THE EFFECT OF VISCOSITY ON THE ACCURACY AND STABILITY OF ELASTIC IMPRESSION MATERIALS

by

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INTRODUCTION

The cast gold restoration was brought to the attention of the dental profession in 1897 when Philbrook introduced the technique of investing and casting an inlay.

Taggart's refinements served to popularize the investing and casting process where today it is common to produce complex restorations.

Dental castings may be used for the restoration of tooth structures where the destruction is either minimal or extensive; however, their greatest contribution lies with the latter.

There are two methods by which the cast dental restoration may be developed; the direct and the indirect method. The great majority of extensive dental castings are fabricated by utilizing the indirect method. This method permits the sculpturing of a wax pattern and preliminary finishing of the dental casting on an accurate replica of the teeth and associated oral structures. Several factors play very important roles in this indirect procedure. One of the most essential factors is the impression material and the methods employed in its use.

Specifically, the indirect process consists of the following. After appropriate tooth preparation the impression material, while in a plastic state, is carried to the mouth in a rigid structure termed an impression tray. This tray conforms to the dental arches in a closely fitting manner. When the material assumes an elastic structure the tray is removed from the mouth. Various means are used to cause the impression material to adhere to the tray. This negative reproduction is then cast (poured) with a material which can be introduced into the impression in liquid form and which will attain a set or hardened form within a relatively short period of time. The casting material used in dentistry is usually gypsum. Upon removal of the impression tray and material the model or cast of the dental arch and surrounding structure is then available for laboratory use. It is upon this reproduction of oral structures that dental castings can be constructed. After fabrication the restoration is then carried to the mouth for placement.

Since undercut tooth surfaces are present, only those impression materials which are elastic can be used. An elastic impression material must pass over undercuts without rupture, return to its original shape upon removal and have the rigidity to resist deformation when filled with the gypsum material.

Reversible hydrocolloid, developed by Alphons Poller (1) of Vienna in about 1925, was the first material produced that would accurately reproduce undercut surfaces. This material was used primarily in the construction of partial dentures until Sears (2) in 1937 adapted it for use in the construction of inlays, crowns and bridges. This innovation resulted in the acceptance and now widespread use of the indirect procedure which involves the duplication of the dental arch and surrounding structures upon which restorations can be fabricated.

Other elastic impression materials, in addition to reversible hydrocolloid, are now in vogue. A polysulfide polymer which is a synthetic rubber was introduced to the American market in 1950. A few years later, silicone base impression materials were made available to the dental profession. Early problems encountered with the polysulfide and silicone elastomers have now been largely overcome.

In order to produce a restoration which properly fits the teeth involved, the indirect procedure must be exceedingly accurate (0.1-0.2%) (3,4). This implies that each material and step in the procedure must be of even greater accuracy. The accuracy of impression materials is affected by a number of factors which have received widespread attention. Some of these are the type of material used, the thickness of the impression material between the tooth and the tray, the method of attaching the impression material to the tray and the time of pouring (casting) the impression.

Another factor, although mentioned in the literature, has not been subjected to serious investigation and could influence the accuracy of the impression considerably. This factor is the viscosity of the impression material at the time it is placed in contact with the oral structures.

It is in the placement of the impression that viscosity considerations are most important. If the viscosity of the material is too low the material will either run out of the tray or will not be held in intimate contact with the impression site. If the viscosity is too high elastic strains may be induced, which upon release would result in a distorted or inaccurate impression. Some of these strains would be released immediately while others would be released with time of storage of the impression prior to pouring the cast. Therefore, a study of the effects of pre-placement viscosity on the immediate dimensional change (accuracy) and the subsequent dimensional change (stability) of an impression, appeared to be worthwhile.

Polysulfide and silicone base materials are required by the American Dental Association Specifications (5) to pass a dimensional stability test where stability is defined as the ability to retain dimension with time.

Because the ADA Specification Test for stability is unidirectional and involves flat surfaces only, its relationship to a clinical impression, with its curved surfaces, sharp line angles and the restraint offered by an impression tray, is rather tenuous.

Minimum working times and consistency tests are also delineated in the ADA specifications.

A review of methods used to measure accuracy, stability and viscosity of impression materials, as well as their shortcomings, will be found in the following section titled Literature Review.

The reversible hydrocolloids exhibit a wide temperature range in which they may be used clinically. In fact, Specification Number 11 for reversible hydrocolloid, states that the material shall not run out of an inverted tray while maintained within the temperature range 43-50°C. Since the viscosity of reversible hydrocolloid is directly dependent on temperature in this range, the specification allows a broad range of viscosity.

Specification Number 19 for polysulfide and silicone rubber base, also permits a range in viscosity. The consistency test, which is a measure of viscosity, sanctions an average range of a compressed disk of 12.6 millimeters in diameter under a specified load.

In using polysulfide or silicone impression materials, there is a considerable period of time during which the material must be held in position over the dental arch prior to the setting process. Manufacturers' recommendations for removal of the material from the mouth vary between 10 to 12 minutes after beginning of the mixing procedure. This is a time-consuming as well as a tiring procedure for the patient and the dentist. It would be of significance to know whether a delay of insertion, until the material becomes more viscous, would adversely affect the accuracy of the impression. If not, the time of maintaining the impression material in the mouth could be shortened.

The primary purpose of this investigation was to determine the effect of the viscosity of impression materials at their time of insertion upon the dimensional accuracy and stability of the subsequent impression. In this study dimensional accuracy is defined as the difference in dimension between the tooth and the impression immediately after removal, in the case of the elastomers (polysulfide and silicone); and ten minutes after removal, in the case of the reversible hydrocolloid since reversible hydrocolloid is treated for ten minutes prior to casting (pouring). Dimensional stability was defined in this study as the difference in dimension between the tooth and the impression one hour after removal. The accuracy at designated viscosities was tested clinically and under clinically-oriented laboratory conditions. The two procedures were then compared to determine if the laboratory tests could be used to predict the dimensional behavior of the impression materials under clinical conditions. The stability was tested under clinically-oriented laboratory conditions.

The laboratory phase of this investigation was included to establish the validity of non-clinical testing. Since testing requires several replications to establish reliability, a favorable clinical-laboratory relationship would provide a basis for eliminating the tiring and more difficult clinical tests in future investigations.

In the section on data interpretation, comparisons are made of the differences due to viscosity within the material and differences between materials regardless of viscosity.

LITERATURE REVIEW

The following section is a review of published laboratory research pertinent to accuracy, stability and viscosity of impression materials.

Accuracy

Tests devised to study the accuracy of impression materials by a laboratory method other than the previously mentioned American Dental Association Specification Tests are the tapered bar test (6), reproduction of various geometric forms (7,8,9), master castings methods (10,11), ring and plug (12), and the oversize model (13,14).

The ring and plug method along with the master casting method rely upon the seating of metal around or into a gypsum die. That is, an impression is made of a master die, the impression is cast in gypsum which is allowed to set, the gypsum die is separated and a plug or ring that accurately fits the master die is fitted to the duplicated die. The fit is therefore a reflection of the accuracy of the impression material. One of the inherent disadvantages of gypsum dies is their lack of abrasion resistance -- when seating the ring or plug, the gypsum abrades and it is therefore difficult to measure dies precisely by this method.

The tapered bar, the reproduction of non-tooth geometric forms and the oversize model are stringent tests and their clinical analogies may not be applicable.

The use of the traveling microscope represents a better method for determining directionally related changes. The distance between markers set in the impression material are measured and their changes noted. However, this method as employed by Phillips (15) and Fairhurst (16) only takes account of the changes in one plane. With the influencing factor of the dental impression tray, changes must be studied in three planes or dimensions.

Because of the high coefficients of linear thermal expansion exhibited by the polysulfides and silicones (17,18) the changes from mouth to room temperatures are thought to influence their accuracy. Hosada (12) attempted to reduce the effects of the high thermal expansion coefficient of thiokols by using a thermostatic box. While the method may have merit, it is not used in normal laboratory procedure.

In this study, the accuracy of the impression materials were studied in three planes using a traveling microscope.

Stability

The stability of impression materials (their ability to retain dimension with time) is a factor that has been extensively investigated. Lund (19) and Eberle (20) used the tapered bar test to study dimensional stability of rubber base impression materials.

Gilmore (21,22), Schnell (23), Skinner (28), and Molnar (30) measured linear length change, either with a comparator microscope or a slide gauge.

In these previous studies, the elastomers were stored in air while the hydrocolloids were stored in air, tap water, 100% humidity or 2% potassium sulfate; 100% humidity proved to be the most stable media for the storage of hydrocolloid material.

The reported work on stability has established the fact that all elastic impression materials have varying dimensional changes with time and that they should be cast immediately. The relationship of stability and viscosity was investigated in this study since more strain, which might result from increased viscosity of the impression material, could tend to be released during storage of the impression, thereby altering the accuracy of the die.

Since in clinical practice it is sometimes necessary to delay the impression casting for a short period of time, the one-hour stability of the three materials, reversible hydrocolloid, polysulfide and silicone, was investigated.

Viscosity

Fish (31), using an Atkinson-Nancarrow Viscometer, showed that an index of viscosity for an alginate impression material can be defined and that the time for onset of the setting reaction (t_1) and the formation of an elastic gel (t_2) can be identified by plotting a force-time graph. The temperature dependence of t_1 and t_2 obeys the activation energy law $1/t_1$ = constant X $e^{-Q/RT}$ where Q = activation energy in units of calories/mole, R = gas constant and T = °K. Therefore, data for a wide range of different materials can be presented in a unified way.

Braden (32,33) using an Atkinson-Nancarrow Viscometer, has shown that the force necessary to extrude a polymer at a constant rate through a capillary could be measured as a function of time. An increase in the extrusion force indicates commencement of set. Results show that the increase of force with time obeys the law, $\Delta F = \Delta \exp(Rt)$, as shown by a linear relationship with log F plotted against log t; where F = force, A = constant, t = rate parameter, t = °K. With the silicones the extrusion force remained constant until after a well defined time, after which the extrusion force rose rapidly according to the power law. In the case of the polysulfides, the transition from a viscous to an elastic material is not so well defined.

Wilson (34), using a curemeter, investigated setting ranges of several impression materials. The disadvantages of a curemeter are that very fluid materials flow out of the plates, the assessment of rigidity is empirical and the fluidity cannot be measured.

Anderson (35) used a cylinder and ram equipped with a dial gauge to measure the rate of extrusion of various alginate impression materials. The clinical application of this type of study is to determine optimum times of handling of materials. He states that materials with a sharper set point indicate more clearly the end of accurate manipulation and so reduce the possibility of distortion from this source.

Wilson (36) later reported on two methods used to determine the setting characteristics of silicone and polysulfide impression materials. The first was an instrument designed to test materials whose viscosity changes are large and whose setting characteristics are temperature dependent. Rotary motion is changed to reciprocating motion and a pen arm records deflection. Water-jacketed horizontal side plates maintained the desired temperature. The second method involved a penetrometer test. The size of the needle and the load applied to it could be changed according to the test. The mixed materials were placed in a ring which was in turn placed in a water bath at 32 ± 1°C. The data showed that all the elastomers set gradually and that the polysulfides were affected more by changes in temperature than were the silicones.

The curemeter, the reciprocating rheometer and the penetrometer all disturb the material while it is setting; the first two to a greater degree than the last method.

Skinner (37) states that when a penetrometer test is used consisting of the penetration of a needle 3 mm in diameter under a load of 200 gms., the working time at room temperature of various elastomers varies between 3 and 9 minutes with setting times of 6 to 13 minutes. In general, the silicone base materials appear to set faster than do the mercaptan base products. The syringe type products seem to exhibit a longer working time and setting time than do the regular or heavy type materials.

Clark (38) used a modification of the A.D.A. consistency test for zinc phosphate cement to establish a flow test; he used 0.25 cc. with a weight of 200 gms. Starting at 1 1/2 minutes after the beginning of spatulation and at 15 second intervals up to a maximum time of 4 minutes, the mix was ejected from a tube and placed in a humidifier at an atmosphere of approximately 100% humidity and at 98°F. In order to establish the relationship of setting time to flow, Clark tested each material for its initial and final set. A 1/4 pound Gilmore needle was applied at 15 second intervals, measured from the start of spatulation. Results indicated that flow of the thiokols tested was not greatly influenced by the time interval elapsing between spatulation and application of the load. Those materials showing a marked decrease in flow at the various time intervals also had decreased setting times, and a shorter time interval between the initial and the final set.

Miller (39) tested silicones for initial and final setting times. In one method a penetrometer with a 3 mm needle and a 300 gm weight was used. In another method, coalescence of small quantities ejected from a syringe was noted; failure to coalesce was recorded as the initial set. With the penetrometers, the initial setting times ranged from 2 to 7 minutes and the final setting times from 4 to 11 minutes. When the initial set was determined by the syringe method, the values were lower and ranged from 1 to 4.5 minutes.

Gilmore's conclusions (21), perhaps not well substantiated by experimental evidence, state that accuracy is improved by permitting the impression material to become slightly elastic before seating.

