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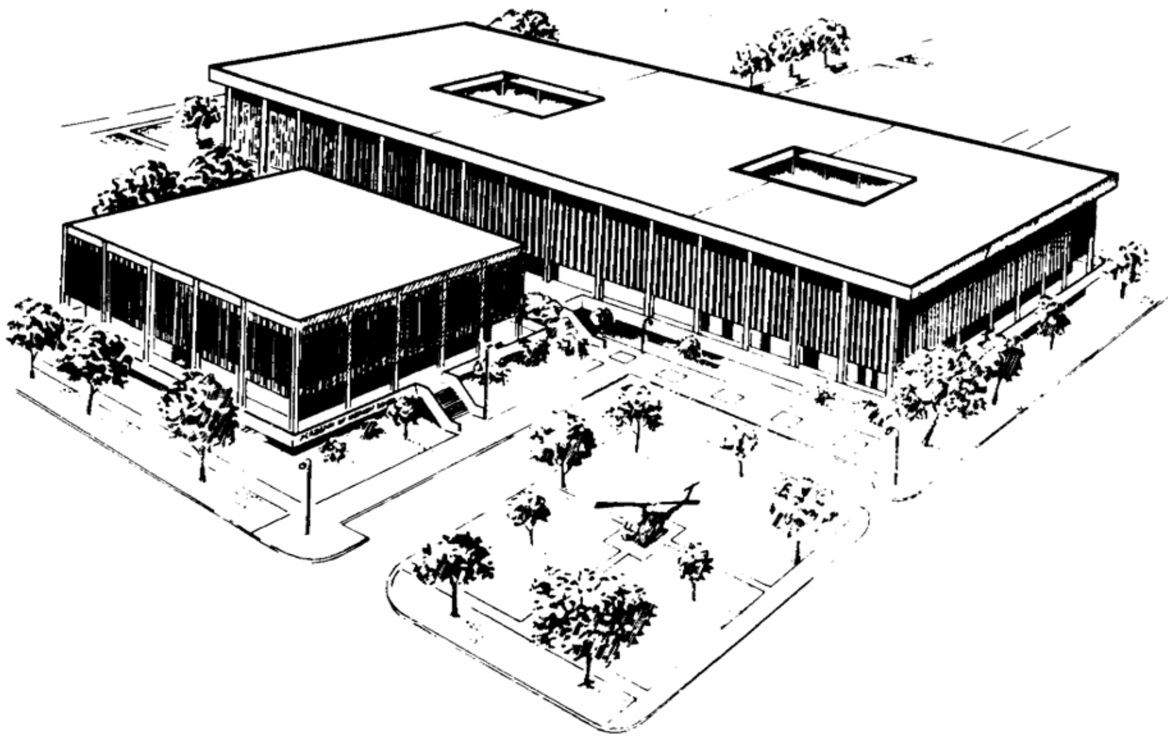

Dental Materials

SUBCOURSE MD0502 EDITION 100

DEVELOPMENT

This subcourse is approved for resident and correspondence course instruction. It reflects the current thought of the Academy of Health Sciences and conforms to printed Department of the Army doctrine as closely as currently possible. Development and progress render such doctrine continuously subject to change.

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When used in this publication, words such as "he," "him," "his," and "men" are intended to include both the masculine and feminine genders, unless specifically stated otherwise or when obvious in context.

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CORRESPONDENCE COURSE OF THE
U.S. ARMY MEDICAL DEPARTMENT CENTER AND SCHOOL

SUBCOURSE MD0502

DENTAL MATERIALS

INTRODUCTION

"Every tooth in a man's head is more valuable than a diamond."

From "Don Quixote"

"For there was never yet a philosopher
that could endure the toothache patiently."

William Shakespeare

The lines above hold as true today as when written more than three centuries ago!

Consider these quotations as they apply to a fighting soldier of the United States Army and you can readily understand the importance of military dentistry. A rifleman or squad leader with neglected teeth threatens the efficiency of the entire platoon. A toothache can impair physical and mental powers or even knock a man out of action. Servicemen must stay healthy, and your job, as a dental specialist, is to help keep them physically fit. The Dental Service is charged specifically with the conservation of oral health and with the diagnosis, prevention, and treatment of oral diseases, injuries, and deficiencies among military personnel.

This subcourse deals with the composition, property, use, and manipulation of materials used in the dental profession. This basic information is vital for the fulfillment of your role in assisting the dental officer toward the successful accomplishment of the mission of the Army Dental Service.

Subcourse Components:

This subcourse consists of three lessons. The lessons are as follows:

Lesson 1, Restorative Materials.
Lesson 2, Dental Resins, Miscellaneous Dental Materials, and Dental Gold/Alloys.
Lesson 3, Gypsum Products, Dental Waxes, and Impression Materials.

Credit Awarded:

To receive credit hours, you must be officially enrolled and complete an examination furnished by the Nonresident Instruction **Section** at Fort Sam Houston, Texas. Upon successful completion of the examination for this subcourse, you will be awarded 10 credit hours.

You can enroll by going to the web site http://atrrs.army.mil and enrolling under "Self Development" (School Code 555).

A listing of correspondence courses and subcourses available through the Nonresident Instruction Section is found in Chapter 4 of DA Pamphlet 350-59, Army Correspondence Course Program Catalog. The DA PAM is available at the following website: http://www.usapa.army.mil/pdffiles/p350-59.pdf.

LESSON ASSIGNMENT

LESSON 1 Restorative Materials.

LESSON ASSIGNMENT Paragraphs 1-1 through 1-20.

LESSON OBJECTIVES After completing this lesson, you should be able to:

1-1. Identify terms related to dental restorative materials.

1-2. Identify the composition and properties of dental amalgam.

1-3. Identify the preparation procedures for dental amalgam.

1-4. Identify mercury hygiene practices.

1-5. Identify the composition and properties of zinc phosphate cement.

1-6. Identify the preparation procedures for zinc phosphate cement.

1-7. Identify the characteristics and preparation procedures for polycarboxylate cement.

1-8. Identify the characteristics and preparation procedures for glass ionomer cement.

1-9. Identify the characteristics and clinical uses of zinc oxide and eugenol.

SUGGESTION After studying the assignment, complete the exercises of this lesson. These exercises will help you to achieve the lesson objectives.

LESSON 1

RESTORATIVE MATERIALS

Section I. INTRODUCTION TO DENTAL MATERIALS

1-1. GENERAL

Dental materials used in the dental profession are indeed many, varied, and complex. The dental specialist who prepares and uses many of these materials in assisting the dental officer must know their composition, properties, uses, and manipulation. Restorative materials, miscellaneous dental materials, dental waxes, gypsum products, and impression materials are covered in this subcourse. A thorough knowledge of dental materials and the skill to manipulate these materials is one of the important duties of a dental specialist.

1-2. RESTORATIVE MATERIALS - GENERAL

Restorative materials are the metallic or nonmetallic materials used to restore diseased or damaged teeth to health and function. Restorative materials have been greatly improved, although a universally ideal restorative material has not yet been developed. The corrosive nature of saliva and the expansion and contraction of tooth structure with changes in temperature make great demands upon a restorative material. The stress brought to bear on the restoration by masticatory forces also makes great demands. Restorative materials must be compatible with living tissue. If used in the anterior region of the mouth, the materials must also be esthetically pleasing. Restorative materials, used when and where indicated, help to ensure the placement of a successful restoration and preservation of the tooth.

1-3. PHYSICAL PROPERTIES OF MATERIALS

Definite and precise terms are used to describe the physical properties of dental materials. These terms must be clearly defined in order for one to understand the interrelationships between physical properties, structures, and composition. The following definitions apply to metals or alloys used in the Army dental service.

a. **Hardness.** Hardness is the measure of the resistance of a metal to indentation or scratching. It is an indication of the strength and wearability of an alloy or metal.

b. **Ductility**. Ductility is the measure of the capacity of a metal to be stretched or drawn by a pulling or tensile force without fracturing. This property permits a metal to be drawn into a thin wire.

c. **Malleability**. Malleability is the measure of the capacity of a metal to be extended in all directions by a compressive force, such as rolling or hammering. This property permits a metal to be shaped into a thin sheet or plate.

d. **Flexibility and Elasticity**. These terms differ in their technical definition but they are very closely related. Flexibility is the characteristic of a metal, which allows it to deform temporarily. The elasticity of a metal is used when it returns to its original shape when the load or force is removed.

e. **Fatigue**. Fatigue is the property of a metal to tire and to fracture after repeated stressing at loads below its proportional limit.

f. **Structure (Crystalline or Grain Structure).** Metals are crystalline and many of their physical properties depend largely upon the size and arrangement of their minute crystals called grains.

(1) Grain size. The size of the grains in a solidified metal depends upon the number of nuclei of crystallization present and the rate of crystal growth. In the practical sense, the faster a molten is cooled to solidification, the greater will be the number of nuclei and the smaller will be the grain size. Generally speaking, small grains arranged in an orderly fashion give the most desirable properties.

(2) Grain shape. The shape of the grains is also formed at the time of crystallization. If the metal is poured or forced into a mold before cooling, the grains will be in a flattened state. Metal formed by this method is known as cast metal. If the metal is shaped by rolling, bending, or twisting, the grains are elongated and the metal becomes a wrought wire.

g. **Crushing Strength**. Crushing strength is the amount of resistance of a material to fracture under compression.

h. **Thermal Conductivity**. Thermal conductivity is defined as the ability of a material to transmit heat or cold. A low thermal conductivity is desired in restorative materials used on the tooth whereas a high thermal conductivity is desirable where the material covers soft tissue.

1-4. METALLURGICAL TERMS

a. **Cold Working**. This is the process of changing the shape of a metal by rolling, pounding, bending, or twisting at normal room temperature.

b. **Strain Hardening.** This occurs when a metal becomes stiffer and harder because of continued or repeated application of a load or force. At this point, no further slippage of the atoms of the metal can occur without fracture.

c. **Heat Softening Treatment (Annealing)**. This treatment is necessary in order to continue manipulating a metal after strain hardening to prevent it from fracturing. The process of annealing consists of heating the metal to the proper temperature (as indicated by the manufacturer's instructions) and cooling it rapidly by immersing in cold water. Annealing relieves stresses and strains caused by cold working and restores slipped atoms within the metal to their regular arrangement.

d. **Heat Hardening Treatment (Tempering).** This treatment is necessary to restore to metals properties that are decreased by annealing and cold working. Metals to be heat hardened should first be heat softened (annealed) so that all strain hardening is relieved and the hardening process can be properly controlled. Heat hardening is accomplished in dental gold alloy by heating to 840^o Fahrenheit, allowing it to cool slowly over a 15-minute period to 480^o Fahrenheit, and then immersing it in water.

Section II. DENTAL AMALGAM

1-5. DENTAL AMALGAM

a. **History of Amalgam**. Dr. G. V. Black investigated the properties of amalgams and their possible use for dentistry about 1895. His studies showed the effects of chemical composition and physical structure on the properties of amalgam restorations. Due largely to the work done by Dr. Black and the National Bureau of Standards, and other researchers, amalgam is now used more than any other filling material for the restoration of posterior teeth.

b. **Definitions**.

(1) Alloy. An alloy is a solid mixture of two or more metals. It is possible to produce a material in which the desirable properties of each constituent are retained or even enhanced, while the less desirable properties are reduced or eliminated. With few exceptions, the metals used in dentistry are in fact alloys.

(2) Amalgam. When one of the metals in an alloy mixture is mercury, an amalgam is formed. A dental amalgam is a combination of mercury with a specially prepared silver alloy, which is used as a restorative material.

(3) Mercury. Mercury is a silver-white, poisonous, metallic element that is liquid at room temperature (symbol Hg).

c. **Composition and Effects of Amalgam.**

(1) Combining desirable properties. Each metal incorporated into a dental silver alloy has specific properties when combined with mercury. Some properties are desirable and some are undesirable. An acceptable alloy is balanced. The combined effects of the properties of its ingredients should provide the most satisfactory restorative material.

(2) Quantity of mercury. Too little mercury in the mix results in a grainy, weak, readily tarnished, and corroded amalgam. Too much mercury will cause excessive expansion and weakened amalgam.

(3) Standards and requirements. Like other restorative materials, amalgam must meet the standards and requirements set by the National Bureau of Standards and the American Dental Association's (ADA) Specification #1 for alloy used in amalgam.

(4) Composition of the alloy. The ADA specification states that the composition of the alloy must include a minimum of 65 percent silver, a maximum of 29 percent tin, a maximum of 6 to 13 percent copper, and a maximum of two percent zinc by weight. See figure 1-1.

(5) Correct proportion important. Immediately prior to use, the silver alloy is mixed with pure and uncontaminated mercury. (Mercury, although an indispensable ingredient, imparts undesirable properties to the amalgam if added in incorrect proportions.) There are some alloys that are completely zinc free. They can therefore be used more successfully in a moisture-contaminated environment.

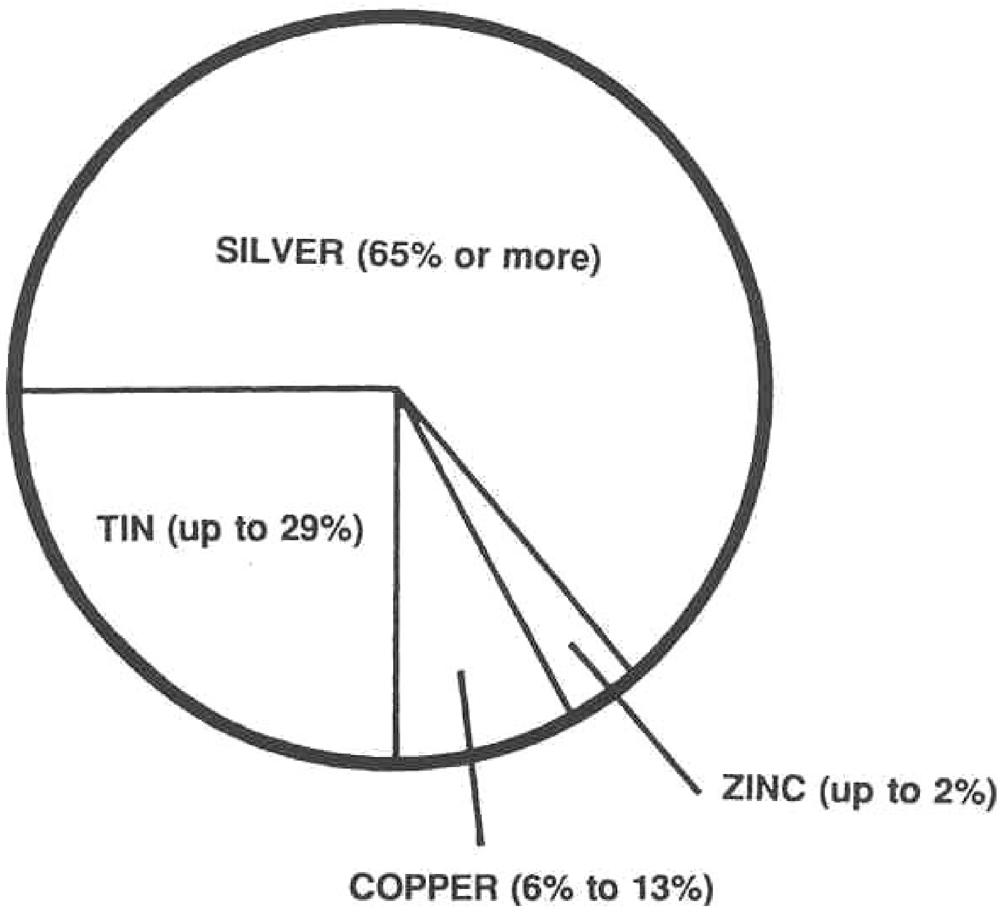

Figure 1-1. Approximate composition of an acceptable amalgam alloy.

(6) Properties of the finished product. Each element composing amalgam imparts certain properties to the finished product. Table 1-1 summarizes these properties. Silver imparts strength, durability, and color, gives the alloy desirable setting expansion, decreases flow, and accelerates (decreases) the setting time. Tin makes the amalgam easier to work, controls excessive setting expansion, and increases both flow and setting time. Copper increases hardness, contributes to setting expansion, reduces flow, and decreases setting time. Zinc increases workability, and unites with oxygen and other "impurities" to produce a clean amalgam.

PROPERTY	INGREDIENT			
	Silver	Tin	Copper	Zinc
Strength	Increases			
Durability	Increases			
Hardness			Increases	
Expansion	Increases	Decreases	Increases	
Flow	Decreases	Increases	Decreases	
Color	Imparts			
Setting time	Decreases	Increases	Decreases	
Workability		Increases		Increases
Cleanliness				Increases

Table 1-1. Effects on properties of an amalgam restoration imparted by ingredients.

d. **Physical Properties of Amalgam.** The most important physical properties of amalgam are flow and creep, dimensional change, and strength.

(1) Flow and creep. Flow and creep are characteristics that deal with an amalgam undergoing deformation when stressed. The lower the creep value of an amalgam, the better the marginal integrity of the restoration. Alloys with high copper content usually have lower creep values than the conventional silver-tin alloys.

(2) Dimensional change. An amalgam can expand or contract depending upon its usage. Dimensional change can be minimized by proper usage of alloy and mercury.

(3) Compression strength. Sufficient strength to resist fracture is an important requirement for any restorative material. At a 50 percent mercury content, the compression strength is approximately 52,000 pounds per square inch (psi). In comparison, the compressive strength of dentin and enamel is 30,000 psi and 100,000 psi, respectively. The strength of an amalgam is determined primarily by the composition of the alloy, the amount of residual mercury remaining after condensation, and the degree of porosity in the amalgam restoration.

