HEAT CURE ACRYLIC
DENTURE BASE RESIN

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OUTLINE

- Introduction
- Background
- Composition
- Chemical basis of polymerization
- Manipulation techniques
- Physical properties
- Heat cure v/s self cure
- Ideal requirements V/S clinical performance
- Clinical implications
- Defects
- Recent advances
- Conclusion

INTRODUCTION




- Dentistry as a specialty is believed to have begun about 3000 BC. All through the history of the making of dentures, we find a constant struggle of the dentist to find a suitable denture base material




According to GPT 8-

- **Denture base material** : any substance of which a denture base may be made.

- **Resin**: a broad term used to describe natural or synthetic substances that form plastic materials after polymerization. They are named according to their chemical composition, physical structure, and means for activation of polymerization.

- **Acrylic resin** : any of a group of thermoplastic resins made by polymerizing esters of acrylic or methylmethacrylate acids.

BACKGROUND

Wood	**Bone** *-Fauchard*	**Ivory**	**Porcelain** *-Alexis Duchateau*
Gold *-John Greenwood*	Vulcanite	**Tortoise Shell** *-CF Harrington*	**Gutta Percha** *-Edwin Truman*
Cheoplastic **Ag- Bi- Sb**	**Aluminium**	**Celluloid**	**Bakelite**
Stainless Steel	**Base Metal Alloys**	**Vinyl Resin**	**Poly Methyl Methacrylate (PMMA)**

POLYMETHYL METHACRYLATE

According to GPT 8-

- Poly(methyl methacrylate): a stable, hard transparent resin of marked clarity with a Knoop hardness number ranging from 18-20, a tensile strength of approximately 60 MPa, a density of 1.19 and a modulus of elasticity of approximately 2.4 GPa.

- Poly(methyl methacrylate) (PMMA) resin has been successfully used for various applications in dentistry for many years.

- **Rohm and Hass** (1936) introduced this material in sheet form and **Nemours** (1937) in powder form.

- It was introduced in 1937 by **Dr Walter Wright** and continues to be the material of choice for fabricating many denture prostheses because of its
  - superior esthetics
  - ease of processing and repair
  - favorable working characteristics
  - accurate fit
  - use with inexpensive equipment.

COMPOSITION

Available as:

- Heat cure denture base resins are commercially available as
  - Powder and liquid
  - Gel: sheets and cakes

The powder may be transparent or tooth colored or pink colored

The liquid (monomer) is supplied in tightly sealed amber colored bottles.

Gel Types:

Chemical accelerators cannot be used in a gel, because the initiator, accelerator, and monomer would be in intimate contact.

The **storage temperature** of a gel and the amount of inhibitor present have a pronounced effect on the shelf life of the material.

When stored in a refrigerator, the **shelf life** is about *2 years*.

POWDER

POLY- MMA
Major Component

ETHYL / BUTYL MA
Copolymers

BENZOYL PEROXIDE
Initiator

COMPUNDS OF MERCURIC/ CAD-MIUM SULFIDE
Dyes

ZINC/ TITANIUM OXIDE
Opacifiers

DIBUTYL PTHALATE
Plasticizer

INORGANIC FILLERS
(GLASS/ Al_2O_3/ ZIRCONIA SILICATE)
Improved physical properties like stiffness

DYED SYNTHETIC NYLON / ACRYLIC FIBRES
Simulate small capillaries

LIQUID

METHYL- MA

Plasticizes polymer

DIBUTYL PTHALATE

Plasticizer

GLYCOL DIMETHACRYLATE

Cross linking agent: Reduces crazing

HYDROQUINONE

Inhibitor : Prevents premature polymerization

MANUFACTURING POLYMER POWDER

- **Spherical particles**

By suspension polymerization:

  - monomer and water are mixed with an emulsifier i.e, powder talc.
  - then the mixture is heated and stirred
  - at the end talc is washed off to get polymerized polymer particles

- **Granular particles**
  - solid block followed by grinding or milling

COMMERCIAL NAMES

Commercial Products

Stellon (DPI)
Lucitone (Bayer)
Trevelon (Dentsply)

CHEMICAL BASIS OF POLYMERISATION

ACTIVATION	Conversion of low molecular weight compounds to high molecular weight polymers in presence of heat
INITIATION	Initiator like benzoyl peroxide yields free radicals which sets off chain reaction
PROPOGATION	Formation of copolymers and cross linking Addition polymerization reaction
CHAIN TRNASFER	Activation of monomer molecules by macromolecule
TERMINATION	Direct coupling of free radicals and formation of polymer

MANIPULATION TECHNIQUE

1. Compression Moulding Technique

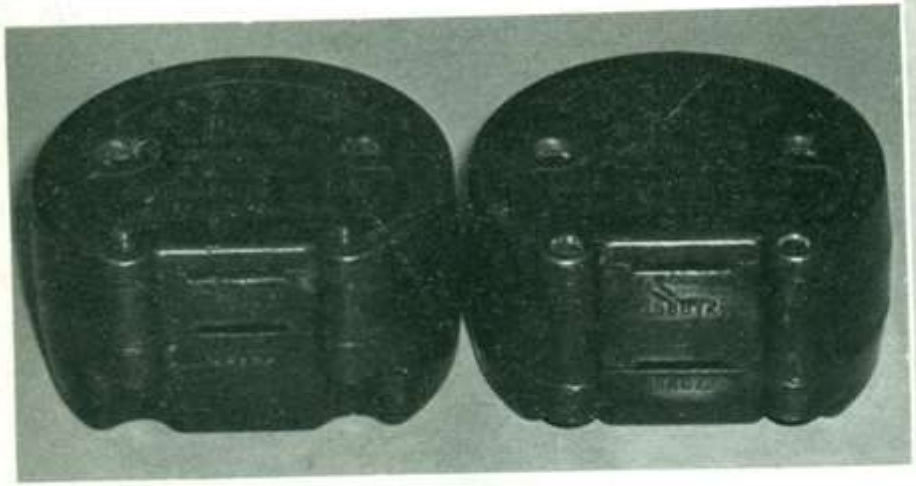
According to Rudd and Morrow,

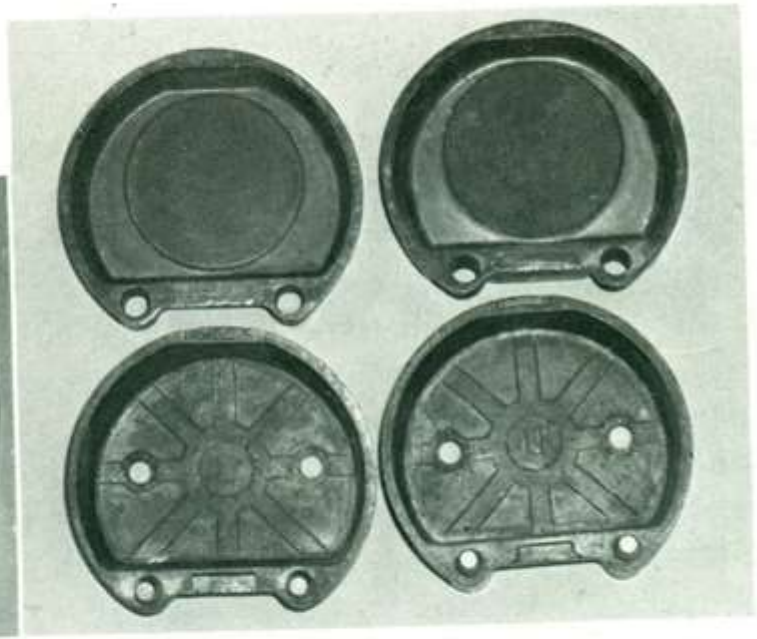
- Technique 1: Using only gypsum products
- Technique 2: Using silicon based investment material

2. Injection Molding Technique

Compression Moulding Technique #1

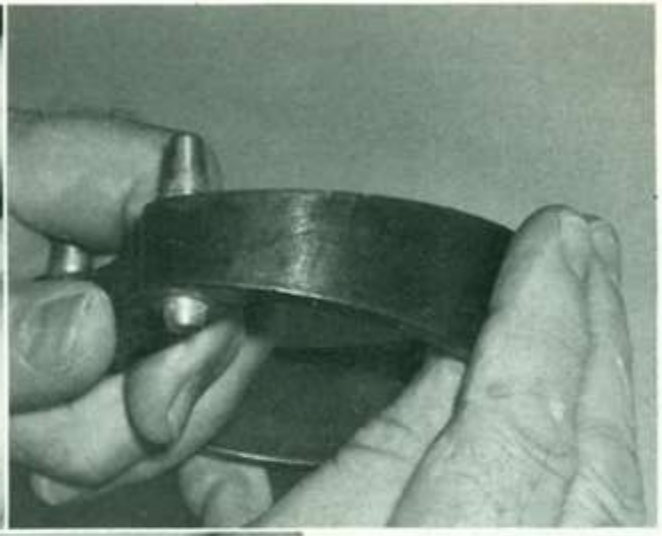
A





B

Flasks should fit together without rocking. Be certain that numbers match. **B,** Flasks should be clean and free of plaster.

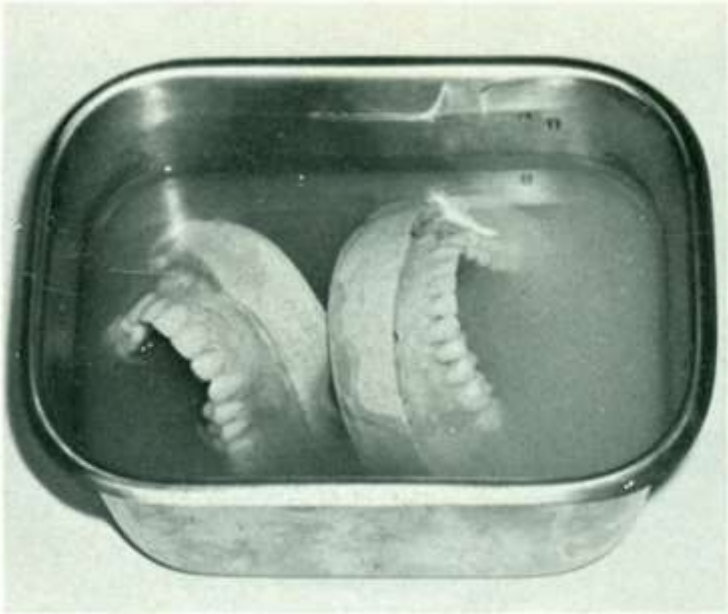


B

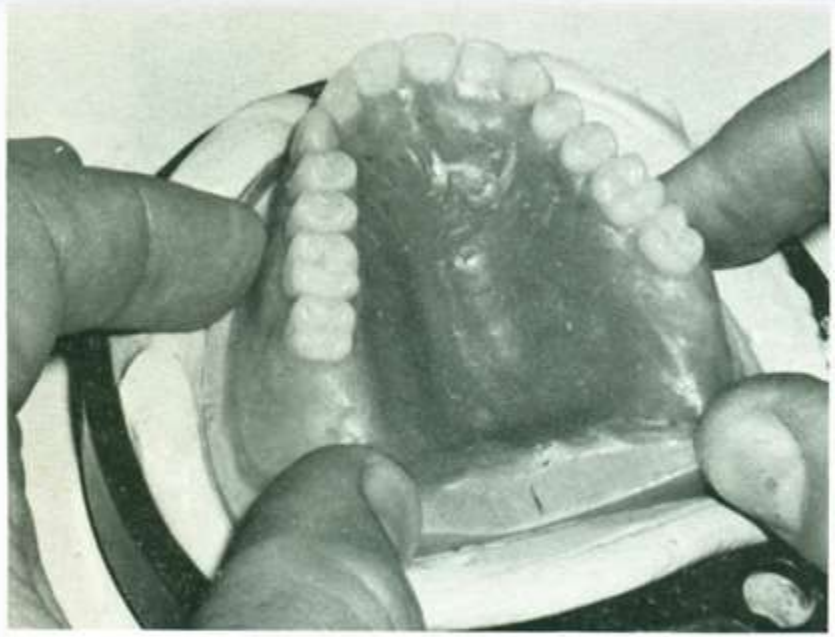
C

Interior of flask is lubricated with silicone lubricant. **B** and **C,** Exterior and joining surfaces are coated with silicone lubricant.

