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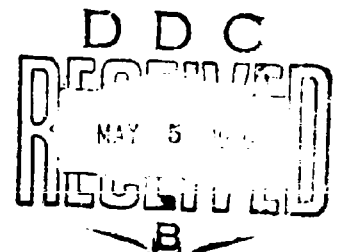
MECHANICAL PROPERTIES, INCLUDING FRACTURE TOUGHNESS
AND FATIGUE, CORROSION CHARACTERISTICS AND
FATIGUE-CRACK PROPAGATION RATES OF
STRESS-RELIEVED ALUMINUM ALLOY HAND FORGINGS

D. J. Brownhill, C. F. Eebilon
G. E. Nordmark and D. O. Sprowls
Aluminum Company of America

TECHNICAL REPORT AFML-TR-70-10

FEBRUARY 1970

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FOREWORD

This investigation was conducted by the Alcoa Research Laboratories, Aluminum Company of America, New Kensington, Pennsylvania, under USAF Contract No. F33615-68-C-1385, Project No. 7381, "Materials Applications", Task No. 738106, "Engineering and Design Data". The work was under the direction of the Materials Laboratory, Wright-Patterson Air Force Base, Ohio, with Mr. A. W. Gunderson (MAAE) as project engineer.

This report covers work done from March 1968 through December 1969.

The investigation was made under the supervision of Mr. D. J. Brownhill with Mr. C. F. Babilon as project leader for the phase covering the mechanical properties including fracture toughness and fatigue. Mr. D. O. Sprowls was the project leader for the phase covering the corrosion characteristics and Mr. G. E. Nordmark was project leader for the phase covering the fatigue-crack propagation rates. The statistical analyses were made by Messrs. S. F. Collis and M. C. Milligan. Significant advisory and technical assistance were supplied by Messrs. J. G. Kaufman and J. D. Walsh.

The report was released by the authors for publication in January.

This technical report has been reviewed and is approved.

Albert Olevitch

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Chief, Materials Engineering Branch
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ABSTRACT

The tensile, compressive, shear, bearing, fracture-toughness, axial-stress fatigue, resistance to stress-corrosion cracking and fatigue-crack propagation rates have been determined for a total of 40 lots of 2014-T652, 2024-T852, 7075-T7352 and 7079-T652 stress-relieved aluminum alloy hand forgings ranging in thickness from 2 through 6 in.

Tables of computed design mechanical properties and typical and minimum stress-strain and compressive tangent-modulus curves were prepared.

Average values of plane-strain stress-intensity factor, K_{Ic} , at 5 per cent secant offset were determined.

Log-mean fatigue-life values were calculated.

The forgings of all four alloys have a high resistance to exfoliation and a high resistance to stress-corrosion cracking when stressed in the longitudinal direction relative to the grain flow pattern. In the long and short-transverse test directions, the resistance to SCC varied markedly with respect to alloy and temper, with 7075-T7352 being outstanding, 2024-T852 rating second, and 2014-T652 or 7079-T652 rating third.

The rate of fatigue crack propagation was found to vary with the seven orientations tested and to be substantially faster in a humid atmosphere than in a dry atmosphere. For tests in a salt fog atmosphere it was demonstrated that a slower rate of loading caused a faster rate of propagation per cycle. At the lower stress intensities the alloys rate in the following decreasing order of resistance to crack propagation: 2014-T652, 2024-T852, 7075-T7352 and 7079-T652.

Key Words: 2014, 2024, 7075, 7079, aluminum, hand forgings, tensile, compressive, shear, bearing, fracture-toughness, fatigue, stress-corrosion, exfoliation, crack propagation, stress-relieved.

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SECTION I

INTRODUCTION

The design mechanical properties, fracture toughness, corrosion characteristics and fatigue-crack propagation rates are four of the most important factors involved in the selection of materials and efficient design of aerospace structures. The importance of these characteristics has been emphasized by the extensive investigations made in recent years to obtain such information for aluminum alloy plate and extrusions (1-4). It is particularly timely that similar data be developed for aluminum alloy hand forgings since (a) much of the published design data has become obsolete by a change in the basis of specifying minimum tensile properties, from one in which the length, width, thickness and cross-sectional area were considered, to one where only the thickness and cross-sectional area are involved; (b) the development of a technique of stress-relief by cold work in compression has resulted in new tempers (TX52) for many of the alloys; and (c) there have been some significant problems related to the fracture and stress-corrosion characteristics of forged parts.

Accordingly, the properties of some 2 through 6-in. thick stress-relieved 2014-T652, 2024-T852, 7075-T7352 and 7079-T652 aluminum alloy hand forgings have been determined in this investigation. The data were obtained to establish design mechanical properties for use in MIL-HDBK-5A(5), including typical and minimum stress-strain and compressive tangent-modulus curves. In addition, data concerning the fracture toughness, axial-stress fatigue, stress-corrosion, exfoliation and fatigue-crack propagation characteristics of a selected number of the hand forgings have been obtained.

SECTION II

MATERIAL

A total of forty 2014-T652, 2024-T852, 7075-T7352 and 7079-T652 hand forgings were produced by the Cleveland Works of Alcoa for this investigation. Each of the forgings was fabricated independently to represent an individual lot of material.

The identity, size and chemical composition of the individual hand forgings together with the respective specified composition limits are shown in Table I.

These forgings represent the range of sizes usually encountered in commercial production with regard to thickness and width/thickness ratio. The thicknesses ranged from 2 through 6 in., the widths from 5 through 24 in., and the width/thickness ratios from 1 through 4.

The chemical compositions of the forgings are within the applicable limits specified in Federal Specification QQ-A-367g, Military Specification MIL-A-22771C and "Aluminum Standards and Data", The Aluminum Association(6).

The samples were solution heat treated, cold worked and artificially aged in accordance with Military Specification MIL-H-6088D and the recommendations given in "Aluminum Standards and Data"(6). The 7075-T7352 samples were stress-relieved and aged to meet the requirements of paragraph 4.10 of Federal Specification QQ-A-367g and Paragraph 4.6.5.1 of Military Specification MIL-A-22771C.

SECTION III

PROCEDURE

A. Mechanical Properties

A.1. Tensile, Compressive, Shear and Bearing

The specimens and test procedures were, in general, in accordance with ASTM methods, and the same as those used in previous investigations of plate and extrusions (1-4). These methods are essentially in agreement with Federal Test Method 151(7).

The tests were conducted with the smallest suitable load ranges of an Amsler 20,000-lb (Type 10SZBDA58), an Olsen Electomatic 30,000-lb, or a Southwark-Tate-Emery 50,000-lb capacity Universal Testing Machine. The machines were calibrated prior to and during the investigation; the accuracy of each was within that required by ASTM(8) and Federal Specifications.

Single specimens were tested except in a few instances where a review of the data indicated that check tests were needed.

All specimens were taken so that the test sections were within the center third of the cross-section of the forging as illustrated in Fig. 1. Tensile, compressive and shear tests were made of specimens taken in the longitudinal, long-transverse and short-transverse directions; bearing tests were made of longitudinal and long-transverse edgewise specimens.

The nominal dimensions of the specimens are shown in Figs. 2, 3 and 4.

Tensile tests were made in accordance with ASTM Methods E8(9) with 1/2-in. diameter tapered-seat specimens except where it was necessary (in the short-transverse direction) to use subsize round specimens (Fig. 2).

The compressive tests were made in accordance with ASTM Methods E9(10) using a subpress (Fig. 3 of ASTM Methods E9). The specimens were cylindrical, 1/2 in. in diameter x 1-7/8 in. long, with a slenderness ratio (L/r) of 15 (Fig. 2).

Tensile and compressive yield stresses were determined from autographic load-strain diagrams at 0.2 per cent offset.

Tests to determine the ultimate shear stress were made using 3/8-in. diameter specimens (Fig. 2) taken from the same locations as the tensile specimens, except that tests of short-transverse specimens were made only on forgings 3 in. or more in thickness. All tests were made with a relatively rigid double-shear tool, wherein a 1-in. length is sheared from a 3-in. long specimen, the end thirds being supported throughout their lengths. In the tests of longitudinal and long-transverse specimens, the loads were applied in the direction normal to the major surface of the forging; in the tests of short-transverse specimens, the loads were applied in the direction parallel to the major axis of the forging(11).

The bearing tests were made in accordance with ASTM Method E238(12), using longitudinal and long-transverse edgewise specimens, 0.094 in. thick x 1-1/2 in. wide, with a 0.375-in. diameter hole (Fig. 3). The specimens and test fixtures were cleaned ultrasonically in a suitable nontoxic solvent prior to testing. The bearing ultimate stresses and yield stresses were determined at edge distances of 1.5 and 2.0 times the pin diameter. The bearing yield stress was determined as the stress at a permanent deformation of 2 per cent of the pin diameter as indicated on autographic load-deformation diagrams.

Tensile and compressive stress-strain tests, including modulus determinations, were made of longitudinal, long-transverse and short-transverse specimens taken from a selected number of the samples. The tests were conducted in accordance with ASTM Method E111(13) with uniform-reduced-section specimens (Fig. 4). In all tests, the strains were measured over a 2-in. gage length with two Tuckerman optical strain gages positioned diametrically opposite on the specimen. A calibration made of the instruments prior to the start of these tests indicated that they meet the ASTM requirements of a Class A extensometer (14). The values of moduli of elasticity were determined by the strain-deviation method described in ASTM Method E111(13). Based on these selected tests, representative typical and minimum tensile and compressive stress-strain curves and compressive tangent-modulus curves were developed using the procedures outlined in Sections 3.2.3, 3.2.5 and 3.2.6 of Technical Report AFML-TR-66-386(15).

A.2. Fracture Toughness

Fracture toughness tests were made of a selected number of the samples using fatigue-cracked notch-bend specimens of the types shown in Fig. 5; in each case, the largest possible size of specimen was used. The dimensions of the specimens and

the test procedures were essentially in accordance with the ASTM Proposed Method of Test For Plane-Strain Fracture Toughness of Metallic Materials(16).

Tests were made of triplicate longitudinal (LW), long-transverse (WL) and short-transverse (TL) specimens from each of the selected samples.* In the tests of the 6x24-in. 7075-T7352 forging (Sample No. 341036) in the TL direction, the largest notch-bend specimen that could be obtained from the sample was not of sufficient thickness to develop a valid test; therefore, compact tension fracture-toughness specimens of the type shown in Fig. 6 were also used. These tests were made in accordance with the ASTM Method for Plane Strain Fracture Toughness Testing of Metallic Materials(16).

The notch-bend specimens (Fig. 5) were fatigue-cracked by cantilever bending ($R=1.0$) in a Sonntag SF-4 machine at 3650 cpm; the setup is shown in Fig. 7. The compact tension specimens (Fig. 6) were fatigue-cracked by axial loading ($R=0.1$) in Krouse fatigue machines at 1750 cpm.

The setups used for making the fracture-toughness tests of the notch-bend and compact tension specimens are shown in Figs. 8 and 9, respectively. The tests were made in a 30 000-lb capacity Olsen screw-driven testing machine, and load versus crack opening-displacement (COD) curves were obtained autographically with a Mosley X-Y plotter. For each test, a candidate value of the critical plane-strain stress intensity factor, K_{Ic} , was calculated using the load at which there was a crack extension of about 2 per cent of the original crack length, as indicated on the autographic load-displacement curve. This load was determined by applying the appropriate secant offset of 5 per cent for both the notch-bend and compact tension tests† to the autographic curves.

The K_{Ic} values were considered to be meaningful values of K_{Ic} , if they met the following criteria:

a. The thickness and crack length of the specimen were large with respect to the size of the plastic zone at the

* A two-letter system is used to describe the orientation of the fracture-toughness specimens: the first letter indicates the direction of a line normal to the crack plane and the second letter indicates the direction of crack growth.
L - Length of forging; W - Width of forging; T - Thickness of forging.

† Recent action of ASTM Committee E24 has made the secant offset for compact tension specimens 5 per cent instead of 4 per cent as shown in Ref. 16.

crack tip. This requirement was considered to have been met if the thickness and crack length of the test specimen were equal to or greater than 2.5 times the ratio $(K_Q/\sigma_{ys})^2$.

b. Most of the deviation from linearity in the load-displacement curve prior to the secant-offset intersection was caused by crack extension, rather than plastic deformation of the specimen. This requirement was considered to have been met if the horizontal displacement of the load-displacement curve from the initial slope at the load equal to 80 per cent of the load at the secant offset intercept was not more than $1/4$ of the displacement at the secant offset intercept.

c. The fatigue-crack front was sufficiently extended from the machined notch, and was not excessively curved or out of plane.

d. The specimen was fatigue cracked at a stress intensity which was less than half of the calculated K_Q value, or $0.0012\sqrt{\text{in.}}$ times Young's modulus for the material, whichever was smaller.*

In some instances, K_Q values were interpreted to be meaningful values of K_{Ic} if the criteria a, c and d* were exceeded by only a slight margin, as noted in Table XXII.

A.3. Axial-Stress Fatigue

Axial-stress fatigue tests were made on smooth specimens of the type shown in Fig. 10. Three long-transverse specimens were tested from each of several selected samples. They were tested at three stress levels ($R=0.0$) in Krouse fatigue machines operating at 1725 cpm.

B. Corrosion Characteristics

A complete outline of the corrosion tests is given in Table XXV.

B.1. Stress-Corrosion Cracking (SCC)

Five hand forgings of each alloy and temper were stress-

* Recent action of ASTM Committee E24 has moved the limit on stress intensity for fatigue cracking to 60 per cent of K_{Ic} , although this is not yet published in ASTM Standards.

corrosion tested. All were tested in the short-transverse direction, and the 2, 4 and 6-in. thick forgings were also tested in the longitudinal and long-transverse directions relative to the grain flow. Tensile specimens, 0.437 in. in diameter (Fig. 23), were employed for the longitudinal and long-transverse test directions, and tensile specimens, 0.125 in. in diameter (Figs. 24 and 25), were used to test the short-transverse direction. The test specimens were confined to a 2-in. thick x 6-3/8-in. wide block centered on the midplane (T/2) and on the center-line (W/2) of the forging. Inspection of macroetched slices (Figs. 25-29) indicated that this location would provide specimens with the desired orientation relative to the grain flow pattern.

The tensile specimens were stressed in "constant strain" type fixtures (Figs. 23 and 30) by means of loading devices of the type shown in Fig. 31. During exposure, the ends of the specimen and the stressing frames were protected by means of an appropriate coating so that only the test section of the specimen was exposed.

Stressed and unstressed specimens were exposed to the 3.5% NaCl alternate-immersion test. The sodium chloride solution was made with salt of 99.7-per cent purity and New Kensington tap water. Tap water was used because large volumes of water were required and because New Kensington tap water is essentially free of heavy metals. Water lost by evaporation was replaced by additions of tap water, and the salt concentration was regularly checked and adjusted as necessary. The solution was changed monthly and at each change the specimens were cleaned by spraying with tap water.

The alternate-immersion cycle consisted of total immersion of specimens for 10 minutes and aeration above the solution for 50 minutes. This cycle was continued 24 hours a day for the entire test period. The test equipment (Fig. 32) consists of large stationary painted aluminum alloy tanks with the specimens supported on an open aluminum alloy (6061-T6) framework that is raised and lowered to provide the alternate-immersion cycle.

The alternate-immersion test was conducted in a large laboratory room at ambient temperature and humidity. Both the air temperature and solution temperature were subject to seasonal variation, and ambient conditions had the typical ranges shown below.

May to September: air temperature 68 to 90 F
solution temperature 64 to 72 F
relative humidity 35 to 70%

October to April: air temperature 62 to 78 F
solution temperature 58 to 68 F
relative humidity 25 to 60%

Measurements have shown that the temperature of the test specimens themselves remain within 2 to 3 degrees of the solution temperature throughout the drying cycle.

All specimens that failed during exposure were inspected visually, and representative failures were examined microscopically to verify that stress-corrosion cracking (SCC) was the cause of failure. In addition, the tensile specimens that did not fail during exposure were tension tested to determine the change in ultimate tensile strength caused by corrosion. For comparison, control specimens that had been concurrently exposed without stress were also tested.

Many years of experience at Alcoa Research Laboratories in stress-corrosion testing various products made of the alloys included in this program have shown that the 3.5% NaCl alternate-immersion test relates very well to seacoast atmospheric exposures(17). That is, test specimens stressed to various levels at which SCC occurs in the alternate-immersion test also will fail when exposed to a seacoast atmosphere, and test specimens that are resistant to SCC in the alternate-immersion test will be resistant in both seacoast and industrial atmospheres, also. A partial exception to the latter exists with 7079 alloy which, at low stress levels, has a higher probability of SCC in the atmosphere than in the 3.5% NaCl alternate-immersion test(18).

B.2. Exfoliation

Because exfoliation of aluminum alloy forgings is relatively infrequent in service, exfoliation tests were restricted to only two sizes (2x8 in. and 6x24 in.) of forgings of each alloy.

Two panels, 4x6 in. in size, were machined from each forging. One panel was machined so as to place the test surface at 10 per cent of the forging thickness to represent parts which would receive slight machining, and the second panel was machined to mid-thickness (T/2 plane), to simulate extensively machined material.

The test panels were exposed at a 45 degree angle to an acidified salt spray in a cabinet designed to meet the requirements of ASTM Method B287-68 for acidified salt spray tests(19). The test conditions were the same as those required by ASTM except for the following variations which develop more severe exfoliation attack than the standard ASTM test:

- (1) Operating temperature was 120 F, rather than 95 F.
- (2) Specimens were intermittently sprayed in 6-hr repetitive cycles, consisting of 3/4-hr spray time, 2 hours of dry-air purge, 3-1/4 hours at 100-per cent relative humidity.

The specimens were inspected daily, and at the termination of the two-week exposure period, the panels were chemically cleaned and visually examined for evidence of exfoliation attack. Previous testing experience has shown that test results from this accelerated test can be correlated with exposure tests in a seacoast atmosphere(20).

C. Fatigue-Crack-Propagation Tests

These tests were performed only on forgings of 6x24-in. cross section. Table XXXI gives the schedule of the tests, with pertinent information regarding type of notch, specimen proportions and orientation within the forging, test environment and the stress conditions under which cracks were propagated.

In previous tests of this kind on thick plate and extrusions (2,3 and 21), extensive use was made of the mild notch crack starter shown in Fig. 41. Because of the eccentric cracking often obtained, however, it was decided that a sharper notch should be tried. Details of a "sharp" notch are shown in Figs. 43 and 44 for 24-in. and 6-in. long specimens. Comparative tests of the two notch designs in the 2014-T652 forging showed that crack initiation and propagation with the sharp notch was still not as uniform as desired. Accordingly, the Elox notch shown in Fig. 45 was adopted for the remainder of the program. With this design it was necessary to propagate a fatigue crack from the 0.2-in. initial notch width to a total of 0.5 in., where measurements of crack-propagation rates were begun. Crack initiation was produced by cycling the specimens to a maximum gross tensile stress of 12.5 ksi. The machine load was then adjusted, as scheduled, to the test stress and the cracking continued to produce a 0.5-in. notch length.

In a few tests, limited to the 2014-T652 forging, the maximum stress in the test cycle was increased, or decreased, after the total length of notch plus crack reached 1.0 in.

The majority of tests were made in laboratory air having a wide range of relative humidity. The humidity was monitored during each test and the range of values recorded. In a few tests made in a controlled atmospheric environment, the specimens were enclosed in the container shown in Fig. 46. Dry air, having a relative humidity of 10%, was obtained by use of a dessicant. High relative humidity, above 90%, was obtained by having a small water reservoir within the specimen enclosure. Salt fog was obtained by spraying a 35% NaCl sea-water solution into the container at 15-minute intervals. The humidity was maintained at a high level by means of salt water in the reservoir.

Crack-propagation characteristics were investigated in the three principal directions of the 7075-T7352 and 7079-T652 forgings. Also, specimens were taken from one skewed direction to provide a condition of grain runout. It was assumed, on the basis of the comparative tests of 6-in. and 24-in. long sharp-notched specimens, taken from the same direction in the 2014-T652 forging, that specimen length was not a significant factor in evaluating directional effects.

The fatigue-crack-propagation tests were made in machines of 50,000-lb capacity. Pictures of these, with some of the fixtures used, are shown in Figs. 47 and 48.

Crack propagation was deduced from lengths measured at the surfaces of the specimen with a magnifying glass and scale, the latter graduated in 0.01 in. More precise measurements did not seem justified because the cracks tended to propagate on a convex front.

SECTION IV

RESULTS OF TESTS

The results of the individual tensile, compressive, shear and bearing tests, the ratios among certain properties, the statistical analysis of these ratios, and the computed design values are presented in Tables II through XIX. The results of the stress-strain and modulus of elasticity tests are shown in Tables XX and XXI and in the stress-strain and compressive tangent-modulus curves in Figs. 11 through 18.

The results of the fracture-toughness tests are shown in Tables XXII and XXIII. The results of the axial-stress fatigue tests are shown in Table XXIV and in Figs. 19 through 22.

The results of the stress-corrosion tests are shown in Tables XXVI through XXX.

The results of the fatigue-crack propagation tests are presented in Figs. 49 to 109. For each condition studied, two plots are presented: the first is a plot of the crack-propagation data and the second is a plot of the fatigue-crack growth rate versus $\sqrt{K}$, the range of stress-intensity factor for the same data. The crack-growth rates, $\frac{da^*}{dN}$, were determined by computer from the slopes of the crack-propagation curves. The actual crack-propagation data for each specimen are given in the Appendix. Figs. 110 and 111 show a comparison of the crack-growth rates of these alloys and with those previously determined for thick specimens of plate and extrusions (2,3 and 21).

* a = 1/2 total crack length (notch length plus fatigue cracks);
N = number of cycles

SECTION V

DISCUSSION OF RESULTS

A. Mechanical Properties

A.1. Tensile, Compressive, Shear and Bearing

The results of the tensile, compressive, shear and bearing tests of the individual samples of 2 to 6-in. thick 2014-T652, 2024-T852, 7075-T7352 and 7079-T652 hand forgings are summarized in Tables II through V. The tensile properties of each sample meet the applicable minimum-property requirements shown in Table VI.

The ratios among the properties determined for the individual samples are summarized in Table VII. The statistical analyses of the ratio data were made in accordance with the procedures outlined in Mil-Handbook-5 Guidelines for Presentation of Data(15).

A regression analysis of each group of ratios was made to determine whether the data showed a significant correlation with thickness. When a significant correlation with thickness was indicated, values of minimum-ratios, $\bar{R}$, were selected which correspond with the lower limit of the confidence band around the regression line at the mean of each respective thickness range. When no correlation was shown, a single minimum value of $\bar{R}$ was selected for all thicknesses. These values of minimum $\bar{R}$ were used for determining derived design values for the respective thickness ranges.

The distribution of the ratios, and the values for the various terms in the statistical analyses, are shown in Tables VIII to XI. Of the ratios involving compressive yield stresses, only those for 2024-T852 in the longitudinal and long-transverse directions show a correlation with thickness. There is no correlation with thickness indicated in the ratios involving shear and bearing stresses for any of the alloys investigated.

Since the shear and bearing tests were made with specimens taken in two or three directions (L, LT and ST), Student's "t" test and "f" test were applied to the ratios for each direction to determine if there were significant differences in the average ratios or in the variability for the different directions. Where none was indicated, the ratios for the different directions were combined for computation of the minimum ratios to be used; where there was a significant difference, the most conservative value was used.

The ratio values used in computing the design values from the specified tensile properties of the respective thickness ranges of each alloy are summarized in Tables XII to XV. The corresponding computed design values for each of the alloys are summarized in Tables XVI to XIX; also shown are the differences between these values and the corresponding values presently in MIL-HDBK-5A.

In preparing the design tables for 2014-T652, 7075-T7352 and 7079-T652, the respective tensile-property values in Federal Specification QQ-A-367g and Military Specification MIL-22771C, as shown in Table VI, were used as basis-property "S" values. The tentative values for 2024-T852 were based on the tensile data determined in this investigation and Alcoa production data. The basis-property values and the ratios shown in Tables XII to XV, were used in computing the remaining design values.

As shown in Tables XVI and XIX, the derived design values of compressive, shear and bearing properties for 2014-T652 and 7079-T652 hand forgings differ slightly from the values now published in MIL-HDBK-5A. For 2014-T652, the computed derived values of F_{cy} (LT) are 1 ksi higher; the F_{su} and F_{bru} values, 2-3 ksi lower; the F_{bry} values for $e/D=1.5$ are 1-2 ksi lower and for $e/D=2.0$, 1 ksi lower to 1 ksi higher. For 7079-T652, the computed derived values for F_{cy} (L) are 2 ksi lower and those of F_{su} are the same or 1 ksi lower. The slightly lower values of shear stresses developed in this contract may be partially explained by the fact that the loads in the shear tests were applied normal to the major surface of the hand forgings, whereas in previous tests, the loading direction was not controlled(11). No design values are presently shown for 2024-T852 and 7075-T7352 hand forgings in MIL-HDBK-5A.

The results of the individual tensile and compressive stress-strain tests and the modulus of elasticity tests are summarized in Table XX; the average modulus values are shown in Table XXI.

In the modulus tests, none of the alloys investigated showed any significant difference in modulus values that might be readily associated with thickness of sample or the specimen direction (L, LT or ST). The modulus of elasticity of each alloy is indicated to be three or four per cent higher in compression than in tension.

The average moduli for the two alloys of each series (2000 and 7000) were nearly equal; average tensile and compressive modulus values for the two series are:

<u>Alloy Series</u>	<u>Modulus, psi</u>	
	<u>Tension</u>	<u>Compression</u>
2000	10 500 000	10 800 000
7000	10 000 000	10 400 000

The average modulus values shown above for the 2000 alloy series (2014 and 2024) are the same for tension and 1 per cent higher for compression than the applicable values now shown in MIL-HDBK-5A, whereas the applicable values for the 7000 series (7075 and 7079) are slightly lower by 3 per cent in tension and 1 per cent in compression. These average values are 1 to 4 per cent lower than those obtained for stress-relieved plate and extrusions in previous contracts, Technical Reports AFML-TDR-64-105, May 1964, and AFML-TR-68-34, February 1968, respectively(1 and 4). The modulus values determined for the hand forgings are shown in Tables XVI to XIX, and were used in preparing the stress-strain and compressive tangent-modulus curves shown in Figs. 11 to 18.

The results of the individual stress-strain tests indicated that, for a given alloy, temper and direction, there was no apparent trend with thickness in the offsets from the modulus line at stresses expressed in per cent of yield stress. Typical and minimum ("S" value) stress-strain and compressive tangent-modulus curves have been prepared for the alloys in thickness ranges as shown in Figs. 11 to 18. The curves were derived and presented in accordance with the procedures outlined in MIL-HDBK-5 Guidelines for Presentation of Data(15). The tensile yield stresses used in deriving the typical stress-strain curves are the typical values indicated in Alcoa's production in recent years; it is assumed that these values would be representative for the industry. The compressive yield stresses were based on the average ratios shown in Tables XII to XV. For the minimum stress-strain curves, the tensile and compressive yield stress values shown for the appropriate thickness range in Tables XVI to XIX were used.

A.2. Fracture Toughness

The results of the individual fracture toughness tests are shown in Table XXII. Although some of the values are not strictly valid by all of the criteria of the ASTM Recommended Method of Test for Plane-Strain Fracture Toughness of Metallic Materials(16), most of the calculated K_{Ic} values are considered to be meaningful values of K_{Ic} since certain

criteria were exceeded only by a small amount, as indicated in the table. With but two exceptions, meaningful K_{Ic} values were obtained for all of the contract materials in the different directions. The data indicate that the fracture toughness of each alloy is greater in the longitudinal (LW) direction than in the long-transverse (WL) direction and least in the short-transverse (TL) direction.

The meaningful values of K_{Ic} from Table XXII are summarized in Table XXIII. The fracture toughness values determined for 2014-T652, 2024-T652 and 7079-T652 indicate no definite trend with thickness, however, the values for 7075-T7352, in each direction, show a tendency to increase with increased thickness.

Also included for comparison are the average fracture toughness values determined for some extrusions (TX510 tempers) in a previous contract (4). In most instances, the respective average values shown for the hand forgings and the extrusions are in good agreement; there are large differences (in excess of 10 per cent) between the long-transverse values for alloys 2014 and 7079, with the hand forgings having the lower values. It is pointed out, however, that the values shown for the 2014 and 7079 extrusions are based on duplicate tests of only one sample of material, whereas the values for the 2024 and 7075 extrusions are based on tests of 4 to 6 samples.

A.3. Axial-Stress Fatigue

The results of the axial-stress fatigue tests ($R=0.0$) of long-transverse specimens from the 2, 4, 5 and 6-in. thick forgings are shown in Table XXIV and in Figs. 19 to 22. Log-mean fatigue life values for two of the three preselected stress levels, at which the respective alloys were tested, are shown in the table; the curves have been drawn through these points and extended to indicate the trend of the data. Log-mean lives could not be calculated for the lowest stress because, for each alloy, at least one specimen did not fail within the number of cycles allotted to the test.

The test results for all four alloys indicate that there may be a correlation between the fatigue life and thickness of the hand-forging sample; in most of the tests, at all three stress levels, fatigue life decreased with increase in forging thickness.

To allow comparison, the fatigue curves determined for plate and extrusions in previous investigations (2,3,4) are also plotted in Figs. 19 to 22. In general, the log-mean

Alloy Series	Modulus, psi	
	Tension	Compression
2000	10 500 000	10 800 000
7000	10 000 000	10 400 000

The average modulus values shown above for the 2000 alloy series (2014 and 2024) are the same for tension and 1 per cent higher for compression than the applicable values now shown in MIL-HDBK-5A, whereas the applicable values for the 7000 series (7075 and 7079) are slightly lower by 3 per cent in tension and 1 per cent in compression. These average values are 1 to 4 per cent lower than those obtained for stress-relieved plate and extrusions in previous contracts, Technical Reports AFML-TDR-64-105, May 1964, and AFML-TR-68-34, February 1968, respectively (1 and 4). The modulus values determined for the hand forgings are shown in Tables XVI to XIX, and were used in preparing the stress-strain and compressive tangent-modulus curves shown in Figs. 11 to 18.

The results of the individual stress-strain tests indicated that, for a given alloy, temper and direction, there was no apparent trend with thickness in the offsets from the modulus line at stresses expressed in per cent of yield stress. Typical and minimum ("3" value) stress-strain and compressive tangent-modulus curves have been prepared for the alloys in thickness ranges as shown in Figs. 11 to 18. The curves were derived and presented in accordance with the procedures outlined in MIL-HDBK-5 Guidelines for Presentation of Data (15). The tensile yield stresses used in deriving the typical stress-strain curves are the typical values indicated in Alcoa's production in recent years; it is assumed that these values would be representative for the industry. The compressive yield stresses were based on the average ratios shown in Tables XII to XV. For the minimum stress-strain curves, the tensile and compressive yield stress values shown for the appropriate thickness range in Tables XVI to XIX were used.

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The meaningful values of K_{Ic} from Table XXII are summarized in Table XXIII. The fracture toughness values determined for 2014-T652, 2024-T652 and 7079-T652 indicate no definite trend with thickness, however, the values for 7075-T7352, in each direction, show a tendency to increase with increased thickness.

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The test results for all four alloys indicate that there may be a correlation between the fatigue life and thickness of the hand-forging sample; in most of the tests, at all three stress levels, fatigue life decreased with increase in forging thickness.

To allow comparison, the fatigue curves determined for plate and extrusions in previous investigations (2,3,4) are also plotted in Figs. 19 to 22. In general, the log-mean

fatigue values of the hand forgings are about the same or slightly higher than those of the extrusions, and somewhat lower than those of plate of the corresponding alloy and temper. However, at the lower stress level, the fatigue life for 2024-T652 hand forgings is indicated to be substantially greater than those of both 2024-T651 plate and 2024-T651X extrusions.

B. Corrosion Characteristics

B.1. Resistance to Stress Corrosion Cracking (SCC)

The data obtained from tests of longitudinal and long-transverse 0.437-in. diameter tensile specimens are given in Tables XXVI and XXVII, and similar data from tests of short-transverse 0.125-in. diameter tensile specimens are given in Tables XXVIII and XXIX. Supplemental test data (retests) for selected forgings are given in Table XXX.

A high resistance to stress-corrosion cracking was exhibited by longitudinal specimens from each of the forgings tested. Long-transverse specimens from the 2024-T652 and 7075-T7352 alloy forgings were also highly resistant to SCC, but long-transverse specimens from the 2014-T652 and 7079-T652 were generally susceptible (Figs. 33-36) at stresses equal to 75% of yield strength. These results generally are in good agreement with existing stress-corrosion guidelines for these forged products.

Tests of the short-transverse specimens showed good agreement with expected performance of the various alloys and tempers; i.e., the 7075-T7352 specimens, in general, were highly resistant to stress-corrosion cracking, the 2024-T652 specimens showed some susceptibility at high stresses only, and the 2014-T652 and 7079-T652 specimens were susceptible at relatively low levels of stress. Some nontypical behavior was observed, however, and limited supplemental testing was conducted to check the initial results.

The performance of short-transverse specimens from the 2, 3 and 5-in. thick 2014-T652 and 7079-T652 alloy forgings was better than that previously observed with forgings of these alloys, but was within the sphere of existing data for these materials. Retests with specimens from the 2-in. thick forgings showed these alloys to be susceptible to SCC at a stress of 22.5 ksi, while neither alloy had failed at that stress during initial testing. The 2014-T652 specimens also failed at a stress of 15 ksi during these retests. The retest data better typify the expected performance of these forgings.

In comparing the initial and supplementary test results (Table XXX) for the 2-in. thick 2014-T652 and 7079-T652 forgings, it was observed that the two tests had been conducted during different seasons of the year. The initial tests were conducted during the winter months (November - February), and the retests during the summer months (July - October). The data strongly suggest that tests conducted under ambient conditions can be significantly influenced by seasonal variations.

Failures were encountered at 75% YS of short-transverse specimens from the 3 and 4-in. thick 7075-T7352 forgings. For the 4-in. thick 7075-T7352 forging, 1 of 3 specimens failed after an exposure of 64 days; however, metallographic examination revealed that the failure was not typical of stress-corrosion cracking (Figs. 37 and 38). Three specimens from the 3-in. thick forging failed after only 8 days exposure, and microscopic examination showed the failures to be typical of stress-corrosion cracking (Figs. 39 and 40). Although Federal Specification QQ-A-367g does not list stress-corrosion cracking criteria for 7075-T7352 alloy forgings, the new edition of MIL-A-22771C does require that the criteria specified for 7075-T73 forgings also be applied to forgings in the T7352 temper. These criteria state that short-transverse specimens stressed at 75 per cent of the minimum longitudinal yield strength shall satisfactorily complete a 30-day exposure in the 3.5% NaCl alternate immersion. On the basis of the strengths listed in "Aluminum Standards and Data", April, 1968, the test stress for a 3-in. thick forging would be 39.7 ksi. Hence, the 3-in. thick hand forging did not fulfill the stress-corrosion cracking requirements of the Military Specification MIL-A-22771C. The forging, therefore, cannot be considered to represent the T7352 temper from the standpoint of corrosion resistance. This is surprising because the forging met the electrical conductivity - yield strength criterion, though in borderline fashion, for adequate resistance to stress-corrosion cracking.

B.2. Resistance to Exfoliation

No exfoliation was detected on the panels exposed to the acidified intermittent spray regardless of alloy, and no significant differences were observed between specimens from different regions (T/10, T/2) relative to the forging thickness.

C. Fatigue-Crack Propagation

C.1. Tests of 2014-T652 Hand Forging

The 2014-T652 specimens were selected to investigate, for one orientation in the forging, the effects of (1) notch shape, (2) specimen length and (3) change of load on crack-propagation rates. These results are presented in Figs. 49 to 67. Although the sharp notches produced somewhat more symmetrical cracking than the mild notches, the crack-growth rates were not significantly different.

The results for this alloy show a surprisingly large amount of scatter, which may have obscured the effects of some of the test variables. The fracture surfaces of the mild-notched specimens, 7 and 10, which showed a large difference in crack-growth rate, were visibly different, as were those of the adjacent sharp-notched specimens, 8 and 11. Cross sections near the fracture surfaces of specimens 7 and 10 are shown in Fig. 57; Specimen 7 shows a directional or fibrous-type fracture whereas specimen 10, which had a higher crack-propagation rate, shows a coarse, nonfibrous fracture. These specimens were taken from the same central portion of the forging cross section at locations only 3 in. apart.

The results for specimens of 6-in. and 24-in. lengths do not show consistent differences in crack-growth rates for the loadings investigated. Thus, it appears that variations in specimen length do not have to be taken into account in evaluating crack-propagation behavior.

Rates of crack propagation were influenced, of course, by the loadings applied. Increasing or decreasing the load after reaching a total crack length of 1.0 in., however, had no apparent effect on growth rates at the new loads. That is, propagation at low stresses did not influence subsequent rates at higher stresses, and vice versa.

One variable listed in Figs. 49 to 67, referred to above, is the range of relative humidity existing in the laboratory during the tests. These generally ranged from 5 to 50 per cent. Although it appears in some cases that rate of cracking increased with increasing humidity, all results are not consistent in this respect.

C.2. Tests of 2024-T652 Hand Forging

Tests of this alloy were limited to specimens of one orientation at three different stress levels. Results are presented in Figs. 68 and 69. In contrast to the results shown for the 2014-T652 forging, the crack-propagation data for duplicate specimens at any one stress are quite consistent.

This is attributed in part to the use of the Klox notch. Fig. 69 shows excellent correlation between propagation rates for stress levels of 8.2 ksi and 12.5 ksi. The tests at 17.5 ksi show a higher rate of propagation for the same stress-intensity factors.

C.3. Tests of 7075-T7352 and 7079-T652 Forgings

Crack-propagation was investigated in seven directions in these forgings, at one to three stress levels, and in different controlled environments. Results are presented in Figs. 70 to 109.

For both alloys, there was fairly good agreement between crack-growth rates at the different stress levels. Alloy 7075-T7352 was generally more resistant to crack propagation than 7079-T652. Short-transverse specimens in both alloys cracked more rapidly than those from the other orientations. Propagation in the face specimens tended to be slightly faster than in the edge specimens.

Environment was shown to have a significant effect on crack-growth rates. Both alloys cracked more rapidly in the high humidity tests, but 7079-T652 was affected more than 7075-T7352. The salt fog was slightly more damaging than high humidity.

Figures 106 to 109 show that the rate of cycling did not appreciably affect the rate of fatigue-crack propagation of 7075-T7352 and 7079-T652 LT(E) specimens in the salt-fog atmosphere.

C.4. Comparison of Alloys

Figure 110 compares the average crack-propagation rates for long-transverse edgewise specimens of the four alloys. At the lower stress intensities, the propagation was slowest for alloy 2014-T652 but at the highest stress intensities propagation was fastest for this alloy. Some of this difference is due to the greater eccentricity of cracking in the 2014-T652 specimens. For these long-transverse specimens, propagation for alloy 2024-T852 was consistently slower than for alloys 7075-T7352 and 7079-T652. This is contrary to the findings of Ref. 3 which rated 7075-T7351 plate above 2024-T851 plate from the standpoint of resistance to fatigue-crack propagation.

Figure 111 compares the propagation rates for longitudinal specimens of several 7075-T73XX and 7079-T6XX products. The data are consistent in showing 7075-T73XX to have lower propagation rates than alloy 7079-T6XX. The agreement between the rates for the various 7075-T73XX products is better than that shown for 7079-T6XX products.

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SECTION VI

SUMMARY AND CONCLUSIONS

Based on the results of tests of commercially-produced hand forgings that met the requirements for composition and tensile properties in applicable Federal and Military specifications, the following conclusions seem warranted concerning the mechanical properties, including fracture toughness and fatigue strengths, resistance to stress-corrosion and exfoliation and fatigue-crack propagation rates of stress-relieved 2014-T652, 2024-T852, 7075-T7352 and 7079-T652 hand forgings:

1. Ratios among the tensile, compressive, shear and bearing properties are shown in Table VII.

2. For 2014-T652, 7075-T7352 and 7079-T652, these ratios among properties do not indicate a significant variation with thickness.

3. For 2024-T852, only the ratios involving longitudinal and long-transverse compressive yield stresses show a correlation with thickness; the ratios decrease with increase of thickness.

4. Ratios used in computing the design mechanical properties are as shown in Tables XII to XV. The ratios are applicable for computing properties in the L, LT and ST directions and for thicknesses ranging up through 6 in.

5. Computed design mechanical properties for the respective alloys are as shown in Tables XVI to XIX. These values for 2014-T652 and 7079-T652 are no more than 1 ksi higher or 3 ksi lower than the respective values now published in MIL-HDBK-5A. No values are published in MIL-HDBK-5A for 2024-T852 or 7075-T7352 hand forgings.

6. The modulus of elasticity of each alloy is 3 or 4 per cent higher in compression than in tension. The values for the alloys in the respective 2000 and 7000 series are approximately the same regardless of test direction (L, LT and ST), sample thickness and temper.

7. The average modulus values, for all directions, are:

<u>Alloy Series</u>	<u>Modulus, psi</u>	
	<u>Tension</u>	<u>Compression</u>
2000	10 500 000	10 800 000
7000	10 000 000	10 400 000

8. Typical and minimum ("S" value) stress-strain and compressive tangent-modulus curves are shown in Figs. 11 to 18.

9. The average values of plane-strain stress-intensity factor, K_{Ic} (psi $\sqrt{\text{in.}}$), at 5-per cent secant offset are as follows:

<u>Alloy and Temper</u>	<u>Longitudinal (LW)</u>	<u>Long-Transverse (WL)</u>	<u>Short-Transverse (ST)</u>
2014-T652	28 800	21 600	20 500
2024-T852	26 300	18 400	15 900
7075-T7352	34 000	25 900	20 800
7079-T652	27 600	23 000	18 100

10. The results of the axial-stress fatigue tests ($R=0.0$) are plotted in Figs. 19 to 22. For 2014-T652, 7075-T7352 and 7079-T652, the log-mean fatigue lives of the respective hand forging alloys are about the same or slightly higher than those of extrusions, and slightly lower than those of plate of corresponding alloys and tempers tested in previous investigations. For 2024-T852 hand forgings, the log-mean fatigue lives at the higher stresses are about the same as those of both 2024-T851 plate and 2024-T851A extrusions; at the lower stress level, the fatigue life is substantially greater than those of the plate and extrusions.

11. All forgings were resistant to stress-corrosion cracking when longitudinally stressed to 75% of longitudinal yield strength. Long-transverse specimens stressed to 75% of long-transverse yield strength also were resistant in the case of 2024-T852 and 7075-T7352 but were generally susceptible in the case of 2014-T652 and 7079-T652; long-transverse specimens of 2014-T6 and 7079-T6 were resistant at stresses of 50% YS.

12. The resistance to stress-corrosion cracking of short-transverse specimens ranged widely with the alloy and temper: 7075-T7352 was resistant at 75% YS (except for the nontypical 3-in. thick forging); 2024-T852 was susceptible at

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75% YS, but generally resistant at 50% YS; 7079-T652 and 2014-T652 were generally susceptible at 15 ksi (approximately 25% YS).

13. There was no indication that the resistance to SCC of any of the alloys was influenced by forging section thickness.

14. All alloys and tempers demonstrated a high resistance to exfoliation corrosion.

15. The most consistent fatigue-crack growth rates were obtained in the tests of specimens having the Elox crack starter (Fig. 45).

16. Short-transverse specimens showed somewhat higher crack-growth rates than specimens from other directions in the forgings.

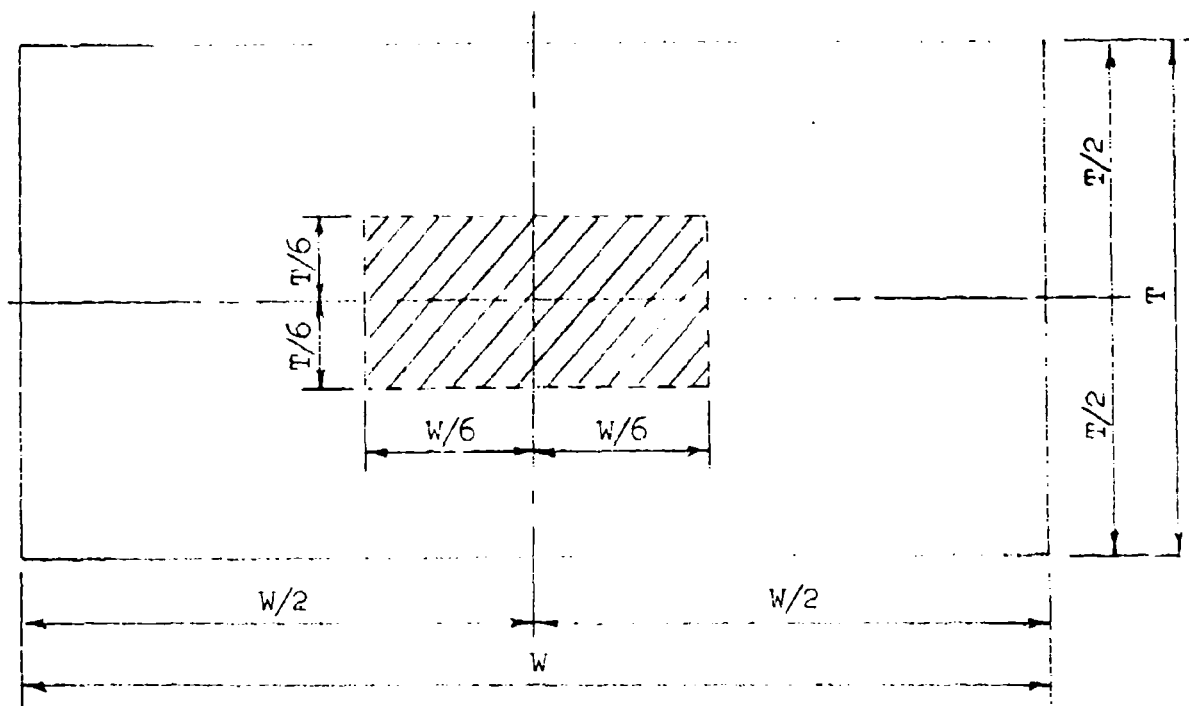
17. Tests in a high humidity produced higher crack-growth rates than tests in dry air. A salt-fog environment was slightly more damaging than high humidity.

18. At the lower stress intensities, the tests would rate these forging alloys in the following decreasing order of resistance to fatigue-crack propagation:

2014-T652
2024-T852
7075-T7352
7079-T652

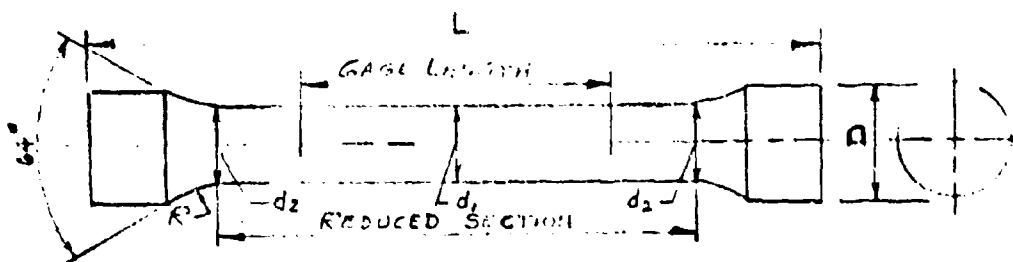
However, at the high stress intensities, propagation was fastest for alloy 2014-T652.