1-6. ADVANTAGES AND DISADVANTAGES OF AMALGAM

a. **Advantages.** Amalgam has many advantages over other materials as a restorative material. Amalgam is used more than any other material to restore carious teeth. It is easy to insert into the cavity preparation and adapts readily to cavity walls. In obtaining its initial set, or hardness, amalgam allows time for condensing and carving. It has an acceptable crushing strength and is recognized as having a long life as a restoration. As an amalgam restoration ages in the oral cavity, corrosion products form along the restoration-tooth interface. These compounds act as a mechanical block to microleakage and account for the excellent clinical results obtained with silver amalgam.

b. **Disadvantages.** Amalgam has many disadvantages as a restorative material. Because amalgam's color does not match the color of the teeth, it is generally not used on the visible surfaces of anterior teeth. Amalgam will tarnish with time, no matter how well the amalgam restoration is prepared and inserted. To avoid or to reduce tarnish, the restoration is smoothed and highly polished a day or two after its insertion. The restoration may be reshined later at any time with little effort. Amalgam will also conduct heat or cold readily (high thermal conductivity). If the amalgam is placed too close to the pulp, it may irritate the pulp. Therefore, an intermediate base that will not conduct heat or cold as readily (low thermal conductivity) is placed under the amalgam.

1-7. USAGE AND PREPARATION OF AMALGAM

a. **General.** The dental specialist has the direct responsibility for the correct preparation and use of amalgam. Incorrect use may produce a faulty restoration that can cause or contribute to the loss of a tooth. Therefore, the dental specialist must use extreme care in preparing a good mix of amalgam that will provide the best qualities obtainable from the alloy.

b. **Proportioning Alloy and Mercury.** To proportion and mix dental alloy and mercury, the size of the mix (the number of alloy pellets to be used) and the alloy-mercury ratio must be known. The dental officer determines the size of the mix used. Dental alloy is supplied in pellet form or in sealed capsules containing premeasured mercury. The pellets are composed of silver alloy filings compressed under pressure without a binding agent. They are supplied in weights ranging from 4.8 to 6 grains per pellet. A special dispenser is used to drop the pellets individually. (See figure 1-2.) Since the pellets are preformed in a set amount of silver alloy, only the amount of mercury used with each pellet needs to be measured. The mercury dispenser is furnished with four interchangeable plungers lettered A through D. (See figure 1-2.) The manufacturer's instructions accompanying the pellets should be followed in selecting the size of plunger to use in providing the desired ratio of alloy to mercury. The alloy-mercury capsules are preweighed and premeasured, needing only to be combined internally. This is done by penetrating a membrane separating the alloy and mercury prior to trituration.

c. **Trituration of Amalgam.** Trituration is the mechanical mixing of the alloy and mercury. Trituration is done by hand using a mortar and pestle or a mechanical amalgamator. (See figure 1-3.) Trituration is done by setting the timer according to the manufacturer's instructions for the alloy and for the type amalgamator used. Special capsules are furnished with the mechanical amalgamator to hold the alloy-mercury mixture during trituration. Each capsule is fitted with a cap and a small rod-like pestle. A small funnel is also furnished to help in pouring the mercury into the capsule. The

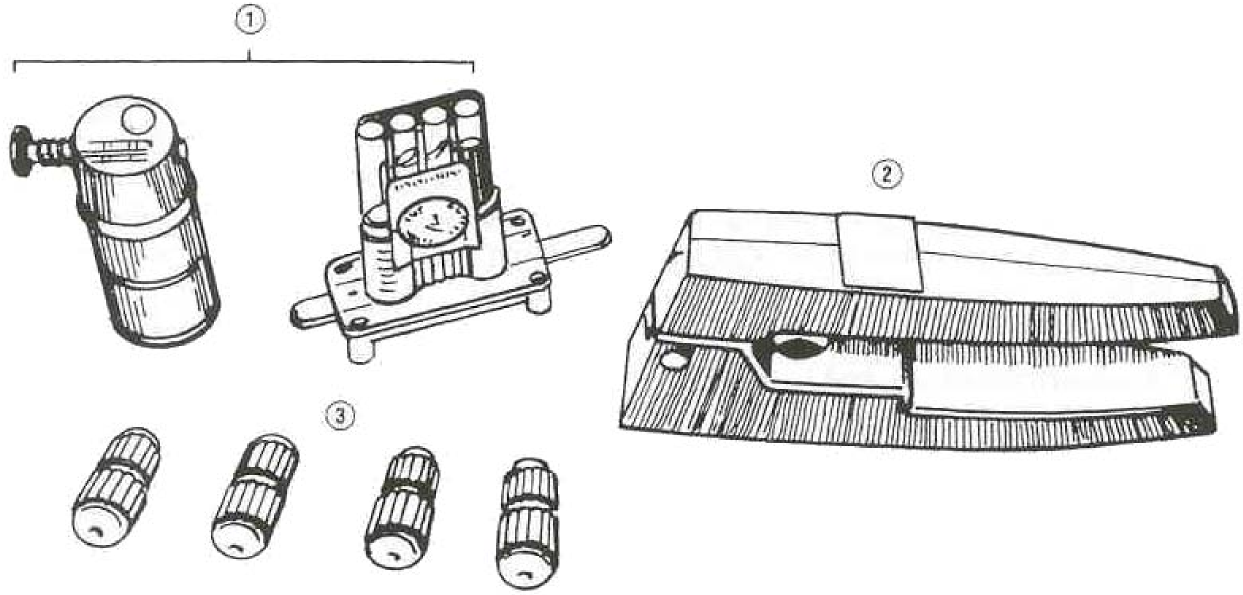

Figure 1-2. Amalgam dispensing systems.

amalgamator mixes the amalgam in the capsule by rapid shaking or vibration. This produces a consistently uniform mix. The amalgamator reduces trituration to a matter of seconds. When using the pellet method, first insert the pestle in the capsule, dispense the required mercury, and then dispense the pellets. Usually one pellet is used for a small mix and two pellets for a large mix. Most manufacturers recommend mixing times of approximately 10 seconds per pellet. When the time selected has elapsed, the automatic timer will stop the machine. The dental specialist must be careful not to overtriturate or undertriturate. Overtrituration results in shorter setting time and increased shrinkage. Undertrituration results in increased expansion, lengthened setting time, and weakened amalgam.

d. **Filling Amalgam Carrier.** Modern dental amalgams use precise proportioning methods for dispensing the mercury with the alloy. Since the mercury content in the original mix is less than the maximum level of 55 percent, it is not necessary to eliminate mercury from the amalgam before it is carried to the cavity preparation. The amalgam is taken from the capsule and placed in an amalgam cup. The amalgam carrier is loaded by forcing the open cylinder of the amalgam carrier into the balled amalgam. The amalgam is then carried to the mouth and deposited in the cavity preparation.

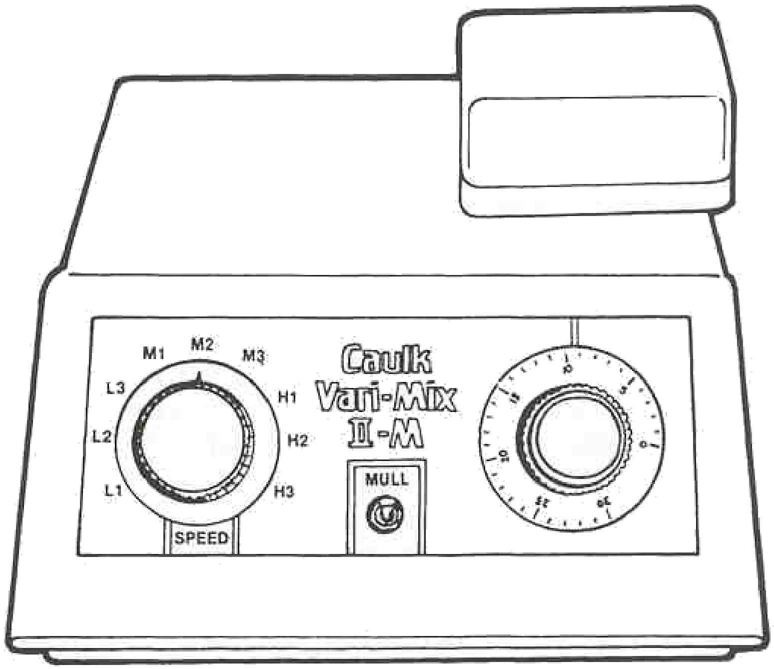

Figure 1-3. Mechanical amalgamator.

e. **Condensation and Carving of Amalgam.** Condensation is the process of packing an amalgam mix into a cavity preparation. Both time and pressure are important to achieve the best results. Condensation must be accomplished before crystals start to form. Delay will result in a breakdown of these crystals and a weakened amalgam. Sufficient condensation pressure is necessary to prevent voids in the restoration. The amount of pressure varies with each type of amalgam. Usually the amalgam restoration is well set and hardened so that carving can be started with sharp instruments immediately after condensation. The carving operation results in a completely restored tooth.

1-8. PRECAUTIONS DURING AMALGAM PREPARATION

a. **Moisture Contamination.**

(1) Four possible adverse effects.

(a) Excessive expansion of the amalgam.

(b) Postoperative pain.

(c) Lowered crushing strength.

(d) Blister formation on the surface of the amalgam.

(2) Avoidance procedures. Moisture can be introduced into amalgam by triturating below the dew point (temperature at which moisture collects on a surface). Moisture can also be introduced by the presence of moisture in the cavity being filled or by accidental contact with saliva. To avoid moisture contamination, all instruments and equipment encountering the amalgam should be dry. The temperature of equipment and materials should be high enough so that no moisture collects. Saliva should be kept out of the cavity preparation during the insertion of the material.

b. **Guidance for Amalgam Preparation.** Any portion of amalgam that is too dry or has begun to crystallize must be discarded. Its use would result in a weak, nonhomogeneous mass. For large restorations, it may be necessary to prepare two or more mixes. Each mix is prepared as needed.

c. **Training of Personnel Required.** All dental personnel must be familiar with the potential hazards and the proper handling of mercury.

1-9. MERCURY HYGIENE PRACTICES BY THE DENTAL SPECIALIST

a. **General.** Amalgam restorations do not constitute a hazard to patients. However, dental personnel may invite a health hazard if exposed to concentrated mercurial vapors over an extended period of time. Mercury hygiene precautions should be used.

b. **Mercury Hygiene Precautions.**

(1) Training. All dental personnel must be instructed regarding the potential health hazards of mercury and what constitutes proper handling.

(2) Covering cuts and abrasions. All cuts and abrasions of the skin must be covered when handling amalgam or mercury.

(3) Washing hands and arms. All dental personnel must wash hands and arms thoroughly after amalgam operations.

(4) Inspection of capsules. Capsules must be checked for general condition and seal. Cracked capsules or those in poor condition will be discarded.

(5) Use of masks. All dental personnel must wear masks when removing amalgam restorations.

(6) Use of water coolant. A water coolant must be used to reduce and minimize the dispersion of particles during removal of amalgam restorations.

(7) Use of gloves. Handling amalgam with bare hands must be avoided.

(8) Use of standard containers. An amalgam well or a dappen dish must be used to hold prepared amalgam.

(9) Storage of materials. Old amalgam and mercury must be stored under fresh, clean fixer solution in strong, closed containers in a cool, fireproof area.

(10) Disposal of wastes. Disposable paper, cloths, and rubber items that are mercury or amalgam contaminated must be deposited into bag-lined, covered containers after use. Bag and contents must be disposed of daily.

(11) Avoiding heat. Amalgam mixing equipment, as well as mercury, must be kept away from any source of heat.

(12) Use of closed containers for amalgamators. Amalgamators must be kept inside closed containers as much as possible.

(13) Weekly cleaning of amalgamators. Amalgamators must be cleaned at least once a week.

(14) No carpeting in work area. There must be no carpeting in the part of the dental clinics where mercury or amalgam are used.

(15) Separate area for cleaning. The cleaning area for equipment for laboratories and other clinic areas must be kept separate and distinct from the cleaning area for equipment used with amalgam or mercury in order to avoid wide dispersal of mercurial vapors.

Section III. DENTAL BASES AND CEMENTS

1-10. GENERAL

Dental cements are generally low strength materials prepared by mixing a powder with a liquid. These cements vary in their chemical composition, properties, and uses. Dental cements have lower heat conductivity than do metallic restorative materials. Dental cements, however, have the disadvantages of relatively low strength, varying degrees of solubility in mouth fluids, and setting shrinkage. As a group, they are more natural in appearance and are easier and faster to use. Although they are widely used in restorative dentistry, dental cements are considered to be among the least permanent of restorative materials. Four types of cement used in dentistry are zinc phosphate cement, polycarboxylate cement, glass ionomer cement, and zinc oxide and eugenol cement.

1-11. CHARACTERISTICS OF ZINC PHOSPHATE CEMENT

a. **History.** More than 100 years ago, a French architect proposed the use of zinc oxide as a stopping medium for carious teeth. Zinc phosphate cement has progressively advanced from the original wall plaster that induced its development over a century ago.

b. **Clinical Uses.** Zinc phosphate cement is used both as an intermediate base and as a cementing medium.

(1) Intermediate base. A thick mix of zinc phosphate cement is used as an intermediate base beneath a permanent metallic restoration. This layer of cement protects the pulp from sudden temperature changes that may be transmitted by the metallic restoration.

(2) Cementing medium. Zinc phosphate cement is used to permanently cement crowns, inlays, and fixed partial dentures upon the remaining tooth structure. It is also used to hold splints, orthodontic appliances, and other appliances in place. This cement is used to cement facings to fixed partial dentures and certain types of artificial teeth to artificial denture bases. A creamy mix of cement is used to seat the restoration or appliance completely into place. The cementing medium does not cement two objects together. Instead, the cement holds the objects together by mechanical interlocking, filling the space between the irregularities of the tooth preparation and the cemented restoration.

c. **Chemical Composition.**

(1) Powder. The primary ingredients of zinc phosphate cement powder are zinc oxide and magnesium oxide.

(2) Liquid. The liquid used with the powder is phosphoric acid and water in the ratio of two parts acid to one part water. The solution may also contain aluminum phosphate and zinc phosphate. The water content of the liquid is critical and must be carefully controlled by the manufacturer to provide a satisfactory setting time. Liquids exposed in open bottles will absorb moisture from the air in high humidity. The liquids will lose moisture if humidity is low. Water gain hastens setting; water loss lengthens setting time. Liquid that has been left unstoppered for a long period, or is discolored, or is the last 25 percent portion remaining in the bottle should be discarded. Since the manufacture of zinc phosphate cement is a carefully controlled process, satisfactory results can seldom be achieved by mixing the powder of one brand of cement with the liquid of another.

1-12. PROPERTIES OF ZINC PHOSPHATE CEMENT

a. **Advantages.** Some advantages of zinc phosphate cement as a cementing medium are:

(1) Inconspicuous appearance.

(2) Speed and ease of usage.

(3) Sufficient flow to form a thin layer for the cementing of closely adapted crowns, fixed partial dentures, and inlays.

(4) Low thermal conductivity beneath a metallic restoration.

b. **Disadvantages.** Some disadvantages of zinc phosphate cement as a cementing medium are:

(1) Low crushing strength that varies between 12,000 and 19,000 psi.

(2) Slight solubility in mouth fluids.

(3) Opaque material not suitable for visible surfaces.

c. **Strength.** The ratio of powder to liquid increases the strength of phosphate cements to a certain point. For this reason, the dental specialist must use as thick a mix as practical for the work being performed.

1-13. SETTING REACTIONS OF ZINC PHOSPHATE CEMENT

a. **Chemical Reaction.** The chemical reaction that takes place between the powder and liquid of setting phosphate cement produces heat. The amount of heat produced depends upon the rate of reaction, the size of the mix, and the amount of heat extracted by the mixing slab.

b. **Powder to Liquid Ratio.** The less powder used in ratio to the liquid, the longer the cement will take to harden. Good technique minimizes the rise in temperature and acidity of the setting cement that can injure the pulp. Generally, for increased strength, decreased shrinkage, and resistance to solubility, it is advisable to blend as much powder as possible to reach the desired consistencies.

c. **Setting Time.** The setting time of zinc phosphate cement is normally between 5 and 9 minutes. Four actions that may be taken to maintain and prolong the normal setting time are given below.

(1) Lower the temperature of the glass mixing slab to between 65^{o} and 75^{o} F (18^{o} to 24^{o} C), if the glass mixing slab is not already cooled below the temperature at which moisture will condense on it.

(2) Blend the powder slowly.

(3) Mix the powder over a large area of the cool slab.

(4) Use a longer mixing time, within optimum limits.

1-14. PREPARATION AND USAGE OF ZINC PHOSPHATE CEMENT

a. **Equipment.** The equipment required for mixing zinc phosphate cement consists of a glass mixing slab, a stainless steel spatula, and a matched set of powder and liquid. See figure 1-4.

