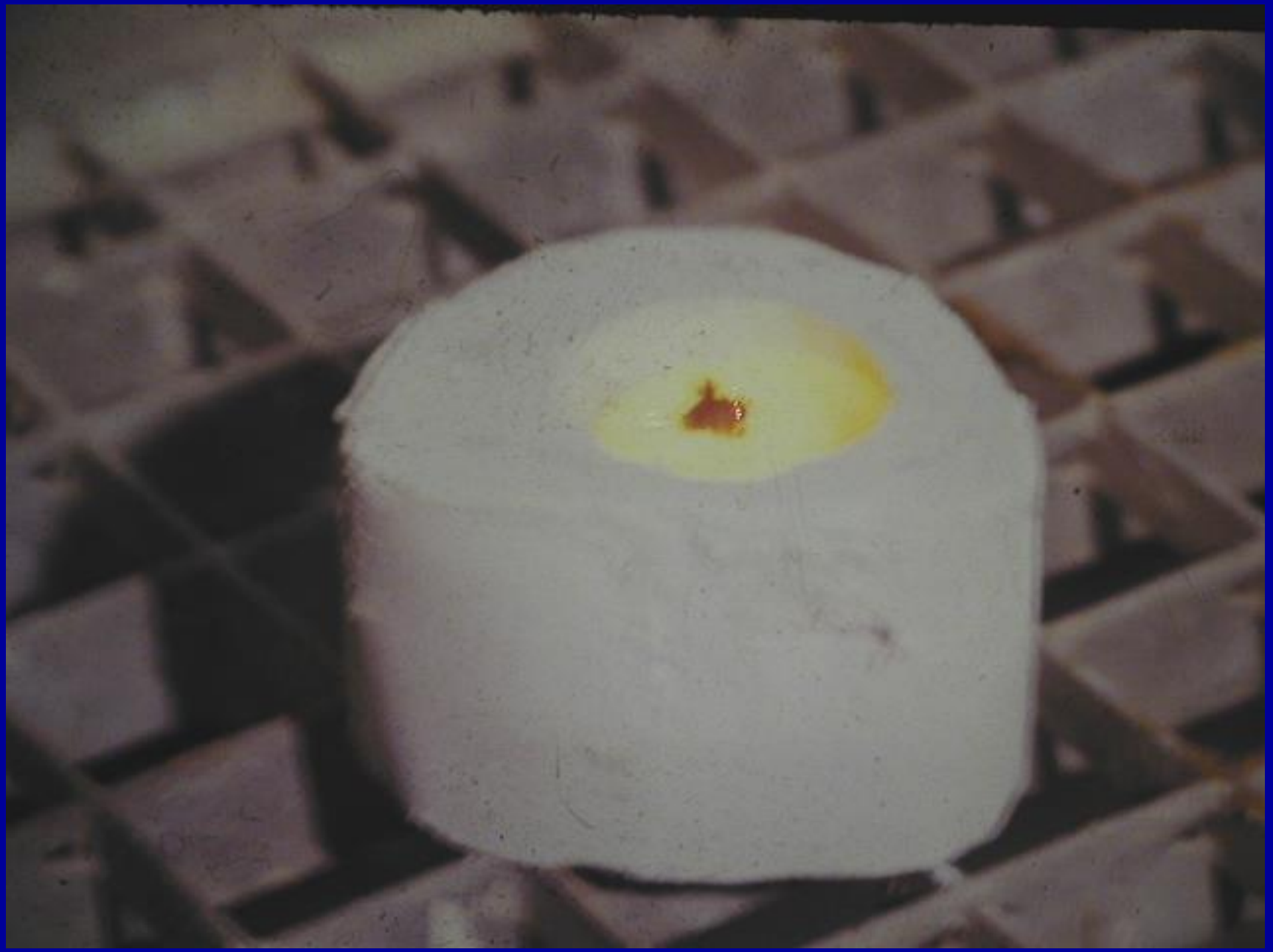

Classification of Gold alloy

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Gold alloys:

they are classified according to yield strength & percentage of elongation:

Type I (soft):

- it is indicated for small inlay,
- well supported inlay restoration not subjected to mastication stress like gingival cavities (Cl V) cavities

Gold alloys:

they are classified according to yield strength & percentage of elongation:

Type II (medium):

- it is indicated for large inlay restoration,
- less ductile
- can resist high masticatory stress.

Gold alloys:

they are classified according to yield strength & percentage of elongation:

Type III (hard):

- it is indicated for crown and bridge,
- low ductility with high content of platinum and /or palladium.

