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Progress Report

DENTURE RELINERS -
DIRECT, HARD, SELF-CURING RESIN

by

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Abstract

Physical properties of direct, hard, self-curing denture reliners which have gained considerable clinical acceptance were investigated. New procedures for evaluating heat rise, plasticizer in the monomer and polymer, impression detail, and flow were developed.

The reliner slurry mixes harden in a few minutes with considerable evolution of heat with the formation of a porous resin. Water sorption values are similar to those of denture base resins, but water solubility is somewhat higher. Most commercial products change color when exposed to a sunlamp. Knoop hardness, indentation recovery, and transverse strength of the products are poorer than for denture base resin. Many materials are quite tacky at the time suggested by the manufacturer for removal of the relined denture from the mouth. When properly cured reproduction of detail is adequate. A clinical study showed no significant dimensional change or warpage for a number of relined dentures. Due to their high porosity, ease of staining and difficulty to take an accurate impression under clinical conditions the

direct, self-curing, hard, relining resins should be considered as temporary expedients.

1. INTRODUCTION

Materials for relining dentures have been available to the dental profession for a number of years and have gained considerable clinical acceptance. Although a number of papers have described technics for using these materials little information about their physical properties is available. In this paper a survey of the properties of a number of commercial hard-setting reliners is reported.

Denture reliners have properties similar to self-curing denture base and self-curing repair materials. Therefore, whenever possible, the tests described in American Dental Association Specification No. 12 for Denture Base Resin [1] and American Dental Association Specification No. 13 for Denture Self-Curing Repair Resins [2] were used. Obviously, some tests were modified or new procedures had to be developed. Details of these methods are described later.

2. EXPERIMENTAL PROCEDURE

2.1 Materials Investigated

Six brands of self-curing reliners which were considered representative of the hard reliners available on the market were examined. The materials were purchased in June 1957 and are listed in Table 1. One of the products was withdrawn by the

manufacturer before completion of the tests. The identification numbers in subsequent tables are not in the same order as the brands listed in Table 1 because it was not the purpose of this report to compare brands but to determine properties of reliners These brands were selected as representative of this class of denture reliners at the time the investigation was initiated. The data may not be applicable to materials manufactured later under the same designations.

2.2 Mixing Technics

The monomer-polymer slurries were mixed according to the manufacturers' directions at 23 ± 2°C (73.4 ± 3.6°F) and 65 ± 10% relative humidity. If no specific mixing procedures were given, the monomer-polymer slurries were mixed for 30 seconds in a glass mixing jar with a stainless steel spatula and then vibrated for 15 seconds to eliminate any air incorporated in the mix during spatulation.

2.3 Physical Properties of Uncured Resin

2.3.1 Packing Test

The uncured resin was subjected to a packing test similar to that described in American Dental Association Specification No. 12 [1]. The only modification of this specification test was omission of the 5000 g load. Only the glass plate was placed on top of the specimen. As can be seen from Table 2 all materials passed the test; that is, they could be intruded into at least two holes of the die to a depth of not less than 0.5 mm. Some difficulties were encountered in removing the hardened reliner from the die.

The consistency of the slurries, mixed as previously described, was determined as follows: 0.5 ml of the mix was placed in the center of a glass plate approximately 6 cm square, a similar plate weighing 6 to 8 g was placed on top of the mix immediately. Two minutes after start of the mix a 907 g (2 lb) weight was placed on the top plate and allowed to remain for 5 minutes, then removed and the diameter of the resulting disk was measured. The average of three equally spaced diameters was considered as an index of the consistency. The consistency of the materials varied from 3.6 to 4.6 cm (Table 2).

2.3.2 Temperature Rise

Because the reliners are applied directly to the denture and placed in contact with the oral tissue, the temperature of the relining material during polymerization is important. Excessively high temperatures resulting from the polymerization of the resin during hardening may injure the tissues.

The amount of material polymerized on relining a denture is considerable. It is much larger than the quantity of monomer-polymer slurry used in resin fillings. The relining slurry is spread over a large surface area of the denture and hence some of the heat produced will be dissipated readily. The ring used in the test described below was of dimensions which would approximate the clinical conditions with respect to the quantity of reliner used and the surface area of the relining material on the denture.

The mixed slurry was placed in a brass ring, (60 mm inside diameter, 67 mm outside diameter and 2 mm high) supported on a flat glass plate lined with 0.03 mm thick polyethylene in a 37 ± 2°C (98.6 ± 3.6°F) bath at 100% relative humidity. The temperature rise was measured with a fine wire thermocouple (30 gauge) which passed through two grooves cut in one side of the ring. The junction of the thermocouple was adjusted to within 2 mm of the center of the ring by index lines ruled on the glass plate. A sheet of polyethylene and a second glass plate were placed on top of the slurry. Temperature readings were made at 30-second intervals from 2 minutes after the start of mix until 2 minutes after the maximum temperature had been reached. Also, the time the peak temperature occurred was noted. The tests were run in duplicate and results varied ± 2°C (3.6°F) in peak temperature and ± 1 minute in peak time, in most instances.

The temperature rise of slurries polymerized at 23 ± 2°C (73.4 ± 3.6°F) and 65 ± 10% relative humidity was also measured.

The peak temperatures and the time of occurrence of these peaks are shown in Table 3. As would be expected, peak temperatures were much lower and occurred later when the materials were polymerized at the lower temperature; that is, 23°C (73.4°F). Reliners cured at 23°C had peak temperatures ranging from 30°C (86.0°F) to 53°C (127.4°F) which were reached after 13 to 38 minutes from start of the mix. When the polymerization temperature was raised to 37°C (98.6°F) peak temperatures ranged from 59°C (138.2°F) to 79°C (174.2°F) and appeared between 6 and 11 minutes.

increase in peak temperature resulted in the occurrence of the peak in a shorter interval of time.

It is very doubtful that temperatures as high as 79°C (174.2°F) can be tolerated by the oral tissues. Instructions usually state that the relined denture be removed within 30 seconds to 4 minutes after seating in the mouth. Therefore, the relined denture is not in contact with the tissue when the peak temperature is reached. Any delay in removal may result in serious injury to the patient and must be avoided.

