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The Physical Properties of Dental Amalgam with Special Reference to the Eames Technic

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THE PHYSICAL PROPERTIES OF DENTAL AMALGAM WITH SPECIAL REFERENCE TO THE EAMES TECHNIC

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In Partial Fulfillment
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Master of Science

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I certify that I have read this thesis and that in my opinion it is fully adequate, in scope and quality, as a thesis for the degree of Master of Science.

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PREFACE

The purpose of this study was to re-evaluate the Eames technic for handling dental amalgam by comparing the tensile, transverse, and crushing strengths with those of conventionally prepared dental amalgam. Included in this study was a new spherical amalgam alloy which is still in the experimental stage.

The author is greatly indebted to Doctor George M. Hollenback for his continual guidance and help, and for fabricating the testing equipment which was used in this study. The author also wishes to acknowledge Doctor Melvin R. Lund for his helpful suggestions in carrying out this research work; to Doctor Lloyd Baum for reading the manuscript, and to Doctor Earl W. Collard for his help with the photography.

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CHAPTER I

THE PROBLEM

Amalgam has been in use for many years and has been investigated by a great many researchers. The majority of the studies of late have had to do with the residual mercury content of the amalgam alloy fillings [1][2][3][4] and with the crushing strength of the amalgam alloy fillings. [5] Very little work has been done on the tensile strength or the transverse strength of amalgam alloy.

I. THE PROBLEM

Statement of the problem. It was the purpose of this study (1) to evaluate the Eames technic for proportioning alloy and mercury and condensation to see how it compares with the regular conventional methods of handling amalgam alloy; (2) to evaluate the transverse strength of amalgam alloys; (3) to evaluate the tensile strength of amalgam alloys; (4) to make a brief evaluation of the spherical amalgam alloy to see how it compared with other alloys for crushing, tensile, and transverse strength.

Importance of the study. The Eames technic shows promise to the dental profession in that it cuts out a step in the preparation of the amalgam alloy; namely the squeezing out of the excess mercury. It also makes a filling with which one does not need to worry about having an excess of residual mercury, because the mercury content is never over the optimum amount. (3)(6) The transverse strength of an amalgam alloy restoration plays an important part in the life expectancy of that restoration. Many restorations that have failed have failed due to a fracture across the isthmus portion of the filling and this fracture is due, in part, to the transverse stress placed upon that restoration. The tensile strength is also an important physical property of the amalgam alloy restoration. The newly developed spherical amalgam alloy seems to show quite a bit of promise for amalgam alloy restorations, therefore this study dealt with some of the physical properties of this alloy when manipulated in the conventional manner and also with the Eames technic.

It is not in the scope of this study to evaluate all of the physical properties and their relationships to variables of manipulation, but only to evaluate the problems outlined above.

Organization of remainder of the thesis. The next chapter of this thesis will be a history of the early studies that have been conducted on amalgam, and then a review of some of the work that is being done presently on the physical properties of the amalgam alloys.

The following section will deal with a description of the instruments used and an explanation of how they operate and what their function was in this study.

The fourth section deals with the methods that were used in proportioning the alloy and mercury and the methods of condensing the alloy. A description of the materials used is also included.

Section five describes the results of the experiments that were carried out, with the comparisons between different alloys and between the same alloys using the Eames technic and the conventional technic.

The last section gives a brief summary of the paper, and also states the conclusions of this study.

CHAPTER II

REVIEW OF LITERATURE

Amalgam as a dental restorative material has been in use for about 200 years. [7] Among the dentists at the time that amalgam was first coming into use in this country there were two sides, those that used it, and those that did not use it and thought it should be banned from the practice. Among the early proponents of amalgam is the well known Doctor J. Foster Flagg who did much to defend amalgam from those who opposed its use. [8] A Doctor A. Snowden Riggot was one of those who opposed the use of amalgam, and said that "the use of a mercurial amalgam is, under all circumstances, wrong." [9]

The first attempts at scientific experimentation with the new silver alloys was the determination of shrinkage or expansion in the alloy upon setting. The first man to attempt scientific investigation of the sort was a John Tomes of London, in 1861. His work consisted of making holes in pieces of ivory that had been cut out in the form of glass microscope slides. These were clamped upon another piece of ivory and the holes filled with amalgam. When the amalgam hardened, the margins of the fillings were examined with a microscope to see whether they remained in contact with the sides of the cavity or not. However, there was no attempt made to measure the amount of contraction or expansion.[10]

The next man to work on the dimensional change of the amalgam alloys was a Doctor Thomas Fletcher of Warrington, England. His experiments consisted of placing fillings in short glass tubes. The fillings were carefully made, allowed to harden and then placed in ink or some other coloring agent. If the coloring penetrated around the filling it was considered to be due to the shrinkage of the alloy.[11]

Up until 1874 when Doctor Hitchcock did his work, all of the work had been whether the alloy shrank or expanded, but no one had tried to measure the amount of change. Doctor Hitchcock made an instrument that had an arm on a pivot, one end short, and the other end long. A specimen was placed against the short arm, and as the specimen expanded or contracted it moved the arm causing the long arm to move across a scale thereby measuring the amount of change to 1/1000 inch. This instrument, however, was not delicate enough to measure the finer changes which occur in the setting amalgam.[12]

Other men were working on other aspects of the amalgam alloys. Doctor Bogue ran tests to determine the mercury released from the amalgam fillings. In these tests he subjected amalgam to different acid solutions such as nitric, acetic, citric and hydrochloric.[13]

Perhaps the man who really started scientific investigation of dental amalgam on a planned program, was Doctor G. V. Black.[14]

Doctor Black developed a micrometer that would measure to 1/10,000 inch so that the dimensional change of amalgam could be measured more accurately than had been possible before. He soon found that all of the existing amalgams had very inconsistent behaviors. So he began making alloys of different silver-tin combinations as well as adding modifiers. He worked with these alloys both annealed and unannealed. He tested these alloys for working properties, the amount of mercury required, setting time, the shrinkage or expansion, the crushing strength, and the amount of flow. All of these experiments were recorded and the knowledge gained helped the manufacturers make a better amalgam.

Recently a lot of work has been done on the residual mercury content of amalgam fillings[1][3][15][16][17] as it affects strength and the other physical properties of amalgam. Some work has also been done on the effect mercury has on the tooth[18] as well as on the entire human system.[19] Other investigators have probed into the micro structure of the amalgam filling materials.[20][21][22]

Doctor Wilmer B. Eames proposed a mercury to alloy ratio of 1:1 so that the filling would contain a near optimum ratio of less than 50% mercury. As there is little or no excess mercury to remove the operator need concern himself only with the proper condensation of the amalgam. His technic consists of using equal parts of mercury and alloy by weight. He recommends a fine grain alloy, triturated in a mechanical triturator. No mulling or expressing of mercury is necessary. The bulk of the cavity is condensed using a 1 mm condenser with a 0.5 mm condenser for the line angles and retentive points. A packing thrust of about 10 pounds is recommended for the 1 mm condenser. Using the technic one gets higher early strength and the routine clinical use for over four years confirms the laboratory findings.(23)

An evaluation of the Eames technic (24) found that the early compressive strength using the technic were greater than those obtained with the conventional technic of using eight parts mercury to five parts alloy. However it was found that at seven days all the amalgams attained essentially the same strength, regardless of the mercury-alloy ratio that was used. This article also postulates that the early compressive strength may be attributed to the method of condensation rather than to the mercury-alloy ratio. However, it states that further research is necessary before a conclusion can be reached.

Another study was conducted on the strength of amalgam relative to the mercury percentages and plasticity.(25)

This study showed that dryness does not improve the crushing strength of amalgam and that a very dry amalgam requires greater condensing force and adds to the danger of lamination, whereas an amalgam of 1:1 mercury to alloy ratio is dry by most standards, it is easily condensed and produces consistently higher strength values. This study also confirms findings by other investigators [3] that a mercury content of 45% to 53% is not critical.

CHAPTER III

INSTRUMENTATION

I. MANUDYNOMOMETER

Figure 1, page 10, shows the manudynomometer which was used for the purpose of packing each specimen under a definite and known pressure. It consists of an aluminum base 1½ inches high, 2½ inches wide, and 5 inches long, which is drilled for the packing platform and a gauge with a hole connecting them. There is a circular packing platform at the front on which the die is placed when packing. It is mounted on a small piston which exerts a force on the oil in the hydraulic system which actuates the gauge. At the back is an upright dial pressure gauge that reads from 0 to 15 pounds in one-half pound increments. The manudynomometer is manufactured by Marshalltown Manufacturing Company, Iowa, U.S.A.

II. DILLON UNIVERSAL TESTER

The instrument that was used for testing the crushing strength, transverse strength, and tensile strength of the amalgam alloy specimens was a Dillon Model L Universal Tester, Serial 30/20, manufactured by W. C. Dillon and

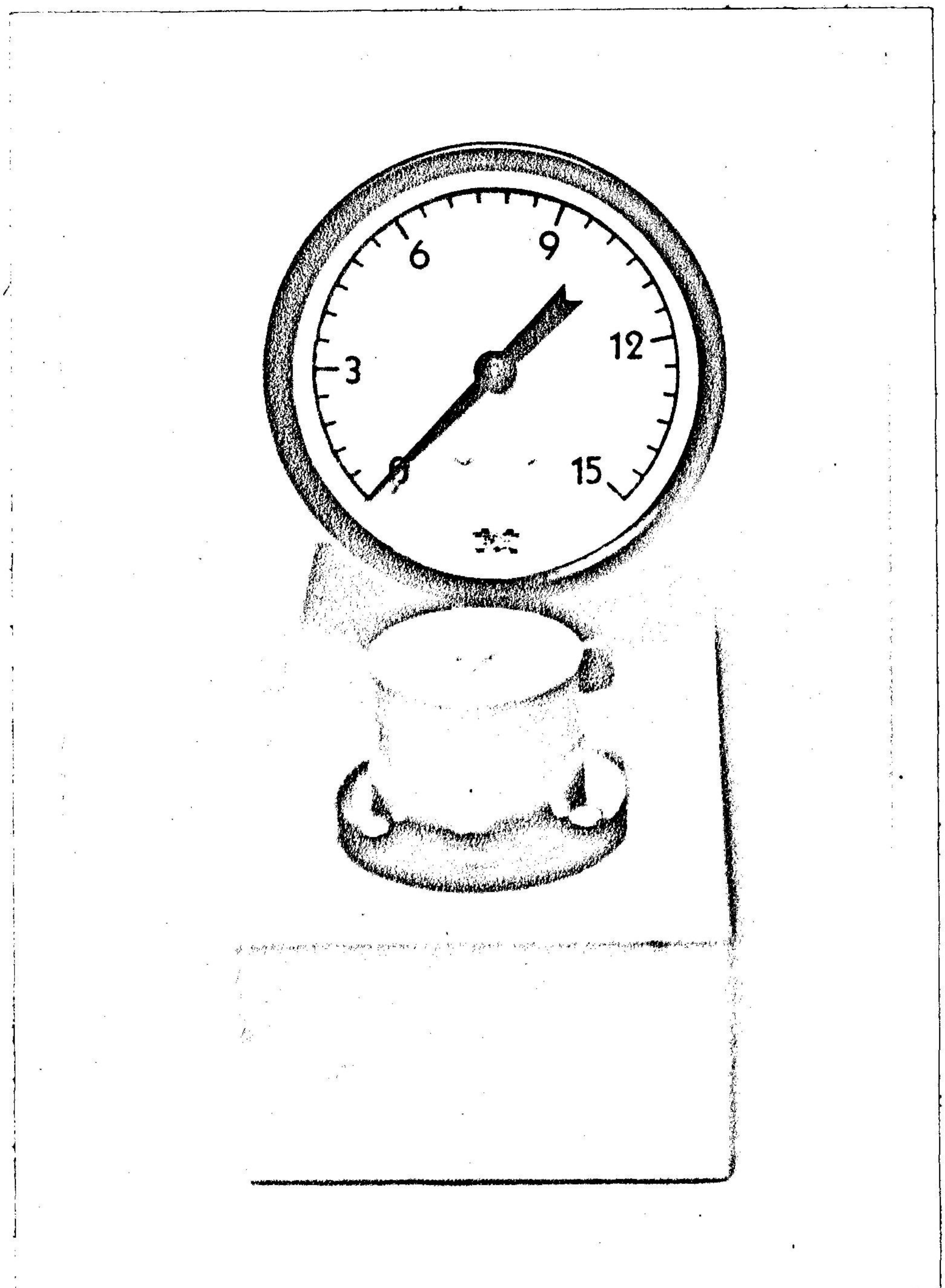

FIGURE 1

MANUDYNOMOMETER WITH CRUSHING

STRENGTH DIE IN PLACE

Company, Incorporated, 14620 Keswick Street, Van Nuys, California, U.S.A. The Dillon Universal Tester is shown in Figure 2, page 12.

The instrument stands 40 inches high with a base 6 inches high by 12 inches deep, and 18 inches wide. In the base is a hand wheel that raises and lowers the upper platform. The dial is mounted at the top and is supported by four round steel rods 1.25 inches in diameter. The lower platform is suspended from the dial on four steel rods 3/4 of an inch in diameter. There are three interchangeable dials held in place with two sliding pins 11/16 of an inch in diameter. One reads 0 to 500 pounds in five pound divisions; one reads 0 to 1,000 pounds in ten pound divisions, and one reads 0 to 7,500 pounds in fifty pound divisions. The dials are equipped with a shock absorber that prevents the needle from snapping back once a specimen is broken. The dials also have a red follower hand which stops at the exact point where breakage occurs as the needle drops back a slight amount when the specimen breaks.

III. DIES

The dies that were used in this study were made by Doctor George M. Hollenback, except the die for dimensional change which Doctor Hollenback had made by a tool and die maker many years ago.