Skinner and Cooper (40), testing the hypothesis that thiokol material should be the consistency of softened compound before pressing to place, found that when this technic was applied to stainless steel dies, distorted stone dies resulted and the castings did not fit.

With the foregoing methods and their limitations in mind a viscometer was designed which would allow the viscosity values of the three impression materials used in this study to be determined. A detailed description of this device is included in the section titled Materials and Methods.

STATEMENT OF THE PROBLEM

The purposes of this investigation were as follows:

1. To investigate the effect of viscosity on the dimensional accuracy and stability of a silicone, a polysulfide and a reversible hydrocolloid impression material.
2. To measure this effect under both clinical and laboratory conditions and compare these results.
3. To develop a method for measuring the viscosity of impression materials and to quantitatively define the viscosities which were studied.

MATERIALS AND METHODS

Methods

General. The general procedure consisted of measuring the significant dimensions of tooth preparations in the mouth, making an impression using three classes of impression materials prepared to provide both high and low viscosity, and measuring casts poured into these impressions. Dimensional accuracy was defined as the difference in dimensions between the prepared teeth and the casts when the casts were poured immediately. A master die was made of the tooth preparations and the tests were repeated in the laboratory by making impressions of the master die rather than of the teeth. Additionally, laboratory tests were conducted to determine dimensional stability which was defined as the difference in dimensions between the master die and the casts when the impressions were stored for one hour prior to pouring the casts.

Initial Preparation. A patient was selected who required a three-unit bridge, the missing tooth being a maxillary right second premolar. The anterior abutment was prepared to receive a M.O.D. inlay and the posterior abutment was prepared to receive a full crown. Both preparations were slightly overcut. A polysulfide impression was made of these clinical preparations and a densite[1] die was poured to provide a duplicate or master die of these clinical preparations for the laboratory test procedures to follow. Thin cobalt-chromium castings were made in the form of

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[1] Duroc, Ransom and Randolph Co., Toledo, Ohio.

a staple for the premolar and a coping for the molar. The tooth preparations were slightly overcut so that the clinical preparations with the staple and coping in place were normal in outline form. A photograph of the staple and coping in place in the mouth is shown in Plate 1.

Dimensions Studied. The castings were polished to a dull luster and six Vickers indentations were made in each one. The indentations were made using a load sufficient to produce pyramidal indentations having axes of about 75 microns (this size proved to be well within the limit which could be reproduced by all of the impression materials used). The placement of the indentations is shown schematically in Figure 1. Two indentations were used to delineate mesio-distal-occlusal, bucco-lingual-proximal and gingivo-occlusal-proximal dimensions on each casting. The mesial surface of the premolar and the distal surface of the molar were the proximal surfaces studied. It was felt that these proximal surfaces, adjacent to natural teeth, would be liable to distort more than surfaces adjacent to the edentulous area. A "between" dimension was also measured as illustrated in Figure 1.

Measurements. Fiducial measurements were made on the castings using a measuring microscope[1] having an accuracy of 1 micron. Prior to measurement, the plane containing each pair of indentations was oriented perpendicular to the axis of the microscope by means of a paralleling device.[2] For the laboratory tests the "between" dimension (as measured from the disto-occlusal of the premolar to the mesio-occlusal of the molar) was determined on the castings mounted on the master densite die. For the

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[1] Gaertner Scientific Corporation, Chicago, Illinois.

[2] E. Lietz Incorporated, New York, New York.

PLATE I

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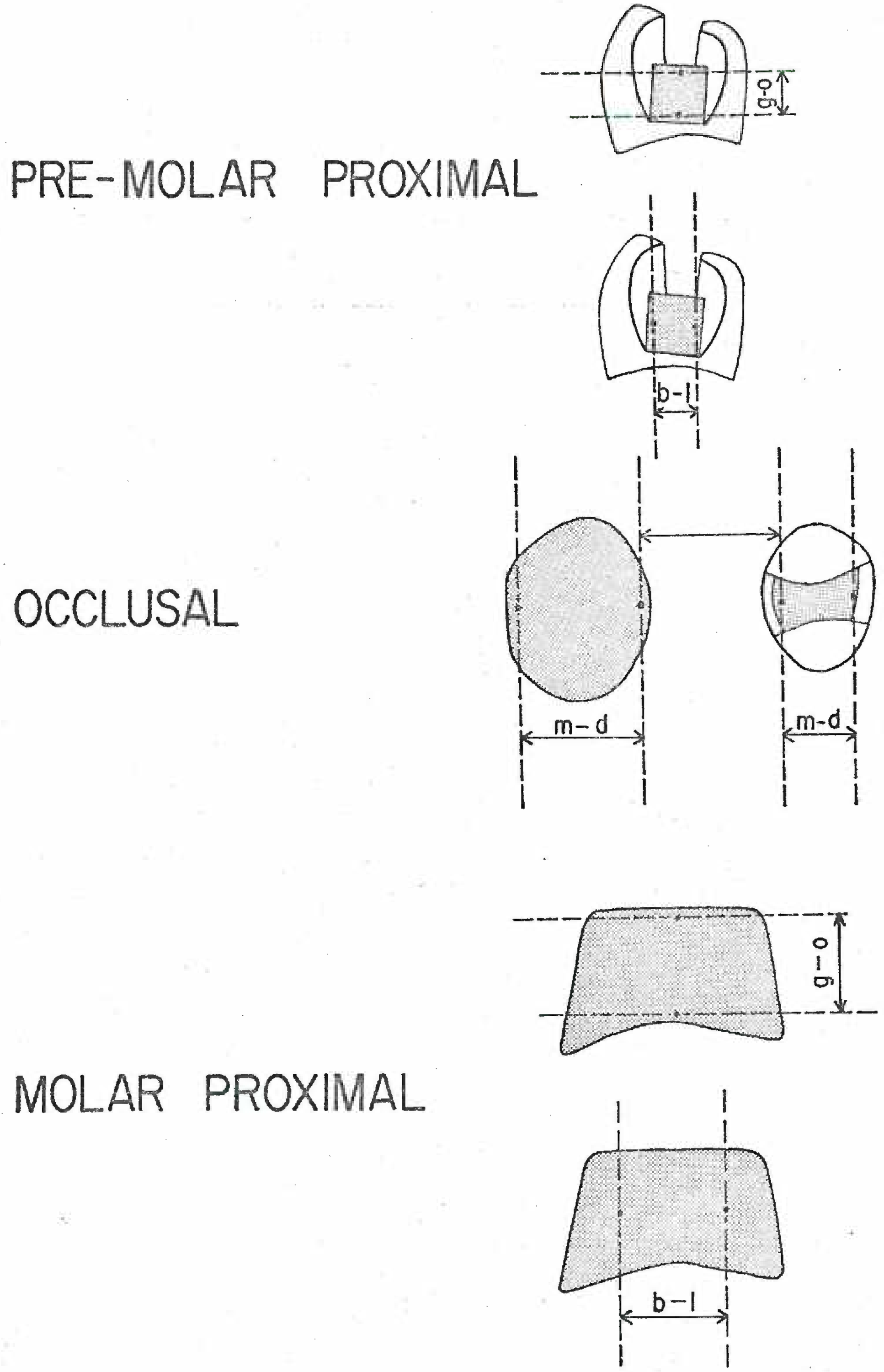
• JUL • 69.

FIG. I CASTINGS AND MEASUREMENTS



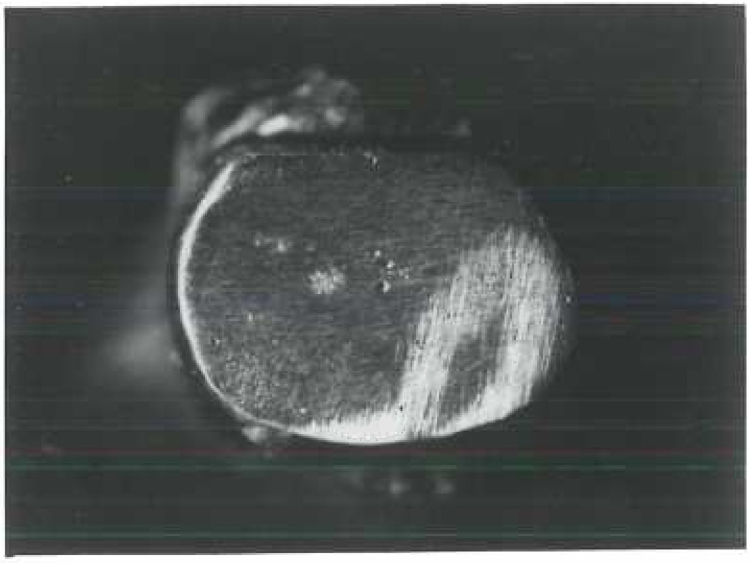
clinical tests a special procedure was employed since the "between" measurement could not be taken in the mouth with the methods employed; in addition, this measurement would vary as the teeth shifted with time. A new fiducial measurement of this dimension was made prior to each impression series. This was performed by placing a perforated brass bar between the teeth. The bar covered the two reference indentations. A small amount of silicone material was placed on the perforated ends of the brass bar prior to its placement. After the silicone had set, the bar was removed and placed under the measuring microscope in an inverted position. The distance between the pyramidal tips was taken as the fiducial introoral "between" measurement. This measurement was replicated 10 times to provide a valid mean value.

Final measurements of the specified dimensions were made between the indentations reproduced in the densite casts which had been poured into the impression materials. The "between" measurements were made first. Then the dies were separated with a coping saw and were systematically oriented with the paralleling device so that each plane of measurement was perpendicular to the measuring microscope. Each dimension was measured twice. The determination of dimensional accuracy and stability was reflected in the difference between these fiducial and final measurements. Plate 2 shows the indentations in the coping and the reproduction of those indentations in the final densite cast.

Impression Storage and Treatment. For the condition of immediate pour, the hydrocolloid impressions were immediately immersed in a 2% K_2SO_4 solution for 10 minutes prior to pouring the densite cast. In the case of the elastomeric impressions, the K_2SO_4 treatment was not used and the impressions were poured immediately after removal from the impression

PLATE 2

densite duplication



chrome-cobalt casting

site.

For the condition of the one-hour pour, the hydrocolloid impressions were stored for 50 minutes at 100% relative humidity and at 25°C. They were then removed from the humidor and immersed in a 2% K_2SO_4 solution for 10 minutes prior to pouring. The elastomeric impressions were stored in air at 25°C and at 31% relative humidity for one hour prior to pouring (laboratory bench conditions).

Cast Preparation. The densite material was mixed at a ratio of 50 grams of powder to 11 cc of distilled water. After initial hand spatulation to wet the powder with the water, mechanical spatulation at 700 rpm was employed for 15 seconds. The mix was gently vibrated into the impression and the cast was separated in one hour.

Viscosities Studied. Two viscosities were selected for evaluation for each of the impression materials studied. These viscosities were selected as representing the lowest and highest viscosities that might reasonably be used in dental practice and were additionally defined by the viscosity measurement tests to be described in a subsequent section.

Other Conditions. For the laboratory tests, the master die was maintained at 36°C which was determined to be the temperature of the teeth in the oral environment. This was done to make the laboratory tests consistent with the thermal environment in which the impression material is placed under clinical conditions. The determination of the 36°C is outlined in a subsequent section.

Reversible Hydrocolloid

Composition and Properties (41). Reversible hydrocolloid contains 8 to 15% agar. Agar is an organic hydrophillic colloid (polysacchride) extracted from certain types of seaweed. It is a sulfuric ester of a linear polymer of galactose. The principal ingredient by weight is water. Borax is added to increase the strength of the gel. A borate is formed which increases the strength or density of the micelle framework.

Since Borax is an excellent retarder of the setting of gypsum products, the impression must be immersed in a solution of 2% K_2SO_4 which accelerates the setting of gypsum.

Manipulation. Surgident reversible hydrocolloid[1], used in this investigation, was boiled 10 minutes and stored at 65°C for a minimum of 30 minutes before use. The two viscosity conditions studied were produced by tempering in a controlled water bath for 5 minutes at 45°C (low viscosity) and tempering in a controlled water bath for 5 minutes at 35°C (high viscosity). The material in its flexible plastic tube was kneaded every 30 seconds in order to obtain a uniform temperature. A sectional tray was loaded, placed over the teeth or master die and cooled with room temperature (25°C) water for 5 minutes. These impressions were immersed in a 2% K_2SO_4 solution for 10 minutes prior to pouring the densite cast.

Silicone Rubber

Composition and Properties (42). The silicone polymer system undergoes cross-linking readily at 37°C and consists of three components. The first is the silicone polymer that has terminal hydroxyl groups. This polymer together with a filler constitutes the unset impression material. The second is a cross-linking agent which is either an alkoxy ortho-silicate or an organo-hydrogen siloxane. The cross-linking is facilitated by

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[1] Surgident, Ltd., Los Angeles, California. (Batch no. 1699258).

the use of an activator, the third component of the system. Only cross-linking occurs; there is no polymerization.

Manipulation. Jelcone Syringe[1] and Jelcone Regular[1] were the impression materials used in this study to represent the silicones. The manufacturer's recommended base-catalyst ratios of 25/1 for syringe and 17/1 for regular were utilized. All materials were accurately weighed before mixing. Mixing was completed in one minute.