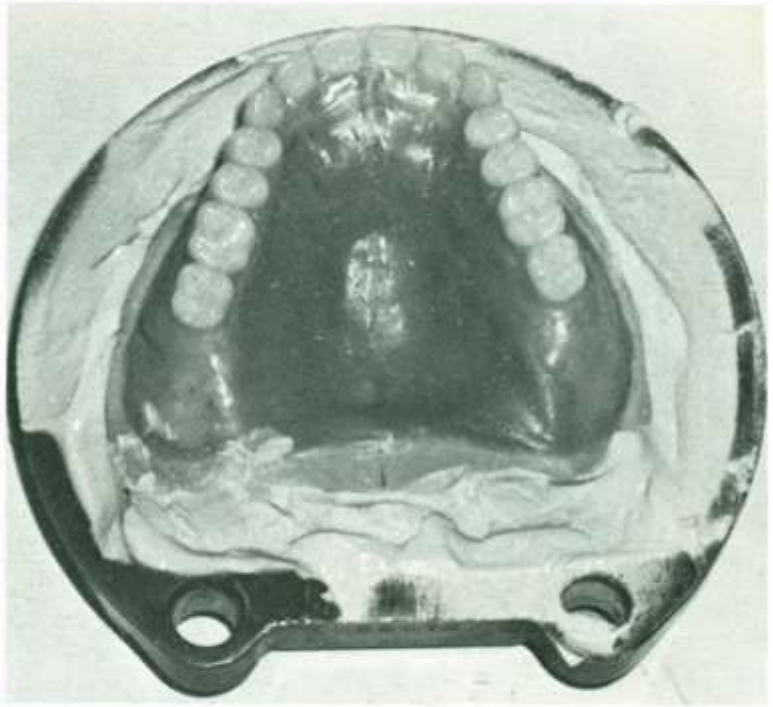
Wax denture and cast are removed from mounting stone.



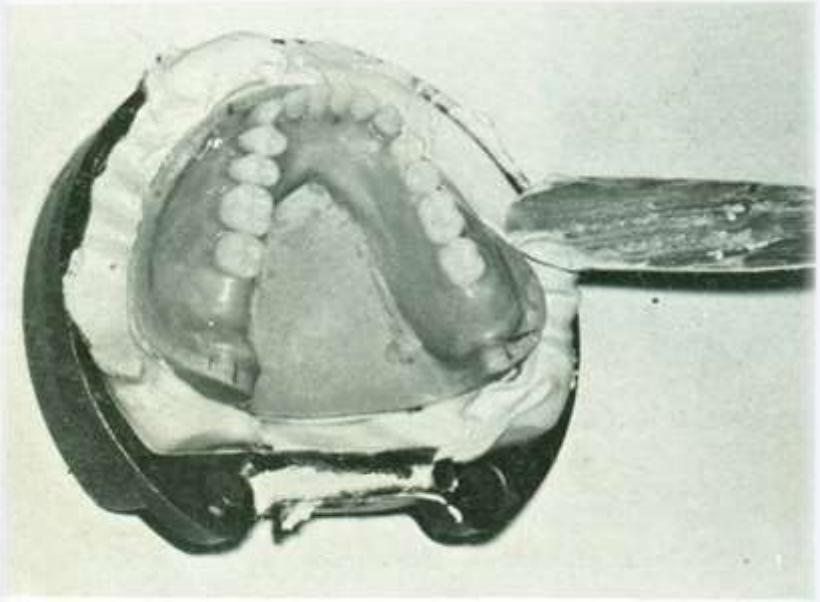
. Waxed denture and cast are soaked in clear slurry water for few minutes.



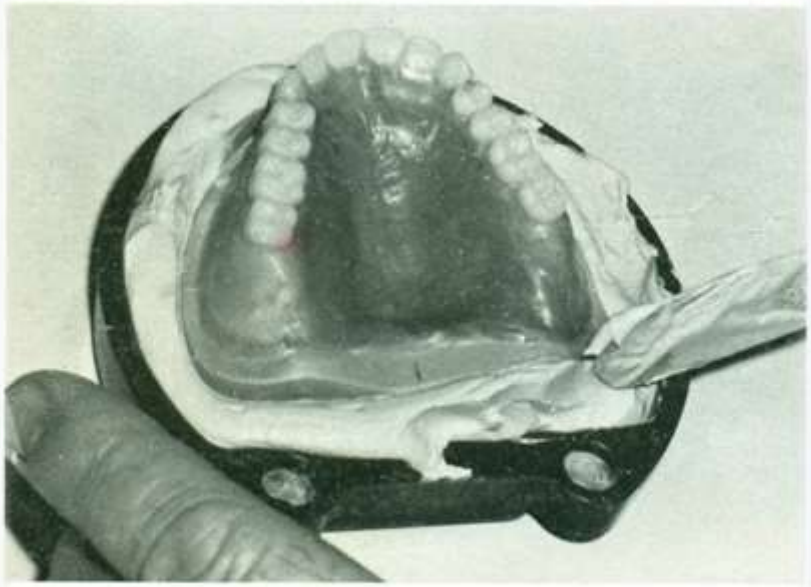
Denture and cast are settled into stone mix.



Cast is centered in flask, keeping occlusal surfaces parallel to bench top.



Stone is smoothed with spatula.



Areas are filled where needed to eliminate undercuts.

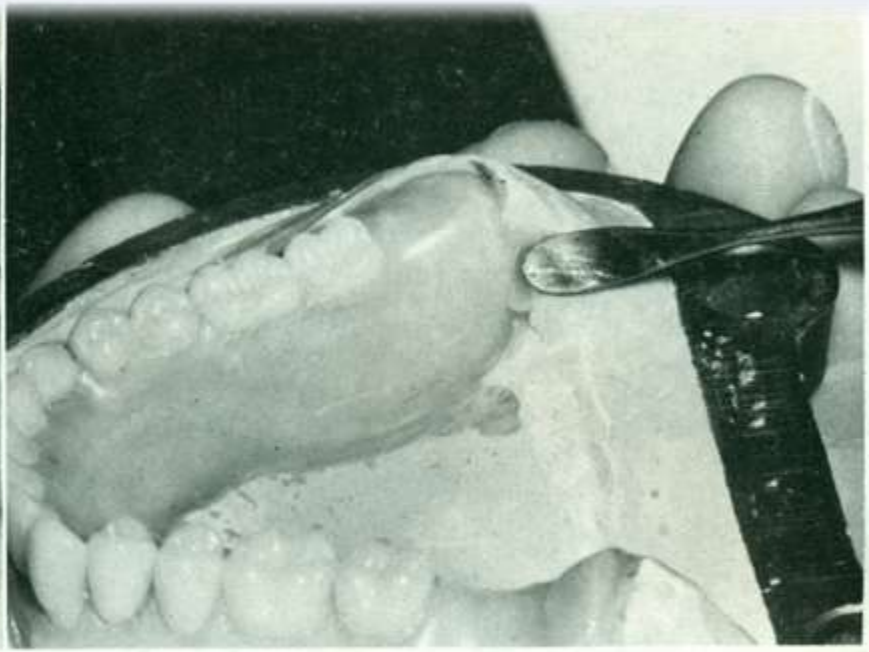
A

B

C

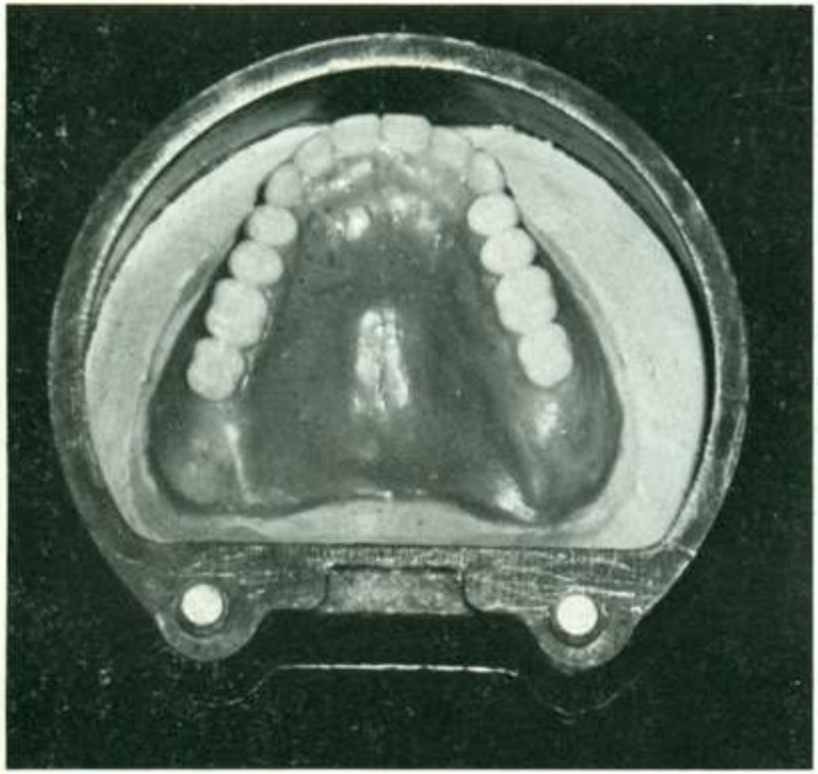
A, Stone is trimmed with sharp plaster knife. **B,** All stone is removed on flask rims. **C,** Avoid gouging or cutting wax denture. Note curved blade, which is recommended for trimming flasking stone.