2.3.3 Plasticizer in Monomer and Polymer

The powders and some of the liquids of the reliner contain appreciable amounts of plasticizers. Large amounts of plasticizer in the hardened material affect physical properties such as hardness and transverse strength. Plasticizers may also leach out slowly, changing the physical properties of the relined denture.

The percentage of plasticizer in the monomer was determined by measuring the residue left on slowly heating 5 g of monomer at 180 mm Hg pressure and finally heating at 100°C (212°F) and 1 mm Hg for at least 8 hours. The percentage of non-volatiles, which are nearly pure plasticizer, as well as the identification of the plasticizers from their infrared absorption spectra are given in Table 4. Plasticizer content varies from 26% to negligible amounts.

The plasticizer content of the polymers was obtained by determining the quantity of methanol soluble extract from the powder. Five grams of powder were extracted in a Soxhlet extractor

for 48 hours with 100 ml of methanol. The solvent was evaporated from the extract which was then subjected to a pressure of 180 mm Hg and finally to 1 mm Hg or less. Plasticizer content of the powder varies from 4 to 14%. Infrared absorption spectra of these extracts were used to identify the plasticizers. Difficulties were encountered with sample 3 since the methanol extract contained solid products which could not be readily identified.

2.4 Properties of the Cured Resin

2.4.1 Water Sorption and Solubility

2.4.1.1 Preparation of the Specimens

Since it was found that curing pressure affects the porosity of the disk specimens, two methods were used to prepare the disk for the water sorption and solubility tests.

Pressure-cured disks, 50 ± 1 mm in diameter 0.5 ± 0.1 mm thick were made by the following procedure: The monomer-polymer slurry was placed in a tin foiled (thickness of tin foil 0.001 in.) stainless steel die in a flask. Dimensions of the die are given in American Dental Association Specification No. 12 [1]. After closure the flask was compressed in a flask press. Thirty minutes from start of the mix the flask was removed from the press and the specimen trimmed. The procedure as described in American Dental Association Specification No. 12 was followed thereafter.

The low pressure specimens were made as follows: The reliner was mixed and placed in the die as before. The flask was closed and a 907 g (2 lb.) weight placed on top of the flask. The

total load on the specimen was 1360 ± 115 g (3 lb. ± 4 oz.). The remainder of the test was conducted as before.

In both procedures curing was accomplished at 23 ± 2°C (73.4 ± 3.6°F) and 65 ± 10% relative humidity.

2.4.1.2 Water Sorption

Results of the water sorption determinations are shown in Table 5. All the materials tested met the requirements for water sorption of the American Dental Association Specification No. 12. Differences in water sorption values among the brands were small, varying from 0.3 to 0.4 mg/cm^2 for pressure-cured specimens. The sorption of disks cured under low pressure was slightly higher. With the exception of sample 1 apparent water sorption decreased if the specimens were kept in water for 14 days. The lower values are probably due to the leaching out of soluble constituents of the hardened materials.

2.4.1.3 Water Solubility

Only one of the brands investigated passed the requirements of American Dental Association Specification No. 12 [1] for water solubility. Solubility values for pressure-cured disks (Table 5) ranged from 0.04 to 0.14 mg/cm^2. Sample 6 has a somewhat higher solubility than the other materials. Specimens cured under little pressure (1360 g load) have about the same solubility as those prepared under higher pressure.

It is conceivable that plasticizer can be leached out of the relining resin when the material is stored in water. Therefore, the cured reliner disks were placed in distilled water for one

week. The water was then changed. After immersion for a total of 14 days the disks were dried to constant weight. Solubility values increased three to four times that of the one day test and ranged from 0.13 mg/cm^2 to 0.23 mg/cm^2 (Table 5). There appears to be no correlation between plasticizer content and 14-day solubility.

2.4.2 Porosity

One of the most frequent complaints about denture base relining materials is the unpleasant odor the denture often acquires after relining. This odor may result from the breakdown of food which becomes lodged in the pores of the reliner. The surface porosity of hardened reliner specimens, cured in a flask clamped in a press or under 1360 g (3 lb.) load, was investigated visually. Five circles, 5 mm in diameter, were drawn with one in the center and four evenly spaced around the circumference on the water solubility disks. The average number of bubbles in each circle that could be seen at an approximate magnification of 1.5 times in natural light is given in Table 6. Some specimens cured in the clamped flask had less porosity than those cured under the 1360 g load. Difficulties arose when there were too many bubbles or the size of the bubbles was too small to be counted at the 1.5 times magnification. Figure 4 shows the surface porosity of a hardened relining resin used in the detail impression test.

2.4.3 Color Stability

A change in color of the relining material is particularly undesirable if the patient shows the periphery of the denture in smiling or speaking. Therefore, the color stability of the relining resins was determined according to American Dental Association Specification No. 12 [1]. Specimens cured under pressure as outlined in the specification and specimens cured under a total load of 1360 g were used. Results of the color stability tests are given in Table 7 and Figure 1. Only one of the products passed the color stability test of American Dental Association Specification No. 12. Color stability of specimens cured under 1360 g load was sometimes poorer than flask-cured specimens of the same brand.

2.4.4 Knoop Hardness

Hardness tests separate the soft reliners that contain high percentages of plasticizer from the hard reliners.

Specimens for hardness tests were prepared at 23 ± 2°C (73.4 ± 3.6°F) and 65 ± 10% relative humidity in a dental stone mold 34 mm long, 12 mm wide and 1.5 mm deep, lined with tin foil. A strip of tin foil, a glass plate and a 2000 g weight were placed on top of the mold. The cured specimens were removed from the mold 30 minutes after start of the mix. They were surfaced plane on a No. 400 Aloxite paper, followed by 3/0 and 4/0 emery paper. Final polishing was accomplished on a metallographic lap using a felt covered wheel and levigated alpha alumina.