Gold alloys:

they are classified according to yield strength & percentage of elongation:

Type IV (extra hard):

- it is indicated for crown and bridge and removable partial denture frames,
- has high strength, resilience,
- low modulus of elasticity.

Composition of gold alloys

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1) Gold:

1) Gives yellowish colour.
2) Increases corrosion and tarnish resistance.
3) Increases ductility.
4) Gives high specific gravity.

2) Copper:

1) Gives reddish colour.
2) Decreases corrosion and tarnish resistance.
3) Increases strength and hardness.
4) Reduces melting points.

3) Silver:

1) Gives white colour.
2) Decreases corrosion resistance.
3) Increases tarnish production.

4) Platinum:

1) Gives white colour.
2) Increases corrosion and tarnish resistance.
3) Increases hardness.

5) Palladium:

1) Gives white colour.
2) Decreases corrosion resistance.
3) Increases tarnish production.

6) Zinc:

1) Acts as a scavenger by combining with oxides.
2) Increasing the castibility of alloy.

Properties:

1. ***Color:*** it is yellow and there is white gold depending on the whitening elements present (silver, platinum, palladium).

2. ***Melting range:*** 920-960 C.

3. ***Density:*** pure gold is 19.3 gm/cm.

Properties:

4. ***Yield strength***: type III - 207 Mpa type IV-275 Mpa.
5. ***Hardness***: type III -121 Mpa type IV-149Mpa.
6. ***Elongation***: type III 30 -40 % type IV – 30 -5%.

Properties:

7. ***Tarnish and corrosion resistance:*** they are resistance to tarnish and corrosion due to high noble metal content.

8. ***Casting shrinkage:*** it is less than 1.25 – 1.65 %.

9. ***Biocompatibility:*** they are relatively biocompatible.

10. ***Investment:*** gypsum bonded investment.

Alternative to gold alloys

Silver – palladium alloys

These alloys are cheaper than gold alloys, whiter in color, their properties are similar to type III and IV gold alloys but:

1. Lower ductility and corrosion resistance.

2. Lower density.

Metal ceramic alloys

- They are alloys that are compatible with porcelain and capable of bonding to it, a layer of porcelain is fused to the alloy to give it natural tooth like appearance.
- Porcelain is brittle so these alloys reinforce porcelain (ceramic). They should have coefficient of thermal expansion match that of porcelai

Requirements of metal ceramic alloys

1. Melting temp. should be higher than the porcelain firing temp.
2. coefficient of thermal expansion should be compatible with that of porcelain.
3. Should be able to bond with porcelain.

Requirements of metal ceramic alloys

4. Should have high stiffness (high modulus of elasticity).
5. Should not stain or discolor porcelain.
6. It should resist ***creep***.

Creep is the physical property of dental material; it is ***time-dependent plastic deformation*** of a material under static or dynamic loading.

Creep is a type of deformation that occurs in materials subjected to a constant load over time. The deformation is permanent and results in a change in the shape of the material. Creep is most commonly observed in metals, alloys, and polymers.

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Sag is a form of **creep** that occurs in metal at high temperature under its own weight.

For example, metals used for long-span bridges should have high sag resistance, so that when porcelain is fired onto them, which requires high temperature for fusing porcelain, these metals should not sag.

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Removable denture alloys

Large structures that require more quantities of alloy can make them quite heavy and expensive.