A



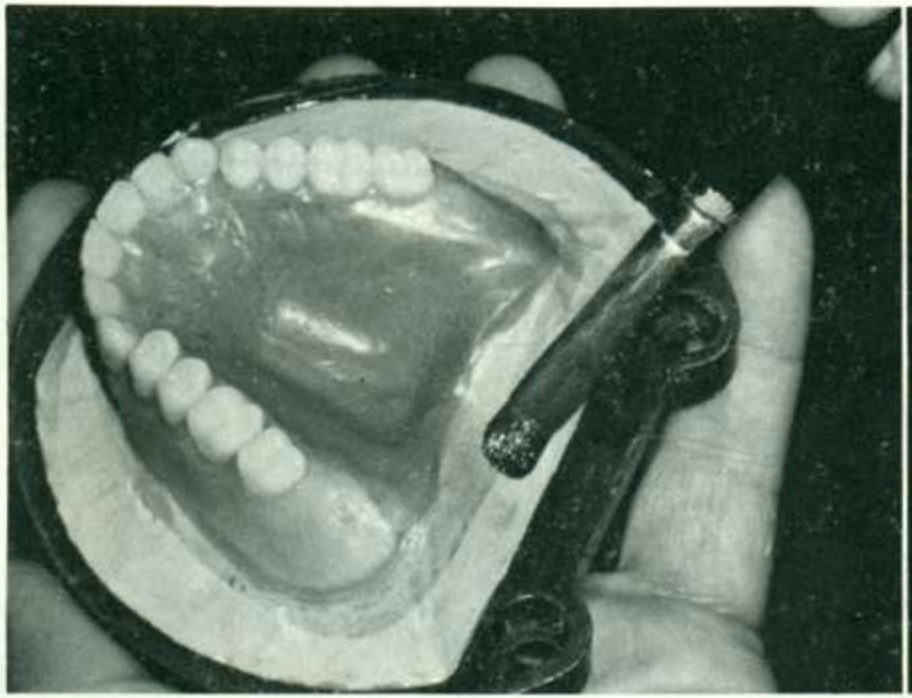
B

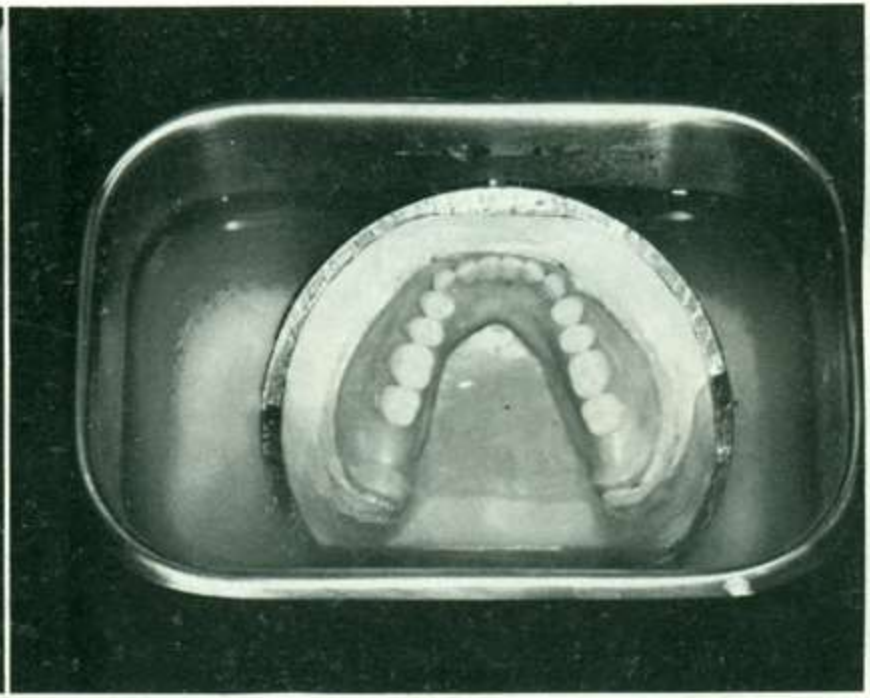
A, Heel undercuts are blocked out with baseplate wax. **B,** Distolingual region is frequently undercut and should be blocked out.



Flask halves are assembled and checked for stone that could prevent accurate seating.

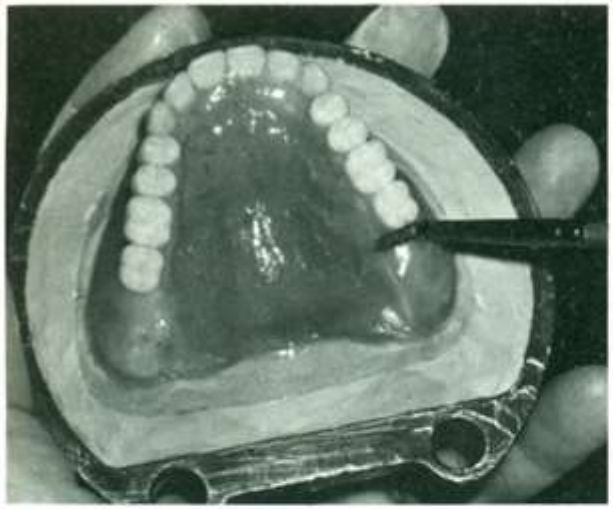
A





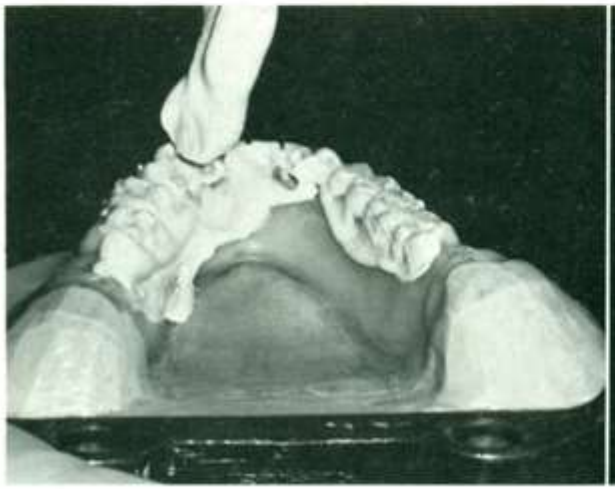
B

A, All stone surfaces are painted with separating medium. **B,** Flask is soaked in clear slurry water for few minutes before second pour is added.



Wax is painted with surface tension-reducing agent t minimize bubbles.

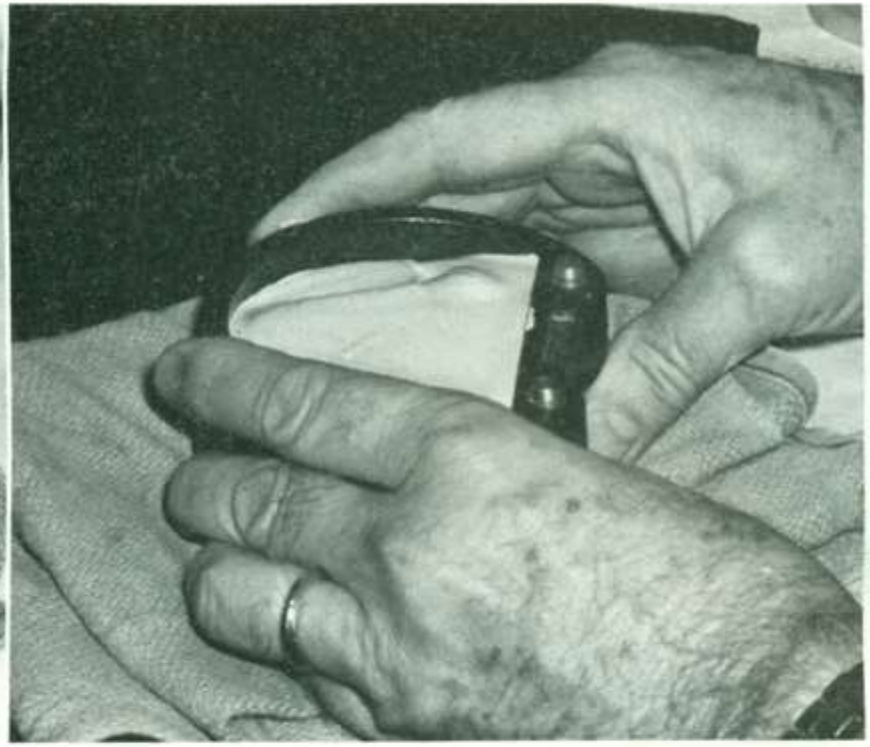
A



B

A, Stone is painted on occlusal surfaces with stiff brush. **B,** Stone is painted on wax surfaces to minimize voids.

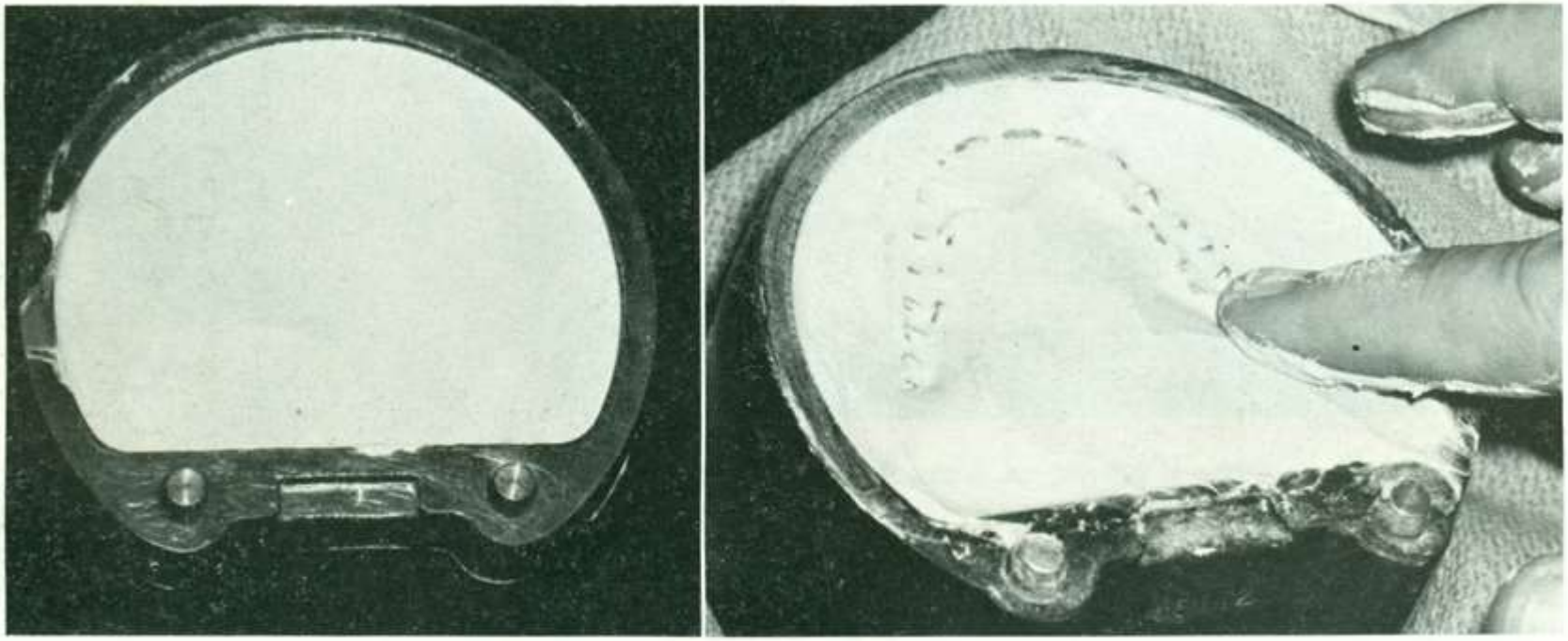
A



B

. **A,** Stone is poured into flask slowly while on vibrator to reduce air entrapment. **B,** If vibrator is not available, flask can be tapped against towel on bench top, using care to hold flask halves together.