From the viscosity data determined in this investigation, it was apparent that 3.5 minutes from the start of mix was the latest time that the impression could be taken. This point was chosen as representative of high viscosity. Two minutes from start of the mix was selected as representative of low viscosity. This represented a reasonably short time which one might use in preparing the material, loading the tray and placing over the teeth.

The silicone material was allowed to set for 10 minutes from the beginning of mixing before tray removal.

Polysulfide Rubber

Composition and Properties (43). The polysulfide polymer and a setting agent are mixed to form the set impression rubber. The straight chained polymer is produced to contain terminal and pendant mercaptan groups. This material must be of sufficiently low molecular weight and viscosity for use as an impression material. The setting agent (mainly lead dioxide) on mixing with the polymer causes both polymerization and cross-linking. Cross-linking is essential to form the elastic material;

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[1] The L. D. Caulk Co., Milford, Delaware. (Batch nos. 26368B, 29868C, 30568B, 369C.

the chain-lengthening is necessary to develop optimum physical properties.

Manipulation. Permlastic light-bodied[1] and Permlastic heavy-bodied[1] were selected to represent the polysulfide impression materials. The manufacturer does not specify a base-catalyst ratio but recommends using equal extruded lengths of base plus catalyst. The base-catalyst ratio was determined by weighing several equal extruded lengths which gave mean ratios of 0.94 for the light-bodied and 2.70 for the heavy-bodied material. These ratios were utilized throughout the experimental procedures. Mixing was completed in one minute.

The same times from the beginning of the mix used for Jelcone were also selected as the "viscosity times" for Permlastic; namely, 2 minutes for low viscosity and 3.5 minutes for high viscosity.

The polysulfide was allowed to react 12 minutes from the start of mixing before removal of the tray from the impression site.

Viscosity Determination

To establish the viscosity of the materials used at their times of insertion, a ram and cylinder penetrometer was devised (see Plates 3 and 4). The travel of the ram was recorded using a linear motion transducer wired to a one pen potentiometric strip chart recorder (Plate 5). The time-base was set at 6 inches per minute. Interchangeable rams made it possible to use the same time-base for the different viscosities studied. Each ram was calibrated by means of viscosity standards.[2]

Each material was prepared as previously indicated and inserted into

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[1] Kerr Manufacturing Co., Detroit, Michigan. (Batch nos. 1183P940, 0261H672).

[2] Brookfield Engineering Laboratories Inc., Stoughton, Massachusetts.

PLATE 3

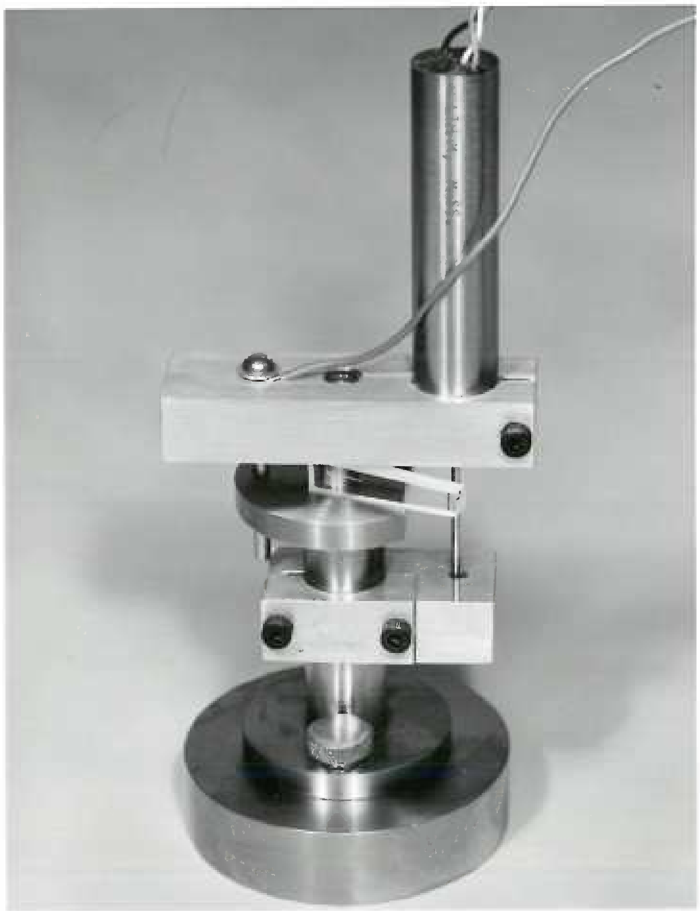
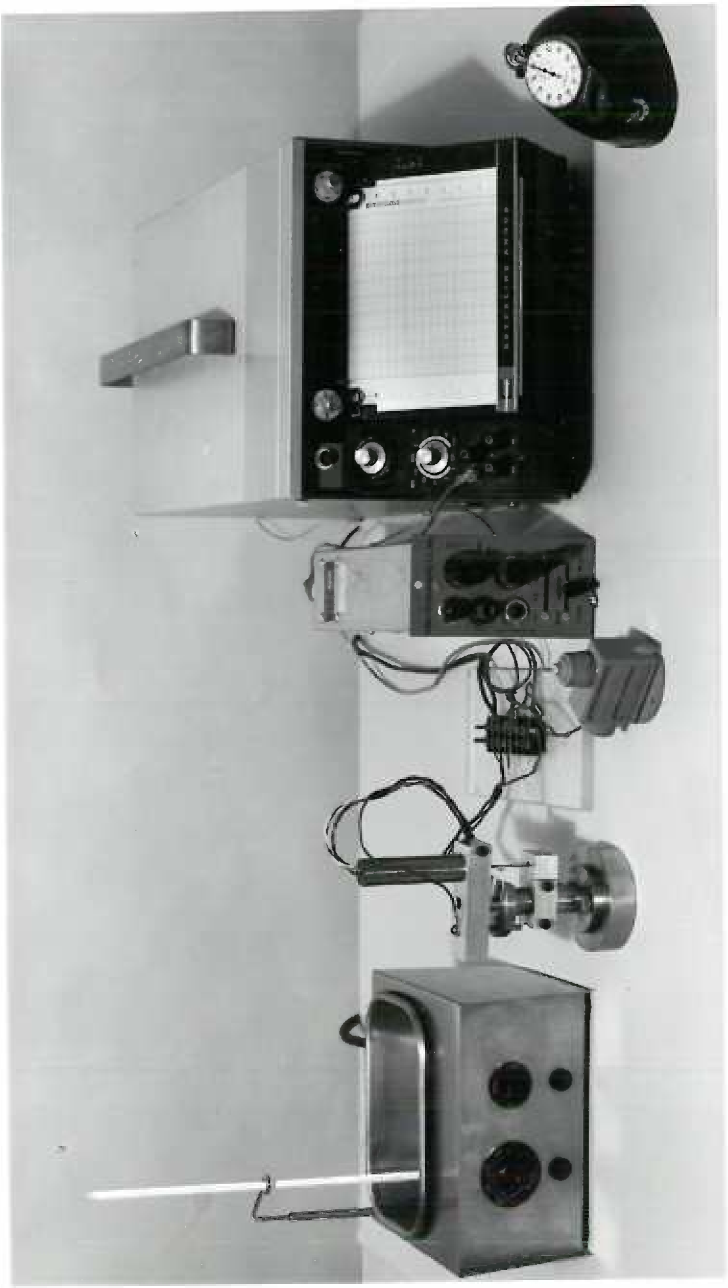


PLATE 4

PLATE 5



the viscometer 5 seconds before t_1 and 5 seconds after t_2. The times t_1 and t_2 represented 5 minutes at 35°C and 5 minutes at 45°C for the hydrocolloid and 2.0 minutes and 3.5 minutes for the rubber base impression materials. The viscosity was taken as the slope of the line between the points t_1 and t_2, the units being millivolts/second (Plate 6). It should be noted that the penetrometer was maintained at 36°C by means of a water bath before and during the viscosity determinations.

The absolute viscosities in centipoise units were calculated as follows:

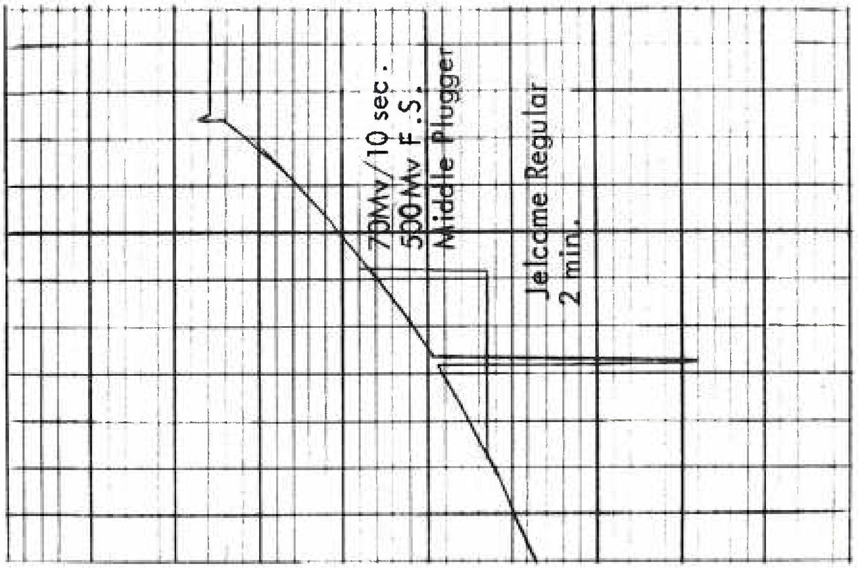
$$\text{Cp} = \frac{\dfrac{1}{\text{experimental millivolts}} \cdot \text{Cp Units of Standard}}{\dfrac{1}{\text{Millivolts Standard}}}$$

See Appendix A for calculated values.

Intra-Oral Temperature Measurement

To make the laboratory tests more meaningful, it was necessary to determine a temperature which would represent the thermal environment in which the impression material was placed under clinical conditions. This was accomplished by determining the oral temperature of the fabricated castings which were cemented in place. A thermistor placed against each casting and embedded in a palatal plate was the temperature sensitive device used for this determination (Plate 7). These thermistors were, through proper circuitry, wired to a two-channel recorder (Plate 8). Temperatures were recorded with the mouth slightly open, simulating clinical conditions prior to impression making (Plate 9). Temperatures were recorded during the making of the impressions and the time was noted for

PLATE 6


70Mv/10 sec.
500Mv F.S.
Middle Plugger
Jelcome Regular
2 min.

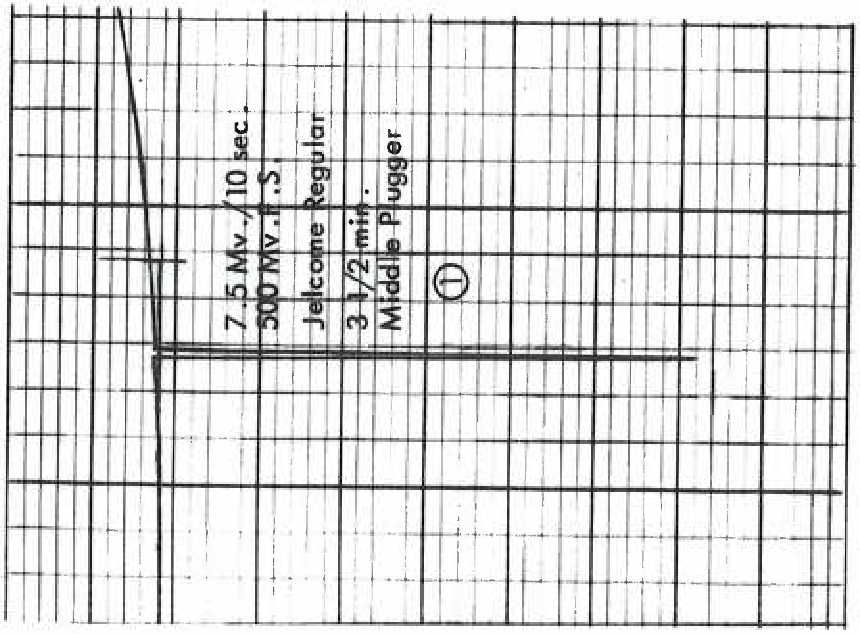
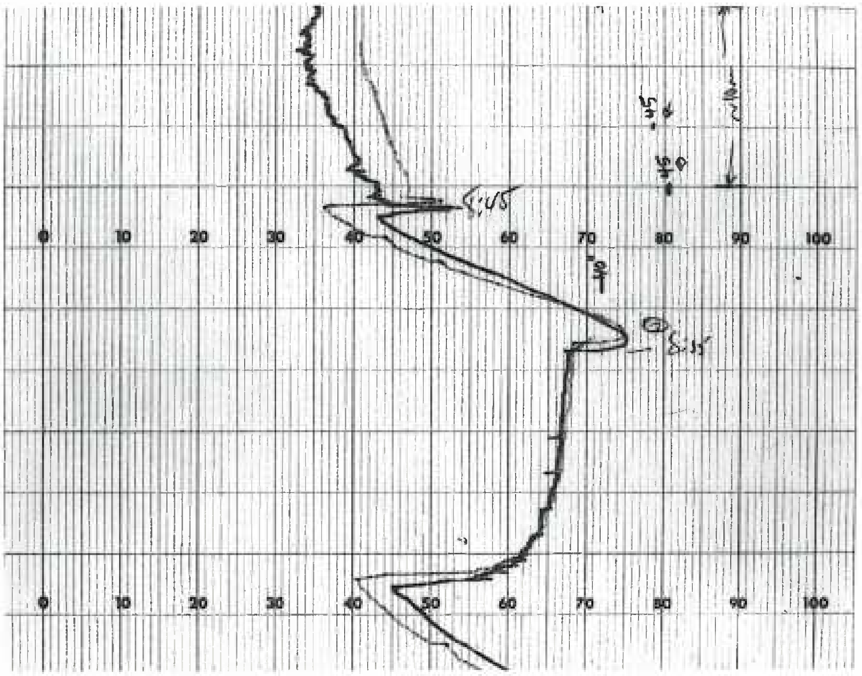

7.5 Mv./10 sec.
500 Mv. F.S.
Jelcome Regular
3 1/2 min.
Middle Plugger
①

PLATE 7

PLATE 8

PLATE 9



the return to a stabilized mouth temperature. Elborn (44) used copper-constantan thermocouples for determining the temperature rise of impression materials when used in the oral environment. However, his results were taken from the soft tissues.