Knoop numbers were determined 24 hours after mixing using a 100 g load, 10 second descent and 20 second contact. At least two specimens of each reliner were used. Ten indentations were made on each specimen.

The Knoop hardness numbers ranged from 9.5 to 13.5 kg/mm^2 (Table 8). Hardness values for different specimens of the same brand usually agreed within ± 0.5 Knoop numbers. The brand having the most plasticizer in the monomer was the softest.

2.4.5 Indentation and Recovery

Indentation and recovery values measure a combination rather than a single physical property of the cured reliner. However, this test gives a valuable index for such physical properties as elastic and plastic deformation under load.

Indentation and recovery were determined by the procedure of Sweeney, Sheehan and Yost [3]. The specimens were prepared in the same manner as the Knoop hardness specimens. A Rockwell superficial hardness tester employing a minor load of 3 kg, a major load of 15 kg and a 1/2 in. steel ball was used. The minor load was employed for the fiducial reading and the major load, which was applied for 10 minutes, was used to indent the resin. The recovery was obtained by subtracting the depth of the indentation under the 3 kg load 10 minutes after removal of the major load from the depth under the 15 kg load and dividing the difference by the depth of indentation caused by application of the major load. Indentation and recovery were determined after 1, 4 and 24 hours (Table 8). Sample 1 that contained the largest percentage of plasticizer in the cured

resin and hardened slower than the other products, had the largest indentation and the lowest recovery. Values for the other brands did not vary significantly.

2.4.6 Transverse Strength of Relined Denture Base Resin

To determine the effect of relining on the transverse strength of denture base resin, heat cured denture base specimens of 2.5 mm thickness were relined with the various brands so that the final thickness of the relined specimens was approximately 3 mm. Transverse specimens of S. S. White clear denture base resin, made according to directions given in American Dental Association Specification No. 12 [1], were placed in a metal mold having the same dimension as the specimens with the exception of the thickness which was 3 mm. Relining slurries of the different brands were applied to the top surface of the specimens. To ensure even deposition of cured reliner the mold was overfilled. A tin foiled glass plate and a 907 g (2 lb.) weight were placed on the specimens and the reliner was allowed to cure. Excess slurry caused formation of a flash and made the specimens 3.2 to 3.5 mm thick, that is, 0.2 to 0.5 mm oversize.

The specimens were placed in distilled water at 37°C (98.6°F) for 48 hours and tested according to American Dental Association Specification No. 12. The average of the transverse strength of four specimens of each brand was compared with specimens (3 mm thick) of heat cured denture base resin. Because of the variance in the thickness among the specimens the test should be considered

semi-quantitative.

Average breaking load ~~transverse strength~~ of the relined specimens varied from 6,500 to 10,500 g ~~psi~~. Transverse strength of specimens relined with brands 3, 2 and 4 were slightly higher than that of the standard. Relining with sample 1 produced a significant reduction in transverse strength. This indicates that a high percentage of plasticizer in a reliner as is present in product 1 lowers the strength of the denture.

2.4.7 Detail and Impression Flow Test

A reliner should take and keep a detailed impression of the denture supporting tissue. The material should also show little tackiness at the time the manufacturer recommends removal of the relined denture. Directions for four of the materials suggest that the reliner be separated initially from the tissue by cellophane, polyethylene or petrolatum.

Two methods were investigated to estimate reproduction of detail. The more rigid test was conducted as follows: At the time recommended in the directions for placing the reliner on the denture, the slurry was placed in a tray consisting of an aluminum form (70 mm square and 25 mm deep) which rested on a glass plate covered with polyethylene. A separator (cellophane or polyethylene) was placed on top of the reliner slurry if this was suggested in the directions, otherwise a thin coat of petrolatum was placed on the impression block (Figure 2), the dimensions of which are given in American Dental Association Specification No. 3 [4]. At the time recommended for seating the denture the

block weighing 430 g was placed on top of the reliner slurry and a Lucite form was placed around the block to prevent the relining material from escaping from the top of the crevice between the form and the test block. The block was removed according to instructions for removal of the relined denture from the mouth. However, some reliners adhered strongly to the separating medium at the recommended removal time. If this occurred, the reliner was removed in the shortest time at which the detail was not seriously affected. Tackiness, detail of the impression, as well as the flow of the reliner were noted during the minute between the removal and the replacement of the test block. The block was finally removed from the relining resin in from one to three minutes after positioning.

The final impressions were judged for the amount of detail they retained; that is, if the ridges corresponding to the large cross grooves of the test block (Figure 2) were sharp, if the ridges corresponding to the fine grooves were complete and visible to the unaided eye, and on how well the points of the pyramids were reproduced. Any flow of the cured material with time, that is, loss of detail, was also noted. In one series all phases of the test were conducted at 23 ± 2°C (73.4 ± 3.6°F) and 65 ± 10% relative humidity. In the second series, the block was kept at 37 ± 2°C (98.6 ± 3.6°F) and 100% relative humidity and placed at that temperature on the reliner which had been mixed at room temperature. When the block was removed the reliner was taken out of the bath

and stored at room temperature.

Results of the detail impression test are given in Tables 9 and 10. Some of the reliners have considerable flow after first removal of the test block. Detail of the impression was often improved on placing the block back on the material. However, a number of materials had hardened to such an extent that replacing the test block did not improve detail. Final detail was judged good for 2 brands cured at 23°C and 3 brands at 37°C. None of the reliners flowed appreciably after the 37°C cure, but two materials still showed flow after the total time allowed for curing at 23°C. Although experimental conditions were chosen to approximate clinical conditions, clinical experience may not always correlate with the results obtained.

A simpler detail impression test was also conducted. A die shown in Figure 3 that has been described in a proposed specification for detail impression of alginate materials was employed [5]. It contains seven "V" grooves cut at a 60 degree taper and ranging in width from 0.0015 in. to 0.0120 in. The reliner slurry was poured in a ring (3/16 in. high and inside diameter 7/8 in.) which rested on the test block. A tin foil-covered glass plate weighing 6 to 7 g was placed on top. The ring and hardened reliner were removed from the die 30 minutes after starting the mix and the lines reproduced on the reliner were visually inspected. All products clearly reproduced the seven lines of the test block over the full width of the ring indicating that the flow of the

slurry and the detail of the impression of the cured material are quite adequate. A typical detail impression given in this test by one of the reliners is shown in Figure 4.