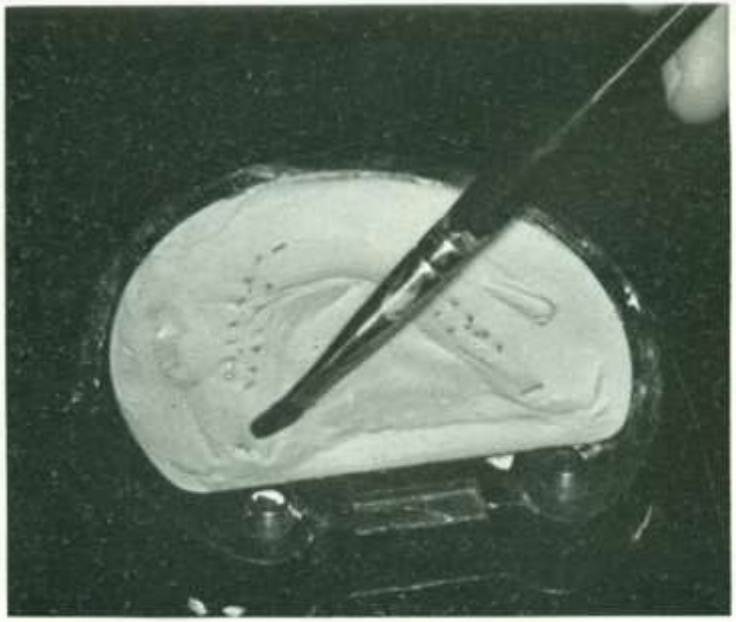
A



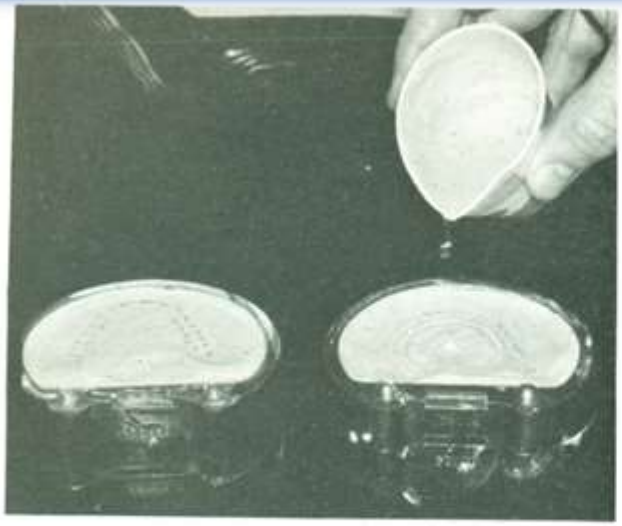
B

A, Flask is filled to within ¼ inch (0.64 cm) of top. **B,** Stone is removed from occlusal surfaces of teeth.

Small retentive grooves are placed in set stone to maintain cap in position.

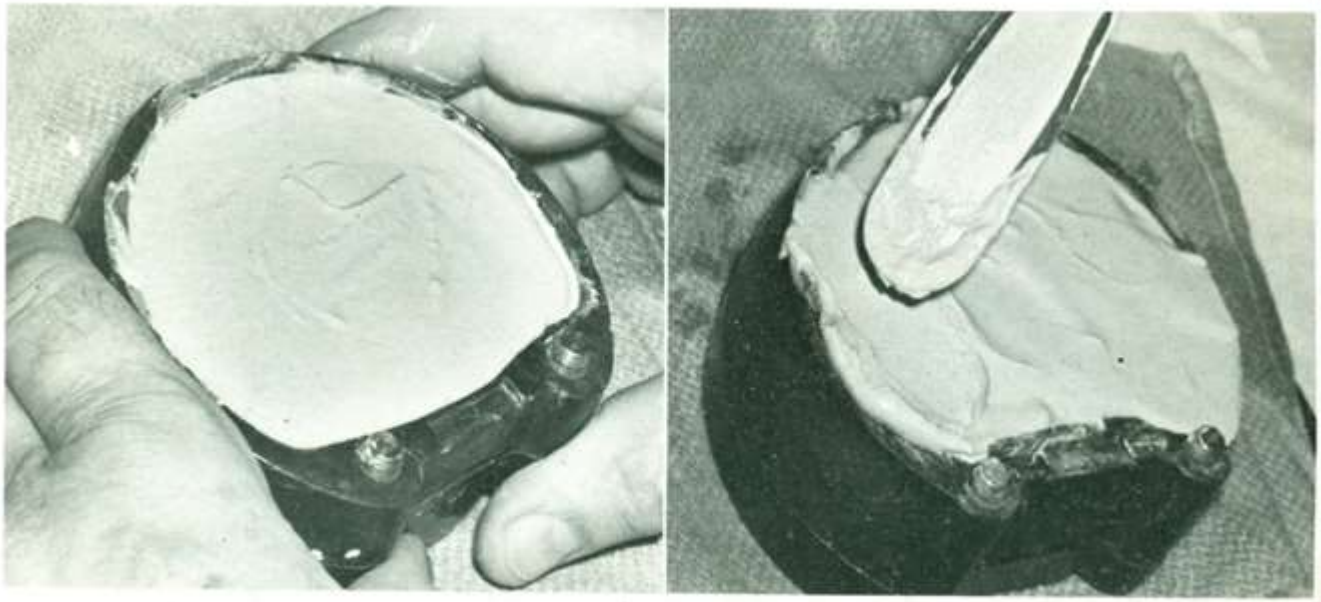


Stone surface is painted with separating medium. Do not perit separating medium to contact resin denture teeth.

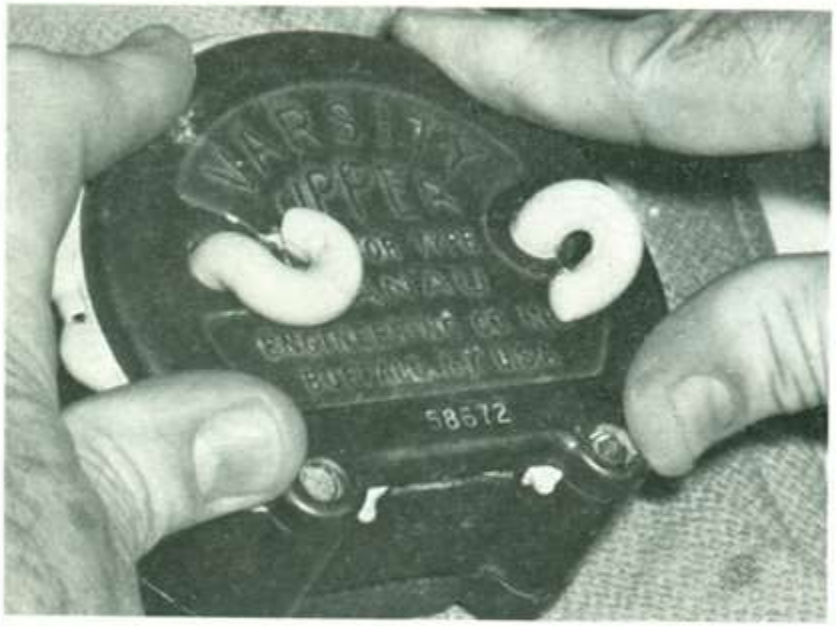


Clear slurry water is poured on stone and allow
remain while stone for cap is mixed.

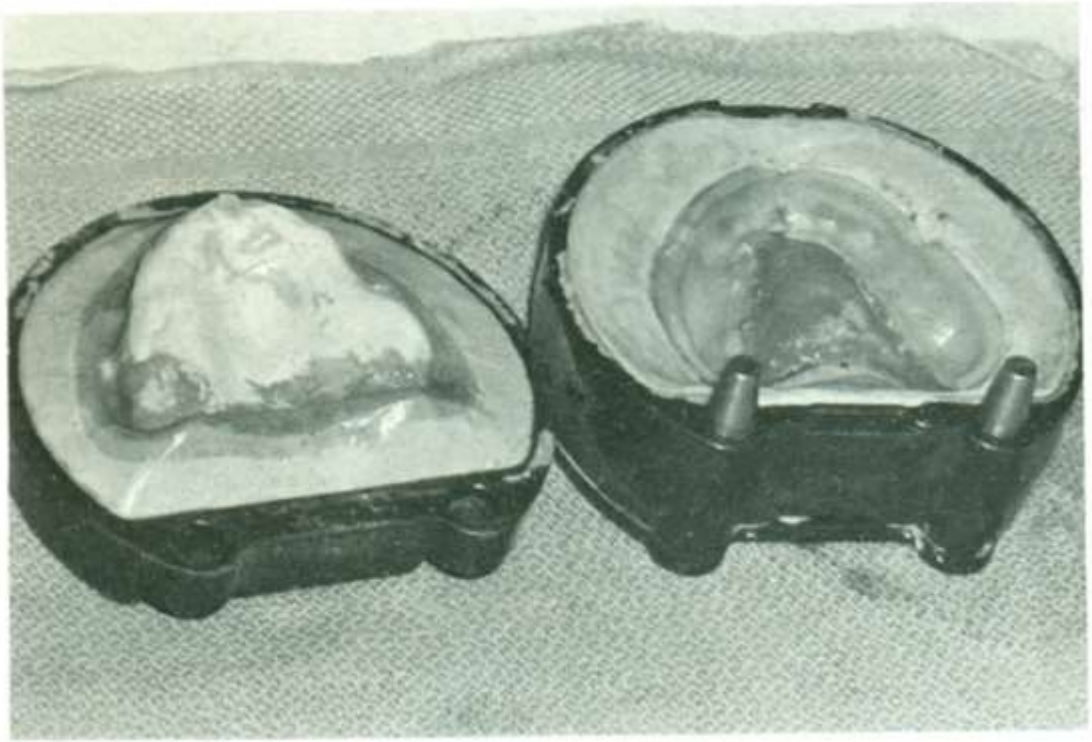
A



. A, Slurry water is poured off, and flask is filled with stone. B, Flask is completely filled with