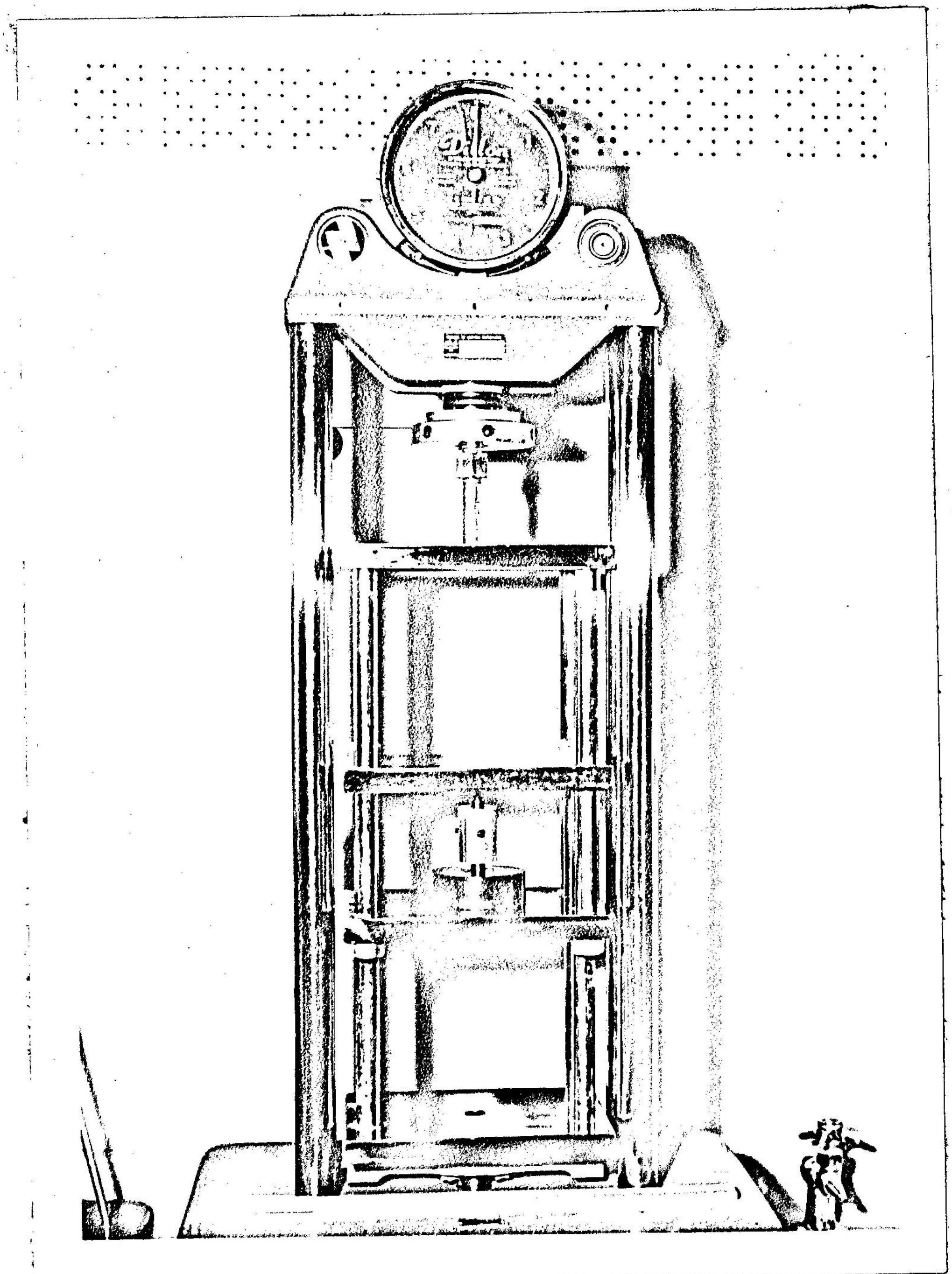

FIGURE 2

DILLON UNIVERSAL TESTER WITH TRANSVERSE TESTING APPARATUS IN PLACE

Crushing and transverse strength dies. The first die used was a two-piece split die that was securely held together by a steel base and a set screw, but this proved unsatisfactory due to the fact that it is nearly impossible to have the die split exactly in the center, so the specimen tended to stick in one half of the die and it (the specimen) was invariably fractured at the edge when removed from this half of the die.

The next die, shown in Figure 3, page 14, was a single piece split die which proved very satisfactory and was used throughout the remainder of the study for crushing strength specimens, and transverse specimens. This die consists of an aluminum base 1 1/8 inches in diameter, and ¼ inch high with a steel insert in the center. The diameter of the insert is .189 inch. This steel insert was the facing against which the specimen was packed. Next a spring steel cylinder was split, and then when clamped shut, was reamed out to make a perfectly rounded cavity. The cylinder was ½ inch long and allowed a specimen .190 inch diameter by .375 inch long. The spring steel cylinder was clamped together by an aluminum cylinder 1 1/16 inches in diameter by ½ inch high, and with a ¼ inch diameter hole in the center with a steel set screw in the side. When assembled the collar fits over the spring steel insert, and these fit over the steel insert in the base. The set screw is then tightened and makes a rigid die. See Figure 4,

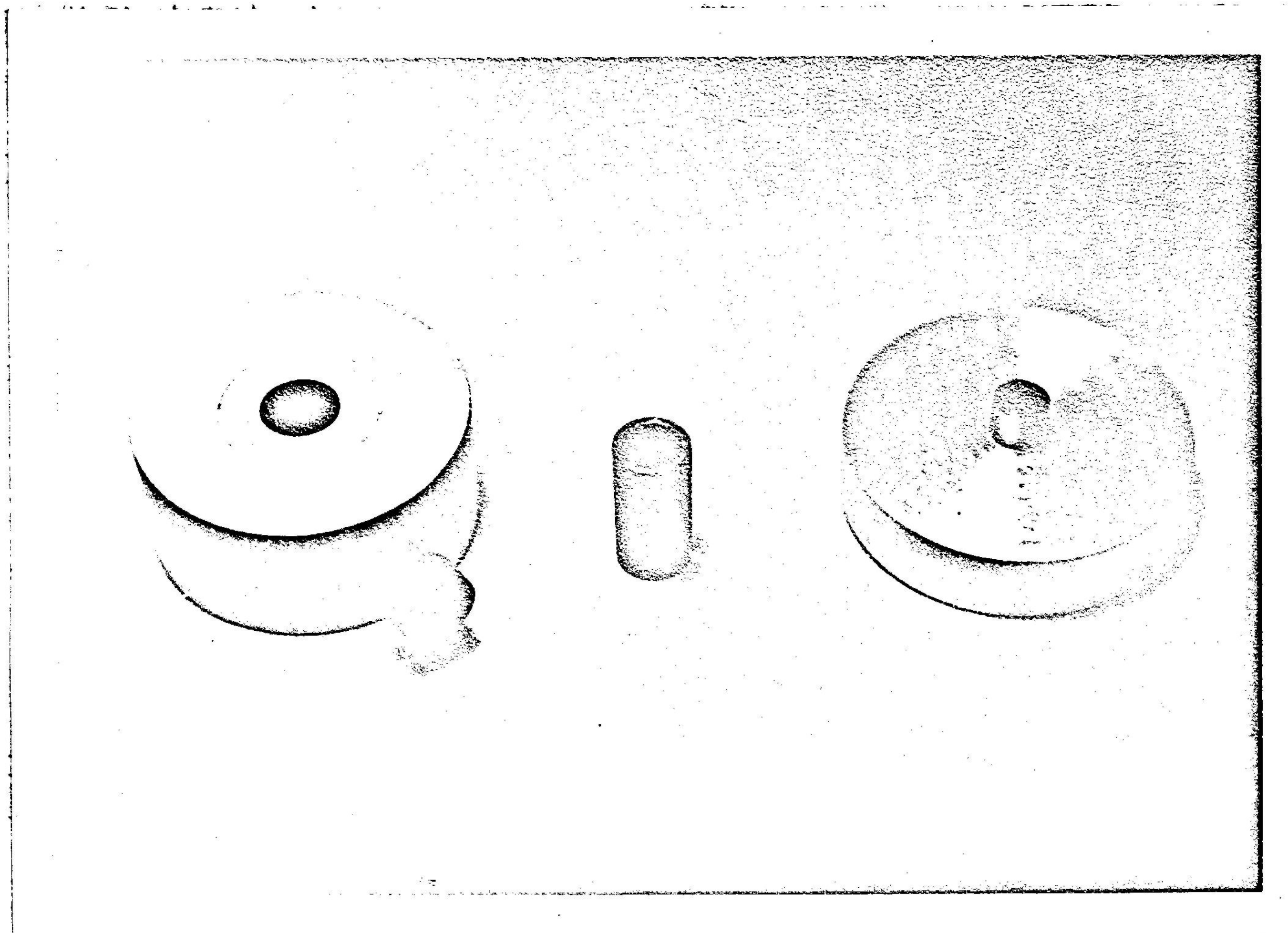

FIGURE 3

CRUSHING AND TRANSVERSE STRENGTH DIE DISASSEMBLED page 16.

Tensile die. This die, shown in Figure 5, page 17, consists of a base of aluminum and a three piece split die insert.

The base is made from a hexagonal base, and is 1 1/8 inches high with a diameter of 1¼ inches. Into the top of this is milled a slot 3/4 inch wide, and 1/2 inch deep with a set screw tapped into one side.

The die itself is 3/4 inch wide, 7/16 inch high, and 1 1/16 inches long when assembled. It has two larger ends with a .04 inch shim in the middle. The whole assembly is held together with four taper pins and then held rigidly in the base by tightening the set screw as in Figure 6A, page 18A. The die is made so the specimen has a larger portion on either end. The diameter of the ends is .180 inch with the center portion 3/64 of an inch less in diameter. The specimen is .462 inch long. These ends provide areas to hold the specimen in the tensile testing cage without exerting any lateral pressure on it.

The die is packed from one end so a special condenser was devised to condense the shoulder of the lower collar.

Dimensional die. Thie die is an all steel die of three piece split design. See Figure 6B, page 18B.

The base is 1 1/8 inches in diameter, and is threaded.