19. The crack-growth rates for the 7075-T7352 forging were consistent with those obtained in previous tests for 7075-T7351 plate and 7075-T73510 extrusions.



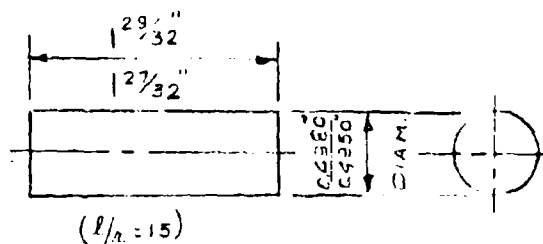
NOTE: Test Sections of All Specimens Were Within Center Third of Width and Thickness (cross-hatched area).

Fig. 1 Location of Test Sections of Specimens In Cross-Section of Hand Forgings.

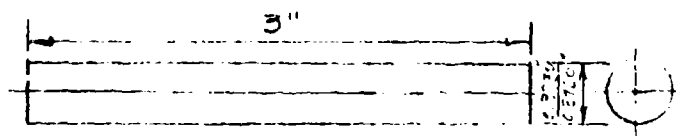


DIAMETER, IN. d_1	DIAMETER, IN. d_2	GAGE LENGTH, IN.	REDUCED SECTION LENGTH, IN.	RADIUS (R), IN.	DIAMETER (D), IN.	LENGTH (L), IN.
0.500 ± 0.005	$d_1 + \frac{0.005}{0.003}$	2.000 ± 0.002	$3\frac{1}{8}$	$\frac{5}{8}$	$\frac{3}{4}$	$4\frac{3}{4}$
0.357 ± 0.004	$d_1 + \frac{0.004}{0.003}$	1.400 ± 0.002	$2\frac{15}{16}$	$\frac{1}{4}$	$\frac{1}{32}$	$3\frac{5}{8}$
0.250 ± 0.003	$d_1 + \frac{0.002}{0.001}$	1.000 ± 0.002	$1\frac{9}{16}$	$\frac{3}{16}$	$\frac{3}{8}$	$2\frac{3}{8}$
0.160 ± 0.002	$d_1 + \frac{0.002}{0.001}$	0.640 ± 0.002	1	0.120	$\frac{15}{16}$	$1\frac{1}{2}$

Tapered-Seat Tensile Specimens



Round Compressive Specimen



Shear Specimen

Fig. 2 General Dimensions of Tensile, Compressive and Shear Specimens

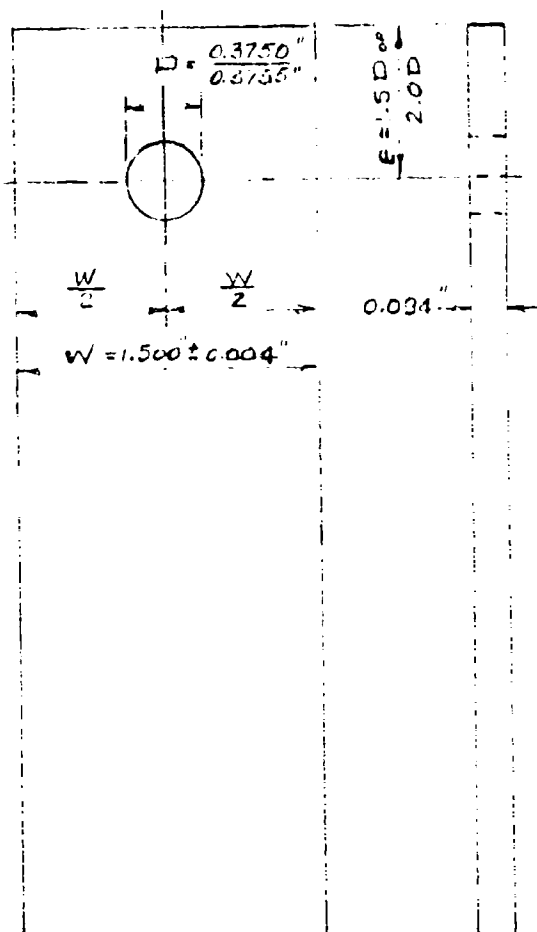
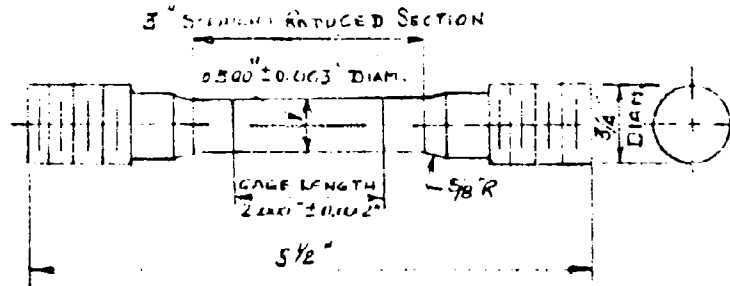
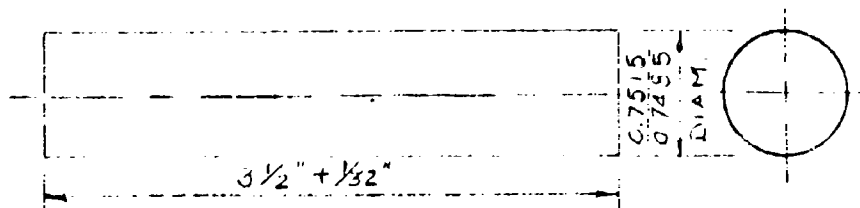


Fig. 3 General Dimensions of Bearing Specimens

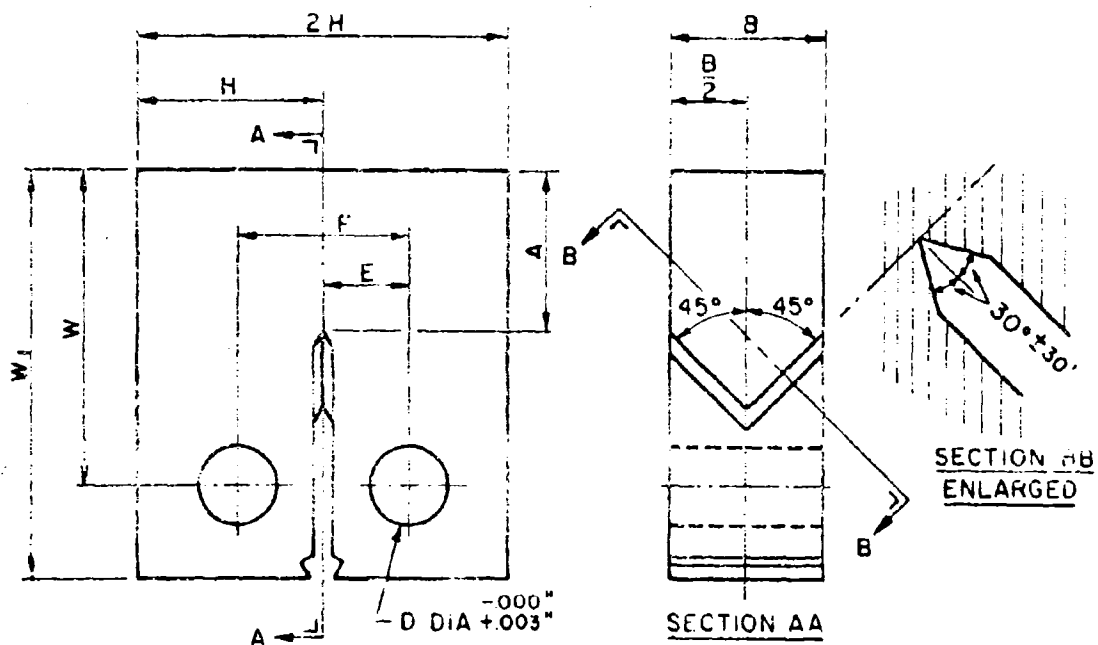


Round Tensile Specimen

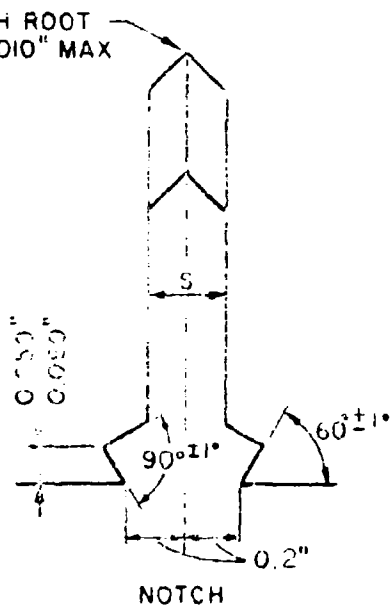


Round Compressive Specimen

Fig. 4 General Dimensions of Tensile and Compressive Specimens
For Modulus and Stress-Strain Tests



NOTCH ROOT
RADIUS .010" MAX



NOTCH

ENLARGED VIEW

PROPORTIONS	DIMENSIONS, IN.
$B = \text{THICKNESS}$	1.000
$A = 1.1B$	1.10
$W = 2B; W_1 = 2.5B$	2.000; 2.500
$S = 0.1B$	0.125
$F = 2E = 1.10B$	1.100
$H = 1.2B$	1.200
$D = 0.5B$	0.500

FIG. 6 COMPACT TENSION FRACTURE TOUGHNESS SPECIMEN



Fig. 7 Cantilever Beam Setup for Fatigue Cracking
Notch-Bend Fracture Toughness Specimens

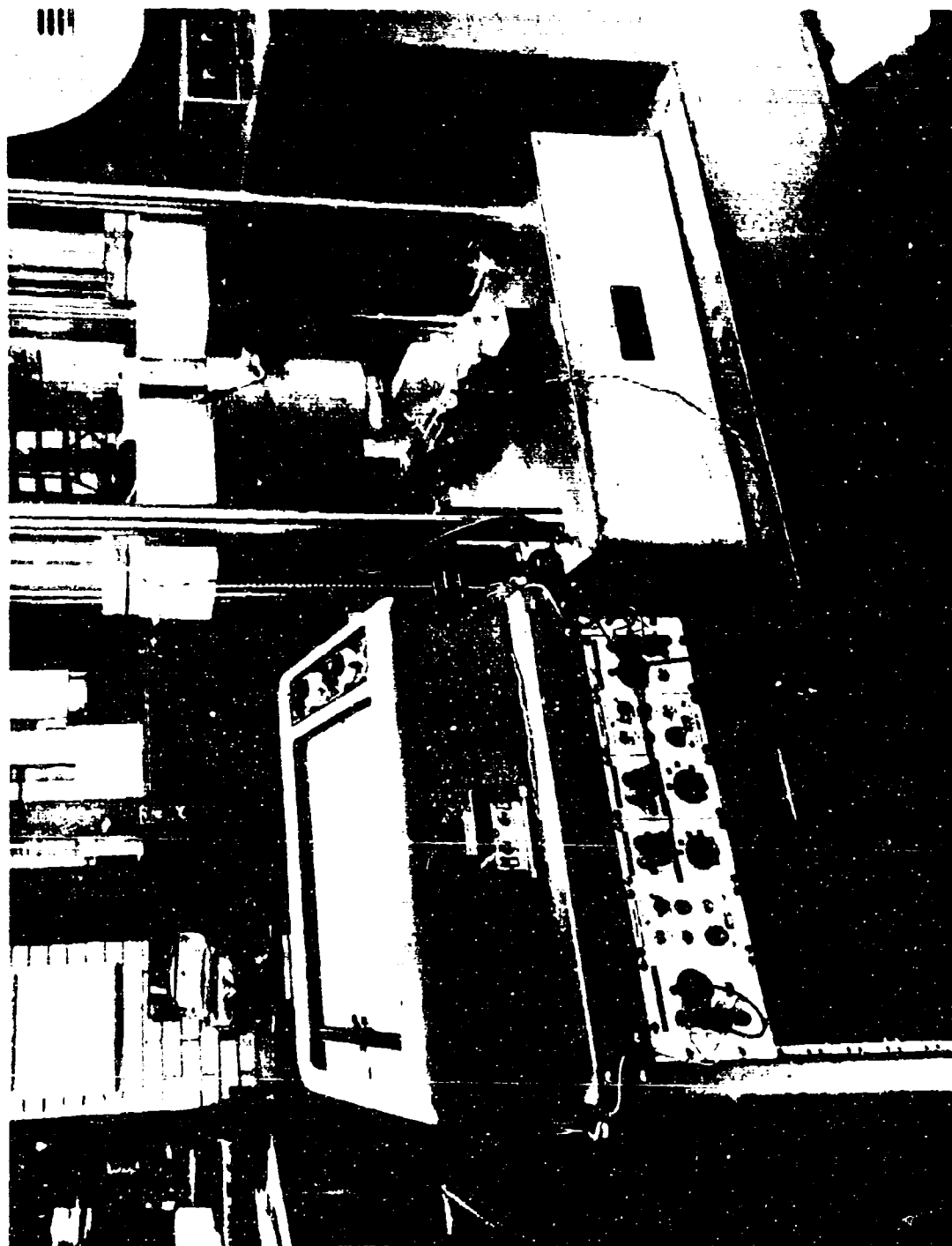


Fig. 8 Setup For Notch-Bend Fracture Toughness Testing

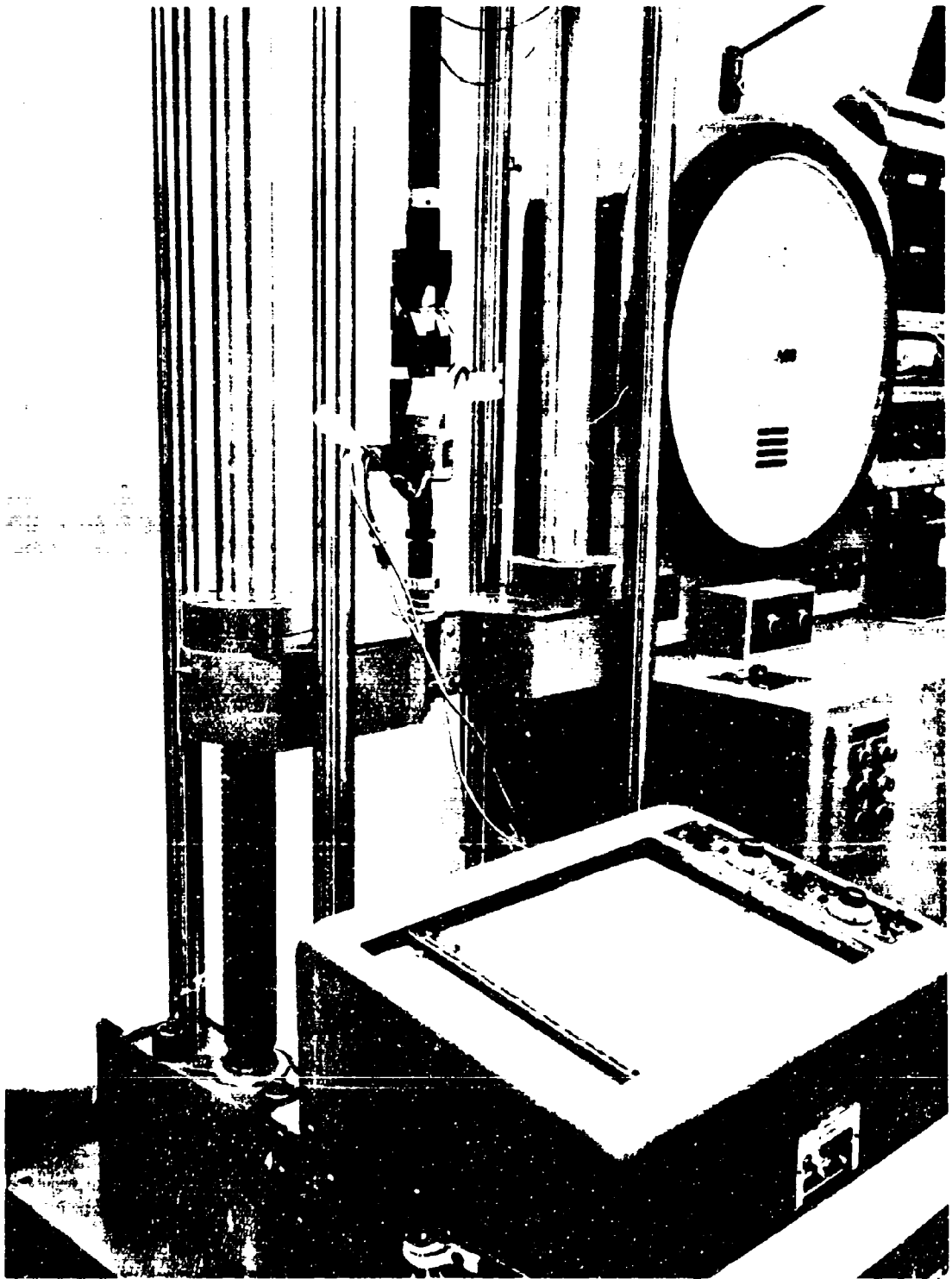


Fig. 9 Setup for Compact Tension Fracture Toughness Testing

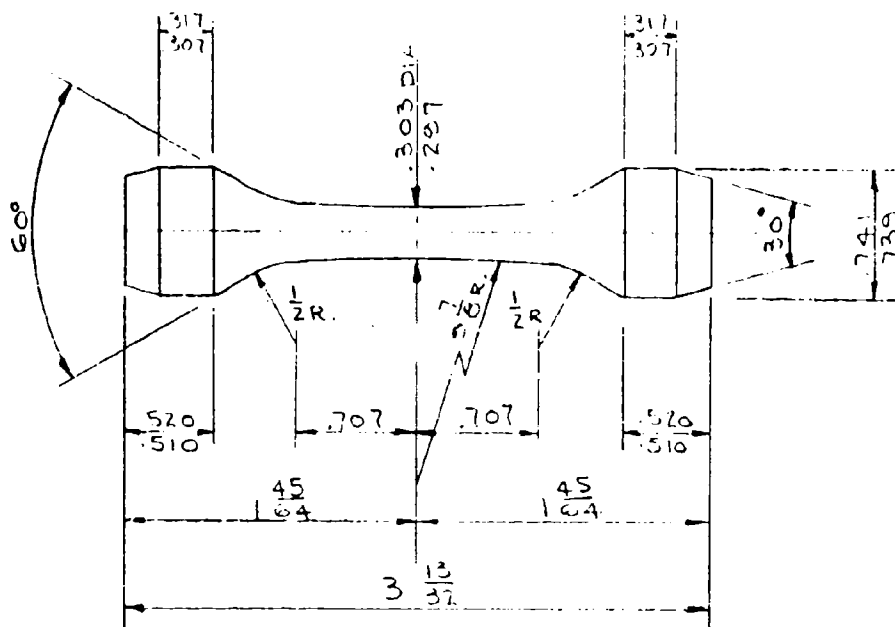


Fig. 10 Axial-Stress Fatigue Specimen

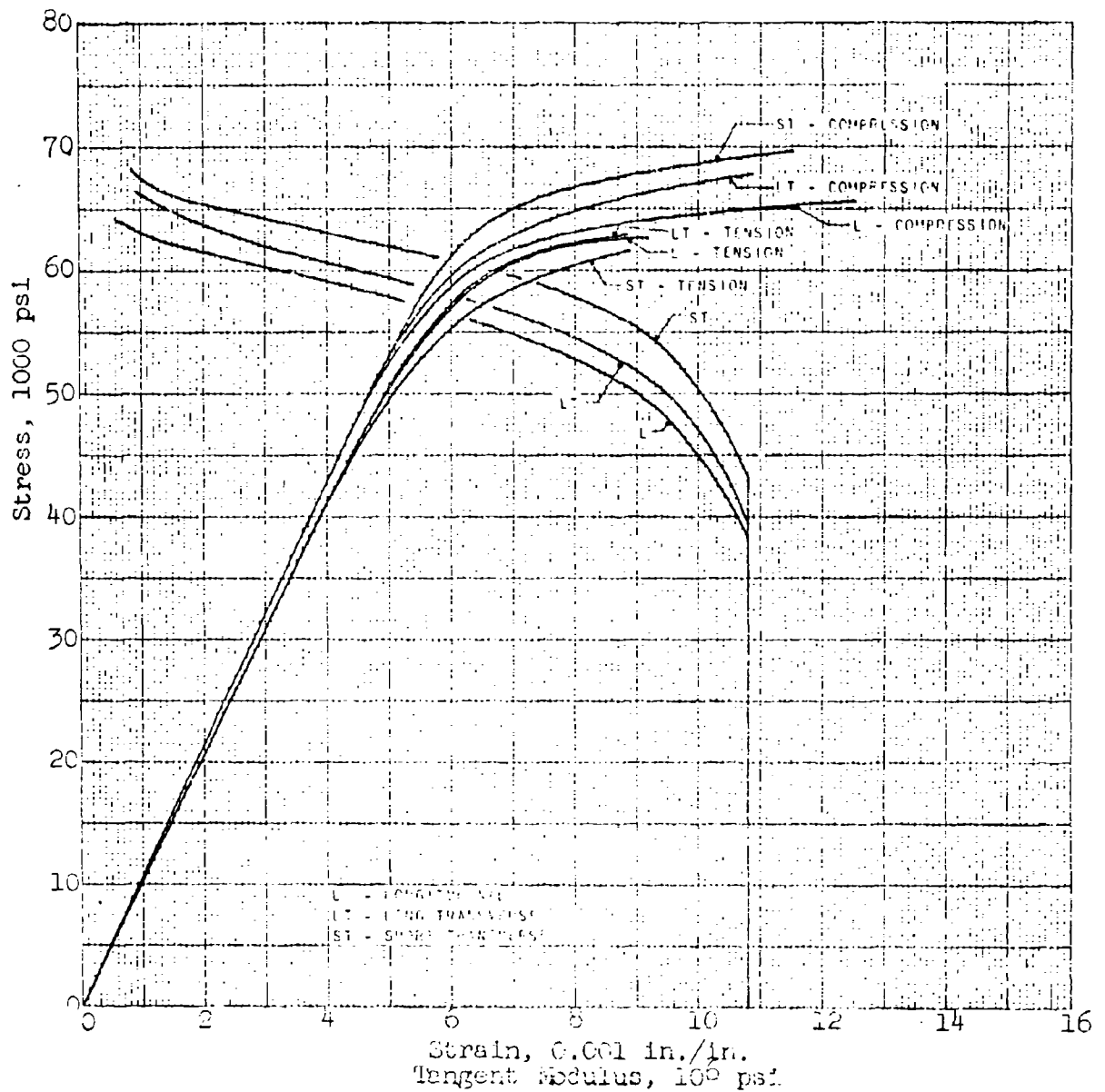


Fig. 11 Typical Stress-Strain and Compressive Tangent-Modulus Curves for 2014-T652 Aluminum Alloy Hand Forgings, 2.001-3.000 in.

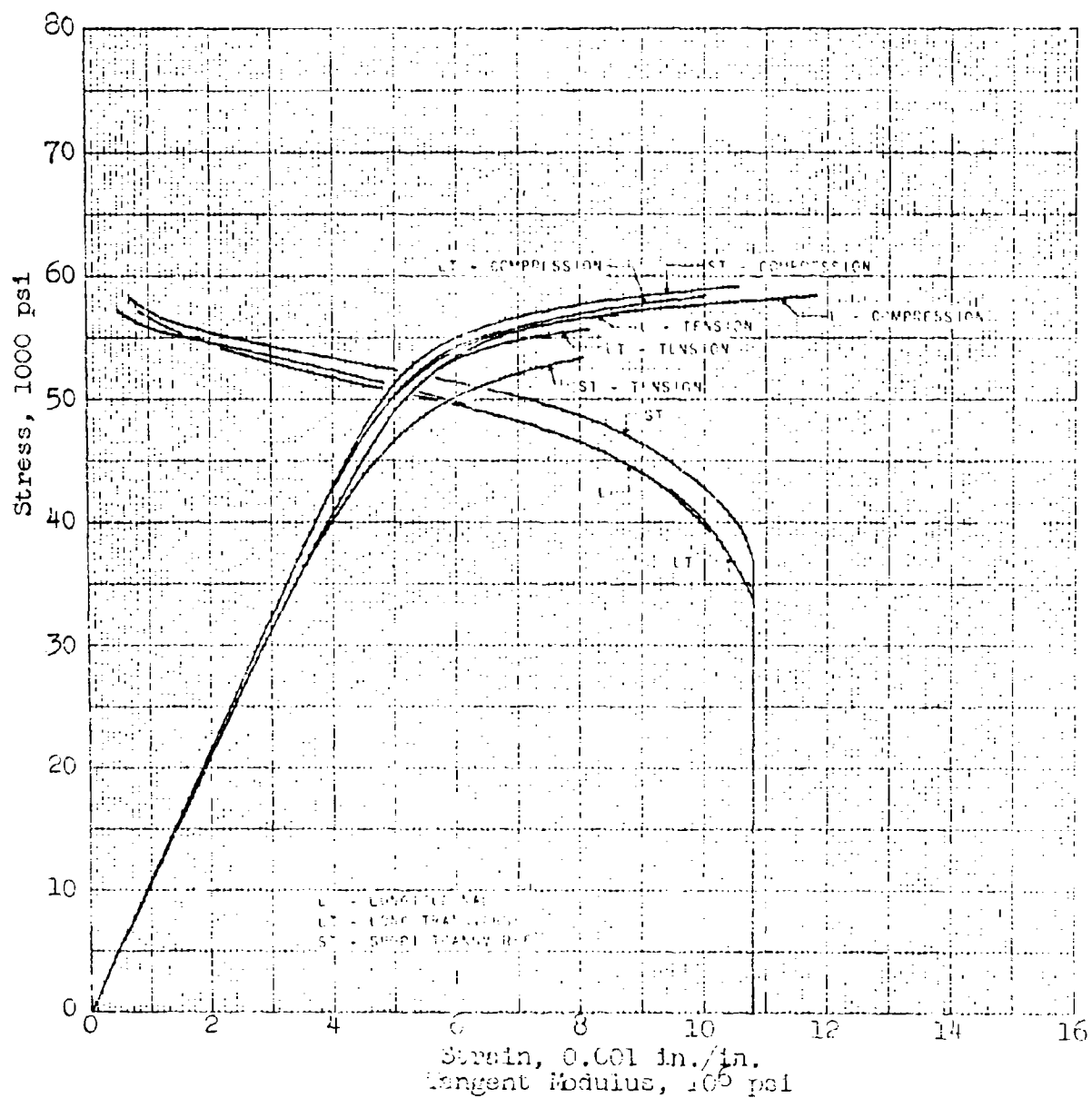


Fig. 12 Minimum ("0" Value) Stress-Strain and Compressive Tangent-Modulus Curves for 2014-T652 Aluminum Alloy Hand Forgings, 2.001-3.000 in.

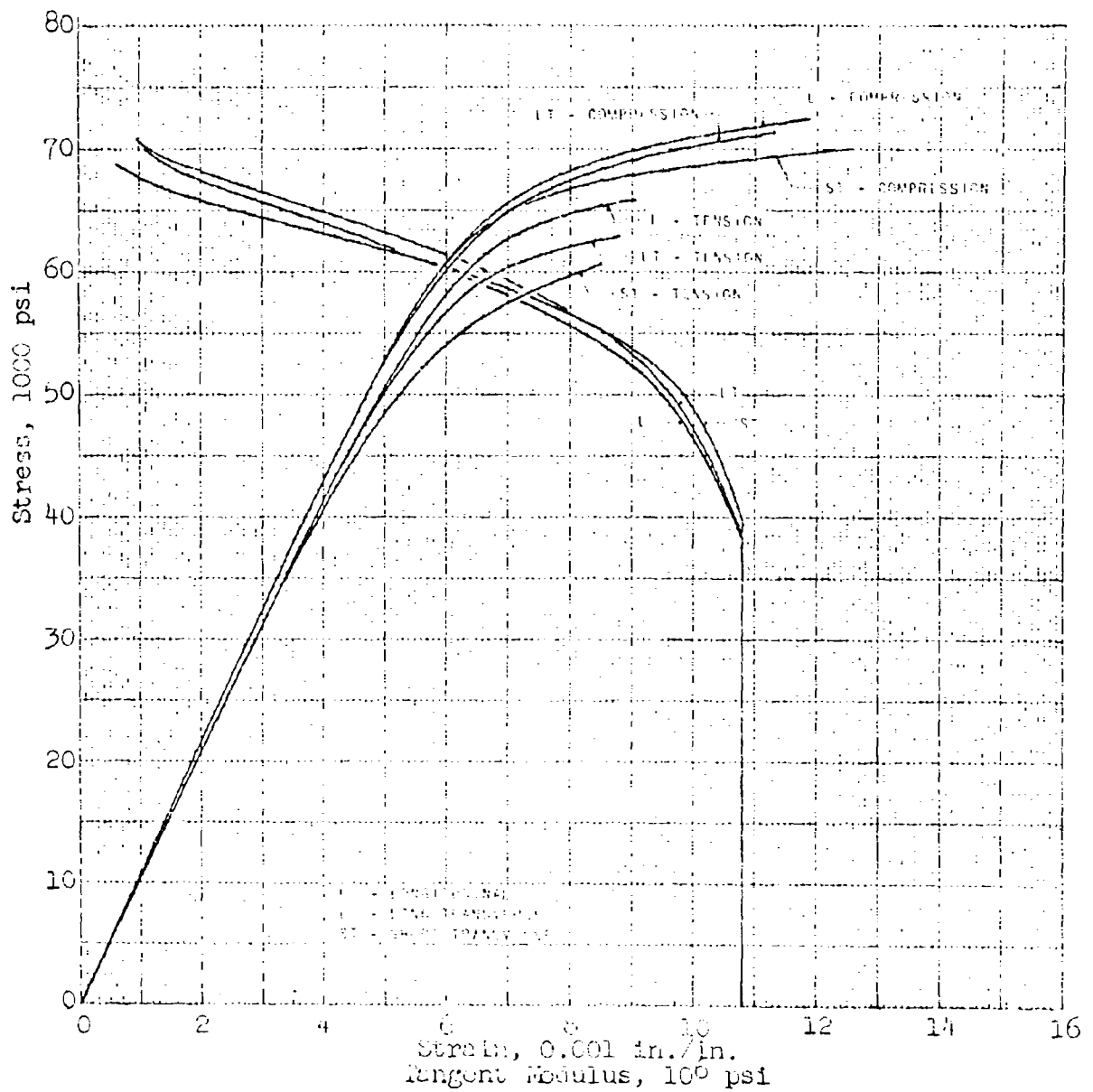


Fig. 13 Tentative Typical Stress-Strain and Compressive Tangent-Modulus Curves for 2024-T352 Aluminum Alloy Hand Forgings, 2.001-3.000 in.

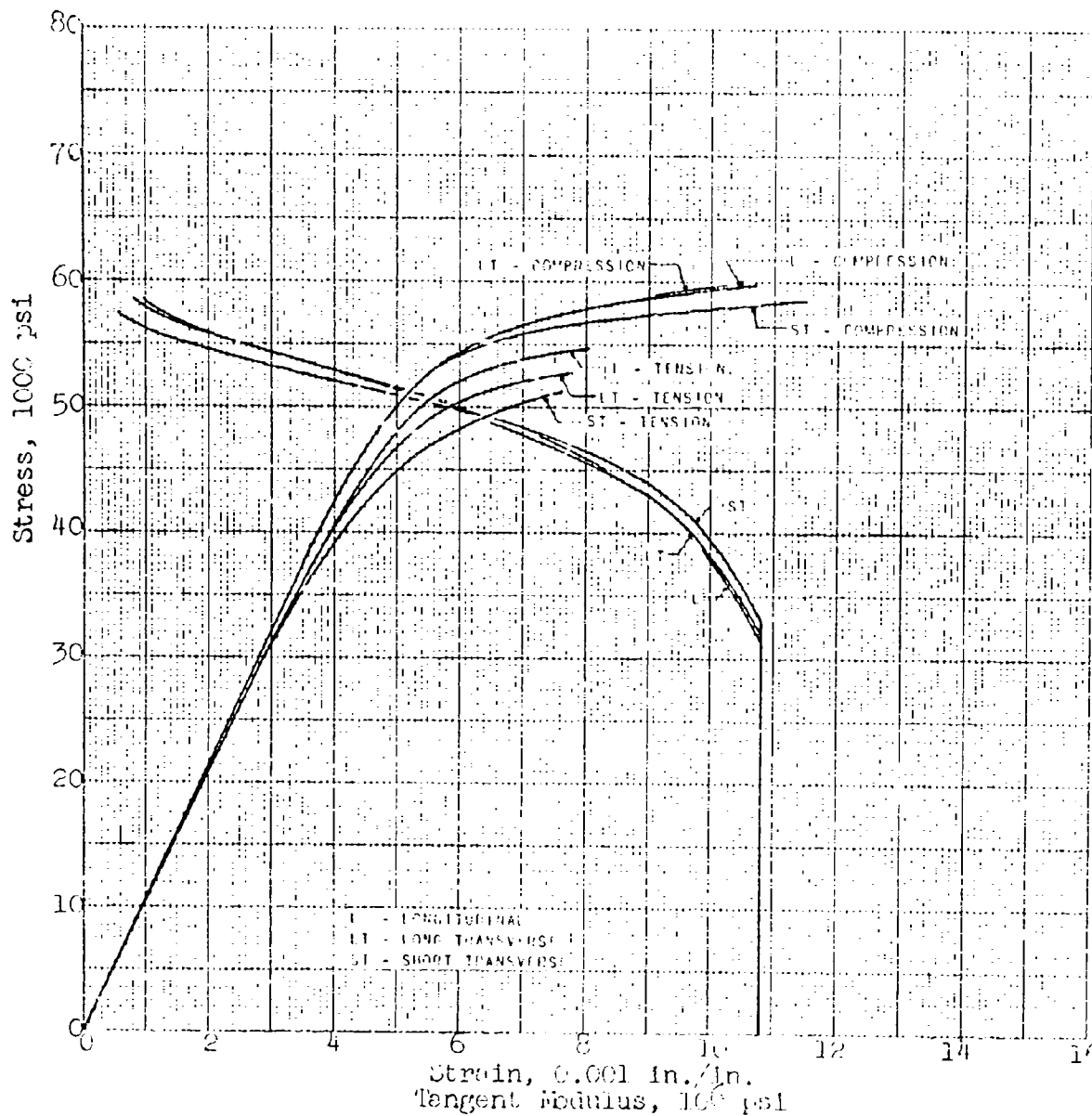


Fig. 14 Tentative Minimum Stress-Strain and Compressive
Tangent-Modulus Curves for 2024-T352
Aluminum Alloy Hand Forgings, 2.00-3.00 in.

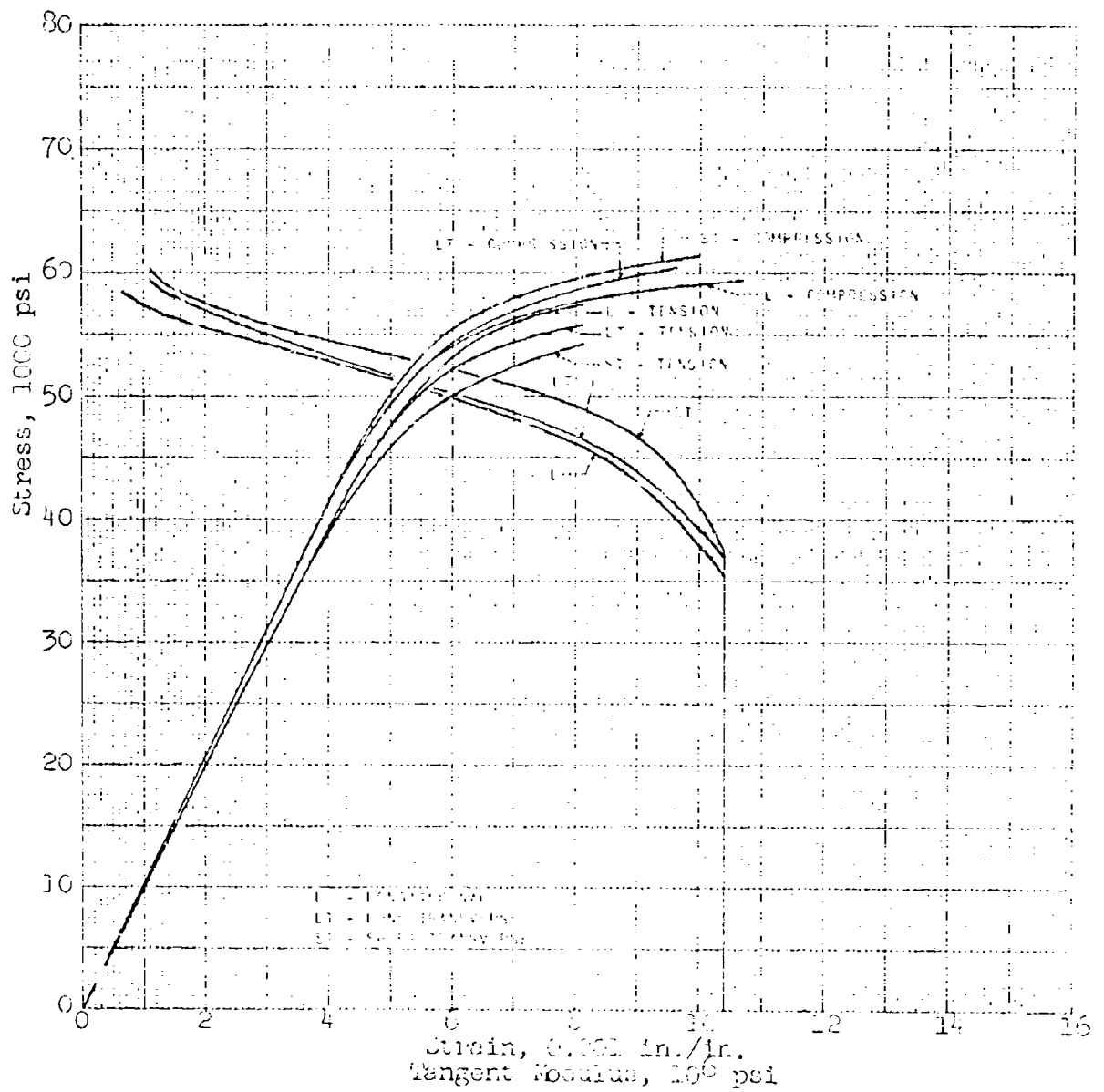


Fig. 15 Typical Stress-strain and Compressive Tangent-Modulus Curves for 7075-T7352 Aluminum Alloy Head Forgings, 3.001-5.000 in.

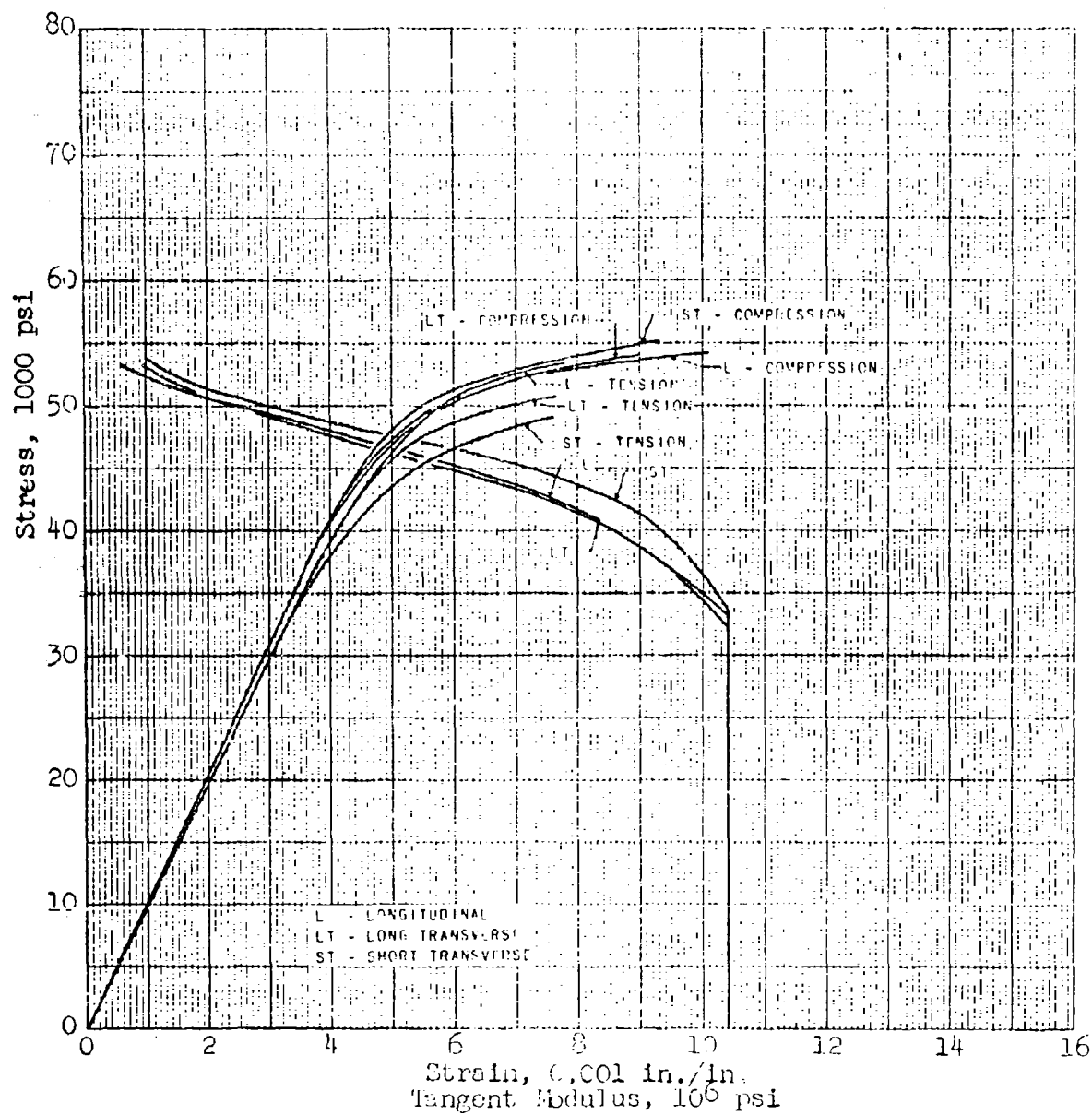


Fig. 16 Minimum ("S" Value) Stress-Strain and Compressive Tangent-Modulus Curves for 7075-T7352 Aluminum Alloy Hand Forgings, 3.001-4.000 in.

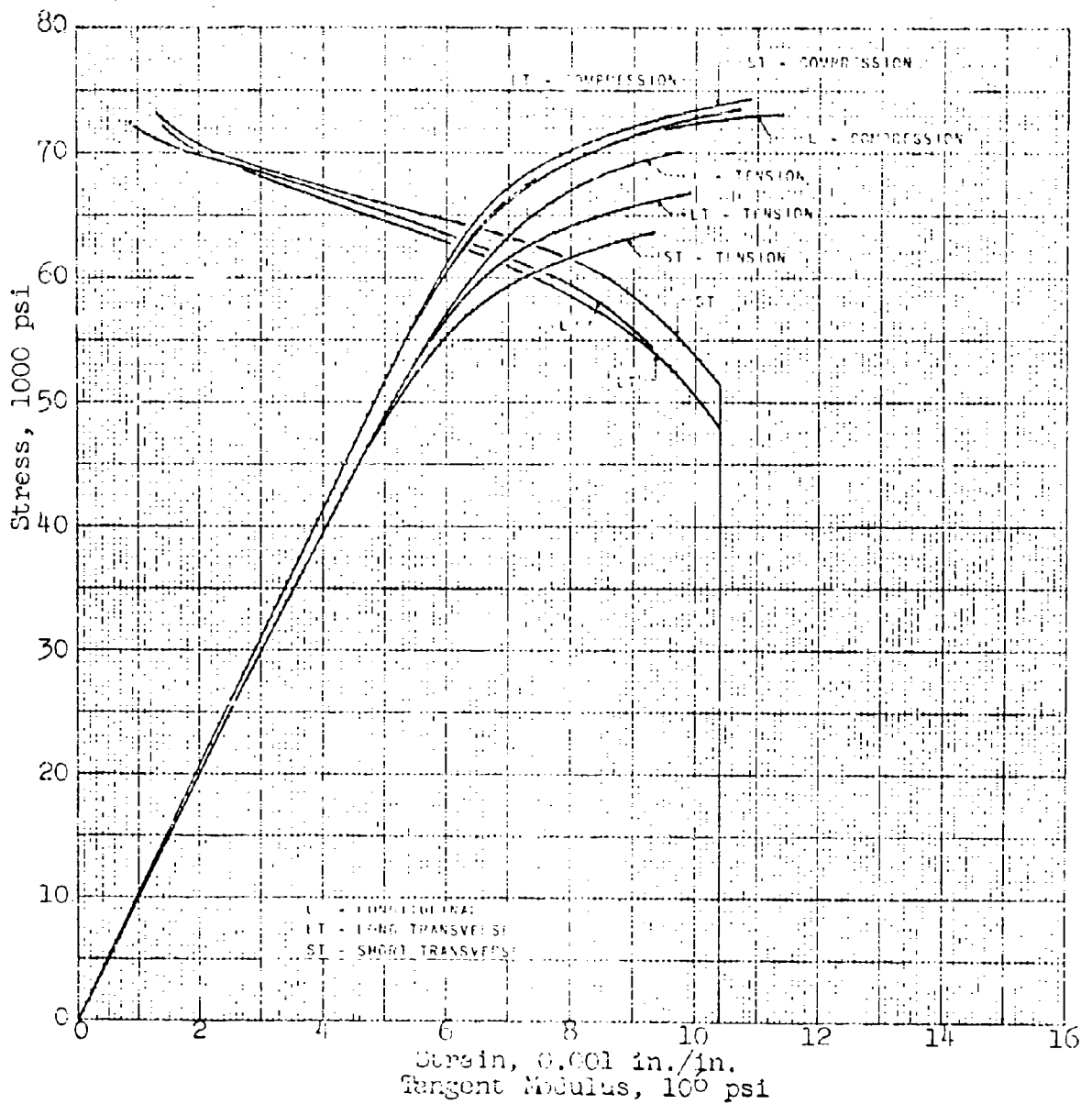


Fig. 17 Typical Stress-Strain and Compressive Tangent-Modulus Curves for 7079-T652 Aluminum Alloy and Forgings, 3.001-5.000 in.