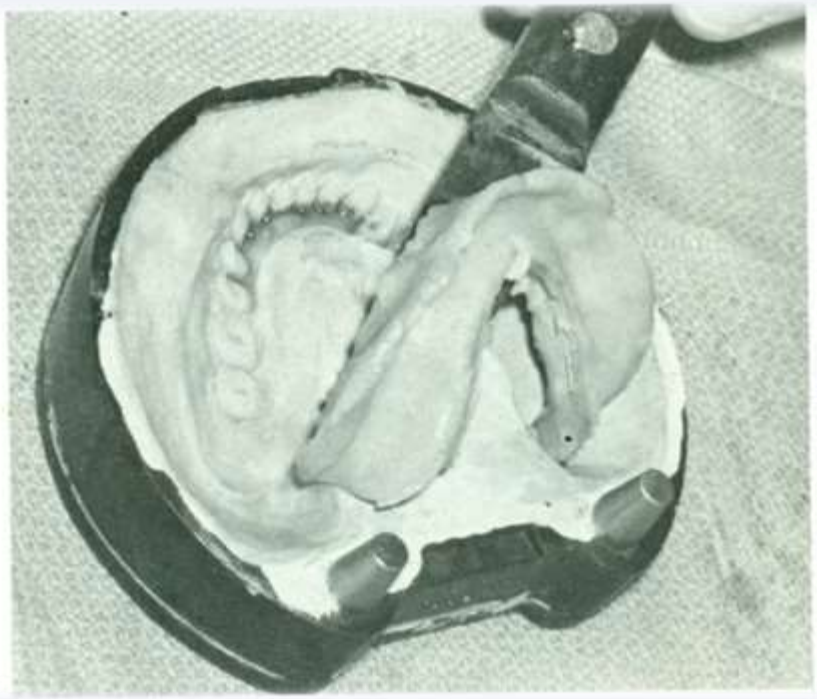


Lid is placed on flask and tapped to determine that flask is filled.



Flask halves separated.

Baseplate and softened wax are removed. Check for dislodged denture teeth at this time.



Flasking the denture

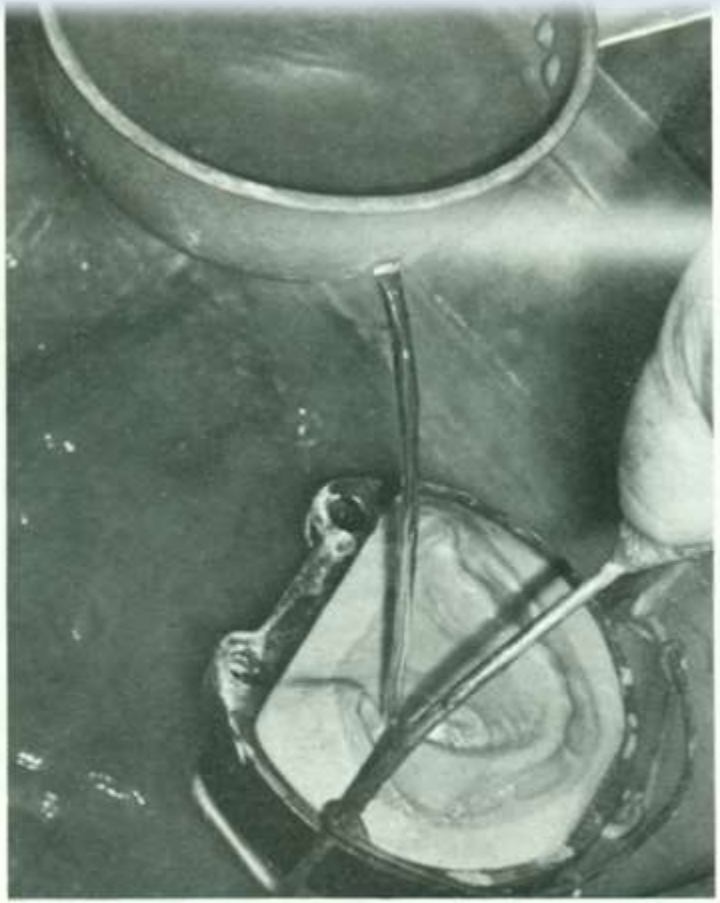
Problem	Probable cause	Solution
Flask halves cannot be separated after removal from boiling water	Undercuts exist in flasking stone or on casts	Examine casts and flasking stone carefully to locate and block out undercuts
	Separating medium not painted on stone in lower half of flask	Paint separating medium on stone in lower half of flask before pouring upper half
Heel broken on mandibular cast on flask separation	Undercut on cast not blocked out with wax	Check heel area of mandibular denture after half flasked to locate and block out undercuts
Denture has many nodules of acrylic attached when removed from flask	Investing stone not painted on denture during flasking	Paint investing stone on teeth; wax denture with stiff brush
	Investing stone not vacuum spatulated	Mix investing stone in mechanical spatulator under reduced atmospheric pressure

Mold is flushed with hot water to which detergent has been added.

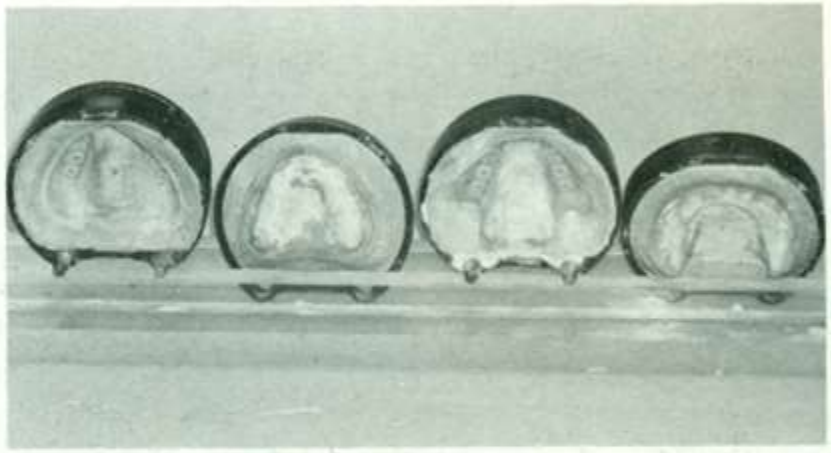
B

C

. **A,** Worn-out lathe brush wheel can be used to scrub cast to eliminate all traces of wax. **B** and **C,** Molds should be thoroughly cleansed.



Detergent solution is removed with final flush of clean boiling water.



Flasks are allowed to drain and cool in upright position. Note grooved plastic holder used to hold casts upright.

Fig. 9-64. Tinfoil substitute is poured in small container for immediate use. Any tinfoil substitute remaining after using should be discarded and not returned to storage container.

Painting the tinfoil substitute

Problem	Probable cause	Solution
Flasking stone sticks tenaciously to cured denture surface	Tinfoil substitute not applied to cast or flasking stone	Paint stone and cast with tinfoil substitute
	Tinfoil substitute contaminated with stone	Pour fresh tinfoil substitute in small container for immediate use; do not dip brush in principal storage container
	Tinfoil substitute too diluted as a result of thinning	Do not add too much water to thin tinfoil substitute
	Wax elimination not completed during boilout, rendering tinfoil substitute ineffective	Cleanse interior of mold and cast surface thoroughly with boiling water to which detergent has been added; flush with clean boiling water
Resin teeth fail to bond to denture base resin	Tinfoil substitute painted on ridge laps of denture teeth	Remove any tinfoil substitute that contacts ridge laps of resin teeth
	Wax residue remains on ridge laps of denture teeth	Cleanse interior of mold, denture teeth, and cast thoroughly with boiling water to which detergent has been added; flush with clean boiling water

A

B

C

A, Tinfoil substitute is carefully painted on stone. **B,** Do not allow tinfoil substitute to puddle in interproximal areas. **C,** Do not place tinfoil substitute on ridge laps of teeth.

Review of Separating Media

An experimental separating agent composed mainly of **trimethylol-propane-tolylenediisocyanate and ethyl-acetate**, with a small amount of **bis-tributyl-tin oxide** was used on gypsum moulds.

The molds treated with this separating agent had a glossy, hard surface.

The surface of the cured resins treated in this way was glossier and smoother than that of resin treated with the water-soluble alginates.

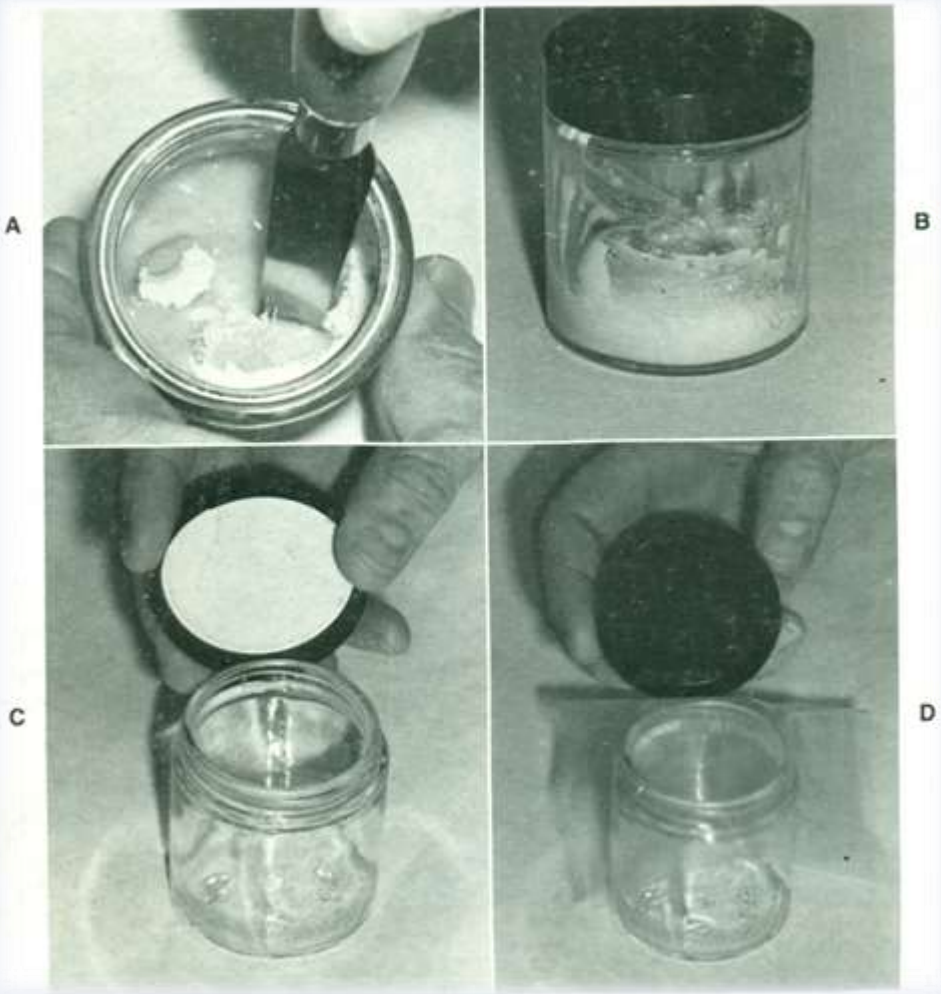
Takahashi Y et al, ***Application of isocyanate separating agent for acrylic resin,*** *Shika Zairyo Kikai 1989 Jul;8(4):580-6*