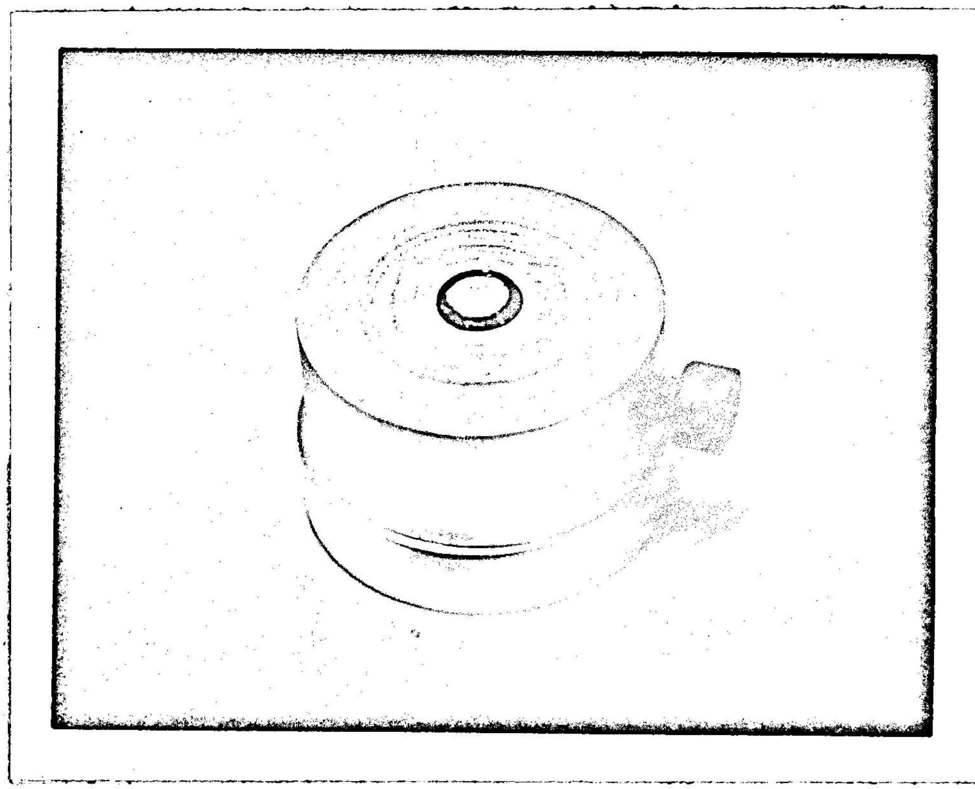

FIGURE 4

CRUSHING AND TRANSVERSE STRENGTH

DIE ASSEMBLED

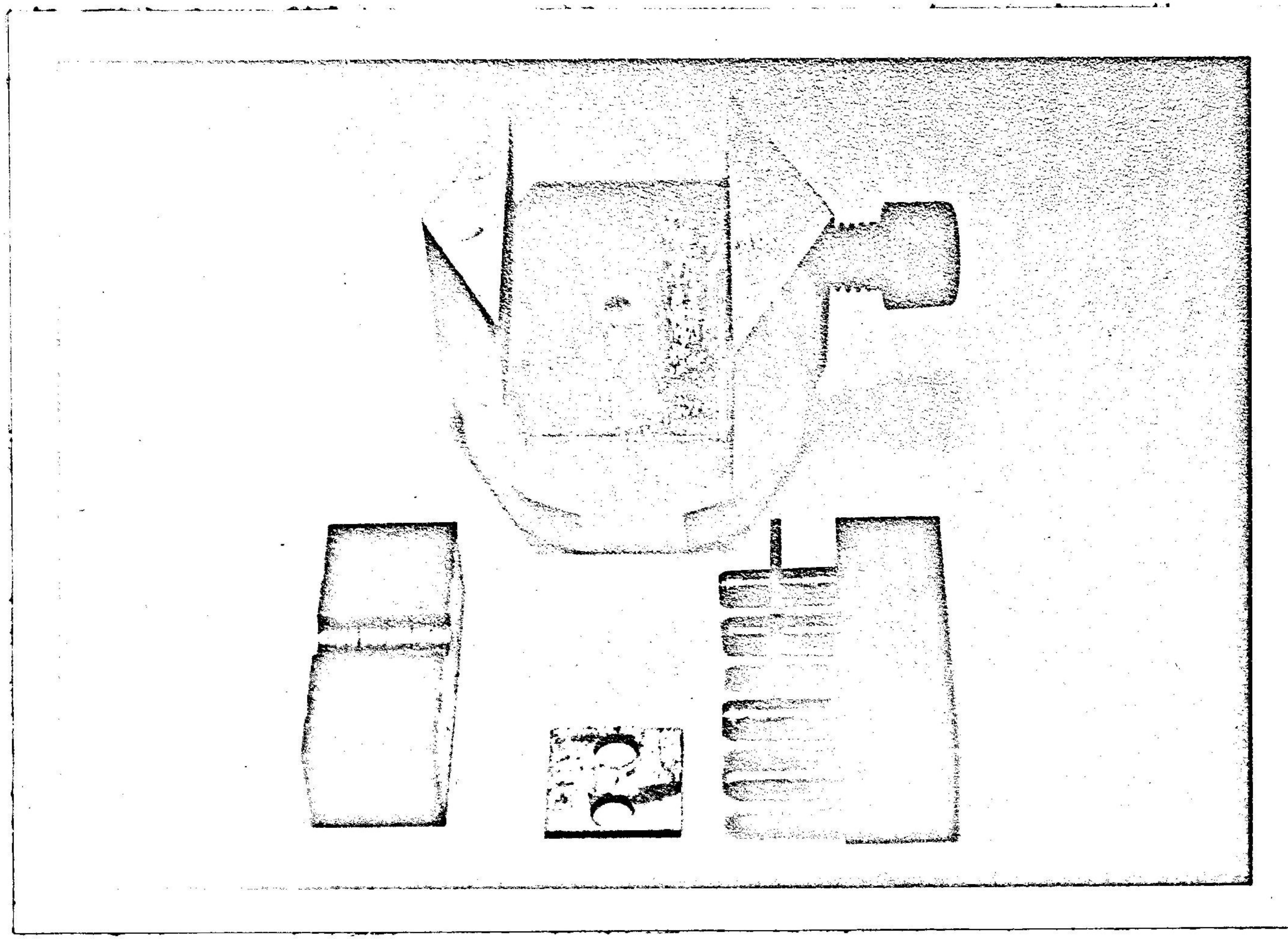

FIGURE 5

TENSILE STRENGTH DIE DISASSEMBLED

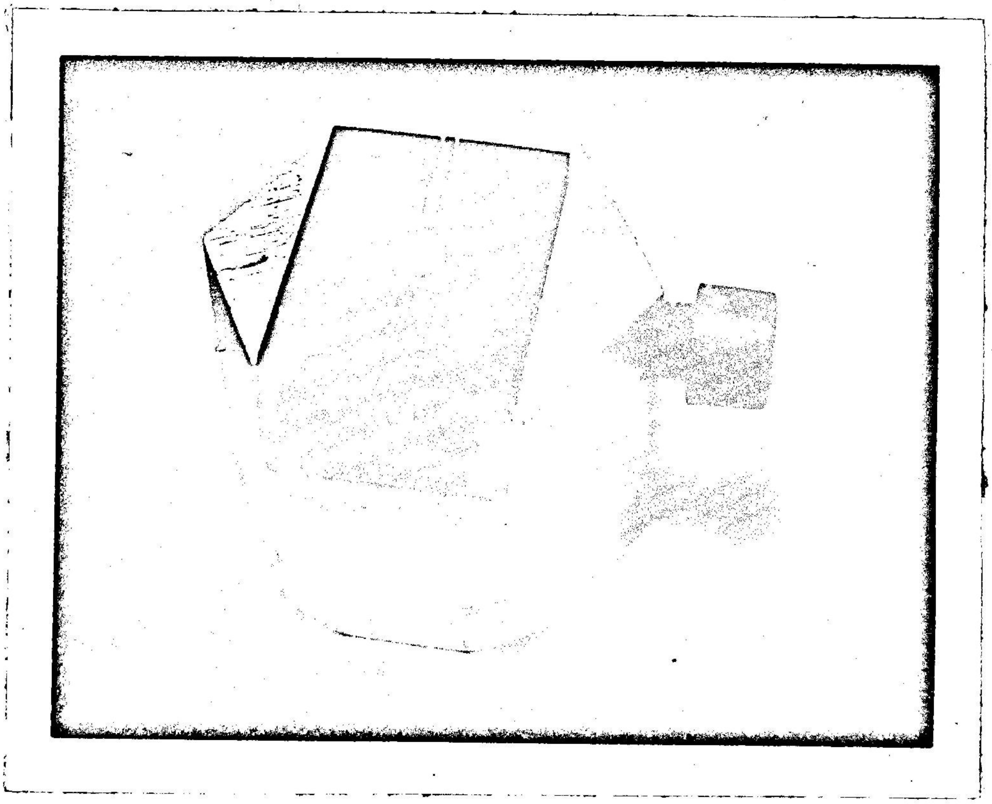

FIGURE 6A

TENSILE STRENGTH DIE ASSEMBLED

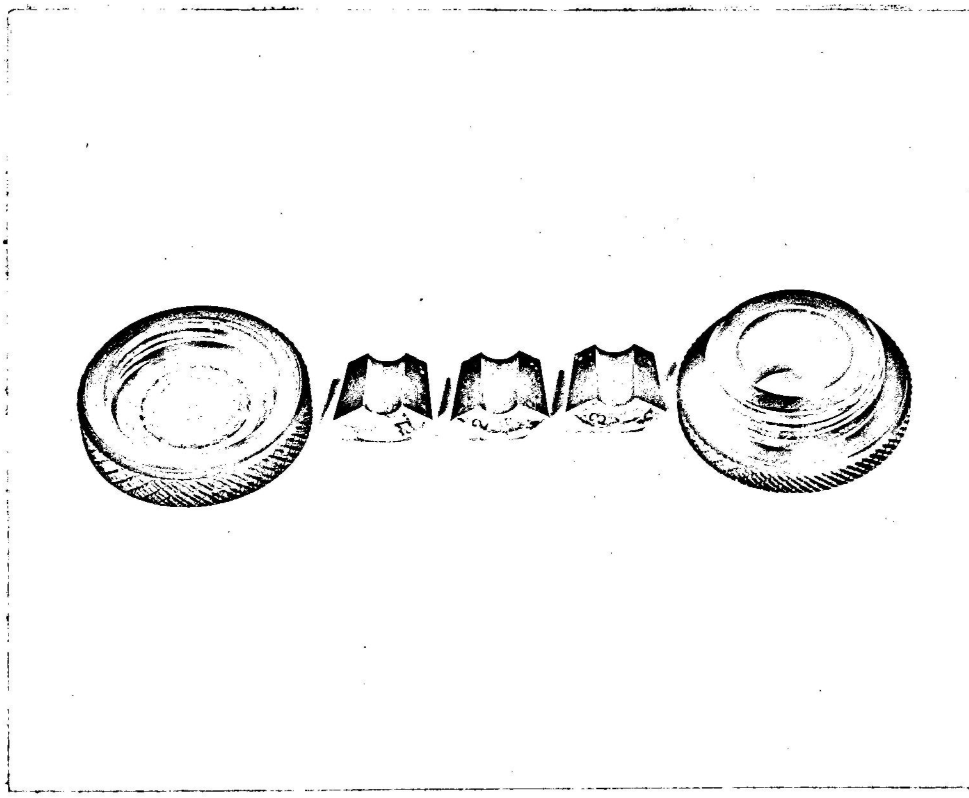

FIGURE 6B

DIMENSIONAL DIE DISASSEMBLED

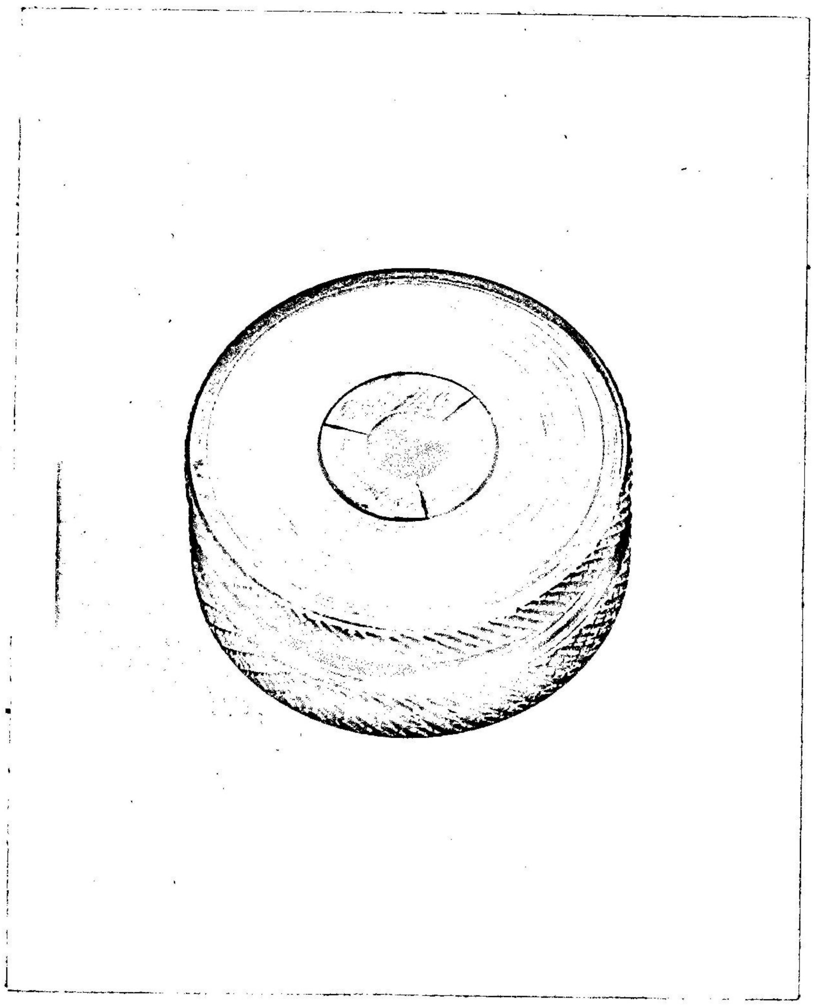

FIGURE 6C

DIMENSIONAL DIE ASSEMBLED

There is a top part that is the same diameter and threaded to fit the base. This top part has a tapering hole in the center and holds the three pieces of the die. The three pieces are numbered so that they can always be aligned in the proper order. When the top and bottom parts are screwed together, the three pieces of the die are forced together and the top part with the tapered hole acts as a Jacobs chuck and holds the die pieces firmly together. See Figure 6C, page 18C. The specimen is exactly 1 cm long and 5 mm in diameter. It is easily removed from the die, as the die being in three pieces will not grip the specimen.

IV. TESTING APPARATUS

The special testing cages and grips were made by Doctor George M. Hollenback especially for this study. A common cage was used for the crushing and transverse strength equipment.

Crushing. The main cage or part that holds the ends in alignment is made of aluminum, and is 1¼ inches in diameter, and 1 3/4 inches long with a 7/16 inch hole lengthwise through the center of the block. The block is split through on one side, and a screw hole tapped crosswise to the long axis with a screw placed so that when the screw is tightened this device acts as a circular clamp. This testing apparatus is shown in Figure 7, page 21.

The crushing holder proper consists of two ends. One end is 7/16 inch in diameter by 1 1/8 inches long, and is made of steel. In one end is inserted a 3/8 inch steel ball, and the other end has a concave cut that holds one end of the specimen. This end piece is held securely in the cage.

The other end is made of a hollow cylinder 7/16 inch in diameter on the outside, and 5/16 inch inside diameter. Into this is fitted a piston with a ¼ inch steel ball on one end, and a concave surface on the other end to hold the other end of the specimen. This piston is 1¼ inches long. When the specimen is inserted and both ends are put into the cage, Figure 8, page 22, the only moving part is this inner piston. As there are balls on both ends, there is always a perfect alignment of the specimen and ends when placed in the Dillon Testing Machine.