2.5 Clinical Results

The effect of self-curing relining resin on several clinically serviceable dentures was studied. Linear measurements were chosen as the criterion for dimensional change or warpage occurring in these dentures. Measurements recorded were: (1) distance from second molar to second molar (2) distance between buccal flanges on the tissue side. A previous study [6] has demonstrated that the dimensional changes occurring across the second molars and buccal flanges are larger than changes occurring antero-posteriorly. Like changes occurring on the tissue and on the polished surfaces of a denture indicate a symmetrical shrinkage or expansion whereas a differential change indicates warpage.

Six dentures (four uppers and two lowers) were chosen from a group of patients exhibiting good oral health, having correct occlusal relationships, and having had satisfactory functional service from these dentures for at least four years. Five of these dentures were prepared and relined; as a control, the sixth was not altered. Three of the dentures had been fabricated of self-curing resins, the other two of heat-curing resins. Material 1 was selected to reline the five clinical dentures because its high plasticizer content would be expected to affect the dentures more than the others. Also it had lower physical properties as represented by hardness, resistance to indentation, and recovery.

Measurements on linear dimensional change were observed on steel pins inserted in second molars and buccal flanges, as described by Mowery, et al [7]. The measurements were accurate to 0.01%. Prior to measuring, the dentures were placed in distilled water at 22° ± 1°C (71.6 ± 2°F) for one-half hour, wiped dry and aligned on the microscope at 22° ± 1°C and 65% ± 10% humidity.

Measurements were made of the original denture, after grinding out the inside of the denture to receive the reliner, and one hour, twenty-four hours, eight days, and one, two, three, four and six months after the start of the mix.

The reliner was proportioned and mixed according to the manufacturer's instructions. Some monomer was applied sparsely to the roughened inner surface of the denture. The reliner was uniformly applied five minutes after the start of the mix. The patient's mouth was freed from excess saliva, dentures were inserted seven minutes after the start of the mix, carried to place manually, and the patient was instructed to close into centric occlusion. The borders were molded and the patient was instructed to close into centric occlusion two or three times and then to hold this position for four to five minutes. At this time the denture was removed from the mouth and allowed to cure in air for twenty-five minutes before placing it in water for the one-hour measurement.

All patients experienced a rather unpleasant burning sensation immediately following insertion of the denture containing the relining material. Duration of this burning sensation was one minute or less and was eased somewhat by spraying cold water

on the periphery of the denture. Only very minor denture adjustments on the tissue surface were made on three of the five relinings. The other two dentures did not require any adjustments. Patients were satisfied with the improved fit of their dentures, although two patients commented on the somewhat rough inner surface. One patient had difficulty keeping the tissue-bearing surface as clean as he wanted to and used an abrasive cleanser which caused some blanching of the reliner. New dentures were made for all six patients at the conclusion of this study.

The results of the dimensional changes occurring are shown in Table 11. The greatest change over the six-month period was +0.0044 inch or a change of +0.17 percent. The one denture not relined changed +0.0030 inch or +0.12 percent during this same period. In the way of comparison, the linear curing shrinkage on a heat-cured poly(methyl methacrylate) denture is normally about 0.5 percent [8]. Furthermore, an increase from 22°C (71.6°F) (room temperature) to 37° C (98.6°F) (body temperature) would alone produce an expected dimensional change of +0.12 percent in a resin denture.

It seems apparent that no significant dimensional change or warpage occurred on the five dentures relined in this study. Any expected change from the addition of the reliner to the denture would most likely have occurred during this six-month period.

As mentioned in the discussion of the physical properties most of the reliners did not retain their color when exposed to the sunlamp for twenty-four hours. Figure 5 shows two dentures

relined with material 1 after four years of clinical service. According to the dentist and the patient, the color match was fairly good at the time these dentures were relined. However, after four years, the reliner had turned to a light orange-brown color (Figure 5). This color was almost identical with that of the disk of this material after twenty-four hours of exposure in the color stability test, indicating the validity of this test.

The relined surfaces of two dentures after four years' service (Figure 6) show porosity, erosion and even crazing (see arrow, upper denture Figure 6). Also evident is a considerable amount of staining on the relined surfaces even though this patient did not smoke and maintained scrupulous oral hygiene. The patient and the dentist reported that this amount of porosity was not evident immediately after relining but developed subsequently. This may have been caused by the gradual release of the plasticizer from the reliner.

The amount of surface and subsurface porosity on a circumscribed area of the tissue-bearing surface (Figure 6) is readily seen upon a slight magnification (Figure 7).

3. SUMMARY

Direct, hard, self-curing, denture reliners harden with considerable rise in temperature. When cured under clinical conditions, porous resins are obtained. Water solubility and recovery values are poorer than those for self-curing denture

base resins. Color stability of most brands is unsatisfactory. Materials often show tackiness at the time suggested by the manufacturer for removing of the relined denture from the mouth. Detail reproduction of the surface of the tissues appears adequate. A clinical study of relined dentures gave no significant warpage or dimensional change.

The photographs of the relined dentures (Figures 5, 6, and 7), the results of the laboratory and clinical tests of the direct, hard, self-curing reliners and a consideration of their comparative advantages and disadvantages indicate that the direct reliners are not adequate for long term clinical serviceability. It is thought that a more permanent type of relining service should be encouraged at the professional level and recommended to the patient. The direct self-curing hard relining resins should be considered as temporary expedients.