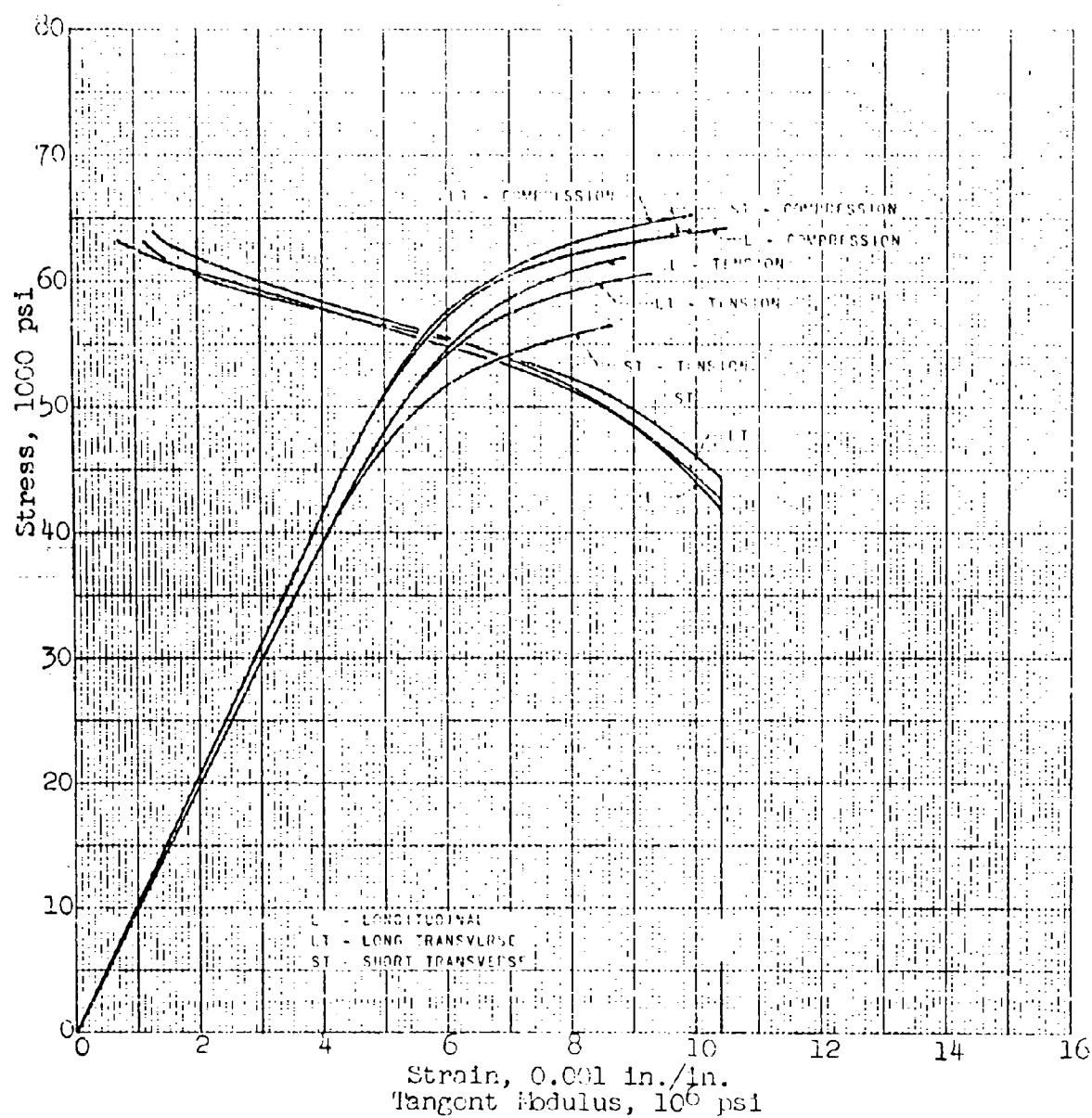


Fig. 18 Minimum ("S" Value) Stress-Strain and Compressive Tangent-Modulus Curves for 7079-T552 Aluminum Alloy Hand Forgings, 3.001-4.000 in.

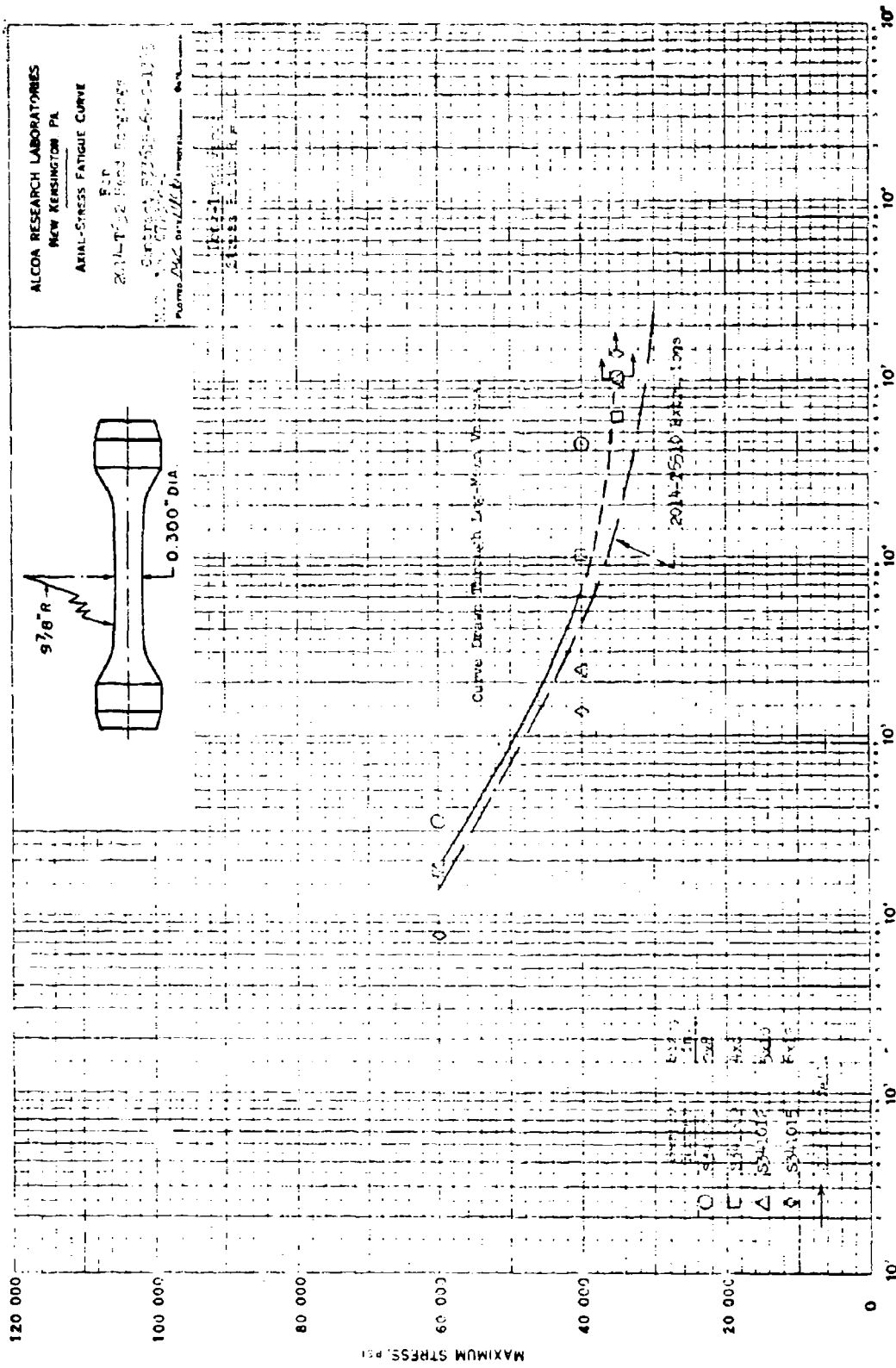
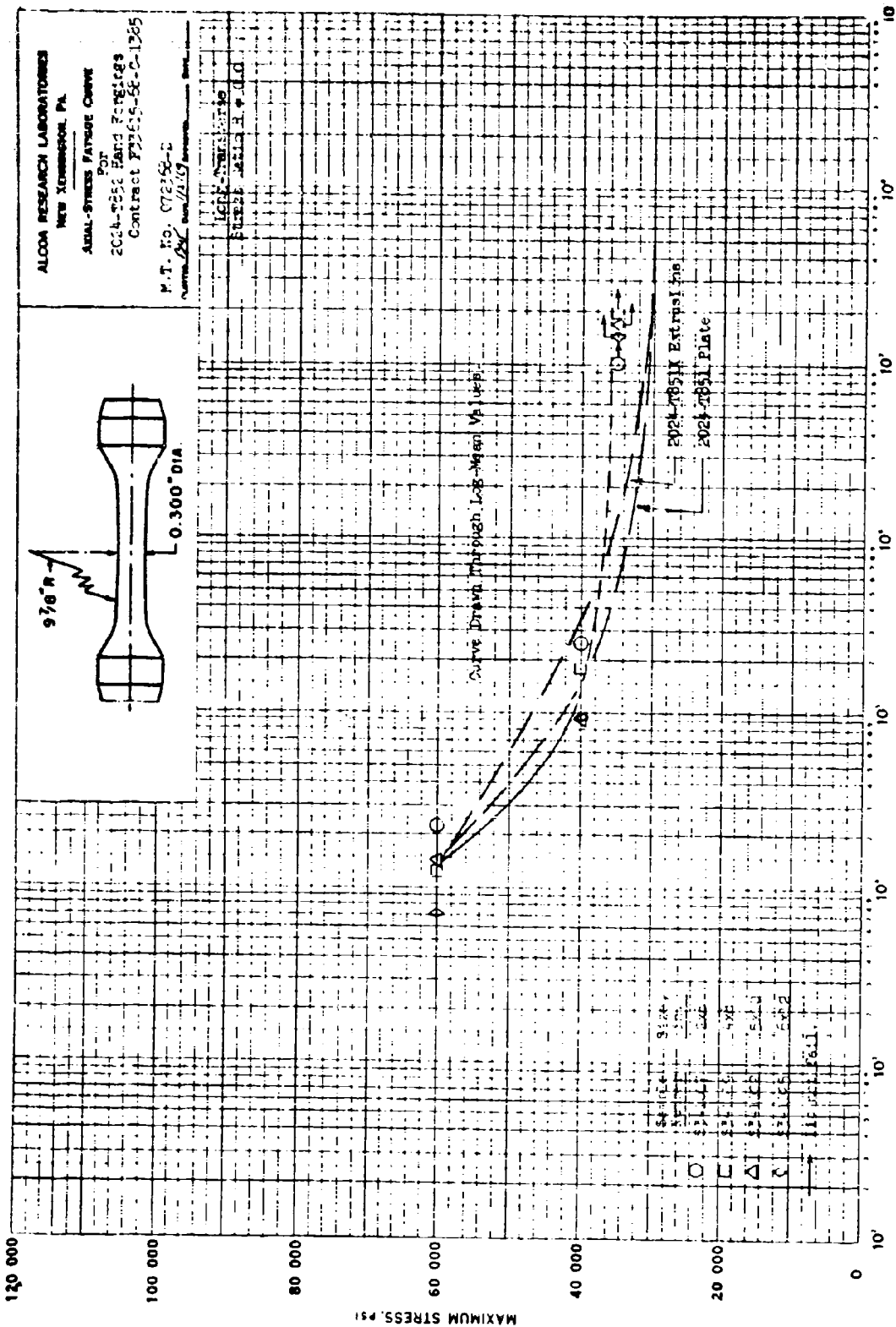


Fig. 19



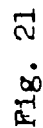


Fig. 22

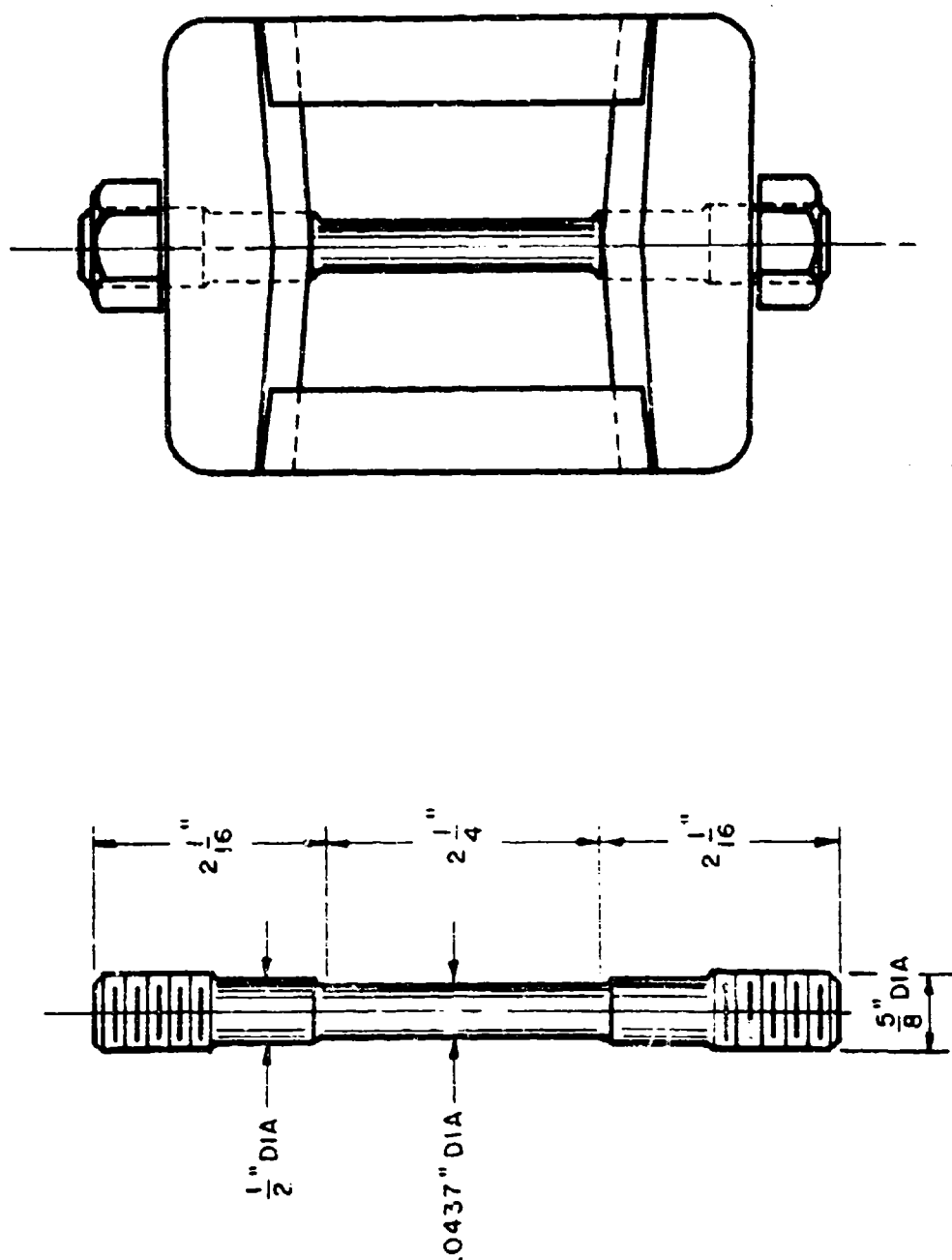


FIG. 23 0.437 IN. DIA. TENSILE SPECIMEN AND STRESSING FRAME
SIMULTANEOUS INWARD MOVEMENT OF THE WEDGE-SHAPED SIDE PIECES
INDUCES UNIAXIAL TENSION STRESS IN THE SPECIMEN

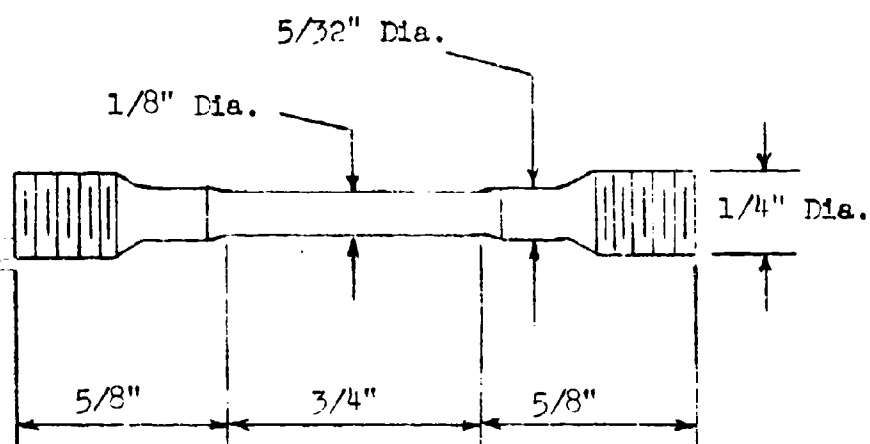
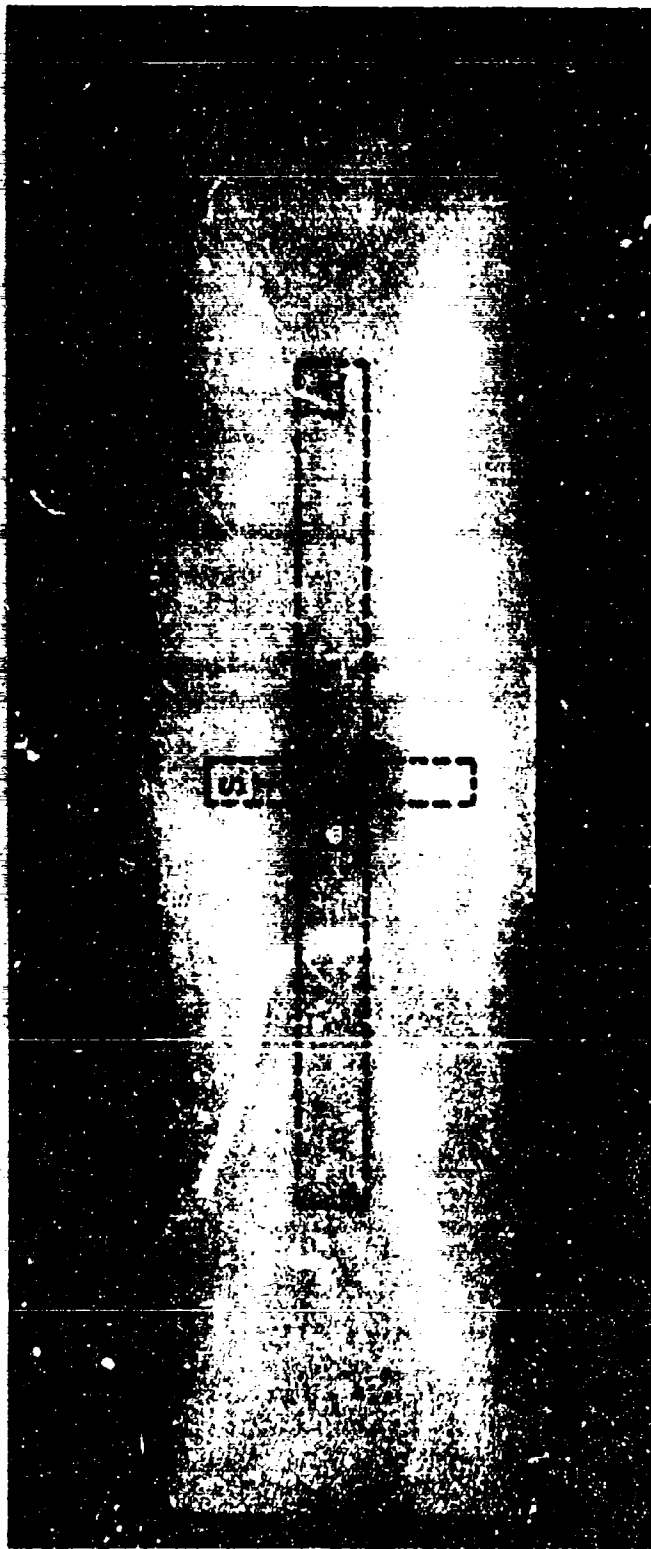


Fig. 24. 0.125-inch Diameter Tensile Specimen
For Stress-Corrosion Tests.



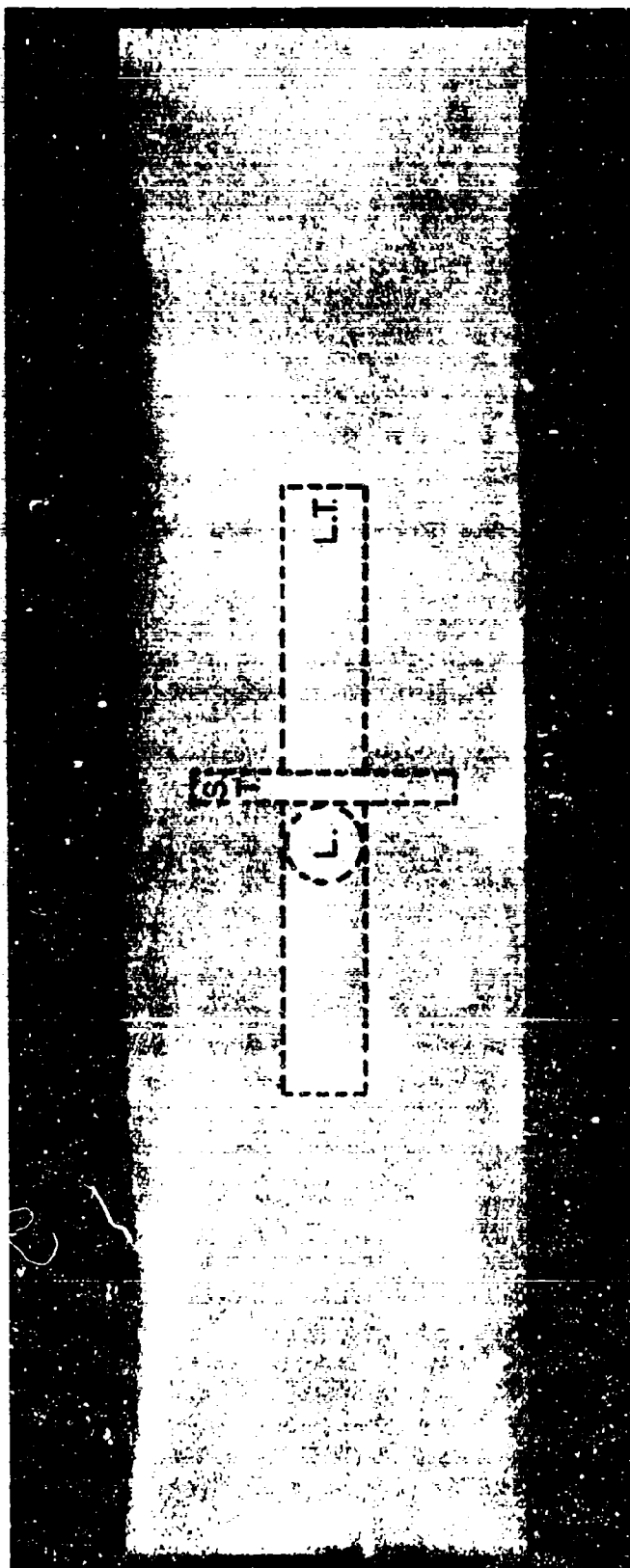
MAG: 1.2X

Figure 25 Macroetched transverse section of 2 x 8-in. hand forging of 2014-T652 alloy. Superimposed on the photograph is a schematic diagram of the location of stress-corrosion test specimens.



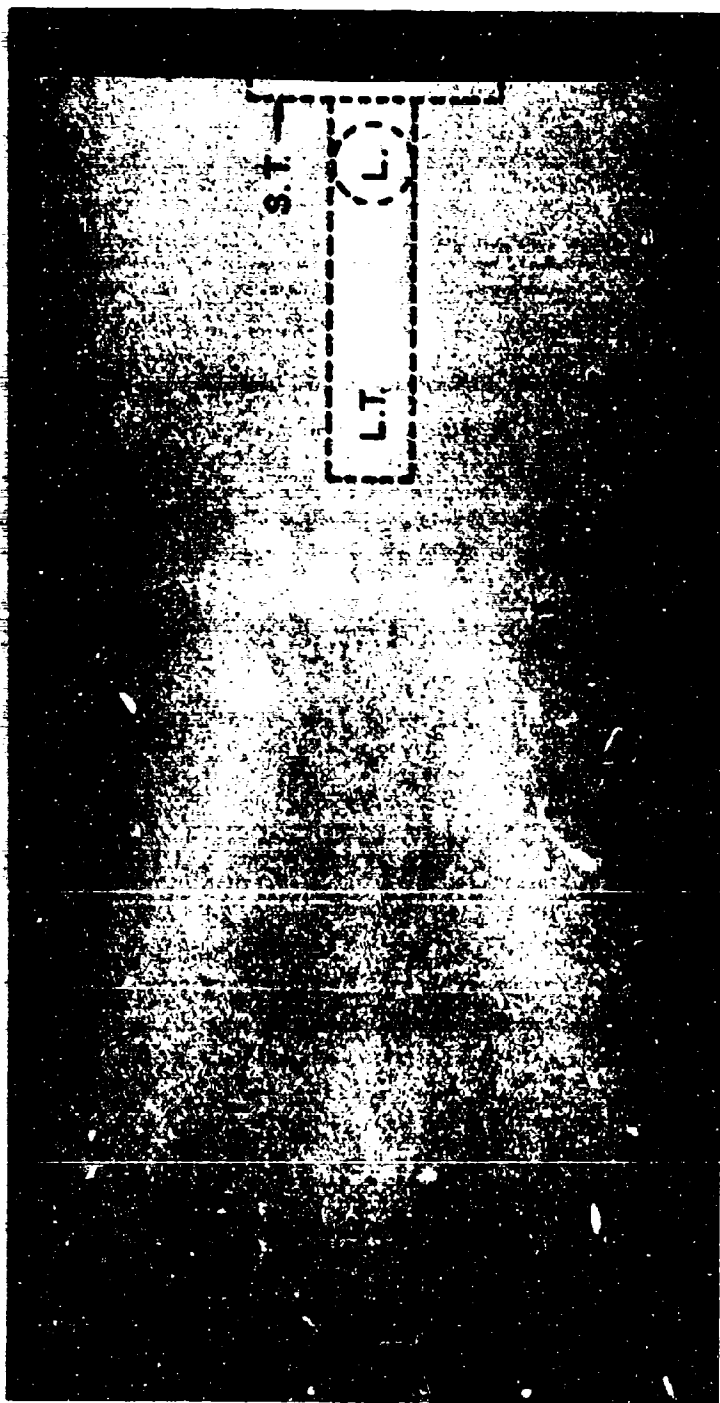
MAG: 0.8x

Figure 26 Macroetched transverse section of 3 x 12-in. hard forging of 2014-T652 alloy. Superimposed on the photograph is a schematic diagram of the location of stress-corrosion test specimens.



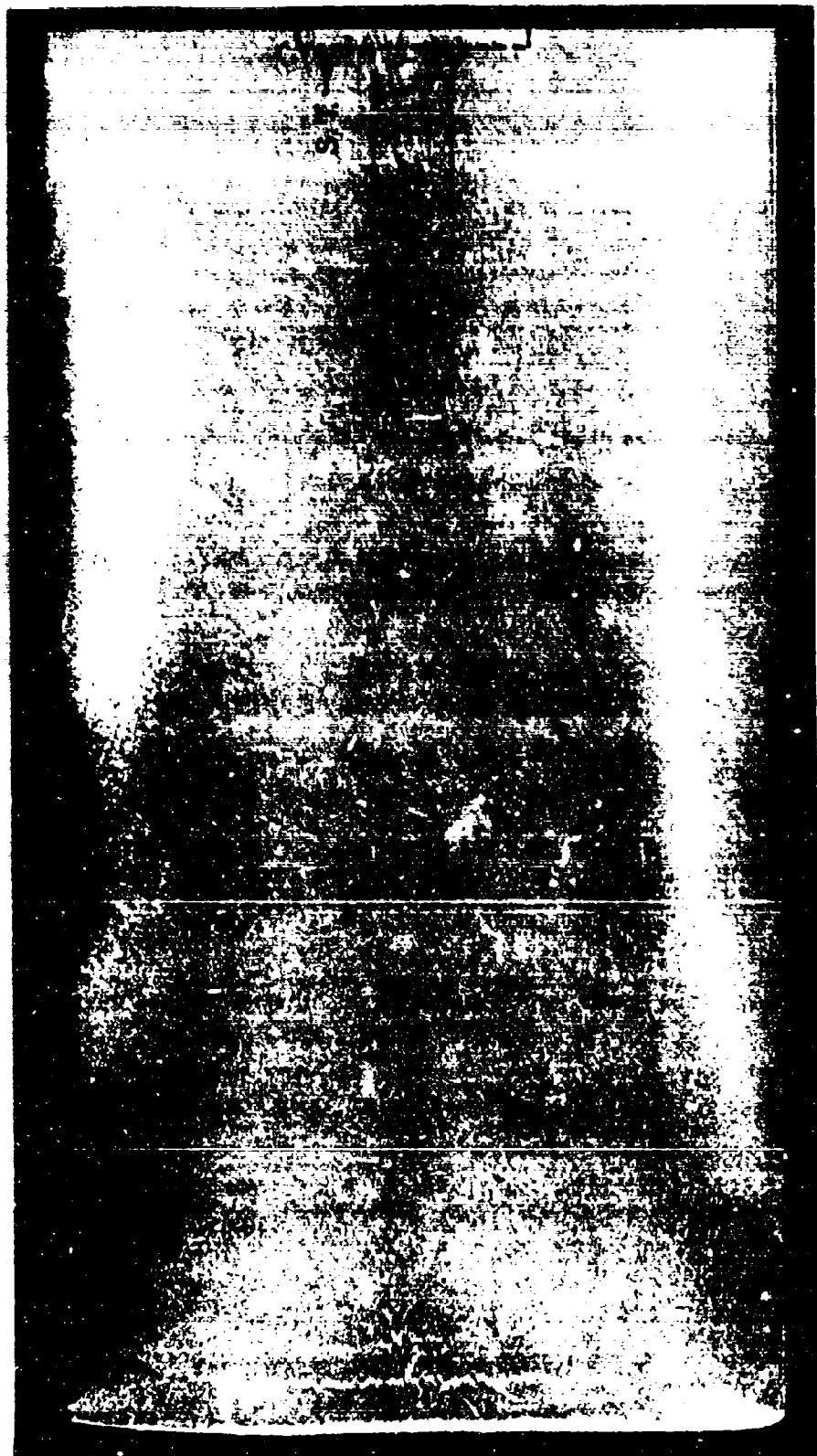
MAG: 0.6X

Figure 27 Macroetched transverse section of 4 x 16-in. hand forging of 2014-T652 alloy. Superimposed on the photograph is a schematic diagram of the location of stress-corrosion test specimens.



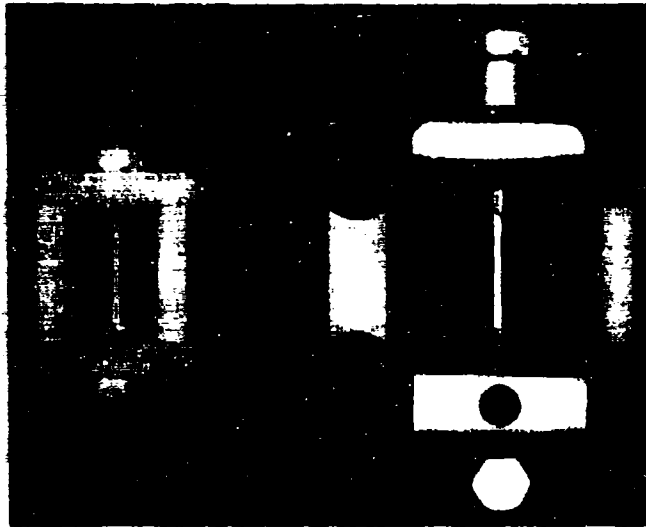
MAG: 0.75X

Figure 28 Macroetched half of transverse section of 5 x 20-in. hand forging of 2014-T652 alloy. Grain pattern in the other half of the transverse section was symmetrical to that shown above. Superimposed on the photograph is a schematic diagram of the location of stress-corrosion test specimens.



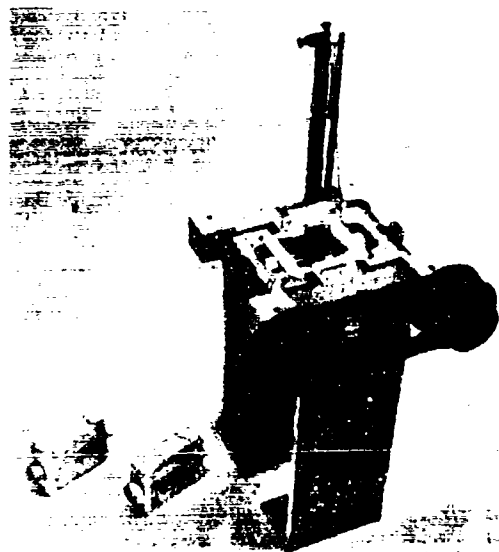
MAG. 0.75X

Figure 29 Macroetched half of transverse section of 6 x 24-in. hand forging of 2014-T652 alloy. Grain pattern in the other half of the transverse section was symmetrical to that shown above. Superimposed on the photograph is a schematic diagram of the location of stress-corrosion test specimens.



Mag: 1/2X

FIG. 30 SHOWS THE 1/8-IN. DIAMETER TENSILE SPECIMEN, THE VARIOUS PARTS OF THE STRESSING FRAME AND THE FINAL STRESSED ASSEMBLY.



Mag: 1/5X

FIG. 31 SYNCHRONOUS LOADING DEVICE USED TO STRESS SPECIMENS, A STRESSED ASSEMBLY AND ONE ASSEMBLED FINGER-TIGHT READY FOR STRESSING ARE SHOWN TO THE LEFT, BOTH THE STRESSING FRAME AND THE LOADING DEVICE WERE DEVELOPED BY THE ALCOA RESEARCH LABORATORIES, PRIOR TO THIS CONTRACT.

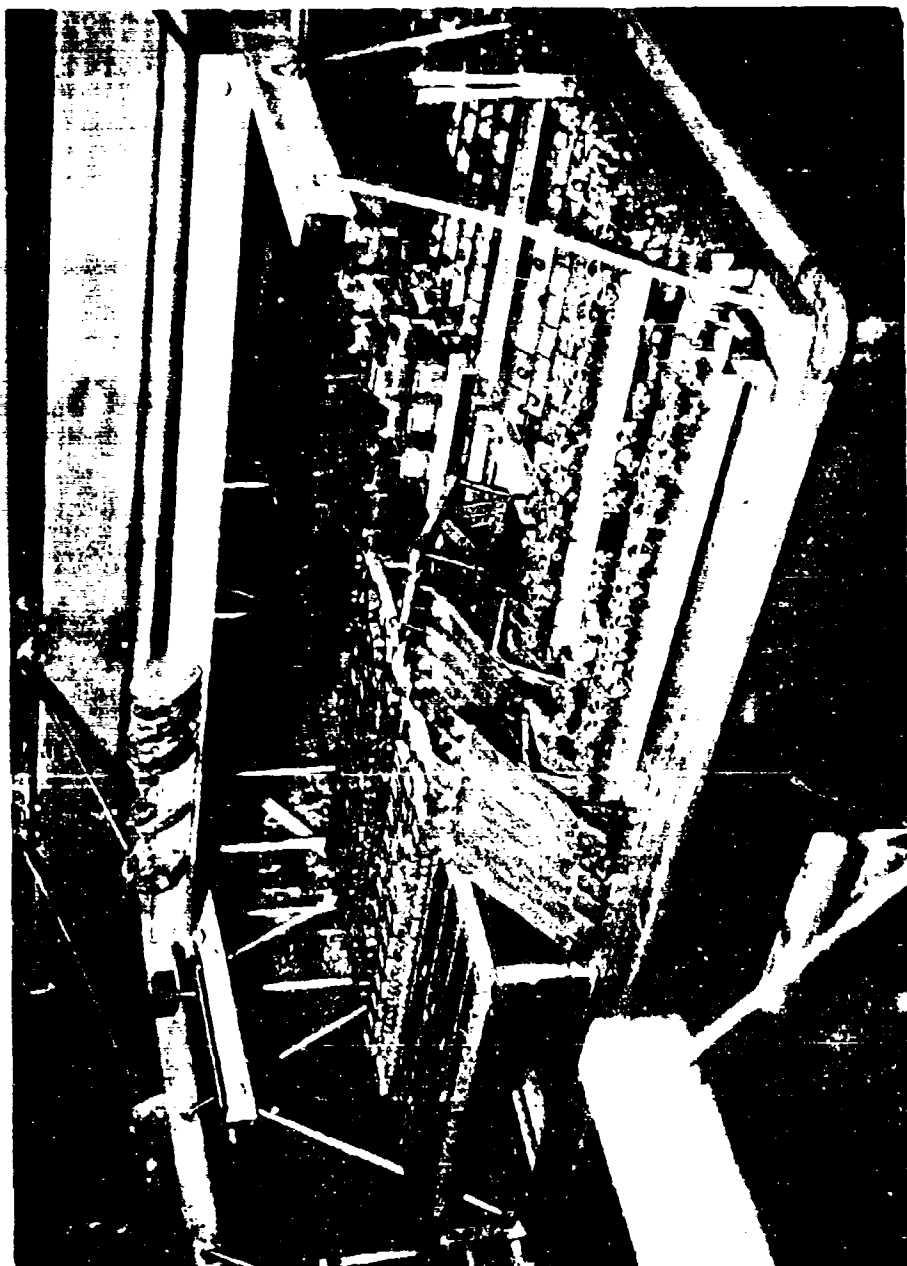
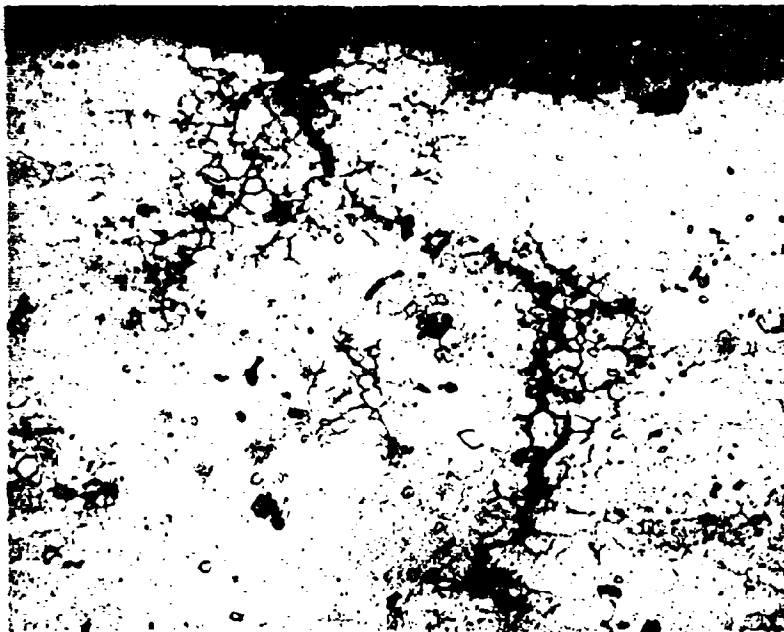


Fig. 32 Equipment for Alternate Immersion Corrosion Tests



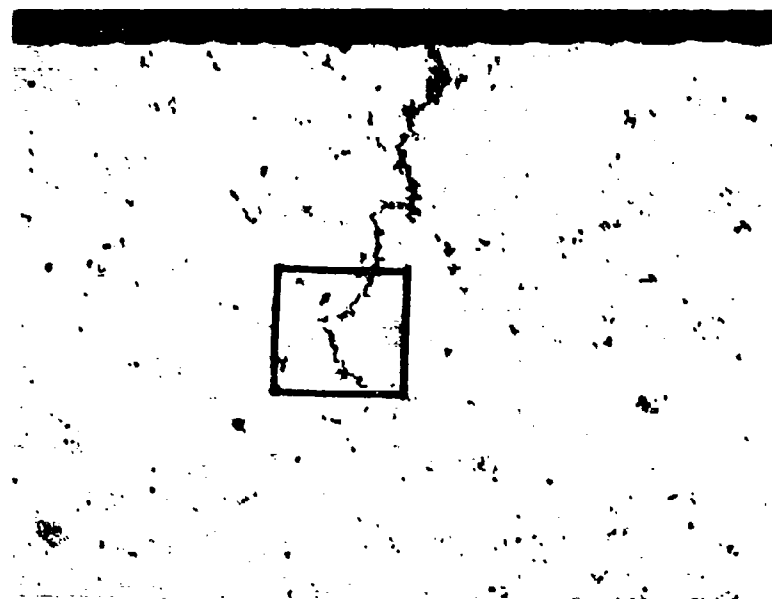
S.No. 341007-T4 Etch: Keller's Mag. 100X

FIG. 33 Section Illustrating an Auxiliary Crack in Long-Transverse Specimen from 2-in. Thick 2014-T652 Forging which Failed at a Stress Equal to 75% Y.S.



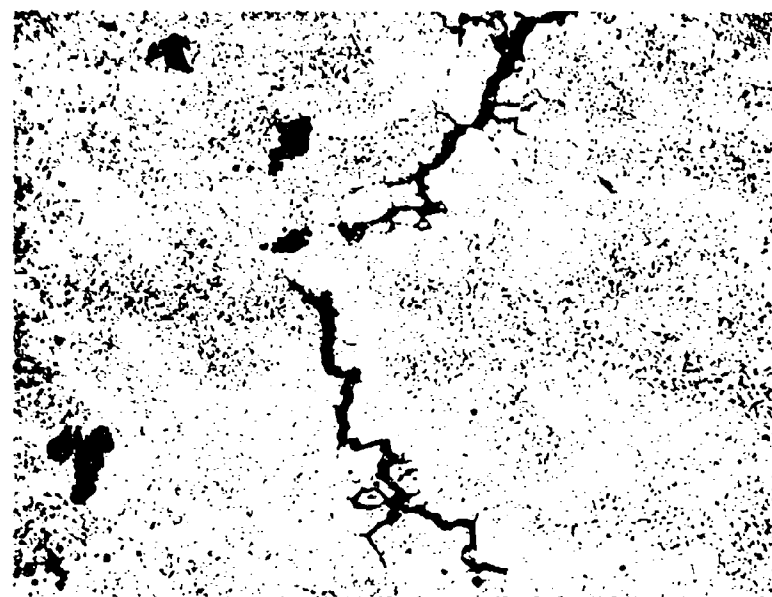
S.No. 341007-T4 Etch: Keller's Mag. 500X

FIG. 34 Illustrates the Intergranular Character of the Crack Shown Above, Indicating that Failure was Result of Stress-Corrosion Cracking.



S. No. 341040-T4 Etch: Keller's Mag. 100X

Figure 35 Section illustrating an auxiliary crack in long-transverse specimen from 4 in. thick 7079-T652 forging which failed at a stress equal to 75% Y.S.



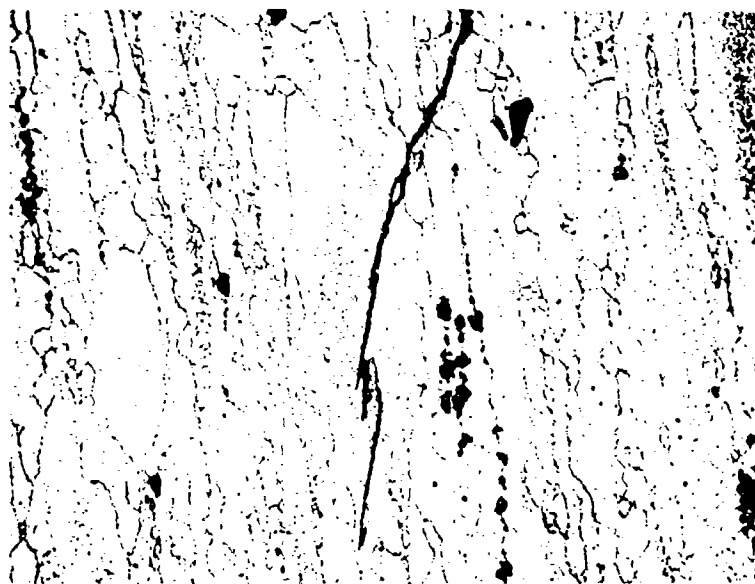
S. No. 341040-T4 Etch: Keller's Mag. 500X

Figure 36 Illustrates the intergranular character of the crack shown above, indicating that failure was result of stress-corrosion cracking.



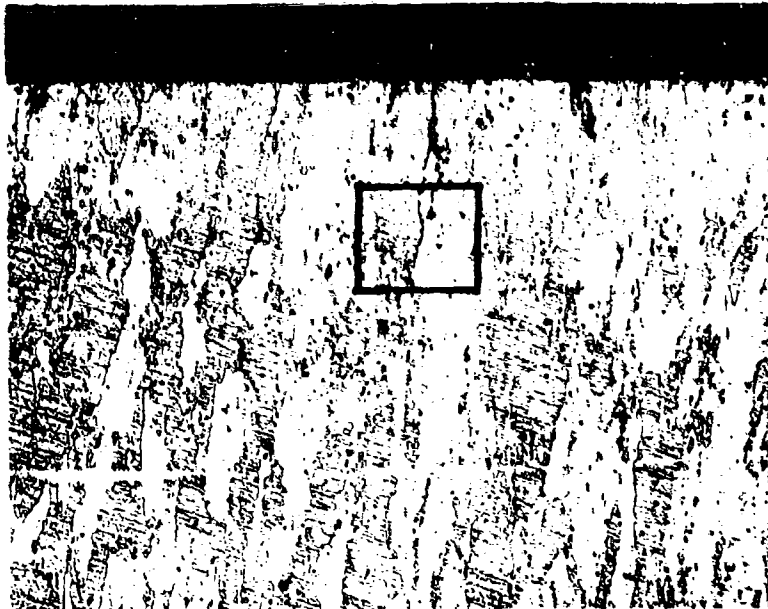
S. No. 341030-N3 Etch: Keller's Mag. 100X

Figure 37 Section illustrating fine crack emanating from the base of a corrosion pit in specimens from 4 in. thick 7075-T7352 forging which failed at a stress equal to 75% Y.S.



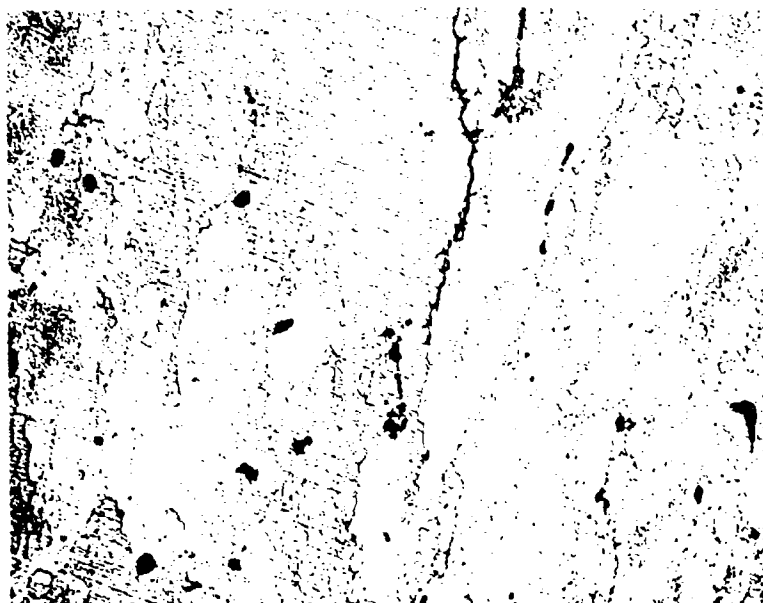
S. No. 341030-N3 Etch: Keller's Mag. 500X

Figure 38 Illustrates the transgranular character of the crack shown above, indicating that fracture was due to tensile overload resulting from severe localized corrosion.