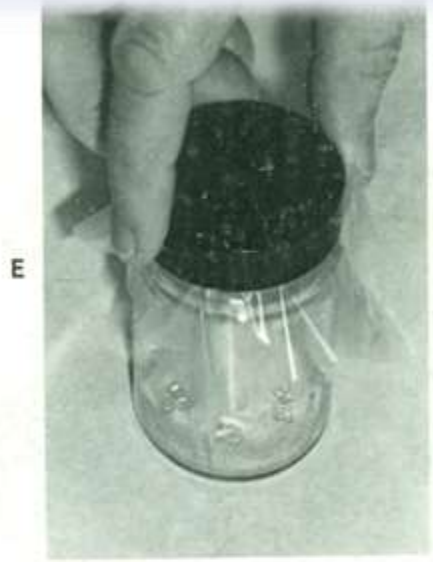
David N et al(1980) stated that the PMMA denture base was smoothest when separated from the gypsum cast by **tinfoil** as opposed to COE-SEP and in specimens which did not use any separating media.

- Failure to place an appropriate separating media may cause 2 major difficulties:

i. If water is permitted to pass from the mold surface to denture base resin, it may affect **polymerization rate** as well as the **optical and physical properties** of the processed resin

ii. If dissolved polymer or free monomer is permitted to soak into the mold surface, portions of the **investing medium may become fused to the denture base**





A, Resin is mixed in clean mixing jar with stainless steel spatula. **B,** Resin is allowed to set in closed jar until dough stage is reached. **C,** Mixing jar lid should form tight seal when in place. **D,** Lid does not provide good seal, thus plastic sheet is placed over jar before lid is screwed on. **E,** Plastic serves as gasket, forming tight seal.

Polymer- Monomer Ratio

The accepted polymer monomer ratio is **3:1 by volume** which yields approx. **6% volumetric shrinkage**.

This provides sufficient monomer to thoroughly wet the polymer particles but does not contribute excess monomer that would lead to increased **volumetric shrinkage of 21% which is unacceptable**.

Polymer-Monomer Reaction

Sandy:

No interaction at molecular level

Consistency of mixture is coarse or grainy

Stringy:

Some polymer chain dispersed in liquid monomer

Stringiness or stickiness when material is touched or drawn apart

Dough-like:

Increased number of polymer chain enter solution

Ideal for compression molding

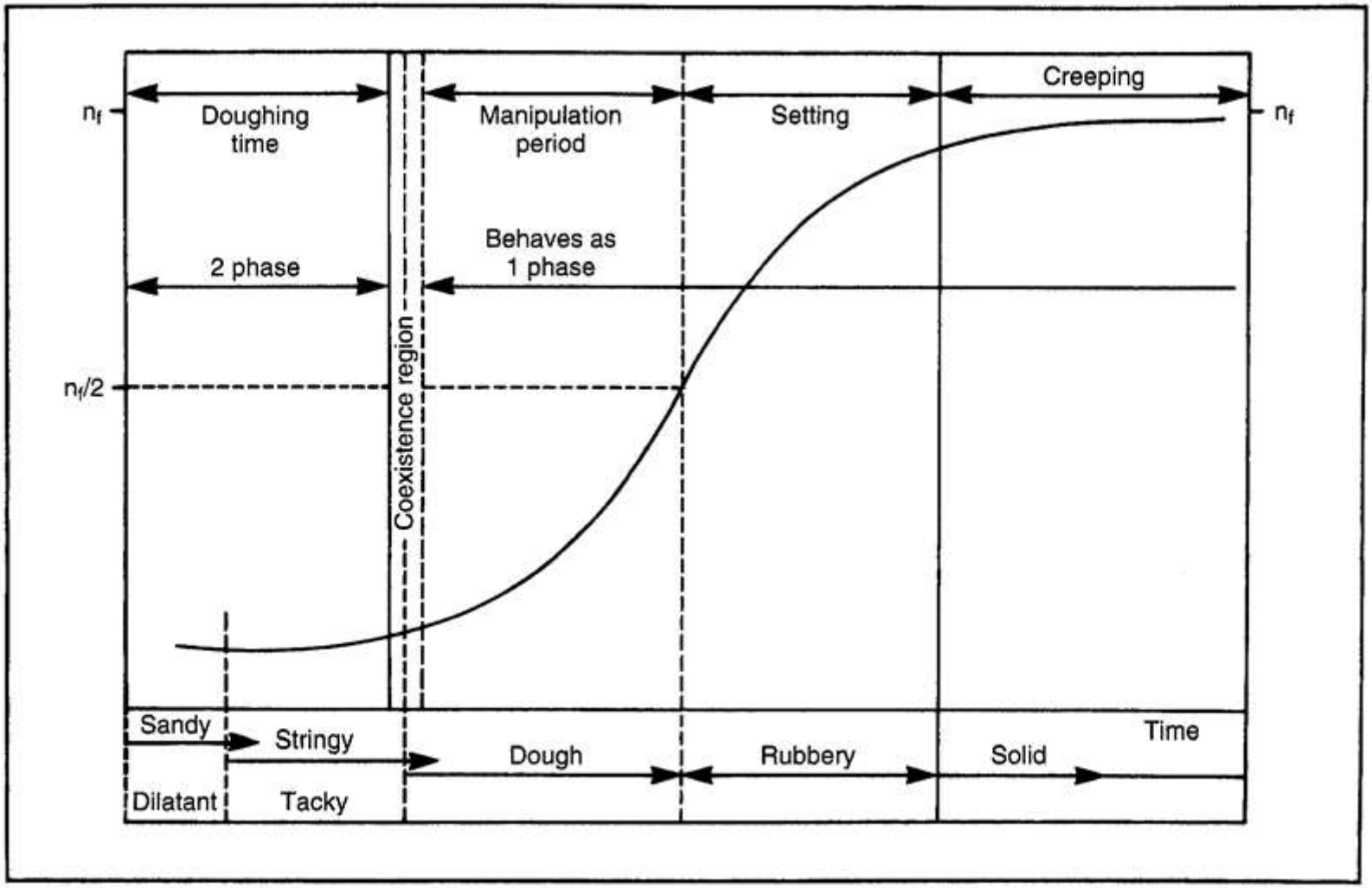
Rubbery /Elastic:

Mass rebounds when compressed or stretched

Stiff:

Evaporation of the free monomer

Mixture appears very dry & is resistant to mechanical deformation



Rheology stages of pre-polymerized denture acrylic after mixing of powder and liquid. *Nf* is the final viscosity and *nf/2* is half of the final value.

(From Mutlu G, Huggett R, Harrison P, Goodwin JW, Hughes RW: *Dent Mater* 6:288, 1990.)

Dough Forming Time:

ADA specification no. 12 requires that dough like consistency be attained **in less than 40 min**. from start of mixing process

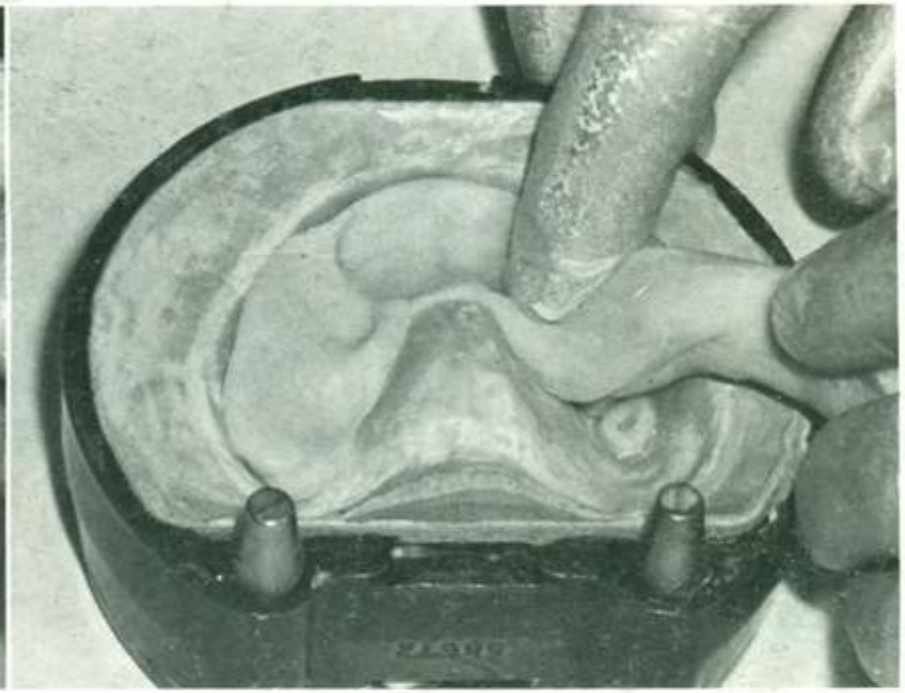
Clinically, most resins reach dough like stage **in less than 10 min**

Working Time:

ADA specification no. 12 requires the dough to remain moldable for **atleast 5 min**

The working time of the resin may be extended by refrigeration.