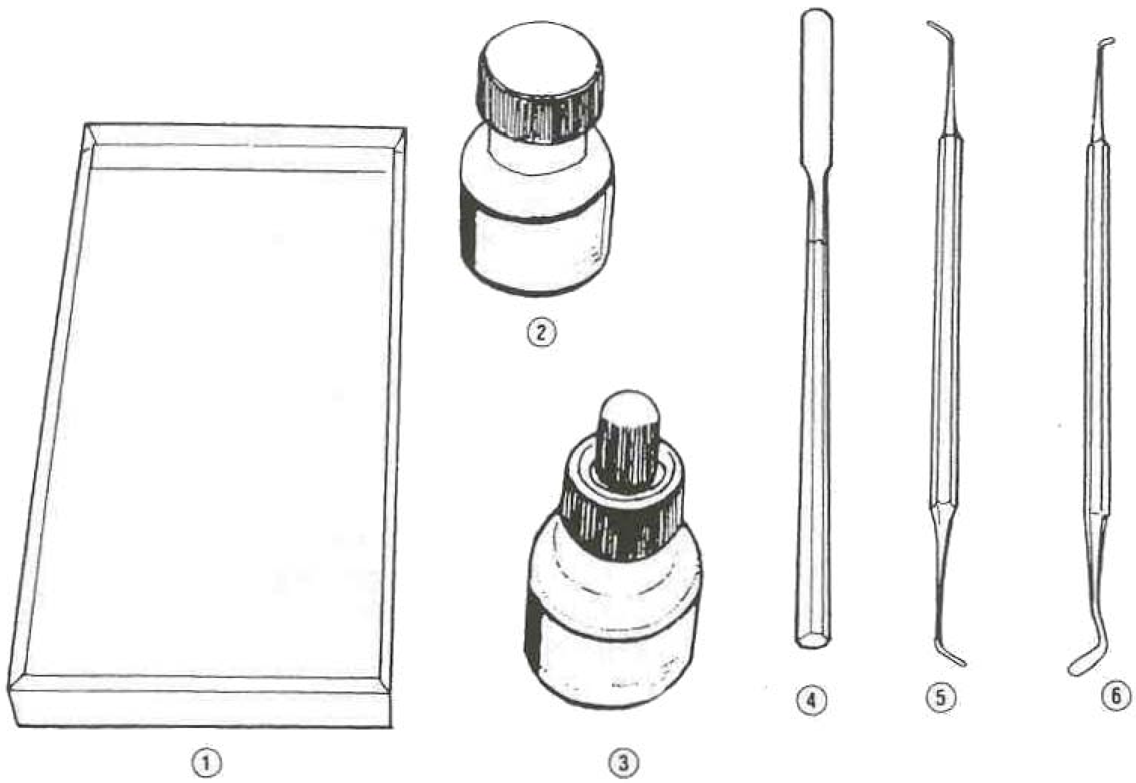

Figure 1-4. Setup for mixing zinc phosphate cement.

b. **Powder and Liquid.** The first step in preparing a mix of zinc phosphate cement is to measure the desired amount of liquid and powder onto the surface of a clean, cool, dry, glass-mixing slab. The amount of each ingredient depends upon the amount and the consistency desired. Experience gained in usage of desired consistencies enables the dental specialist to estimate accurately the amount of powder used according to the number of drops of liquid dispensed. The estimated powder is placed on one end of the slab. The powder is divided into quarters. Then, the first quarter (only) is divided in half (into eighths), and the eighth portion (only) is further divided in half (into sixteenths). When the process is completed, a total of six portions of powder is readied for mixing. See figure 1-5. An additional small amount of powder is often placed on the corner of the slab for use if the estimated powder is insufficient for the desired mix. The liquid is dispensed with the dropper supplied by the manufacturer. The required number of drops of liquid is dispensed from the dropper bottle in accordance with the manufacturer's instructions. The drops are dispensed over a wide area. The close estimation of powder, according to type of mix and number of drops, and the small increments will enhance the slow blending of powder. This slows the setting reaction and enables the user to blend the maximum amount of powder to attain desired consistency. This will help obtain a cement with optimum physical properties.

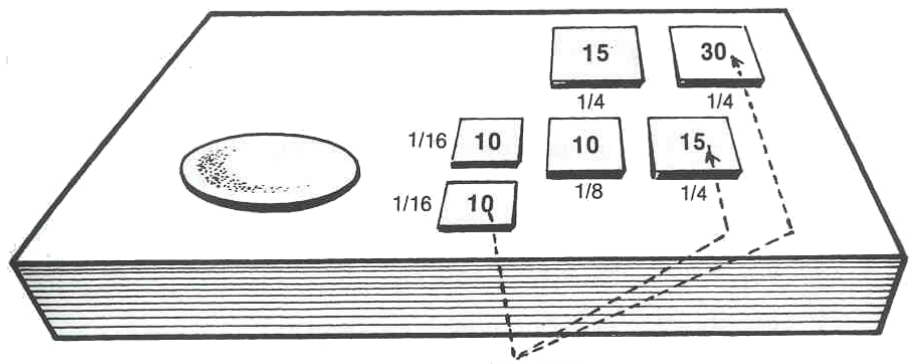

Figure 1-5. The division of powder into standard portions.

c. **Mixing.** Mixing is done by the slow blending of the segments one at a time. This procedure aids in neutralizing the acid and achieving a smooth consistency. A considerable portion of the slab is used. Mixing is done with a moderate circular motion of the spatula blade held flat against the slab. The spatula should be rotated occasionally to blend the material that collects on the top of the blade. A good rule is to spatulate the first three segments for about 15 seconds. (See figure 1-5.) The next two segments should be spatulated for about 20 seconds. The final segment should be spatulated for 30 to 35 seconds. If this is done, the mixing time is not critical and completion of the mix will take about 1 1/2 minutes. It is important to reach the desired consistency by using more powder and not to allow a thinner mix to stiffen by crystallization.

d. **Characteristics of Completed Mixes.** When a mix is ready for use, it should be similar to the consistency of melted ice cream or liquid glue (adhesive rubber). When the spatula is placed on the slab and the spatula is raised to one inch, the mix will cling to the spatula in a thin thread (peak) for one or two seconds before it breaks and then gradually spreads.

e. **Precautions.** The following precautions should be observed.

(1) Prevent loss or gain of moisture in liquid cement by keeping bottles tightly stoppered.

(2) Dispense drops only when ready to mix.

(3) Use a cool, dry glass slab (65^{o} to 75^{o} F).

(4) Use the same brand of powder and liquid.

(5) Add increments of powder slowly.

(6) Use the maximum amount of powder to obtain the desired consistency. (To incorporate the most powder, the material should be mixed with a moderate circular motion over a large area of the slab, turning the spatula often.)

1-15. CHARACTERISTICS OF POLYCARBOXYLATE CEMENT

a. **General.** The primary use of polycarboxylate cement is as a cementing medium of cast alloy and porcelain restorations. In addition, it can be used as a cavity liner, as a base under metallic restorations, or as a temporary restorative material.

b. **Clinical Uses.** Polycarboxylate cement is used in the same way as zinc phosphate cement, both as an intermediate base and as a cementing medium.

c. **Chemical Composition.**

(1) Powder. The composition of polycarboxylate cement powder may vary slightly depending on manufacturers. It generally contains zinc oxide, 1 to 5 percent magnesium oxide, and 10 to 40 percent aluminum oxide or other reinforcing fillers. A small percentage of fluoride may be included.

(2) Liquid. Polycarboxylate cement liquid is approximately a 40 percent aqueous solution of polyacrylic acid copolymer with other organic acids such as itaconic acid. Due to its high molecular weight, the solution is rather thick (viscous).

d. **Properties.** The properties of polycarboxylate cement are identical to those of zinc phosphate cement with one exception. Polycarboxylate cement has lower compressive strength.

e. **Setting Reactions.** Unlike zinc phosphate cement, the setting reaction of polycarboxylate cement produces little heat. This has made it a material of choice. Manipulation is simpler, and trauma due to thermal shock to the pulp is reduced. The rate of setting is affected by the powder-liquid ratio, the reactivity of the zinc oxide, the particle size, the presence of additives, and the molecular weight and concentration of the polyacrylic acid. The strength can be increased by additives such as alumina and fluoride. The zinc oxide reacts with the polyacrylic acid forming a cross-linked structure of zinc polyacrylate. The set cement consists of residual zinc oxide bonded together by a gel-like matrix.

1-16. PREPARATION AND USAGE OF POLYCARBOXYLATE CEMENT

a. **Equipment.** The equipment required for mixing polycarboxylate cement consists of a nonporous, polymer paper pad, a glass mixing slab, a stainless steel spatula, and a matched set of powder and liquid. See figure 1-6.

b. **Powder and Liquid.** Dispense the powder and liquid according to manufacturer's instructions (to achieve the desired consistency). Do not predispense and allow to sit. Loss of moisture will cause the liquid to thicken.

c. **Mixing.** Mixing is done by rapidly blending the powder and the liquid for 30 seconds on a polymer paper-mixing pad. Ensure that all the powder is incorporated into the mix. If extended working time is desired, mix on a cooled glass slab.

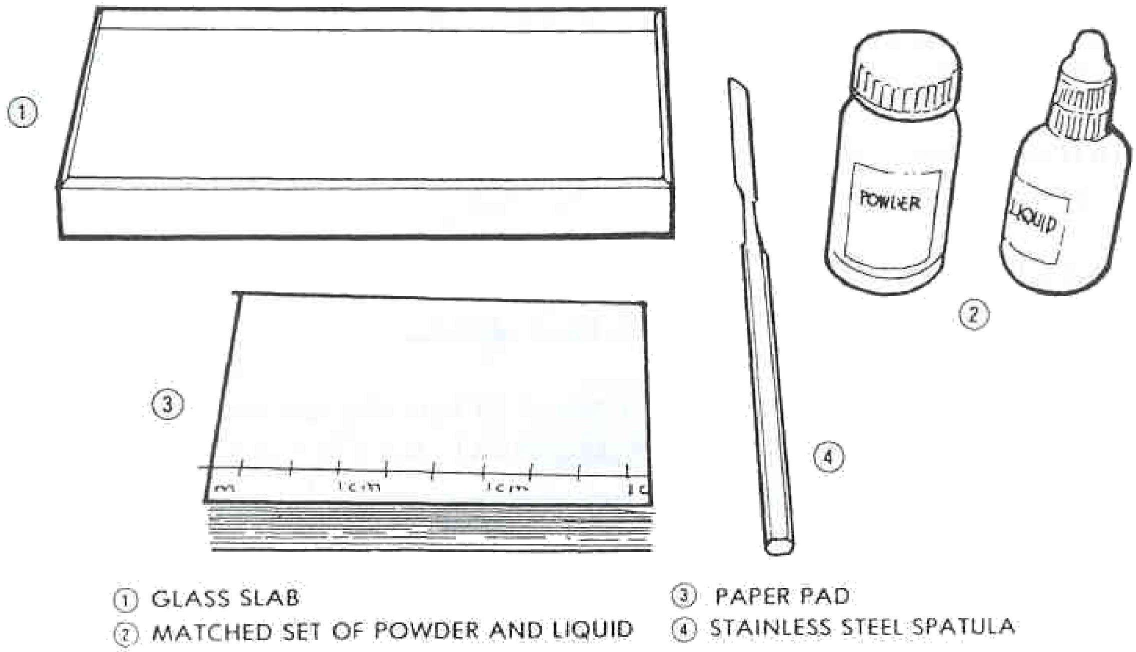

Figure 1-6. Setup for mixing polycarboxylate cement.

d. **Characteristics of a Completed Mix.** The correct cementing mix is more viscous than zinc phosphate cement. Because of its composition, the cementing mix flows adequately under pressure.

e. **Precautions.** The following precautions should be observed.

(1) The interior of restorations and tooth surfaces must be free of saliva.

(2) The mix should be used while it is still glossy, before the onset of cobwebbing.

(3) The powder and liquid should be stored in stoppered containers under cool conditions. Loss of moisture from the liquid will lead to thickening.

1-17. CHARACTERISTICS OF GLASS IONOMER CEMENT

a. **General.** The primary use of glass ionomer cement is for permanent cementing of inlays, crowns, bridges, and/or orthodontic band/brackets. In addition, it can be used as a cavity liner and as a base.

b. **Clinical Uses.** Glass ionomer cement is used in the same way as zinc phosphate cement, both as an intermediate base and as a cementing medium.

c. **Chemical Composition.**

(1) Powder. The composition of glass ionomer cement powder may vary slightly depending on the manufacturer. It generally contains a mixture of aluminosilicate glass with dry polymaleic acid.

(2) Liquid. Glass ionomer cement liquid consists of an aqueous solution containing an accelerator. (A chemical accelerator shortens the setting time.)

d. **Properties.** Glass ionomer cement is free from phosphoric acid and has very low solubility. It adheres chemically to enamel and dentin and, readily, to wet tooth structure, leaving minimal film thickness. It is well tolerated by the pulp and remains rigid under a load, exhibiting no creep. Glass ionomer possesses high compressive strength. It releases fluoride ions to tooth structure. It is simple to proportion, mix, apply, and clean up.

e. **Setting Reactions.** For glass ionomer cement as for other dental cements, the working time is reduced if a higher powder to liquid ratio has been used. Higher temperature shortens working time and lower temperature extends working time. Glass ionomer cement should always have a glossy appearance. When the surface becomes dull, the setting reaction has started, and the mix should be discarded. Exceeding the working time will result in loss of adhesion to enamel and dentin.

1-18. PREPARATION AND USAGE OF GLASS IONOMER CEMENT

a. **Equipment.** The equipment required for mixing glass ionomer cement consists of a polymer paper pad or a glass mixing slab, a stainless steel spatula, and a matched set of powder and liquid.

b. **Powder and Liquid.** The normal ratio is one level scoop of powder to two drops of liquid. For cement bases, more powder may be added to the mix to achieve a thicker consistency. For accurate proportioning, shake the powder bottle to fluff the powder. Then, fill the scoop that comes with the bottle of powder without packing the powder down. When removing the scoop from the bottle, slide it against the plastic lip in the neck of the bottle to scrape off excess powder. Be sure to hold the bottle of liquid vertically when dispensing drops of liquid so as to produce precise and uniform drops. See figure 1-7.

c. **Mixing.** All powder is incorporated into the liquid in two or three large increments. Each portion of the powder should be added to the liquid all at once. To extend the working time, mix the powder and the liquid on a cold and dry glass slab. At room temperature, the mix should be completed in about one minute (60 seconds).

d. **Characteristics of a Completed Mix.** The right consistency is obtained when the material breaks away from the spatula when it is raised one-half inch from the glass slab.

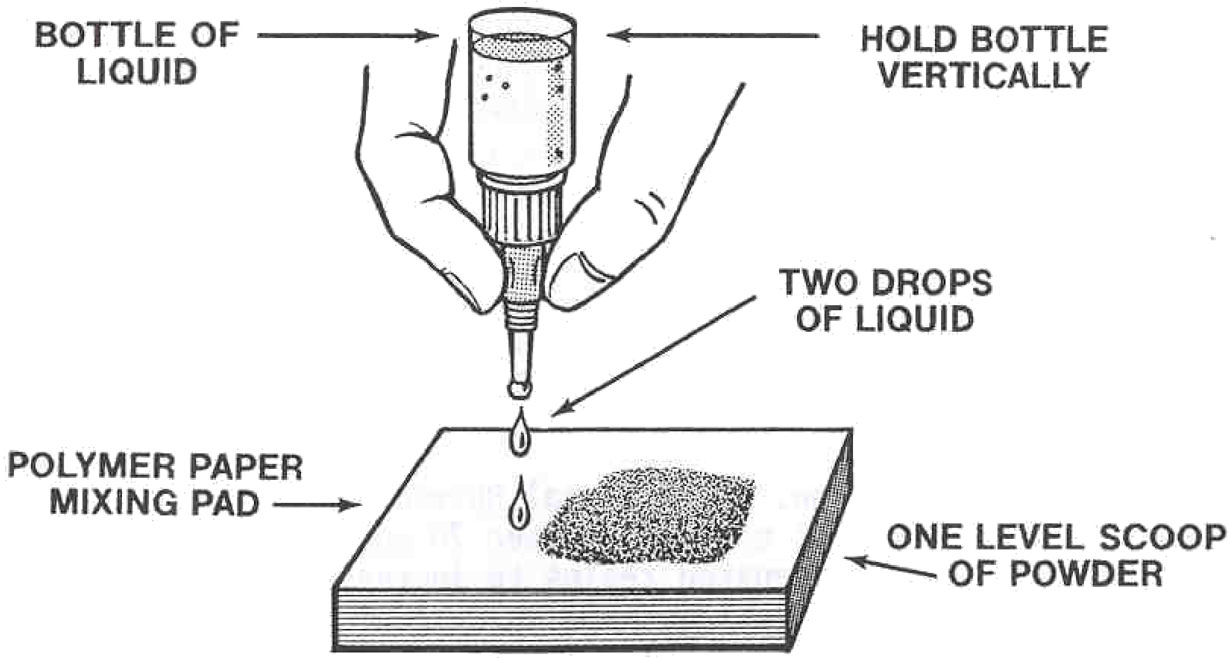

Figure 1-7. Dispensing uniform drops of glass ionomer liquid.

e. **Precautions.** The following precautions should be observed.

(1) Do not insert glass ionomer cement as a ball of material into deep cavities or where the dentin is thin or where there is danger of pulpal involvement. In these cases, set in place a calcium hydroxide liner before inserting the glass ionomer cement.

(2) There may be an allergic reaction to the glass ionomer cement, in some cases.

(3) Upon contact with eyes, the powder may cause irritation due to foreign body reaction. Similarly, ingestion of the liquid may cause local irritation.

(4) All enamel, dentin, and metal surfaces must be clean and dry before use of glass ionomer cement.

(5) Do not overfill the crown. Brush a thin coat of glass ionomer cement on the internal crown surface and abutments.