The value of 36°C, obtained from this determination, was utilized for the viscometer temperature setting and for the oven temperature at which the gypsum cast and the cobalt-chrome castings were maintained before and during impression making for the laboratory phases (Part II, Part III).

Experimental Design

The test conditions for each of the clinical and laboratory phases are given in Table I. Each of the 10 conditions were replicated 5 times for a total of 50 impressions. All of the 7 specified dimensions were measured twice for each of the 50 impressions. This procedure was followed for the clinical phase-immediate pour to be referred to as Part I, the laboratory phase-immediate pour to be referred to as Part II, and the laboratory phase-one hour pour to be referred to as Part III.

Method of Data Analysis

The treatment means (n = 5) are reported in percentage change for each dimension. These means were first analyzed by a one-way analysis of variance. This was done to determine equality of means. Differences which are noted were determined by Scheffe's method for multiple comparisons (45).

Table I. Test Conditions.

1.	Jelcone Syringe	Low - 2.0 min.
2.	Jelcone Syringe	High - 3.5 min.
3.	Jelcone Regular	Low - 2.0 min.
4.	Jelcone Regular	High - 3.5 min.
5.	Permlastic Light-Bodied	Low - 2.0 min.
6.	Permlastic Light-Bodied	High - 3.5 min.
7.	Permlastic Heavy-Bodied	Low - 2.0 min.
8.	Permlastic Heavy-Bodied	High - 3.5 min.
9.	Surgident Reversible	Low - 5 min. at 45°C
10.	Surgident Reversible	High - 5 min. at 35°C

n = 5

N = 50

Scheffe (45) has proven that the probability is $1 - \alpha$ that all imaginable contrasts will be captured by the set of intervals given by:

$$\hat{L} - S\hat{\sigma}_{\hat{L}} \leqq L \leqq \hat{L} + S\hat{\sigma}_{\hat{L}}$$

where: $S^2 = (r-1)\ F_{1-\alpha;r-1,\ N-r}$

and $\hat{\alpha}^2_{\hat{L}} = MS_w \cdot \sum_{j=1}^{r} \frac{c_j^2}{n_j}$.

Thus again, the probability is α that one or more false conclusions will be made.

For this study, $\alpha = 0.05$.

For this study, $H_o: M_1 = M_2 = M_3 \ldots\ldots M_{10}$ (that is, all treatment means are equal regardless of viscosity).

$H_A: M_1 \neq M_2 \neq M_3 \ldots\ldots M_{10}$ (that is, at least one mean is different).

COMPARISONS MADE

1. Individual - within the material $\quad S\hat{\sigma}_{\hat{L}} = [(9)(2.12)(MS_w)(\sum_{j=1}^{r} \frac{c_j^2}{n_j})]^{1/2}$

2. $\frac{\text{All high}}{5}$ cf. $\frac{\text{all low viscosity}}{5}$ $\quad S\hat{\sigma}_{\hat{L}} = [(9)(2.12)(MS_w)(\sum_{j=1}^{r} \frac{c_j^2}{n_j})]^{1/2}$

3. $\frac{\text{High viscosity + low viscosity}}{2}$ $\quad S\hat{\sigma}_{\hat{L}} = [(9)(2.12)(MS_w)(\sum_{j=1}^{r} \frac{c_j^2}{n_j})]^{1/2}$

4. $\frac{\text{Silicones}}{4}$ cf. $\frac{\text{Polysulfides}}{4}$ $\quad S\hat{\sigma}_{\hat{L}} = [(9)(2.12)(MS_w)(\sum_{j=1}^{r} \frac{c_j^2}{n_j})]^{1/2}$

5. $\frac{\text{Hydrocolloid}}{2}$ cf. $\frac{\text{Elastomers}}{8}$

$$S\hat{\sigma}_{\hat{L}} = [(9)(2.12)(MS_w)(\sum_{j=1}^{r} \frac{c_j^2}{n_j})]^{1/2}$$

The statistical relationship between Part I and Part II was determined using a paired "t" test while pairing means from all cells.

$= 0.05$

$$t = \frac{\overline{d} - 0}{s/\sqrt{N}}$$

$H_o = \mu_1 = \mu_2$

$H_A = \mu_1 = \mu_2$

RESULTS

As previously outlined, all results were statistically analyzed by Analysis of Variance (45) followed by Scheffe's comparisons where appropriate. These comparisons for all three phases (intra-oral-immediate pour, laboratory-immediate pour and laboratory one-hour pour) are systematically reported in the following order. The following statements are made at the 0.95 level of confidence $\alpha = 0.05$.

1. Individual. This comparison is made to determine if there is a difference between low and high viscosity for each dimension. This is a comparison within each material type.

2. All High versus All Low Viscosities. This comparison is made to determine if there is a difference between high and low viscosity regardless of material type.

3. Materials Comparison. This comparison is made to determine if there is a difference between materials regardless of viscosity. The specific contrasts made were:
    (a) Silicone Syringe (S-S) cf. Polysulfide Syringe (P-S)
    (b) Silicone Regular (S-R) cf. Polysulfide Heavy (P-H)
    (c) Silicone Regular (S-R) cf. Agar (A)
    (d) Polysulfide Heavy (P-H) cf. Agar (A)

4. All Silicones versus all Polysulfides. This comparison is made

to determine if there is a difference between all silicones and all polysulfides.

5. All Elastomers versus all Agar Hydrocolloid. This comparison is made to determine if there is a difference between the polysulfides and silicones as a group, and the agar as a group, regardless of viscosity.

Clinical Phase-Immediate Pour - Part I

(See Appendix A for Raw Data)

Analysis of Variance

	F	$F_{.95}$; r-1, N-r	MS_w
*BETWEEN	12.15	2.12	0.035
*MOLAR (M.-D.)	3.70	2.12	0.032
*MOLAR (G.-O.)	7.39	2.12	0.197
MOLAR (B.-L.)	0.88	2.12	0.060
*PREMOLAR (M.-D.)	2.52	2.12	0.157
PREMOLAR (G.-O.)	0.69	2.12	0.144
*PREMOLAR (B.-L.)	3.27	2.12	0.124

*Significant Differences

SCHEFFE'S COMPARISONS

1. Individual.

$$S\hat{\sigma}_{\hat{L}} = \left(S \cdot MS_w \cdot \sum_{j=1}^{r} \frac{c_j^2}{n_j}\right)^{1/2}$$

$$\sum_{j=1}^{r} \frac{c_j^2}{n_j} = (1/5)^2 + (-1/5)^2 = 0.4$$

	Jelcone Syringe	Jelcone Regular	Permlastic Syringe	Permlastic Heavy	Surgident	$S\hat{\sigma}_{\hat{L}}$
BETWEEN	0.164	0.001	0.490	0.258	0.251	0.516
MOLAR (M.-D.)	0.018	0.232	0.036	0.107	0.124	0.494
MOLAR (G.-O.)	0.549	1.071	0.357	0.110	0.082	1.240
MOLAR (B.-L.)	0.020	0.236	0.078	0.158	0.034	0.676
PREMOLAR (M.-D.)	0.163	0.205	0.408	0.163	0.448	1.090
PREMOLAR (G.-O.)	0.256	0.257	0.103	0.359	0.051	1.044
PREMOLAR (B.-L.)	0.044	0.351	0.176	0.000	0.747	0.972

No Significant Differences

2. All High versus All Low Viscosity:

$$S\hat{\sigma}_{\hat{L}} = (S \cdot MS_w \cdot \sum_{j=1}^{r} \frac{c_j^2}{n_j})^{1/2}$$

$$\sum_{j=1}^{r} \frac{c_j^2}{n_j} = \frac{5(1/5)^2}{5} + \frac{5(-1/5)^2}{5} = 0.08$$

	Low Viscosity $(\overline{X})$	High Viscosity $(\overline{X})$	$S\hat{\sigma}_{\hat{L}}$
*BETWEEN	1.0048	0.772	0.231
MOLAR (M.-D.)	0.242	0.253	0.221
MOLAR (G.-O.)	0.769	0.632	0.548
MOLAR (B.-L.)	0.236	0.169	0.303
PREMOLAR (M.-D.)	0.342	0.375	0.490
PREMOLAR (G.-O.)	0.133	0.216	0.469
PREMOLAR (B.-L.)	0.968	1.161	0.435

*Significant Differences

3. Materials Comparison:

$$S\hat{\sigma}_{\hat{L}} = (S \cdot MS_w \cdot \sum_{j=1}^{r} \frac{c_j^2}{n_j})^{1/2}$$

$$\sum_{j=1}^{r} \frac{c_j^2}{n_j} = \frac{2(1/2)^2}{5} + \frac{2(-1/2)^2}{5} = 0.2$$

a. Silicone Syringe (SS) cf. Polysulfide Syringe (PS)

	SS$(\overline{X})$	PS$(\overline{X})$	$S\hat{\sigma}_{\hat{L}}$
*BETWEEN	0.685	1.285	0.365
*MOLAR (M.-D.)	0.027	0.410	0.349
*MOLAR (G.-O.)	1.374	0.289	0.867
MOLAR (B.-L.)	0.108	0.236	0.478
PREMOLAR (M.-D.)	0.082	0.285	0.774
PREMOLAR (G.-O.)	0.231	0.052	0.741
PREMOLAR (B.-L.)	1.297	1.143	0.688

*Significant Differences

b. Silicone Regular (SR) cf. Polysulfide Regular (PR)

	SS($\overline{X}$)	PS($\overline{X}$)	$S\hat{\sigma}_{\hat{L}}$
*BETWEEN	1.002	0.636	0.365
MOLAR (M.-D.)	0.348	0.250	0.349
MOLAR (G.-O.)	0.811	0.192	0.867
MOLAR (B.-L.)	0.157	0.236	0.478
PREMOLAR (M.-D.)	0.347	0.326	0.774
PREMOLAR (G.-O.)	0.180	0.180	0.741
PREMOLAR (B.-L.)	0.836	0.836	0.688

*Significant Differences

c. Silicone Regular (SR) cf. Agar (A) Hydrocolloid

	SR($\overline{X}$)	A($\overline{X}$)	$S\hat{\sigma}_{\hat{L}}$
BETWEEN	1.002	0.836	0.365
MOLAR (M.-D.)	0.348	0.205	0.349
MOLAR (G.-O.)	0.811	0.838	0.867
MOLAR (B.-L.)	0.157	0.128	0.478
PREMOLAR (M.-D.)	0.347	0.754	0.774
PREMOLAR (G.-O.)	0.180	0.231	0.741
PREMOLAR (B.-L.)	0.836	1.210	0.688

No Significant Differences

d. Polysulfide Heavy (PH) cf. Agar (A)

	PH($\overline{X}$)	A($\overline{X}$)	$S\hat{\sigma}_{\hat{L}}$
BETWEEN	0.636	0.836	0.365
MOLAR (M.-D.)	0.250	0.205	0.349
MOLAR (G.-O.)	0.192	0.838	0.867
MOLAR (B.-L.)	0.236	0.128	0.478
PREMOLAR (M.-D.)	0.326	0.754	0.774
PREMOLAR (G.-O.)	0.180	0.231	0.741
PREMOLAR (B.-L.)	0.836	1.210	0.688

No Significant Differences

4. <u>All Silicones (S) versus All Polysulfides (P)</u>:

$$S\hat{\sigma}_{\hat{L}} = (S \cdot MS_w \cdot \sum_{j=1}^{r} \frac{c_j^2}{n_j})^{1/2}$$

$$\sum_{j=1}^{r} \frac{c_j^2}{n_j} = \frac{4(1/4)^2}{5} + \frac{4(-1/4)^2}{5} = 0.1$$

	$S(\overline{X})$	$P(\overline{X})$	$S\hat{\sigma}_{\hat{L}}$
BETWEEN	0.843	0.961	0.258
MOLAR (M.-D.)	0.188	0.330	0.247
*MOLAR (G.-O.)	1.092	0.240	0.613
MOLAR (B.-L.)	0.133	0.236	0.338
PREMOLAR (M.-D.)	0.214	0.305	0.547
PREMOLAR (G.-O.)	0.205	0.116	0.524
PREMOLAR (B.-L.)	1.066	0.990	0.486

*Significant Differences

5. <u>All Elastomers (E) versus All Agar (A) Hydrocolloid</u>:

$$S\hat{\sigma}_{\hat{L}} = (S \cdot MS_w \cdot \sum_{j=1}^{r} \frac{c_j^2}{n_j})^{1/2}$$

$$\sum_{j=1}^{r} \frac{c_j^2}{n_j} = \frac{2(1/2)^2}{5} + \frac{8(1/8)^2}{5} = 0.125$$

	$E(\overline{X})$	$A(\overline{X})$	$S\hat{\sigma}_{\hat{L}}$
BETWEEN	0.902	0.836	0.285
MOLAR (M.-D.)	0.259	0.205	0.276
MOLAR (G.-O.)	0.666	0.838	0.685
MOLAR (B.-L.)	0.184	0.128	0.378
PREMOLAR (M.-D.)	0.260	0.754	0.612
PREMOLAR (G.-O.)	0.160	0.231	0.586
PREMOLAR (B.-L.)	1.028	1.210	0.544

No Significant Differences.