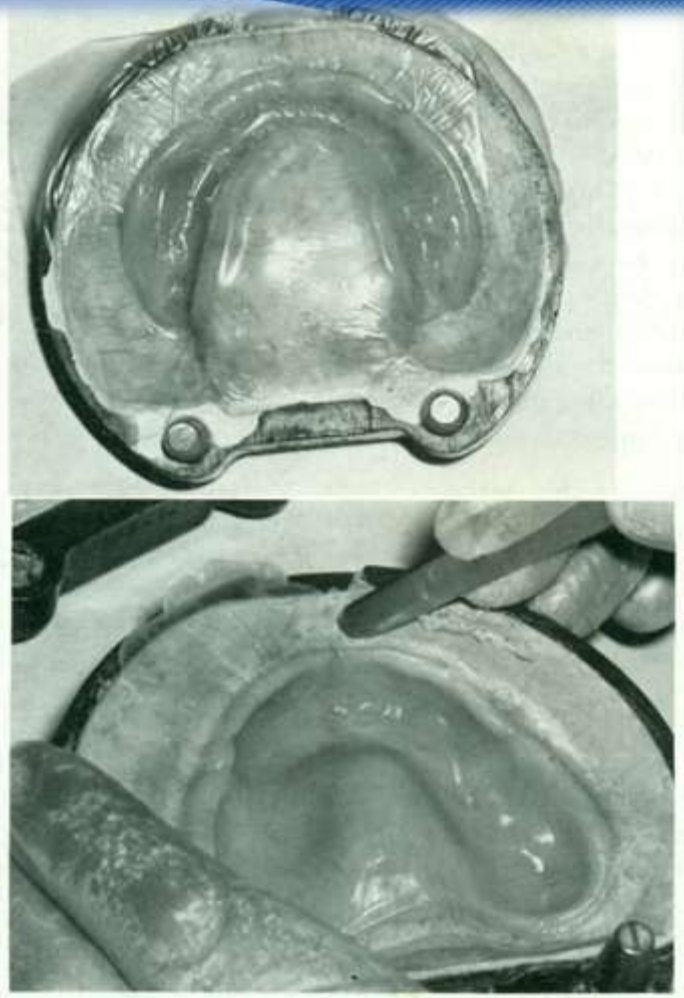
A



B

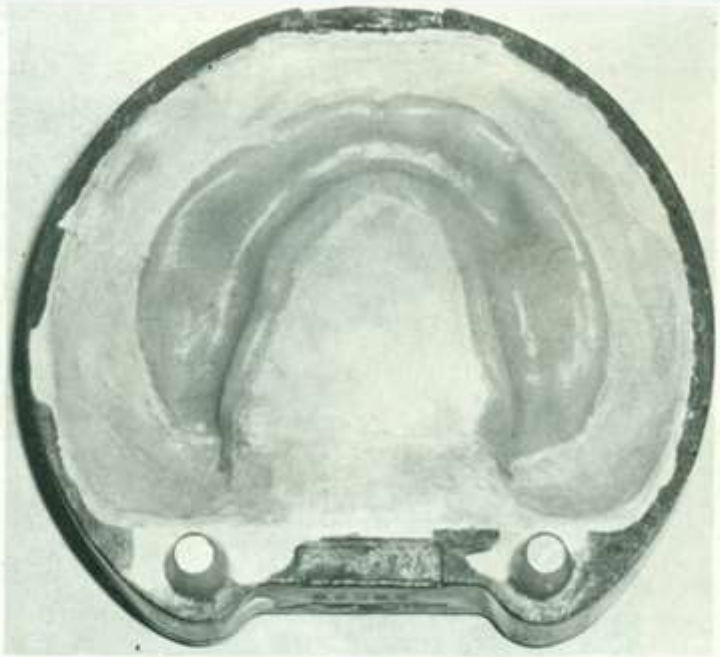
A, Resin dough is removed and formed into roll. **B,** Resin adapted in flask.

. Flask is closed slowly in compress.

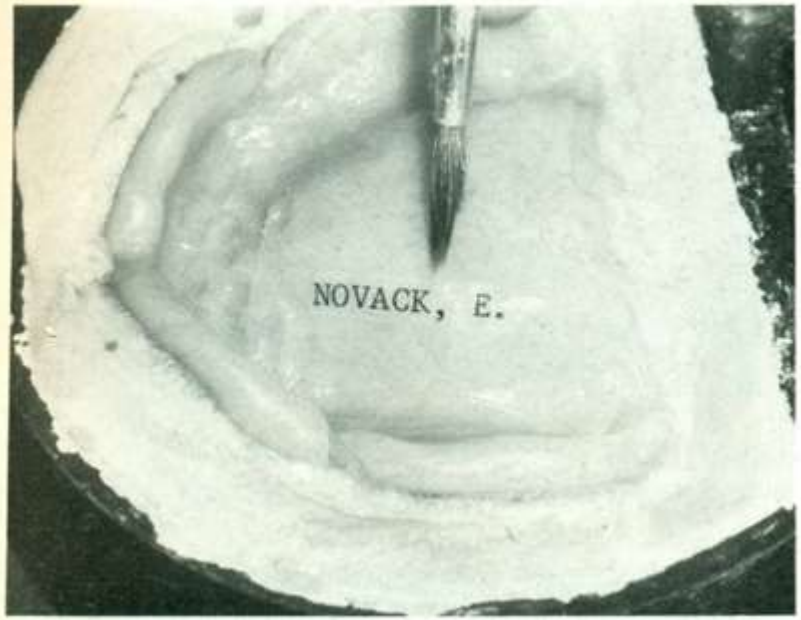


. A, Plastic sheet removed, and resin flash trimmed. B, Dull spatula is used to trim flash. knife can cut stone, allowing stone particles to be incorporated in resin.

Trial packing is continued until no flash is apparent on opening flask.



Resin surface is glossy when flask is opened; however, it dulls rapidly.

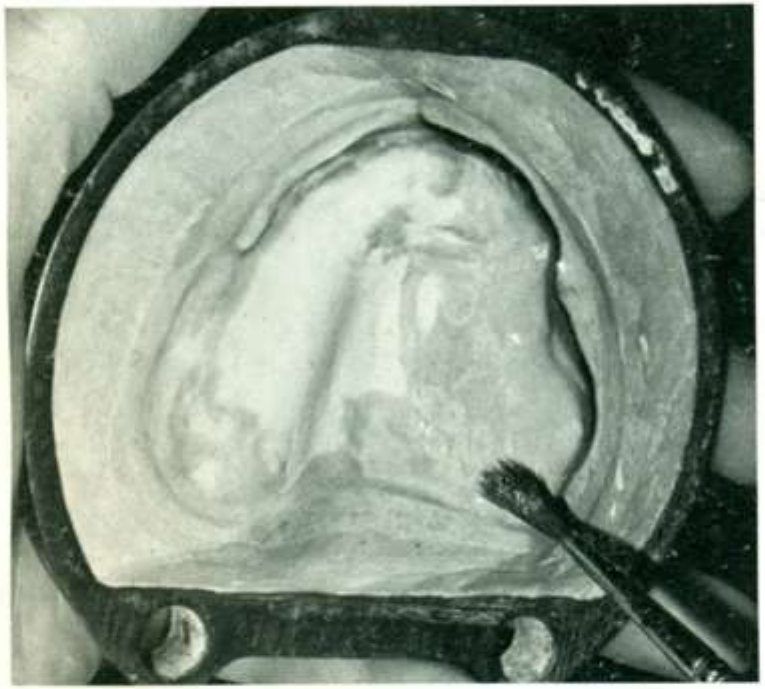


Tissue paper absorbs acrylic resin monomer. Name should be placed where subsequent adjustment of denture is unlikely. Name placed on facial surfaces might be objectionable to patient.

A

C

A, Clear acrylic resin polymer is sifted over name. B, Resin is saturated with monomer. C, Name is completely covered with clear resin and is ready for trial packing.



Cast is again coated with tinfoil substitute and allowed to dry before final closure.

Flask rims contact, indicating flask is closed

Packing the denture

Problem	Probable cause	Solution
Cured denture has porosity	Flask underpacked with resin	Fill mold completely before curing; properly packed resin should exhibit flossy surface when flask is first opened
	Thick denture base heated too rapidly	Bench cure, followed by long curing cycle
Cured denture has increased processing error	Denture resin packed at late, or rubbery, stage	Pack resin during dough stage
	Flask not properly closed prior to curing	Make certain metal-to-metal contact of flask rims is achieved before curing

Curing Cycle

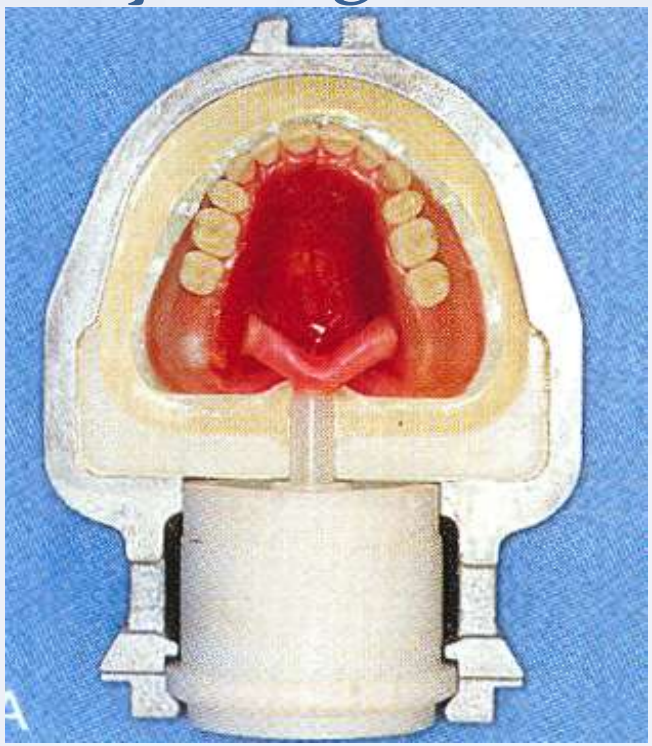
Constant – temperature water bath at **74°C** (165°F) for **8 hours** or longer **without terminal boil** at 100°C

Base at **74°C** (165°F) for **8 hours** or longer followed by a **terminal boil at 100°C for 1 hour**

Shorter cycle: At **74°C** (165°F) for approximately **2 hours** then **boiling at 100°C for 1 hour** or more

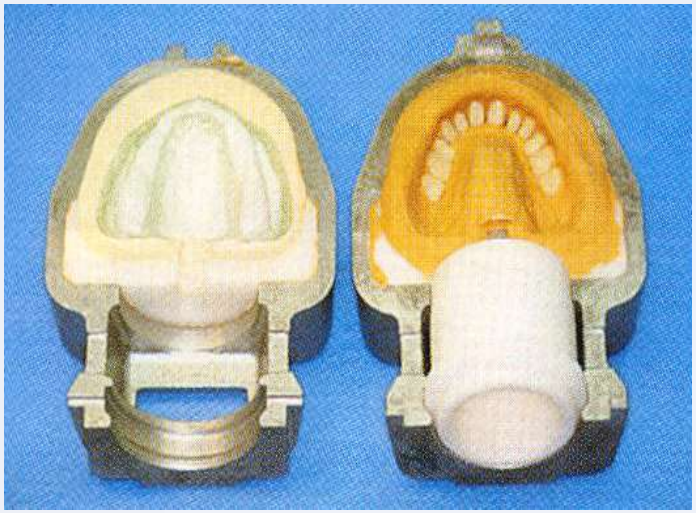
Injection Molding Technique

For this a specially designed flask is used



A. Placement of sprues for introduction of resin

b. Occlusal & incisal portions of the prosthetic teeth are exposed to facilitate denture recovery.



c. Separation of flask segments for wax elimination procedure.