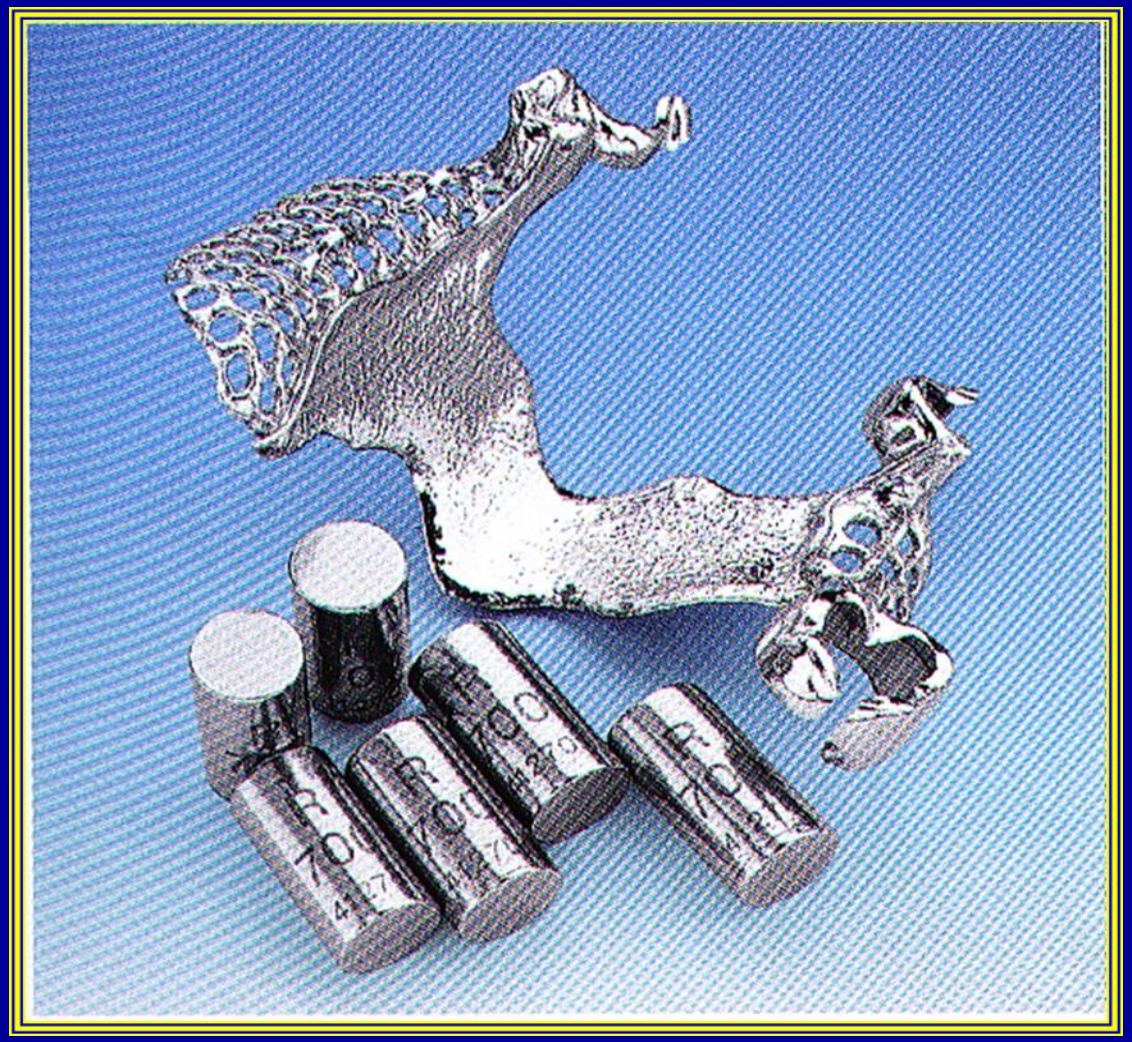
So besides all requirements of metal, casting denture alloys ***requirements*** are:

- Should have low weight because it is large in structure.
- Should have high stiffness which help in making casting thinner which is important in the palate.
- Should have good fatigue resistance; it is important for clasp.
- Should not react with denture cleaners.
- Should have low cost.

Types of Removable denture alloys

Cobalt chromium, nickel chromium, aluminum alloys, type IV gold alloys and titanium.

Cobalt-Chromium Alloy:



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Cobalt chromium alloys :

- Shiny appearance.
- High strength,
- Excellent corrosion resistance
- Hard.

Application

1. Denture base.

2. Cast removable partial denture framev

3. Crown and bridge.

4. Bar connecters.

Composition

- ***Cobalt:*** (35-65%) decrease hardness, strength and rigidity.
- ***Chromium:*** (23 – 30 %) passivity effect, decrease melting point.
- ***Nickel:*** (0-20%) decrease strength and hardness, increase ductility ***(Nickel cause sensitivity in some patients).***
- ***Molybdenum:*** (0-7%) increase hardness.
- ***Carbon:*** (0.4%).

Properties

1. ***Density***: It is half of gold alloys (8-9gm/cm).
2. ***Fusion temp***: Higher than gold alloys (1250-1480 C°).
3. ***Yield strength:*** Higher than gold alloys (710 Mpa).
4. ***Elongation:*** Less than gold (1-12%).
5. ***Modulus of elasticity***: Twice than gold alloys (220–230 GPa).

Properties

6. ***Casting shrinkage:*** It is about 2.3%.