S.No. 341028-N3 Etch: Keller's Mag. 100X

FIG. 39 Section Illustrating Fine Auxiliary Crack in Specimen from 3-in. Thick 7075-T7352 Forging Which Failed at a Stress Equal to 75% Y.S.



S.No. 341028-N3 Etch: Keller's Mag. 500X

FIG. 40 Illustrate the Intergranular Character of the Crack Shown Above, Indicating That Failure Was the Result of Stress-Corrosion Cracking.

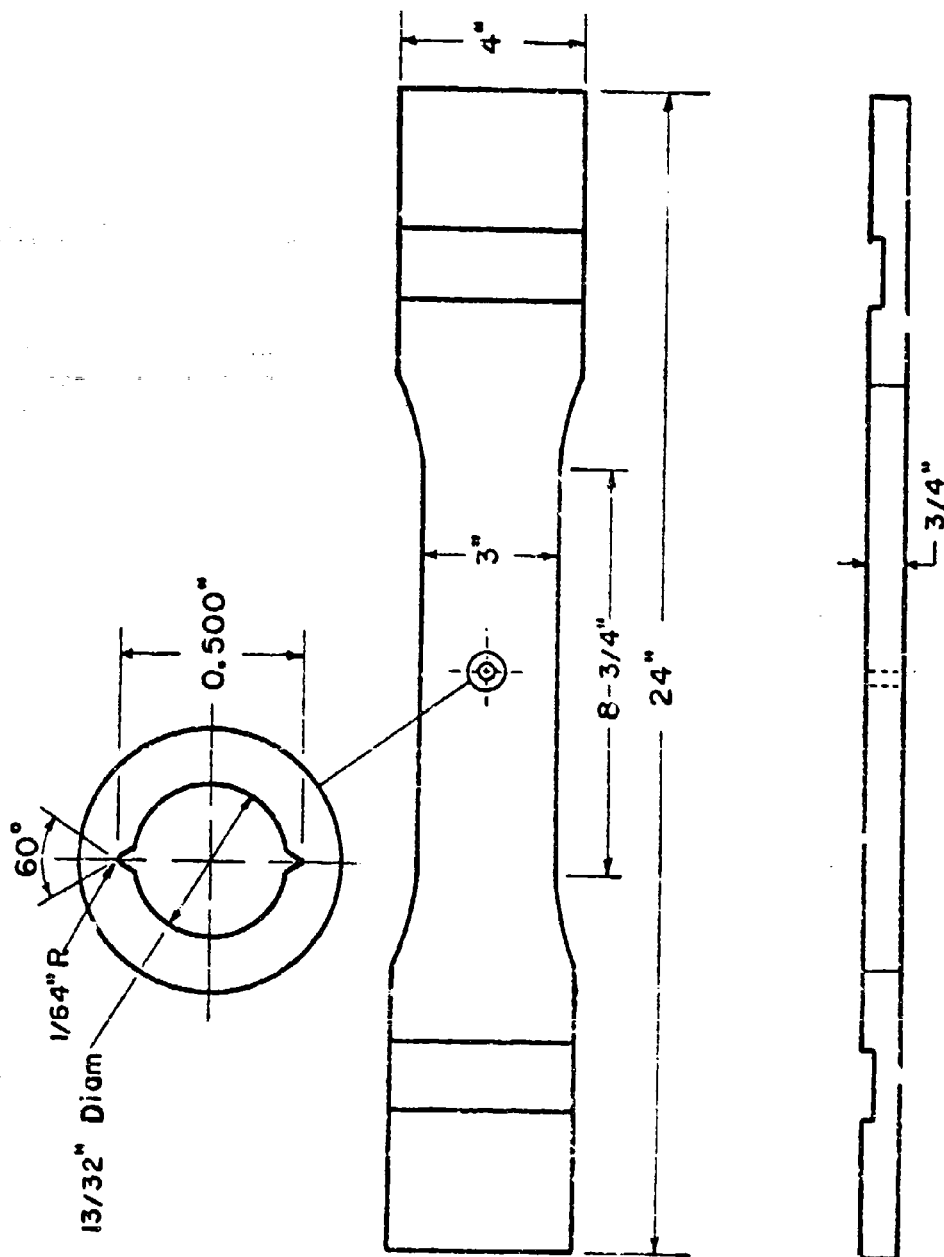


FIG. 41 CENTER-NOTCHED FATIGUE SPECIMENS
(MILD NOTCH)

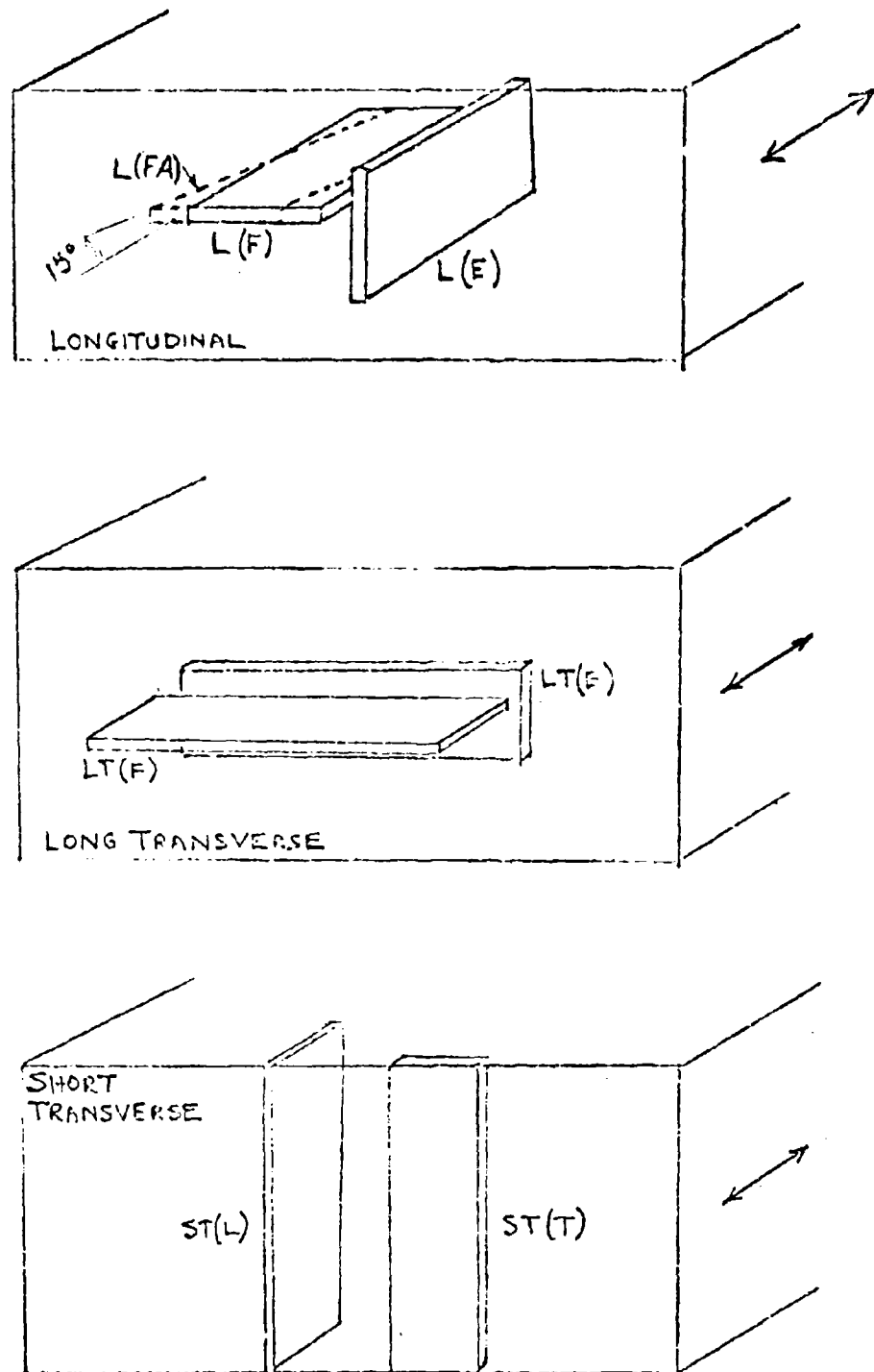


Fig. 42 Orientations of Fatigue-Crack Propagation Specimens.

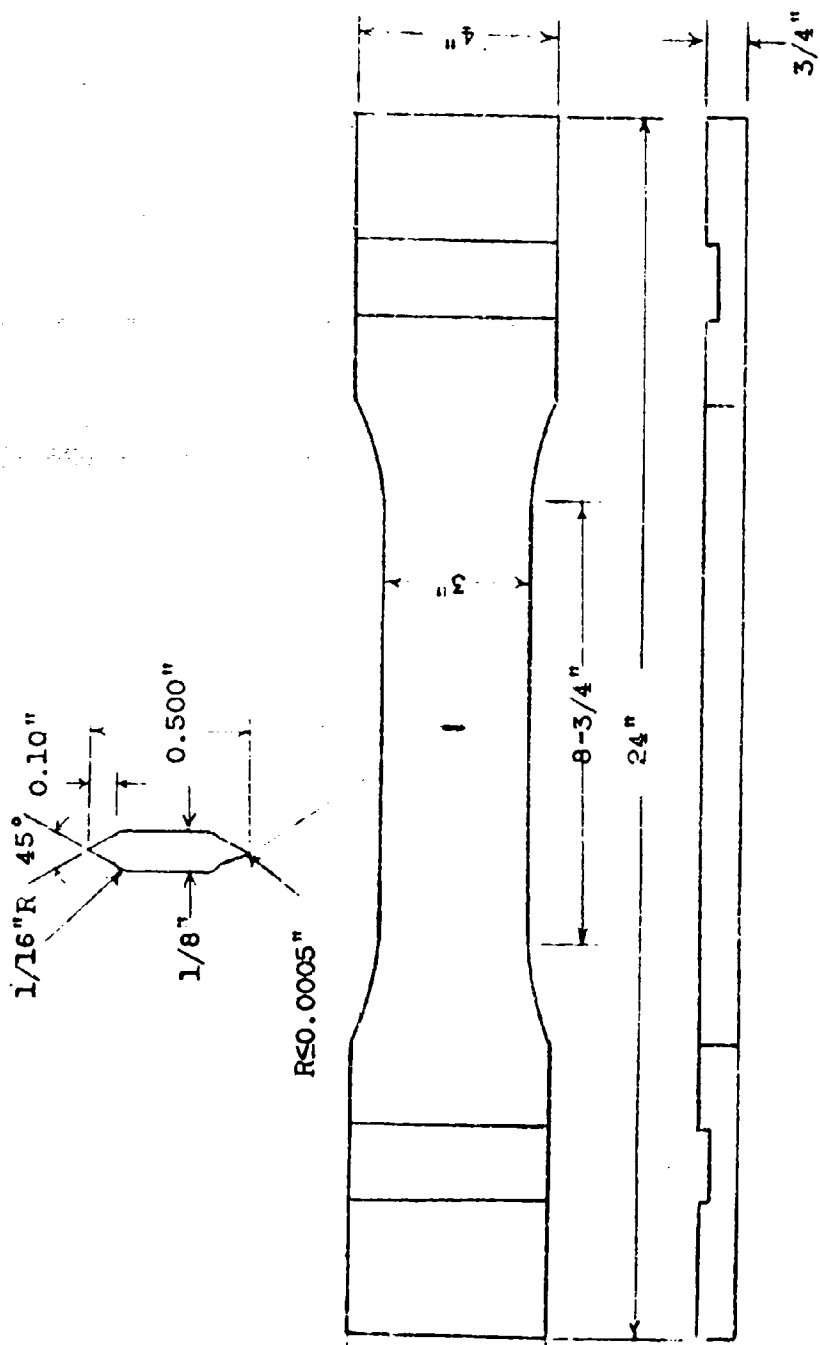


Fig. 43 Center-Notched Fatigue Specimen
(SHARP NOTCH)

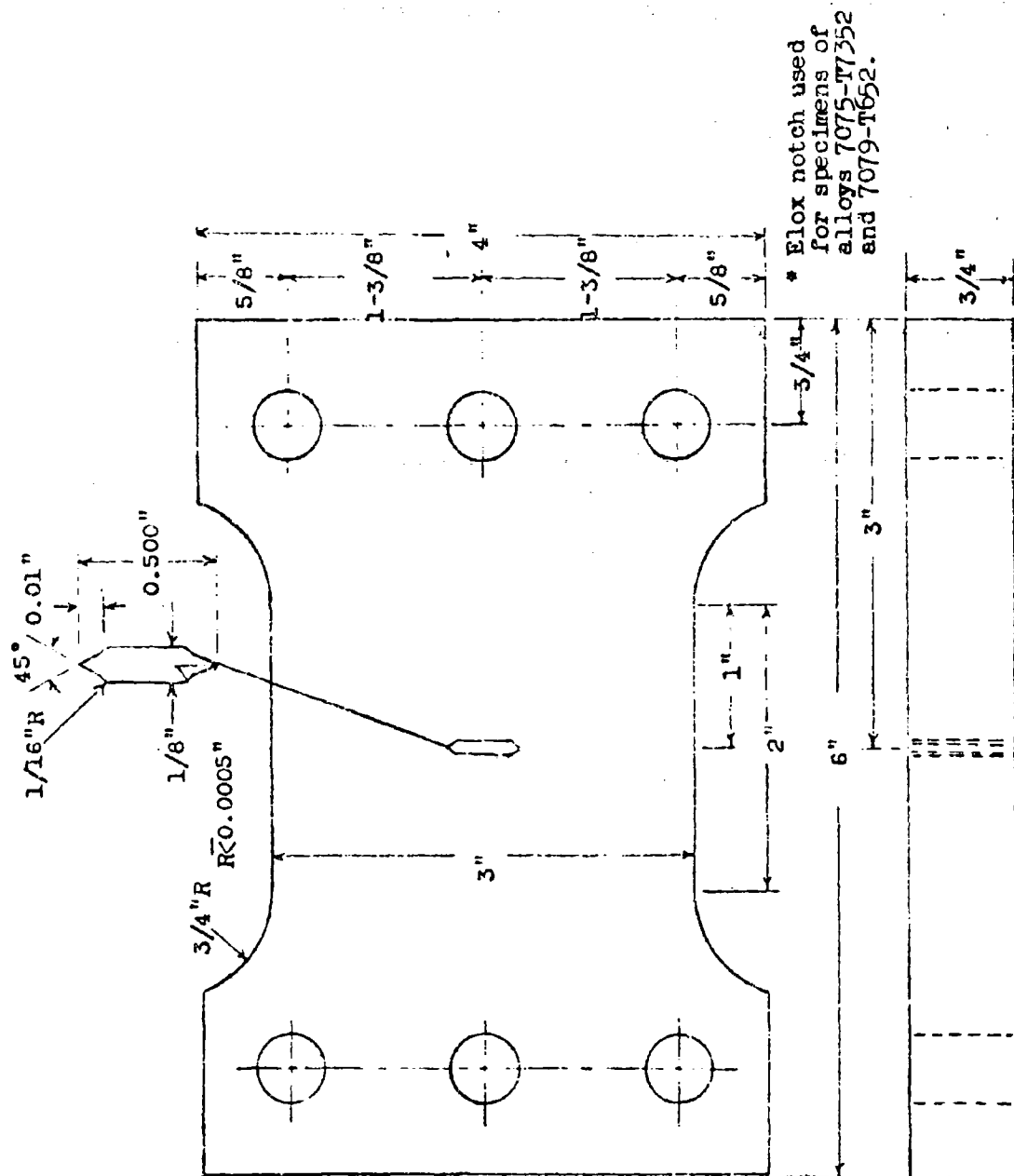
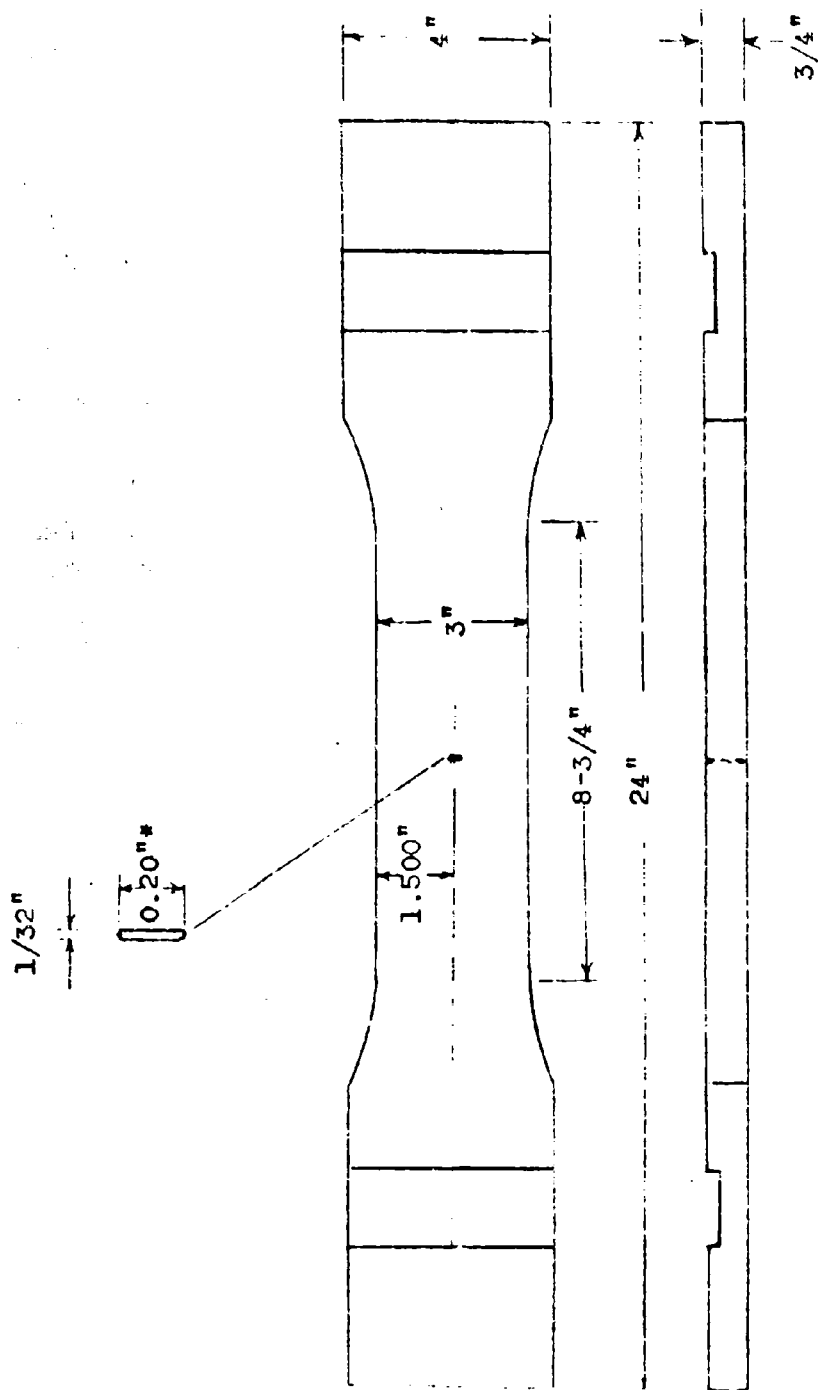


Fig. 44 Short-Transverse Center-Notched Fatigue Specimen*



*Specimen precracked to 0.50 in.

Fig. 45 Klox Notched Crack Propagation Specimen

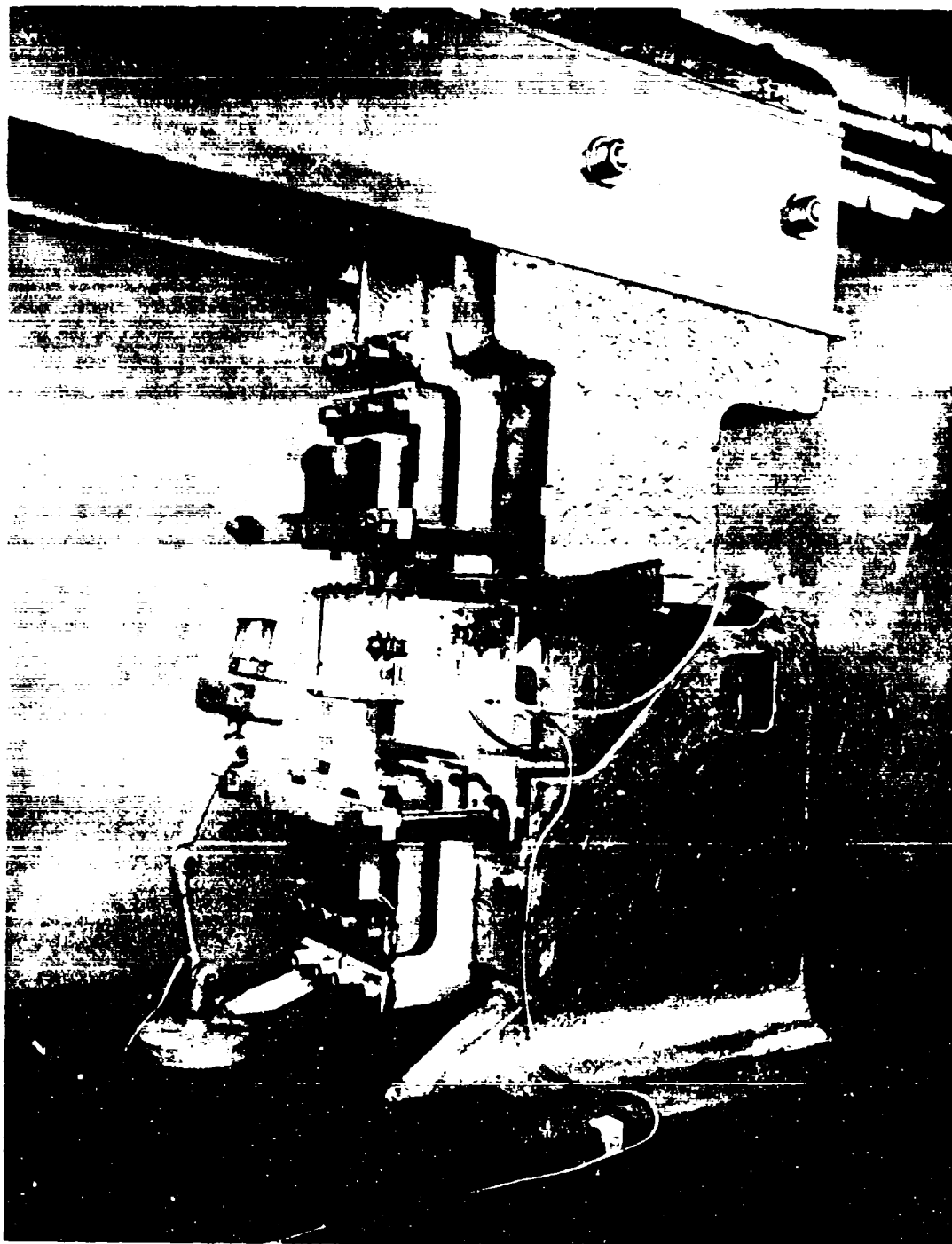


Fig. 46 Crack Propagation Specimen in Environmental Chamber

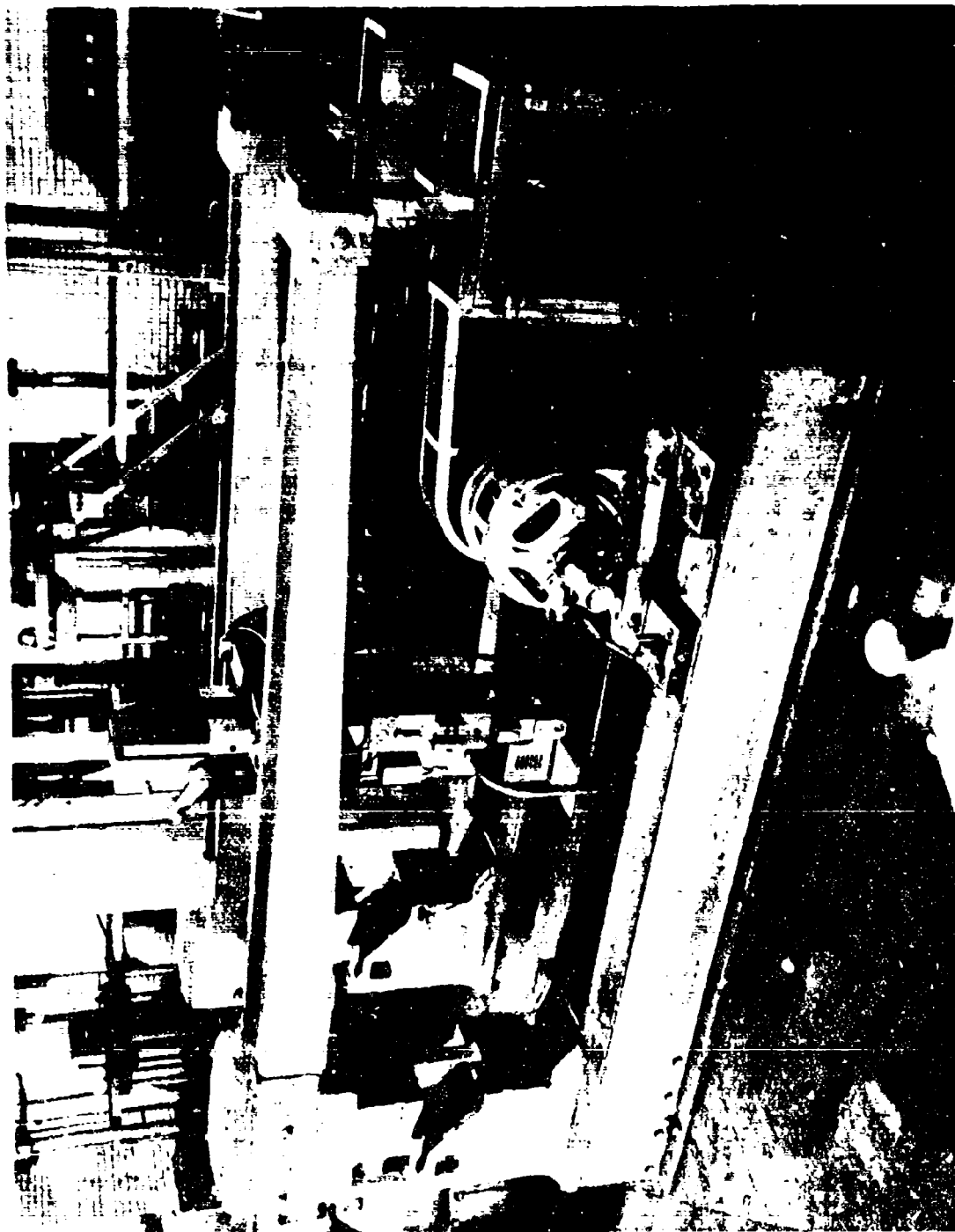


Fig. 47 50 000-lb Structural Fatigue Machine
Used for Crack Propagation Studies.

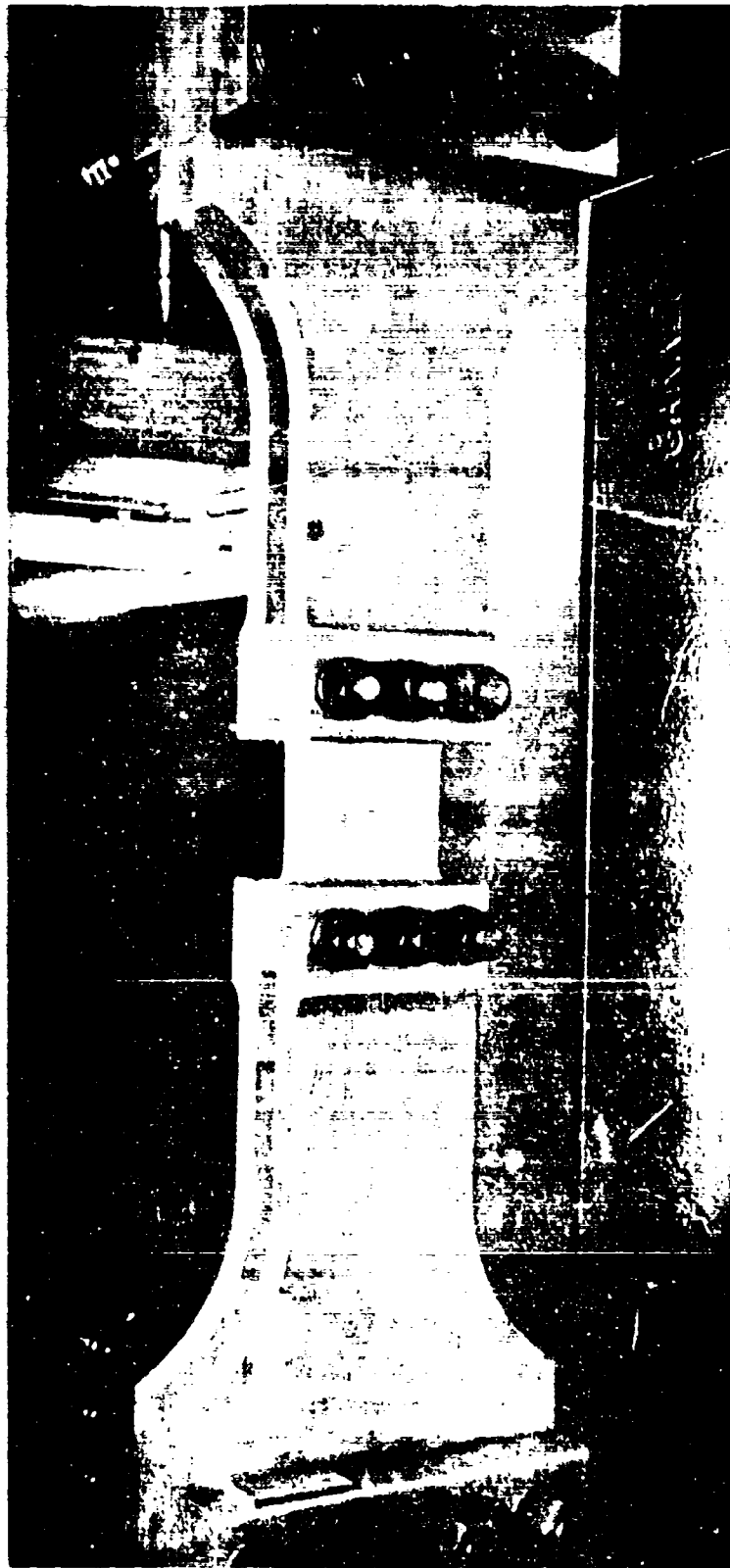
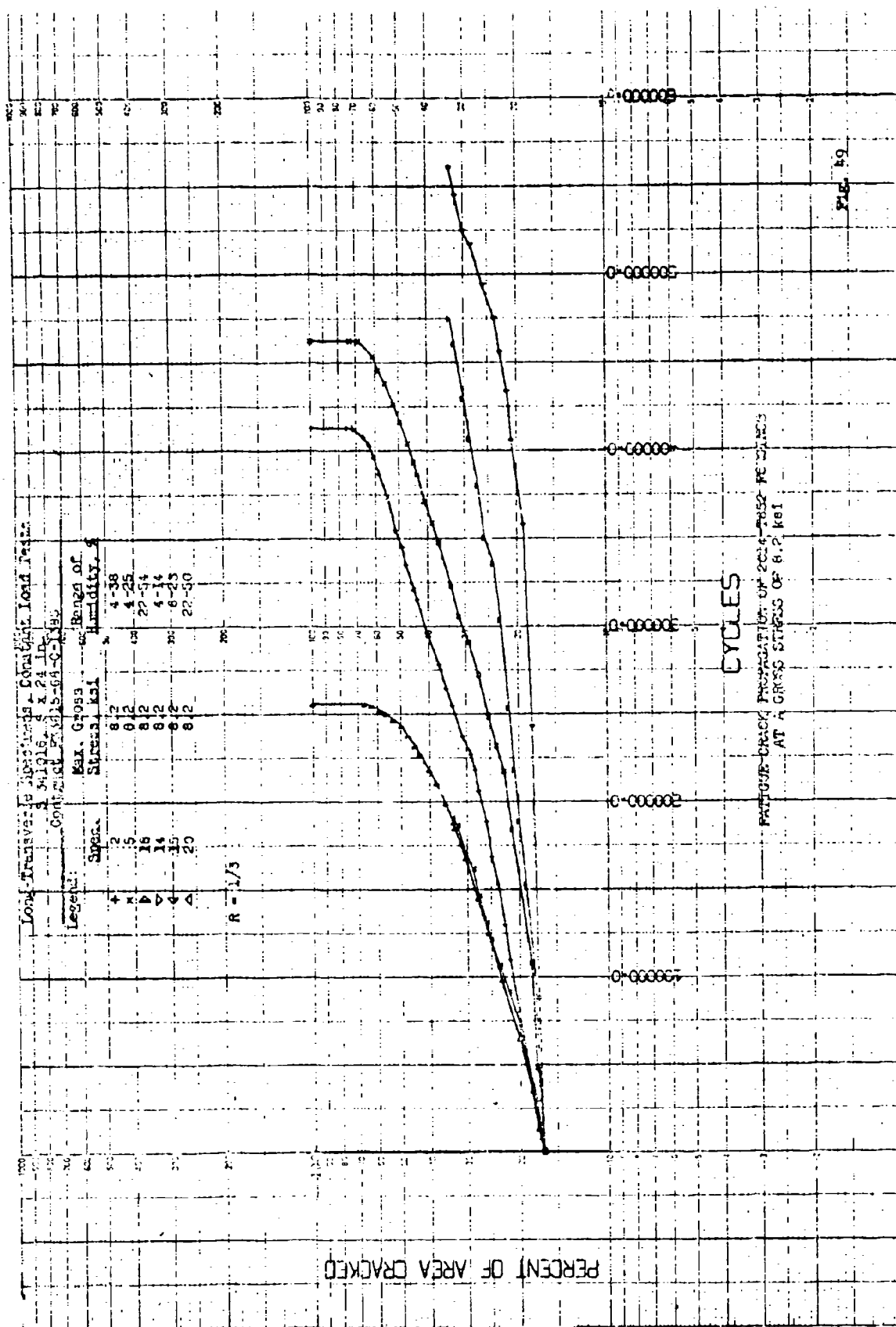


Fig. 48 Fixtures for Crack Propagation Tests of Short-Transverse Specimens



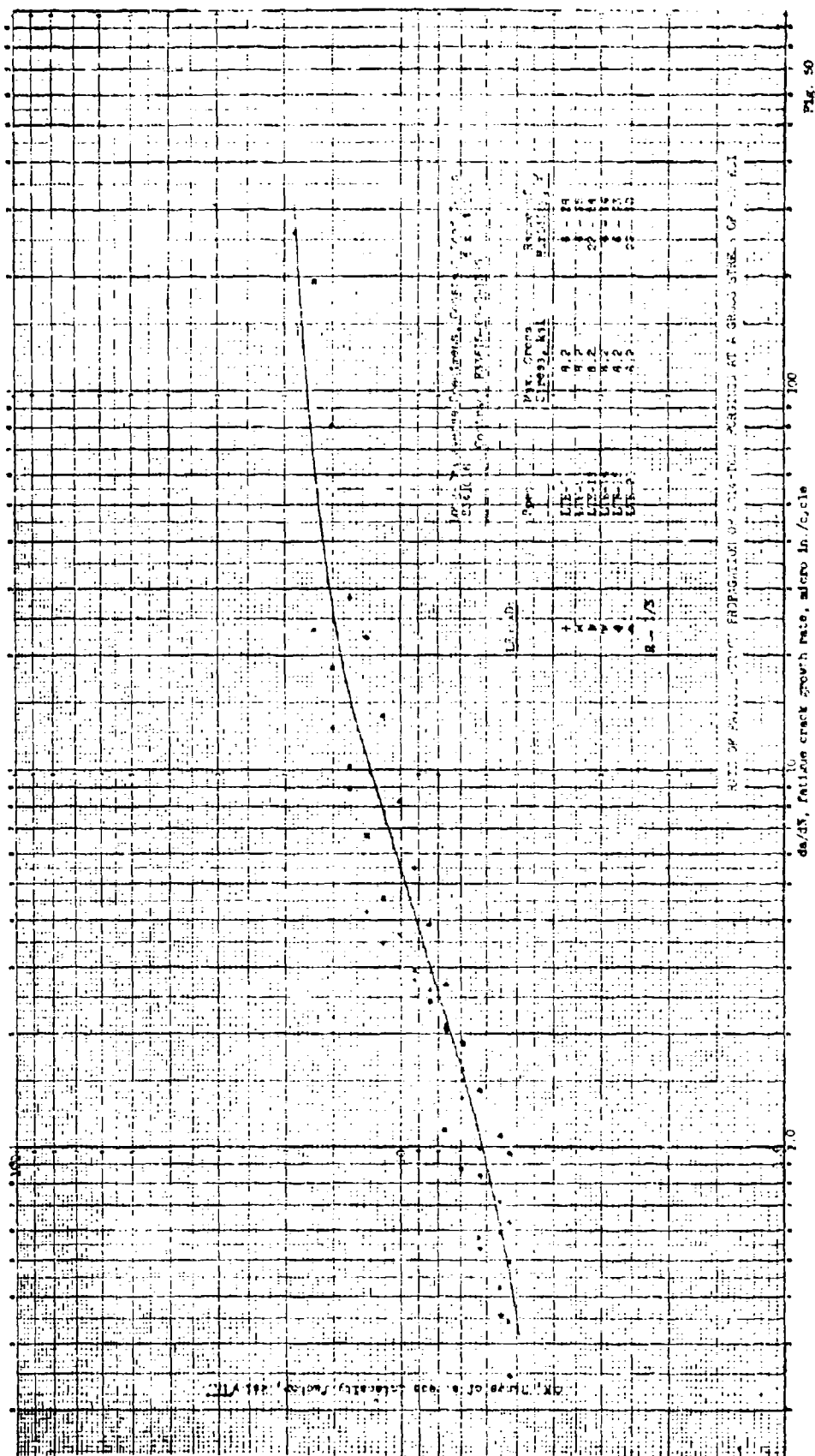
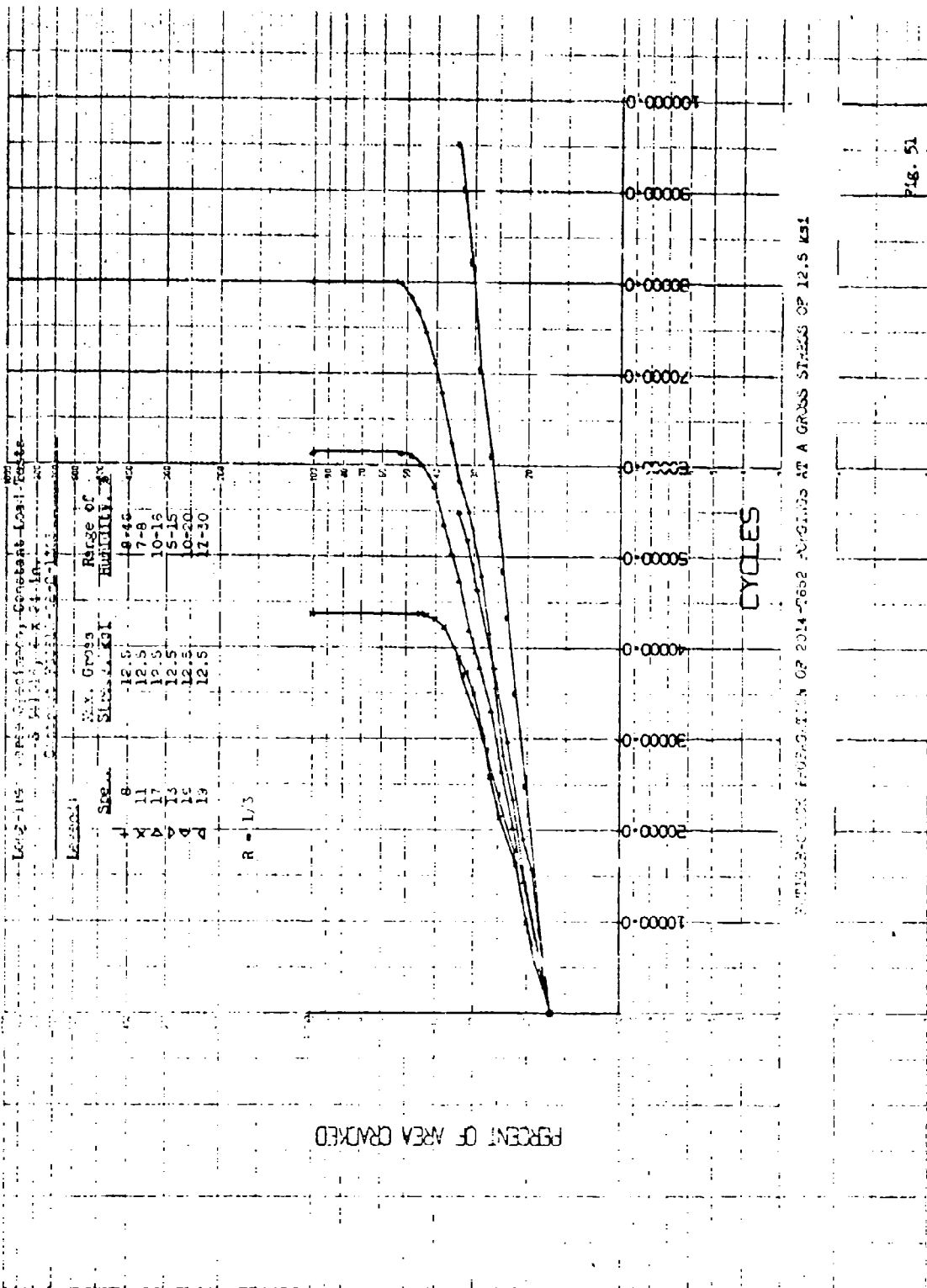


Fig. 50



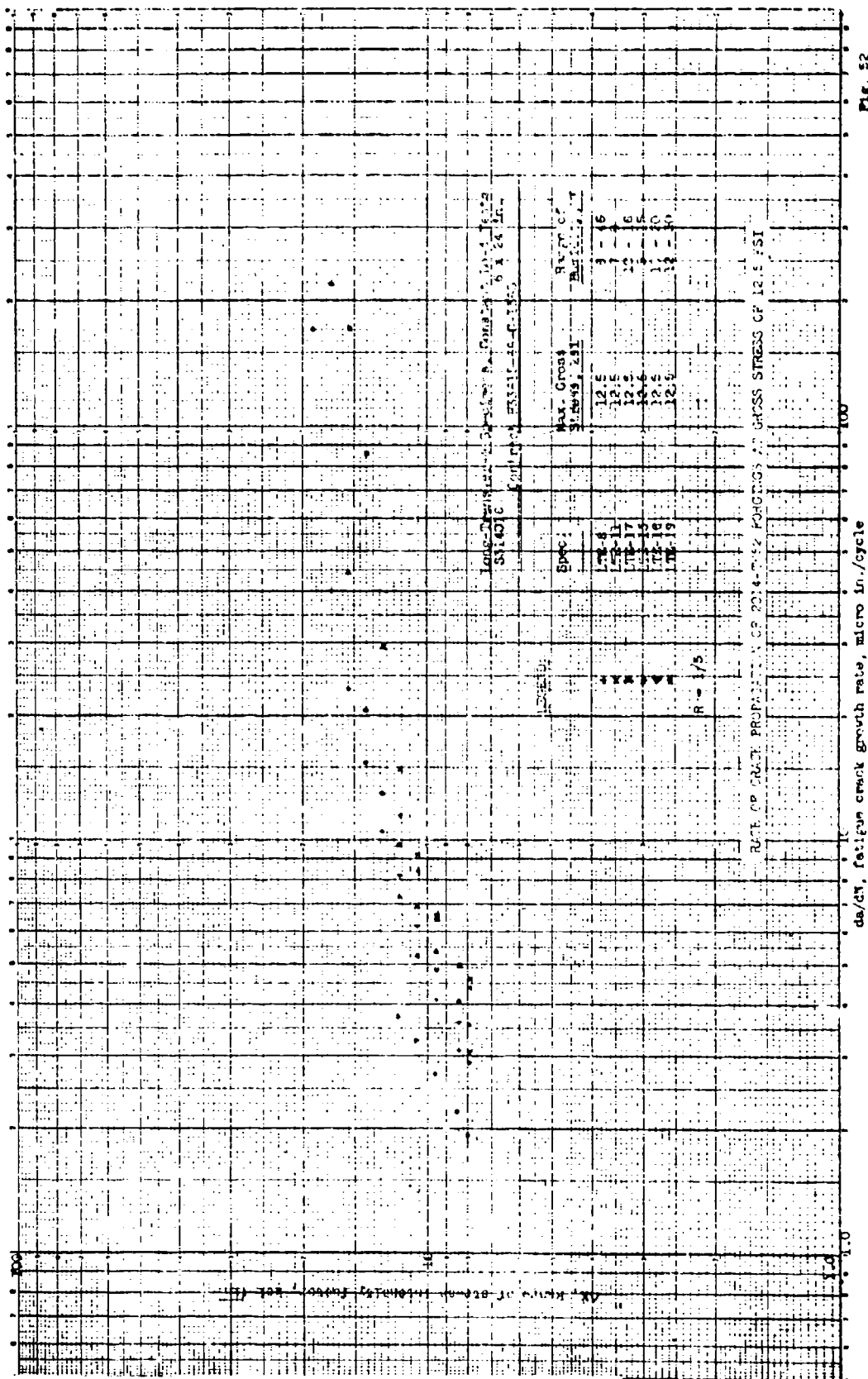


Fig. 52

REPORT OF SHEAR STRESS CRACK FATIGUE GROWTH PROPERTIES
OF 2014-T652 MAGNOLIA AT A GROSS STRESS OF 6.2 ksi

55-374

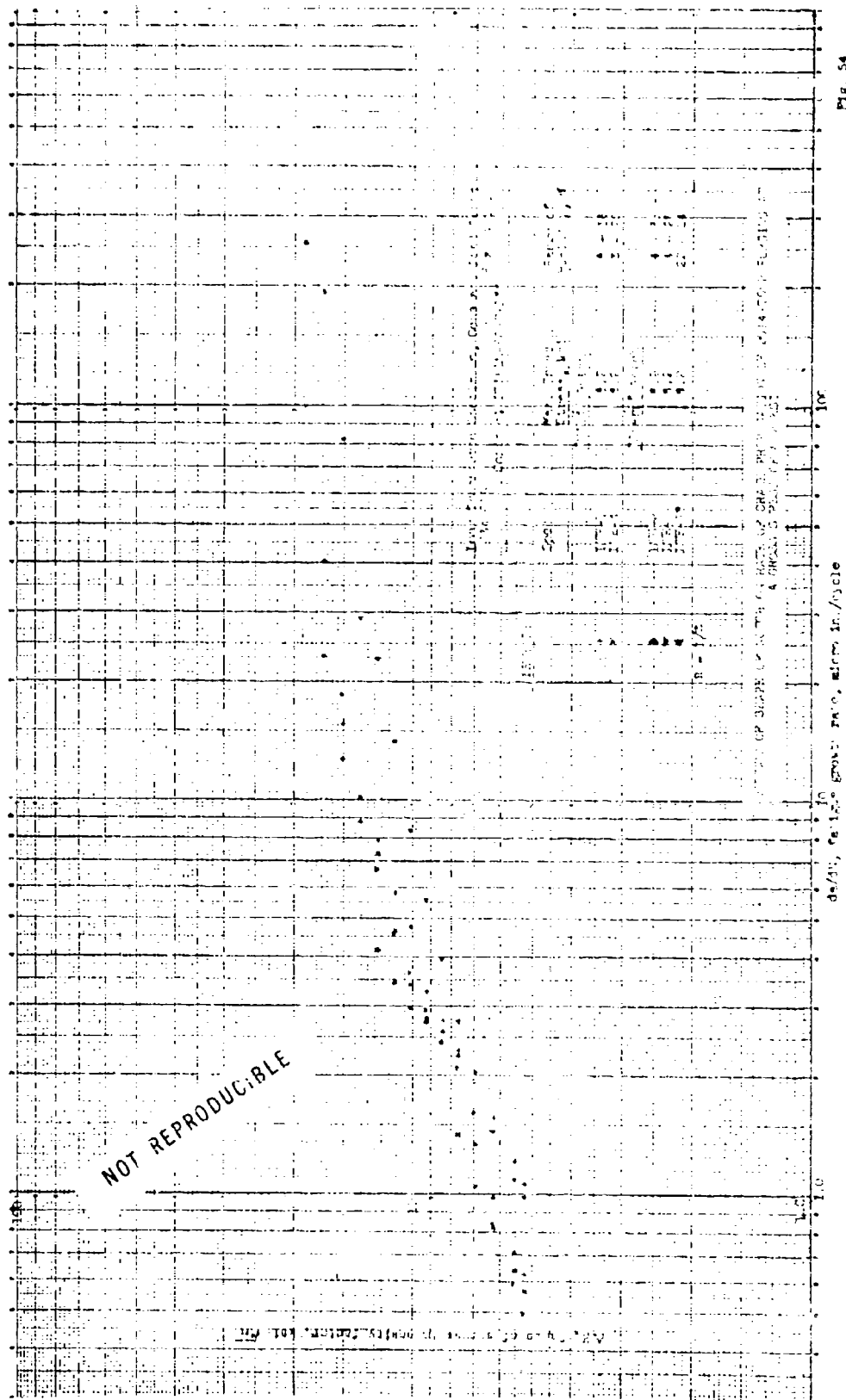


Fig. 54

Logarithmic Scale, Constant Load
 50000, 50000, 50000
 50000, 50000, 50000

Symbol	Range of Stress	Range of Strain
+	10-15	10-15
x	15-20	15-20
Δ	20-25	20-25
◊	25-30	25-30
◻	30-35	30-35
◼	35-40	35-40
◽	40-45	40-45
◾	45-50	45-50
◿	50-55	50-55
◸	55-60	55-60
◷	60-65	60-65
◶	65-70	65-70
◵	70-75	70-75
◴	75-80	75-80
◳	80-85	80-85
◲	85-90	85-90
◱	90-95	90-95
◰	95-100	95-100