Laboratory Phase-Immediate Pour - Part II

(See Appendix B for Raw Data)

Analysis of Variance

	F	$F_{.95}$; r-1, N-r	MS_w
BETWEEN	1.55	2.12	0.114
*MOLAR (M.-D.)	3.22	2.12	0.011
MOLAR (G.-O.)	1.88	2.12	0.173
*MOLAR (B.-L.)	2.78	2.12	0.170
PREMOLAR (M.-D.)	1.08	2.12	0.280
PREMOLAR (G.-O.)	1.23	2.12	0.363
PREMOLAR (B.-L.)	1.69	2.12	0.360

*Significant Differences

SCHEFFE'S COMPARISONS

1. Individual.

$$S\hat{\sigma}_{\hat{L}} = \left(S \cdot MS_w \cdot \sum_{j=1}^{r} \frac{c_j^2}{n_j}\right)^{1/2}$$

$$\sum_{j=1}^{r} \frac{c_j^2}{n_j} = (1/5)^2 + (-1/5)^2 = 0.4$$

	Jelcone Syringe	Jelcone Regular	Permlastic Syringe	Permlastic Heavy	Surgident	$S\hat{\sigma}_{\hat{L}}$
BETWEEN	0.327	0.142	0.194	0.044	0.389	1.068
MOLAR (M.-D.)	0.054	0.053	0.820	0.303	0.053	1.256
MOLAR (G.-O.)	0.110	0.330	0.138	0.247	0.110	1.753
MOLAR (B.-L.)	0.118	0.138	0.216	0.570	0.413	1.020
PREMOLAR (M.-D.)	0.041	0.082	0.366	0.693	0.245	2.293
PREMOLAR (G.-O.)	0.564	0.102	0.000	0.205	0.717	1.918
PREMOLAR (B.-L.)	0.088	0.615	0.352	0.132	0.528	1.829

No Significant Differences

2. <u>All High versus All Low Viscosity</u>:

$$S\hat{\sigma}_{\hat{L}} = \left(S \cdot MS_w \cdot \sum_{j=1}^{r} \frac{c_j^2}{n_j}\right)^{1/2}$$

$$\sum_{j=1}^{r} \frac{c_j^2}{n_j} = \frac{5(1/5)^2}{5} + \frac{5(-1/5)^2}{5} = 0.08$$

	Low Viscosity $(\overline{X})$	High Viscosity $(\overline{X})$	$S\hat{\sigma}_{\hat{L}}$
BETWEEN	0.4152	0.5390	0.470
MOLAR (M.-D.)	0.1568	0.3494	0.565
MOLAR (G.-O.)	0.4394	0.4836	0.783
MOLAR (B.-L.)	0.3344	0.1850	0.457
PREMOLAR (M.-D.)	0.5622	0.5540	1.026
PREMOLAR (G.-O.)	0.3792	0.6560	0.857
PREMOLAR (B.-L.)	0.5280	0.6422	0.685

No Significant Differences

3. <u>Materials Comparison</u>:

$$S\hat{\sigma}_{\hat{L}} = \left(S \cdot MS_w \cdot \sum_{j=1}^{r} \frac{c_j^2}{n_j}\right)^{1/2}$$

$$\sum_{j=1}^{r} \frac{c_j^2}{n_j} = \frac{2(1/2)^2}{5} + \frac{2(-1/2)^2}{5} = 0.2$$

a. Silicone Syringe (SS) cf. Polysulfide Syringe (PS)

	SS$(\overline{X})$	PS$(\overline{X})$	$S\hat{\sigma}_{\hat{L}}$
BETWEEN	0.288	0.291	0.757
MOLAR (M.-D.)	0.080	0.820	0.893
MOLAR (G.-O.)	0.137	0.316	1.238
MOLAR (B.-L.)	0.118	0.128	0.723
PREMOLAR (M.-D.)	0.143	0.794	1.622
PREMOLAR (G.-O.)	0.538	0.410	1.356
PREMOLAR (B.-L.)	0.704	0.660	1.082

No Significant Differences

b. Silicone Regular (SR) cf. Polysulfide Regular (PR)

	SR($\bar{X}$)	PR($\bar{X}$)	$S\hat{\sigma}_{\hat{L}}$
BETWEEN	0.601	0.526	0.757
MOLAR (M.-D.)	0.045	0.170	0.893
MOLAR (G.-O.)	0.577	0.179	1.238
MOLAR (B.-L.)	0.069	0.403	0.723
PREMOLAR (M.-D.)	0.285	0.999	1.622
PREMOLAR (G.-O.)	0.564	0.154	1.356
PREMOLAR (B.-L.)	0.748	0.330	1.082

No Significant Differences

c. Silicone Regular (SR) cf. Agar (A) Hydrocolloid

	SR($\bar{X}$)	A($\bar{X}$)	$S\hat{\sigma}_{\hat{L}}$
BETWEEN	0.601	0.681	0.757
MOLAR (M.-D.)	0.045	0.152	0.893
MOLAR (G.-O.)	0.577	1.099	1.238
MOLAR (B.-L.)	0.069	0.581	0.723
PREMOLAR (M.-D.)	0.285	0.571	1.622
PREMOLAR (G.-O.)	0.564	0.923	1.356
PREMOLAR (B.-L.)	0.745	0.484	1.082

No Significant Differences

d. Polysulfide Heavy (PH) cf. Agar (A) Hydrocolloid

	PH($\bar{X}$)	A($\bar{X}$)	$S\hat{\sigma}_{\hat{L}}$
BETWEEN	0.526	0.681	0.757
MOLAR (M.-D.)	0.170	0.152	0.893
MOLAR (G.-O.)	0.179	1.099	1.238
MOLAR (B.-L.)	0.403	0.581	0.723
PREMOLAR (M.-D.)	0.999	0.571	1.622
PREMOLAR (G.-O.)	0.154	0.923	1.356
PREMOLAR (B.-L.)	0.330	0.484	1.082

No Significant Differences

4. All Silicones (S) versus All Polysulfides (P):

$$S\hat{\sigma}_{\hat{L}} = (S \cdot MS_w \cdot \sum_{j=1}^{r} \frac{c_j^2}{n_j})^{1/2}$$

$$\sum_{j=1}^{r} \frac{c_j^2}{n_j} = \frac{4(1/4)^2}{5} + \frac{4(-1/4)^2}{5} = 0.1$$

	S($\overline{X}$)	P($\overline{X}$)	$S\hat{\sigma}_{\hat{L}}$
BETWEEN	0.444	0.409	0.535
MOLAR (M.-D.)	0.062	0.495	0.631
MOLAR (G.-O.)	0.357	0.247	0.876
MOLAR (B.-L.)	0.094	0.266	0.511
PREMOLAR (M.-D.)	0.214	0.896	1.147
PREMOLAR (G.-O.)	0.551	0.282	0.959
PREMOLAR (B.-L.)	0.726	0.495	0.765

No Significant Differences

5. All Elastomers (E) versus All Agar (A) Hydrocolloid:

$$S\hat{\sigma}_{\hat{L}} = (S \cdot MS \cdot \sum_{j=1}^{r} \frac{c_j^2}{n_j})^{1/2}$$

$$\sum_{j=1}^{r} \frac{c_j^2}{n_j} = \frac{2(1/2)^2}{5} + \frac{8(1/8)^2}{5} = 0.125$$

	E($\overline{X}$)	A($\overline{X}$)	$S\hat{\sigma}_{\hat{L}}$
BETWEEN	0.426	0.681	0.598
MOLAR (M.-D.)	0.279	0.152	0.706
MOLAR (G.-O.)	0.302	1.099	0.979
MOLAR (B.-L.)	0.180	0.581	0.572
PREMOLAR (M.-D.)	0.555	0.571	1.283
PREMOLAR (G.-O.)	0.416	0.923	1.072
PREMOLAR (B.-L.)	0.610	0.484	0.856

No Significant Differences

Laboratory Phase-One Hour Pour - Part III

(See Appendix C for Raw Data)

Analysis of Variance

	F	$F_{.95}$; r-1, N-r	MS_w
BETWEEN	1.83	2.12	0.150
MOLAR (M.-D.)	0.61	2.12	0.209
*MOLAR (G.-O.)	6.05	2.12	0.402
MOLAR (B.-L.)	1.00	2.12	0.137
PREMOLAR (M.-D.)	0.65	2.12	0.690
PREMOLAR (G.-O.)	1.94	2.12	0.482
PREMOLAR (B.-L.)	0.76	2.12	0.307

*Significant Differences

SCHEFFE'S COMPARISONS

1. Individual.

$$S\hat{\sigma}_{\hat{L}} = \left(S \cdot MS_w \cdot \sum_{j=1}^{r} \frac{c_j^2}{n_j}\right)^{1/2}$$

$$\sum_{j=1}^{r} \frac{c_j^2}{n_j} = (1/5)^2 + (-1/5)^2 = 0.4$$

	Jelcone Syringe	Jelcone Regular	Permlastic Syringe	Permlastic Heavy	Surgident	$S\hat{\sigma}_{\hat{L}}$
BETWEEN	0.079	0.080	0.407	0.071	0.062	0.932
MOLAR (M.-D.)	0.107	0.124	0.089	0.196	0.089	0.289
MOLAR (G.-O.)	0.137	0.138	0.330	0.082	0.220	1.149
MOLAR (B.-L.)	0.196	0.020	0.059	0.020	0.040	1.138
PREMOLAR (M.-D.)	0.245	0.285	0.328	0.122	0.204	1.462
PREMOLAR (G.-O.)	0.768	0.462	0.717	0.307	0.769	1.664
PREMOLAR (B.-L.)	0.396	0.308	0.484	0.044	0.132	1.658

No Significant Differences

2. All High versus All Low Viscosity:

$$S\hat{\sigma}_{\hat{L}} = (S \cdot MS_w \cdot \sum_{j=1}^{r} \frac{c_j^2}{n_j})^{1/2}$$

$$\sum_{j=1}^{r} \frac{c_j^2}{n_j} = \frac{5(1/5)^2}{5} + \frac{5(-1/5)^2}{5} = 0.08$$

	Low Viscosity $(\bar{X})$	High Viscosity $(\bar{X})$	$S\hat{\sigma}_{\hat{L}}$
BETWEEN	0.4878	0.5392	0.417
MOLAR (M.-D.)	0.1820	0.1462	0.130
MOLAR (G.-O.)	0.7912	0.8298	0.514
MOLAR (B.-L.)	0.1180	0.1690	0.509
PREMOLAR (M.-D.)	0.2772	0.3340	0.654
PREMOLAR (G.-O.)	0.3896	0.8714	0.744
PREMOLAR (B.-L.)	0.3696	0.3080	0.741

No Significant Differences

3. Materials Comparison:

$$S\hat{\sigma}_{\hat{L}} = (S \cdot MS_w \cdot \sum_{j=1}^{r} \frac{c_j^2}{n_j})^{1/2}$$

$$\sum_{j=1}^{r} \frac{c_j^2}{n_j} = \frac{2(1/2)^2}{5} + \frac{2(-1/2)^2}{5} = 0.2$$

a. Silicone Syringe (SS) cf. Polysulfide Syringe (PS)

	SS $(\bar{X})$	PS $(\bar{X})$	$S\hat{\sigma}_{\hat{L}}$
BETWEEN	0.661	0.443	0.660
MOLAR (M.-D.)	0.179	0.081	0.205
MOLAR (G.-O.)	0.921	0.467	0.813
MOLAR (B.-L.)	0.118	0.069	0.805
PREMOLAR (M.-D.)	0.204	0.204	1.034
PREMOLAR (G.-O.)	0.692	0.462	1.177
PREMOLAR (B.-L.)	0.330	0.594	1.374