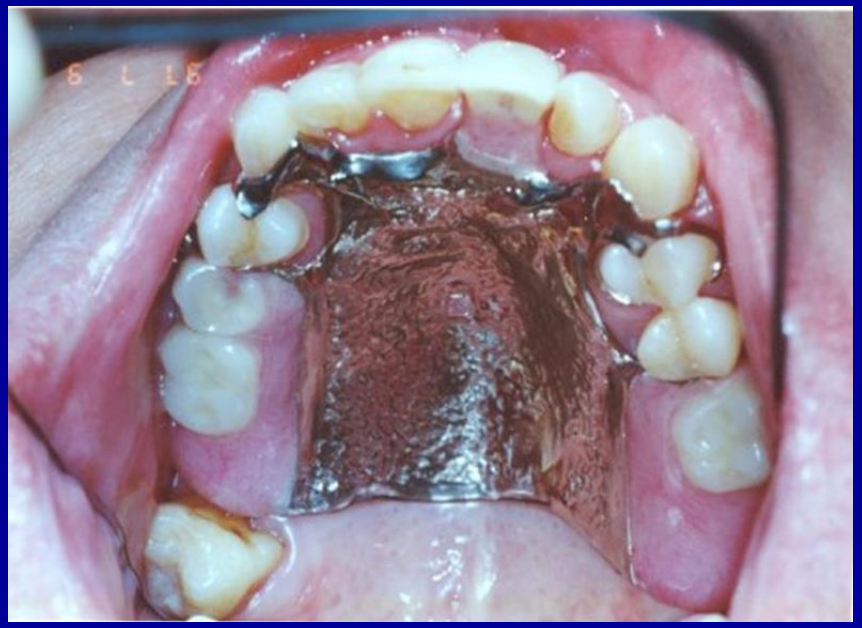
7. ***Hardness***: Harder than gold (432HN) thus cutting, grinding , and finishing is difficult ; special hard high speed finishing tools are needed.

8. Tarnish and corrosion:

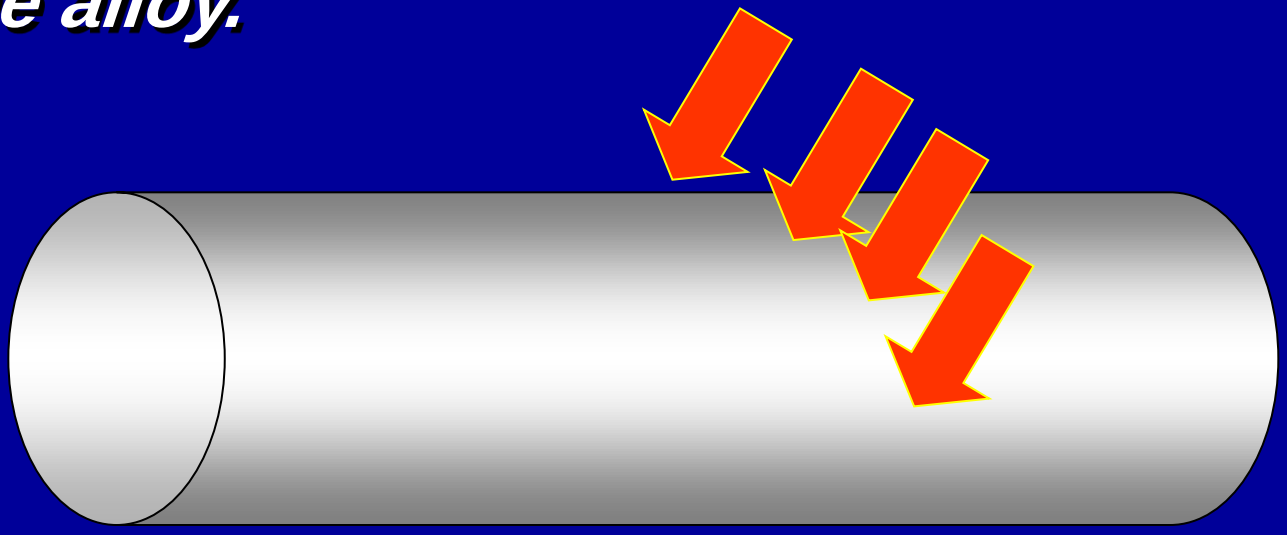
- Passivity affect: the formation of layer of chromium oxide on the surface of these alloys prevents tarnish and corrosion in the mouth.
- Hypochlorite and other chlorine in some denture cleaning solutions should not be used because it will cause corrosion of the alloy.

Advantages:-

1. Lighter in weight.
2. Better mechanical properties.
3. Corrosion resistance as gold alloys (due to passivity effect).
4. Less expensive than gold.