R = 1/3

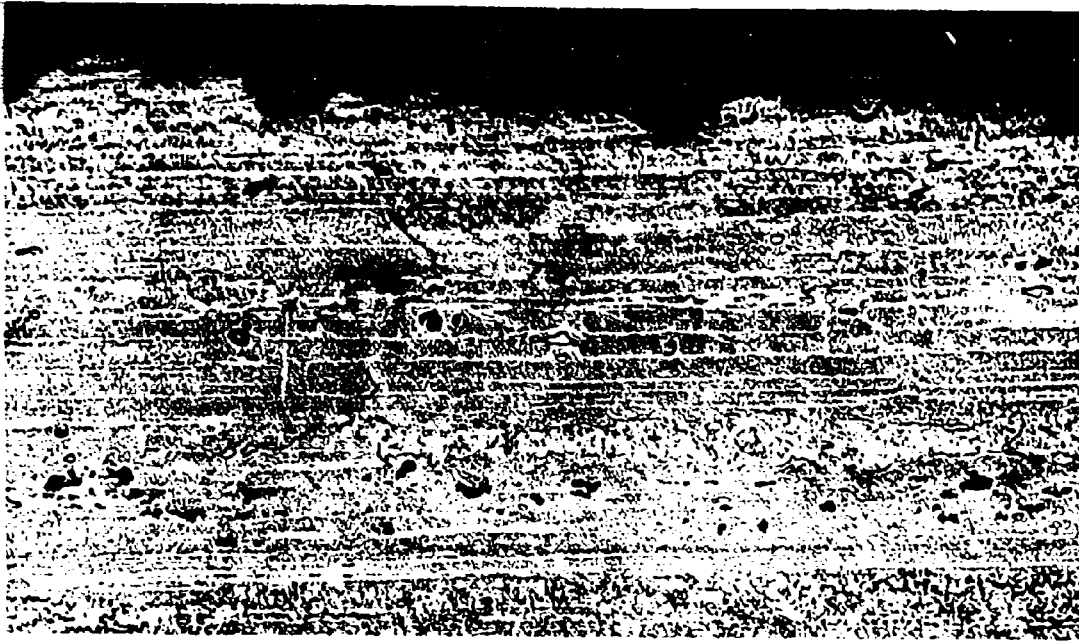
PERCENT OF AREA CRACKED

10000-0
20000-0
30000-0
40000-0
50000-0
60000-0
70000-0
80000-0
90000-0
100000-0

CYCLES

27





Spec. No. 341016-7

Keller's Etch

Mag. 100X

Slow Propagation

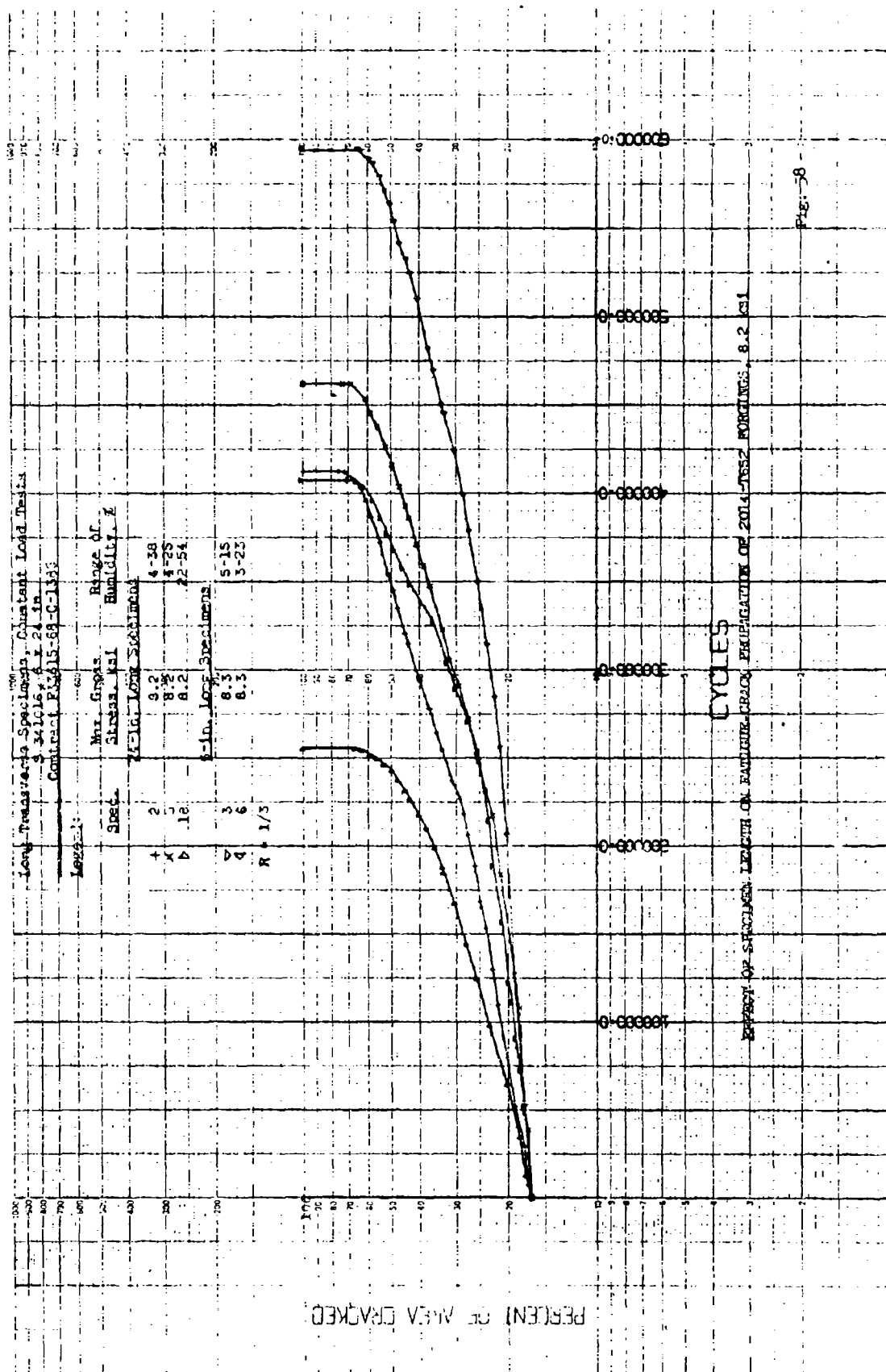


Spec. No. 341016-10

Keller's Etch
Fast Propagation

Mag. 100X

Fig. 57 Structure in the Surface Region of Fatigue Crack Propagation of 2014-T652 Specimens (Max. Gross Stress = 12.5 ksi)



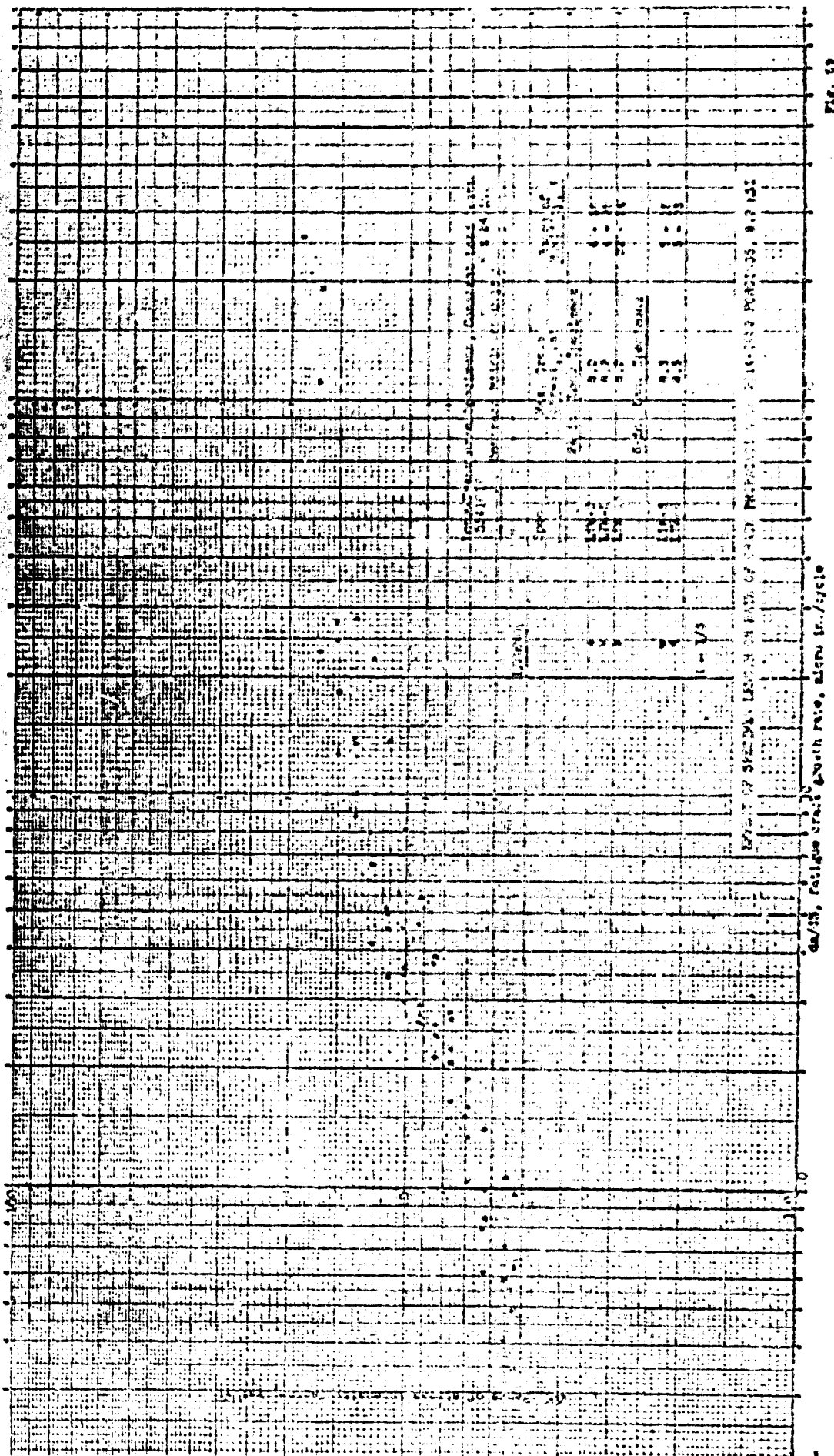


Fig. 13

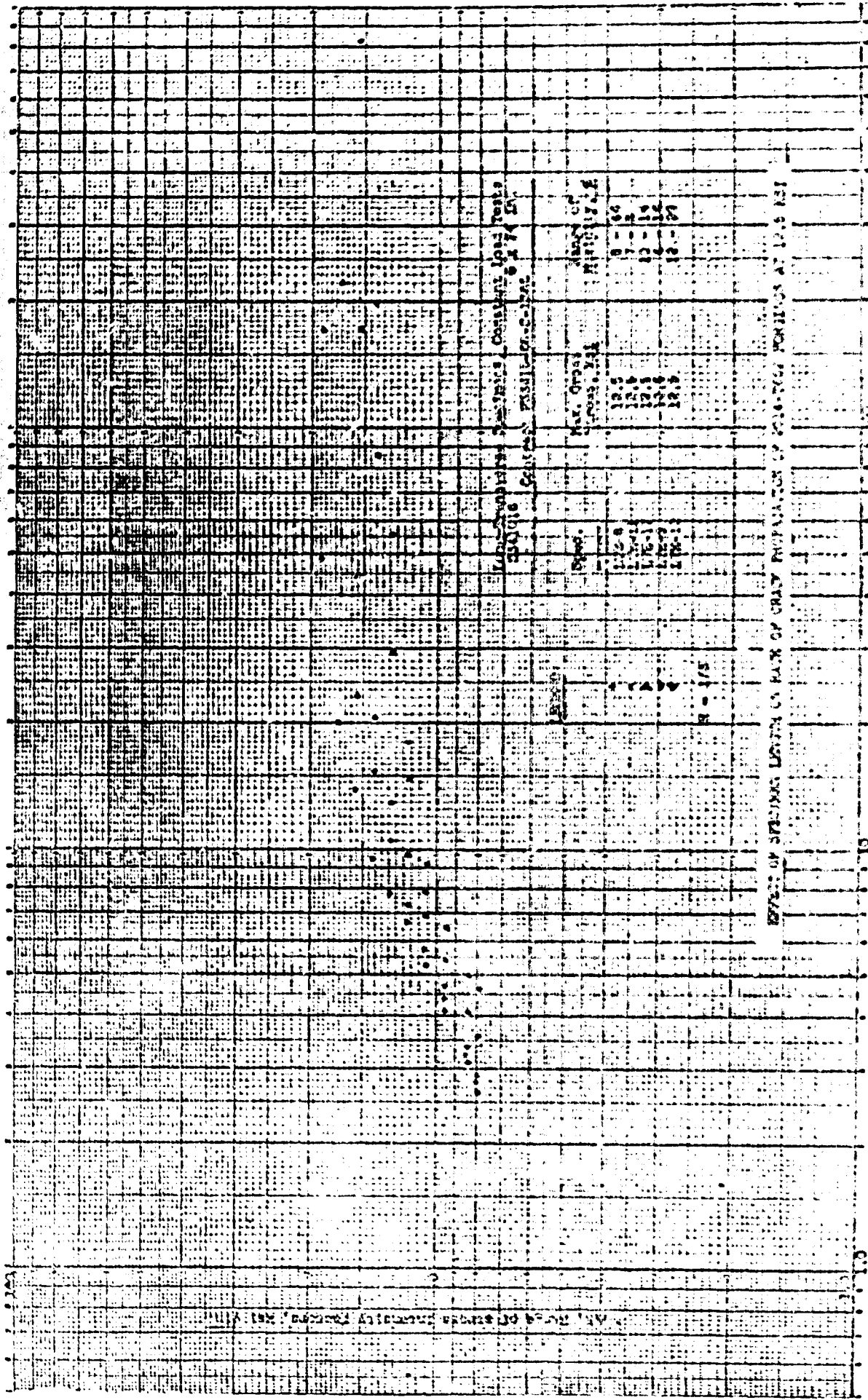
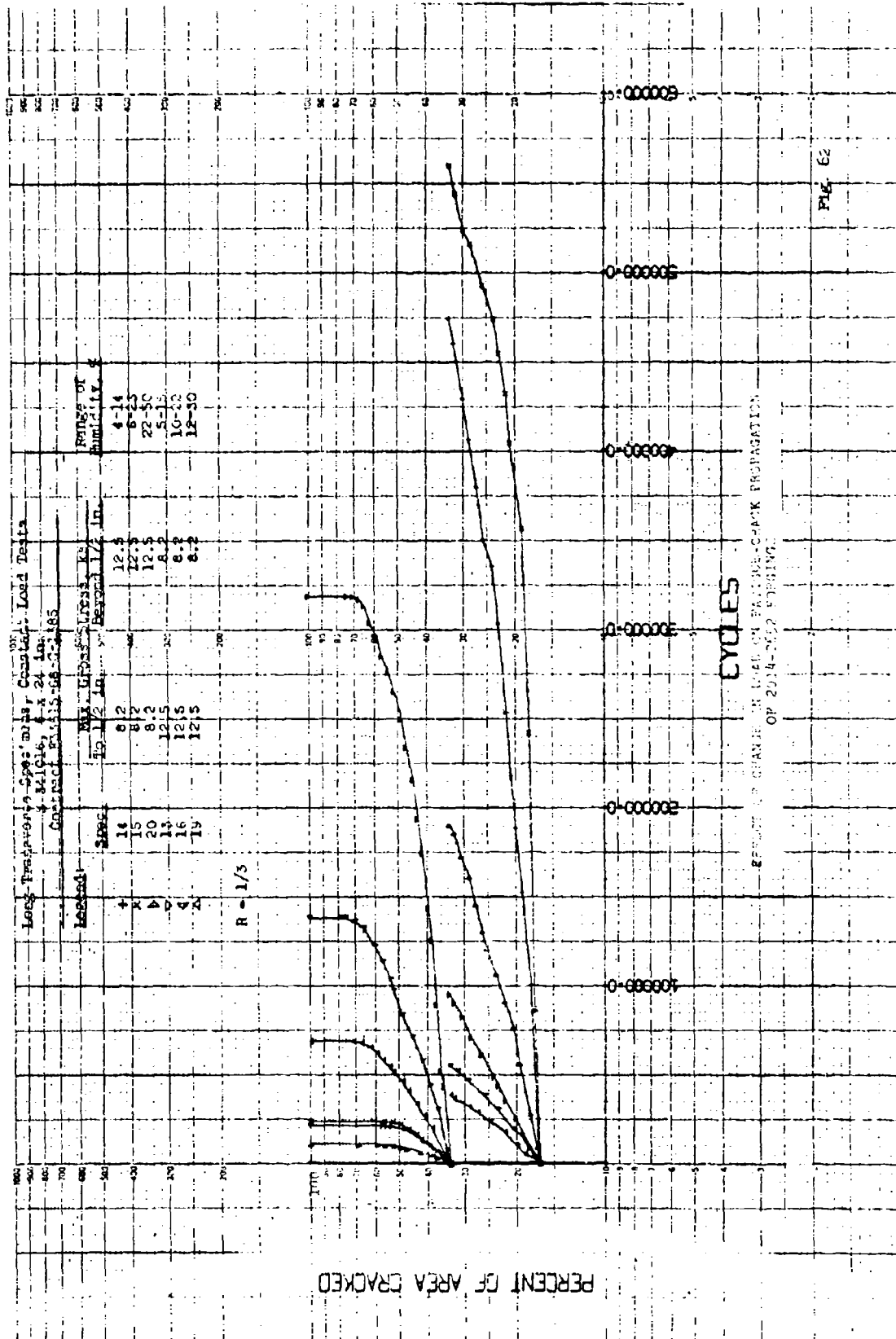
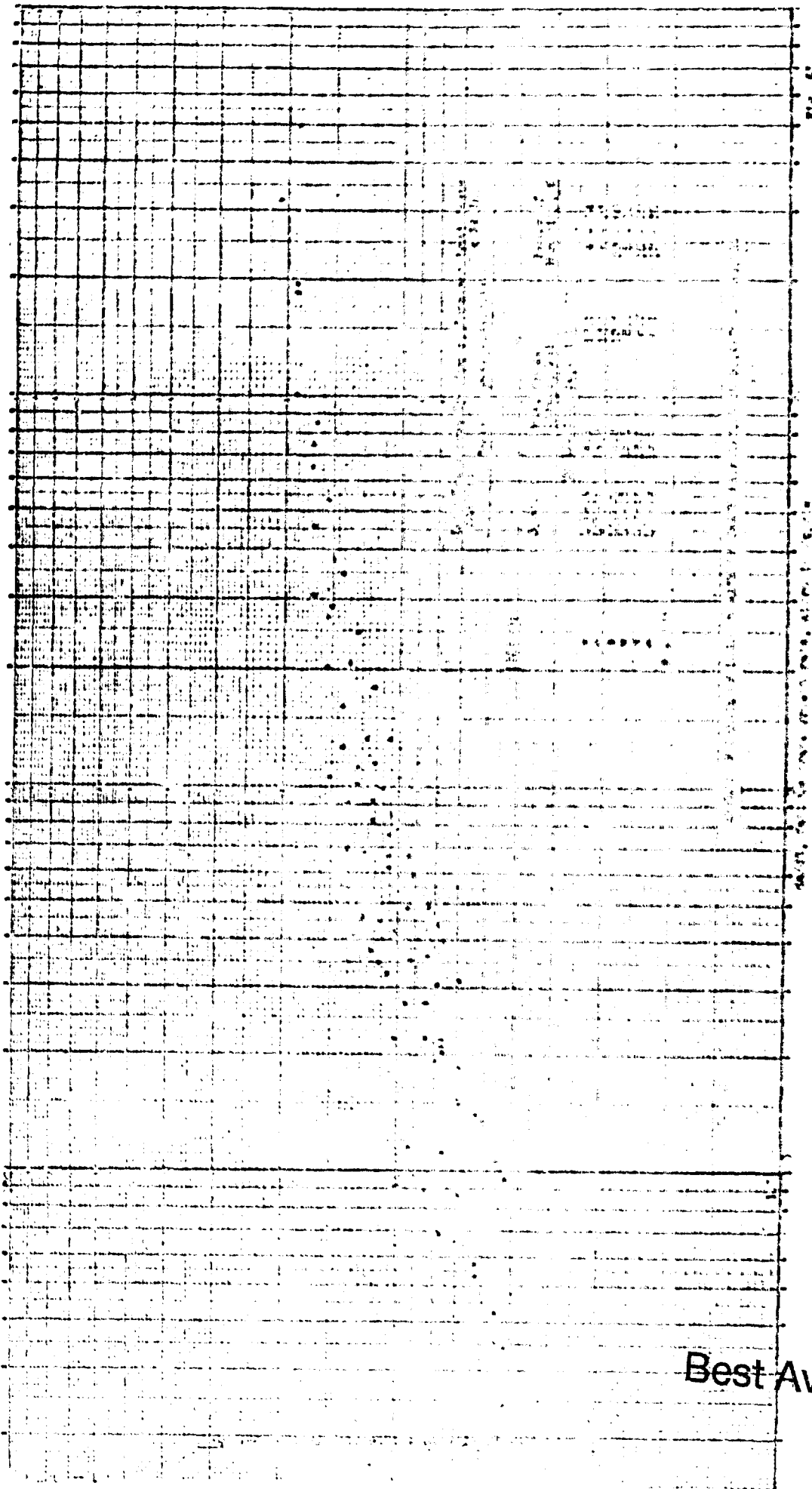


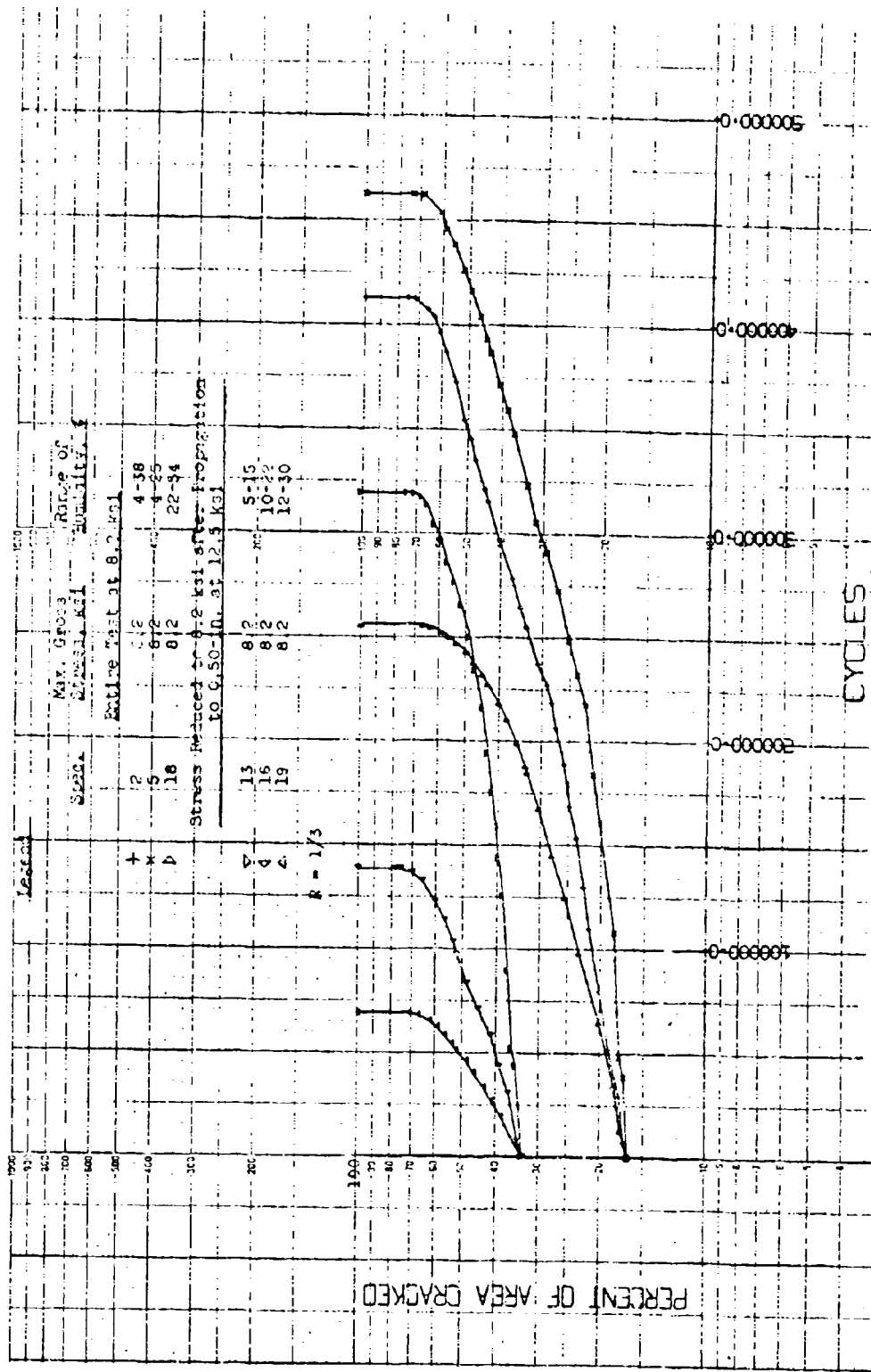
Fig. 61

Fig. 62





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RELATION OF PERCENT OF AREA CRACKED ON RATE OF PROPAGATION OF 2014-T3 ALUMINUM, 8.2 ksi

Left-Transverse Direction, Constant Load Tests

Specimens 2, 5, 18, 13, 16, 19

Constant Load Tests

Fig. 6a

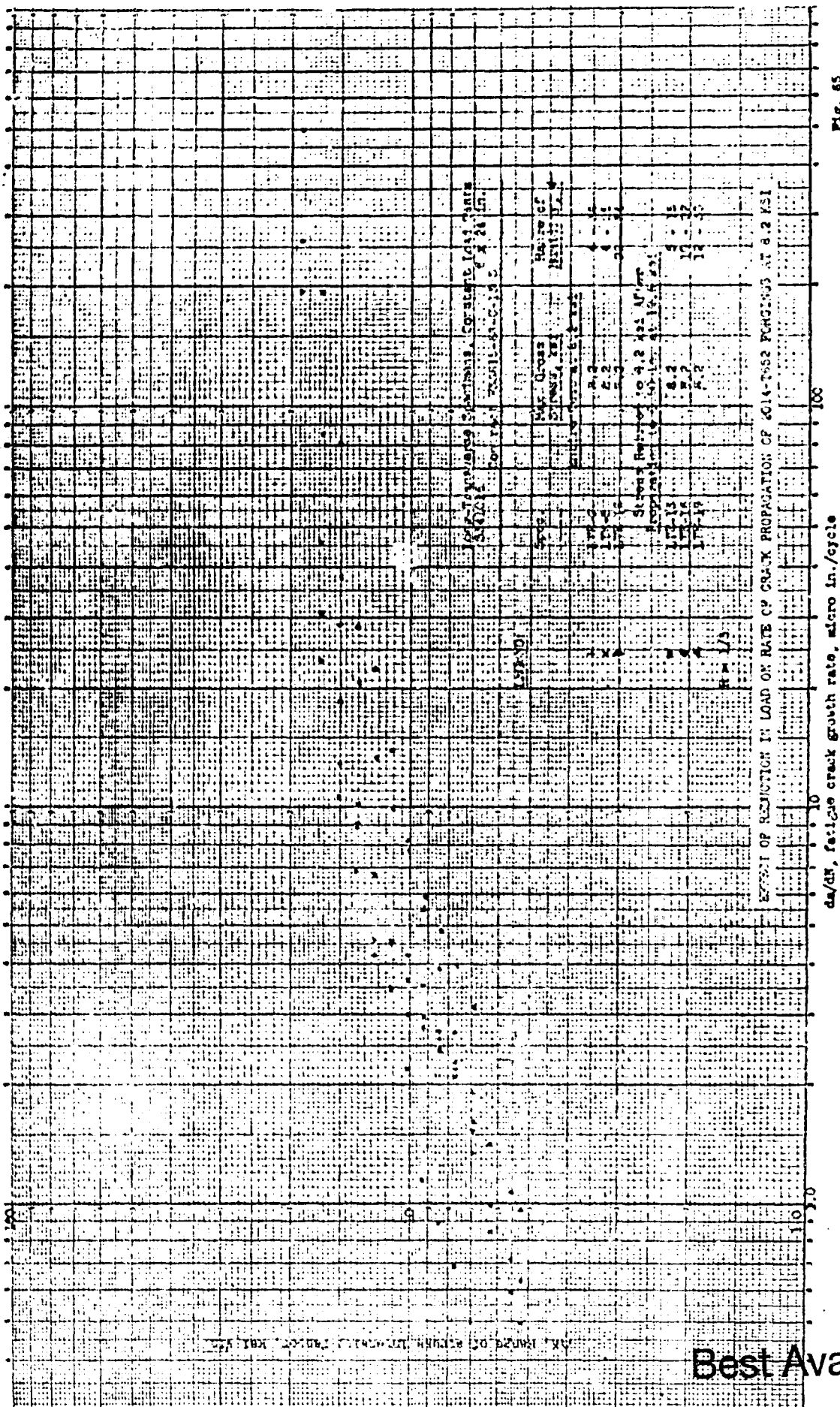
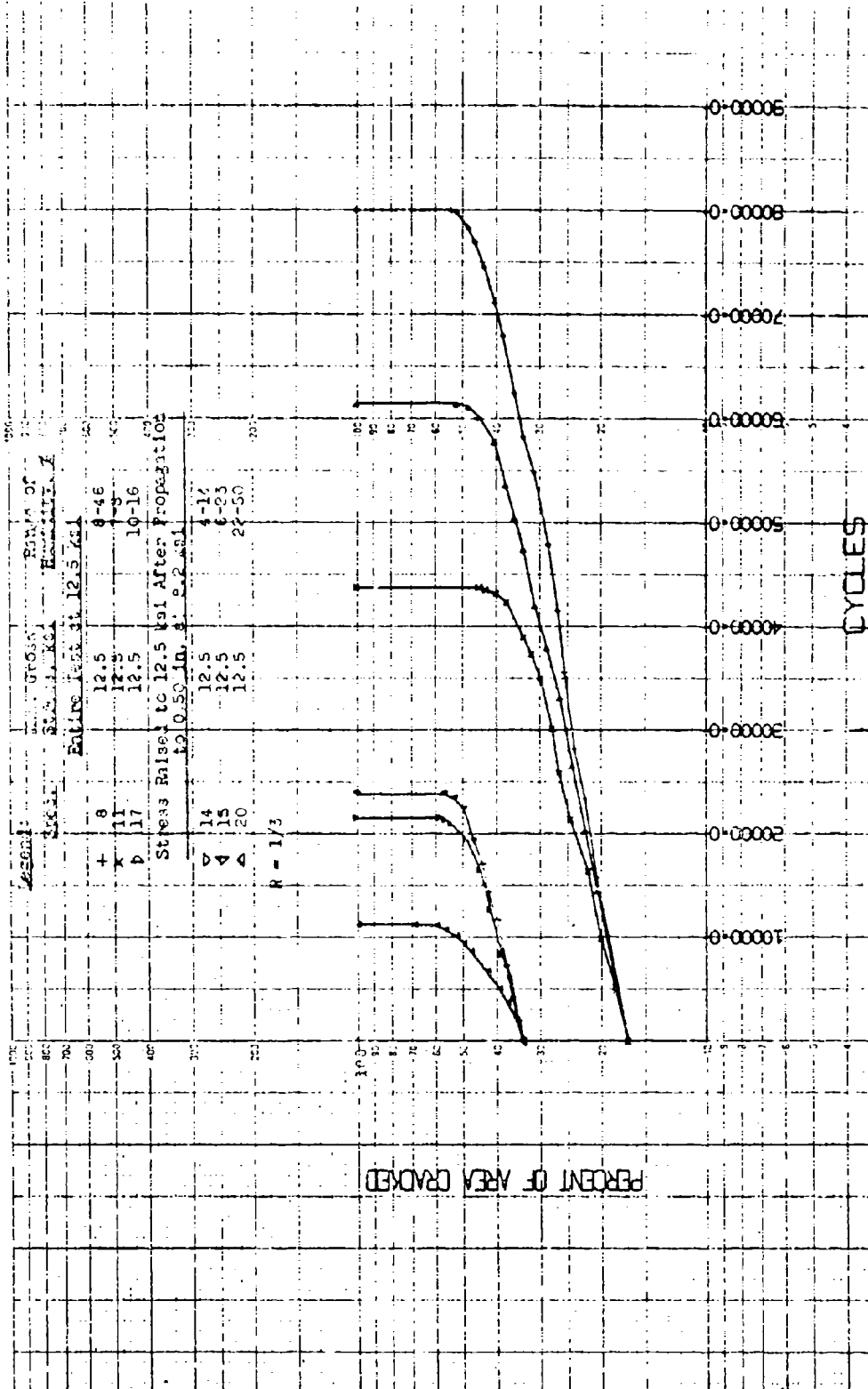


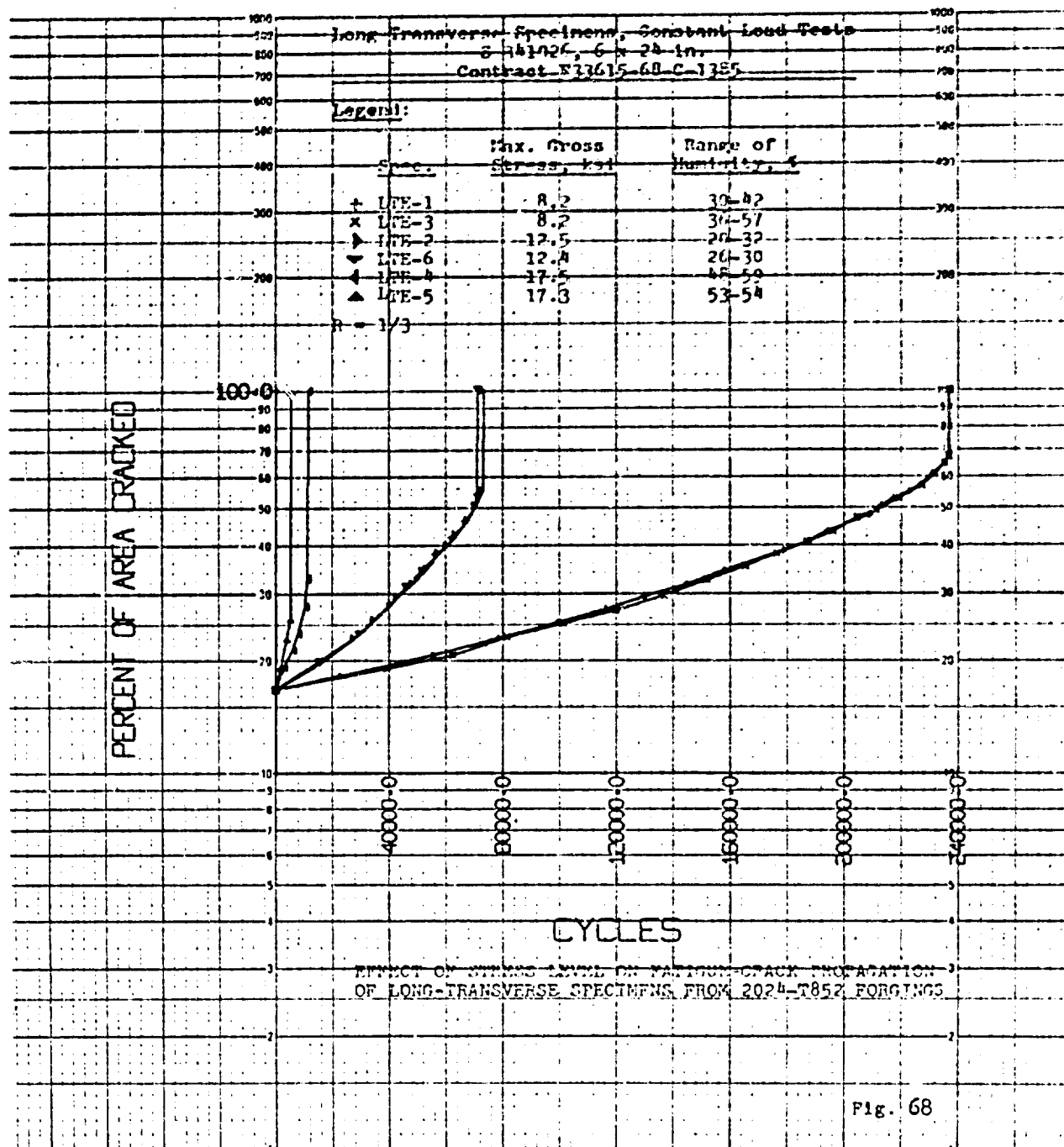
Fig. 85

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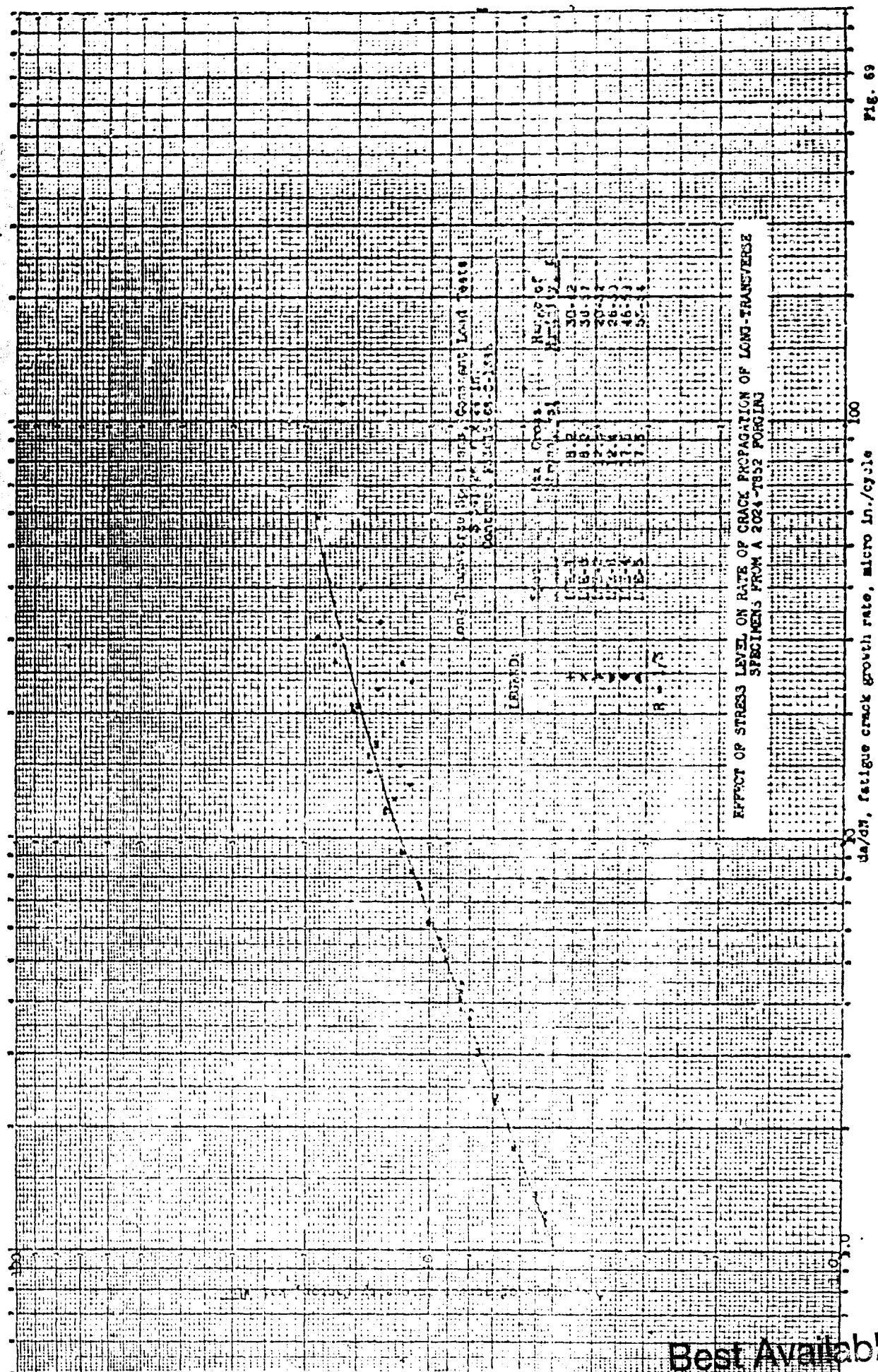


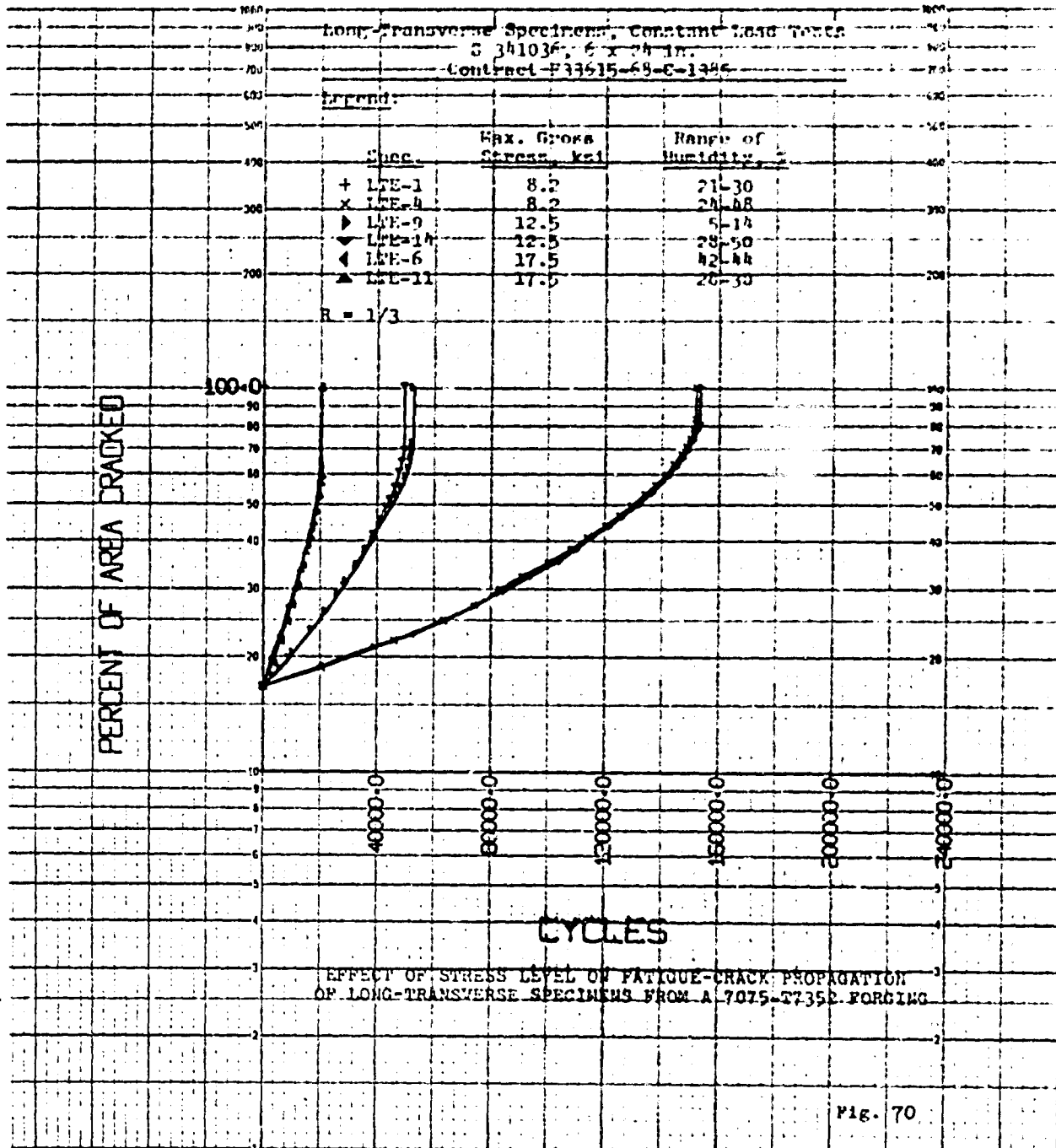
EFFECT OF INCREASE OF LOAD ON FATIGUE-CRACK PROPAGATION OF 2014-T652 ALUMINUM

Long-Transverse Specimen, Constant Load Tests
 S 54106, 6 x 24 in.
 Continued F55615-05-C-1365