(6) Bottles of liquid or powder should be tightly closed after use to prevent moisture contamination of the powder and evaporation of the liquid.

1-19. CHARACTERISTICS OF ZINC OXIDE AND EUGENOL

a. **General.** This material is used for many dental purposes ranging from temporary restorative material to pulp capping. The material is composed of a powder that is basically zinc oxide and a liquid that is called eugenol. Cavitec, a commercial preparation, is an example of zinc oxide and eugenol. Generally, however, a generic form is used in military dental clinics.

b. **Chemical Composition.** By National Bureau of Standards specifications, the powder must contain between 70 and 100 percent zinc oxide. The manufacturer may add hydrogenated resins to increase strength and zinc acetate to hasten the set. Eugenol is usually derived from oil of cloves. The oil of cloves contains more eugenol (82 percent) than do the oils of bay, orange, or cinnamon. Eugenol is an obtundent (pain-relieving agent). It is a clear liquid that gradually changes to amber when exposed to light.

c. **Physical Properties.** This material relieves pain, makes tissue less sensitive to pain, is slightly antiseptic, and is low in thermal conductivity. It provides a good marginal seal when placed in tooth cavities. The crushing strength (compression strength) of pure zinc oxide and eugenol is about 2,000 psi, which is low in comparison to other cements. The addition of hydrogenated resin increases the crushing strength to 5,000 psi.

1-20. CLINICAL USES OF ZINC OXIDE AND EUGENOL

a. **Treatment Restoration.** The most frequent use of zinc oxide and eugenol is as a treatment restoration. It helps prevent pulpal irritation when set in place for treatment of fractured teeth, lost restorations, advanced caries, or pulpitis. This dental material also exerts a palliative effect on the pulp.

b. **Temporary Cementing Medium.** Zinc oxide and eugenol is used as a temporary cementing medium for crowns, inlays, and fixed partial dentures. These fixed appliances may later be permanently cemented with zinc phosphate cement.

c. **Intermediate Base.** Zinc oxide and eugenol is used as an intermediate base. This material provides insulation between metallic restorations and vital tooth structure. Because of the low crushing strength, its use is sometimes contraindicated. The dental officer will often require that a zinc phosphate cement base be placed over the zinc oxide and eugenol to better support a metallic restoration.

d. **Pulp Capping.** This material is used in pulp capping for near and direct exposures of the pulp, but this use is declining. Calcium hydroxide is now preferred for pulp capping.

e. **Surgical Packing or Dressing.** This material is used as a surgical packing or dressing after certain periodontal surgical procedures. An example of this is the surgical dressing applied and adapted over the gingival area after a gingivectomy. This dressing protects the area and makes the tissue less sensitive.

Continue with Exercises

EXERCISES, LESSON 1

INSTRUCTIONS: Answer the following exercises by marking the lettered response that best answers the question or best completes the incomplete or by writing the answer in the space provided.

After you have completed all the exercises, turn to "Solutions to Exercises" at the end of the lesson and check your answers.

1. List factors that make demands upon restorative dental materials.

   a. The corrosive nature of __________________.

   b. The _______________ and _________________ of tooth structure with changes in temperature.

   c. The stress of _____________________ forces (grinding and chewing).

   d. Compatibility with ___________________ tissues.

   e. Where visible, materials must be ________________________ pleasing.

2. Select the grain size in metals that gives the most desirable properties.

   a. Small grains.

   b. Large grains.

3. In cast metal, the grains are:

   a. Elongated.

   b. Flattened.

4. Match the term in Column I to the definition in Column II.

COLUMN I		COLUMN II
(1) ___ Hardness	a.	Permits a metal to be shaped into a thin sheet or plate
(2) ___ Ductility	b.	Allows a metal to deform temporarily
(3) ___ Malleability	c.	Returns a metal to its original shape
(4) ___ Flexibility	d.	Resistance of a metal to indentation or scratching
(5) ___ Elasticity	e.	Capacity of a metal to be stretched without fracturing

5. Match the term in Column I to the definition in Column II.

COLUMN I		COLUMN II
(1) ___ Fatigue	a.	Ability to transmit heat or cold
(2) ___ Crushing strength.	b.	Resistance to fracture under compression
(3) ___ Thermal conductivity.	c.	Fracture point after repeated stressing

6. Match the term in Column I to the definition in Column II.

COLUMN I		COLUMN II
(1) ___	Cold working	a. Heat softening treatment
(2) ___	Strain hardening	b. Heat hardening treatment
(3) ___	Annealing	c. Changing the shapes of metal at room temperature.
(4) ___	Tempering	d. Metal becomes stiffer after force is applied, to the point of fracture

7. Select the metallurgical process that restores properties to metals that are decreased by cold working and annealing.

   a. Cold working.

   b. Softening heat treatment.

   c. Strain hardening.

   d. Hardening heat treatment.

8. Select the metal included in dental silver alloy which has a specified percentage range of from 6 to 13 percent.

   a. Mercury.

   b. Silver.

   c. Tin.

   d. Zinc.

   e. Copper.

9. The metallic element in dental amalgam that is silver-white, liquid at room temperature, and poisonous is ________________________.

10. Dental amalgam is a:

    a. Solid mixture of silver, tin, copper, and zinc.

    b. Specially prepared silver alloy combined with mercury.

11. Which of the following ingredients of dental amalgam imparts strength, durability, and color, decreases the setting time and flow, and gives desirable setting expansion?

    a. Mercury.

    b. Copper.

    c. Silver.

    d. Zinc.

    e. Tin.

12. Which of the following ingredients of an amalgam restoration increases workability and unites with oxygen to produce a clean amalgam?

    a. Tin.

    b. Zinc.

    c. Silver.

    d. Copper.

    e. Mercury.

13. The most important physical properties of amalgam are:

    a. Flow and ____________________.

    b. ____________________________ change.

    c. _________________________strength.

14. At 50 percent mercury content, the compression strength of amalgam is:

    a. 30,000 psi.

    b. 52,000 psi.

    c. 100,000 psi.

15. Which of the following is an <u>advantage</u> of amalgam?

    a. As it ages, corrosion products form along the interface of the restoration and the tooth.

    b. It conducts heat or cold readily.

    c. The color does not match the color of the teeth.

    d. It will tarnish with time.

16. Which dispenser in the amalgam dispensing system has four interchangeable plungers?

    a. The alloy dispenser.

    b. The mercury dispenser.

17. How long does the amalgamator take to mix one alloy pellet?

    a. 30 seconds.

    b. 20 seconds.

    c. 10 seconds.

    d. 5 seconds.

18. Select the result that is NOT caused by undertrituration.

    a. Lengthened setting time

    b. Increased expansion.

    c. Weakened amalgam.

    d. Increased shrinkage.

19. Complete information related to the usage of amalgam.

    a. The amalgam is taken from the capsule and placed in an _______________

    b. The process of packing an amalgam mix into a cavity preparation is called _____________________________.

    c. Sufficient packing pressure is necessary to prevent _________________in the restoration.

    d. Immediately after condensation, ____________________ can be started with sharp instruments.

20. List four adverse effects of moisture contamination.

a. Excessive ____________________ of amalgam.

b. __________________________ pain.

c. Lowered ____________ ________________.

d. ________________formation on the ________________ of the amalgam.

21. What should you do with capsules in poor condition or cracked capsules?

a. Store them in a closed container in a fireproof area.

b. Cleanse them with a water coolant.

c. Discard them IAW SOP.

22. There must be no ___________________in the part of the clinic where mercury or amalgam are used.

a. Carpeting.

b. Storage of materials.

c. Source of heat.

23. How often must amalgamators be cleaned?

a. Every day.

b. Once a week.

c. Once a month.

24. List the four types of dental cement discussed in the lesson.

a. ___________ ________________ cement.

b. ____________________________ cement.

c. ___________ _________________ cement.

d. ___________ ________________ and _____________________ cement.

25. List two ways that zinc phosphate is used.

a. As an _____________________________ __________________

b. As a_____________________ ______________________.

26. The primary ingredients of zinc phosphate cement powder are:

a. _____________________ _____________________.

b. ________________________ __________________.

27. The ratio of the ingredients of zinc phosphate cement liquid is as follows.

a. Two parts of __________________ __________________.

b. One part of ____________________.

28. Zinc phosphate cement liquid should NOT be discarded when:

a. The liquid has been left unstoppered for a long time.

b. The liquid is discolored.

c. The liquid is down to the last 30 percent in the bottle.

29. List advantages of zinc phosphate as a cementing medium.

   a. ______________________________ appearance.

   b. Speed and _________________ of usage.

   c. Sufficient flow to form a thin ______________________ for cementing.

   d. Low ___________________ conductivity beneath a metallic restoration.

30. List disadvantages of zinc phosphate as a cementing medium.

   a. _______________________ crushing strength.

   b. ____________________________ solubility in mouth fluids.

   c. ____________________________ material (not suitable for visible surfaces).

31. The compression strength of zinc phosphate cement is between:

   a. 12,000 and 19,000 psi.

   b. 21,000 and 29,000 psi.

   c. 30,000 and 52,000 psi.

32. Zinc phosphate cement will take longer to harden when:

   a. Less powder is used.

   b. More powder is used.

   c. Powder in equal amounts is used.

33. List four actions to maintain and prolong the normal setting time for zinc phosphate cement.

a. Keep (or lower) the temperature to between ______ and ______ F.

b. Blend the powder __________________.

c. Mix the powder over a ____________ ________________of the cool slab.

d. Use a ___________________mixing time.

34. When preparing a mix of zinc phosphate cement, the powder is divided and subdivided into portions. Of the total number of portions to be mixed, how many are <u>sixteenth</u> portions?

a. Six.

b. Four.

c. Two.

35. When mixing zinc phosphate cement, how is the liquid dispensed?

a. With a special dropper supplied by the manufacturer.

b. With a generic dropper supplied by the dental clinic.

36. List the segments and time rules for spatulation.

a. Spatulate the first three segments for about ______ seconds.

b. Spatulate the next two segments for about ______ seconds.

c. Spatulate the final segment for ______ to ______ seconds.

37. When mix is ready for use, it should be similar in consistency to:

a. Putty.

b. Skim milk.

c. Thick cream.

d. Melted ice cream.

38. Describe what happens after the spatula is placed on the slab.

a. The spatula is raised ______ inch(es).

b. The mix clings in a __________ ______________ (a peak).

c. The mix holds for _____ or ______ seconds before it breaks and gradually spreads.

39. List the uses of polycarboxylate cement.

a. As a cementing medium of ____________ ___________.

b. As a cementing medium of _______________ _____________.

c. As a ________________ _______________.

d. As a base under _________________ restorations.

e. As a ________________________ restorative material.

40. Polycarboxylate cement powder contains:

a. Zinc oxide.

b. Magnesium oxide, ______ to ______ percent.

c. Aluminum oxide, ______ to ______ percent.

d. Sometimes, a small percentage of ________.

41. Polycarboxylate cement liquid is rather thick. It has:

    a. Low molecular weight.

    b. High molecular weight.

42. List advantages of polycarboxylate cement over zinc phosphate cement.

    a. It is easier to ____________________.

    b. There is less ___________________ due to thermal shock to the pulp.

43. Mixing of polycarboxylate cement is done by rapidly blending the powder and the liquid for ______ seconds on a nonporous, polymer paper mixing pad.

44. List three precautions concerning polycarboxylate cement.

    a. The mix should be used while it is still ______________, before the onset of _______________________

    b. ___________________ containers should be used to store the powder and the liquid. They should be stored in a __________________ place.

    c. The interior of restorations and tooth surfaces must be free of ____________.

45. The primary use of glass ionomer cement is for permanent cementing of:

    a. ____________________.

    b. ____________________.

    c. ____________________.

    d. Orthodontic ______________________________.

46. The glass ionomer cement powder contains a mixture of __________________ glass with dry __________________________ acid.

47. List important properties of glass ionomer cement.

    a. It adheres chemically to _____________ and _______________ and, also, to _________________ tooth structure.

    b. It is well tolerated by the dental ________________.

    c. It remains __________________ under a load.

    d. It possesses high _____________________ strength.

    e. It is simple to proportion, to _____________, to _________________, and to ______________ ______________ .

48. Describe the appearance of glass ionomer cement.

    a. It should always have a ___________________ appearance.

    b. When the surface becomes _________________, the setting reaction has started. The mix should be discarded.

49. For glass ionomer cement, why is it important never to exceed the working time? Exceeding the working time will result in __________ of ____________ to enamel and dentin.

50. The normal ratio of powder to liquid for glass ionomer cement is:

    a. One level scoop of powder to two drops of liquid.

    b. Two drops of liquid to one heaping scoop of powder.

51. In order to produce precise and uniform drops from the liquid bottle for glass ionomer cement, what do you have to do?

_______________ it __________________

52. Complete information related to mixing glass ionomer cement.

a. Powder is incorporated into the liquid in_____ or_____ large increments.

b. Each portion of the powder is added to the liquid ______________________

c. The mix should be completed in about _____ seconds, at room temperature.

53. For glass ionomer cement, you know that the right consistency is obtained when the spatula is raised from the glass slab and the material breaks away at:

a. 1/4 inch.

b. 1/2 inch.

c. 1 inch.

d. 1 1/2 inches.

54. Should glass ionomer cement be inserted close to the pulp?

a. Yes.

b. No.

55. Is it a requirement to set in place a calcium hydroxide liner before inserting glass ionomer cement?

a. Yes.

b. No.

56. List potential hazards of glass ionomer cement.

a. Some people may have an ____________________________ to glass ionomer cement.

b. Powder in the___________ may cause _____________ due to foreign body reaction.

c. If you ________________ some of liquid that is used to mix glass ionomer cement, you will probably get some localized irritation.

57. It is known that glass ionomer cement adheres to wet tooth structure. Enamel and dentin ______________clean and dry before application.

a. Have to be.

b. Don't have to be.

58. List the clinical uses of zinc oxide and eugenol.

a. For treatment ___________________.

b. As a __________________ cementing medium.

c. As an intermediate ___________________.

d. For ___________________ capping.

e. As a ________________ __________________ or dressing.

59. According to NBS specifications, what is the percentage of zinc oxide powder required for zinc oxide and eugenol cement?

a. 70 to 100 percent.

b. 70 to 90 percent.

c. 60 to 90 percent.

d. 60 to 80 percent.

60. Oil of __________ contains 82 percent eugenol.

a. Cinnamon.

b. Oranges.

c. Cloves.

d. Bay.

61. Which dental cement is more likely to be used when there is pulpitis, advanced caries, or fractured teeth?

a. Polycarboxylate.

b. Zinc oxide and eugenol.

c. Glass ionomer.

d. Zinc phosphate.

62. Select the dental cement with the lower crushing strength that may be used to provide insulation between metallic restorations and vital tooth structures. (It may be used alone or in combination with another dental cement.)

a. Zinc phosphate.

b. Polycarboxylate.

c. Glass ionomer.

d. Zinc oxide and eugenol.

Check Your Answers on Next Page

SOLUTIONS TO EXERCISES, LESSON 1

1. a. saliva
   b. expansion; contraction
   c. masticatory
   d. living
   e. esthetically (para 1-2)

2. a (para 1-3f(1))

3. b (para 1-3f(2))

4. (1) d
   (2) e
   (3) a
   (4) b
   (5) c (para 1-3)

5. (1) c
   (2) b
   (3) a (para 1-3)

6. (1) c
   (2) d
   (3) a
   (4) b (para 1-4)

7. d (para 1-4d)

8. e (figure 1-1)

9. mercury (para 1-5b(3))

10. b (para 1-5b(2))

11. c (para 1-5c(6); Table 1-1)

12. b (para 1-5c(6); Table 1-1)

13. a. creep
    b. Dimensional
    c. Compression (para 1-5d)

14. b (para 1-5d(3)

15. a (para 1-6a)

16. b (para 1-7b)

17. c (para 1-7c)

18. d (para 1-7c)

19. a. amalgam cup
    b. condensation
    c. voids
    d. carving (para 1-7d,e)

20. a. expansion
    b. Postoperative
    c. crushing strength
    d. Blister; surface (para 1-8a(1))

21. c (para 1-9b(4))

22. a (para 1-9b(14))

23. b (para 1-9b(13))

24. a. Zinc phosphate
    b. Polycarboxylate
    c. Glass ionomer
    d. Zinc oxide and eugenol (para 1-10)

25. a. intermediate base.
    b. cementing medium. (para 1-11b)

26. a. Zinc oxide.
    b. Magnesium oxide. (para 1-11c(1))

27. a. phosphoric acid.
    b. water. (para 1-11c(2))

28. c (para 1-11c(2))

29. a. Inconspicuous
    b. ease
    c. layer
    d. thermal (para 1-12a)

30. a. Low
    b. Slight
    c. Opaque (para 1-12b)

31. a para 1-12b(1))

32. a (para 1-13b)

33. a. 65^o and 75^o.
    b. slowly.
    c. large area
    d. longer (para 1-13c)

34. c (para 1-14b)

35. a (para 1-14b)

36. a. 15
    b. 20
    c. 30 to 35 (para 1-14c)

37. d (para 1-14d)

38. a. one inch
    b. thin thread
    c. one or two (para 1-14d)

39. a. cast alloy
    b. porcelain restorations
    c. cavity liner
    d. metallic
    e. temporary (para 1-15a)

40. b. 1 to 5
    c. 10 to 40
    d. fluoride (para 1-15c(1))

41. b (para 1-15c(2))

42. a. manipulate
    b. trauma (para 1-15e)

43. 30 to 40 (para 1-16c)

44. a. glossy; cobwebbing
    b. Stoppered; cool
    c. saliva (para 1-16e)

45. a. Inlays.
    b. Crowns.
    c. Bridges.
    d. band/brackets. (para 1-17a)

46. aluminosilicate; polymaleic (para 1-17c(1))

47. a. enamel and dentin; wet
    b. pulp
    c. rigid
    d. compressive
    e. mix; apply; clean up (para 1-17d)

48. a. glossy
    b. dull (para 1-17e)

49. loss of adhesion (para 1-17e)

50. a (para 1-18b)

51. Hold it vertically. (para 1-18b)

52. a. 2 or 3
    b. all at once.
    c. 60 (para 1-18c)

53. b (para 1-18d)

54. b (para 1-18e(1)

55. a Yes, where the dentin is thin, in deep cavities, or where the pulp is involved.
    b No, in other cases. (para 1-18e(1)

56. a. allergic reaction
    b. eyes; irritation
    c. drink (OR ingest) (para 1-18e(2)(3))

57. a (para 1-18e(4))

58. a. restoration
    b. temporary
    c. base.
    d. pulp
    e. surgical packing (para 1-20)

59. a (para 1-19b)

60. c (para 1-19b)

61. b (para 1-20a)

62. d (para 1-20c)

End of Lesson 1

LESSON ASSIGNMENT

LESSON 2 Dental Resins, Miscellaneous Dental Materials, and Dental Gold/Alloys.