*Chromium increases corrosion resistance by **passivating effect**, as chromium exposed to the air, becomes rapidly oxidized to form a thin passive surface layer of chromic oxide which prevents further attack of the alloy.*



Disadvantages:-

1. More technique sensitive.

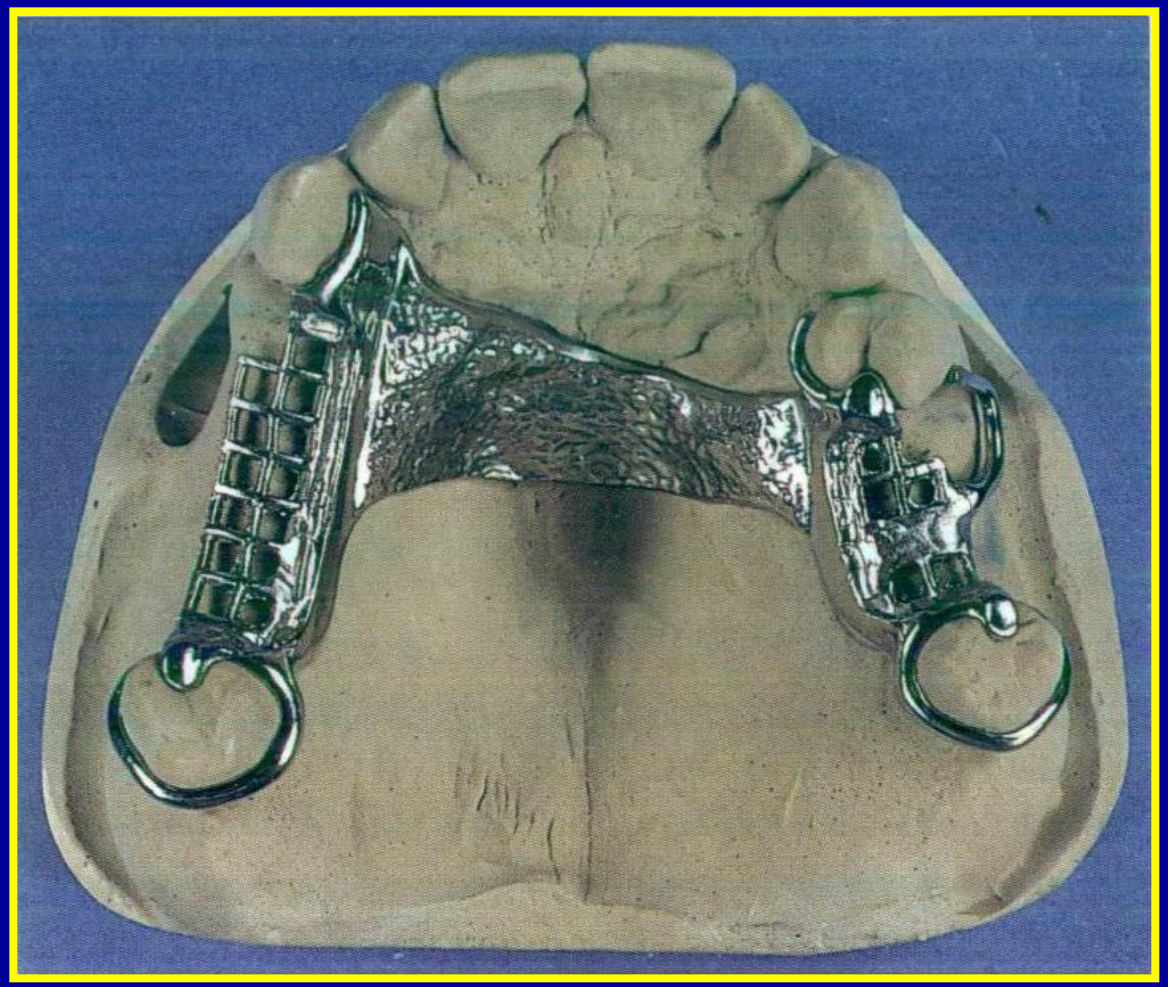
2. Complexity in production of dental appliance.