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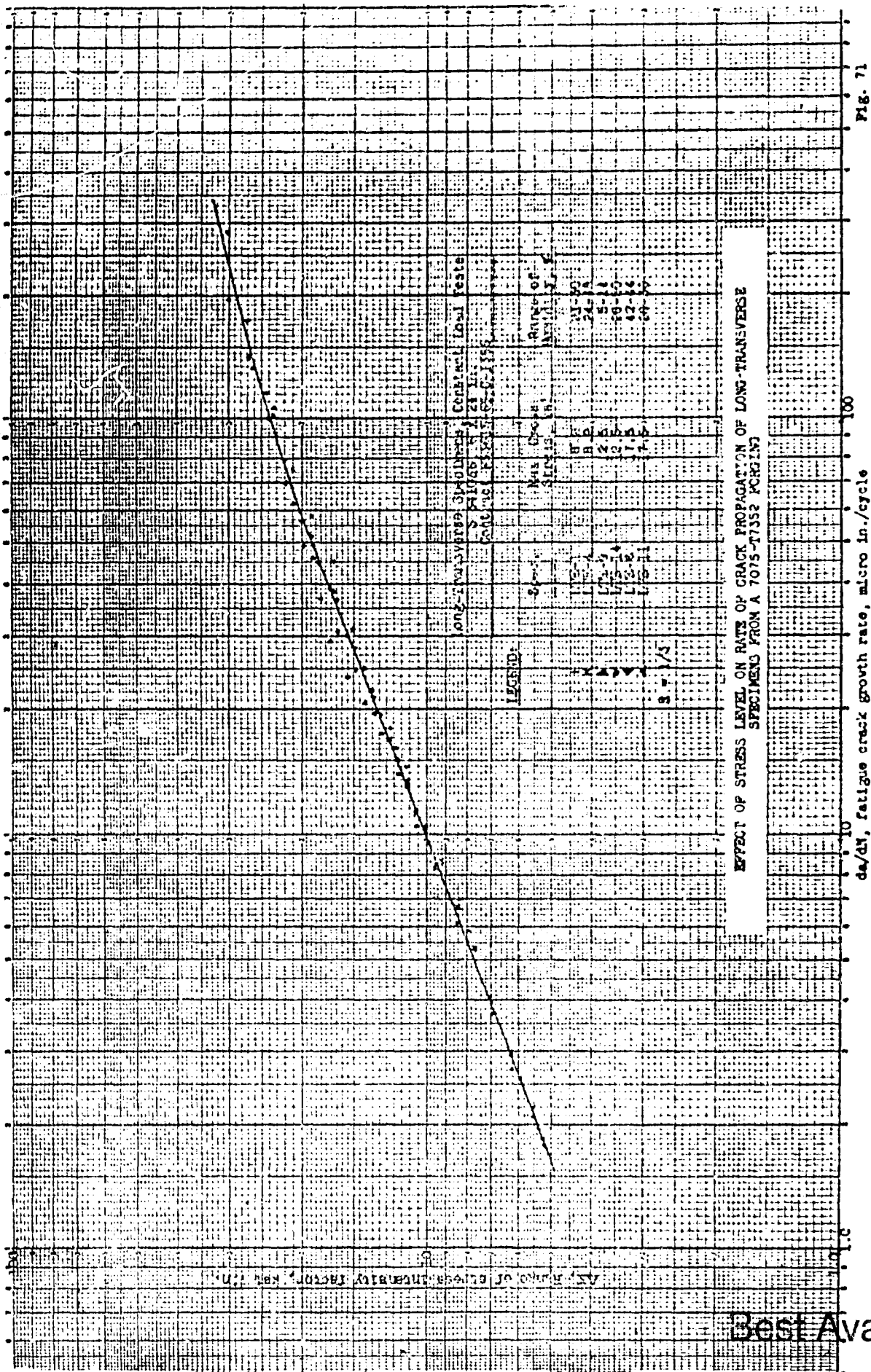
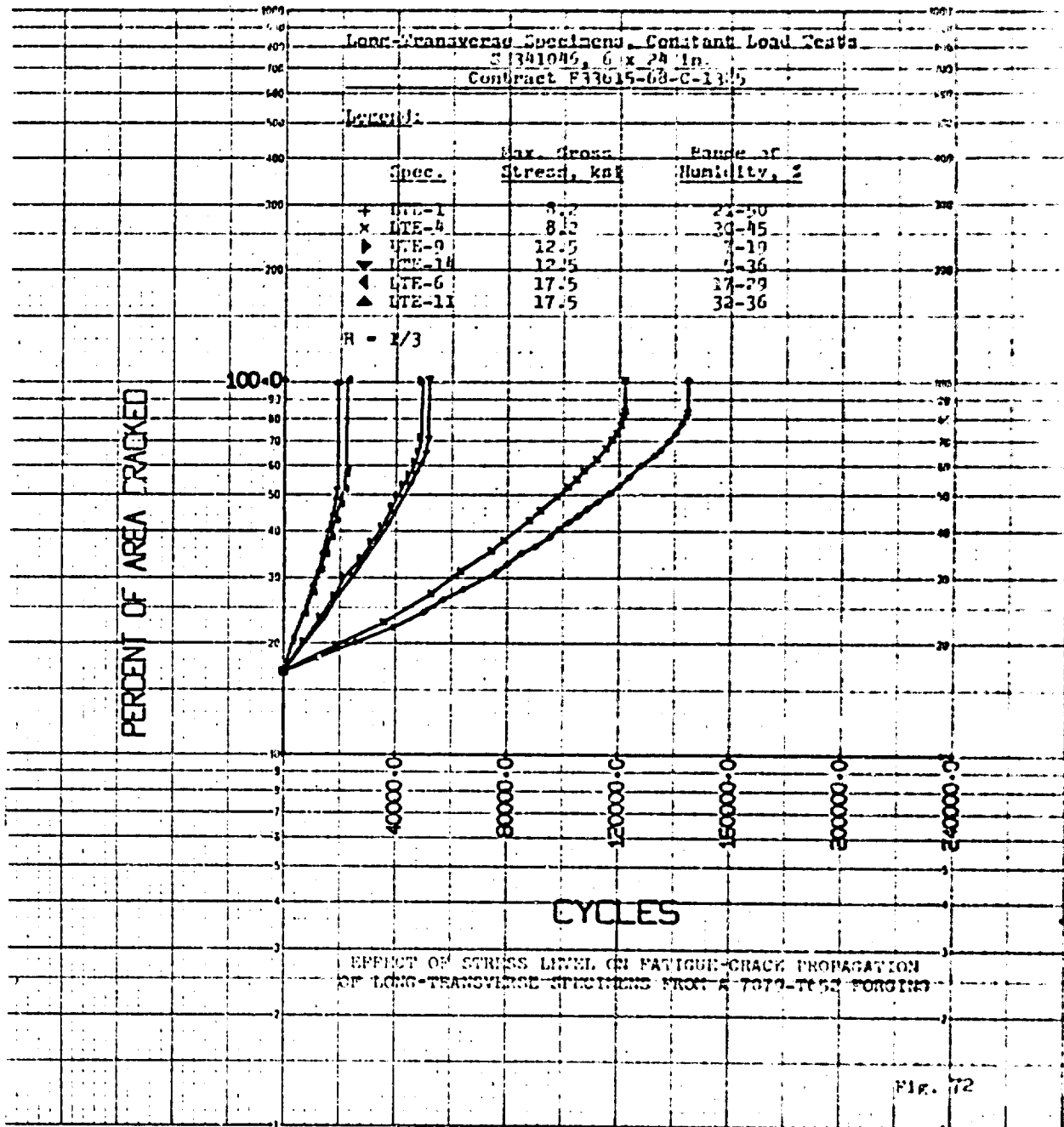


Fig. 71



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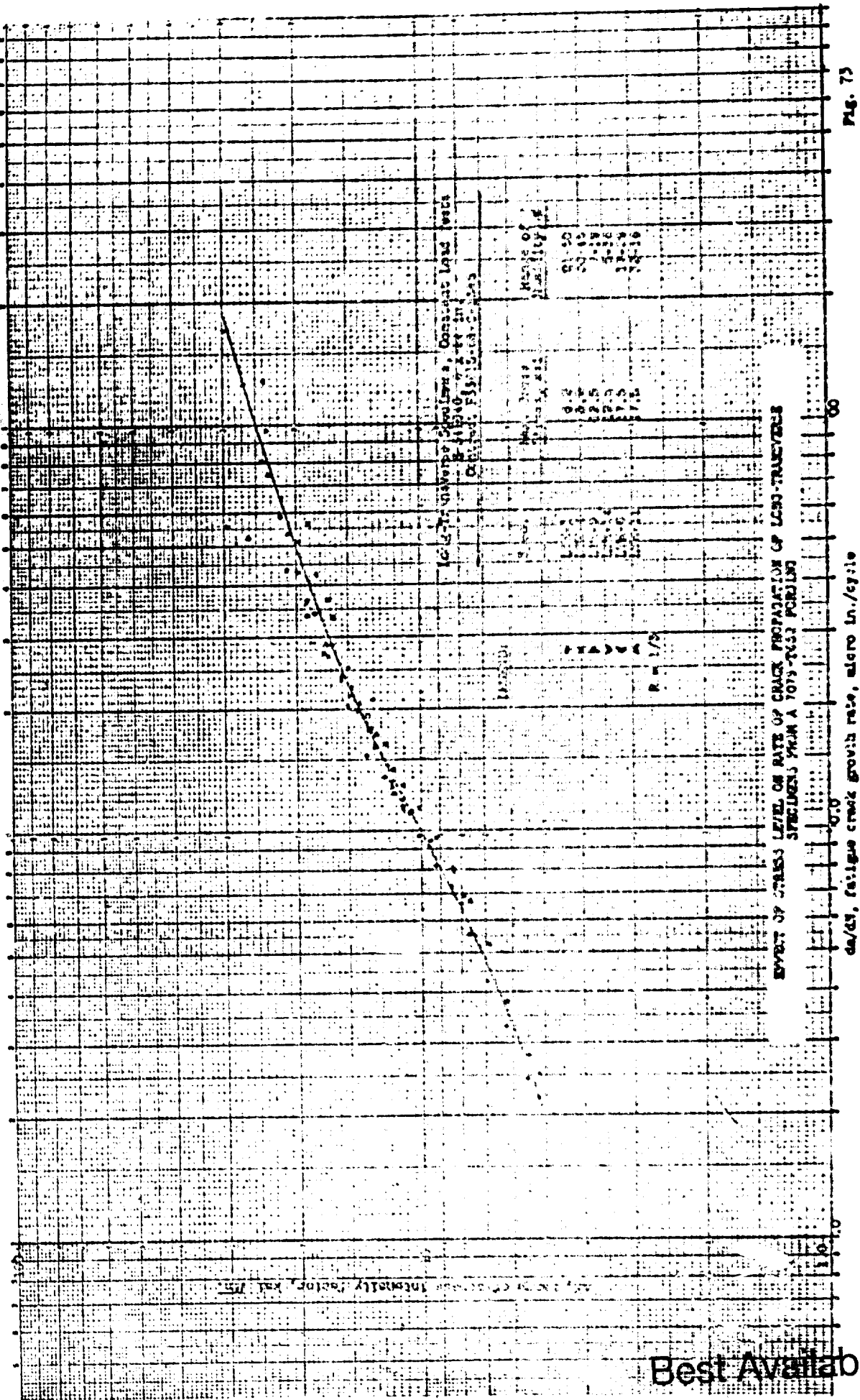
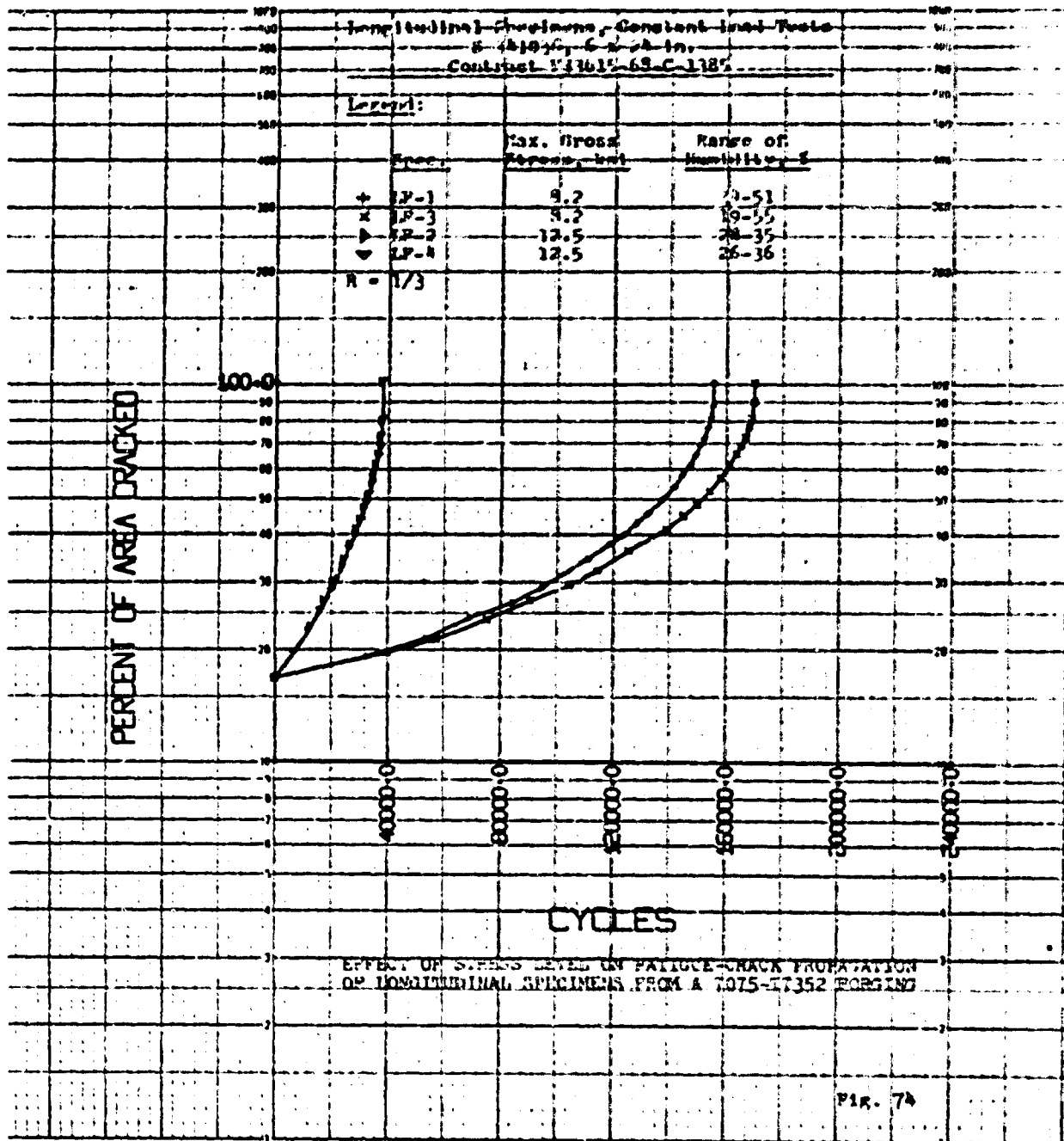


FIG. 73



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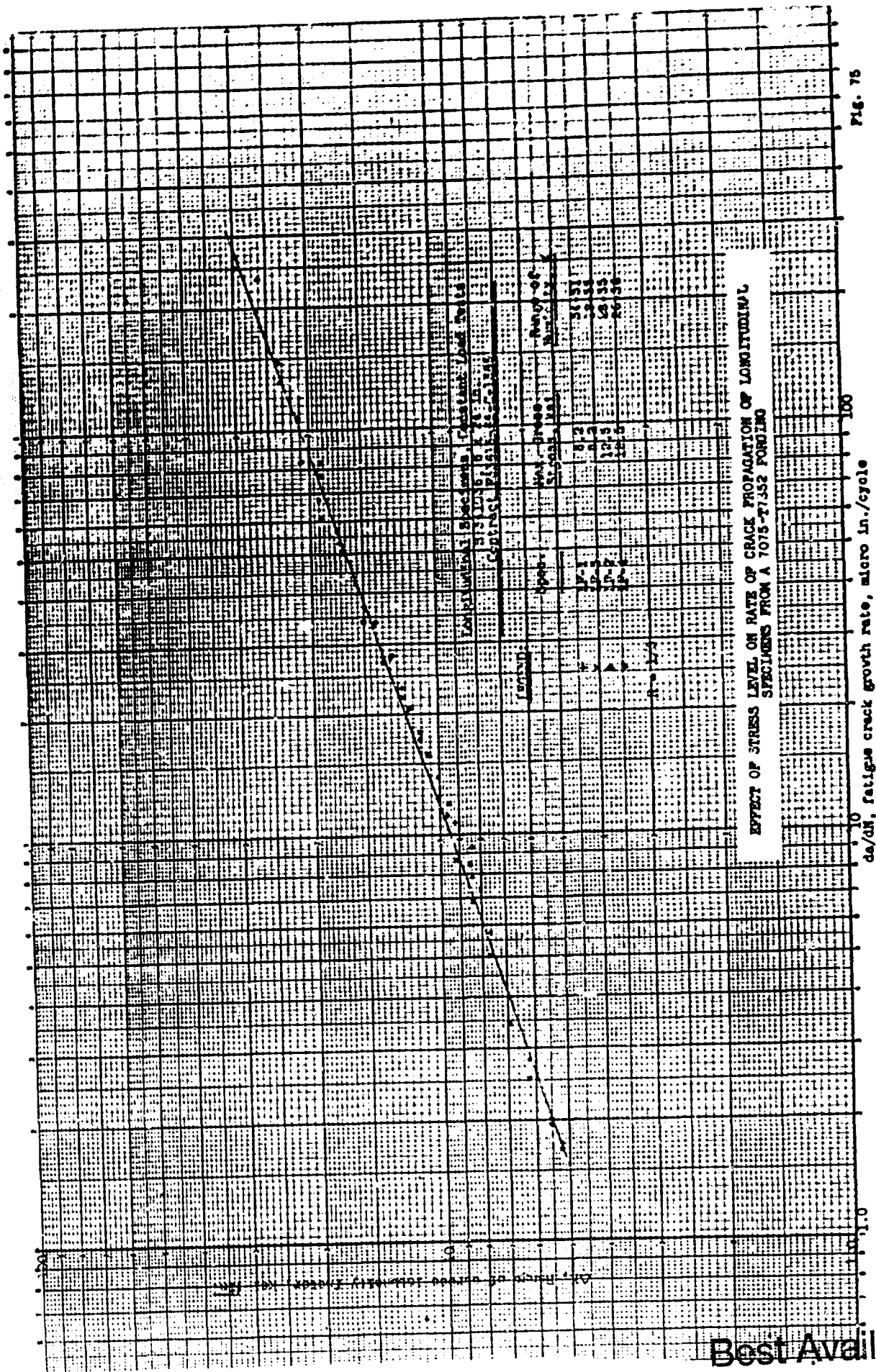
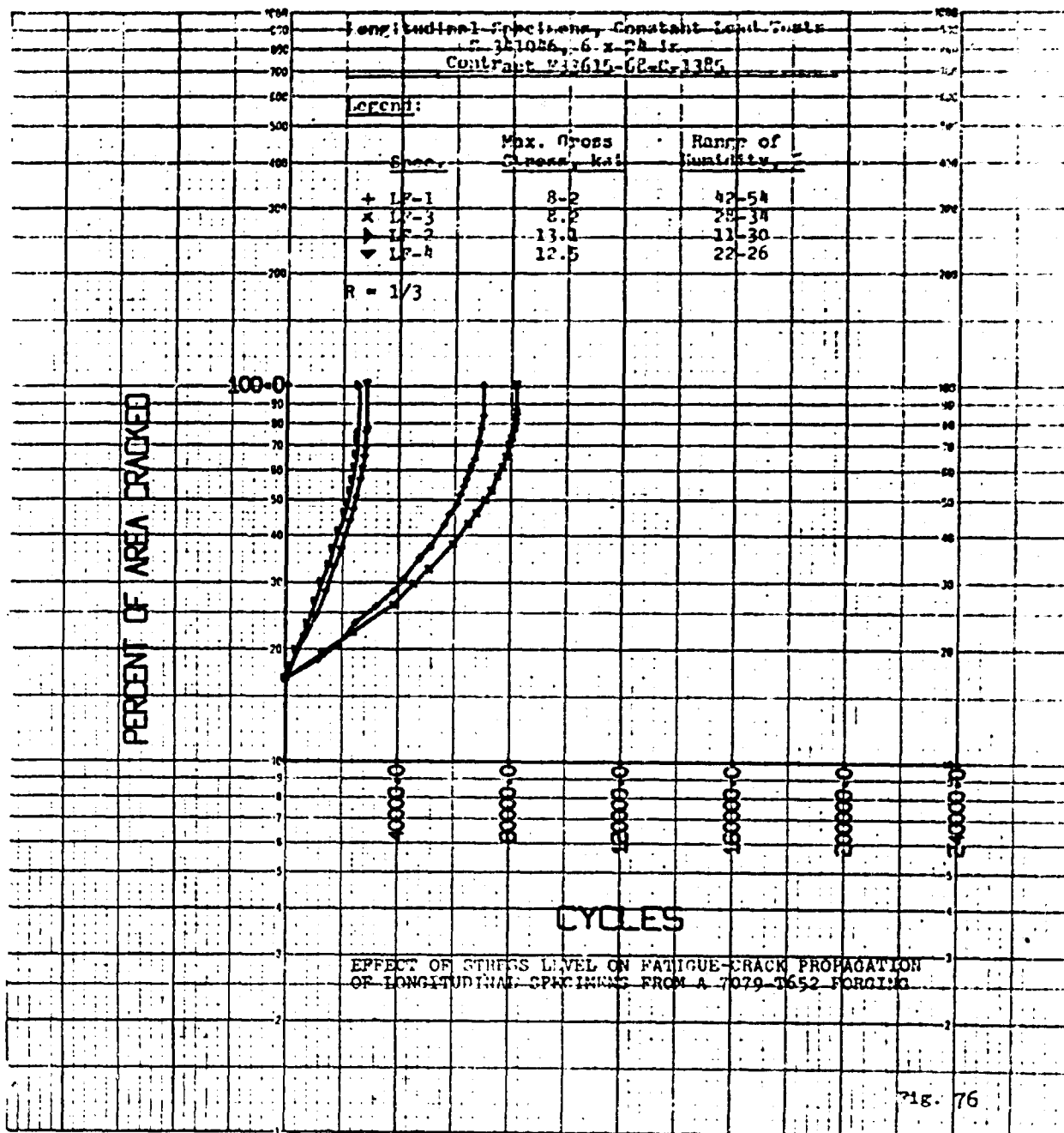


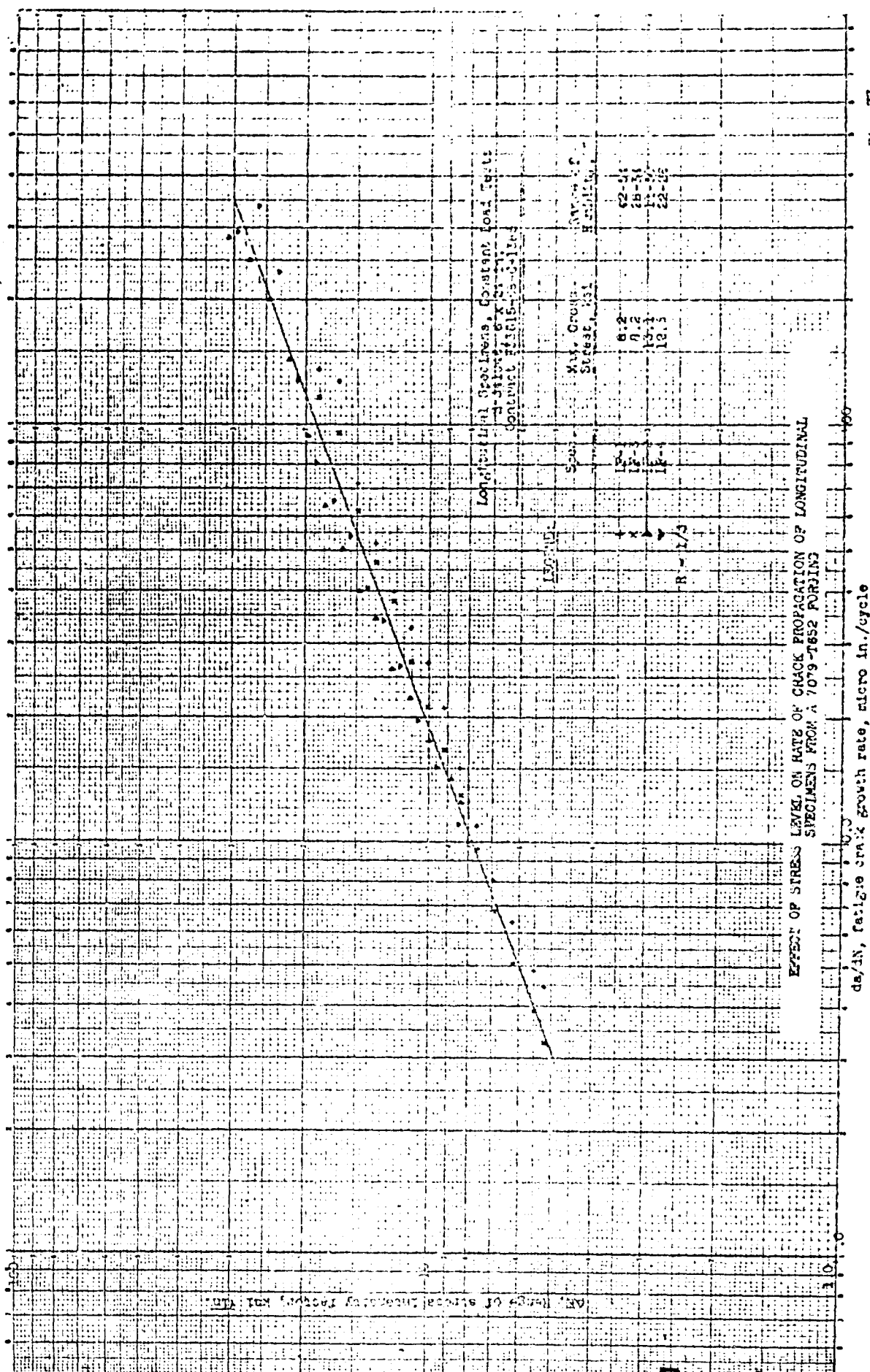
Fig. 75

EFFECT OF STRESS LEVEL ON RATE OF CRACK PROPAGATION OF LONGITUDINAL SPECIMENS FROM A 7075-T7352 FORGING

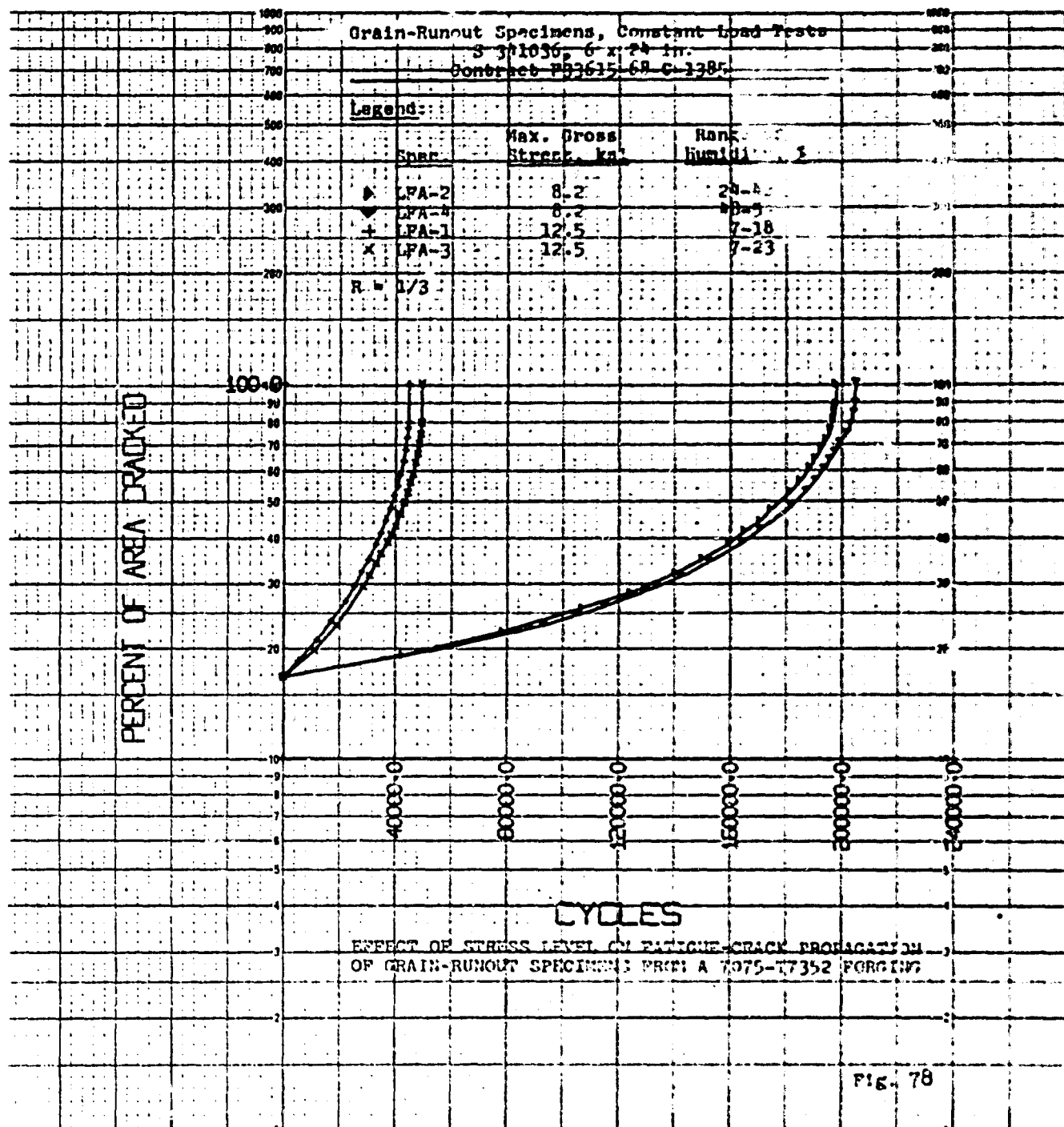
da/dN , fatigue crack growth rate, micro in./cycle



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PL: 77



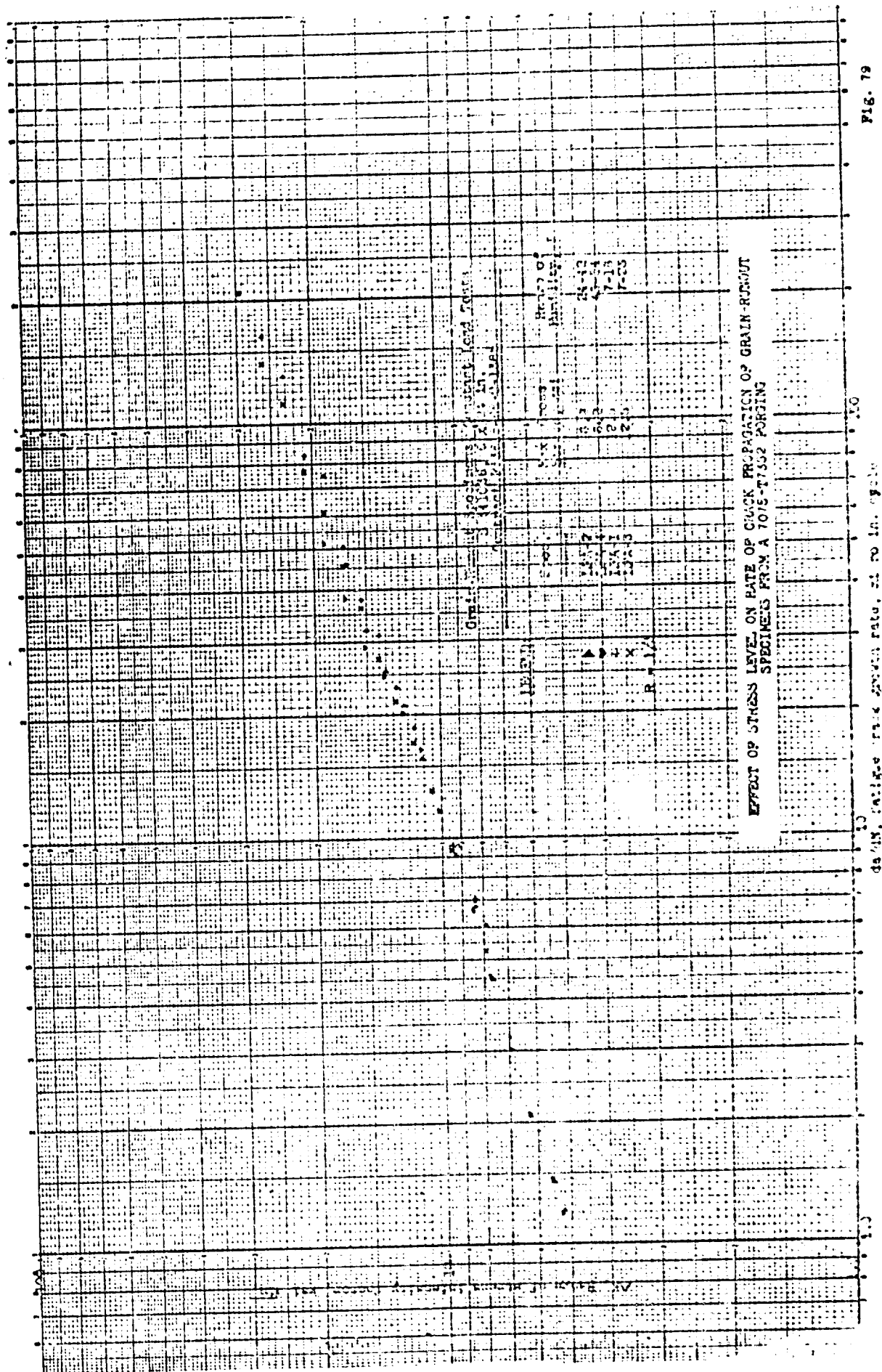
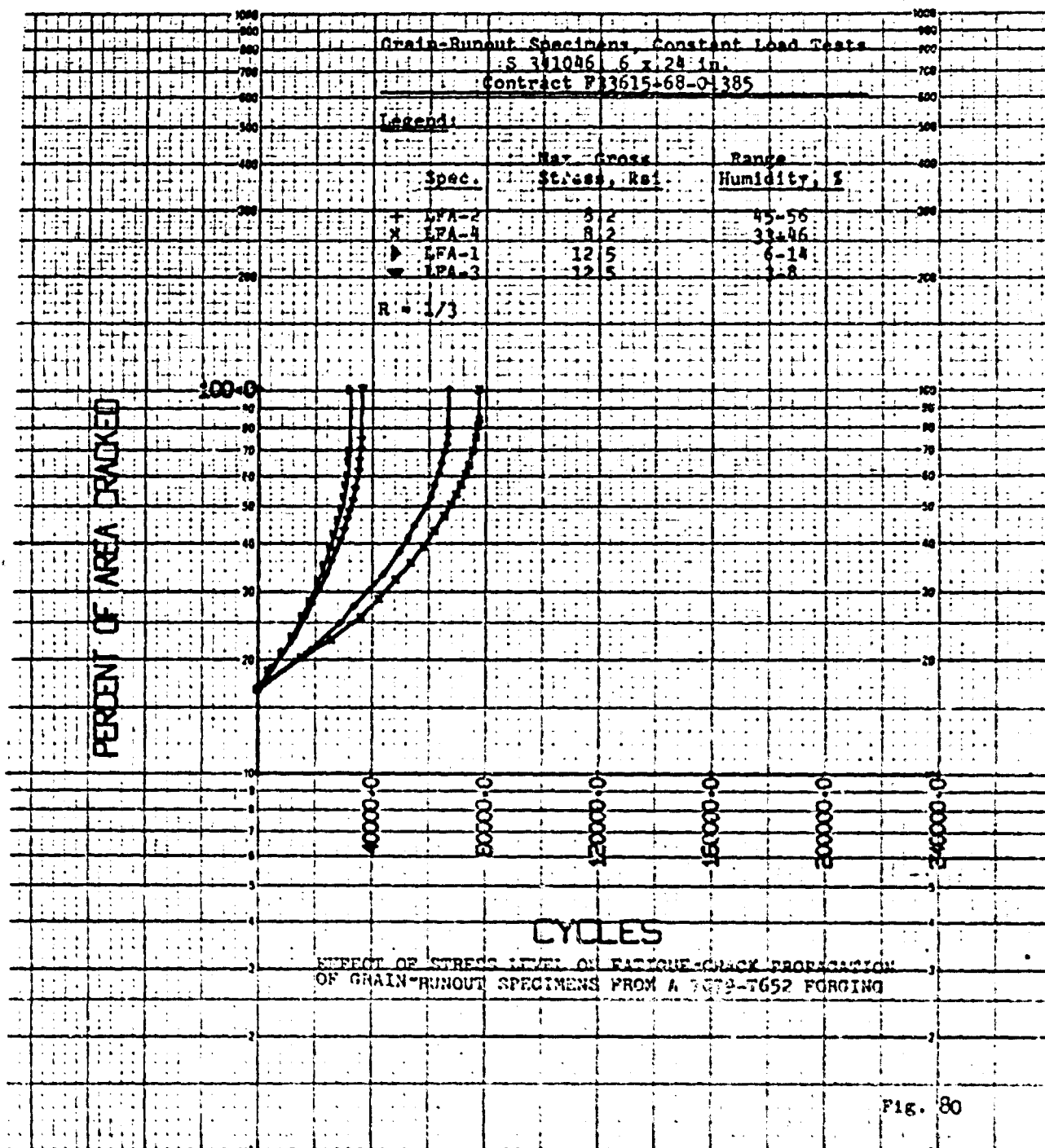


FIG. 19



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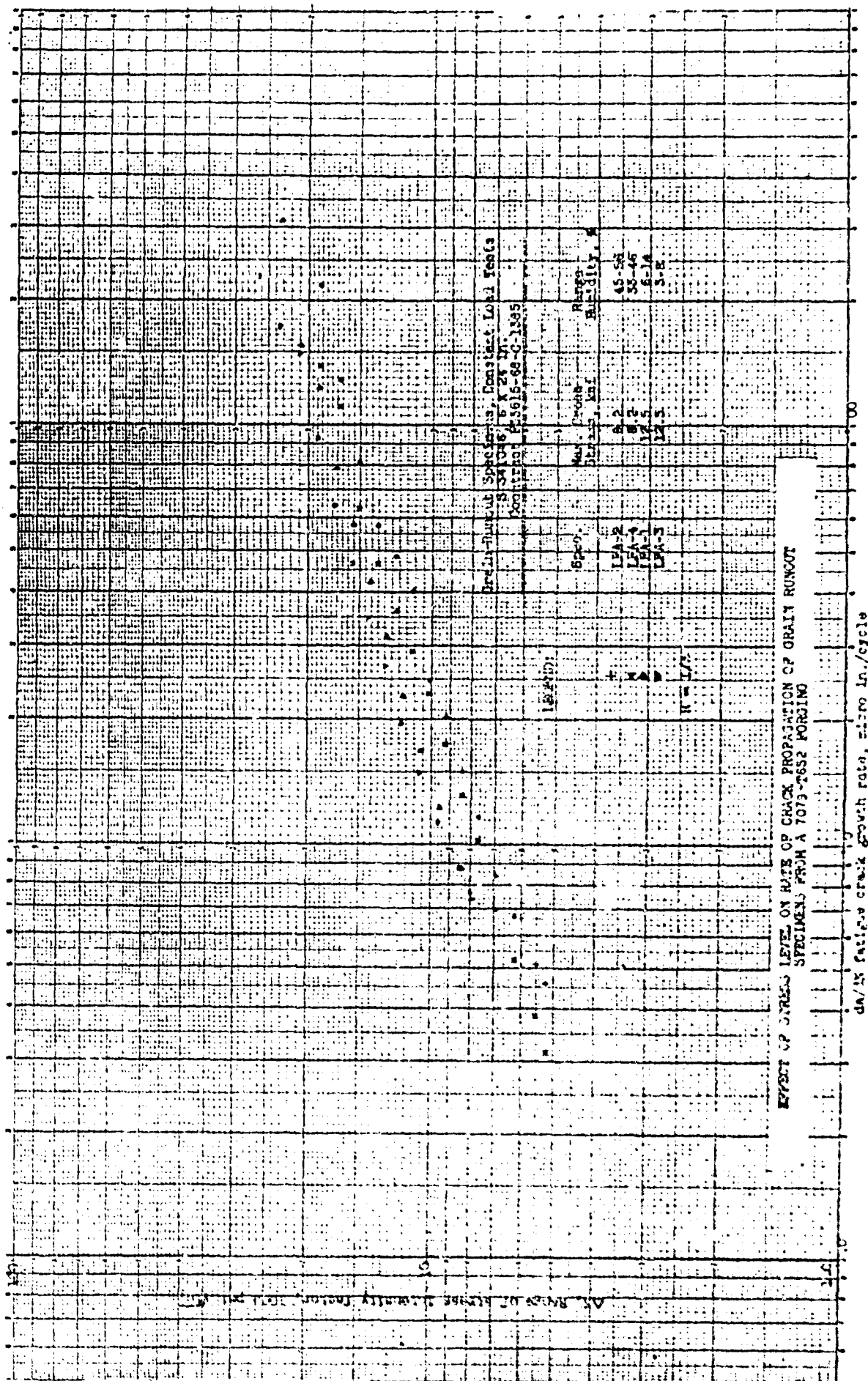
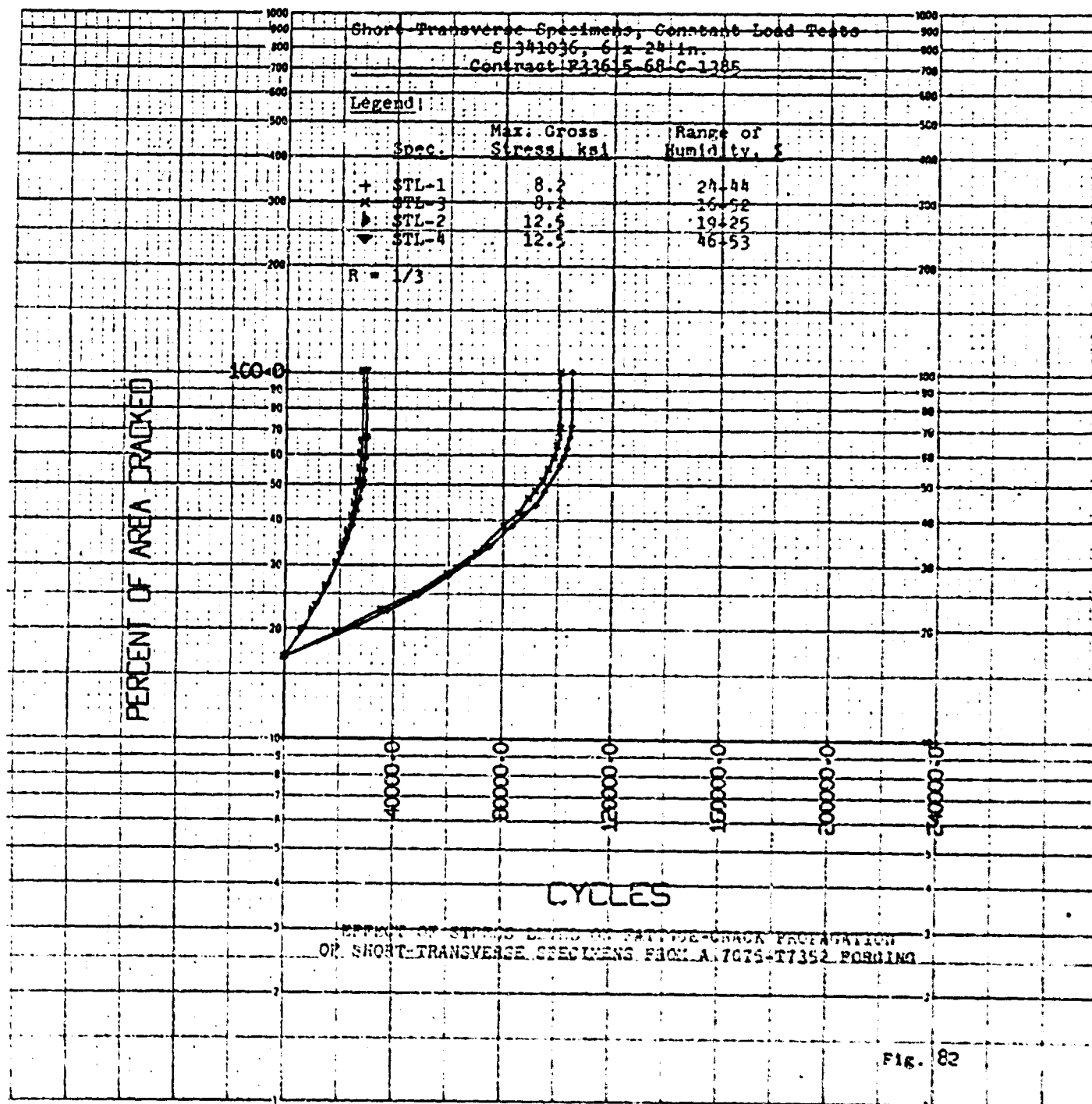