Transverse. The apparatus for testing the transverse strength of amalgam alloy uses the same cage or base part as that for crushing strength, but uses separate ends. See Figure 9, page 23. One end piece is a solid steel rod 7/16 inch in diameter by 1 1/8 inches long. This piece is flat on one end, and the other end has a slot 3/16 inch wide, and 1/8 inch deep, milled across one way. The specimen rests in this slot. Crosswise to this is another

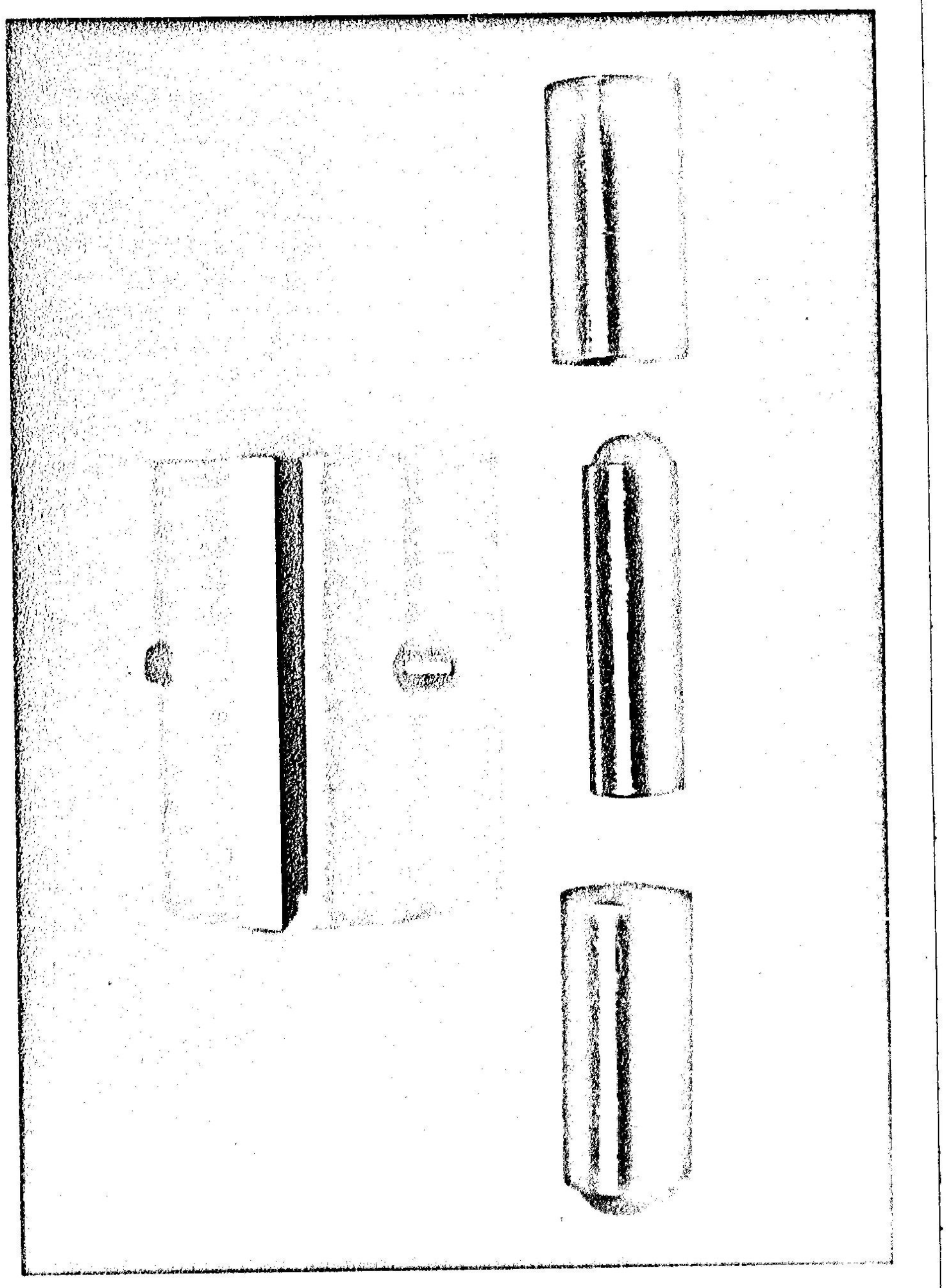

FIGURE 7

CRUSHING STRENGTH TESTING

APPARATUS DISASSEMBLED

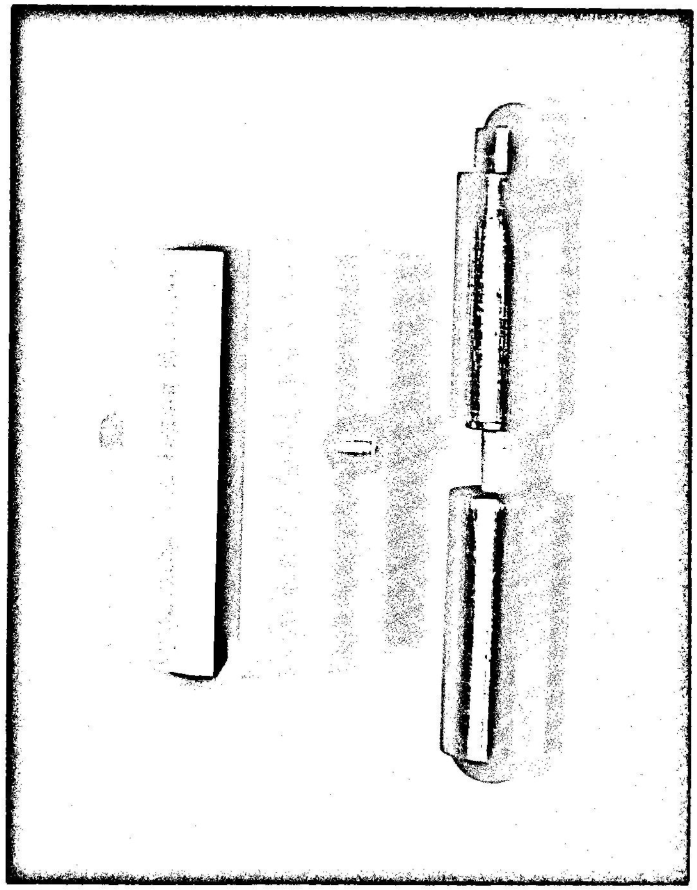

FIGURE 8

CRUSHING STRENGTH TESTING APPARATUS

PARTIALLY ASSEMBLED

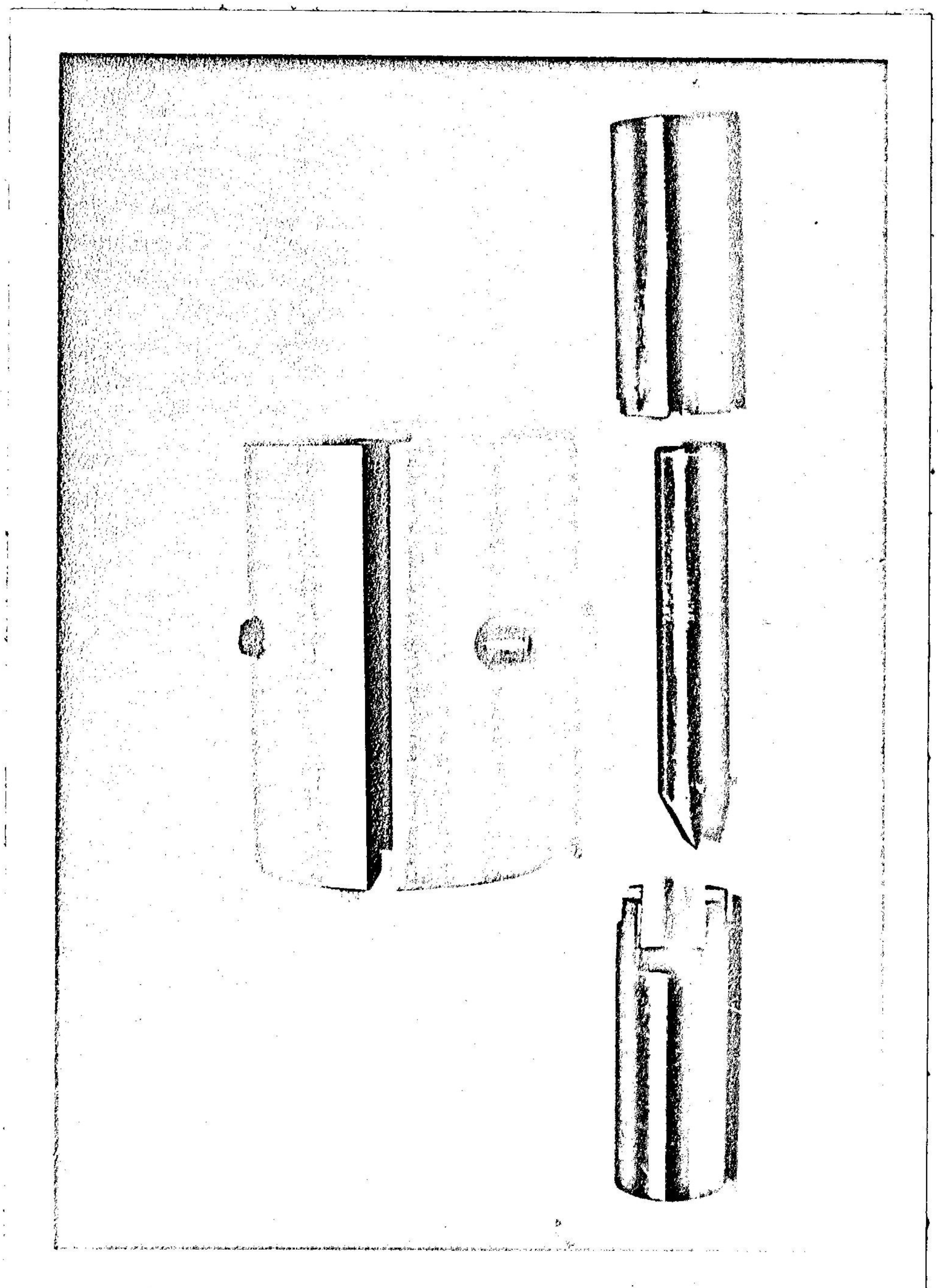

FIGURE 9

TRANSVERSE STRENGTH TESTING

APPARATUS DISASSEMBLED

slot ¼ inch wide and ¼ inch deep, milled to allow the specimen to be held at each end by 1/16 inch.

The other end piece is in two parts. One a cylinder 7/16 inch outside diameter, and ¼ inch inside diameter by 1 1/16 inches long. One end is milled with a slot 3/16 inch wide and 1/8 inch deep. This fits over the specimen and holds the ends. There is also a crosswise slot ½ inch deep and 1/16 inch wide which is a guide slot for a pin in the inner sliding part. The inner sliding part is also steel ¼ inch in diameter by 1½ inches long, and flat at one end with a wedge point on the other end. One-fourth inch from the point is a cross pin which will guide this center sliding part.

When the specimen is placed in these two holders, as in Figure 10, page 25, and in the cage, the punch or sliding part is the only movable part. This assembly is then placed in the Dillon Universal Tester, Figure 11, page 26.

<u>Tensile</u>. The tensile testing apparatus, Figure 12, page 27, consists of two main parts. The larger one is 2¼ inches wide by 2 1/16 inches high by 3/4 inch deep. This consists of a top piece and a bottom piece held together by two rods, one on either side 5/16 inch in diameter by 1¼ inches long. The top cross member has three holes drilled and into the two side holes the side