TEXT ASSIGNMENT Paragraphs 2-1 through 2-23.

LESSON OBJECTIVES After completing this lesson, you should be able to:

2-1. Identify the characteristics and uses of acrylic resins and composite resins.

2-2. Identify the characteristics of intermediate restorative material (IRM).

2-3. Identify the uses of root canal filling materials, calcium hydroxide, and cavity lining varnish.

2-4. Identify basic information concerning dental porcelain.

2-5. Identify dental polishing materials and their uses.

2-6. Identify the characteristics of dental gold alloy.

2-7. Identify the types of gold alloys used in dentistry.

SUGGESTION After studying the assignment, complete the exercises of this lesson. These exercises will help you to achieve the lesson objectives.

LESSON 2

DENTAL RESINS, MISCELLANEOUS DENTAL MATERIALS, AND DENTAL GOLD/ALLOYS

Section I. DENTAL RESINS FOR RESTORATIVE DENTISTRY

2-1. GENERAL

Because of its esthetic properties, resin can be used for the reproduction of lost tooth structure. The dental officer prepares the cavity in the tooth in the usual manner, inserts the plastic mixture directly into the cavity, and allows it to polymerize at mouth temperature. These materials are often referred to as direct-filling resins. Certain shortcomings in the physical properties of resins restrict their use when esthetics, such as the restoration of anterior teeth, are the principal concern. There are two types of direct filling resins. The older type is an unfilled polymethyl methacrylate. Such a resin is often referred to as an acrylic resin. The newer type is the composite resin.

2-2. ACRYLIC RESINS

a. **Clinical Use.** Acrylic (unfilled) resins are used as temporary crown material. Temporary crowns are placed to protect the crown preparation and provide patient comfort during the time the permanent crown is being constructed.

b. **Composition of Acrylic Resins.**

(1) Powder. The powder is composed of a polymethyl methacrylate, a polymer, and contains some inert coloring pigments.

(2) Liquid. The liquid is a monomethyl methacrylate, a monomer, and is the same material as the polymer except in a different molecular form.

c. **Properties of Acrylic Resins.**

(1) Desirable properties. Acrylic resins are available in several shades to match tooth shading (esthetics). They have a low thermal conductivity. These resins are not easily washed out by the acids of the oral cavity (low solubility). Acrylic resins are also resilient, which allows them to be used in stress-bearing areas.

(2) Undesirable properties. Acrylic resins exhibit a moderate shrinkage of from 3 to 8 percent. This shrinkage and low marginal strength can lead to marginal leakage. Acrylic resins have a low resistance to wear. Acrylic resins cannot be used over a zinc oxide and eugenol-type base because eugenol interferes with the acrylic curing process.

d. **Mixing.** Always follow the manufacturer's directions when mixing any material. Each brand of acrylic resin requires a slightly different mixing procedure. Insufficient mixing will cause an uneven color or streaks in the mixture. Overmixing will cause the material to harden before it can be placed.

2-3. COMPOSITE RESINS

a. **Clinical Use.** Composite resins are the most commonly used material for all permanent anterior restorations. These resins make excellent restorative materials because of their good resistance to wear and their excellent esthetics. Silar, Adaptic, and Concise are some of the trade names of composite resins.

b. **Chemical Composition.** Composite resins are composed of universal paste with filler and catalyst paste. All composite resins use quartz as a filler.

c. **Properties.** Composite resins have excellent esthetic properties. In fact, the universal paste will match 89 percent of all tooth shades. Tints are available for the other 11 percent. Composite resins have good resistance to wear because of the filler. They also have an acceptable compressive strength of 35,000 psi. Thermal expansion is at a minimum. (The manufacturer claims that the thermal expansion is close to the normal expansion of tooth structure.) Solubility and shrinkage are low. Refrigeration of the composite resin is required to prevent deterioration.

d. **Mixing.** As with unfilled resins, the manufacturer's directions should be followed when mixing composites. There are several types available and each requires a specific mixing procedure. The two-paste system is the most common form used. To mix this system, equal parts of the pastes are mixed (with a folding motion) to a uniform color within 20 to 30 seconds. The average working time from start of mixing to insertion of product is 1 1/2 to 2 minutes. It is important to avoid cross-contamination between jars of universal and catalyst pastes. The double-ended spatula provided with the kit has differently shaped ends, each clearly labeled "uni" and "cat." Improper mixing could cause failure of the restoration. Also, improper ratio of pastes will decrease the strength as will insufficient spatulation. Use of a metal spatula will result in discoloration of the material, giving poor esthetics. Some composite resins are activated by the application of ultraviolet or visible light. The material is placed in the cavity preparation, then exposed to a source of light for a specified time to produce polymerization or setting of the composite.

2-4. ACID ETCH TECHNIQUE

Cavities requiring added retention (to hold firmly) are treated with an acid etching technique. This technique improves the seal of the composite resin to the cavity wall. The enamel adjacent to the margins of the preparation is slightly decalcified with a 40 to 50 percent phosphoric acid solution. This etched enamel enhances the mechanical retention of the composite resin. In addition, the acid etch technique is used to splint unstable teeth to adjacent teeth. The acid is left on the cut tooth structure only 15 seconds, in accordance with the directions for one common commercial brand. The area is then flushed with water for a minimum of 30 seconds to remove the decalcified material. Etched tooth structure will have a chalky appearance.

2-5. PIT AND FISSURE SEALANTS

Pit and fissure sealants are similar to the unfilled resin portion of acid etch composite filling materials. This plastic resin is used as a prophylactic seal of occlusal pits and fissures. The purpose is to prevent carious destruction of tooth structure. The sealant is used when there is a deep occlusal pit or fossa or a lingual pit, when there is an intact occlusal surface with a carious or restored contralateral tooth surface, and where there is high carious activity, poor oral hygiene, or newly erupted posterior teeth.

2-6. INTERMEDIATE RESTORATIVE MATERIAL

Intermediate restorative material (IRM) is a zinc oxide and eugenol cement that has been reinforced for increased strength. It is used as an intermediate base beneath a metallic restoration and also as a temporary restoration.

a. **Composition.**

(1) <u>Powder</u>. The powder is composed of 80 percent zinc oxide and 20 percent polymethyl methacrylate (the powder used for acrylic resin).

(2) <u>Liquid</u>. The liquid is 99 percent eugenol and 1 percent acetic acid.

b. **Dispensing.** The first step in dispensing IRM is to fluff the powder for uniform density. The measuring scoop is then filled but not packed with powder and leveled with the spatula. The powder is then placed on the mixing pad. Finally, one drop of liquid is added for each level scoop of powder (at a 1 to 1 ratio). After using the liquid, immediately recap to prevent evaporation and contamination.

c. **Mixing.** Spatulate quickly with a stainless steel spatula, combining half the powder with all the liquid. Add the remaining powder in 2 or 3 increments and spatulate thoroughly. The mix will be stiff and should be stropped (whipped vigorously) each time with the spatula for 5 to 10 seconds. This type of mixing results in a smooth and adaptable working consistency. Mixing the IRM should be completed in approximately 1 minute (60 seconds).

Section II. MISCELLANEOUS DENTAL MATERIALS

2-7. CALCIUM HYDROXIDE

Calcium hydroxide is used in operative procedures such as pulp capping (protection for an exposed or nearly exposed pulp). It is available in premixed commercial preparations ready for immediate use. Because of its low crushing strength, calcium hydroxide alone is not used as an intermediate base. It is usually covered with zinc phosphate cement or zinc oxide and eugenol cement. Dycal, a commercial preparation, is an example of calcium hydroxide.

2-8. ROOT CANAL FILLING MATERIALS

Root canal filling materials consist of tapered gutta-percha or silver points in standard sizes that match the size of the files used. The points are cemented in place with root canal sealer that is usually a zinc oxide and eugenol preparation. Root canal filling materials are used to fill previously prepared root canals. They are a part of root canal, or endodontic, therapy.

2-9. GUTTA-PERCHA POINTS

a. **General.** Gutta-percha points are made from the refined, coagulated, milky exudate of trees in the Malay peninsula. Gutta-percha is pink or gray in color. It is softened by heat and is easily molded. When cool, gutta-percha maintains its shape. Gutta-percha points are used as a root canal filling material.

b. **Advantages.**

(1) They have a high thermal expansion.

(2) They do not shrink unless used with solvent.

(3) They are radiopaque, conduct heat poorly, and are easy to remove from the root canal.

(4) They may be kept sterile in antiseptic solution, are impervious to moisture, and are bacteriostatic (prevent the growth or multiplication of bacteria).

c. **Disadvantages.**

(1) They shrink when used with a solvent.

(2) They are not always easy to introduce into the root canal.

2-10. SILVER ROOT CANAL POINTS

a. **Advantages.** The dental officer has the option to use silver root canal points in filling a root canal.

(1) They are more easily inserted than gutta-percha points and they have all the same advantages.

(2) Sight selection of silver points is easy because they come in the same sizes and tapers as standard root canal broaches and reamers.

b. **Disadvantages.**

(1) They are more expensive than gutta-percha.

(2) They do not adapt to contours of the root canal.

(3) They tend to corrode if subjected to body fluids.

2-11. CAVITY LINING VARNISH

Cavity lining varnish is used as a seal under an otherwise unbased restoration. It is composed of resins dissolved in a volatile thinner. Cavity lining varnish is used extensively to seal dentin tubules (small tubes in the dentin that contain dentinal fibers) and thus isolate the pulp of the tooth from the acidity of zinc phosphate cement. In some cases, it is used to help prevent marginal leakage around restorations. Cavity lining varnish is issued as a liquid in a container, usually together with a bottle of thinner. The bottle of varnish should be kept tightly sealed when not in use. If the varnish gets too thick, thinner is added to restore the original consistency. Copalite is the trade name for a common cavity varnish.

2-12. DENTAL PORCELAIN

a. **General.** Dental porcelain is manufactured as a powder. When it is heated to a very high temperature in a special oven, it fuses into a homogeneous mass. The heating process is called baking. Upon cooling, the mass is hard and dense. The material is made in a variety of shades to closely match most tooth colors. Baked porcelain has a translucency similar to that of dental enamel, so that porcelain crowns, pontics, and inlays of highly pleasing appearance can be made. Ingredients of porcelain include feldspar, kaolin, silica in the form of quartz, materials which act as fluxes to lower the fusion point, metallic oxide, and binders. Porcelains are classified into high-, medium-, and low-fusing groups, depending upon the temperature at which fusion takes place.

b. **High-Fusing Porcelains.** High-fusing porcelains fuse at 2,400^{o} Fahrenheit or over. They are used for the fabrication of full porcelain crowns (jacket crowns).

c. **Medium-Fusing Porcelains.** Medium-fusing porcelains fuse between 2,000^o and 2,400^o Fahrenheit. They are used in the fabrication of inlays, crowns, facings, and pontics. A pontic is the portion of a fixed partial denture, which replaces a missing tooth.

d. **Low-Fusing Porcelains.** Low-fusing porcelains fuse between 1,600^o and 2,000^o Fahrenheit. They are used primarily to correct or modify the contours of previously baked high- or medium-fusing porcelain restorations.

2-13. POLISHING MATERIALS

a. **Tin Oxide.** Tin oxide is used in polishing teeth and metal restorations. Tin oxide is a fine, white powder that is made into a paste by adding water or glycerin.

b. **Pumice.** Pumice is used as an abrasive and polishing agent for acrylic resins, amalgams, and gold. It consists mainly of complex silicates of aluminum, potassium, and sodium. Two grades--flour of pumice and coarse pumice--are listed in the Federal Supply Catalog.

c. **Chalk (Whiting).** Chalk is used for polishing acrylic resins and metals. It is composed primarily of calcium carbonate.

d. **Tripoli.** Tripoli is usually used for polishing gold and other metals. It is made from certain porous rocks.

e. **Rouge (Jeweler's).** Rouge is used for polishing gold and is composed of iron oxide. It is usually in cake or stick form.

f. **Zirconium Silicate.** Zirconium silicate is used for cleaning and polishing teeth. It may be mixed with water or with fluoride solution for caries prevention treatment. For full effectiveness, instructions must be followed exactly to obtain the proper proportions of powder to liquid.

Section III. DENTAL GOLD AND GOLD ALLOYS

2-14. GENERAL

Gold, the most noble of metals, seldom tarnishes or corrodes in the oral cavity. Because of the softness of pure gold, it is not indicated for use in the mouth except in the form of gold foil. Gold is frequently used in combination with other metals to produce alloys that can be used to fabricate various types of dental restorations where metal is indicated. The basic types of gold alloys used in dentistry are casting gold, gold solder, wrought gold, and gold plate. The principal metals used to combine with gold to form the alloys are silver, copper, platinum, palladium, and zinc.

2-15. ADMINISTRATIVE CONTROL

Controlled items subject to strict accountability and safeguarding are gold solder, platinum foil, and gold, silver, and chromium alloys. In addition, scrap from these controlled items and from amalgam are also subject to the same controls. Certain delegated members of a dental facility control these items. However, all members of the dental care system must be aware of safeguarding precious metals, collecting precious/semiprecious scrap, and accounting for receipt, use, and turn-in of these items. If dental precious metal appliances, such as gold crowns and gold bridges, are retrieved from a patient, they are turned in as precious metal scrap subject to accounting controls.

2-16. FINENESS, CARAT, AND WEIGHING

The amount of gold in a gold alloy may be rated in terms of fineness or carat. Fineness is determined by the parts per thousand of pure gold contained in the alloy. In terms of fineness, pure gold is 1,000 fine, and an alloy with three-fourths pure gold is 750 fine. In the carat system of rating, the carat refers to the parts of gold determined by dividing the substance into 24 units and then counting the number of units of gold. Thus, a 24-carat substance would be pure gold and a 12-carat alloy would be one- half gold. In weighing precious metals like gold and platinum, the troy system of weight is used. In this system, the basic units of measurement of alloy quantity are grains, pennyweights, and ounces. Gold alloys are recorded and issued by the troy system as indicated in Table 2-1.

24 grains (gr)	=	1 pennyweight (dwt)
20 pennyweight (dwt)	=	1 ounce (oz)
12 ounces (oz)	=	1 pound (lb)

The conversion formula for carat to fineness is:

$$\frac{\text{carat}}{24} = \frac{\text{fineness}}{1000}$$

Table 2-1. Troy system of weight.

2-17. ANNEALING AND TEMPERING

Through the use of controlled heat and rate of cooling, gold alloys can be annealed (softened) or tempered (hardened). Gold alloys are hardened by slow cooling. Rapid cooling from a high temperature will soften a gold alloy. Rapid cooling is done by quenching the heated gold alloy in tap water.

2-18. GOLD FOIL

Gold foil is a restorative material used in the pure state. It is used most often on facial surfaces, proximal surfaces of anterior teeth, and occlusal surfaces of posterior teeth. Its chief disadvantages are color, high thermal conductivity, and difficulty in manipulation. Gold foil is available in either adhesive or nonadhesive form. To prevent pellets of adhesive foil from sticking together before use, their surfaces are treated with moisture or gas residues. When ready for use, the moisture and gas residues are vaporized by heating.

2-19. CASTING GOLD ALLOY

a. **General.** Restorations made with gold foil do not exhibit as much overall strength and resilience as do restorations made with gold alloys. Casting gold alloy is used in the fabrication of various types and classes of restorations. It is alloyed and made into ingots suitable for melting and casting into molds for the restorations.

b. **Four Types of Casting Gold Alloys.**

(1) Soft. For inlays not subjected to stress.

(2) Medium. For ordinary inlay work.

(3) Hard. For full crowns, three-quarter crowns, and retainers.

(4) Extra hard. For saddles, clasps, and one-piece cast partial dentures.

c. **Usage.** Casting gold alloys can be whitened (white gold) by adding palladium, platinum, or silver. Casting gold alloy is also used for crowns and abutments requiring great strength and hardness.

2-20. GOLD ALLOY SOLDER

Gold alloy solder is used for joining the parts of fixed partial dentures, for building up or forming restorations, and for gold repairs. Soldering is the process of joining metals by means of a solder or a lower fusing metal.

2-21. WROUGHT GOLD

Wrought gold is used for the construction of clasps and orthodontic appliances.