Fig. 81



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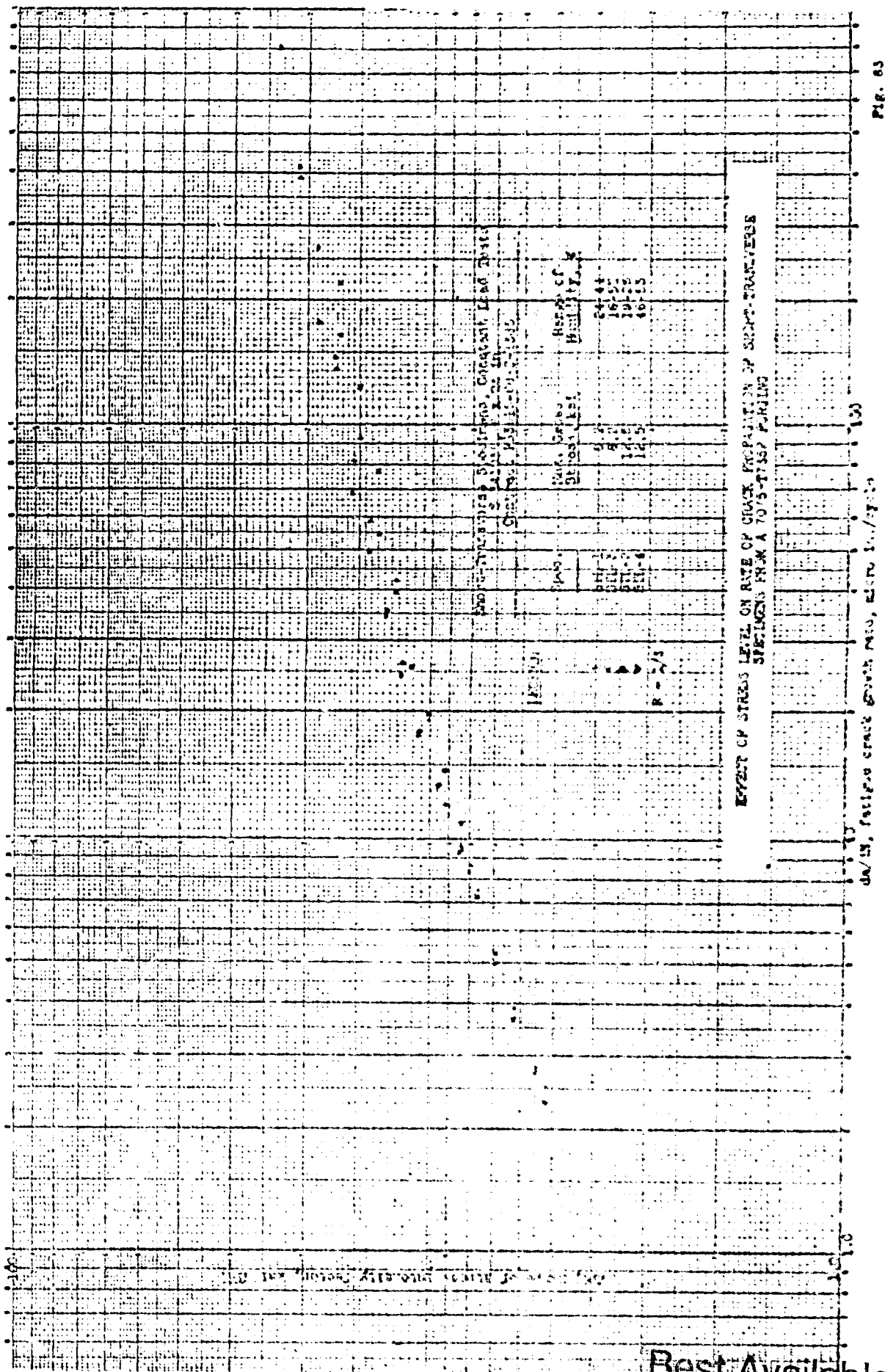
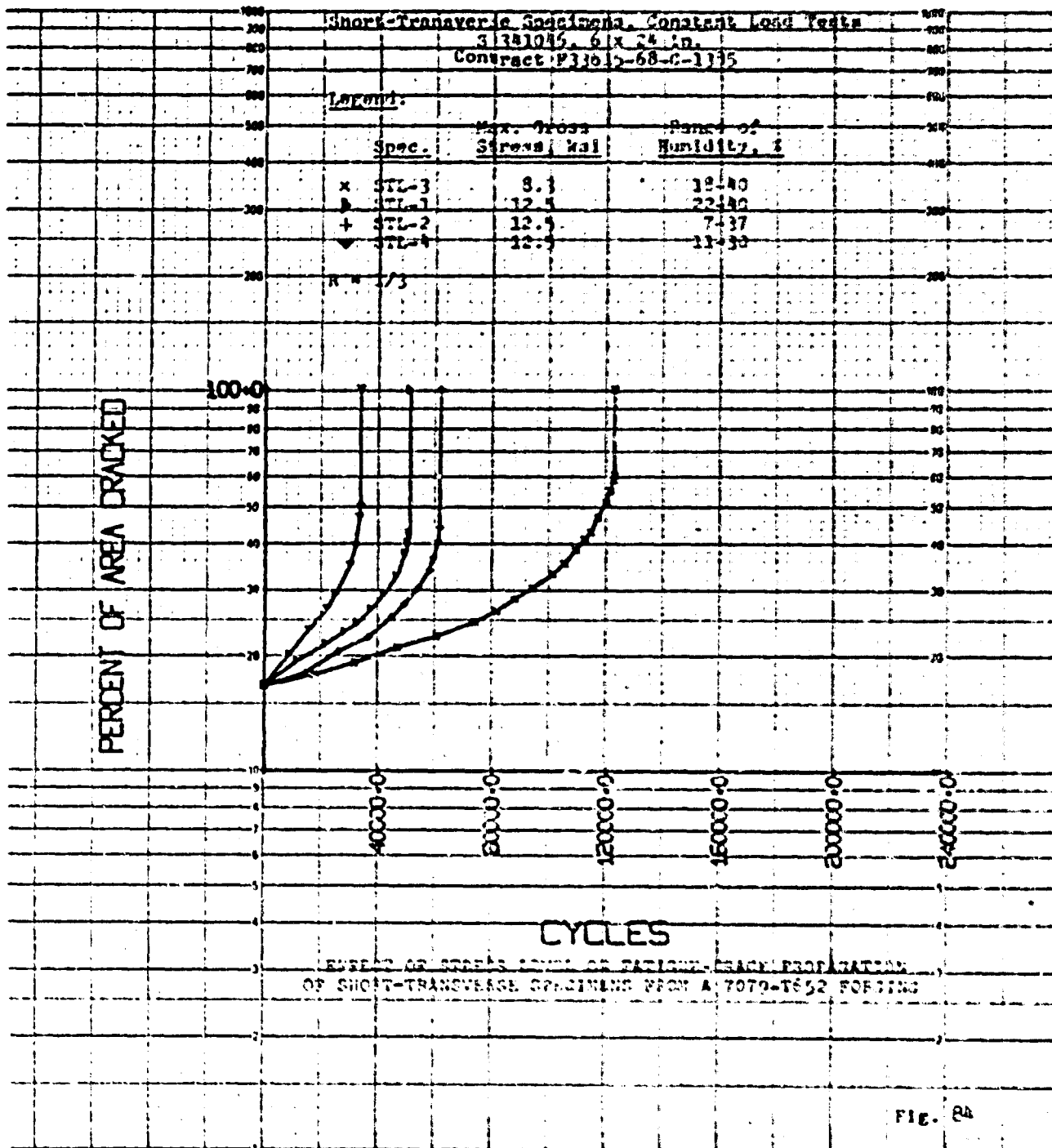
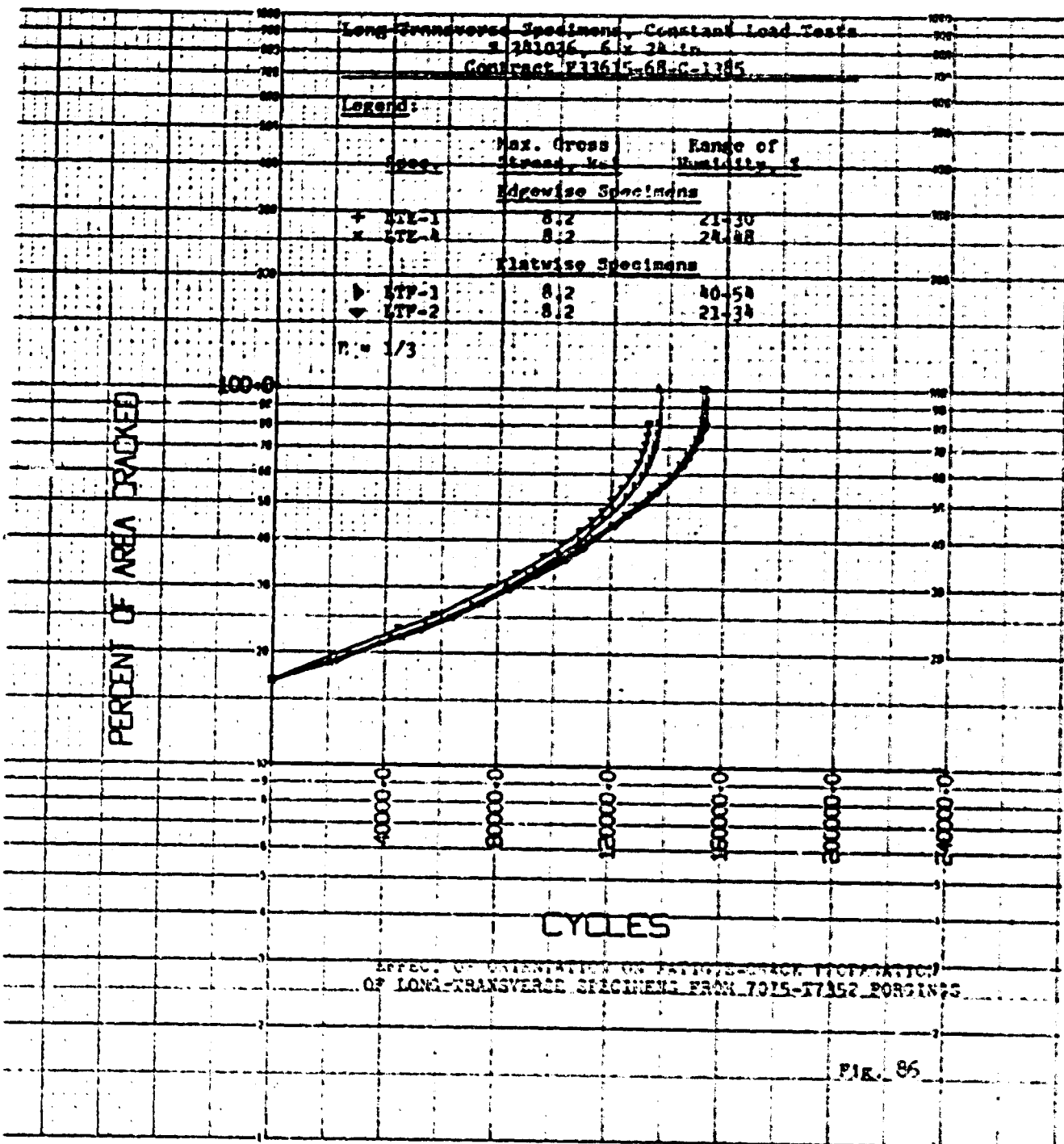
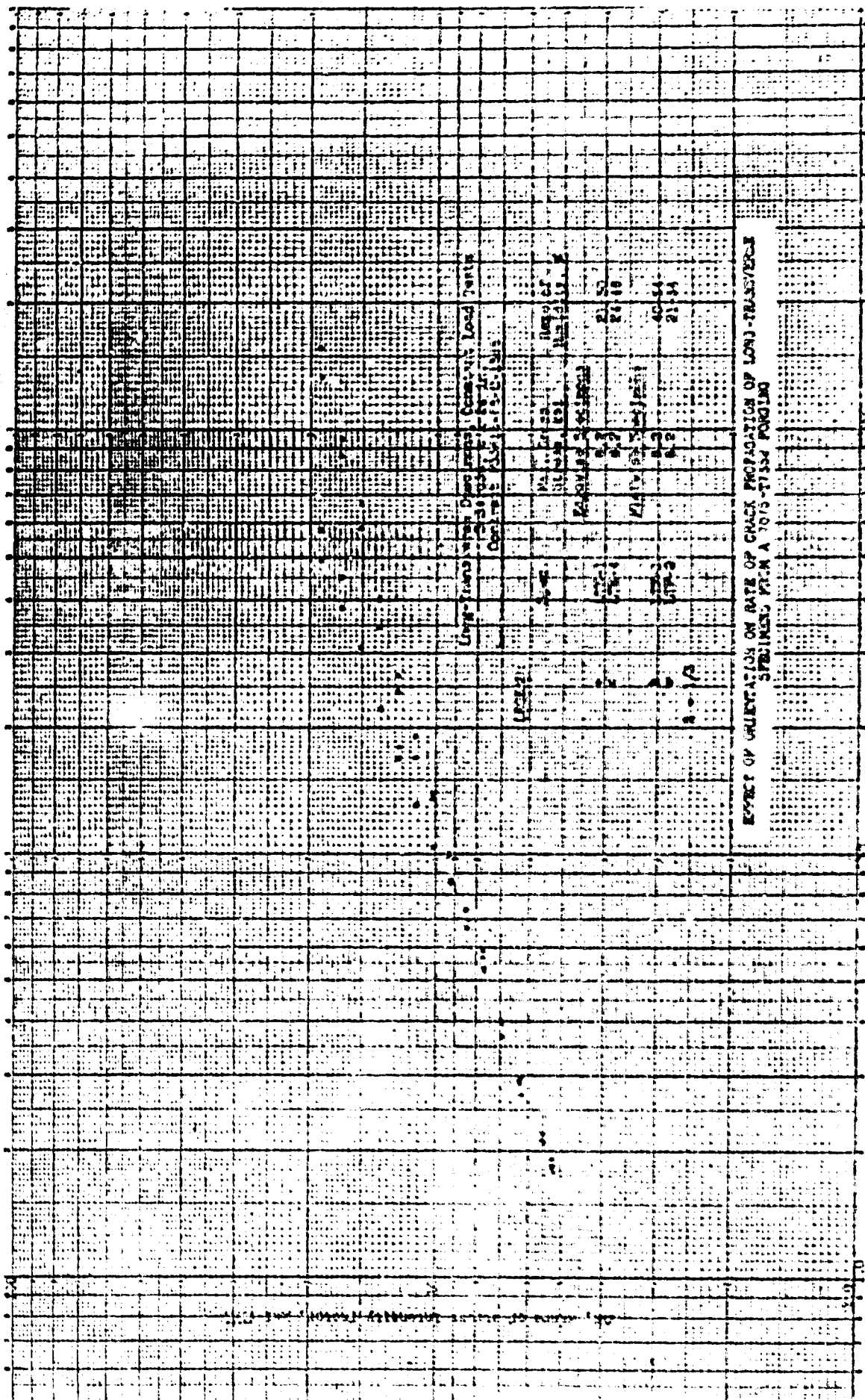


Fig. 83

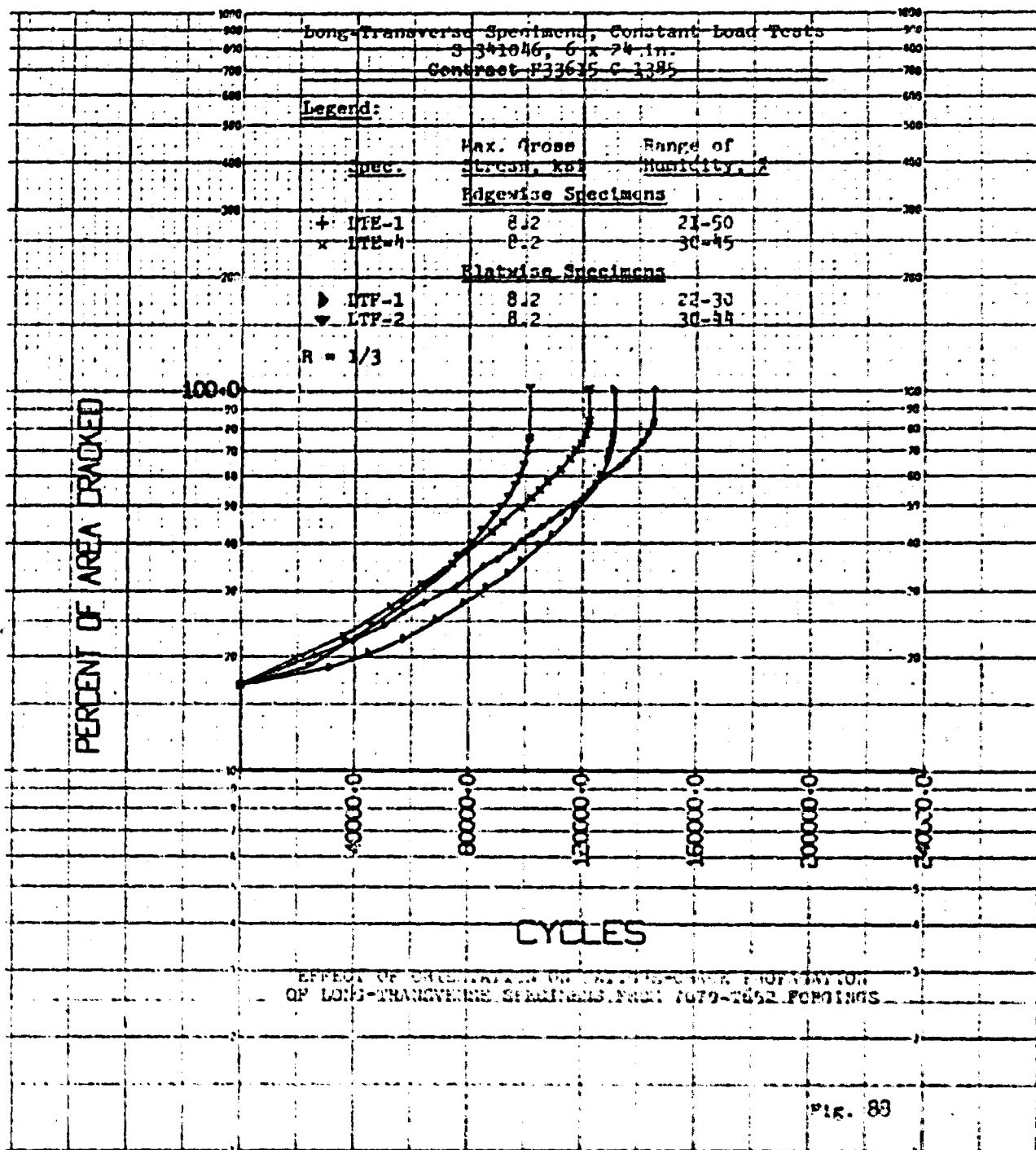


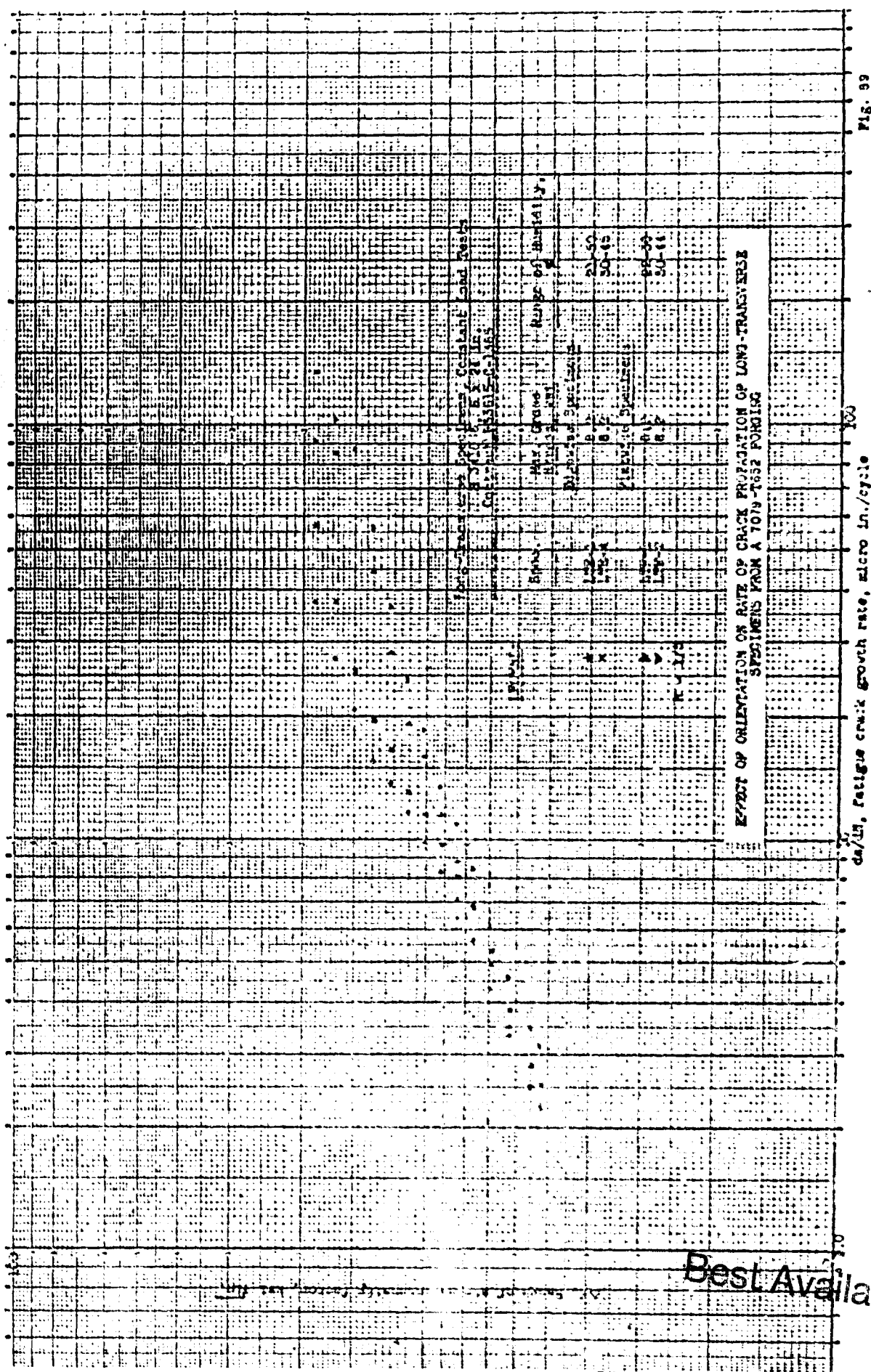
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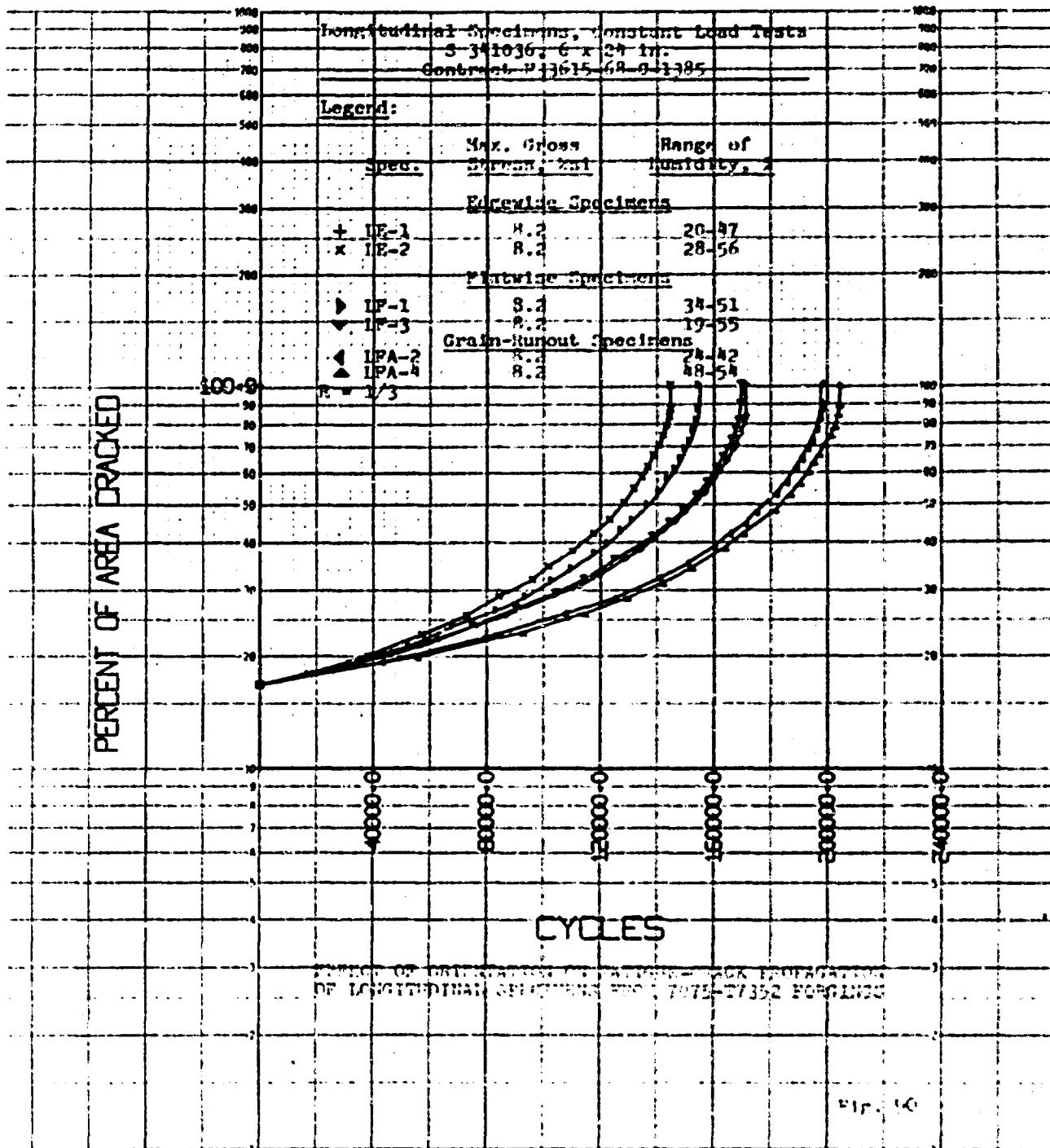




EFFECT OF ORIENTATION ON RATE OF CRACK PROPAGATION OF LONG-TRANSVERSE SPECIMENS FROM A 70/30 FERRITE







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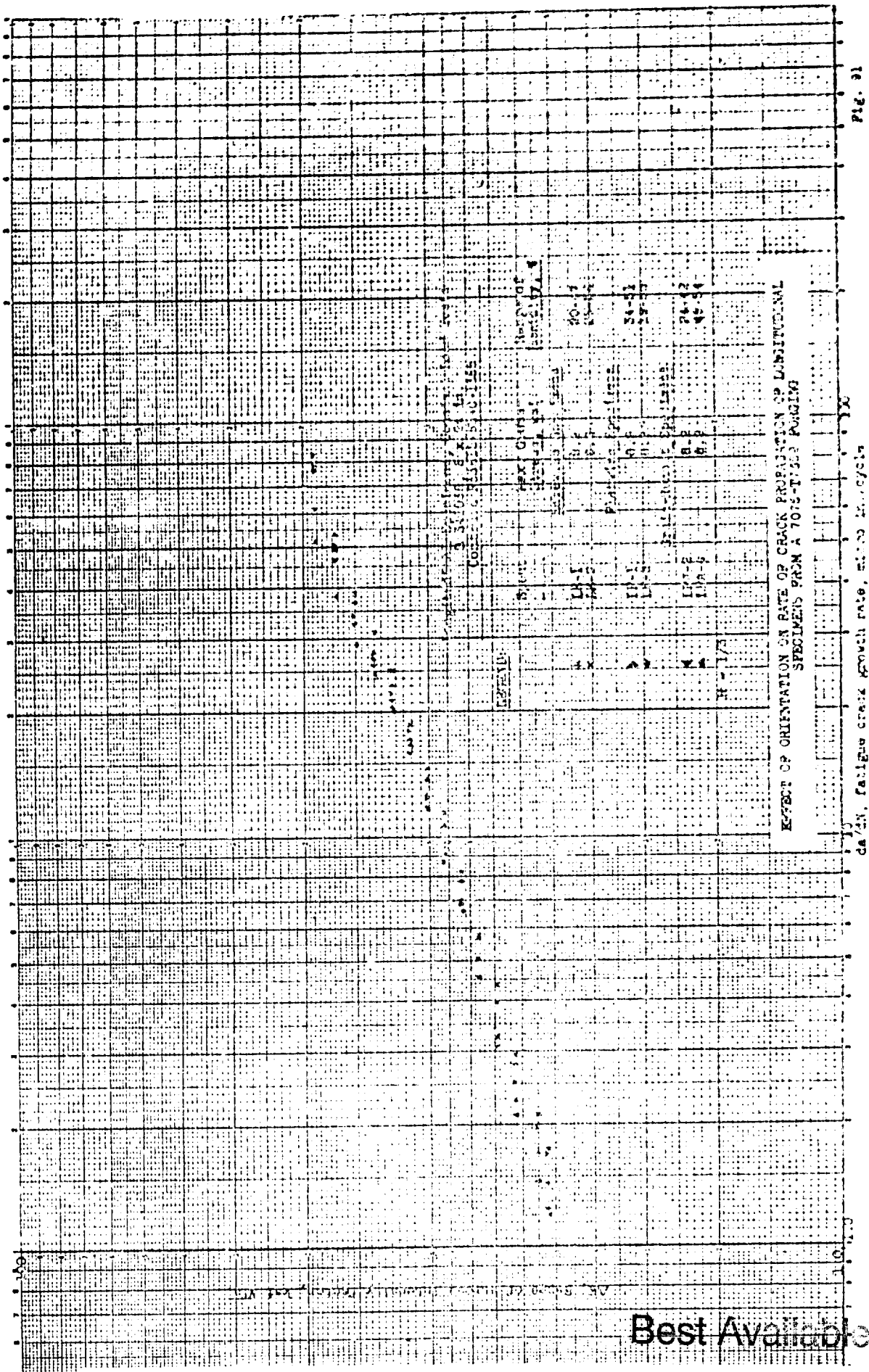
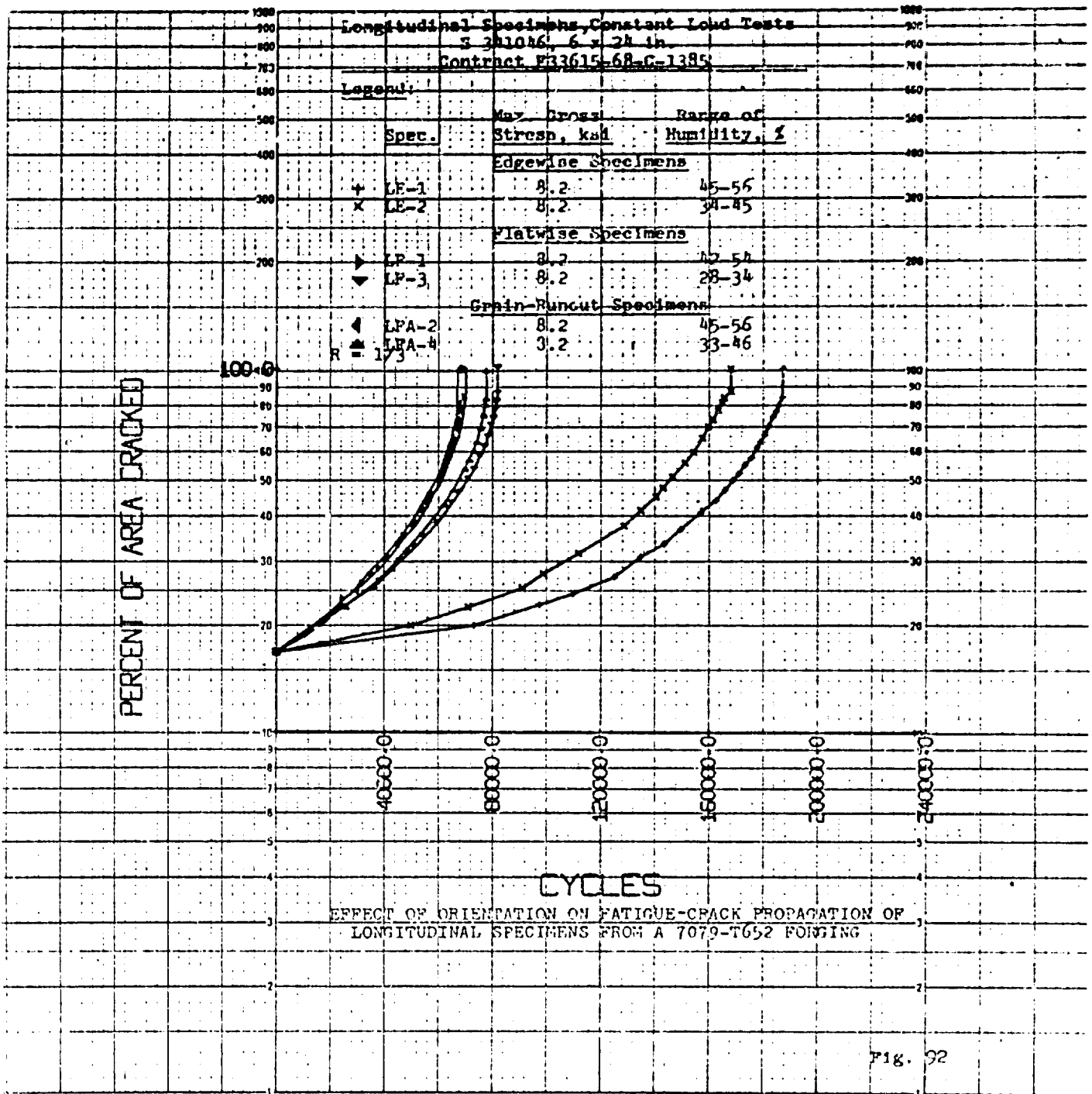
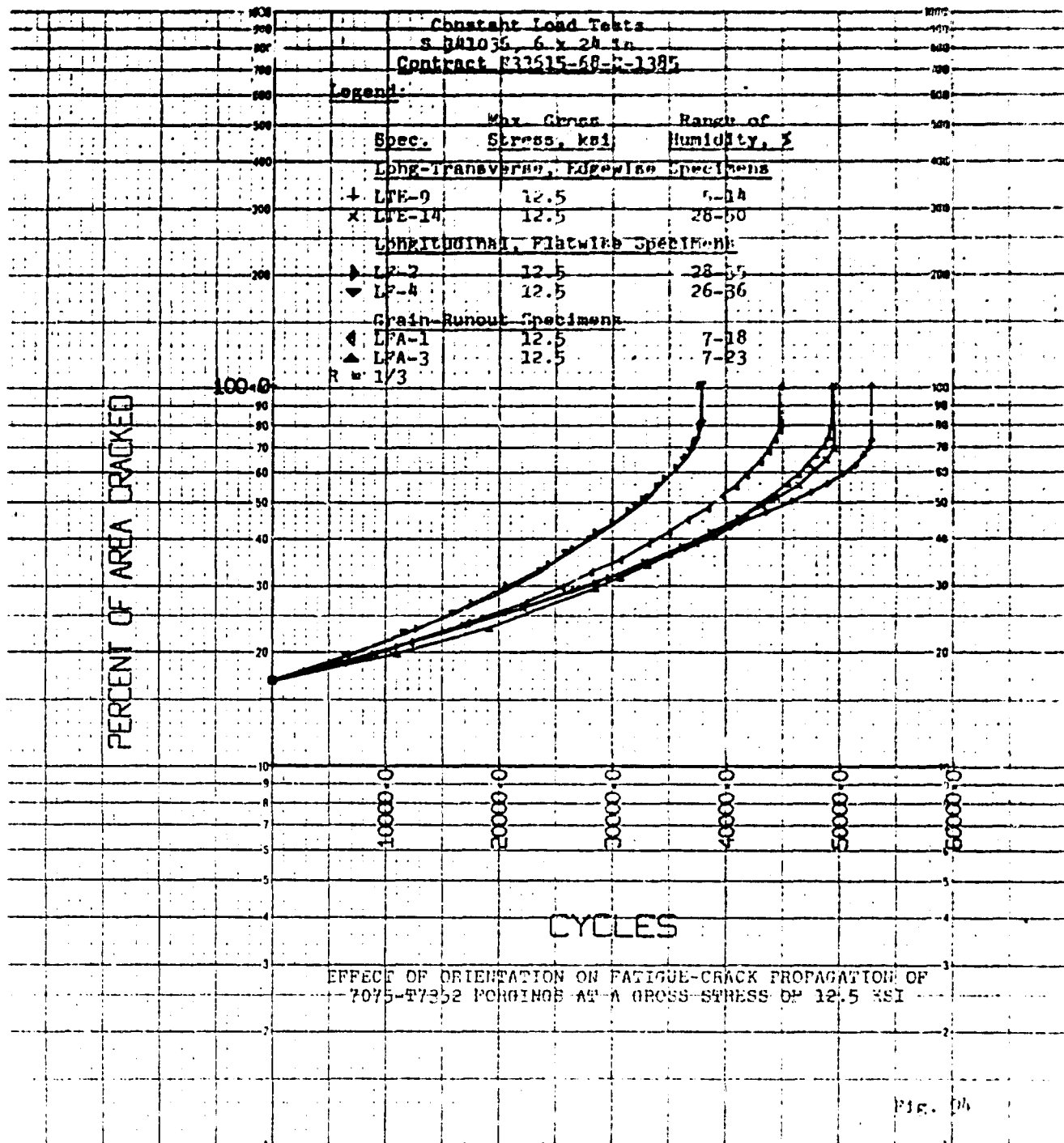


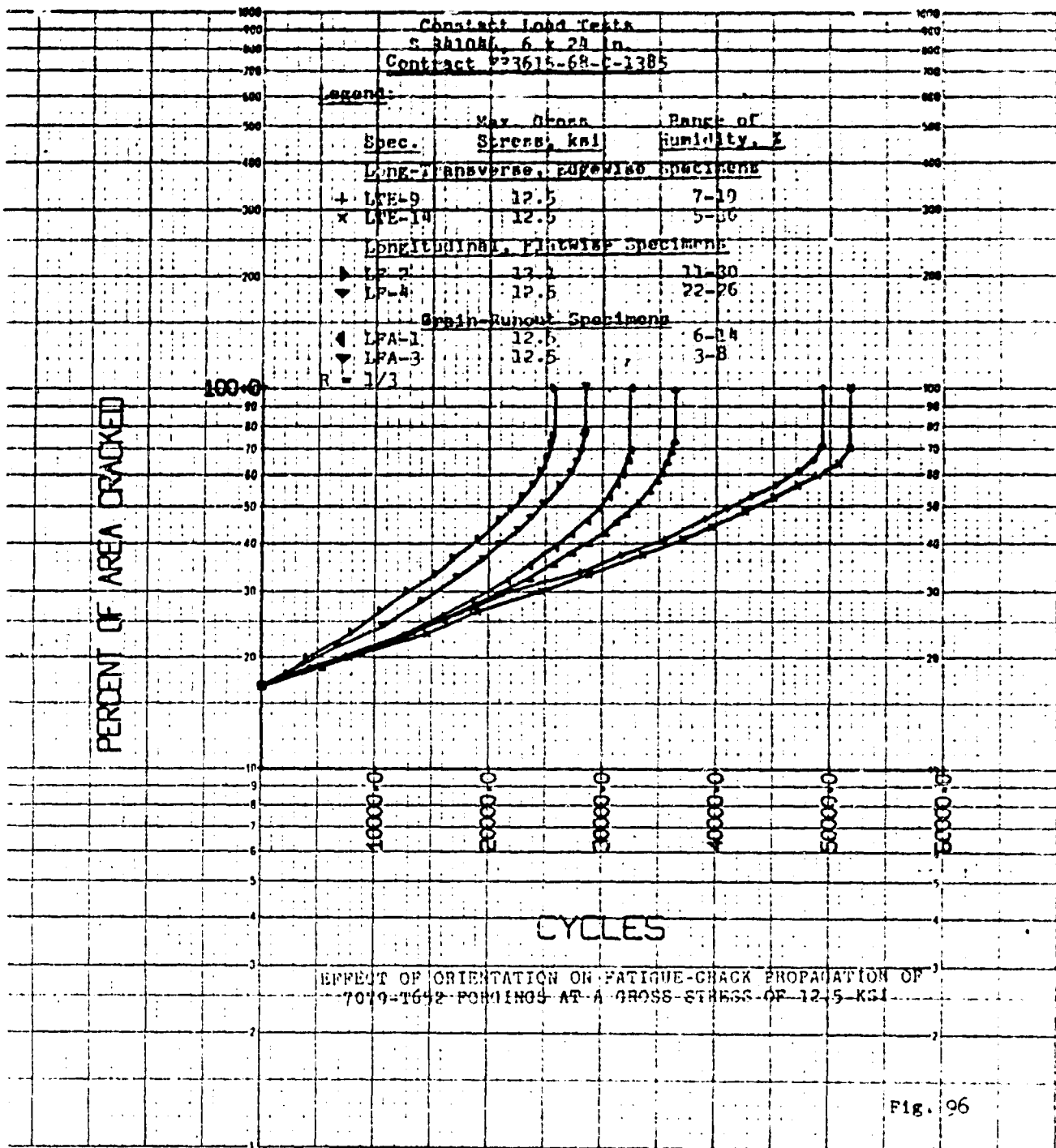
Fig. 21



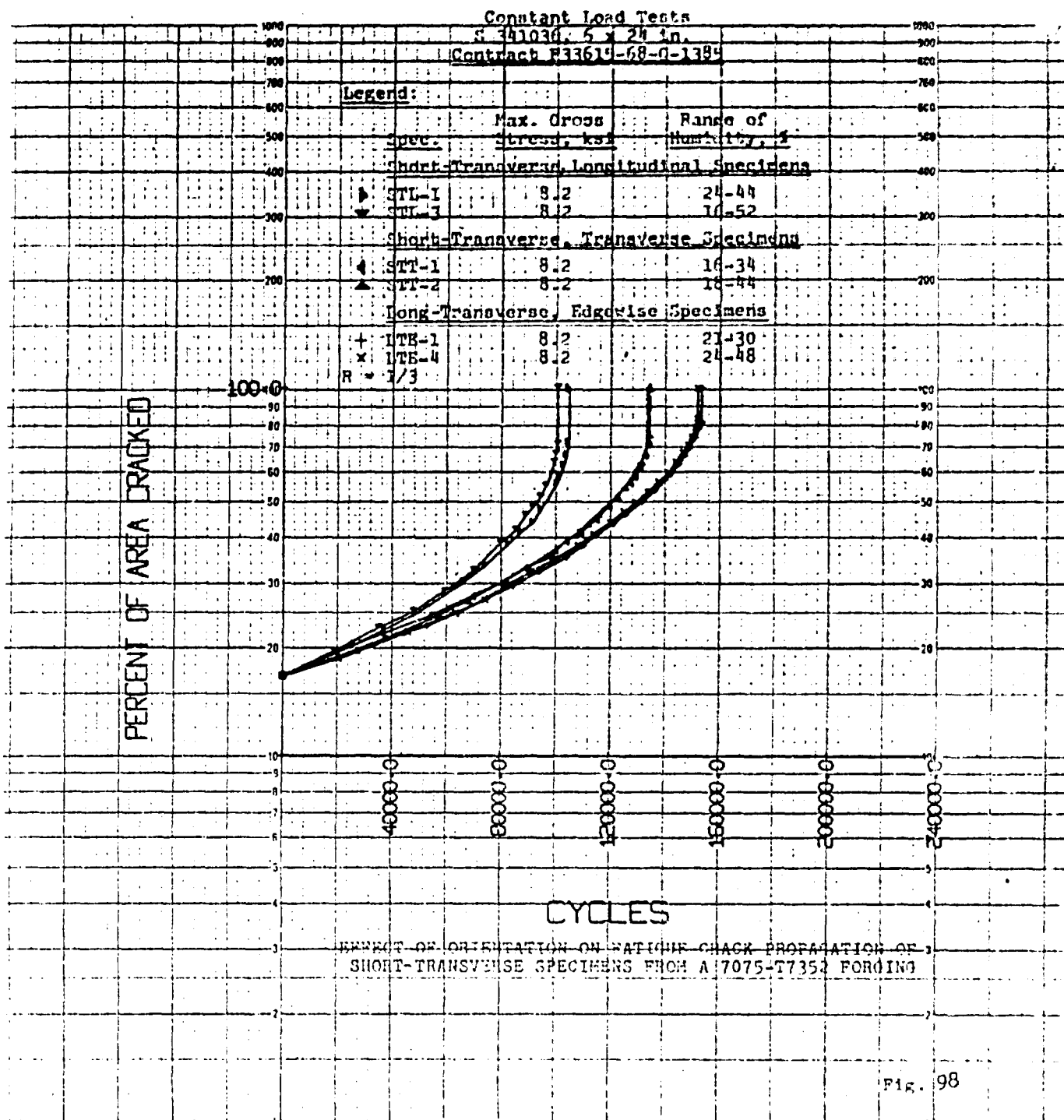
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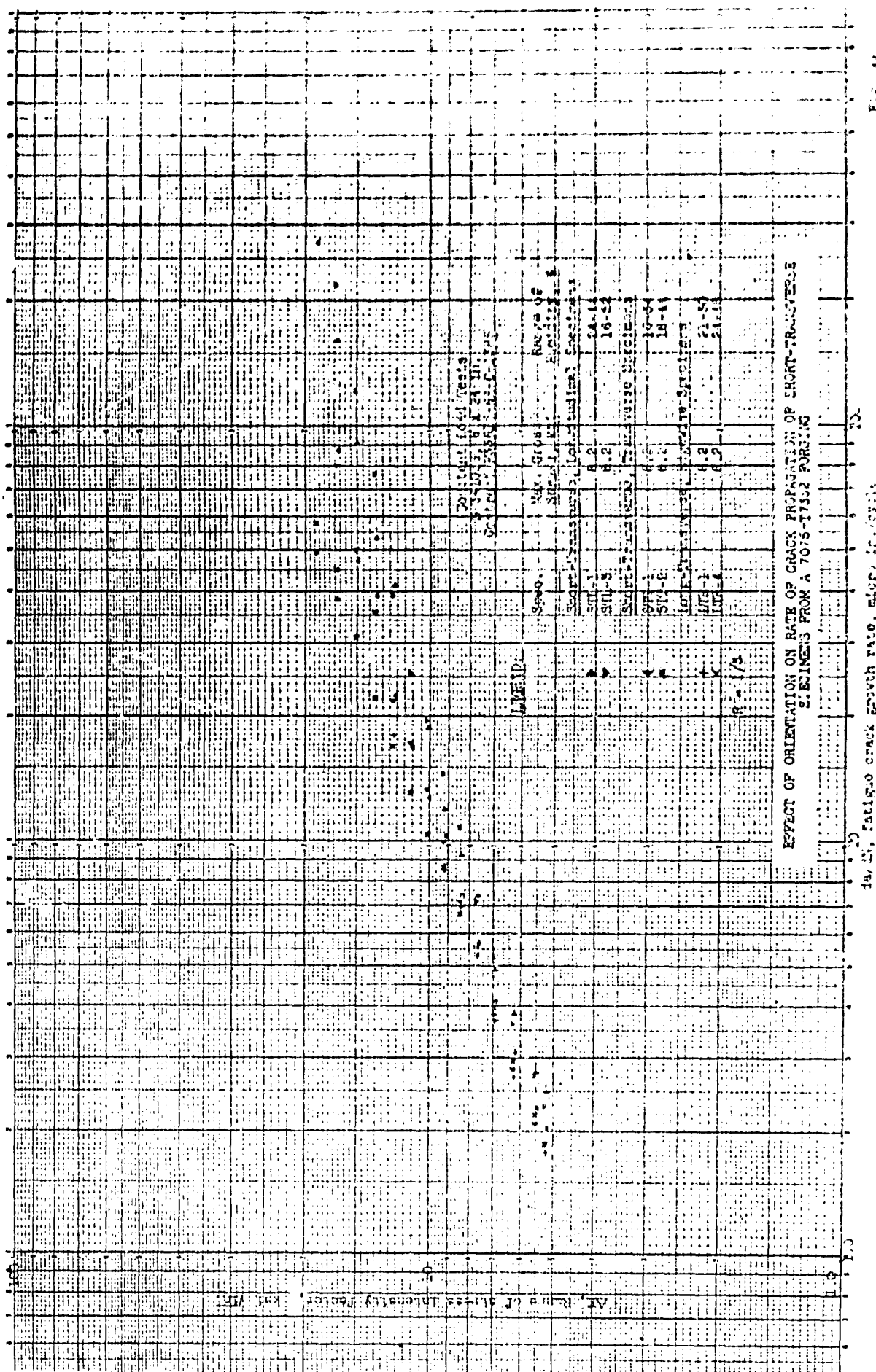
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EFFECT OF ORIENTATION ON RATE OF CRACK PROPAGATION OF SHORT-TRANSVERSE SPECIMENS FROM A 70'S-T532 BORING