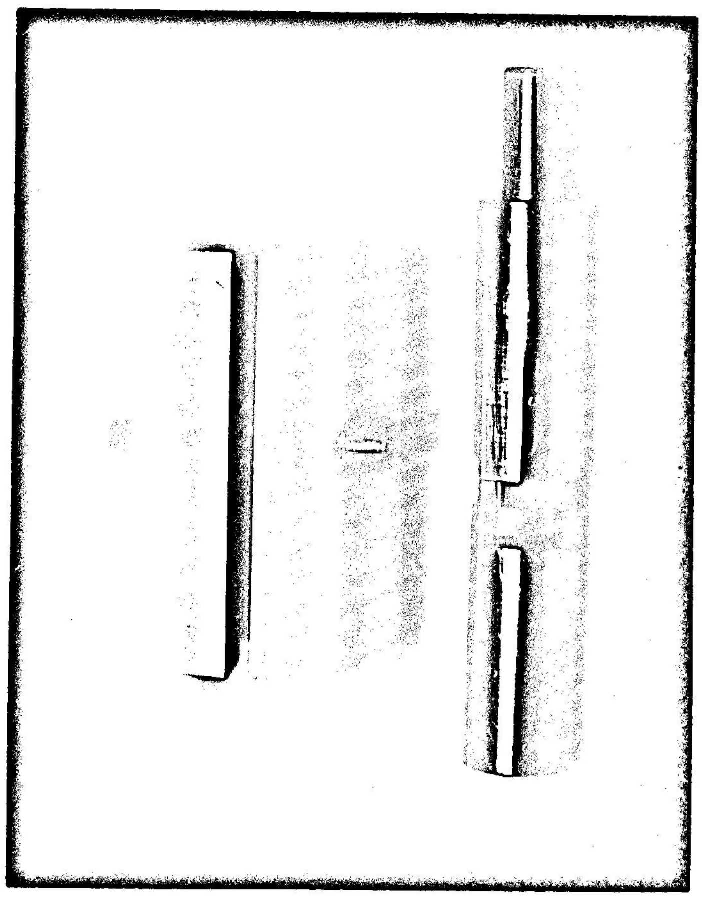

FIGURE 10

TRANSVERSE STRENGTH TESTING APPARATUS

PARTIALLY ASSEMBLED

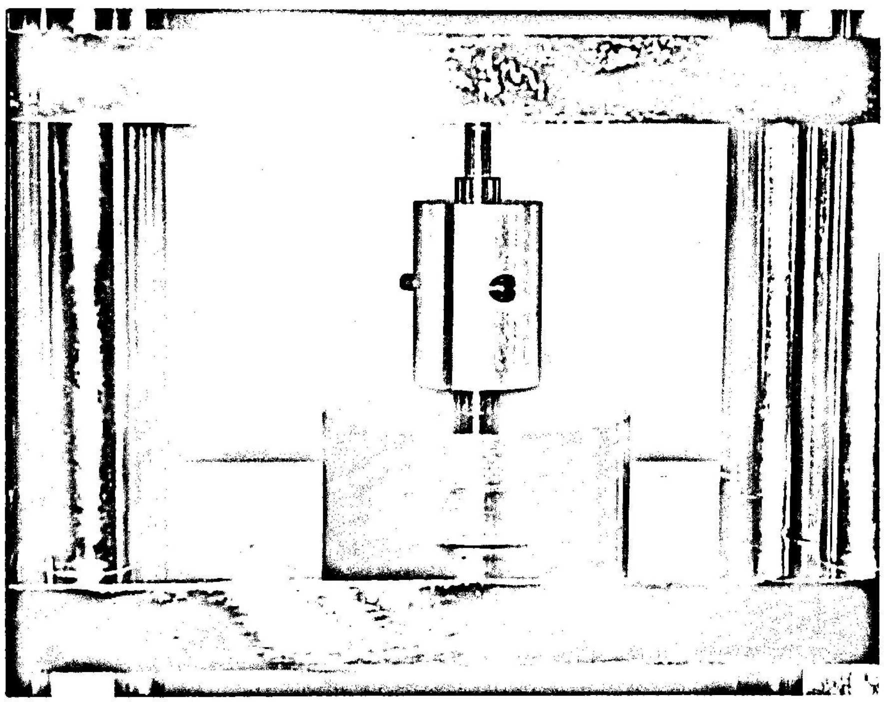

FIGURE 11

TRANSVERSE STRENGTH TESTING APPARATUS

IN DILLON UNIVERSAL TESTER

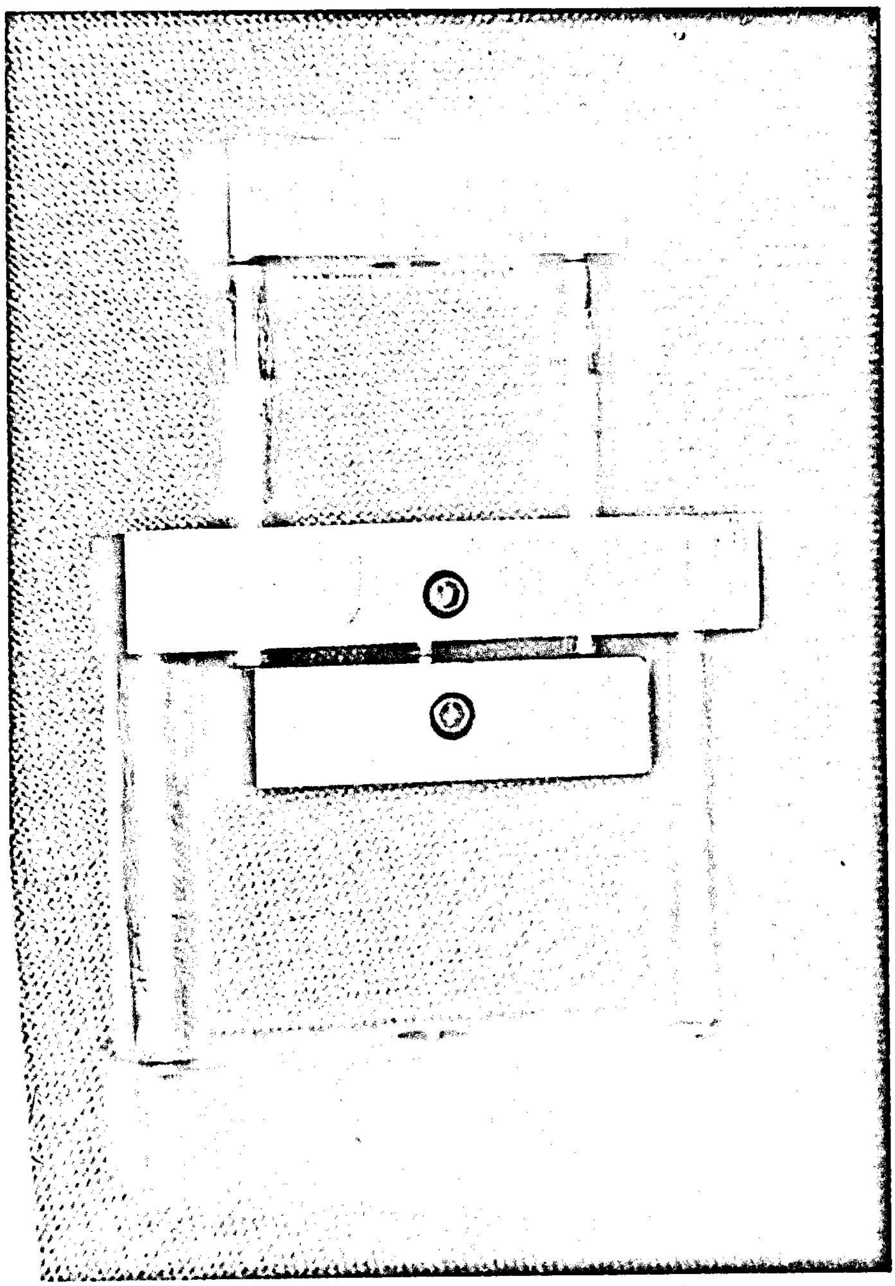

FIGURE 12

TENSILE STRENGTH TESTING APPARATUS

WITH GRIPS AND SPECIMEN IN PLACE

pins of the other smaller part of the cage ride. This smaller part also has a top and bottom cross member, and two side pins 4/16 inch in diameter by 1¼ inches long. In the center of the top crossmember of the larger half, and in the center of the bottom half of the lower crossmember are drilled holes into which the grips fit. Tapped into the sides of these holes are set screws that may be tightened to hold the grips in place.

There are two sets of grips, see Figure 13, page 29. They are turned out of brass 3/8 inch in diameter by 7/16 inch long and have a shoulder to correspond to the shoulder of the specimens so that there is no lateral pressure exerted on the specimens but only a pull on the rim of the shoulder. The grips are split and are guided together by a threaded plug soldered to one half of the grip. (Different pitch screws are used for the two grips so that the parts cannot be put together incorrectly, thereby ruining the shoulder alignment.) These grips have a flat slot milled on one side, as in Figure 14, page 30, so that the set screw will fit into it to provide better holding. See Figure 15, page 31. This apparatus is then placed in the Dillon Universal Tester, Figure 16, page 32.

Graphic recorder. This instrument, Figure 17, page 33, was built by Doctor George M. Hollenback some years ago when he was studying the dimensional change of amalgam.