2-22. GOLD PLATE

Gold plate is used less often than casting gold alloy, gold alloy solder, or wrought gold. It is used in the fabrication of some types of crowns and often used in repair procedures.

2-23. NONPRECIOUS ALLOYS

Nonprecious alloys were developed as an alternative to the expensive precious metal alloys. They are used primarily in the fabrication of ceramometal restorations. These alloys are composed chiefly of chromium, nickel, and molybdenum.

Continue with Exercises

EXERCISES, LESSON 2

INSTRUCTIONS: Answer the following exercises by marking the lettered response that best answers the question or best completes the incomplete or by writing the answer in the space provided.

After you have completed all the exercises, turn to "Solutions to Exercises" at the end of the lesson and check your answers.

1. The liquid of dental restorative acrylic resin is composed of:

   a. Polymethyl methacrylate.

   b. Monomethyl methacrylate.

2. List desirable properties of acrylic resins.

   a. Available in several _____________ to match tooth shading.

   b. ________________ thermal conductivity.

   c. _________________ solubility.

   d. _________________ used in stress-bearing areas.

3. List undesirable properties of acrylic resins.

   a. A moderate ________________ occurs, from 3 to 8 percent.

   b. Low resistance to __________________.

   c. Eugenol interferes with the acrylic ___________________ process.

4. Describe the results of incorrect mixing of acrylic resins.

   a. _______________mixing will cause an uneven color or streaks in the mixture.

   b. _____________will cause the material to harden before it can be put in place.

5. Silar is an example of a commercial product used in restorative dentistry. It is a/an:

   a. Acrylic resin.

   b. Zinc oxide and eugenol.

   c. Calcium hydroxide.

   d. Composite resin.

   e. Cavity lining varnish.

6. Describe composite resins.

   a. ____________________ paste with filler (in a jar).

   b. ____________________ paste (in a jar).

   c. A filler, usually ______________________.

7. Complete information related to properties of composite resins.

   a. The universal paste will match ___________ percent of all tooth shades.

   b. The compressive strength is __________ psi.

   c. They have low _______________ and ____________________.

   d. ____________________________ is required.

8. Complete information related to the mixing of composite resins.

   a. In the two-paste system,_____________parts of the paste are mixed to a uniform color.

   b. Mixing is done within______ to ______ seconds.

   c. ___________________ spatulation will decrease the strength of the mixture.

9. Describe why a double-ended, nonmetal spatula is used to mix composite resin.

   a. To avoid cross-contamination between jars of paste, each end of the spatula is clearly labeled ____________ or _________________.

   b. Use of a metal spatula will result in _____________________ of the material.

10. Describe the acid etch technique.

   a. The use of this technique improves the __________ of the composite resin to the cavity wall, thus strengthening it.

   b. _____ to ____ percent phosphoric acid is applied to the margins of the cavity.

   c. The acid is left on the cut tooth surface for ______ seconds and then flushed with water for ______ seconds.

   d. Etched tooth structure will have a ___________________ appearance.

11. Complete information related to intermediate restorative material (IRM).

   a. The powder consists of 80% __________ ______________ and 20% _______________ methacrylate (also used for acrylic resin).

   b. The liquid is 99% _________________________.

   c. ______ drop of liquid is added to ________ level scoop of powder.

   d. When mixing, the mix should be _____________ with the spatula for ________ to ______ seconds.

   e. It takes approximately _______ seconds to complete mixing IRM.

12. Dycal, a commercial product, is an example of:

a. Cavity lining varnish.

b. IRM.

c. Composite resin.

d. Pulp capping material.

13. Is it usual to cover a layer of calcium hydroxide with zinc phosphate cement or zinc oxide and eugenol cement?

a. Yes.

b. No.

14. Match the term in Column II to the characteristics in Column I.

COLUMN I		COLUMN II
(1)_____ High thermal expansion	a.	Gutta-percha points
(2)_____ Do not shrink	b.	Silver points
(3)_____ Standard sizes and tapers		
(4)_____ Conduct heat poorly		
(5)_____ Bacteriostatic		
(6)_____ More expensive		
(7)_____ Impervious to moisture		
(8)_____ More easily inserted		

15. Which of the following is more rapidly softened by heat and more easily molded?

    a. Silver root canal points.

    b. Cavity lining varnish.

    c. Gutta-percha root canal points.

    d. Pit and fissure sealants.

16. Which of the following is more easily inserted, when required?

    a. Pit and fissure sealants.

    b. Cavity lining varnish.

    c. Gutta-percha root canal points.

    d. Silver root canal points.

17. Copalite is a commercial product. It is a/an:

    a. Calcium hydroxide.

    b. IRM.

    c. Cavity lining varnish.

    d. Composite resin.

    e. Whiting chalk (calcium carbonate).

18. Which of the following is pink or gray in color?

    a. Gutta-percha points.

    b. Silver points.

    c. Composite resin.

    d. IRM.

    e. Calcium hydroxide.

19. Complete information related to cavity lining varnish.

a. It is used as a _____________ under an unbased restoration.

b. It seals dental _____________ and isolates the _________________ of the tooth from the acidity of the cement.

c. Helps prevent marginal _________________ around restorations.

20. Match the term in Column II to the range of temperature in Column I.

COLUMN I			COLUMN II
(1)	____	2000^o to 2400^o F.	a. High-fusing porcelain
(2)	____	1600^o to 2000^o F.	b. Medium-fusing porcelain
(3)	____	2400^o F or over.	c. Low-fusing porcelain

21. Which of the following dental porcelains is used for the fabrication of full porcelain crowns (jacket crowns)?

a. High-fusing porcelain.

b. Medium-fusing porcelain.

c. Low-fusing porcelain.

22. Which of the following polishing materials is used in polishing teeth and metal restorations.

a. Pumice.

b. Zirconium silicate.

c. Jeweler's rouge.

d. Tin oxide.

e. Tripoli.

23. Which of the following is the least likely to tarnish or corrode in the mouth?

    a. Silver.

    b. Gold.

    c. Amalgam.

24. Is chromium alloy a controlled item subject to strict accountability?

    a. Yes.

    b. No.

25. How many carats are there in a gold alloy that is 750 fine? (Refer to Table 2-1.)

    a. 24.

    b. 21.

    c. 18.

    d. 15.

    e. 12.

26. In the troy system of weight, how many grains are there in gold that weighs 1/2 ounce? (Refer to Table 2-1.)

    a. 720.

    b. 460.

    c. 240.

    d. 120.

27. List the tooth surfaces where gold foil is most often used.

   a. Facial surfaces of ____________________ teeth.

   b. _________________ surfaces of anterior teeth.

   c. _________________ surfaces of posterior teeth.

28. Which type of casting gold alloy is sometimes used for full crowns?

   a. Soft.

   b. Medium.

   c. Hard.

   d. Extra hard.

29. Which type of casting gold alloy is sometimes used for one-piece cast partial dentures?

   a. Soft.

   b. Medium.

   c. Hard.

   d. Extra hard.

30. Which of the following is sometimes used for the construction of clasps?

   a. Wrought gold.

   b. Gold alloy solder.

   c. Gold foil.

   d. Gold plate.

   e. A nonprecious metal alloy.

31. Which of the following is sometimes used for joining the parts of fixed partial dentures or for building up restorations?

    a. Gold foil.

    b. A nonprecious metal alloy.

    c. Gold plate.

    d. Wrought gold.

    e. Gold alloy solder.

Check Your Answers on Next Page

SOLUTIONS TO EXERCISES, LESSON 2

1. b (para 2-2b(2))

2. a. shades
   b. Low
   c. Low
   d. Resilient (para 2-2c(1))

3. a. shrinkage
   b. wear
   c. curing (para 2-2c(2))

. 4. a. Insufficient
   b. Overmixing (para 2-2d)

5. d (para 2-3a)

6. a. Universal
   b. Catalyst
   c. Quartz (para 2-3b)

7. a. 89
   b. 35,000
   c. solubility; shrinkage
   d. Refrigeration (para 2-3c)

8. a. equal
   b. 20 to 30
   c. insufficient (para 2-3d)

9. a. uni; cat
   b. discoloration (para 2-3d)

10. a. seal
    b. 40 to 50
    c. 15; 30
    d. chalky (para 2-4)

11. a. zinc oxide; polymethyl
    b. eugenol
    c. 1; 1
    d. stropped; 5 to 10
    e. 60 (para 2-6)

12. d (para 2-7)

13. a (para 2-7)

14. (1) a
    (2) a
    (3) b
    (4) a
    (5) a
    (6) b
    (7) a
    (8) b (paras 2-9 and 2-10)

15. c (para 2-9a)

16. d (para 2-10a(1))

17. c (para 2-11)

18. a (para 2-9a)

19. a. seal
    b. tubules; pulp
    c. leakage (para 2-11)

20. (1) b
    (2) c
    (3) a (para 2-12)

21. a (para 2-12b)

22. d (para 2-13a)

23. b (para 2-14)

24. a (para 2-15)

25. c (para 2-16; Table 2-1)

26. c (para 2-16; Table 2-1)

27. a. anterior
    b. Proximal
    c. Occlusal (para 2-18)

28. c (para 2-19b(3))

29. d (para 2-19b(4))

30. a (para 2-21)

31. e (para 2-20)

End of Lesson 2

LESSON ASSIGNMENT

LESSON 3 Gypsum Products, Dental Waxes, and Impression Materials.

LESSON ASSIGNMENT Paragraphs 3-1 through 3-31.

LESSON OBJECTIVES After completing this lesson, you should be able to:

3-1. Identify the characteristics and preparation procedures for plaster of Paris and artificial stone (gypsum products).

3-2. Identify the clinical use of seven dental waxes.

3-3. Identify the characteristics and preparation procedures for agar-type hydrocolloid impression materials.

3-4. Identify the characteristics and preparation procedures for alginate-type hydrocolloid impression materials.

3-5. Identify the characteristics and preparation procedures for synthetic rubber base impression materials.

3-6. Identify the characteristics of modeling plastic and impression paste.

SUGGESTION After studying the assignment, complete the exercises of this lesson. These exercises will help you to achieve the lesson objectives.

LESSON 3

GYPSUM PRODUCTS, DENTAL WAXES, AND IMPRESSION MATERIALS

Section I. GYPSUM PRODUCTS

3-1. GENERAL - GYPSUM

a. General. A number of gypsum products are used in dentistry. Plaster of Paris and artificial stone powder are the ones most used as cast materials. A general understanding of the chemistry of gypsum products will enable the dental specialist to use them wisely and increase his knowledge of why they react as they do. Gypsum is composed mainly of calcium sulfate dihydrate. A dihydrate is a material consisting of two parts of water to one part of the compound. Calcium sulfate dihydrate, therefore, is one part calcium sulfate and two parts water.

b. **Properties.** In the manufacturing process, gypsum is converted to plaster of Paris and artificial stone by a process called calcining. The gypsum is first ground to a fine powder of particle size. Plaster of Paris is derived when the gypsum is subjected to heat in an open vat. Artificial stone is produced when the gypsum is processed by steam heat under pressure. In both products, the reaction converts calcium sulfate dihydrate into calcium sulfate hemihydrate by the removal of 75 percent of the water molecules. Chemically, the plaster and artificial stone are identical. However, the plaster particles are rough, irregular, and porous, and the artificial stone particles are prismatic, more regular in size, and dense. When the plaster or stone is mixed with water, a hard substance is formed and the process described above is reversed. In the setting reaction, crystals of gypsum intermesh and become entangled with one another, giving the set material its strength and rigidity.

3-2. PLASTER OF PARIS

a. **Uses.** Plaster of Paris is used for pouring casts, making matrices for prosthodontic restorations, for attaching casts to articulators, and general use in the dental laboratory where strength is not important. The crushing strength for plaster of Paris is 2,600 psi.

b. **Mixing.** Water-powder ratios must be used as stated by the manufacturer. Before mixing, the can containing the material should be agitated to evenly disperse all elements in the powder. A clean, dry rubber bowl and plastic spatula are used to manipulate the materials. First, the water is measured and poured into the rubber bowl. The powder is weighed and sifted into the water to avoid trapping air bubbles. Then, with a spatula, the mix is stirred (spatulated) for 30 to 60 seconds in a knifing or stirring motion, making sure to include all powder from the sides of the bowl. (Whipping the mix will entrap air and should be avoided.) Before the mixed material is poured, it should be vibrated to remove any trapped air bubbles.

c. **Setting Time.** The initial setting time for plaster of Paris is 5 to 10 minutes. In this stage, the plaster loses its glossy appearance and is hard enough to hold for carving. The final setting time is approximately 45 minutes. In this stage, the plaster achieves a dry, hard condition. The setting of plaster can be hastened by using less water, by mixing longer, by using chemical accelerators, or by using warm water (up to 85^{o} F (29^{o} C)). Reversing these processes or using chemical retarders lengthens the setting time. The most satisfactory results will be obtained by following the manufacturer's directions.

3-3. ARTIFICIAL STONE

a. **Uses.** Artificial stone is used in making master casts and dies and for general laboratory use when a very hard, strong product is needed. Artificial stone particles are nonporous. Therefore, the finished product is hard and dense. This provides an excellent master cast for the fabrication of prosthetic restorations. The crushing strength of artificial stone is 7,500 psi.

b. **Mixing.** Artificial stone is mixed much like plaster of Paris. The average mixing ratio is 30 cc (cubic centimeters) of water to 100 grams of stone powder. This ratio may vary with different manufacturers. The required amount of water is placed in a rubber bowl. The stone powder is added slowly. (Incorporate all of the powder with water before spatulating.) Spatulation should be thorough without whipping the mixture. Whipping can trap air bubbles, thus weakening the cast. The bowl should be vibrated during the mixing to make air bubbles rise to the surface. Spatulation should be completed in 30 to 60 seconds; after that, the bowl should again be vibrated. The use of mechanical spatulation helps to reduce air bubbles.

c. **Setting Time.** The initial setting time for artificial stone is usually 8 to 10 minutes. The final setting time is 25 to 45 minutes depending on the type of stone mixed. The surface hardness of artificial stone can be increased by soaking the cast for several hours in a solution of borax.

Section II. DENTAL WAXES

3-4. GENERAL--WAXES

Many different waxes are used in dentistry. The composition, form, and color of each wax are designed to facilitate its use and to produce the best possible results. The discussion in this lesson is limited to aspects of clinical interest.

3-5. INLAY WAX

a. **General.** Inlay wax is used to prepare patterns. These patterns are reproduced in gold or other material in the fabrication of inlays, crowns, and fixed and removable partial dentures. Inlay wax is sometimes called casting wax.

b. **Properties.** For success in these procedures, the wax must have properties which will enable very close adaptation to the prepared portions of the tooth to be restored, must provide freedom from distortion, must permit detailed carving without flaking or chipping, and must not leave excessive residue when it is removed from a mold by burning. The wax should harden at body temperature but soften at a temperature low enough to permit it to be manipulated in a plastic state in the mouth without injury to pulp or oral tissues. Its color should contrast with the colors of teeth and oral tissues to facilitate carving, except that ivory wax is used to avoid risk of color contamination when porcelain or acrylic restorations are constructed. Because of the importance of certain qualities of these waxes, the ADA has developed certain specifications with which an inlay wax must comply to be acceptable.

c. **Usage.** Inlay wax is available in blue, green, ivory, or deep purple sticks, in preformed shapes for partial dentures, and in solidly packed cans. It is hard at room temperatures and breaks if bent sharply. This wax remains hard at mouth temperature and may be carved either in or out of the mouth. It is softened with dry heat or by immersion in warm water until pliable.

3-6. BASEPLATE WAX

a. **General.** Baseplate wax is used mainly for making occlusion rims and for holding artificial teeth to baseplates during the fabrication of dentures.

b**. Properties.** Baseplate wax is composed mainly of beeswax, paraffin, and coloring matter, which are mixed together, cast into blocks, and rolled into sheets. The sheets are red or pink, 3 inches wide and 6 inches long. Baseplate wax is relatively hard and slightly brittle at room temperature but becomes soft and pliable when heated.

c. **Usage.** Baseplate wax must be capable of holding porcelain or acrylic teeth in position both at normal room temperature and at mouth temperature.

d. **Two Types.** There are two types of baseplate wax, hard and medium, listed in the Federal Supply Catalog. The hard type is suitable for use in warm climates but tends to crack and flake at low temperatures. The medium type is suitable for use at low temperatures but flows excessively at high temperatures.

3-7. STICKY WAX

a. **General.** Sticky wax has many uses in a dental clinic and dental laboratory. It holds broken pieces of a denture together and assembles components of fixed partial dentures and wrought partial dentures in preparation for soldering.

b. **Properties.** Sticky wax becomes sticky when melted and has the property of adhering to the surfaces of various materials. Sticky wax is composed of beeswax, paraffin, and resins. It is usually supplied as hexagonal sticks of various colors, often orange or purple. It is brittle at room temperature and assumes a thick liquid consistency when heated.

3-8. UTILITY WAX

Utility wax is used to provide rim locks and otherwise to adapt impression trays for individual impressions, to build up post-dam areas on impressions, and to form a bead or border on preliminary and final impressions. Utility wax is pliable enough at room temperature to use without heating. Utility wax is normally issued in stick form and is usually red in color. When it is supplied in rope form, it is sometimes called rope wax.

3-9. DISCLOSING WAX

Disclosing wax is used to determine unequal pressure points in a denture that may cause discomfort to the patient. These points are located by painting the wax on the tissue side of the denture base and holding the denture in place under pressure in the mouth. The wax flows away from the points needing relief. Disclosing wax is sometimes known as pressure indicator paste.