No Significant Differences

b. Silicone Regular (SR) cf. Polysulfide Regular (PR)

	SR($\bar{X}$)	PR($\bar{X}$)	$S\hat{\sigma}_{\hat{L}}$
BETWEEN	0.368	0.762	0.660
MOLAR (M.-D.)	0.098	0.134	0.205
*MOLAR (G.-O.)	1.085	0.206	0.813
MOLAR (B.-L.)	0.049	0.010	0.805
PREMOLAR (M.-D.)	0.347	0.550	1.034
PREMOLAR (G.-O.)	0.897	0.462	1.177
PREMOLAR (B.-L.)	0.374	0.110	1.374

*Significant Differences

c. Silicone Regular (SR) cf. Agar (A) Hydrocolloid

	SR($\bar{X}$)	A($\bar{X}$)	$S\hat{\sigma}_{\hat{L}}$
BETWEEN	0.368	0.335	0.660
*MOLAR (M.-D.)	0.098	0.330	0.205
MOLAR (G.-O.)	1.085	1.374	0.813
MOLAR (B.-L.)	0.049	0.472	0.805
PREMOLAR (M.-D.)	0.347	0.224	1.034
PREMOLAR (G.-O.)	0.897	0.643	1.177
PREMOLAR (M.-D.)	0.374	0.286	1.374

*Significant Differences

d. Polysulfide Heavy (PH) cf. Agar (A) Hydrocolloid

	PH($\bar{X}$)	A($\bar{X}$)	$S\hat{\sigma}_{\hat{L}}$
BETWEEN	0.762	0.335	0.660
MOLAR (M.-D.)	0.134	0.330	0.205
*MOLAR (G.-O.)	0.206	1.374	0.813
MOLAR (B.-L.)	0.010	0.472	0.805
PREMOLAR (M.-D.)	0.550	0.224	1.034
PREMOLAR (G.-O.)	0.462	0.641	1.177
PREMOLAR (B.-L.)	0.110	0.286	0.374

*Significant Differences

4. All Silicones (S) versus All Polysulfides (P):

$$S\hat{\sigma}_{\hat{L}} = (S \cdot MS_w \cdot \sum_{j=1}^{r} \frac{c_j^2}{n_j})^{1/2}$$

$$\sum_{j=1}^{r} \frac{c_j^2}{n_j} = \frac{4(1/4)^2}{5} + \frac{4(-1/4)^2}{5} = 0.1$$

	$S(\overline{X})$	$P(\overline{X})$	$S\hat{\sigma}_{\hat{L}}$
BETWEEN	0.514	0.602	0.466
MOLAR (M.-D.)	0.138	0.107	0.145
*MOLAR (G.-O.)	1.003	0.337	0.575
MOLAR (B.-L.)	0.084	0.039	0.570
PREMOLAR (M.-D.)	0.275	0.377	0.731
PREMOLAR (G.-O.)	0.795	0.462	0.832
PREMOLAR (B.-L.)	0.352	0.352	0.829

*Significant Differences

5. All Elastomers (E) versus All Agar (A) Hydrocolloid

$$S\hat{\sigma}_{\hat{L}} = (S \cdot MS_w \cdot \sum_{j=1}^{r} \frac{c_j^2}{n_j})^{1/2}$$

$$\sum_{j=1}^{r} \frac{c_j^2}{n_j} = \frac{2(1/2)^2}{5} + \frac{8(1/8)^2}{5} = 0.125$$

	$E(\overline{X})$	$A(\overline{X})$	$S\hat{\sigma}_{\hat{L}}$
BETWEEN	0.558	0.335	0.521
*MOLAR (M.-D.)	0.123	0.330	0.162
*MOLAR (G.-O.)	0.670	1.374	0.642
MOLAR (B.-L.)	0.061	0.472	0.637
PREMOLAR (M.-D.)	0.326	0.224	0.817
PREMOLAR (G.-O.)	0.628	0.641	0.930
PREMOLAR (B.-L.)	0.352	0.286	0.927

*Significant Differences

Comparison of the Data from Part I and Part II - Paired Means

See Appendix A and B for treatment means.

$\alpha = 0.05$

$H_o: \mu_1 = \mu_2$

$H_A: \mu_1 \neq \mu_2$

$d_i = X_{1i} - X_{2i}$

If H_o is true, then $X_{1i} - X_{2i}$ would come from a set of numbers with mean 0.

$t = \underline{\bar{d} - 0}$

degrees of freedom = N - 1 = 69

$t_{0.95}(N-1) = 2.00$

$t = 1.14$

therefore, accept H_o. Unable to show any difference.

Summary of Results

Clinical Phase-Immediate Pour - Part I.

1. There were no significant differences between high and low viscosity within the materials used.
2. When all low viscosity materials were compared with all high viscosity materials the following was noted:
   - (a) A significant difference in the "between" measurement - a 1.005% change for the low viscosity and a 0.772% change for the high viscosity treatment.
3. The following differences were manifest when the materials' comparison was made:
   - (a) Silicone syringe with polysulfide syringe: A significant difference in the "between" measurement - 0.685% change for silicone and 1.285% change for polysulfide. A significant difference in the molar mesio-distal measurement - 0.027% change for silicone and 0.410% change for polysulfide. A significant difference in the molar gingivo-occlusal measurement - 1.374% change for silicone and 0.289% change for polysulfide.
   - (b) Silicone regular with polysulfide heavy: A significant difference in the "between" measurement - 1.002% change for silicone and a 0.636% change for polysulfide.
4. When all silicones were compared with all polysulfides the following occurred:
   - (a) A significant difference in the molar gingivo-occlusal measurement - 1.092% change for silicone and 0.240% change for polysulfide.

5. There were no significant differences when all elastomers were compared with agar hydrocolloid.

<u>Laboratory Phase-Immediate Pour - Part II</u>.

1. There were no significant differences between high and low viscosity within the materials used.
2. There were no significant differences when all low viscosity materials were compared with all high viscosity materials.
3. There were no significant differences when the materials' comparison was made.
4. There were no significant differences when all silicones were compared with all polysulfides.
5. There were no significant differences when all elastomers were compared with all hydrocolloids.

<u>Laboratory Phase-One Hour Pour - Part III</u>.

1. There were no significant differences between high and low viscosity within the materials used.
2. There were no significant differences when all low viscosity materials were compared with all high viscosity materials.
3. The following differences were manifest when the materials' comparison was made:
   (a) <u>Silicone regular with polysulfide syringe</u>: A significant difference in the molar gingivo-occlusal measurement - 1.085% change for silicone and 0.206% change for polysulfide.
   (b) <u>Silicone regular with agar hydrocolloid</u>: A significant difference in the molar mesio-distal measurement - 0.134% change for silicone and a 0.330% change for agar hydrocolloid.

   (c) <u>Polysulfide heavy with agar hydrocolloid</u>: A significant difference in the molar gingivo-occlusal dimension - 0.206% change for polysulfide and a 1.374% change for agar.

4. When all silicones were compared with all polysulfides the following occurred:
   (a) A significant difference in the molar gingivo-occlusal dimension - 1.003% change for silicone and 0.337% change for polysulfide.
5. When all elastomers were compared with all agar hydrocolloid the following was noted:
   (a) A significant difference in the molar mesio-distal dimension - 0.123% change for the elastomers and a 0.330% change for agar.
   (b) A significant difference in the molar gingivo-occlusal dimension - 0.670% change for the elastomers and a 1.374% change for agar.

Discussion

Although the means of the clinical phase-immediate pour (Part I) were not different than the means of the laboratory phase-immediate pour (Part II), differences were noted for various test conditions in Part I whereas no differences were noted in Part II. This result is related first to the power of the statistical tests used, i.e. the paired "t" test for Part I versus Part II and Analysis of Variance for test conditions within each part. Secondly, a more consistent test procedure is possible when making an impression in the laboratory on a master die as compared to making intra-oral impressions. The fact that differences were noted in the clinical phase suggests that impression technique plays an important role in the accuracy of impressions.

CONCLUSIONS

1. Either high or low viscosity, as defined in this study, produce the same degree of accuracy and stability in the clinic or in the laboratory when using Surgident reversible hydrocolloid, Permlastic polysulfide or Jelcone silicone impression materials.
2. The molar crown preparation was the most sensitive to differences between the materials.
3. Generally, agar, polysulfide and silicone show comparable accuracies as evidenced by the comparisons.
4. The stability, after one-hour storage, clearly establishes the elastomers to be more stable than agar hydrocolloid. The descending order of accuracy is polysulfide, silicone, hydrocolloid.
5. The means of the clinical phase (Part I) and the means of the laboratory immediate pour (Part II) are statistically similar by a paired "t" test of means. The statistical assumption can then be made that the laboratory results may be used to predict performance of these materials.
6. Clinically, the direction of change was: always negative for the "between" measurements (0.5% to 1.5%) and always positive for the premolar buccolingual measurement (0.8% to 1.6%). This pattern generally remained throughout the study. This would indicate that the mesio-distal dimension between teeth is difficult to duplicate. Since it is impossible to accurately cast the bucco-lingual dimension of

an inlay, these results suggest that the increase in bucco-lingual width probably aids in the adaptation of inlays in this direction.

7. From the calculated viscosity values (Appendix A) it appears that the rapid polymerization rate of the silicone and the rapid rate of physical setting in the agar would decrease accuracy and stability due to latent strain release. This phenomenon was not evidenced in this investigation.

CLINICAL INTERPRETATIONS OF PERTINENT CONCLUSIONS

Although only one commercial product was tested within each material type, the results of this study suggest that since viscosity within reasonable limits does not affect the accuracy of impressions, a higher viscosity material may be used with safety. The clinical implication of this finding is that the rubber base materials, in particular, may be allowed to set for 3 1/2 minutes after mixing and prior to insertion. This will reduce the time in the mouth to approximately 6 1/2 minutes which will ameliorate significantly patient discomfiture. Additionally, the results of this study suggest that when the cast is poured immediately polysulfide, silicone and agar hydrocolloid are of equal accuracies. However, when the cast is poured one hour after the impression is made, the descending order of accuracy is polysulfide rubber base, silicone rubber base and hydrocolloid.

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APPENDIX A - EXPERIMENTAL DATA - PART I

Clinical Phase - Immediate Pour

	Jelcone Syringe Low Viscosity (2 min.)					Jelcone Syringe High Viscosity (3.5 min.)			
	$\overline{X}$	S	C.V.	S.E.M.	Fiducial Measurement	$\overline{X}$	S	C.V.	S.E.M.
BETWEEN TEETH	10.995	.020	.002	.009	11.080 11.119 Direct Measurement	11.052	.020	.002	.010
MOLAR									
Occlusal (M.-D.)	5.610	.007	.001	.003	5.609	5.607	.011	.002	.005
Proximal (G.-O.)	3.600	.015	.004	.007	3.640	3.580	.020	.006	.009
Proximal (B.-L.)	5.080	.020	.004	.009	5.085	5.091	.020	.004	.008
PREMOLAR									
Occlusal (M.-D.)	2.454	.008	.003	.004	2.454	2.450	.008	.003	.004
Proximal (G.-O.)	1.958	.010	.005	.004	1.951	1.953	.009	.005	.004
Proximal (B.-L.)	2.303	.008	.003	.004	2.274	2.304	.010	.004	.005

	Jelcone Regular Low Viscosity (2 min.)					Jelcone Regular High Viscosity (3.5 min.)			
	$\overline{X}$	S	C.V.	S.E.M.	Fiducial Measurement	$\overline{X}$	S	C.V.	S.E.M.
BETWEEN TEETH	11.084	.025	.002	→ .011	11.195 11.176 Direct Measurement	11.064 ←	.021	.002	.009
MOLAR									
Occlusal (M.-D.)	5.622	.011	.002	.005	5.609	5.635	.010	.002	.005
Proximal (G.-O.)	3.591	.022	.006	.010	3.640	3.630	.015	.004	.007
Proximal (B.-L.)	5.082	.011	.002	.005	5.085	5.099	.004	.001	.002
PREMOLAR									
Occlusal (M.-D.)	2.443	.007	.003	.003	2.454	2.460	.004	.002	.002
Proximal (G.-O.)	1.950	.007	.004	.003	1.951	1.945	.010	.005	.004
Proximal (B.-L.)	2.289	.004	.002	.002	2.274	2.297	.011	.005	.005

	Permlastic Syringe Low Viscosity (2 min.)					Permlastic Syringe High Viscosity (3.5 min.)			
	$\overline{X}$	S	C.V.	S.E.M.	Fiducial Measurement	$\overline{X}$	S	C.V.	S.E.M.
BETWEEN TEETH	11.071	.015	.001	.007	11.243 11.149	11.033	.021	.002	.009
MOLAR					Direct Measurement				
Occlusal (M-D.)	5.631	.016	.003	.007	5.609	5.633	.009	.002	.004
Proximal (G.-O.)	3.623	.018	.005	.008	3.640	3.636	.010	.003	.004
Proximal (B.-L.)	5.095	.009	.002	.004	5.085	5.099	.008	.002	.004
PREMOLAR									
Occlusal (M.-D.)	2.466	.007	.003	.003	2.454	2.452	.009	.004	.004
Proximal (G.-O.)	1.951	.005	.003	.002	1.951	1.949	.010	.005	.004
Proximal (B.-L.)	2.302	.008	.004	.004	2.274	2.298	.002	.001	.001