Flask is reassembled and placed unto the carrier that maintains the pressure on the assembly during resin introduction & processing

↓

Powder-liquid mixture is employed, the resin is mixed & introduced into the mold while at room temperature

↓

Flask is then placed in the water bath for polymerization

↓

As the material polymerizes, additional resin is introduced into the mold cavity to offset the effects of polymerization shrinkage

In the case of polystyrene resin, thermoplastic polymer is softened using heat & introduced into the mold while hot.

Subsequently, the resin is permitted to cool & solidify.

Advantage:

Reduce the risk of monomer vapor inhalation.

COMPRESSION MOLDING TECHNIQUE V/S INJECTION MOLDING TECHNIQUE

Nogueira et al in 1999 compared incisal pin opening & dimensional accuracy for dentures constructed by compression molding & injection molding. They used lucitone 199 material with long curing cycle.

They concluded **that injection molding method produced a significantly smaller pin opening over the standard compression molding technique**. The injection molding technique, using polymethyl methacrylate, was more accurate method for processing dentures.

(J Prosthet Dent 1999;82:291-300)

PHYSICAL PROPERTIES : STRENGTH

ANSI/ ADA SPECIFICATION NO. 12 FOR DENTURE POLYMERS

TENSILE STRENGTH

- 48- 62 Mpa
- Adequate
- Fractures due to accidental dropping or faulty fabrication

COMPRESSIVE STRENGTH

- 76 Mpa
- Fractures due to faulty fabrication or accidental dropping

ELONGATION

- Elongation+ ultimate strength is indication of toughness
- Low elongation= brittle
- 1-2%

PROPORTIONAL LIMIT

- Function of rate of stress application
- Dental plastics have a low proportional limit and are permanently deformed at low stresses

FLEXURAL STRENGTH & MODULUS

- More closely represents type of loading in vivo compared to tensile and compressive strength
- Modulus is much low compared to metals

FATIGUE STRENGTH

- Represents number of cyclic stresses before failure at certain stress
- Adequate
- Superior for rubber reinforced acrylic and lowest for pour type

- Stresses can be concentrated in flaws on surface
- Recorded by assessing crack propogation
- Rapid heat cure: high
- Pour type: low

FRACTURE TOUGHNESS

- Denture base placed under load will creep with time
- Lowest values for heat cure acrylic
- At high stress, creep decreases with increasing cross linking agents

COMPRESSIVE CREEP

- Associated with viscoelastic properties of denture base
- Related to effect of free monomer, plasticizers and degree of cross linking

RECOVERY AFTER INDENTATION

- Indicates these materials may be scratched easily and abraded
- Cross linking improves hardness
- Fillers only alter abrasion resistance but don't affect hardness

HARDNESS

- Vinyl acrylic- best
- Pour type- least

ABRASION RESISTANCE

- Measure of energy absorbed by material when broken by sudden blow
- Increased by addition of plasticiser

IMPACT STRENGTH

PHYSICAL PROPERTIES : THERMAL

THERMAL CONDUCTIVITY

- Poor thermal and electrical conductors
- Serves as an insulator between oral tissues and hot or cold materials

SPECIFIC HEAT

- Heat required to raise the temperature of a gram of plastic by 1 degree Celcius
- Thermal conductivity/ Specific Heat × Density = Constant
- Higher this ratio, (diffusivity) greater the velocity of heat transfer through material

THERMAL COEFFICIENT OF EXPANSION

- A denture that fits the cast at processing temperature should also fit at room temperature and mouth temperature
- Plastics have a high thermal coeeficient

HEAT DISTORTION TEMPERATURE

- Measure of ability of a plastic to resist dimensional distortion by heat
- PMMA- 71 to 91 degree Celcius

  = Need for keeping repair temperatures low by using chemical/ light activated resins

PHYSICAL PROPERTIES : OTHERS

DENSITY	POLYMERISATION SHRINKAGE	DIMESNIONAL STABILITY & ACCURACY
WATER SORPTION & SOLUBILITY	RESISTANCE TO WEAK ACIDS/ BASES/ ORGANIC SOLVENTS	ADHESION
ESTHETICS	TISSUE COMPATIBILITY	SHELF LIFE

HEAT CURE V/S SELF CURE ACRYLIC DENTURE BASE RESINS

CRITERIA	SELF CURE ACRYLIC	HEAT CURE ACRYLIC
POROSITY	+++	---
RESIDUAL MONOMER CONTENT	+++	---
INITIAL DEFORMATION	+++	---
DISTORTION	+++	---
EASE OF DEFLASKING	+++	---
CREEP	+++	---
AVERAGE MOLECULAR WEIGHT	---	+++
STRENGTH	---	+++
RECOVERY	---	+++
COLOUR STABILITY	---	+++

IDEAL REQUIREMENTS V/S CLINICAL PROPERTIES

PROPERTY	HEAT CURE PMMA	DESCRIPTION
Dimensional stability	+++	Good
Resistance to weak acids and bases	+++	Good
Effect of organic solvents	---	Soluble in ketones, esters and aromatic chlorinated hydrocarbons
Processing ease	+++	Good
Adhesion to metal and porcelain	---	Poor
Adhesion to acrylics	+++	Good
Colorability	+++	Good
Color stability	±	Yellows very slightly
Taste and odor	+++	Tasteless and odoless
Tissue compatibility	+++	Good
Shelf life	**P/L:** +++ **Gel:** ++	Powder- liquid: Good Gel: Fair

CLINICAL IMPLICATIONS

Water absorption by diffusion: Linear expansion	• Store in tepid water when removed
Dry out in hot conditions	• Do no place in water >35°C to avoid release of internal residual stresses and distortion
PMMA has low thermal conductivity	• Reduces thermal stimulation of patient's oral tissues • Inconvenient to new wearers
Flexural fatigue failure causing midline fracture of denture	• Periodic recall and evaluation of ridges due to stresses • Rubber reinforced MA/ metal base in case of repeated fracture
Impact fracture Accidentally dropping dentures	• Advice proper handling of dentures • Clean them over a sink full of water

Biocompatibility

Microbial colonisation (cracks/ microporosities/ surface imperfections etc)

- Frequent cleaning and soaking in chemical cleansers
- Nystatin/ CHX gluconate
- Incorporate negative charges in resin surface → Inhibits *C. albicans*
- Coating resin surface with self bonding protective polymer (poly-dimethylsiloxane)

Low abrasion resistance

Surface wear if cleaned inappropriately

- Clean dentures with soap and water using soft brush
- Avoid use of abrasives

Soluble in organic solvents

Alcohol/ acetone

Irreversible surface damage

- Use cross linked polymeric base in patients who frequently drink alcohol

Denture Base Hygiene.

1.Clean with **soft toothbrush** and soap-and-water

2.Use **low abrasive cleaners** like Clinsodent.

3.Avoid **oxidizing or Cl^-** containing materials
- Bleaching the color
- Reduces strengths of denture
- Reduces fatigue resistance

4.Diligently clean both the **top and tissue-borne** surfaces

5.Clean with **lab disinfectant** before denture delivery like 1% sodium hypochlorite or 2% gluteraldehyde.

6. **Microwave disinfection** can be undertaken

DEFECTS

- Porosities
  - Internal Porosities
  - External Porosities

- Crazing

- Warpage

INTERNAL POROSITIES

- Mass of **bubbles within polymerized acrylic**, commonly in thicker portions
- Cause:
  - Due to vaporization of monomer when temperature rises beyond **100.8°C**
- Avoid by: Using long, **low temperature curing cycles**

EXTERNAL POROSITIES

- Seen on the **external surface** of the denture base
- **Cause**:
  - Lack of homogeneity
  - Lack of adequate pressure
- Avoid by: Using **proper P/L** ratio and using required amount of dough for packing at adequate pressure

CRAZING

- Formation of **surface cracks** on denture base resins
- **Weakens** the resin and reduces esthetic properties and can also cause fracture
- **Causes:**
  - Mechanical stresses
  - Attack by solvents
  - Incorporation by water
- It is **a mechanical separation of polymer chains** or groups under tensile stress and is seen at right angles to tensile stress
- **Avoid by:**
  - Using cross linked acrylics
  - Tin foil separating medium
  - Use metal molds

WARPAGE

- Deformity or **change of shape** of denture which can affect the fit of the denture
- **Causes:**
  - Release of stresses incorporated during processing: as a result of curing shrinkage and/ or uneven/ rapid cooling
  - Packing during rubbery stage
  - Stresses incorporated during improper flasking
- These **stresses are released** during polishing/ immersion of denture in hot water or recuring with relining material

RECENT ADVANCES

Microwave Activated PMMA	High Impact Resins	Rapid Heat Polymerising Resins	Radiopaque Acrylics
• Greatly reduced curing time (3 min.) • Shortened dough-forming time • Minimal colour changes • Less fracture of artificial teeth and resin bases • Superior denture base adaptability • Lower residual monomer ratio, • Most stable. • Less bond strength to the denture teeth	• Microdispersed rubber phase (usually butadiene styrene rubber) into polymer • Improvement in impact & fatigue strength • Reduced in rigidity • Processed like heat cure resins • Indicated especially in patients who have difficulty in handling their dentures. E.G., Very old patients, parkinsonism	• Initiator is modified • Allows rapid polymerization of the resin • Polymerization is accomplished by keeping the flask in boiling water for 20 min	• Related to the likelihood of the fragments of fractured appliance being swallowed • Coploymer containing 30-40 % poly(2,3 dibromo propyl methacrylate) has been reported to possess the satisfactory properties

FLEXIBLE DENTURE BASES

THERMOPLASTIC RESINS

THERMOFLEX AND FLEXITE

- Acetal based thermoplastics, which offers strength with flexibility
- Used for preformed partial clasps, partial frameworks, provisional bridges, implant crowns, and occlusal splints
- Resists stains and bacteria

VALPLAST

- Valplast flexible nylon partial dentures semi-translucency
- Allows the true color of the patients gum to be seen

LUCITONE FRS

- High physical strength and when necessary can be used to replace clasps on metal frames
- Nylon resists chemical breakdown , thin and superior comfort

Experimental Types of Acrylic.

Aim to increase impact strength and stiffness

- Butadiene styrene rubber
- Carbon fiber
- Aramid fiber
- Glass fiber
- Polyethylene fiber
- Nylon fiber
- Self reinforcement
- Metal inserts

CONCLUSION

- There is a wide variety of denture base materials and the ever growing urge to find the best and the most feasible material will always bring an evolution in denture base material sciences

- As clinicians, we must understand the basic nature of each of these, to provide the best possible treatment to our patients

Thank You