3-10. BOXING WAX

Boxing wax is used to form a box around impressions of the mouth when making a cast (model). The boxing limits the flow of either plaster of Paris or artificial stone gypsum material. Boxing wax is usually issued in red strips measuring 1 1/2 inches wide, 12 inches long, and 1/8 inch thick. Boxing wax is soft and pliable enough at room temperature to be formed into a desired shape without heating. For further softening, a strip of wax can be passed through an open flame.

3-11. LOW-FUSING IMPRESSION WAX

Low-fusing impression wax is a wax that is especially compounded so that when subjected to controlled pressure it will flow to some extent in the mouth. Its main ingredient, spermaceti, is obtained from the head of the sperm whale. Low-fusing impression wax is often used in relining or rebasing complete and partial dentures. Because it is easily distorted, impressions must be handled with care. Boxing is not recommended, and separators are not necessary when pouring the cast.

Section III. IMPRESSION MATERIALS

3-12. GENERAL

An impression is a negative reproduction of a given area of the oral cavity. The area reproduced may be composed of either hard or soft tissues or both. The material must be inserted into the mouth while it is too soft to retain its shape. A rigid base is needed to carry it to the mouth and hold it against the tissues until it hardens. For this purpose, a variety of trays, called stock trays, are available. These are shaped to fit over the average maxillary and mandibular arches. Some can be trimmed and bent to the requirements of the individual patient. Trays may also be fabricated for each individual patient.

3-13. REQUIREMENTS FOR IMPRESSION MATERIAL

a. **General.** An impression material must meet a wide range of requirements in order to provide an accurate impression of the different tissues.

b. **List of Requirements.** The following are some of the more important requirements.

(1) The material should flow or be pliable at a temperature that will not injure the oral tissue.

(2) It should set quickly, preferably within 2 to 4 minutes, at body temperature.

(3) It should unite into a solid mass without adhering to the oral tissues or to the material used for the cast.

(4) It should fall into all irregularities and fine lines in the area to reproduce without displacing soft tissue.

(5) It must retain an accurate reproduction of surface detail when it solidifies and is withdrawn from the mouth.

(6) It must have dimensional stability. It must not expand, contract, or become deformed in any way because of temperature changes, atmospheric conditions, or the pouring of the cast.

(6) It must not be too unpleasant to the patient.

(7) It must not flake (after solidifying) when trimmed with a sharp knife at room temperature.

3-14. TYPES OF IMPRESSION MATERIALS

Impression materials are of three types: the rigid type, the thermo- plastic type, and the elastic type. Thermoplastic materials soften when warmed and harden when cooled with no change in chemical makeup. Elastic materials expand and contract with no change in structure or shape. All three types have advantages and disadvantages. The dental officer determines which material best meets the requirements of each particular case. He frequently will use two or more materials to make a single impression.

3-15. AGAR-TYPE HYDROCOLLOID--CHARACTERISTICS

a. **General.** The agar-type hydrocolloids are thermoplastic, elastic materials. They are called reversible hydrocolloids because they are softened by heating, hardened by cooling, and used repeatedly. In the hardened state, they are flexible and elastic.

b. **Composition.** The basic component of these hydrocolloids is agar-agar, a product extracted from certain types of seaweed. The exact composition of the material varies with different manufacturers. Most preparations contain about 80 percent water, 15 percent agar-agar, and 5 percent chemicals and inert substances.

c. **Inert Substances.** Inert substances in the material are fillers that increase its strength and stiffness. Small amounts of borax and potassium sulfate are usually included. These chemicals do not affect agar-type hydrocolloids the same way they affect gypsum products. Borax is used to increase the strength of the hydrocolloid. However, both borax and hydrocolloid retard the setting time of gypsum products and may prevent casts from hardening. Consequently, potassium sulfate is added to the impression material to partly counteract the action of the borax.

d. **Instruments and Materials.** Figure 3-1 shows typical instruments and materials for agar-type hydrocolloid impressions. Manufacturers furnish agar-type hydrocolloids either in tubes for making impressions or in bulk form for duplicating casts. Both forms must be stored in 100 percent relative humidity in airtight containers in a cool place. A relative humidity of 100 percent indicates that the air contains as much water vapor as it can take up at a given temperature, usually room temperature. Some of the properties of the agar-type hydrocolloid impression materials are discussed below.

3-16. MIXING AND SETTING TIME

Agar-type hydrocolloids become fluid at temperatures much higher than the temperature at which they gel. The temperature range varies slightly from one manufacturer to another. The tube containing the material used in making impressions is placed in boiling water to soften the material. The tube then is stored in a water bath at a temperature of 145^o to 155^o F (63^o to 68^o C) until it is needed. Before using the tube, it is "tempered" by cooling it to about 115^o F (46^o C) so that it will be of a consistency to remain in the impression tray, set quickly, and not be uncomfortable to the patient. Since most brands gel at 97^o F (36^o C) (slightly below mouth temperature), a water-cooled tray is used. Water at about 70^o F (21^o C) is circulated through the tray for about 5 minutes to gel the impression.

3-17. DIMENSIONAL STABILITY

a. **Water Content.** The water content of agar-type hydrocolloid impression materials is most important for dimensional stability.

(1) Syneresis. When an impression made of this material is removed from the mouth into the air at room temperature, the surface contracts by giving off water to the air. This process is called syneresis and causes the outer layer of the impression to shrink and become distorted.

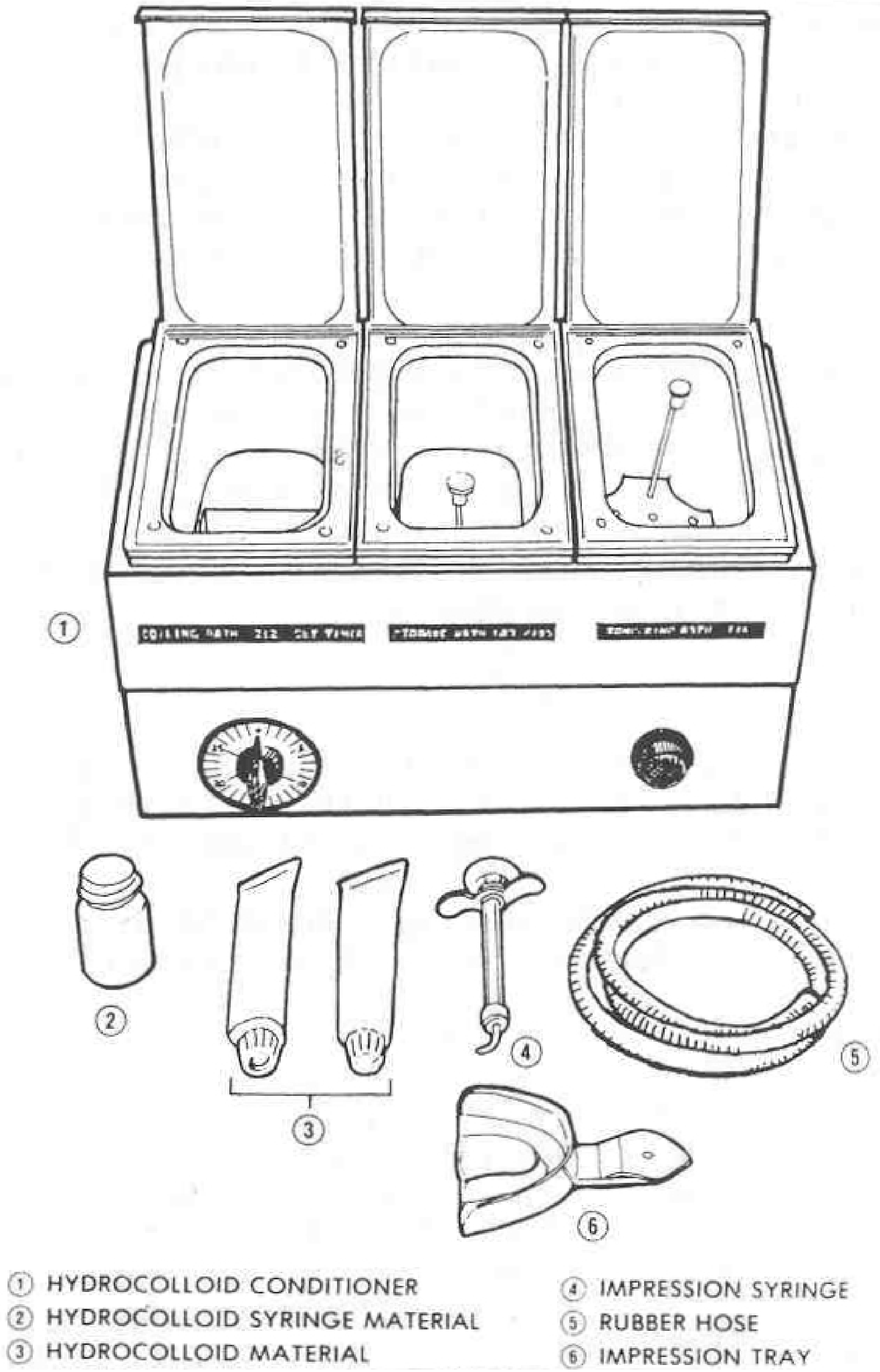

Figure 3-1. Instruments and materials for agar hydrocolloid impressions.

(2) Imbibition. If the impression is placed in water, it will expand (take up water). This process is called imbibition. Unfortunately, the expansion caused by imbibition will not restore an impression to its original dimensions.

(3) Expansion after shrinkage. The expansion does not equal the shrinkage either in volume or direction. Therefore, any attempt to restore an impression after syneresis has occurred will result in a distorted cast or die.

b. **Brief and Abrupt Stress Recommended.** The structure of the hydrocolloid gel is such that it can withstand an abrupt, brief strain (change of form or size) without fracture or permanent distortion more easily than it can withstand a gentle, prolonged strain. Therefore, the impression should be removed from undercut areas quickly rather than be "teased" over these areas. The impression always undergoes stress during removal. Stress is the internal resistance of a material to forces that disarrange its normal molecular structure. After the internal force is removed, the gel "relaxes," but the impression does not quite resume its original shape because the material is not perfectly elastic. The material is also under some slight pressure while the impression is being made. The stresses induced either relax or set when the pressure is removed. This set distorts the impression after a short time. Therefore, it is important that the casts made from agar-type hydrocolloid impression materials be poured immediately after the impressions are made.

3-18. EFFECT ON GYPSUM PRODUCTS

Some agar-type hydrocolloid impression materials retard the setting of gypsum products. The surface of a cast in contact with the gel may harden very slowly or not at all. The cast will also absorb water from the gel. As a result, the surface will be soft and rough. The hardness of the cast can be improved by "fixing" the impression with a hardening solution. For this purpose, a 2 percent solution of potassium sulfate is recommended. The impression is immersed in the solution for 5 to 10 minutes. Immersion for longer time may affect the dimensional stability of the hydrocolloid gel. The stone cast or die should be left in the impression for at least 30 minutes--preferably for 60 minutes--before the impression is separated from the cast. This is recommended because the setting time of the gypsum product in contact with the impression material will be lengthened even though a proper hardening solution is used.

3-19. ALGINATE-TYPE HYDROCOLLOID--CHARACTERISTICS

a. **General.** The alginate-type hydrocolloids are an elastic type impression material. An alginate is a salt of alginic acid (an extract from seaweed). Alginate-type hydrocolloids gel by chemical action. Once the gelation process begins, it is irreversible.

b. **Composition.** The composition of the alginate-type hydrocolloids varies with different manufacturers. The basic components are a soluble alginate (either potassium alginate or sodium alginate) and a reactor (calcium sulfate), which causes the alginate to gel. The product also contains a retarder (sodium or potassium sulfate, oxalate, or carbonate) to prevent gelation from occurring too rapidly. A fluoride is usually added to prevent retardation of the setting time of the casts. The remainder of the material is composed of fillers that increase the strength and stiffness of the gel.

c. **Usage.** Alginate-type hydrocolloids are supplied in powder form, either in bulk or in measured portions packaged in foil envelopes. The powder must be stored in a cool place. The bulk form must be kept in a tightly closed container to protect it from contamination and to prevent it from absorbing moisture from the air. The containers are agitated to loosen the bulk powders before they are measured, thus preventing use of an excessive proportion of the powder. The powder is mixed with a measured amount of water. Further discussion follows below.

3-20. DISPENSING

Water and powder measuring cups are provided by the manufacturer in each can of alginate-type material. Lines on the water measurer correspond to the number of scoops of powder used. The ratio of use is 1 to 1 or, for example, three scoops of powder to three units of water. The actual amount will vary, depending on the size of the impression tray. Prior to mixing, it is necessary to tumble the container in order to fluff the powder.

3-21. MIXING AND SETTING TIME

The best method of controlling the gelation time of alginate-type hydrocolloid materials is to alter the temperature of the water used in the mix. The higher the temperature of the water, the faster gelation will occur. Higher temperatures accelerate the chemical reaction. The temperature of the water must be regulated carefully within a few degrees of that recommended by the manufacturer to obtain a constant and reliable gelation time. The average recommended temperature of water is 70^{o} F (21^{o} C). Changing the water-powder ratio and the mixing time will alter the gelation time, but these methods of control also impair certain properties of the material. The amount of the retarder in the material can be regulated only by the manufacturer since the action of the retarder changes the nature of the material.

3-22. STRENGTH

The water-powder ratio recommended by the manufacturer must be used. Too little or too much water will weaken the gel. Mixing must be timed. Undermixing may prevent the chemical reaction from occurring evenly, and overmixing may break up the gel. Either can decrease the strength of the material by as much as 50 percent. The strength of alginate-type hydrocolloids increases for several minutes after the initial gelation. Consequently, the impression must not be removed from the mouth for at least 2 or 3 minutes after gelation has occurred.

3-23. DIMENSIONAL STABILITY

Alginate-type hydrocolloid impression materials are influenced by syneresis, imbibition, strain, and stress in the same way as the agar-type materials. Hence, for the most accurate results, the impression should be fixed and the cast poured soon after the impression is removed from the mouth. If the impression must be stored for a short period of time, it should be placed in a humidor in which the relative humidity is 100 percent.

3-24. EFFECT ON GYPSUM PRODUCTS

Alginate-type hydrocolloid impression materials affect gypsum products in the same manner as the agar-type materials affect them. Some alginates do not require the use of hardening solutions because the manufacturer has incorporated these materials in the powder. However, the hardness of the surfaces of the cast can always be improved by "fixing" the impression with a hardening solution.

3-25. SYNTHETIC RUBBER BASE IMPRESSION MATERIALS--CHARACTERISTICS

a. **General.** Synthetic rubber base impression materials are flexible, rubber-like, and sufficiently elastic to return to their original shape after slight distortion. They are used for making impressions of areas containing undercuts, especially for crowns, inlays, and removable and fixed partial dentures. Figure 3-2 shows typical instruments and materials setup for rubber base impression materials.

b. **Two Types.** There are two types of rubber base impression materials. Type one has a synthetic rubber base of silicone. Type two has a synthetic rubber base of polysulfide. Both types are polymeric compounds. These compounds are composed of molecules of the same elements in the same proportions but differing in size. The compound containing small, simple molecules is called monomer. The compound containing large complex molecules in which the atoms are joined in chains or rings is called polymer. Because of their different molecular structure, the compounds have different physical properties. The chemical process by which the molecules of monomer are combined to form polymer is called polymerization.

c. **Two Liquid Bases.** Both the silicone and polysulfide bases are liquids. They are mixed with liquid chemical reactors which polymerize them. The manufacturers add inert substances or plasticizers to the bases and sometimes to the chemical reactors to make paste of a consistency that will remain in an impression tray until polymerization has taken place. The silicone type must be stored in a cool place and will deteriorate after about 6 months. The polysulfide type does not require special storage and can be stored indefinitely.

d. **Usage.** A thin layer of this material, uniform in thickness, is required to obtain the most accurate impression with the material. For this reason, it is used in individually designed (custom) acrylic resin trays. Synthetic rubber base materials are not adhesive; therefore, a tray adhesive is needed to prevent the impression from pulling away from the tray. If the impression material pulls away from the tray, distortion will result when the tray is removed from the patient's mouth.