	Permlastic Heavy Low Viscosity (2 min.)					Permlastic Heavy High Viscosity (3.5 min.)			
	$\overline{X}$	S	C.V.	S.E.M.	Fiducial Measurement	$\overline{X}$	S	C.V.	S.E.M.
BETWEEN TEETH	11.151	.024	.002	.011 →	11.237 11.237	11.180 ←	.022	.002	.010
MOLAR					Direct Measurement				
Occlusal (M.-D.)	5.626	.009	.002	.004	5.609	5.620	.010	.002	.005
Proximal (G.-O.)	3.635	.005	.001	.002	3.640	3.631	.010	.003	.004
Proximal (B.-L.)	5.101	.005	.001	.002	5.085	5.093	.005	.001	.002
PREMOLAR									
Occlusal (M.-D.)	2.448	.010	.004	.004	2.454	2.464	.017	.007	.008
Proximal (G.-O.)	1.951	.005	.003	.002	1.951	1.958	.007	.003	.003
Proximal (B.-L.)	2.293	.001	.001	.001	2.274	2.293	.004	.002	.002

	Surgident Reversible Low Viscosity (45°C)					Surgident Reversible High Viscosity (35°C)			
	$\bar{X}$	S	C.V.	S.E.M.	Fiducial Measurement	$\bar{X}$	S	C.V.	S.E.M.
BETWEEN	11.025	.023	.002	.010	11.132 11.132 Direct Measurement	11.053	.014	.001	.006
MOLAR									
Occlusal (M.-D.)	5.594	.006	.001	.003	5.609	5.601	.007	.001	.003
Proximal (G.-O.)	3.611	.026	.007	.012	3.640	3.608	.009	.002	.004
Proximal (B.-L.)	5.073	.019	.004	.009	5.085	5.084	.010	.002	.005
PREMOLAR									
Occlusal (M.-D.)	2.441	.006	.003	.003	2.454	2.430	.007	.003	.003
Proximal (G.-O.)	1.946	.006	.003	.003	1.951	1.947	.002	.001	.001
Proximal (B.-L.)	2.293	.008	.003	.004	2.274	2.310	.014	.006	.006

PERCENTAGE CHANGE IN DIMENSIONS - Intra-oral - PART 3

(Means & S.D.)

	cone Syr. - Low	lcone Syr. - High	lcone Regular - Low	lcone Reg. - High	erm. Syr. - Low	erm. Syr. - High	erm. Heavy - Low	erm. Heavy - High	Surgident Rev. - Low	Surgident Rev. - High	MS$_A$, AS$_W$·F, SEM
BETWEEN	0.767(-) 0.033	0.603(-) 0.033	1.001(-) 0.050	1.002(-) 0.034	1.530(-) 0.018	1.040(-) 0.034	0.765(-) 0.045	0.507(-) 0.038	0.961(-) 0.043	0.710(-) 0.017	0.4189991-9 0.0345000-40 12.145 of 2.12 0.083
Molar (M.-D.)	0.018(+) 0.015	0.036(-) 0.042	0.232(+) 0.039	0.464(+) 0.033	0.392(+) 0.080	0.428(+) 0.027	0.303(+) 0.028	0.196(+) 0.033	0.267(-) 0.012	0.143(-) 0.014	0.1194482-9 0.0323000-40 3.698 of 2.12 0.080
Molar (G.-O.)	1.099(-) 0.171	1.648(-) 0.297	1.346(-) 0.366	0.275(-) 0.168	0.467(-) 0.243	0.110(-) 0.074	0.137(-) 0.019	0.247(-) 0.071	0.797(-) 0.503	0.879(-) 0.060	1.4565891-9 0.1972000-40 7.386 of 2.12 1985950
Molar (B.-L.)	0.098(-) 0.168	0.118(+) 0.129	0.039(-) 0.043	0.275(+) 0.006	0.197(+) 0.030	0.275(+) 0.024	0.315(+) 0.009	0.157(+) 0.010	0.236(-) 0.144	0.020(-) 0.039	0.0532155-9 0.0602000-40 0.8840 of 2.12 1097269
Premolar (M.-D.)	0.000 0.106	0.163(-) 0.120	0.449(-) 0.079	0.244(+) 0.236	0.489(+) 0.089	0.081(-) 0.143	0.244(-) 0.157	0.407(+) 0.480	0.530 0.069	0.978(-) 0.086	0.3948525-9 0.1565000-40 2.523 of 2.12 0.1769100
Premolar (G.-O.)	0.359(+) 0.251	0.103(+) 0.206	0.051(-) 0.131	0.308(-) 0.254	0.000 0.069	0.103(-) 0.238	0.000 0.069	0.359(+) 0.112	0.256(-) 0.097	0.205(-) 0.011	0.0999180-9 0.1438000-40 0.6948 of 2.12 0.1695877
Premolar (B.-L.)	1.275(+) 0.122	1.319(+) 0.202	0.660(+) 0.024	1.011(+) 0.226	1.231(+) 0.134	1.055(+) 0.009	0.836(+) 0.003	0.836(+) 0.035	0.836(+) 0.123	1.583(+) 0.360	0.4049186-9 0.1238000-40 3.2707 of 2.12 0.1573531

APPENDIX B - EXPERIMENTAL DATA - PART II

Laboratory Phase - Immediate Pour

	Jelcone Syringe Low Viscosity (2 min.)					Jelcone Syringe High Viscosity (3.5 min.)			
	$\overline{X}$	S	C.V.	S.E.M.	Direct Measurement	$\overline{X}$	S	C.V.	S.E.M.
BETWEEN	11.300	.020	.001	.008	11.314	11.263	.017	.001	.008
MOLAR									
Occlusal (M.-D.)	5.603	.014	.002	.006	5.609	5.606	.012	.002	.005
Proximal (G.-O.)	3.643	.018	.005	.008	3.640	3.633	.017	.005	.008
Proximal (B.-L.)	5.094	.010	.002	.004	5.085	5.082	.018	.003	.008
PREMOLAR									
Occlusal (M.-D.)	2.458	.009	.004	.004	2.454	2.457	.015	.006	.007
Proximal (G.O.)	1.946	.008	.004	.003	1.951	1.935	.015	.008	.007
Proximal (B.-L.)	2.291	.012	.005	.006	2.274	2.289	.005	.002	.002

	Jelcone Regular Low Viscosity (2 min.)					Jelcone Regular High Viscosity (3.5 min.)			
	$\bar{X}$	S	C.V.	S.E.M.	Direct Measurement	$\bar{X}$	S	C.V.	S.E.M.
BETWEEN	11.254	.025	.002	.011	11.314	11.238	.044	.004	.020
MOLAR									
Occlusal (M.-D.)	5.613	.013	.002	.006	5.609	5.610	.016	.003	.007
Proximal (G.-O.)	3.625	.002	.006	.010	3.640	3.613	.015	.004	.007
Proximal (B.-L.)	5.085	.018	.003	.008	5.085	5.092	.014	.003	.006
PREMOLAR									
Occlusal (M.-D.)	2.460	.018	.007	.008	2.454	2.462	.004	.002	.002
Proximal (G.-O.)	1.939	.002	.001	.001	1.951	1.941	.008	.004	.003
Proximal (B.-L.)	2.284	.016	.007	.007	2.274	2.298	.011	.005	.005

	Permlastic Syringe Low Viscosity (2 min.)					Permlastic Syringe High Viscosity (3.5 min.)			
	$\overline{X}$	S	C.V.	S.E.M.	Direct Measurement	$\overline{X}$	S	C.V.	S.E.M.
BETWEEN	11.270	.055	.005	.025	11.314	11.292	.080	.007	.036
MOLAR									
Occlusal (M.-D.)	5.586	.019	.003	.008	5.609	5.540	.065	.012	.029
Proximal (G.-O.)	3.631	.020	.005	.009	3.640	3.654	.023	.006	.010
Proximal (B.-L.)	5.084	.007	.001	.003	5.085	5.073	.018	.004	.008
PREMOLAR									
Occlusal (M.-D.)	2.469	.022	.009	.010	2.454	2.478	.014	.006	.006
Proximal (G.-O.)	1.943	.015	.008	.007	1.951	1.943	.012	.006	.005
Proximal (B.-L.)	2.293	.018	.008	.008	2.274	2.285	.004	.002	.002

	Permlastic Heavy Low Viscosity (2 min.)					Permlastic Heavy High Viscosity (3.5 min.)			
	$\overline{X}$	S	C.V.	S.E.M.	Direct Measurement	$\overline{X}$	S	C.V.	S.E.M.
BETWEEN	11.252	.066	.006	.029	11.314	11.257	.021	.002	.009
MOLAR									
Occlusal (M.-D.)	5.610	.020	.004	.009	5.609	5.591	.021	.004	.009
Proximal (G.-O.)	3.651	.028	.008	.013	3.640	3.638	.028	.008	.013
Proximal (B.-L.)	5.120	.033	.006	.015	5.085	5.079	.018	.003	.008
PREMOLAR									
Occlusal (M-D.)	2.421	.029	.012	.013	2.454	2.470	.031	.013	.014
Proximal (G.-O.)	1.952	.016	.008	.007	1.951	1.946	.024	.012	.011
Proximal (B.-L.)	2.283	.010	.004	.004	2.274	2.268	.011	.005	.005

	Surgident Reversible Low Viscosity (45°C)					Surgident Reversible High Viscosity (35°C)			
	$\overline{X}$	S	C.V.	S.E.M.	Direct Measurement	$\overline{X}$	S	C.V.	S.E.M.
BETWEEN	11.259	.033	.003	.015	11.314	11.215	.027	.002	.012
MOLAR									
Occlusal (M.-D.)	5.619	.014	.003	.006	5.609	5.602	.013	.002	.006
Proximal (G.-O.)	3.598	.028	.008	.013	3.640	3.602	.027	.007	.012
Proximal (B.-L.)	5.045	.018	.004	.008	5.085	5.066	.023	.005	.010
PREMOLAR									
Occlusal (M.-D.)	2.465	.028	.011	.012	2.454	2.437	.017	.007	.008
Proximal (G.-O.)	1.940	.012	.006	.005	1.951	1.926	.012	.006	.005
Proximal (B.-L.)	2.279	.015	.007	.007	2.274	2.291	.016	.007	.007

PERCENTAGE CHANGE IN DIMENSIONS - LAB - PART I

(Means & S.D.)

	elcone Syr. - Low	lcone Syr. - High	lcone Reg. - Low	elcone Reg. - High	erm. Syr. - Low	erm. Syr. - High	erm. Heavy - Low	erm. Heavy - High	Surg. Rev. - Low	Surg. Rev. - High	MS$_A$,AS$_W$·F, SEM
BETWEEN	.124(-) .022	.451(-) .022	.530(-) .048	.672(-) .154	.388(-) .237	.194(-) .505	.548(-) .339	.504(-) .034	.486(-) .085	.875(-) .058	0.2324353-9 0.1504000-40 1.545 of 2.12 0.1734358
Molar (M.-D.)	.107(-) .062	.053(-) .044	.071(+) .057	.018(+) .078	.410(-) .114	1.230(-) 1.346	.018(+) .132	.321(-) .135	.178(+) .066	.125(-) .057	0.6726116-9 0.2091000-40 3.216 of 2.12 0.2044993
Molar (G.-O.)	.082(+) .244	.192(-) .224	.412(-) .355	.742(-) .164	.247(-) .289	.385(+) .391	.302(+) .598	.055(-) .605	1.154(-) .602	1.044(-) .544	0.7551047-9 0.4016000-40 1.880 of 2.12 0.2834078
Molar (B.-L.)	.177(+) .037	.059(-) .120	0.000 .122	.138(+) .079	.020(-) .021	.236(-) .129	.688(+) .415	.118(-) .114	.787(-) .125	.374(-) .205	0.3789011-9 0.1367000-40 2.771 of 2.12 0.1653481
Premolar (M-D.)	.163(+) .127	.122(+) .360	.244(+) .524	.326(+) .024	.611(+) .777	.977(+) .334	1.345(-) 1.366	.652(+) 1.601	.448(+) 1.278	.693(-) .508	0.7419116-9 0.6899000-40 1.075 of 2.12 0.3714565
Premolar (G.-O.)	.256(-) .153	.820(-) .564	.615(-) .011	.513(-) .157	.410(-) .621	.410(-) .354	.051(+) .657	.256(-) 1.54	.564(-) .385	1.281(-) .380	0.590935-9 0.4822000-40 1.225 of 2.12 0.3105479
Premolar (B.-L.)	.748(+) .298	.660(+) .055	.440(+) .485	1.055(+) .215	.836(+) .597	.484(+) .026	.396(+) .189	.264(-) .248	.220(+) .458	.748(+) .500	0.3588205-9 0.3071000-40 1.168 or 2.12 0.2478305