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Table 1

MATERIALS INVESTIGATED

Reliners	Batch No.		Manufacturer
	Powder	Liquid	
Acraliner	53	63	Acralite Co., New York, New York.
Acri-Lux Speed-Liner, Pink	None	1206,677	Acri-Lux Dental Mfg. Co. Long Island City, N. Y.
Contak Reliner	21317	3817	L. D. Caulk Co. Milford, Del.
Durabase, Pink	CGD	DGC	Reliance Dental Mfg. Co. Chicago, Ill.
Justi Permanent Reliner	3-542	32	H. D. Justi and Son, Inc., Phila., Pa.
Lang's Self-Curing Rebase, Acrylic, Pink	None	None	Lang Dental Mfg. Co. Chicago, Ill.

Table 2

PACKING AND CONSISTENCY TESTS

Material	Packing Test	Consistency[a/] Av. Diameter cm
4	Pass	3.6
3	Pass	3.7
1	Pass	3.9
2	Pass	4.1
5	Pass	4.1
6	Pass	4.6

a/ 0.5 ml subjected to 2 lb. load.

Table 3

PEAK TEMPERATURES AND PEAK TIMES

	Polymerized at			
	23°C		37°C	
Material	Peak Temp. °C	Peak Time Min.	Peak Temp. °C	Peak Time Min.
6	30	38	59	11
1	40	26	63	11
4	41	16	67	7
2	50	17	62	10
5	50	14	73	7
3	53	13	79	6

Table 4

PLASTICIZERS IN RELINERS

Material	Monomer		Polymer	
	Plasticizer	Nonvolatile %	Plasticizer	Methanol Soluble %
3	---	Negligible	Mixture	4
4	---	Negligible	MPEG[a]	13
5	DBP[b]	3	P or B[c]	11
2	DBP	15	MPEG	14
1	BPBG[d]	26	MPEG	11

a/ MPEG = Methyl phthalyl ethyl glycolate.

b/ DBP = Di-n-butyl phthalate.

c/ P or B = Phthalate or benzoate.

d/ BPBG = n-Butyl phthalyl-n-butyl glycolate.

Identification of the plasticizers from infared absorption spectra by Miss K. M. Wharton of the Textiles Section, National Bureau of Standards.

Table 5

APPARENT WATER SORPTION AND SOLUBILITY

Material	Apparent Water Sorption			Water Solubility		
	1 day		14 days	1 day		14 days
	Pressure Cured[a]	Cured Under 3 lb. Load	Pressure Cured[a]	Pressure Cured[a]	Cured Under 3 lb. Load	Pressure Cured
	mg/cm^2	mg/cm^2	mg/cm^2	mg/cm^2	mg/cm^2	mg/cm^2
2	0.31	0.37	0.23	0.04	0.02	0.13
5	0.27	0.33	0.15	0.05	0.07	0.23
3	0.34	0.43	0.23	0.06	0.08	0.16
4	0.31	0.45	0.25	0.06	0.06	0.16
1	0.41	0.51	0.65	0.07	0.06	0.22
6	0.34	0.39	--	0.14	0.14	--
Denture Base resin (ADA Spec. No. 12)	≤ 0.7	--	--	≤ 0.04	--	--

(a) Flasked and held in clamp.

Table 6

POROSITY OF RELINING RESINS

Material	Porosity: Pressure Cured	Porosity: Cured Under 3 Lb. Load
	(No. of bubbles per 0.5 cm diameter circle)	
2	0	1
5	0	4
1	1-2	1-2
4	2	10+
3	10+	10+
6	10+	10+

Table 7

COLOR STABILITY OF RELINERS

Material	Color Change of Reliner[a]
5	None
3	Turns slightly - perceptible yellow
1	Turns marked orange
4	Turns very marked orange
2	Turns very marked orange
6	Turns extreme grey-green
Denture base resin	None

a/ Specimens cured according to American Dental Association Specification No. 12.

Table 8

INDENTATION HARDNESS AND INDENTATION AND RECOVERY

Material	Knoop Number	Indentation after			Recovery after		
		1 Hour	4 Hours	24 Hours	1 Hour	4 Hours	24 Hours
	kg/mm^2	mm	mm	mm	%	%	%
2	13.5	0.16	0.10	0.08	29	54	68
4	12.5	0.12	0.09	0.09	33	53	67
3	12.5	0.12	0.08	0.075	31	48	63
5	11.5	0.12	0.10	0.08	26	47	66
1	9.5	0.26	0.17	0.11	13	30	51
Acrylic Denture Base	18-20	--	--	0.08-0.09	-	-	80-85

Table 9

DETAIL IMPRESSION OF RELINERS CURED AT 23°C

Material	Loading Time[a]	Tackiness	Initial Impression		Final Impression[b]	
			Flow	Detail	Flow	Detail
	min.					
1[c]	13-17	Moderate	None	Good	None	Good
2[c]	5-6	None	None	Good	----	----
6[d]	1.5-5	None	None	Good	None	Good
5[d]	1.5-5	None	Excessive	Fair	Moderate	Good, lost by flow
4[d]	1.5-5	None	Excessive	Good	Slight	Fair
3[d]	1.5-5	None	Very slight	Poor	None	Poor

a/ Time interval that block remained in position. Zero time is start of mixing.

b/ After repositioning impression block on material 6 to 7 minutes from start of the mix for brands 3 to 6 and 18 to 21 minutes from start of the mix for brand 1. No separating medium was used.

Separating medium: c/ petrolatum

d/ polyethylene film.

Table 10

DETAIL IMPRESSION OF RELINERS CURED AT 37°C

Material	Loading Time [a]	Initial Impression			2nd Loading Period, [a] [b]	Final Impression	
		Tackiness	Flow	Detail		Flow	Detail
	Min.				Min.		
1[c]	6.5 - 10.5	Moderate	-	Good	11.5 - 12.5	None	V. Good
2[c]	5.0 - 5.5	Slight	None	Fair	6.5 - 7.5	None	Good
5[d]	1.2 - 3	None	-	Fair	4 - 6	None	Good
3[e]	1.5 - 2.5	Slight	-	Fair	3.5 - 4.5	None	Fair
4[d]	1.2 - 2	None	Large	Poor	4 - 6	None	Poor

a/ Interval of time that block remained in position. Zero time is start of mixing.

b/ No separating medium used.