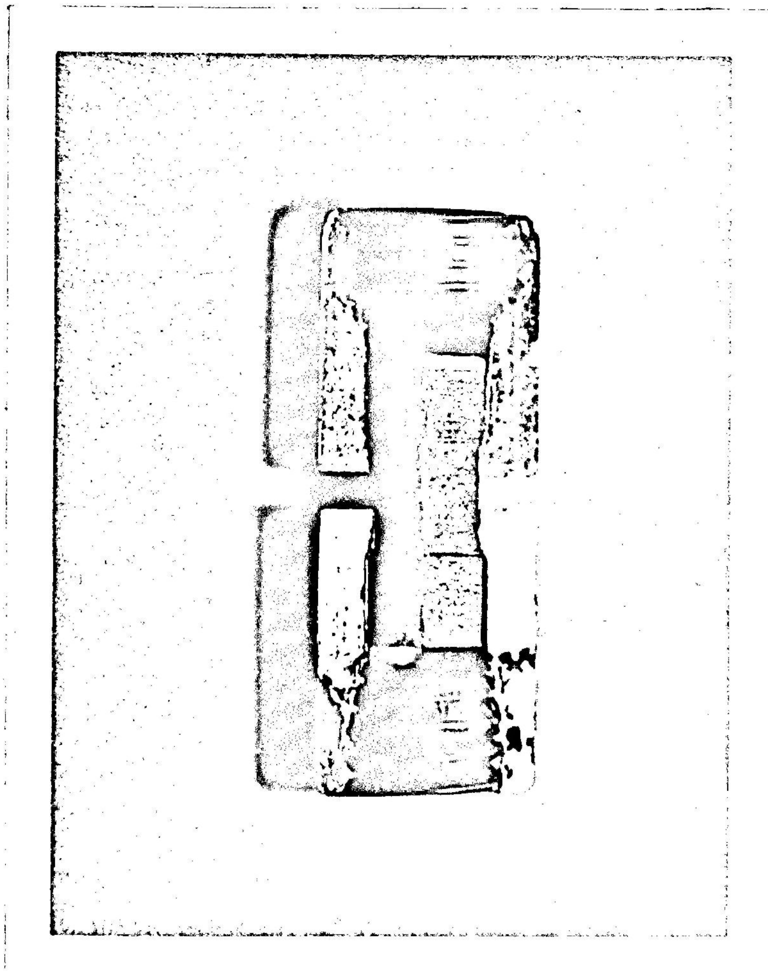

FIGURE 13

TENSILE STRENGTH GRIPS DISASSEMBLED

WITH SPECIMEN IN PLACE

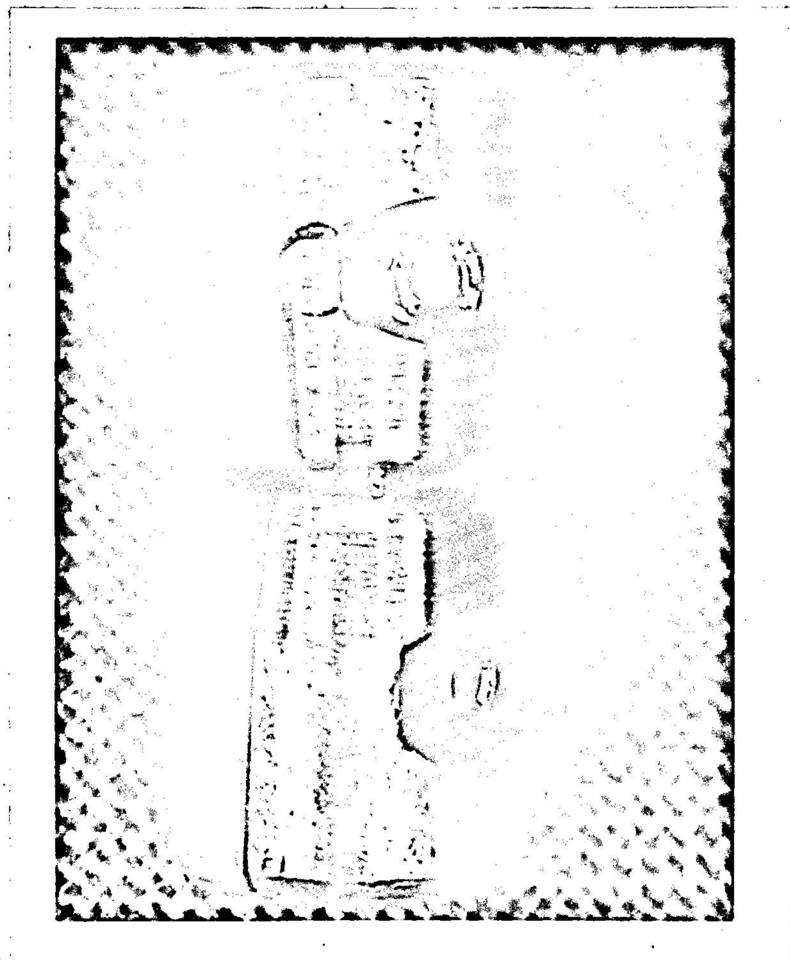

FIGURE 14

TENSILE STRENGTH GRIPS

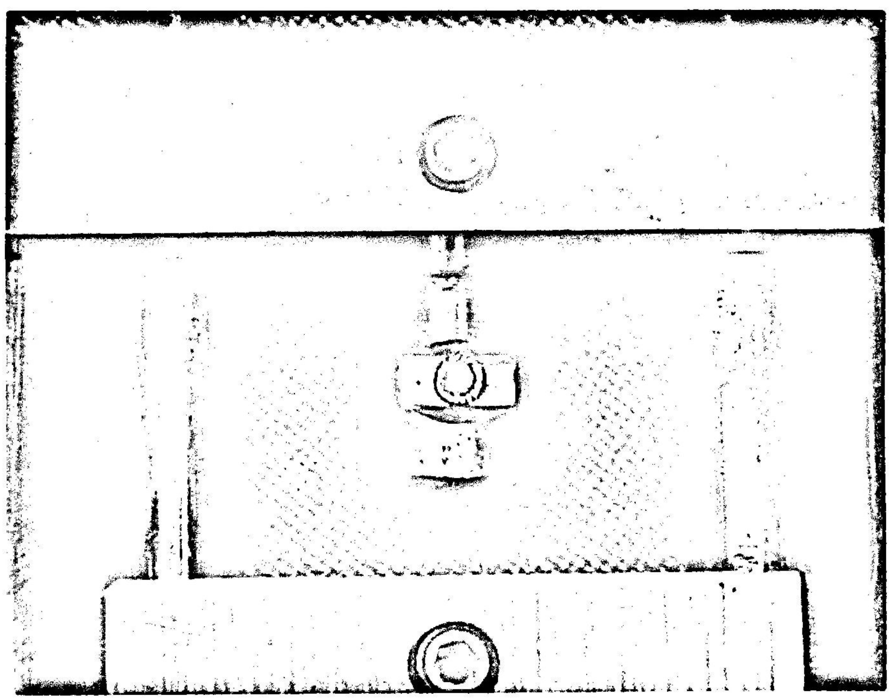

FIGURE 15

ONE TENSILE STRENGTH GRIP IN TENSILE STRENGTH TESTING APPARATUS

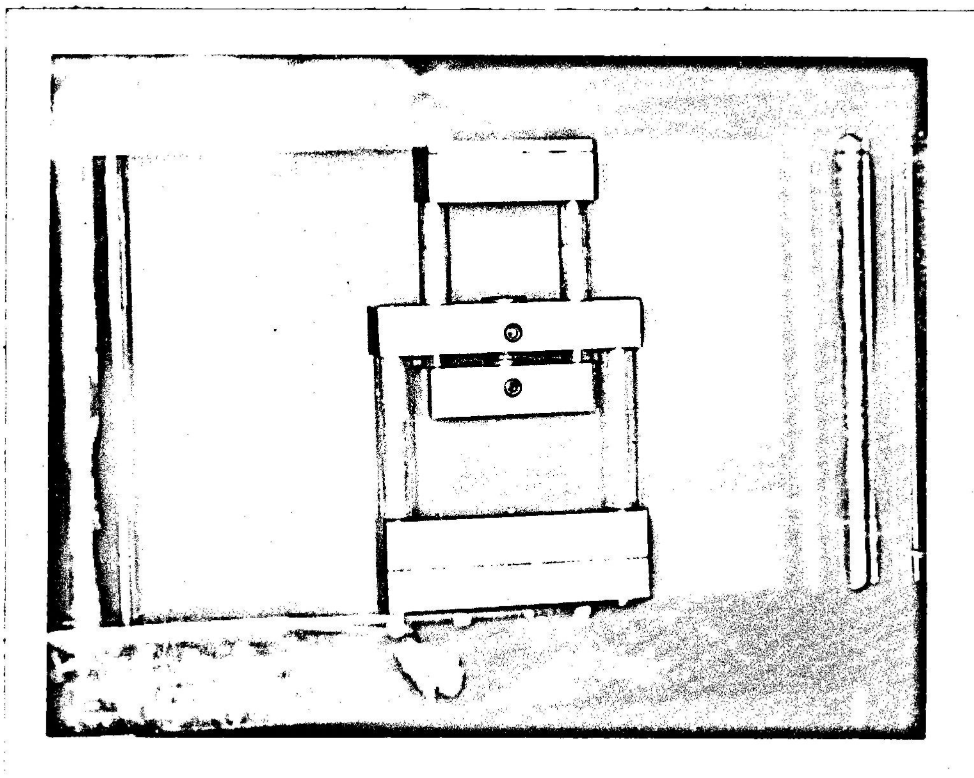

FIGURE 16

TENSILE STRENGTH TESTING APPARATUS

IN DILLON UNIVERSAL TESTER

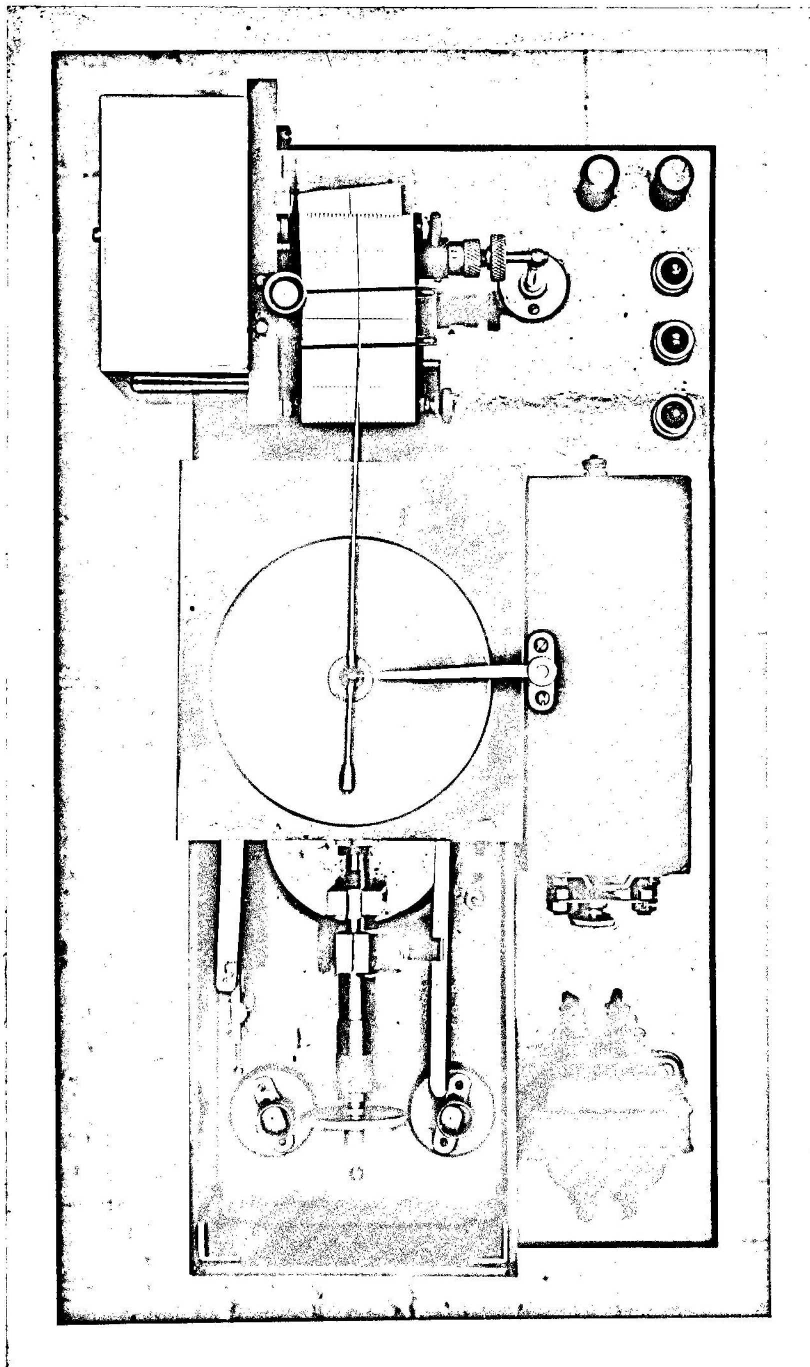

FIGURE 17

GRAPHIC RECORDER

It consists of a base of bakelite 7½ inches by 15½ inches. Along the back side is a micron dial gauge that is mounted horizontally, with the glass face removed and a longer arm attached to the dial with a pointed end which sweeps over a strip of graph paper that is marked in microns; 14 microns each side of the center. This strip is moved past the pointer at a given rate of speed by an electric motor. At the nib end of the dial gauge is a trough that holds the specimen in a horizontal position. Facing the nib of the dial gauge is mounted a micrometer spindle so that when the specimen is placed in the trough the arm of the gauge is set at the center line of the graph paper by adjusting the micrometer spindle. The micrometer spindle, trough, and dial gauge are enclosed in a bakelite box, 3 inches high, 4½ inches wide and 10¼ inches long. The marking device consists of a coil (Model T Ford) which is connected to the arm, the point of which is held a short distance from the graph paper. On the under side of the graph paper is a grounded plate, so that every time the coil discharges a hole is burned in the paper at the point where the arm is located. There are on-off switches for the electric motor and for the coil.

V. PROPORTIONING DEVICES

<u>Alloy and mercury dispensers</u>. The mercury and alloy

dispensers used were the Caulk 20th Century Dispensers. The mercury dispenser has three insets to vary the charge. These dispensers were used for rough measurement only, with the final weighing being done on a triple beam balance.

Balance. The instrument that was used to proportion out the alloy and mercury for the specimens was a triple beam balance that is able to measure to a 0.01 gram. The balance used was a Cent-O-Gram Model 311 which is manufactured by Chanus Scale Corporation, Union, New Jersey, U.S.A.

The balance consists of a pan for placing the object to be weighed and three beams with three poises. The center poise and beam measures to 100 grams in 10 gram increments; the rear poise and beam measures to 10 grams in one gram increments, and the front poise and beam measures to 1 gram in increments of .01 gram.

There are also two attachment weights that are 100 grams apiece so the total amount that can be weighed is 311 grams. A center support holds the bearing assembly and the beams rest on two agate bearings. In the base is a level, and two of the three legs are adjustable so that the balance can be leveled up when it is moved, thereby maintaining its accuracy. At the bearings is an arrest mechanism so that the beams with the knife edges are removed from the bearings when not in use. The pointer has eight divisions each side of zero, and there is a balance spindle to adjust the zero point of the beams. A pan support to hold the pan still while placing or removing the object to be weighed is mounted on the base.

VI. CONDENSERS

The condensers used were those made by the American Dental Manufacturing Company, numbers 3 4, and L. The points of these condensers were serrated and the points of numbers 3 4 were 1.65 mm diameter and 2.5 mm diameter. The points of number L were 1 mm diameter and 1.32 mm diameter. A special condenser was used for packing the shoulders of the tensile strength specimens. This condenser was made by Doctor Hollenback. The condenser has a 2½ mm diameter end, and a .018 inch diameter smaller shank, so that the lip is formed of .03 inch thickness. This then gets around the shoulder of the lower collar to condense that portion of the specimen.

VII. TRITURATORS

Mechanical amalgamators. Two mechanical amalgamators were used in this study.[26] One was the Wig-L-Bug, serial number p70824, manufactured by the Crescent Dental Manufacturing Company, Chicago, Illinois. This amalgamator is 5½ inches high, 4 inches wide, and 9½ inches long. It has an automatic timer on the front which can be set from 0 to 60 seconds. After the timer is set at the desired time the lever is tripped and the amalgamator starts. The trituration arm is on top at the back and accepts standard capsules.

The other amalgamator used was the Torit Amalgamator, Model 610, serial number 00941, manufactured by the Torit Manufacturing Company, 1133 Rankin Street, Saint Paul 16, Minnesota. There is an automatic timer on the top at the left and can be set for any time up to 60 seconds. After setting the time desired you press a button on the timer to start the amalgamator. The trituration arm is on the right and accepts standard capsules. There are five wells on the bottom edge which hold the funnel, two capsules and two pestles.

<u>Hand trituration</u>. The hand trituration was done using an S. S. White number 9 glass mortar and pestle.

CHAPTER IV

METHODS AND MATERIALS

The methods which were used in this study were those advocated by Doctor Wilmer B. Eames, and the conventional accepted technic. The materials used were all procured from a dental supply house.

I. TRITURATION

Hand trituration. Hand trituration was used for part of the study to see if there was a difference in physical properties of the alloys due to the type of trituration. In using hand trituration an S. S. White number 9 glass mortar and pestle were used, using very light pressure and trituration times of from 45 seconds to 1 minute 30 seconds. Using the Eames technic longer times were required to obtain thorough trituration of the amalgam mass. The longer times were also necessary to triturate the spherical alloy. The mortar and pestle were frequently reconditioned with fine carborundum paste to keep them in proper working condition.

Mechanical trituration. The mechanical trituration was accomplished by the use of two different amalgamators.

One was the Crescent Wig-L-Bug, and the other the Torit Amalgamator. Both were used to determine if there was a difference in the amalgamators that would show up in the physical properties of the amalgam alloy.[26] For the conventional procedure, times of from 12 to 18 seconds were used. For the Eames technic the times of from 10 to 20 seconds were tried, but times of from 12 to 15 seconds were used in the experiment. The difference in trituration times used depended on the alloy used and the form that it was in.

II. CONDENSATION

Conventional condensing technic. An alloy to mercury ratio as specified by the manufacturer which ran from 5:7 to 5:8 was used. The triturated alloy was put into a squeeze cloth and the excess mercury was expressed. The alloy was then placed in the die in small increments and, using condensers number 3 4, was condensed with a force of from 7 to 10 pounds. Any excess mercury was expressed and condensation progressed until the die was filled.

Eames condensing technic. In using the Eames technic [23] a mercury to alloy ratio of 1:1 was used with the regular alloys, however with the spherical alloy ratios of 1:1 were used as well as 45% mercury to 55% alloy and

40% mercury to 60% alloy. After trituration was completed the alloy was removed from the capsule and placed in a dapen dish without expressing any mercury. Then small increments of alloy were placed in the die and were condensed using serrated pluggers of 1 mm diameter and 1.5 mm diameter for the bulk of the condensing using 7 to 10 pound pressure, or about 8,000 psi. As the die was filled, larger condenser points were used to give continuity to the specimen.

The specimens were removed immediately after condensation, and placed in an upright position until such time as they were ready to be tested.

III. MATERIALS

In each of the different tests more than one alloy was used to evaluate the Eames technic. This was to eliminate the possibility that any differences could be attributed to the alloy rather than to the method of manipulation.

Alloys. The alloys that were used were Caulk's 20th Century Micro-Alloy, non-zinc, and used both in pellets and granular form. S. S. White's New True Dentalloy was used in non-zinc granular form. Also used was Caulk's copper amalgam, as well as an experimental spherical alloy manufactured by the Wilkinson Company.

The spherical alloy is in the form of little spheres instead of being rough and irregular filings as are the regular alloys.

Mercury. The mercury used was triple distilled CP mercury marketed by Laboratory Products Company, P. O. Box 102, Little Neck 63, New York.

CHAPTER V

RESULTS OF THE EXPERIMENTS

The data that was obtained in this study was obtained in as objective a manner as possible. Many specimens were run so as to reduce the possibility that the differences observed were only due to chance.

Crushing strength. The crushing strength of amalgam alloy specimens that were prepared both in the conventional manner and also with the Eames technic were tested in the Dillon Universal Tester at times of one hour, twenty-four hours, seven days, and some after one month, using the suitable gauges.

In the specimens at one hour (see Table I, page 43), and twenty-four hours (see Table II, page 44), the Eames technic faired somewhat better than the conventional procedure. The values ran high for the Eames technic specimens at these times, however at the seven days tests there were no significant differences between specimens of the Eames technic and the conventional technic. This was also true when using the new spherical alloy. Yet both groups of the spherical alloy were above the regular alloys at the one hour testing time. At the twenty-four hour testing time they were just about the same as the regular alloys.