APPENDIX C - EXPERIMENTAL DATA - PART III

Laboratory Phase - One Hour Pour

	Jelcone Syringe Low Viscosity (2 min.)					Jelcone Syringe High Viscosity (3.5 min.)			
	$\overline{X}$	S	C.V.	S.E.M.	Measurement	$\overline{X}$	S	C.V.	S.E.M.
BETWEEN TEETH	11.201	.029	.003	.013	11.280 11.280	11.210	.035	.003	.016
MOLAR									
Occlusal (M.-D.)	5.596	.015	.003	.007	5.609	5.602	.009	.002	.004
Proximal (G.-O.)	3.604	.007	.002	.003	3.640	3.609	.007	.002	.003
Proximal (B.-L.)	5.086	.009	.002	.004	5.085	5.096	.022	.004	.010
PREMOLAR									
Occlusal (M.-D.)	2.462	.024	.010	.011	2.454	2.456	.008	.003	.004
Proximal (G.-O.)	1.945	.011	.006	.005	1.951	1.972	.022	.011	.010
Proximal (B.-L.)	2.277	.016	.007	.007	2.274	2.286	.019	.008	.008

	Jelcone Regular Low Viscosity (2 min.)					Jelcone Regular High Viscosity (3.5 min.)			
	$\overline{X}$	S	C.V.	S.E.M.	Measurement	$\overline{X}$	S	C.V.	S.E.M.
BETWEEN TEETH	11.234	.038	.003	.017	11.280	11.243	.022	.002	.010
MOLAR									
Occlusal (M.-D.)	5.611	.010	.002	.005	5.609	5.600	.016	.003	.007
Proximal (G.-O.)	3.603	.027	.008	.012	3.640	3.598	.017	.005	.008
Proximal (B.-L.)	5.083	.009	.002	.004	5.085	5.088	.006	.001	.003
PREMOLAR									
Occlusal (M.-D.)	2.459	.016	.006	.007	2.454	2.466	.018	.007	.008
Proximal (G.-O.)	1.938	.015	.008	.007	1.951	1.929	.007	.003	.003
Proximal (B.-L.)	2.286	.008	.004	.004	2.274	2.279	.010	.005	.005

	Permlastic Syringe Low Viscosity (2 min.)				Measurement	Permlastic Syringe High Viscosity (3.5 min.)			
	$\overline{X}$	S	C.V.	S.E.M.		$\overline{X}$	S	C.V.	S.E.M.
BETWEEN TEETH	11.253	.017	.002	.008	11.280 11.299	11.226	.035	.003	.016
MOLAR									
Occlusal (M.-D.)	5.607	.015	.003	.007	5.609	5.616	.011	.002	.005
Proximal (G.-O.)	3.629	.006	.002	.003	3.640	3.617	.007	.002	.003
Proximal (B.-L.)	5.087	.006	.001	.003	5.085	5.090	.013	.003	.006
PREMOLAR									
Occlusal (M.-D.)	2.453	.006	.002	.003	2.454	2.463	.009	.003	.004
Proximal (G.-O.)	1.949	.008	.004	.004	1.951	1.935	.007	.004	.003
Proximal (B.-L.)	2.293	.004	.002	.002	2.274	2.282	.012	.006	.005

	Permlastic Heavy Low Viscosity (2 min.)				Measurement	Permlastic Heavy High Viscosity (3.5 min.)			
	$\bar{X}$	S	C.V.	S.E.M.		$\bar{X}$	S	C.V.	S.E.M.
BETWEEN TEETH	11.217	.026	.002	.011	11.299	11.209	.066	.006	.029
MOLAR									
Occlusal (M.-D.)	5.622	.018	.003	.009	5.609	5.611	.040	.007	.018
Proximal (G.-O.)	3.634	.012	.003	.005	3.640	3.631	.020	.006	.009
Proximal (B.-L.)	5.085	.019	.004	.008	5.085	5.086	.055	.011	.025
PREMOLAR									
Occlusal (M.-D.)	2.466	.004	.002	.002	2.454	2.469	.012	.005	.005
Proximal (G.-O.)	1.939	.008	.004	.003	1.951	1.957	.010	.005	.004
Proximal (B.-L.)	2.271	.013	.006	.006	2.274	2.272	.021	.009	.009

	Surgident Reversible Low Viscosity (45oC)				Measurement	Surgident Reversible High Viscosity (35^{o}C)			
	$\bar{X}$	S	C.V.	S.E.M.		$\bar{X}$	S	C.V.	S.E.M.
BETWEEN TEETH	11.156	.034	.003	.015	11.197	11.163	.053	.005	.024
MOLAR									
Occlusal (M.-D.)	5.588	.016	.003	.007	5.609	5.593	.016	.003	.007
Proximal (G.-O.)	3.586	.012	.003	.005	3.640	3.594	.019	.005	.008
Proximal (B.-L.)	5.060	.007	.001	.003	5.085	5.062	.008	.002	.003
PREMOLAR									
Occlusal (M.-D.)	2.446	.009	.004	.004	2.454	2.451	.011	.005	.005
Proximal (G.-O.)	1.946	.013	.007	.006	1.951	1.931	.005	.003	.002
Proximal (B.-L.)	2.279	.010	.005	.005	2.274	2.282	.014	.006	.006

PERCENTAGE CHANGE IN DIMENSIONS - LAB - PART 2

(Means & S.D.)

	lcone Syr. - Low	elcone Syr. High	elcone Reg. - Low	lcone Reg. - High	erm. Syr. - Low	erm. Syr. - High	erm. Heavy - Low	erm. Heavy - High	Surg. Rev. - Low	Surg. Rev. - High	MS_A, $AS_w \cdot F$, SEM
BETWEEN	.700(-) .068	.621(-) .095	.408(-) .115	.328(-) .038	.239(-) .023	.646(-) .097	.726(-) .051	.797(-) .338	.366(-) .090	.304(-) .225	0.2088669-9 0.1140000-40 1.832 of 2.12 0.1509966
Molar (M.-D.)	.232(-) .068	.125(-) .028	.036(+) .033	.160(-) .085	.036(+) .069	.125(+) .040	.232(+) .107	.036(+) .511	.374(-) .077	.285(-) .082	0.0667771-9 0.011-40 0.607 of 2.12 0.1483239
Molar (G.-O.)	.989(-) .037	.853(-) .042	1.016(-) .567	1.154(-) .226	.302(-) .028	.632(-) .041	.165(-) .103	.247(-) .314	1.484(-) .101	1.264(-) .265	1.0431713-9 0.1724-40 6.051 of 2.12 0.856879
Molar (B.-L.)	.020(+) .033	.216(+) .191	.039(-) .029	.059(+) .014	.039(+) .015	.098(+) .068	0.000 .135	.020(+) 1.169	.492(-) .021	.452(-) .023	0.1689047-9 0.1698-40 0.995 of 2.12 0.1842823
Premolar (M.-D.)	.326(+) .972	.081(+) .102	.204(+) .419	.489(+) .512	.041(-) .061	.367(+) .122	.489(+) .031	.611(+) .229	.326(-) .146	.122(-) .206	0.1831291-9 0.28-40 0.654 of 2.12 0.2366431
Premolar (G.-O.)	.308(-) .338	1.076(+) 1.324	.666(-) .606	1.128(-) .117	.103(-) .166	.820(-) .141	.615(-) .156	.308(+) .246	.256(-) .468	1.025(-) .068	0.7030758-9 0.363-40 1.937 of 2.12 0.2694438
Premolar (B.-L.)	.132(+) .512	.528(+) .689	.528(+) .139	.220(+) .210	.836(+) .034	.352(+) .272	.132(-) .338	.088(-) .825	.220(+) .207	.352(+) .376	0.2754497-9 .3602-40 0.7647132 .2684026

APPENDIX D - VISCOSITY DATA

APPENDIX A

VISCOSITY DETERMINATIONS

Calibration:

Esterline Angus Recorder, = 500 millivolts full scale

(a) Large plunger in viscometer, = 17.7 mv/sec. with 30,800 Cp Standard

(b) Middle plunger in viscometer, = 31.8 mv/sec. with 100,000 Cp Standard

(c) Small plunger in viscometer = 176 mv/sec. with 100,000 Cp Standard

Material	Time	Size Plunger	Millivolts/sec.		Centipoises
Jelcone Syringe	2 min.	a	8.5 9.8 7.7	$\bar{X}$ = 8.66	63,391
Jelcone Syringe	3½ min.	a	0.8 0.8 1.2	$\bar{X}$ = 0.93	586,194
Permlastic Syringe	2 min.	a	4.5 5.0 5.5	$\bar{X}$ = 5.0	109,032
Permlastic Syringe	3½ min.	b	21.6 24.5 24.0	$\bar{X}$ = 23.6	137,745
Jelcone Regular	2 min.	b	7.0 9.0 6.7	$\bar{X}$ = 7.56	420,635
Jelcone Regular	3½ min.	b	0.75 1.05 0.65	$\bar{X}$ = 0.82	3,878,048
Permlastic Heavy	2 min.	c	13.0 12.6 10.0 16.0	$\bar{X}$ = 12.9	1,364,341
Permlastic Heavy	3½ min.	c	4.8 4.0 3.5	$\bar{X}$ = 4.2	4,190,476

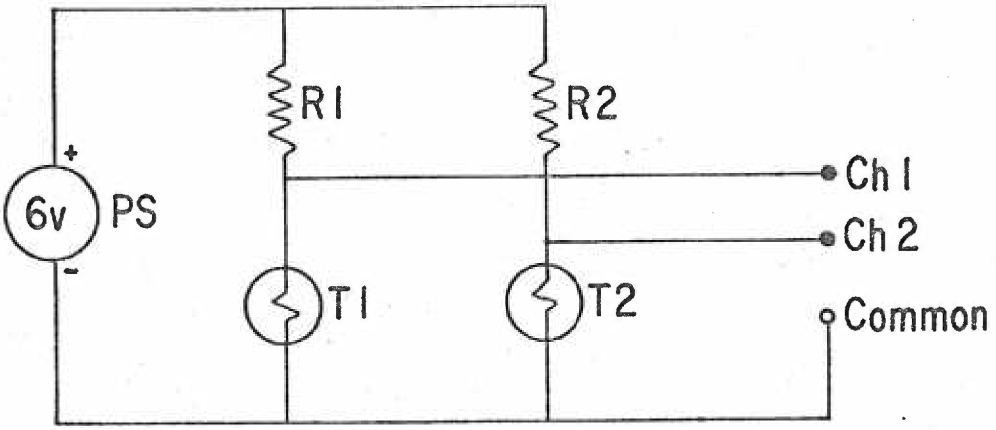
Material	Temp.	Size Plunger	Millivolts/sec.		Centipoises
Surgident	45°C	b	12.3 10.7 11.0	$\bar{X}$ = 113.3	281,416
Surgident	35°C	c	5.3 7.4 8.5 6.0	$\bar{X}$ = 6.8	2,588,235

$$\text{Centipoises} = \frac{\dfrac{1}{\text{experimental millivolts}} \cdot \text{Centipoise Units (of standard)}}{\dfrac{1}{\text{Centipoise Units of standard}}}$$

VISCOSITY DETERMINATIONS

MATERIAL	VISCOSITY (Centipoises)
1. Jelcone Syringe - Low....................	63,391
2. Jelcone Syringe - High...................	586,194
3. Permlastic Syringe - Low.................	109,032
4. Permlastic Syringe - High................	134,745
5. Jelcone Regular - Low....................	420,635
6. Jelcone Regular - High...................	3,878,048
7. Permlastic Heavy - Low...................	1,364,341
8. Permlastic Heavy - High..................	4,190,476
9. Surgident Reversible - Low...............	281,416
10. Surgident Reversible - High.............	2,588,235

FIG. 2 THERMISTOR—RECORDER CIRCUIT



R & R = 69,000 Ohms

T & T = 34A2 Thermister (VECO)

APPENDIX E - INTRA-ORAL TEMPERATURE DATA

INTRA-ORAL TEMPERATURE DATA

CALIBRATION OF THERMISTOR-RECORDER:

RED PEN	BLUE PEN	°C
5	5	10
38	39	21
56	57.3	29
59.8	61	31
62.5	64	33
66.2	66.8	35
67	68.3	36
68.8	70	37
66.9	71	38
70.5	71.8	39.5
72	73	40
74	75	42
78.5	80.5	45
83.5	83.5	52
86	86.5	55

PREMOLAR	°C	MOLAR	°C
67.3		68.8	
66.5		67.8	
67.3		68.0	
67.3		68.5	
67.5		68.0	
67.5		68.0	
$\overline{X}$ = 67.2	36°C	$\overline{X}$ = 68.2	36°C

INTRA-ORAL TEMPERATURE OF CASTINGS

Taken with mouth open:

MOLAR	PREMOLAR
$\overline{X} = 36^{\circ}C$	$\overline{X} = 36^{\circ}C$
$*n = 6$	$*n = 6$

Taken after removal of impressions.

Castings took 5.0± .5 minutes to return to a stable temperature.

FIG. 3 VISCOMETER CIRCUIT