Separating medium: c/ petrolatum

d/ cellophane

e/ polyethylene film

Table 11

CUMULATIVE DIMENSIONAL CHANGES[a/] of RELINED DENTURES

Denture	Distance			Time Period							
	Molar	Flange	Ground Out	1 hr	24 hrs	8 days	1 mo	2 mo	3 mo	4 mo	6 mo
	in	in	%	%	%	%	%	%	%	%	%
U_1	2.2114 --	-- 2.2995	-0.04 -0.06	+0.01 -0.01	-0.06 -0.06	-0.02 -0.02	+0.02 +0.02	-0.01 +0.01	0.00 +0.03	+0.02 +0.04	0.00 +0.03
U_2	2.0271 --	-- 2.6185	+0.01 +0.02	+0.02 +0.01	+0.01 +0.03	+0.03 +0.02	+0.01 +0.05	+0.03 +0.05	-- --	-- --	+0.03 +0.04
U_3	2.3062 --	-- 2.8006	-- --	-0.03 -0.04	-0.01 -0.11	+0.04 -0.06	+0.04 +0.06	0.00 +0.05	-- +0.06	-- +0.09	-- +0.06
U_4 (Control)	2.0155 --	-- 2.4309	-- --	-- --	-- --	-- --	-- --	-- --	+0.06 +0.11	-- --	+0.01 +0.12
L_1	2.1719 --	-- 2.7410	0.00 -0.02	-0.06 -0.03	0.00 +0.01	+0.03 +0.05	-0.01 +0.02	-0.02 +0.06	-0.05 +0.06	-0.07 +0.05	-0.07 +0.05
L_2	1.9506 --	-- 2.6045	+0.02 +0.04	0.00 +0.05	+0.02 +0.05	0.00 0.00	-0.03 +0.05	-0.03 +0.04	-0.04 +0.04	+0.03 +0.11	+0.07 +0.17

a/ Measurements are accurate to ±0.01% (±0.0002 in. per 2 in. distance)

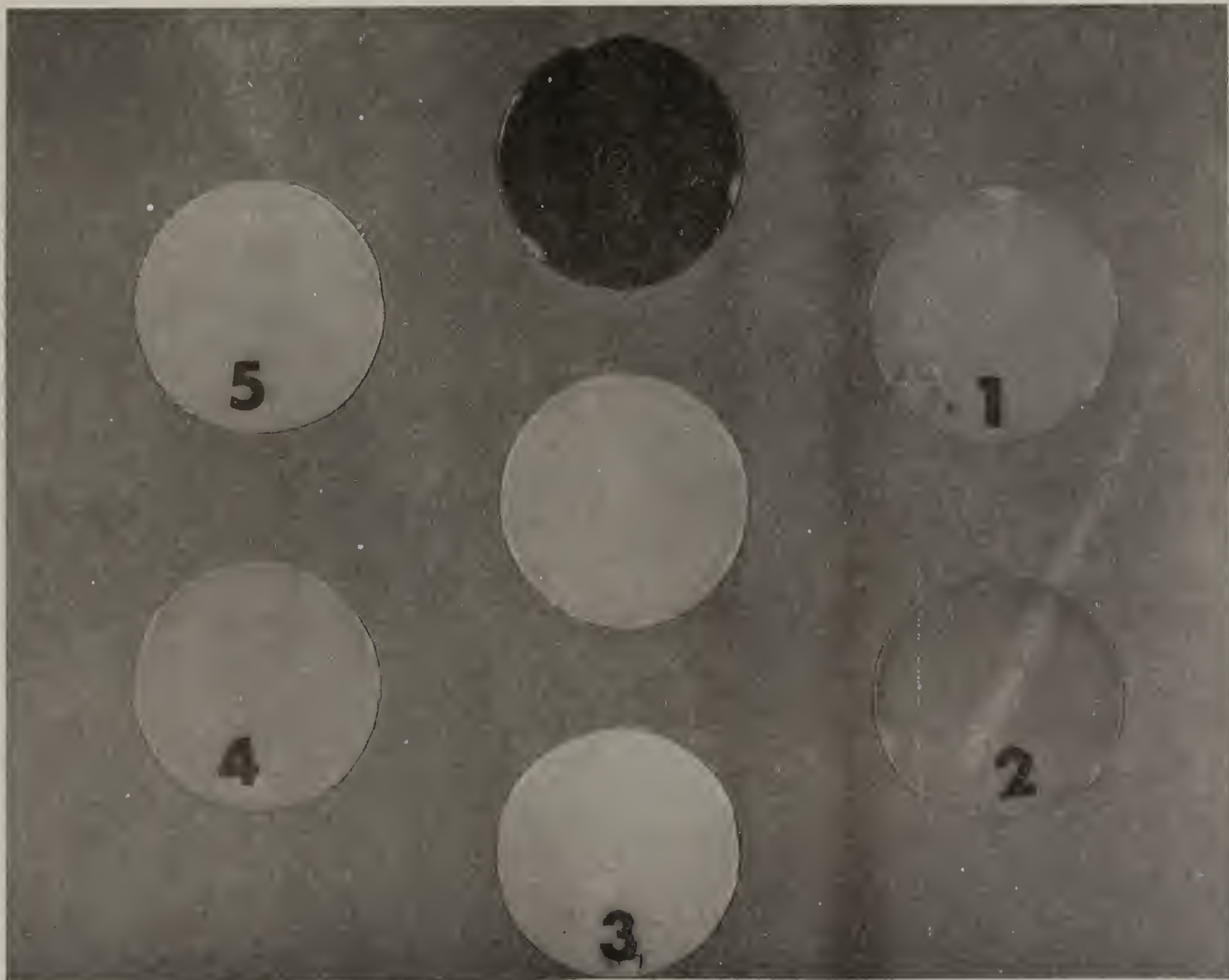

Figure 1. Disks subjected to the color stability test of American Dental Association Specification No. 12. Center disk is a control specimen.