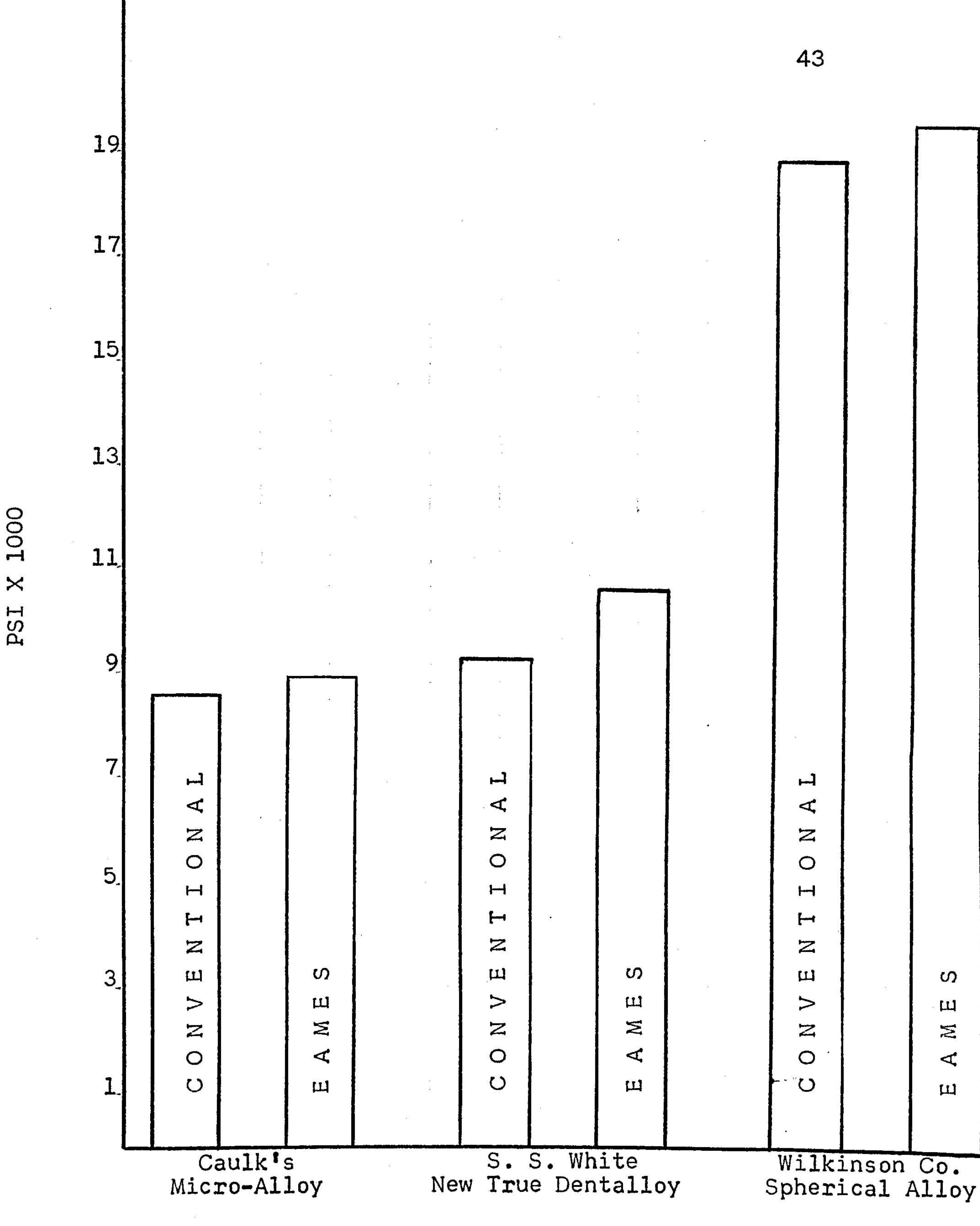

TABLE I

ONE HOUR CRUSHING STRENGTH

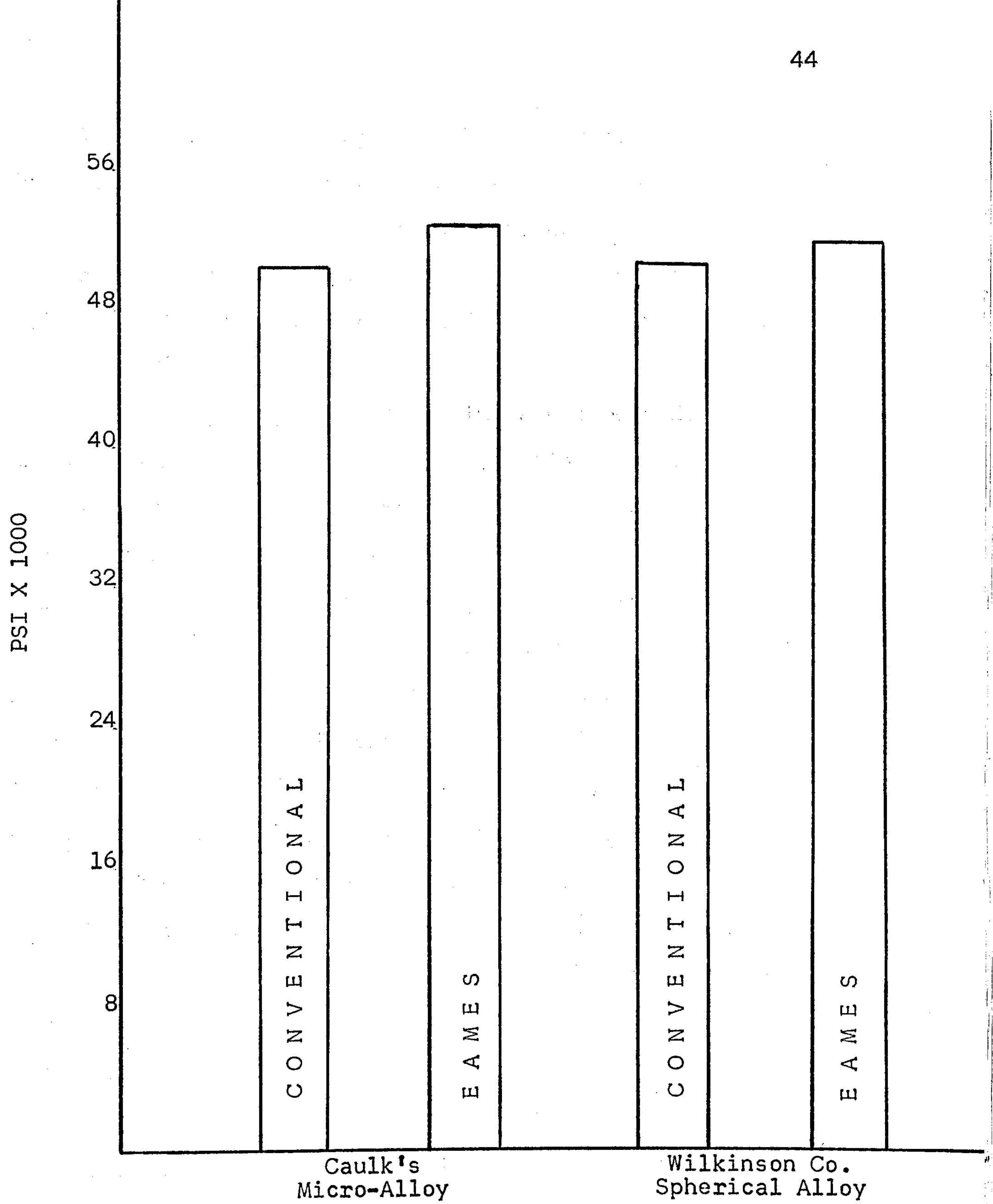

TABLE II

TWENTY-FOUR HOUR CRUSHING STRENGTH

In obtaining the data only those specimens that fractured cleanly, and with a cone at one or both ends were recorded. Any specimens that did not break with a cone at the end were discarded as well as any specimens that, upon fracturing showed a defect within the specimen.

Transverse strength. Very little has been done with the transverse strength of amalgam. This seems to be due mainly to the fact that there never has been adequate equipment developed to perform this test. The apparatus that was designed for this work was very satisfactory and gave consistent results. With the transverse strength as with the crushing strength the specimens prepared with the Eames technic ran consistently higher during the twenty-four hour readings (see Table III, page 46), than those prepared in the conventional manner. This difference being reduced at the later testing times.

In recording the results of the transverse strength tests, only those specimens that gave a clean break and showed no visible flaw at the place of breakage, were counted.

Tensile strength. In tensile strength reports it was said that amalgam tensile strength was about 1/10 the crushing strength although no figures were given. The tensile strength specimens that had been used before were

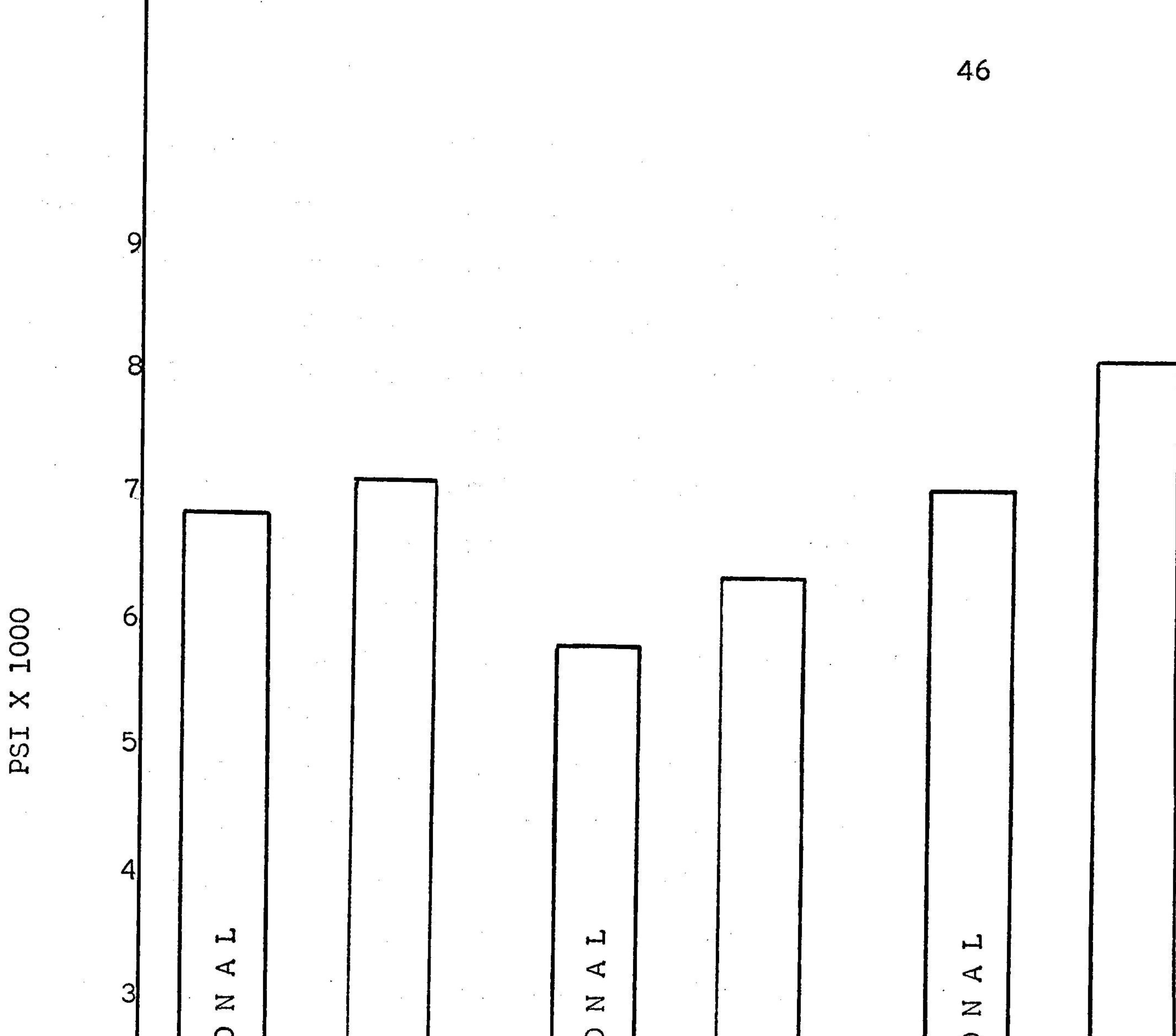

TABLE III

TWENTY-FOUR HOUR TRANSVERSE STRENGTH

dumbell shaped and had to be packed from the side.[27] This does not give as true a picture as with a specimen that is packed from one end, as packing from one end approaches more closely the clinical aspect of condensing amalgam alloy. The tensile strength die and testing apparatus used were designed specifically for this study. The Eames technic again showed slightly better results at the early hours than those obtained with the conventional technic. See Table IV, page 48. The spherical alloy also showed higher strength than those of regular alloys especially at the one hour tests.

Here again, any specimens that showed a defect at the fracture, or, any specimens that fractured at the shoulder were discarded. A fracture at the shoulder was considered to be due to poor condensation at that point. Only the specimens that fractured between the shoulders, or in the middle portion, were counted.