3. High fusing temp.

4. Extremely hard, so require special equipment for finishing.

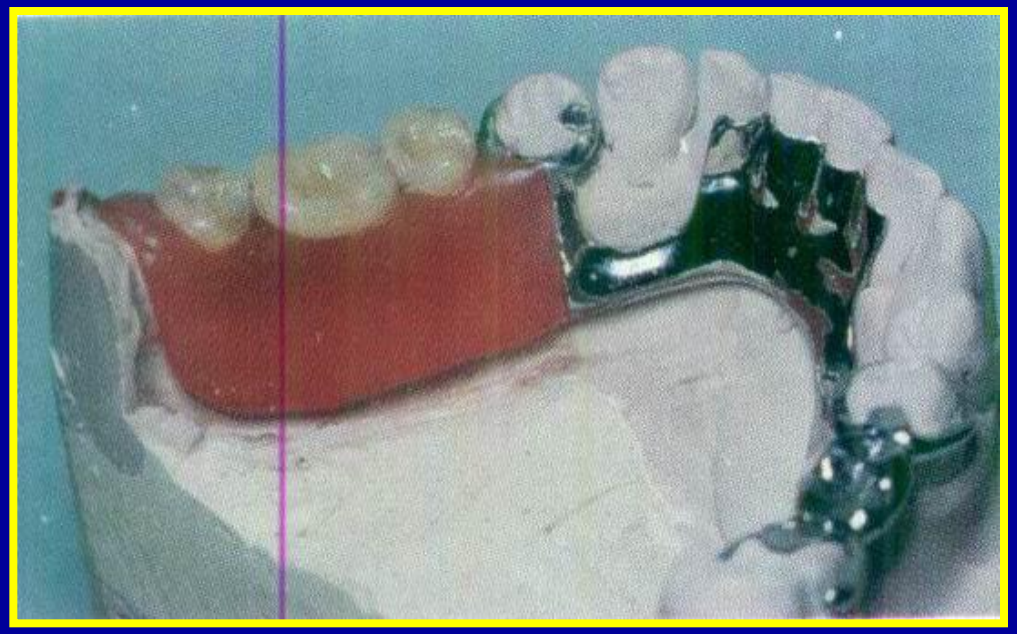
5. High harden cause wear of restoration and natural teeth.

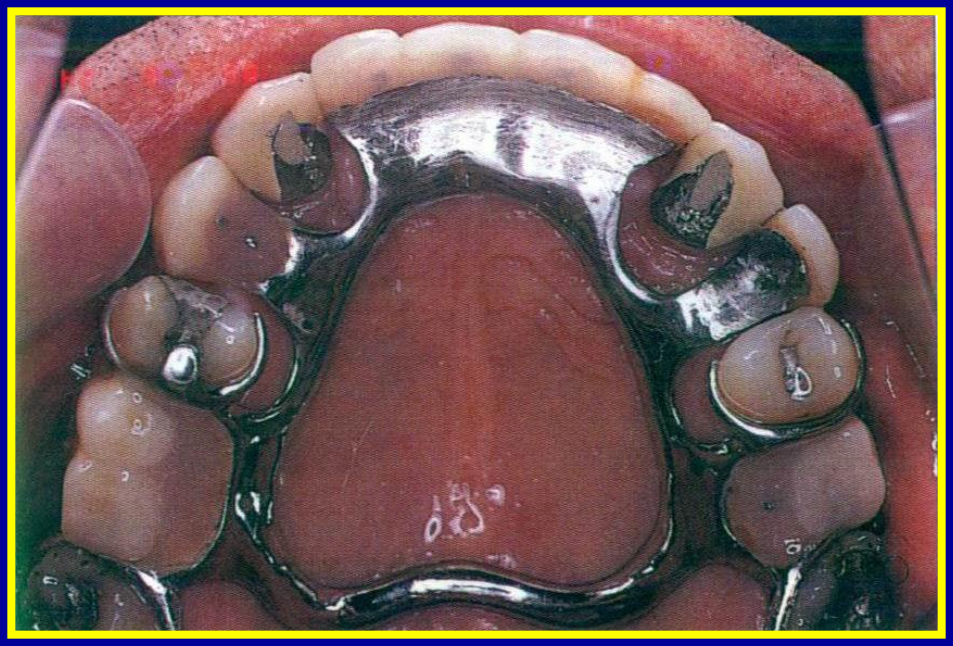
This alloy is mainly used for construction of partial denture framework.