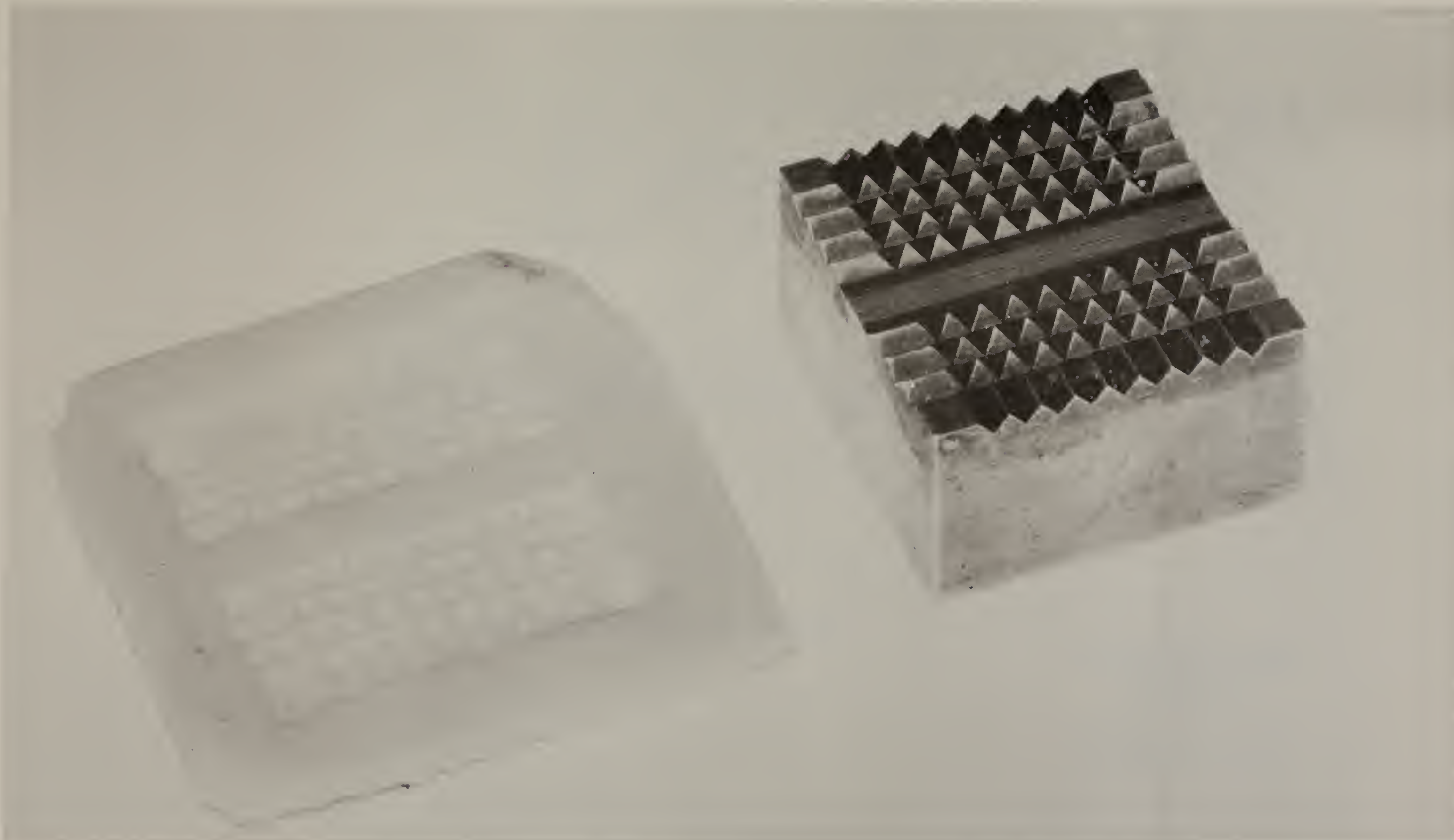

Figure 2. Detail impression and impression block.