Dimensional change. As there is very little work being done at present on the dimensional change of amalgam it was decided that some specimens should be run for their dimensional change, especially the spherical alloy. It was found that the alloys tested shrank and the amount of shrinkage was directly related to the amount of trituration; that is, the shorter the trituration time the less the shrinkage. However, it was not possible to get the

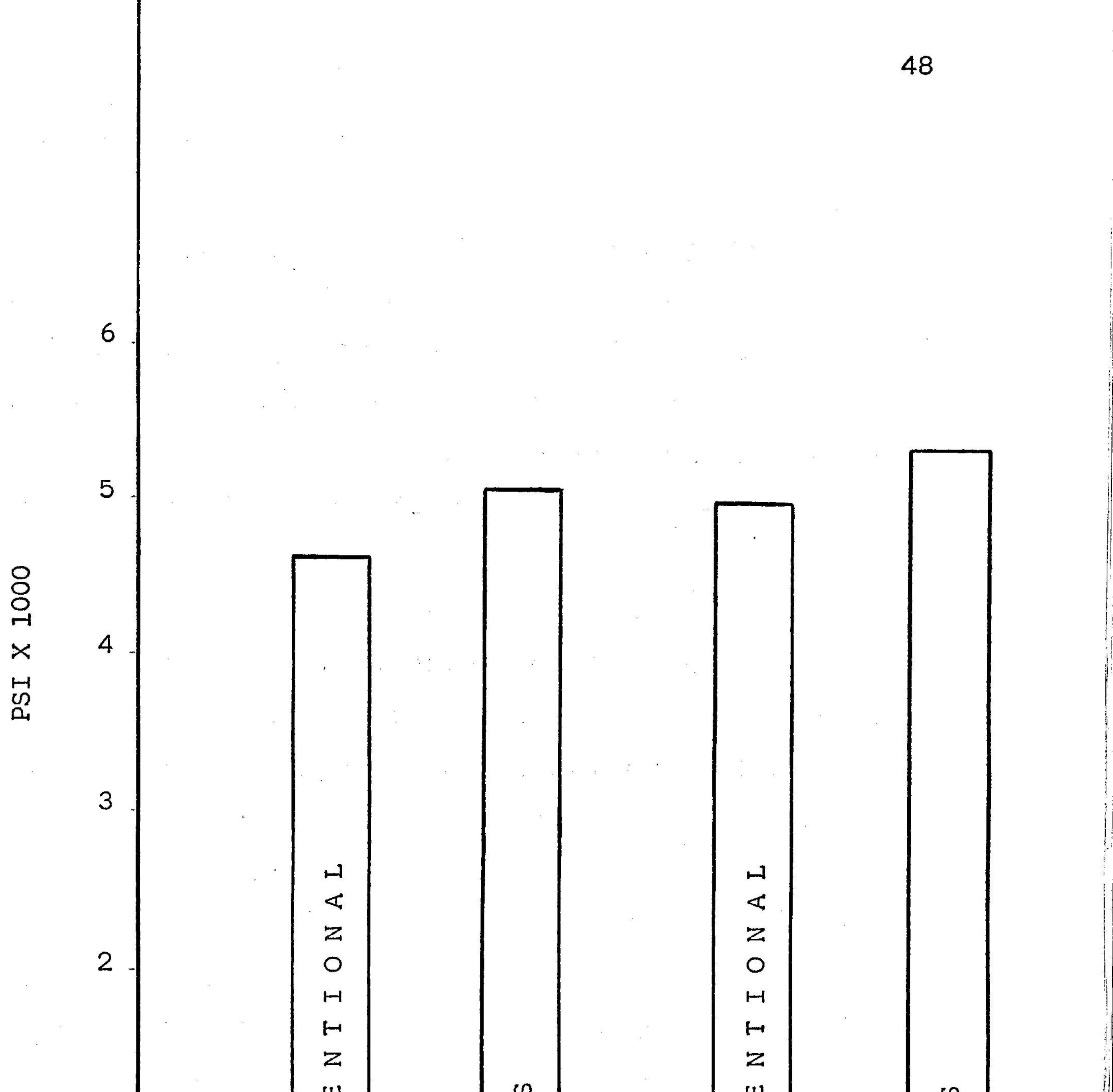

TABLE IV

TWENTY-FOUR HOUR TENSILE STRENGTH

spherical alloy to exhibit an expansion.

Copper amalgam. In testing the copper amalgam it was found that the crushing strength is about one-half; the tensile strength is about one-fourth; with the transverse strength approximately one-third that of the regular alloys. Of course with the copper alloy the mercury content can not be varied as the mercury is in the tablets when it is purchased.

Spherical alloy. In using the lower mercury to alloy rations with the new spherical alloy, it was found that a ration of 45% mercury was still satisfactory and no significant drop in the strength of the amalgam was exhibited. However, at a mercury percentage of 40% there was a significant drop in the tensile, crushing and transverse strengths. Also the lower mercury ratios showed a smaller amount of dimensional shrinkage. This alloy shows promise as a dental restorative material as its early strength is very high when compared to the regular alloys. See Table V, page 50, and Table VI, page 51.

Clinical testing. The Eames technic was used in clinical work, and appears to offer no disadvantages that this operator can see. The setting time may be reduced slightly but not enough to make it difficult to handle.

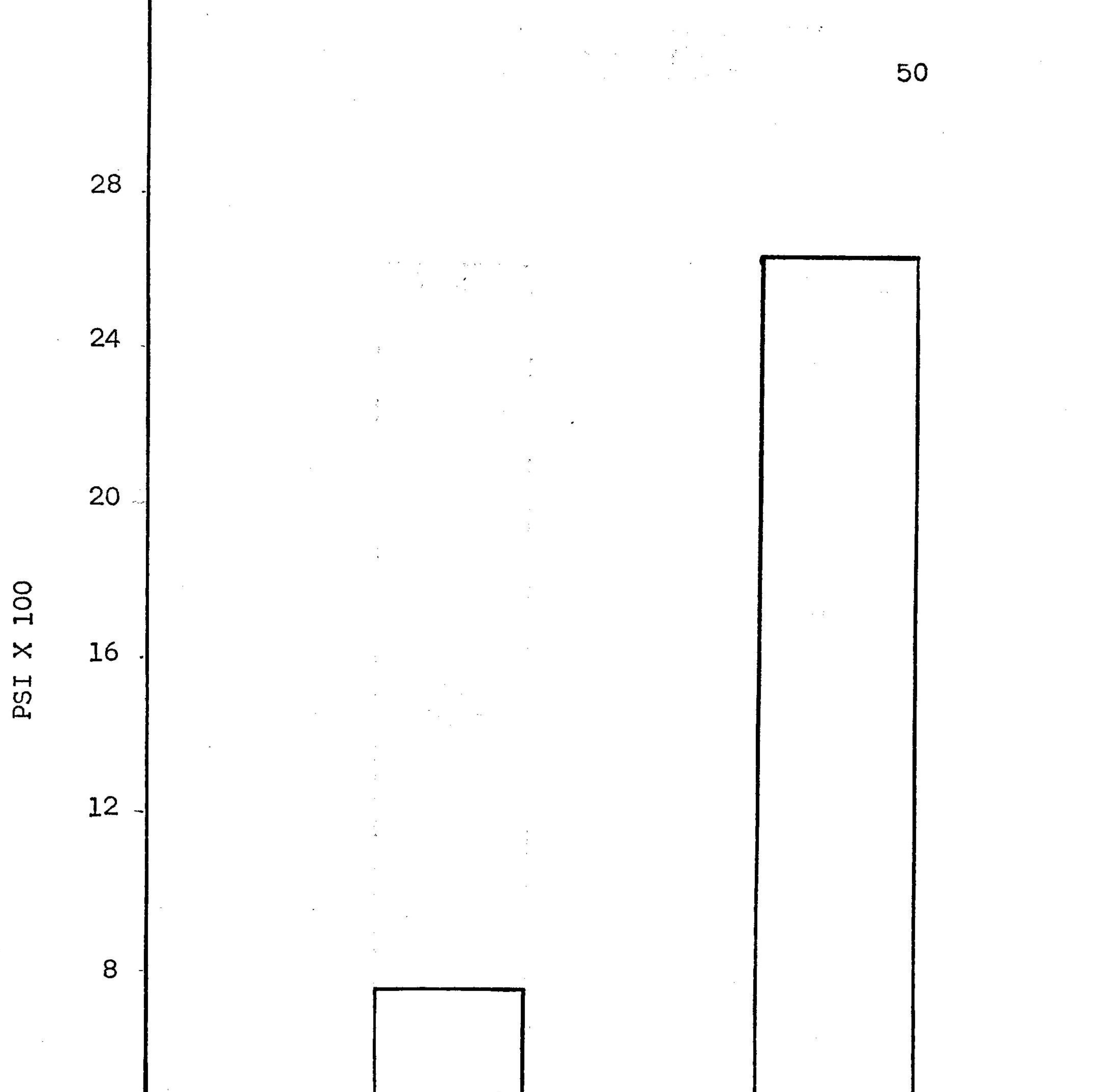

TABLE V

ONE HOUR TRANSVERSE STRENGTH

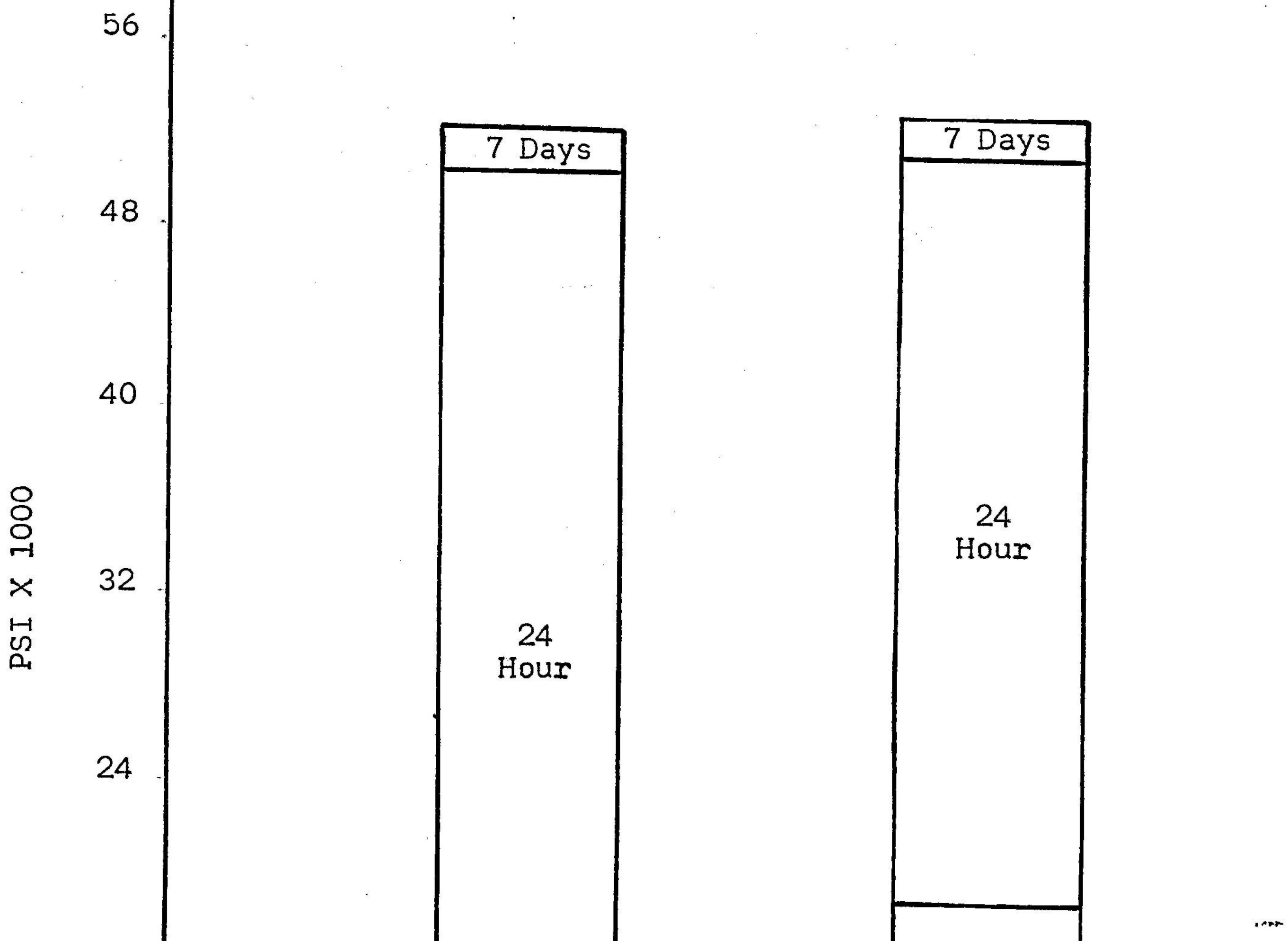

TABLE VI

CRUSHING STRENGTH COMPARING MICRO-ALLOY & SPHERICAL ALLOY

The spherical alloy was also used on some clinical cases. The feeling of condensing this alloy is different as it is smoother than regular alloys and presents a rather creamy texture. The setting time was not excessive, yet, 15 to 20 minutes after trituration it was very difficult to carve, therefore plenty of working time is available.

CHAPTER VI

SUMMARY AND CONCLUSIONS

Summary. The scope of this study was to re-evaluate the Eames technic of handling amalgam alloy and also to test the transverse and tensile strengths of amalgam as well as to do some work with the spherical alloy.

The literature was reviewed, and a short history was written along with a presentation of the articles that were pertinent to this study of amalgam alloys.

New dies and testing apparatus were designed, and made to conduct this study of amalgams tensile, transverse, and crushing strengths. This equipment was made by Doctor George M. Hollenback.

The Eames technic was followed as outlined by Doctor Wilmer B. Eames and the results compared with the results obtained by using the conventional methods of handling amalgam alloy.

Conclusion. It is the conclusion of the author that the Eames technic does offer some advantages to the dental profession, in that it eliminates a step in the procedure of handling amalgam. It also makes a filling that has slightly better physical properties in the early stages. It also makes a filling that has less than the optimum amount of residual mercury.

The new spherical alloy seems very promising, especially its early strength. However, it is necessary to submit this alloy to more testing before a final decision can be made in regard to its acceptability as a dental restorative material.

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THE PHYSICAL PROPERTIES OF DENTAL AMALGAM WITH SPECIAL REFERENCE TO THE EAMES TECHNIC

by

Eugene Darwin Voth

An Abstract of a Thesis

in Partial Fulfillment of the Requirements

for the Degree Master of Science

May 1963

ABSTRACT

The purpose of this study was to make an evaluation of a dental amalgam technic using one part mercury to one part alloy, which is known as the Eames technic.

The study consisted of a comparison of various physical properties of dental amalgam using the Eames technic, and the conventional technic for handling amalgam. Special dies were made for preparing the specimens as well as special equipment for testing the specimens.

Trituration of the alloy was done both by mechanical triturators and by hand trituration. The specimens were condensed by hand using a manudynomometer so that all specimens were packed consistently. Tests for crushing strength, transverse strength, tensile strength, and dimensional change were than made at various intervals of time. An experimental spherical alloy was also tested in this study. Again the Eames technic was compared with the conventional technic of handling dental amalgam.

The results showed that at the earlier testing times, up to twenty-four hours after the specimens were condensed, the Eames technic gave consistently stronger specimens. After twenty-four hours the specimens using the Eames technic were the same as those using the conventional technic.

It can be concluded that the Eames technic has merit

as a method for handling dental amalgam. Using this technic the filling will be stronger earlier than if the conventional technic is employed. Also in using the Eames technic, excess residual mercury is not a problem.