The framework is mainly consisted of two parts:

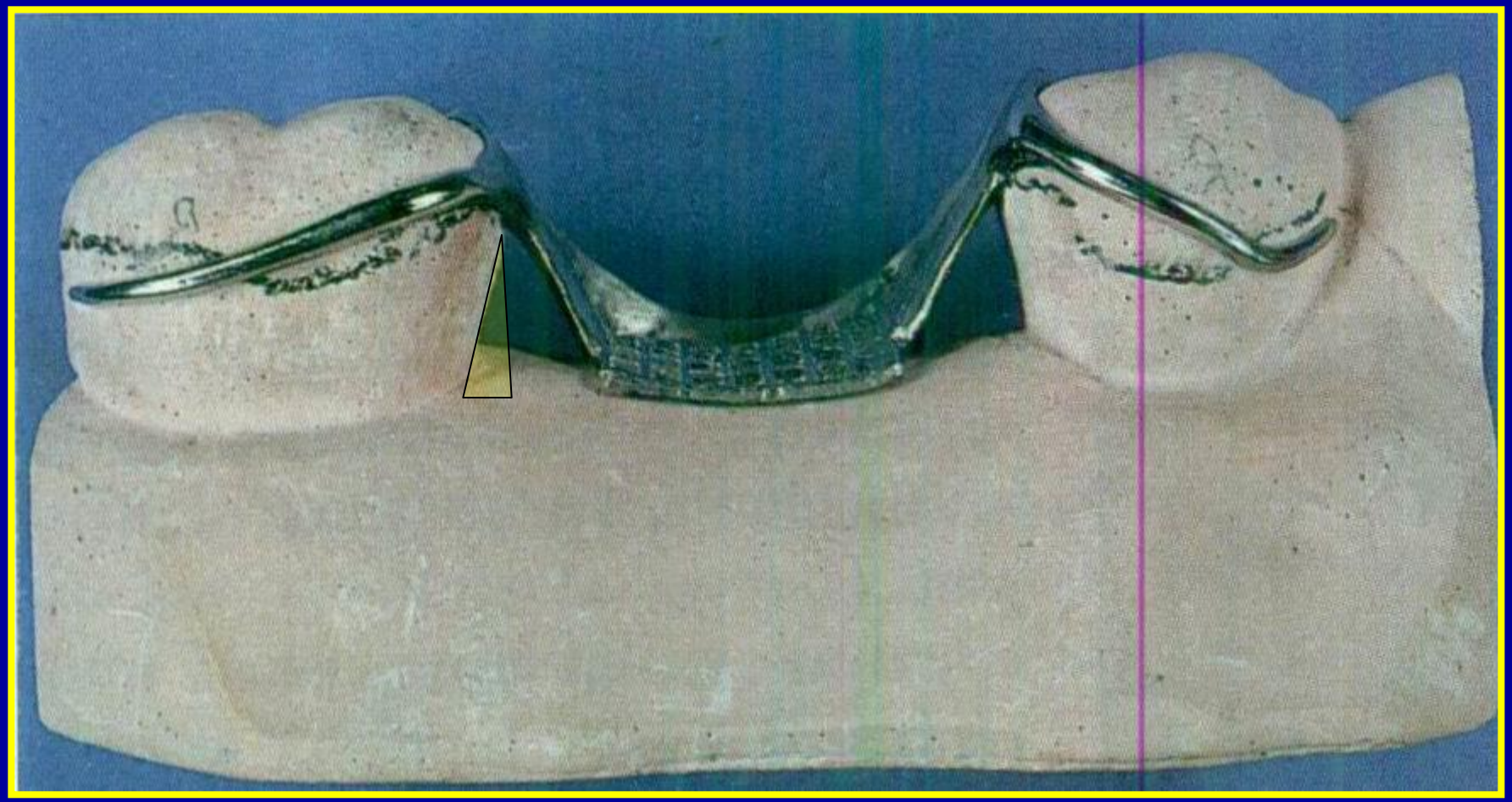
1- Connectors: (Rigid with high modulus of elasticity).





2- Clasps:

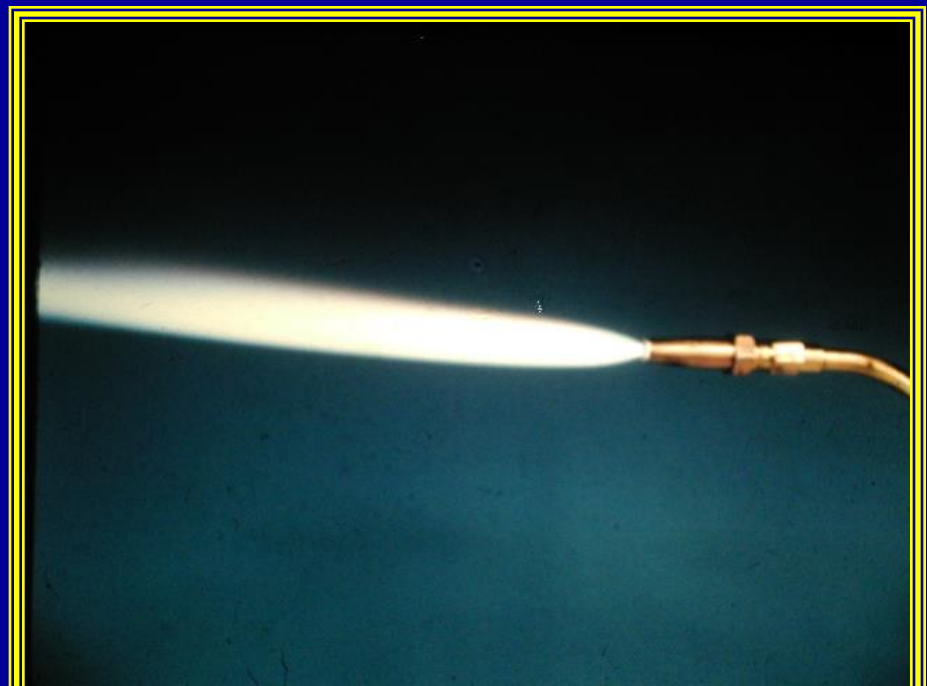
* Flexible with elastic deformation this will enable the clasp to engage deep undercuts,
* Ductile that it allows permanent deformation without fracture when adjustment of the clasp.



The melting temperature ranges from 1350-1500^{o}C

1) Acetylene-oxygen flame.

2) Electrical induction furnaces.



Methods of polishing Co-Cr alloys

1) Sand blasting.

Methods of polishing Co-Cr alloys

2)Electrolytic polishing.

Titanium & Titanium Alloys

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Titanium and titanium alloys (Ti-6Al-4V)

Titanium and its alloys are now used in metal – ceramic and for removable partial denture frames and implants. It has excellent biocompatibility, light weight, good strength and ability to passivity.

Application in dentistry

1. Metal ceramic restoration.

2. Dental implant.

3. Partial denture framework.

4. Complete denture.

5. Bar connecters.

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Titanium and titanium alloys (Ti-6Al-4V)

Properties

1. ***Color:*** white color metal.
2. ***Density:*** light metal (1-4gm/cm).
3. ***Modulus elasticity:*** 110 Gpa, half rigid as base metals.
4. ***Melting temp.:*** high (1668C°) special equipment is needed.

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Titanium and titanium alloys (Ti-6Al-4V)

5. ***Coefficient of thermal expansion CTE***: 8.3*10-6, it is low compared to porcelain 12.7 – 14.2 *10-6, so special low fusing porcelain is used with it.

6. ***Biocompatibility:*** it is non-toxic and excellent biocompatibility with soft and hard tissue.

7. ***Tarnish and corrosion resistance:*** passivity effect and formation of oxide layer to protect the metal from further oxidation.

8. ***Investment:*** phosphate and ethyl silicate bonded investment.

Nickel chromium alloys

They are used for metal ceramic crown and bridge.

Composed of:

- ***Nickel:*** 61-81%.
- ***Chromium***: 11-27% passivity effect, decrease melting point.
- ***Molybdenum:*** 2-9% increase hardness.
- ***Minor elements:*** Beryllium, Aluminum, Silicate, Copper.

Nickel chromium alloys

Properties

1. ***Color:*** white in color.
2. ***Melting range:*** 1155-1304C°.
3. ***Density:*** 7.8-8.4 gm/cm.
4. ***Casting:*** extremely technique sensitive.
5. ***Hardness*** 175-360 VHN, the high hardness make them difficult to cut , grind and polish.

Nickel chromium alloys

Properties

6. ***Yield strength***: 310- 828 Mpa, stronger than gold.
7. ***Modulus of elasticity:*** 150-210Gpa, this mean we can make casting thinner and lighter.
8. ***Elongation:*** 10 – 28% they are ductile but not easily burnishable.
9. ***Porcelain bonding***: this alloy forms adequate oxide layer which bonds to porcelain.
10. ***Aesthetic***: dark oxide layer may be seen at porcelain metal junction.

Stainless Steel Alloy

* Composition:

Iron (70%), chromium (18%), Nickel (8%), Carbon.

* Uses:

Wrought wire (Prosthodontic wire, orthodontic wire).

* Advantages:

Thin, light, conducts heat rapidly, strong and has good resistance to corrosion.

Any Questions?
Thank you

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