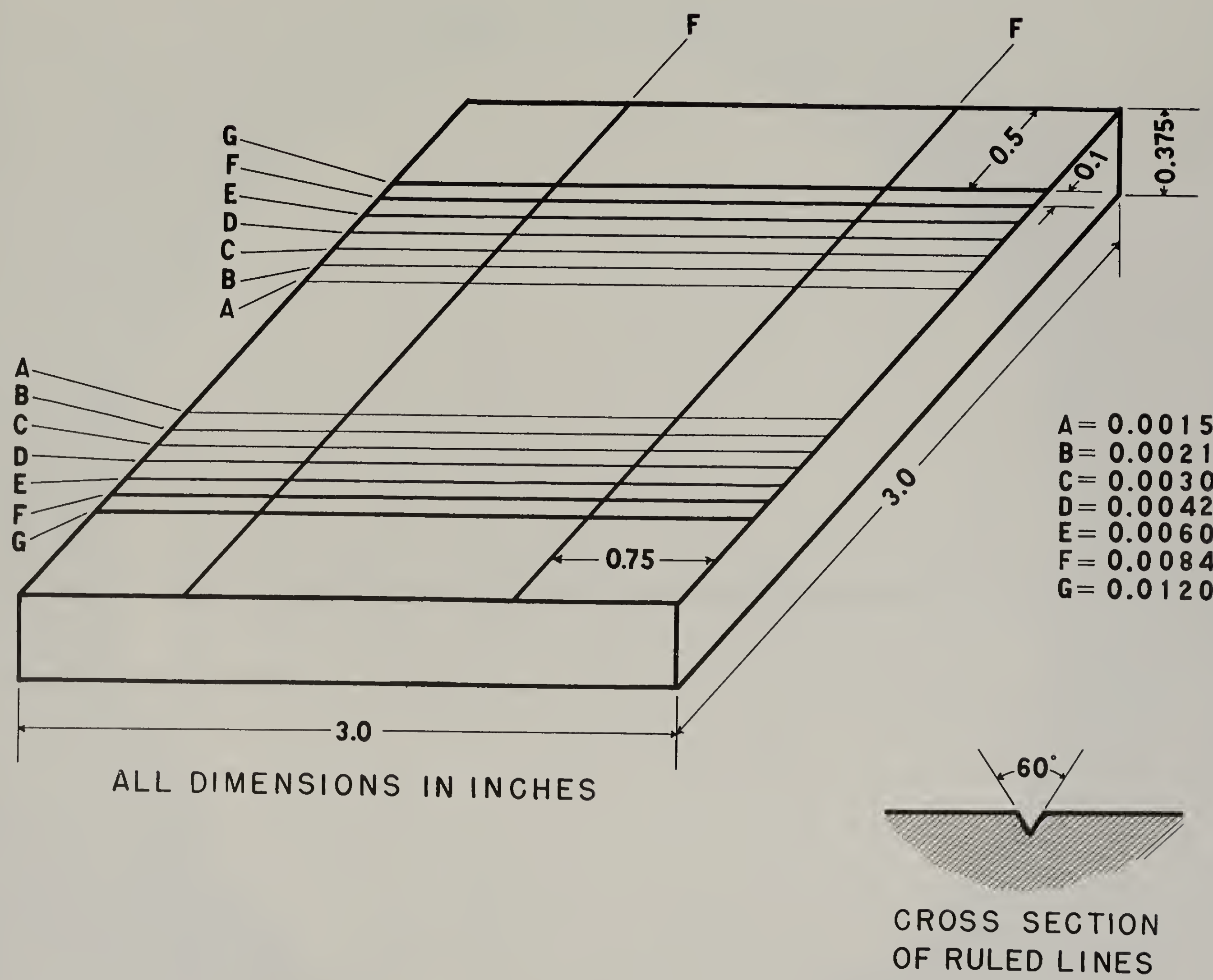

Figure 3. Die for detail impression test.

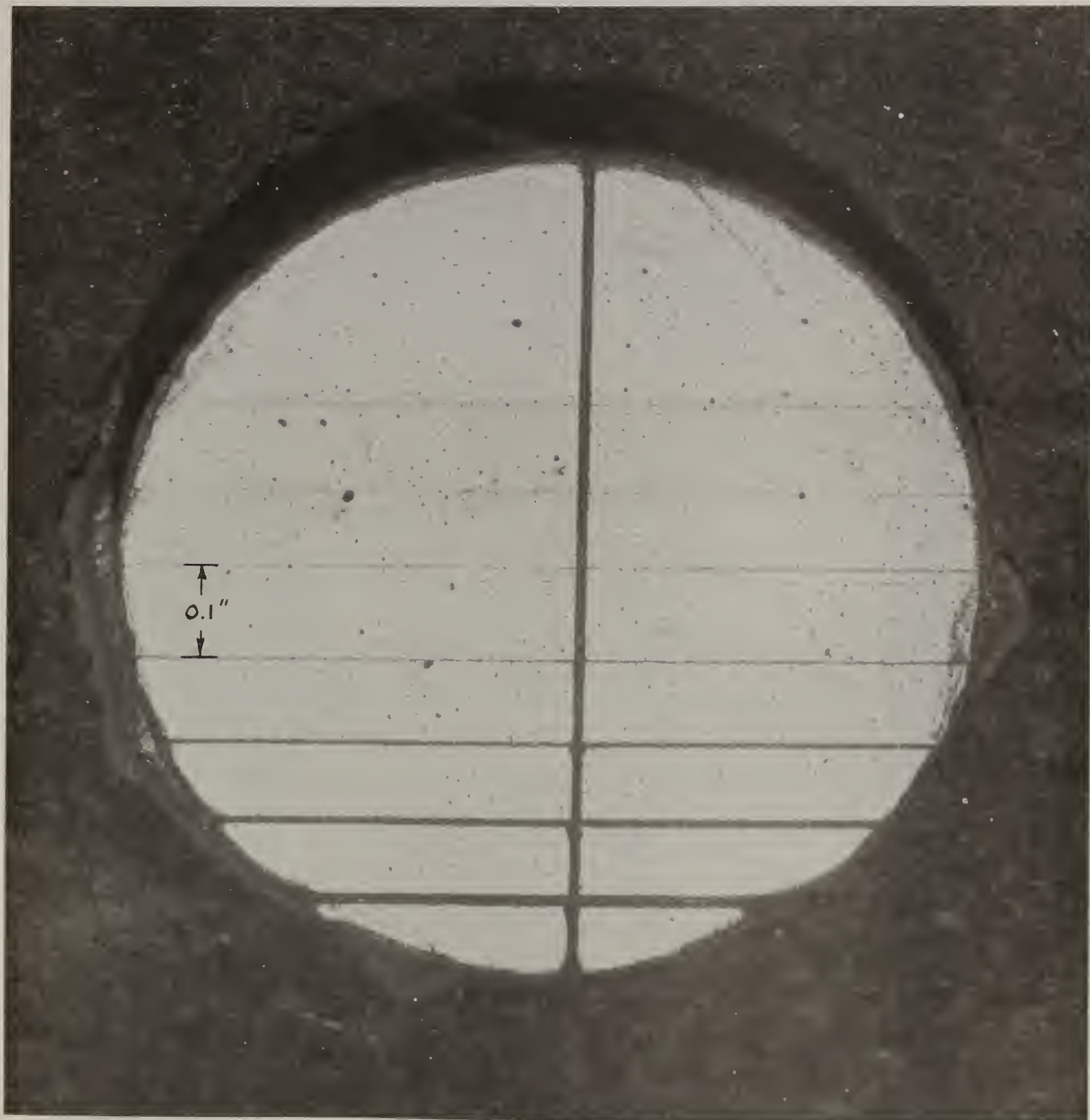

Figure 4. Detail impression of die shown in Figure 3 using a typical reliner. (Magnification 6 times).

Figure 5. Relined denture (with Brand 1) after 4 years of clinical service. Note the color difference at the periphery of the dentures.

Figure 6. Tissue bearing surfaces of two rebased dentures (relined with Brand 1) after four years of clinical service.

Figure 7. Surface porosity of the area encircled in Figure 6 (seven times actual size) and detail impression of die in Figure 3.