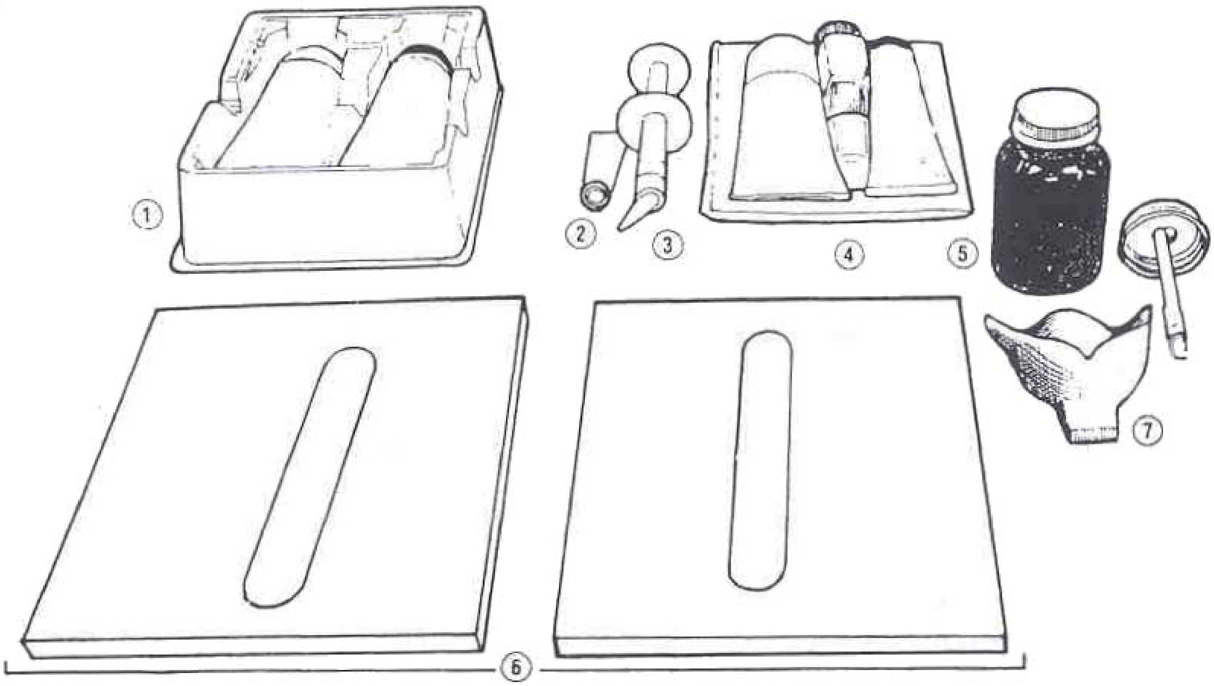

Figure 3-2. Setup for rubber base impression material.

3-26. DISPENSING

Equal lengths (usually 6 inches each) of both the rubber base impression material and the chemical reactor (a catalyst) should be laid out side by side onto a polymer paper or parchment pad. The base material has a tendency to spread once it is dispensed. For that reason, it is better to put the rubber base impression material on the pad first in order to give it time to spread. The chemical reactor should not touch the base material until everything is ready to mix.

3-27. MIXING AND SETTING TIME

The polysulfide base and its chemical reactor are both furnished as pastes that are packaged in separate tubes. The silicone base is also a paste that is packaged in tubes. Its chemical reactor may be either a paste or a bottled liquid. With both types, the proportions and the method of spatulation recommended by the manufacturer must be followed exactly. The bases and the chemical reactors are of different colors. They must be spatulated together until no streaks remain. Undermixing will prevent material from polymerizing evenly and overmixing will increase both the set and the strain pattern, but especially the set. Increased relative humidity and temperature tend to shorten both setting and mixing time, particularly for the polysulfide type. The chemical reactor is necessary to polymerize the material. It is often called an accelerator because the setting time may be shortened by increasing the amount used. It does not change the structure of the materials as does the accelerator used with gypsum products. Varying the amount of chemical reactor is the only method of changing the setting time of the silicone type.

3-28. DIMENSIONAL STABILITY

During polymerization, synthetic rubber base impression materials undergo some shrinkage that continues for some time after the impression is made, particularly with the silicone type. However, these materials are not subject to syneresis and imbibition because they are hydrophobic (water-hating). They have more dimensional stability than do the hydrocolloids. They react to strain and stress in the same way the hydrocolloids do but do not change in volume. The cast must be poured within 30 minutes after an impression is made. This is necessary because the material continues to polymerize, and bubbles trapped in the material are apt to collapse causing the cast to be faulty. No separating material is required between the rubber base impression materials and the cast or die material.

3-29. EFFECT ON GYPSUM PRODUCTS

Polysulfide-type synthetic rubber base impression materials do not interfere with the hardening of gypsum products. A cast poured into an impression made of this material will have a smooth, hard surface. Polymerization of some brands of the silicone type, however, produces gases that mar the surface of the cast.

3-30. MODELING PLASTIC--CHARACTERISTICS

a. **General.** Modeling plastic (modeling composition) is an impression material (thermoplastic type) which can be softened by heat into a soft plastic mass and then hardened by cooling with either a stream of cold water or a blast of air. Modeling plastic is used primarily to make impressions of the edentulous arches (the tooth ridges without teeth).

b. **Properties and Materials.** Modeling plastic is composed of shellac, talc, and glycerides derived from certain tallow oils. The temperature range at which softening occurs depends upon the proportions of the ingredients contained in the material. Modeling plastic is supplied in cakes, wafers, or sticks, and in various colors to aid in distinguishing between products of different softening (fusing) temperature ranges.

c. **Recommended Procedures.** Any of the gypsum products can be poured against a modeling plastic impression without the use of a separator. Also, modeling plastic is one of the impression materials against which an amalgam die can be packed. (An amalgam die is a model of a tooth in silver amalgam, used for making an inlay or crown.) Although no separating medium is required in either of these procedures, extreme care must be exercised in drawing the impression material from the cast or die, since both materials are hard and relatively unyielding. Therefore, the modeling plastic is softened in heated water, at 120° F (49° C), and removed gently so that the cast is not damaged.

3-31. IMPRESSION PASTE--CHARACTERISTICS

a. **General.** Impression paste is a thermoplastic-type impression material. It is usually supplied as two separate units, a base and a hardener. The principal ingredients are zinc oxide and eugenol. When the base and the hardener are mixed together in specific proportions, they form a paste. No separator is required when pouring the cast in an impression taken with this material.

b. **Usage.** Impression paste is used primarily as a corrective material inside an individual impression tray. It is also widely used for rebase impressions for both complete and partial dentures. (A rebase impression replaces the base material of a denture without changing the occlusal relations of the teeth.) Occasionally, it is used in immediate denture fabrication as a lining for a sectional compound impression. Impression paste can be used to provide a lining for a complete denture baseplate to make it fit both the cast and the mouth accurately.

Continue with Exercises

EXERCISES, LESSON 3

INSTRUCTIONS: Answer the following exercises by marking the lettered response that best answers the question or best completes the incomplete or by writing the answer in the space provided.

After you have completed all the exercises, turn to "Solutions to Exercises" at the end of the lesson and check your answers.

1. Select the dental material below that is 1 part calcium sulfate and 2 parts water.

   a. Hydrocolloid impression materials.

   b. Calcium hydroxide.

   c. Modeling plastic.

   d. Dental wax.

   e. Gypsum.

2. Which of the following cast materials is processed by steam heat under pressure?

   a. Plaster of Paris.

   b. Artificial stone.

3. What percentage of water is removed from the raw material to produce plaster of paris or artificial stone?

   a. 100 percent

   b. 75 percent.

   c. 50 percent.

   d. 33 percent.

4. Which of the following has particles that are rough, irregular, and porous?

   a. Plaster of paris.

   b. Artificial stone.

5. The psi for artificial stone is:

   a. 2,600.

   b. 5,000.

   c. 7,500.

   d. 12,000.

6. Match the use made of the product in Column I to the product in Column II.

	COLUMN I		COLUMN II
(1) ____	Make master casts	a.	Plaster of Paris
(2) ____	Make matrices for prosthodontic restorations	b.	Artificial stone
(3) ____	Make dies		
(4) ____	Attach casts to articulators		
(5) ____	Prismatic, more regular in shape, dense, nonporous.		
(6) ____	Rough, irregular, porous.		

7. Complete information related to the steps in the sequence of mixing either plaster of Paris or artificial stone.

   a. Obtain a clean, dry ______________ bowl.

   b. Obtain a ________________ spatula.

   c. _______________ the can of powder before mixing.

   d. _____________ is measured and poured into the bowl.

   e. Powder is _______________ into the water.

   f. All the powder from the ___________ of the bowl must be included in the mix.

   g. Avoid trapping ______________________

8. Describe the process of spatulation used in mixing gypsum products.

   a. With the spatula, stir the mix for _____ to _____ seconds.

   b. Use a _____________ or _____________ motion.

   c. _________________ the mix will entrap air bubbles and weaken the cast.

   d. ____________ the mixed material in the bowl to remove trapped air bubbles.

9. Initial setting time for plaster of paris is:

   a. 5 to 10 minutes.

   b. 8 to 10 minutes.

10. Following the initial setting time,__________ becomes hard enough to hold for carving.

    a. Plaster of Paris.

    b. Artificial stone.

11. Final setting time for artificial stone, depending of the type mixed, is:

    a. 10 to 25 minutes.

    b. 25 to 45 minutes.

12. List the methods used to hasten the setting time for gypsum products.

    a. Use ______________ water.

    b. Mix for a ______________ period of time.

    c. Use a ___________________ accelerator.

    d. Use warm water, up to __________ F.

13. Soaking the cast for several hours in a solution of borax will increase the surface hardness of:

    a. Plaster of Paris.

    b. Artificial stone.

14. Match the common use in Column I to the appropriate dental wax in Column II.

	COLUMN I		COLUMN II
(1)	____ Used to prepare patterns for crowns	a.	Utility wax
(2)	____ Used for making occlusal rims	b.	Boxing wax
(3)	____ Holds together broken pieces of a denture	c.	Low-fusing impression wax.
(4)	____ Adapts impression trays for individual impressions	d.	Inlay casting wax.
		e.	Baseplate wax
5)	____ Forms a box around impressions	f.	.Sticky wax
(6)	____ Used in relining or rebasing dentures		

15. Match the shape, color, and/or size in Column I to the appropriate dental wax in Column II.

	COLUMN I			COLUMN II
(1)	_____	Blue, green, ivory, and deep purple sticks	a.	Sticky wax
(2)	_____	Red or pink sheets (3" X 6")	b.	Utility wax
(3)	_____	Hexagonal sticks, orange or purple in color	c.	Boxing wax
(4)	_____	Stick form (red color) or rope form.	d.	Inlay casting wax
(5)	_____	Red strips (1 1/2" X 12")	e.	Baseplate wax

16. Select the dental wax that remains hard both at mouth temperature and at room temperature.

    a. Utility wax.

    b. Disclosing wax.

    c. Boxing wax.

    d. Baseplate wax.

    e. Low-fusing impression wax.

17. Select the dental wax that is pliable enough at room temperature to use without heating.

    a. Inlay casting wax.

    b. Baseplate wax.

    c. Sticky wax.

    d. Disclosing wax.

    e. Utility wax.

18. What dental wax is used to determine unequal pressure points in a denture that may cause discomfort to a patient?

    a. Sticky wax.

    b. Utility wax.

    c. Disclosing wax.

    d. Low-fusing impression wax.

19. Which dental wax permits detailed carving without flaking or chipping and can be manipulated in the mouth without injury to oral tissues?

    a. Boxing wax.

    b. Inlay casting wax.

    c. Utility wax.

    d. Low-fusing impression wax.

    e. Baseplate wax.

20. Which dental wax must be capable of holding porcelain or acrylic teeth in position both at normal room temperature and at mouth temperature?

    a. Baseplate wax.

    b. Sticky wax.

    c. Inlay casting wax.

    d. Boxing wax.

    e. Low-fusing impression wax.

21. Which dental wax is often used in relining or rebasing complete and partial dentures, but must be handled with care because it is easily distorted?

a. Baseplate wax.

b. Disclosing wax.

c. Inlay casting wax.

d. Sticky wax.

e. Low-fusing impression wax.

22. Which dental wax is usually supplied either in stick form (red in color) or in rope form?

a. Inlay casting wax.

b. Utility wax.

c. Boxing wax.

d. Sticky wax.

e. Baseplate wax.

23. When making a cast (model), which wax is used to limit the flow of plaster of Paris or artificial stone gypsum material?

a. Disclosing wax.

b. Utility wax.

c. Boxing wax.

d. Inlay casting wax.

e. Sticky wax.

24. Complete information related to impression materials.

a. An impression is a __________ reproduction of a given area of the oral cavity.

b. Impression material must be inserted into the mouth while it is too ________ to retain its _________________ .

c. ____________ ____________ carry the impression material to the mouth and provide a ______________base to hold it against the tissues until it hardens.

d. Stock trays may be ____________________ for each individual patient.

25. Describe some requirements for impression material.

a. Impression material should ____________ or be _____________ at a temperature that will not injure the oral tissue.

b. Impression material should set within _____ to_____ minutes, at body temperature.

c. It must retain an accurate ________________________n it solidifies and is withdrawn from the mouth.

d. After solidifying, it must not __________________h a sharp knife at room temperature.

26. Which type of impression material softens when warmed and hardens when cooled, with no change in chemical makeup?

a. Rigid.

b. Elastic.

c. Thermoplastic.

27. Which type of impression material expands and contracts with no change in structure or shape?

a. Rigid.

b. Elastic.

c. Thermoplastic.

28. Borax and potassium sulfate are inert substances used in:

a. Impression paste.

b. Alginate-type hydrocolloid.

c. Synthetic rubber base impression material.

d. Agar-type hydrocolloid.

29. Select the impression material for which it is important to pour the cast <u>immediately</u> after an impression is made.

a. Agar-type hydrocolloid.

b. Synthetic rubber base impression material.

c. Alginate-type hydrocolloid.

d. Modeling plastic.

e. Impression paste.

30. Tubes of agar-type hydrocolloid impression material must be softened by heating in boiling water, to the recommended temperature of:

a. 115^o F.

b. 120^o F.

c. 145^o to 155^o F.

31. A hydrocolloid impression always undergoes stress during removal. Which of the following actions is less likely to cause fracturing or permanent distortion?

    a. A gentle, prolonged strain.

    b. An abrupt, brief strain.

    c. Removal from over undercut areas by "teasing."

32. Calcium sulfate is the chemical reactor for:

    a. Agar-type hydrocolloid.

    b. Type one synthetic rubber base impression material.

    c. Alginate-type hydrocolloid.

    d. Type two synthetic rubber base impression material.

33. Select the impression material that uses water and powder in a one to one ratio.

    a. Synthetic rubber base impression material.

    b. Modeling plastic.

    c. Agar-type hydrocolloid.

    d. Impression paste.

    e. Alginate-type hydrocolloid.

34. Of the two types of synthetic rubber base impression materials, <u>type one</u> refers to a synthetic rubber base of:

    a. Silicone.

    b. Polysulfide.

35. Select the impression material that needs a tray adhesive to prevent it from pulling away from the tray.

    a. Agar-type hydrocolloid.

    b. Modeling plastic.

    c. Alginate-type hydrocolloid.

    d. Synthetic rubber base impression material.

36. Which of the following impression materials is easier to access and to use?

    a. Silicon rubber base impression material.

    b. Agar-type hydrocolloid.

    c. Polysulfide rubber base impression material.

    d. Alginate-type hydrocolloid.

    e. Modeling plastic.

37. Select the impression material for which it is important to pour the cast within 30 minutes after an impression is made?

    a. Agar-type hydrocolloid.

    b. Synthetic rubber base impression material.

    c. Alginate-type hydrocolloid.

    d. Modeling plastic.

    e. Impression paste.

38. Which of the following impression materials is supplied in stick form, or as wafers or cakes, and uses various colors to indicate different softening temperature ranges?

    a. Synthetic rubber base impression material.

    b. Agar-type hydrocolloid.

    c. Impression paste.

    d. Alginate-type hydrocolloid.

    e. Modeling plastic.

39. Select the impression material used for rebase impressions for both complete and partial dentures and that is also used to provide a lining for a complete denture baseplate.

    a. Synthetic rubber base impression material.

    b. Modeling plastic.

    c. Agar-type hydrocolloid.

    d. Impression paste.

    e. Alginate-type hydrocolloid.

40. Which impression material is composed of shellac, talc, and glycerides derived from certain tallow oils?

    a. Modeling plastic.

    b. Agar-type hydrocolloid.

    c. Impression paste.

    d. Alginate-type hydrocolloid.

    e. Synthetic rubber base impression material.

Check Your Answers on Next Page

SOLUTIONS TO EXERCISES, LESSON 3

1. e (para 3-1a)

2. b (para 3-1b)

3. b (para 3-1b)

4. a (para 3-1b)

5. c (para 3-3)

6. (1) b
   (2) a
   (3) b
   (4) a
   (5) b
   (6) a (paras 3-2a and 3-3a)

7. a. rubber
   b. plastic
   c. Agitate
   d. Water.
   e. sifted
   f. sides
   g. air bubbles (paras 3-2b and 3-3b)

8. a. 30 to 60
   b. knifing; stirring
   c. Whipping
   d. Vibrate (paras 3-2b and 3-3b)

9. a (para 3-2c)

10. a (para 3-2c)

11. b (para 3-3c)

12. a. less
    b. longer
    c. chemical
    d. 85^{o} (para 3-2c)

13. b (para 3-3c)

14. (1) d
    (2) e
    (3) f
    (4) a
    (5) b
    (6) c (paras 3-5 through 3-11)

15. (1) d
    (2) e
    (3) a
    (4) b
    (5) c (paras 3-5 through 3-10)

16. d (para 3-6b)

17. e (para 3-7)

18. c (para 3-9)

19. b (para 3-5b)

20. a (para 3-6c,d)

21. e (para 3-11)

22. b (para 3-8)

23. c (para 3-10)

24. a. negative
    b. soft; shape
    c. Stock trays; rigid
    d. fabricated (para 3-12)

25. a. flow; pliable
    b. 2 to 4
    c. reproduction
    d. flake (para 3-13)

26. c (para 3-14)

27. b (para 3-14)

28. d (para 3-15c)

29. a (para 3-17b)

30. c (para 3-16)

31. b (para 3-17b)

32. c (para 3-19b)

33. e (para 3-20)

34. a (para 3-25b)

35. d (para 3-25d)

36. c (paras 3-25a, c, 3-28, 3-29)

37. b (para 3-28)

38. e (para 3-30b)

39. d (para 3-31)

40. a (para 3-30b)

End of Lesson 3