19, 21, fatigue crack growth rate, micro in./cycle

Fig. 10

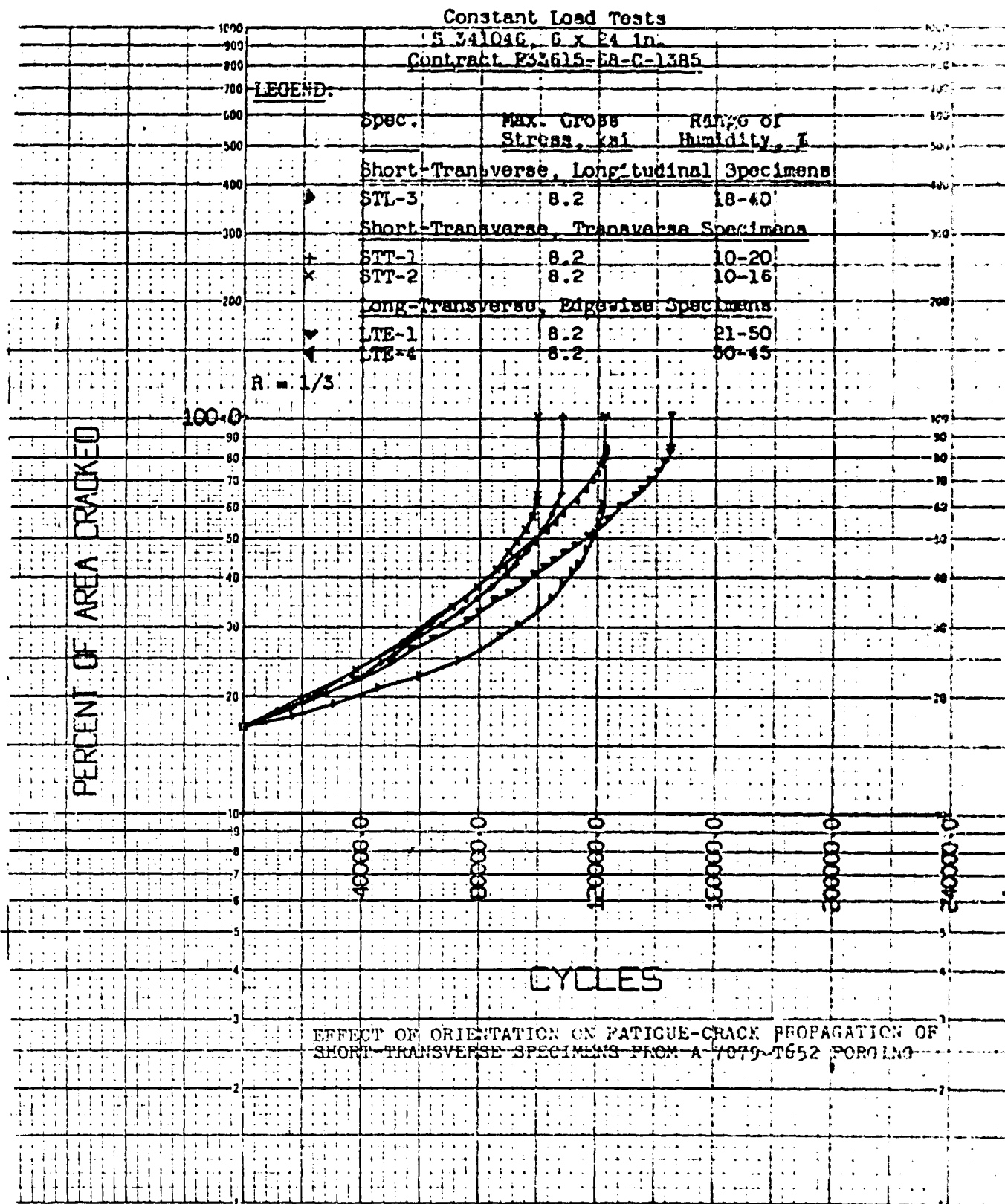


Fig. 100

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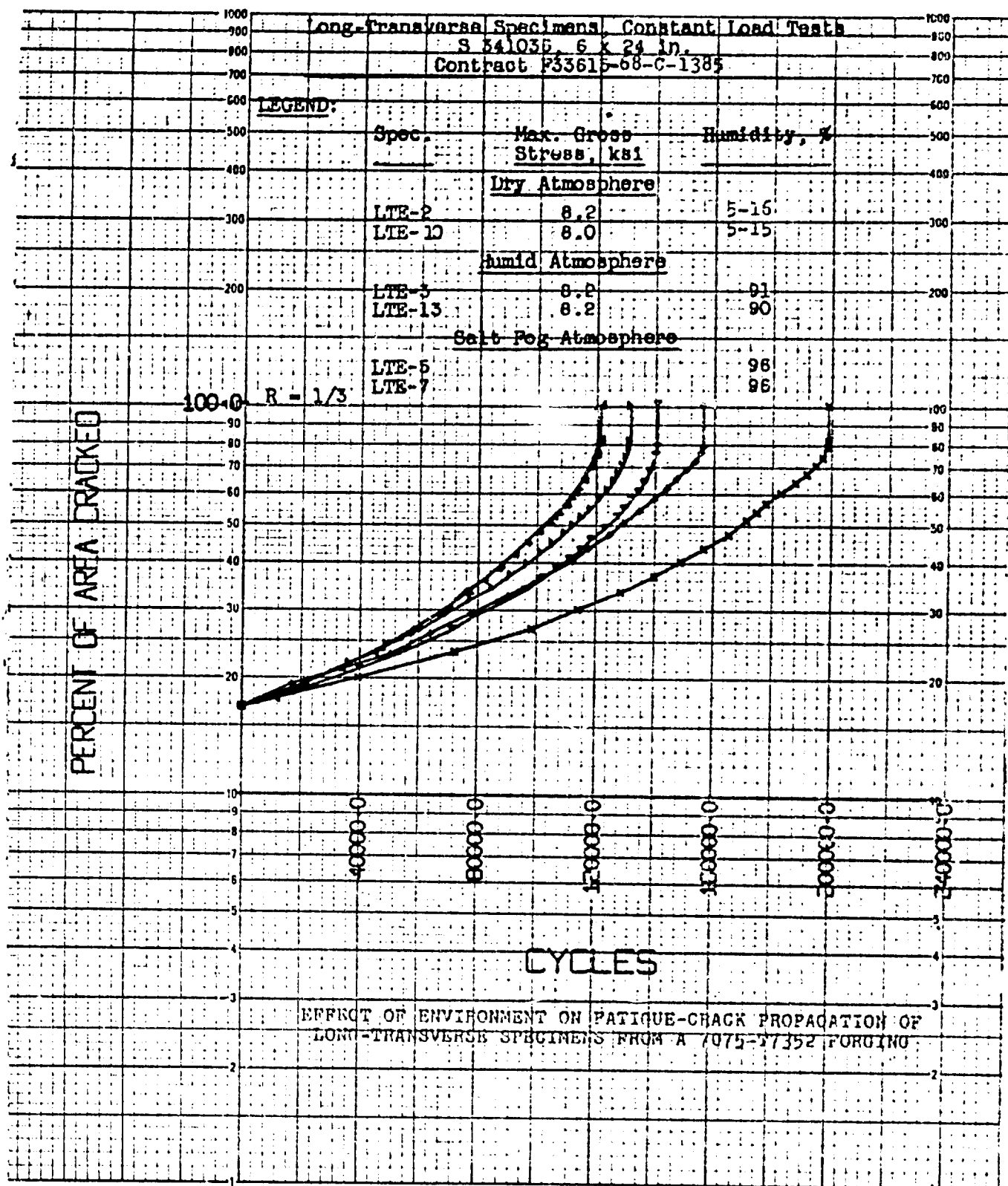
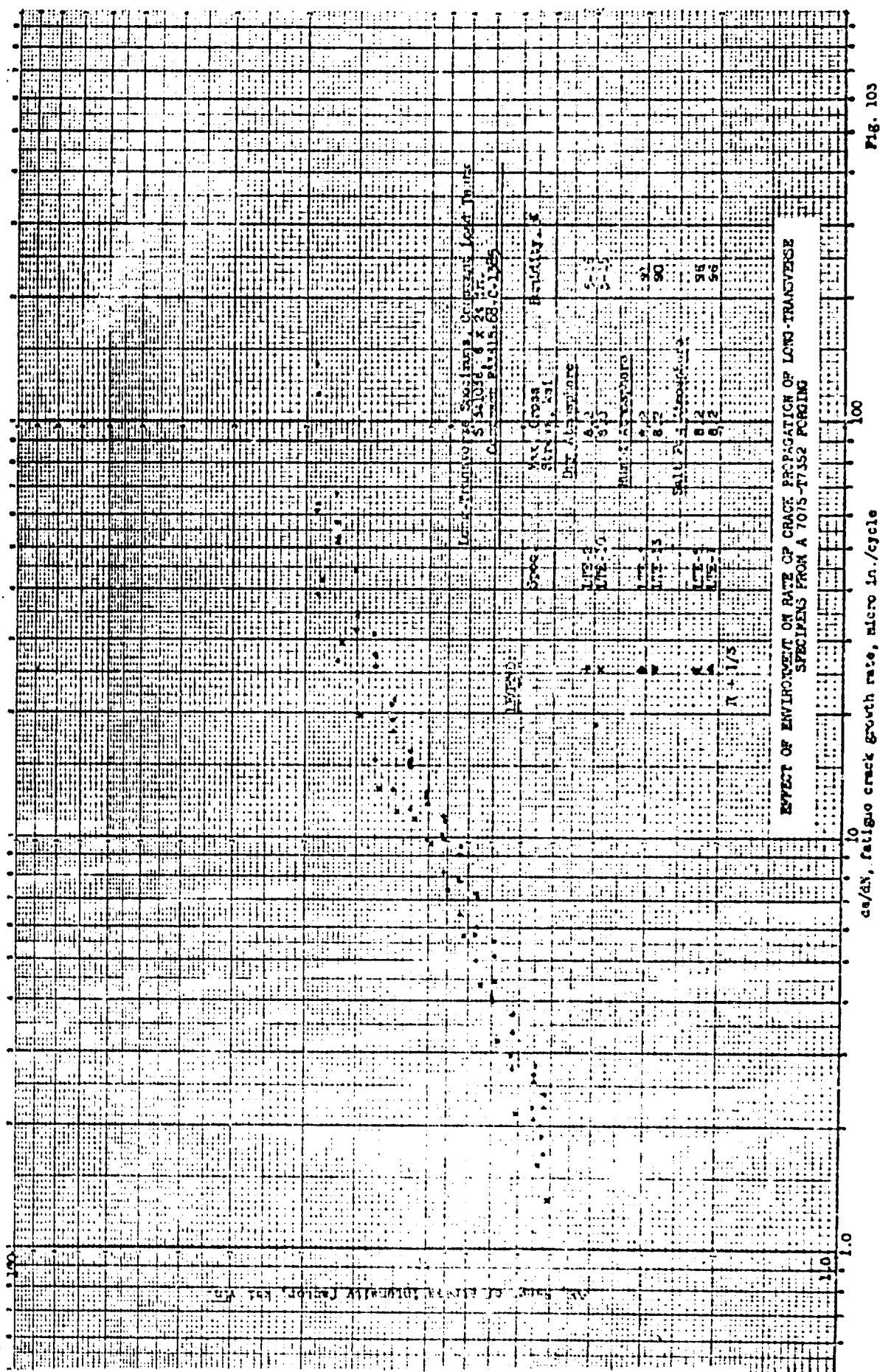
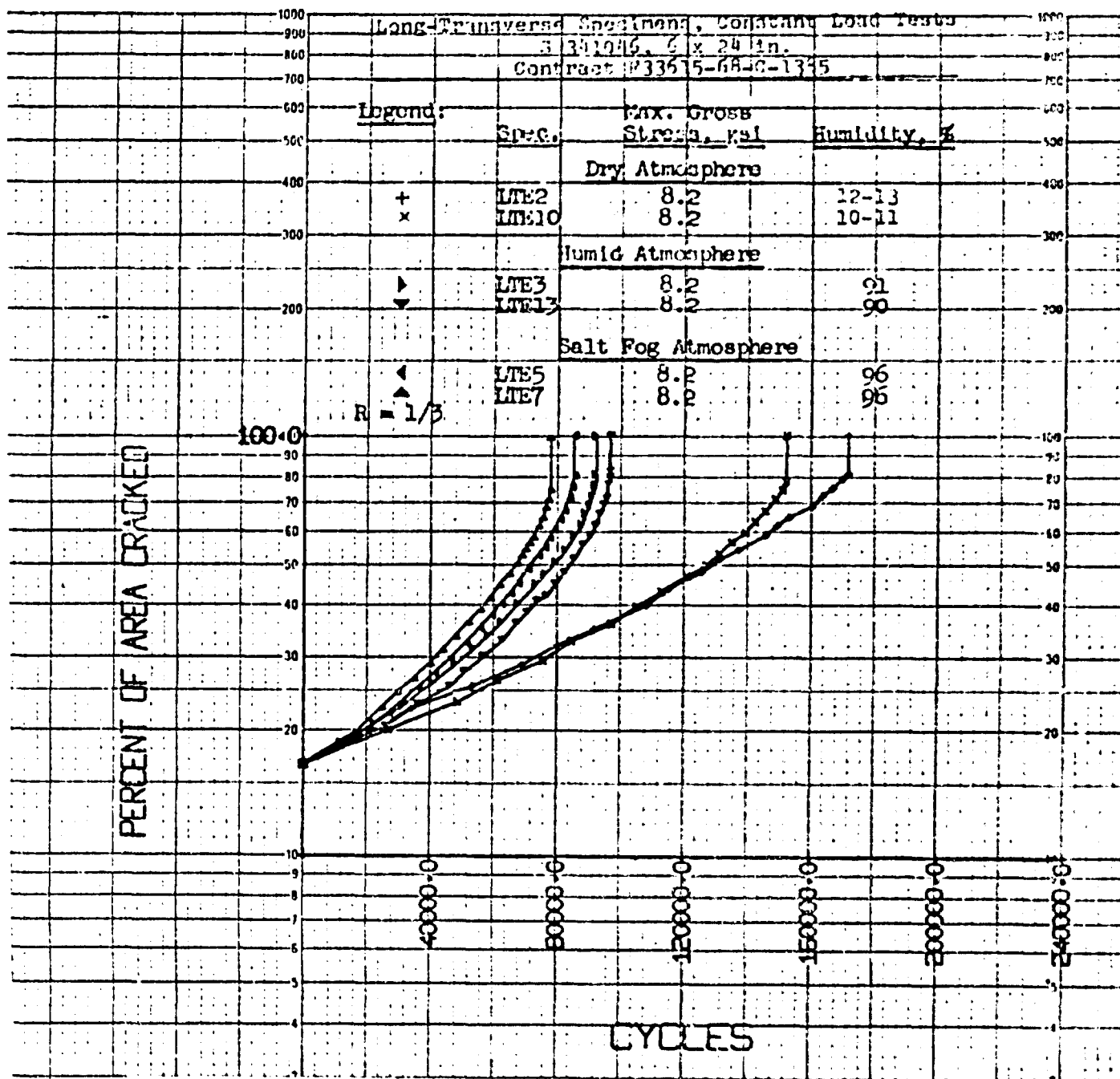


Fig. 161

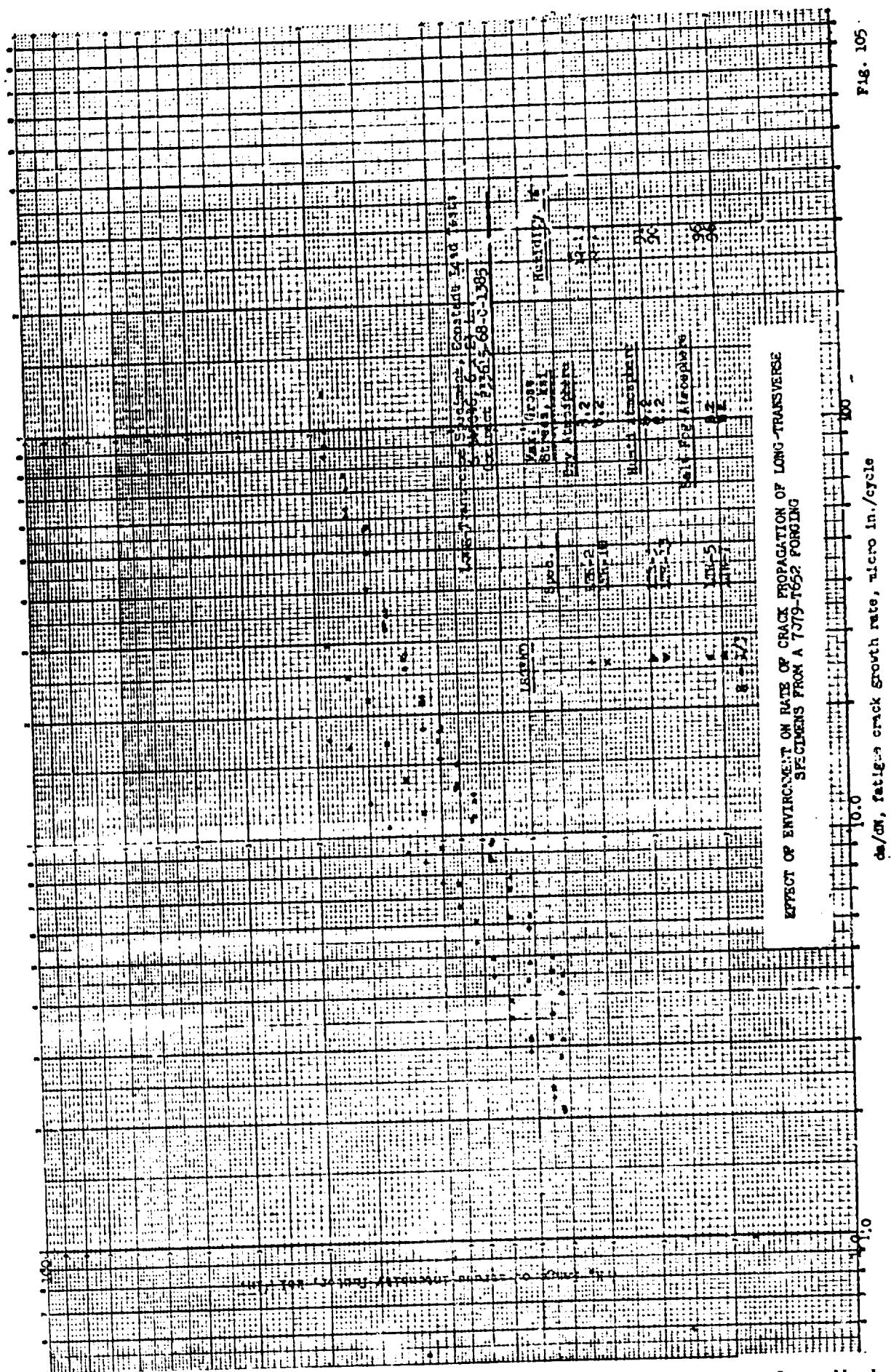
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EFFECT OF ENVIRONMENT ON FATIGUE-CRACK PROPAGATION OF LONG-TRANSVERSE SPECIMENS FROM A 7079-T652 FORGING

Fig. 104



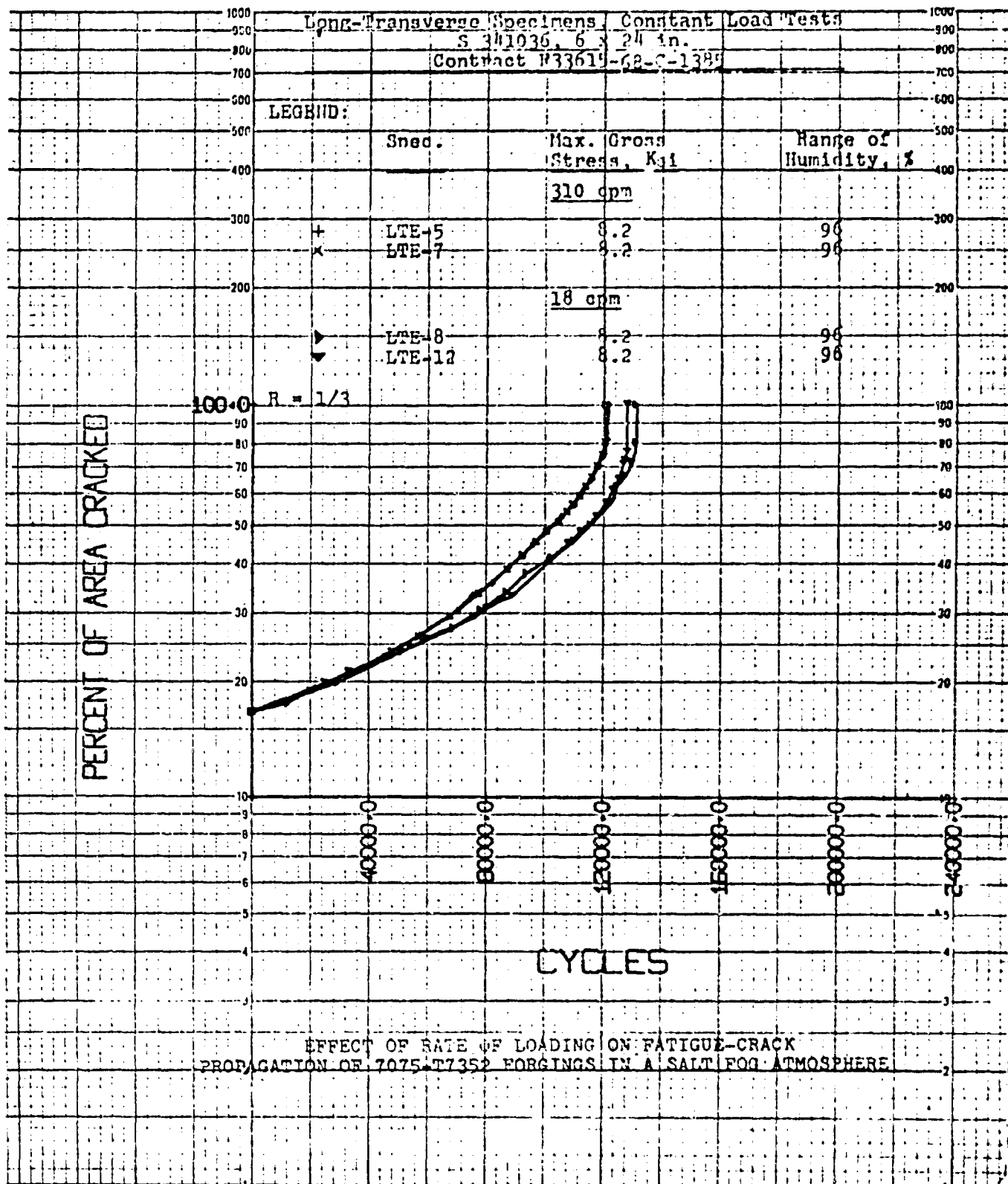
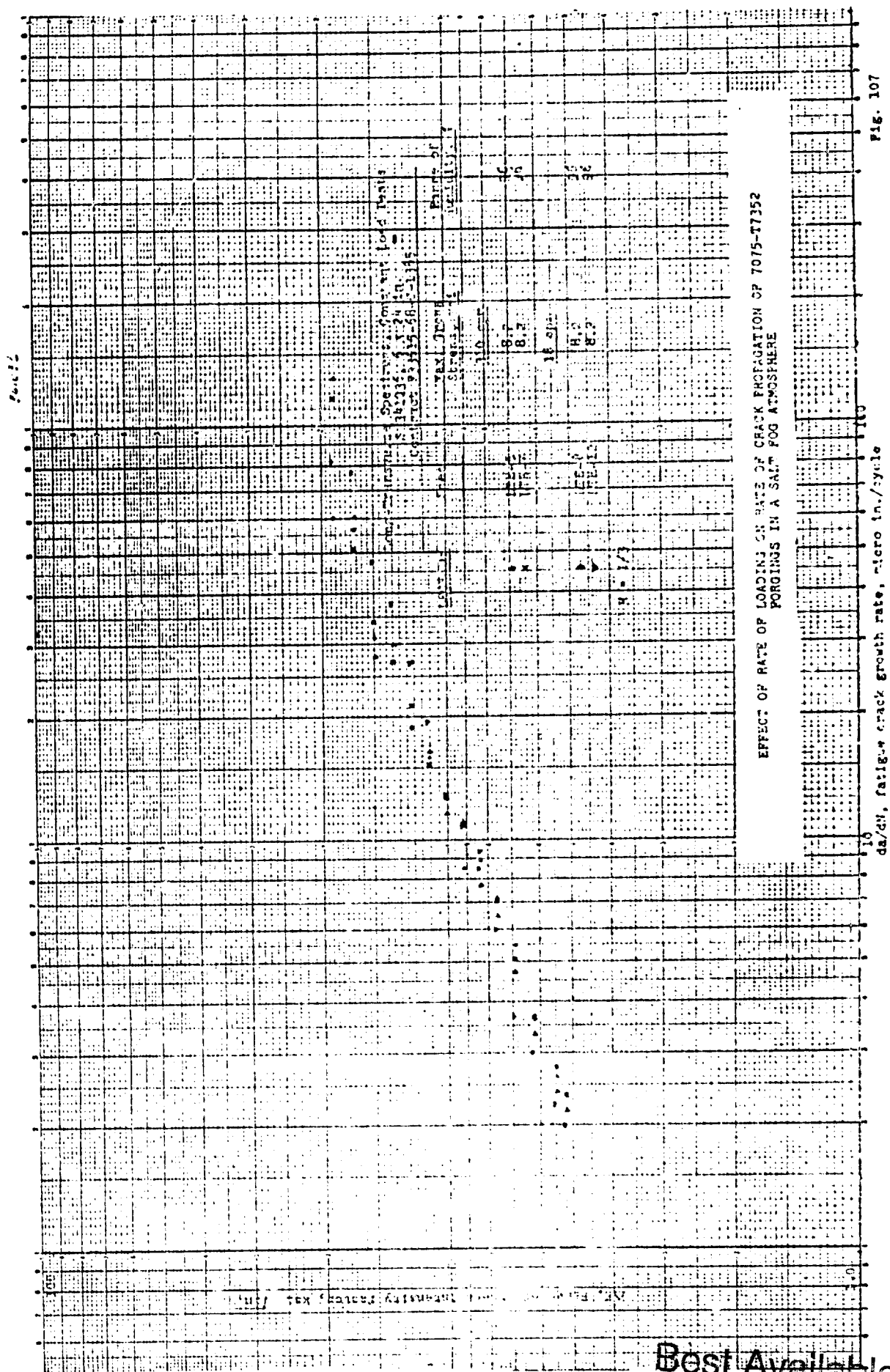


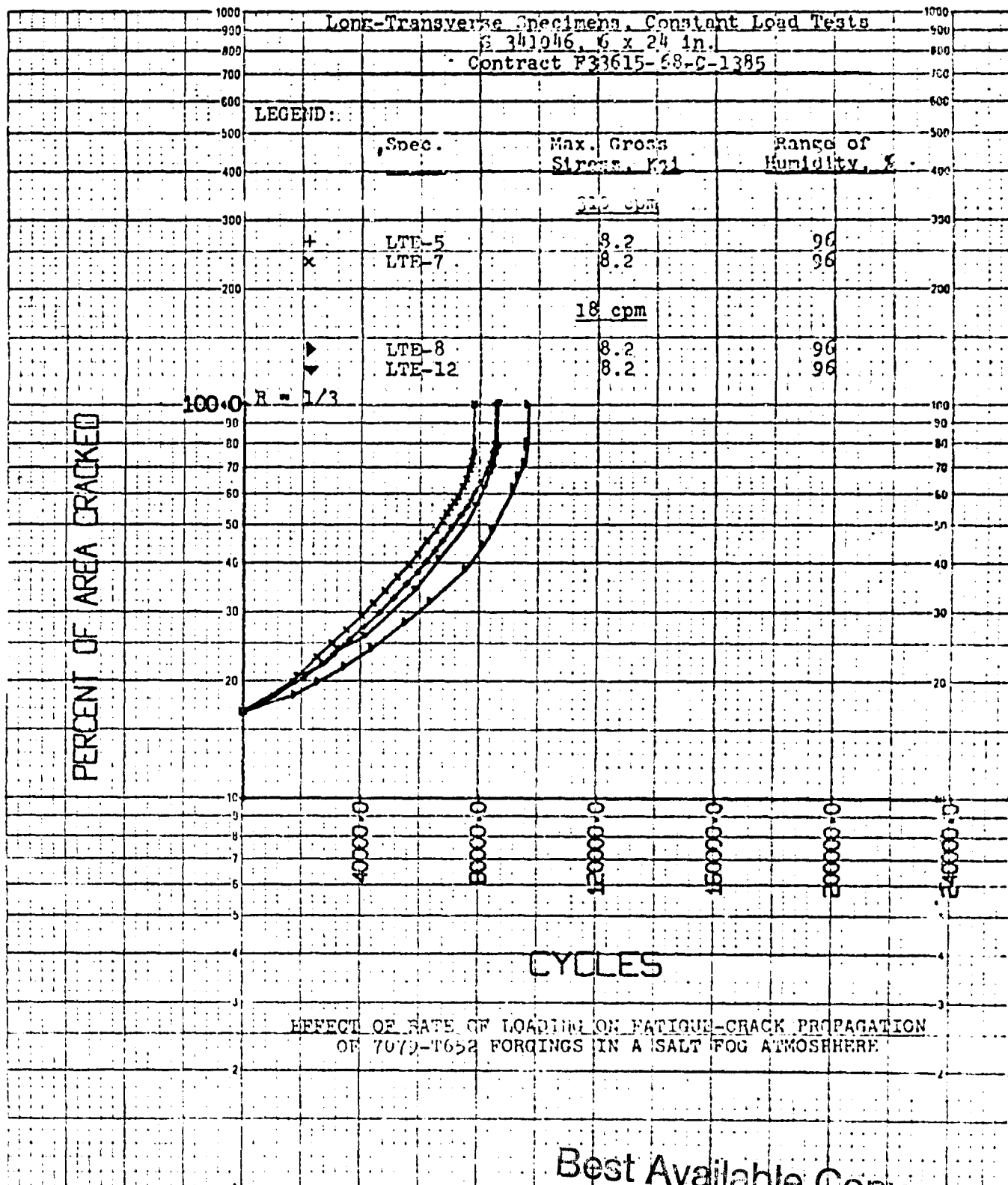
Fig. 106

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PLB. 107

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Fig. 108

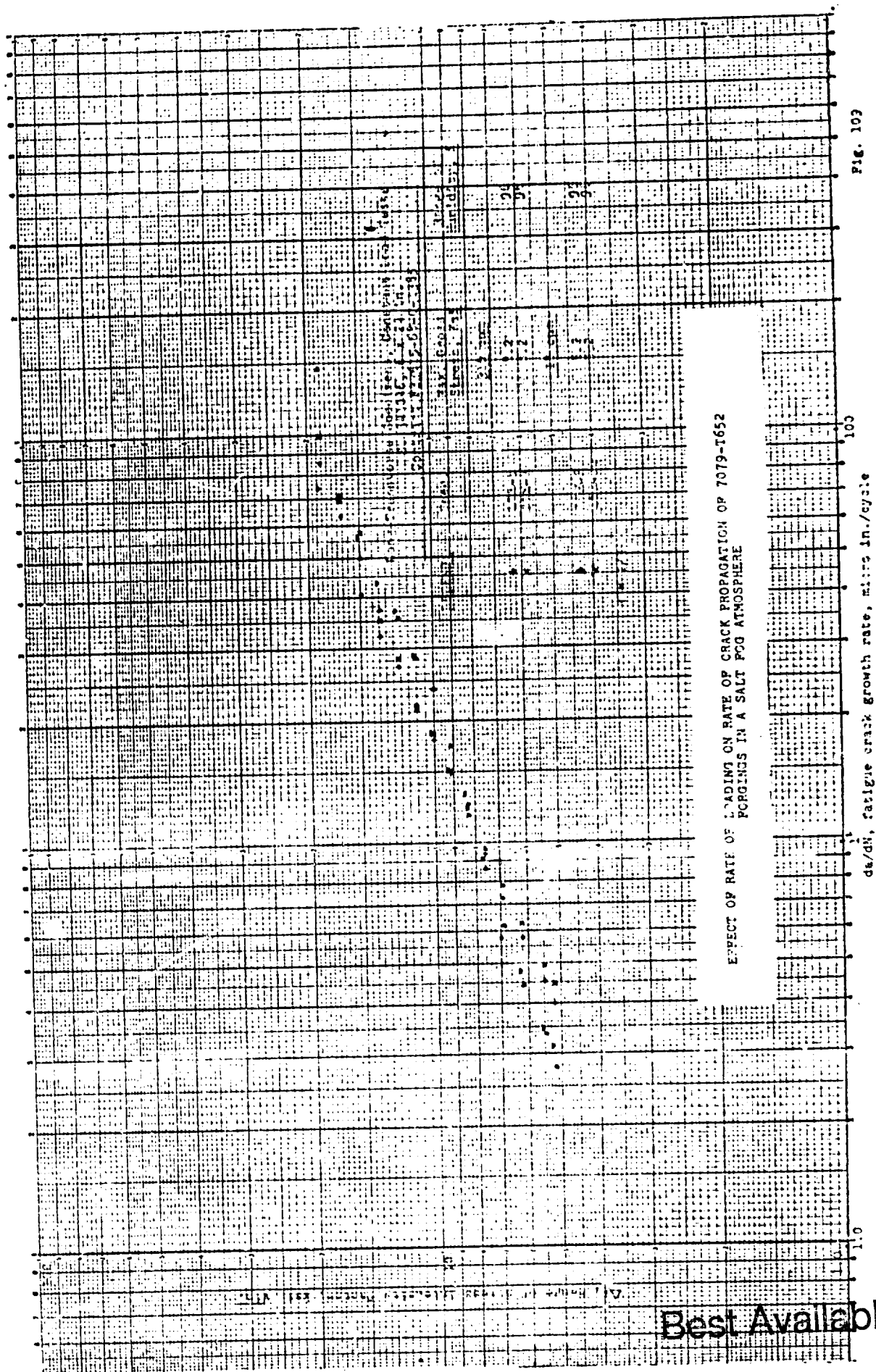
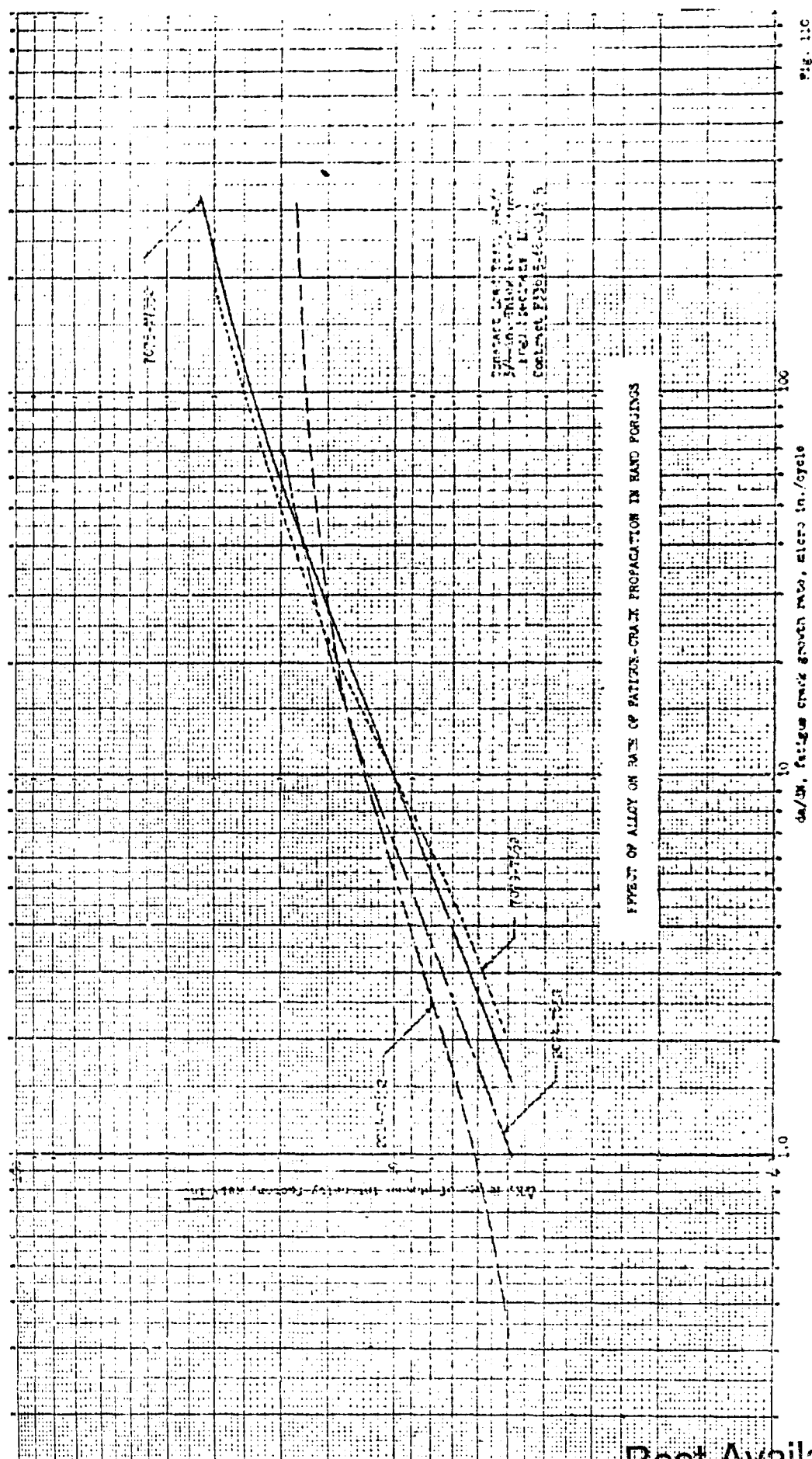


Fig. 103

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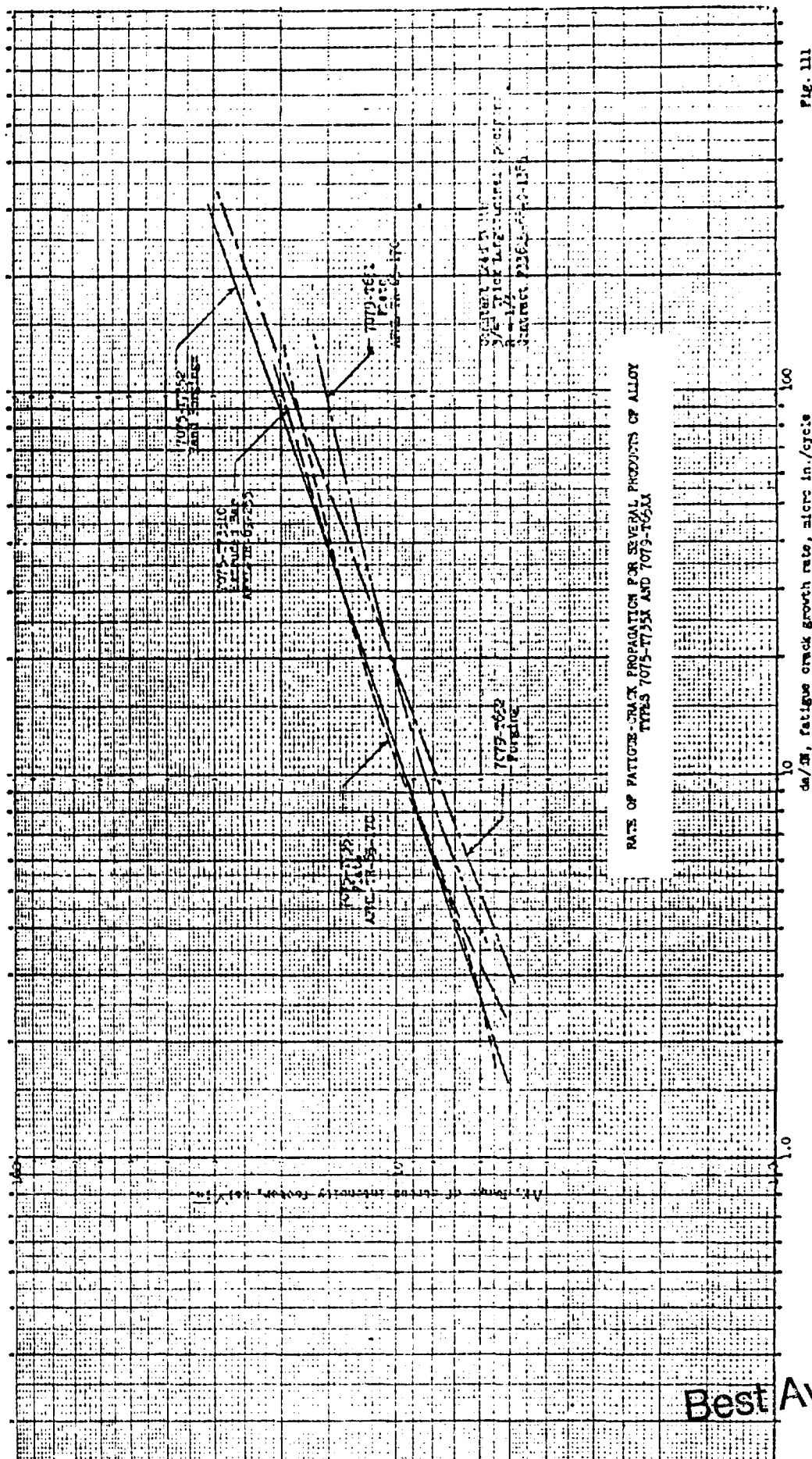


TABLE I
DESCRIPTION AND CHEMICAL COMPOSITIONS OF STRESS-RELIEVED ALUMINUM ALLOY HARD PEGGINGS
(F33615-68-C-1385)

Alloy and Temper	Sample		Element, Percent							
	Cross-Section Size, in.	Number	Cu	Si	Fe	Mn	Mg	Zn	Cr	Ti
2014-T652	2x8	341007	4.41	0.97	0.24	0.73	0.50	0.14	0.01	0.04
	3x12	341008	4.47	0.98	0.22	0.70	0.50	0.11	0.01	0.04
	4x8	341009	4.27	0.89	0.20	0.69	0.57	0.10	0.01	0.04
	4x16	341010	4.58	0.94	0.22	0.72	0.69	0.08	0.01	0.04
	5x5	341011	4.27	0.89	0.20	0.69	0.57	0.10	0.01	0.04
	5x10	341012	4.30	0.91	0.22	0.68	0.56	0.08	0.01	0.04
	5x20	341013	4.36	0.93	0.24	0.70	0.40	0.08	0.01	0.04
	6x6	341014	4.27	0.89	0.20	0.69	0.57	0.10	0.01	0.04
	6x12	341015	4.53	0.94	0.25	0.74	0.53	0.12	0.02	0.05
	6x24	341016	4.41	1.00	0.22	0.69	0.37	0.09	0.01	0.04
	Limits*		3.9-5.0	0.50-1.2	1.0	0.40-1.2	0.20-0.8	0.25	0.10	0.15
2024-T652	2x8	341017	4.63	0.11	0.15	0.53	1.54	0.07	0.00	0.02
	3x12	341018	4.63	0.11	0.15	0.53	1.54	0.07	0.00	0.02
	4x8	341019	4.51	0.13	0.19	0.57	1.72	0.24	0.02	0.03
	4x16	341020	4.51	0.11	0.17	0.57	1.72	0.07	0.01	0.03
	5x5	341021	4.51	0.13	0.19	0.57	1.72	0.24	0.02	0.03
	5x10	341022	4.48	0.10	0.12	0.52	1.52	0.05	0.01	0.03
	5x20	341023	4.51	0.13	0.19	0.57	1.72	0.24	0.02	0.03
	6x6	341024	4.35	0.12	0.16	0.57	1.54	0.07	0.00	0.02
	6x12	341025	4.48	0.10	0.12	0.52	1.52	0.05	0.01	0.03
	6x24	341026	4.56	0.12	0.14	0.65	1.69	0.08	0.00	0.03
	Limits†		3.8-4.9	0.50	0.50	0.30-0.9	1.2-1.8	0.25	0.10	..
7075-T7352	2x8	341027	1.60	0.10	0.13	0.02	2.50	5.66	0.13	0.03
	3x12	341028	1.52	0.11	0.14	0.02	2.29	5.45	0.20	0.03
	4x8	341029	1.48	0.07	0.16	0.02	2.54	5.77	0.20	0.03
	4x16	341030	1.52	0.12	0.16	0.02	2.53	5.62	0.19	0.03
	5x5	341031	1.50	0.07	0.13	0.02	2.50	5.67	0.20	0.03
	5x10	341032	1.53	0.11	0.14	0.03	2.57	5.82	0.19	0.03
	5x20	341033	1.48	0.12	0.16	0.02	2.60	5.73	0.20	0.04
	6x6	341034	1.71	0.12	0.20	0.04	2.42	5.44	0.13	0.03
	6x12	341035	1.65	0.17	0.20	0.04	2.45	5.48	0.20	0.03
	6x24	341036	1.40	0.10	0.14	0.02	2.60	5.68	0.19	0.03
	Limits*		1.2-2.0	0.50	0.7	0.30	2.1-2.9	5.1-6.1	0.18-0.40	0.20
7079-T652	2x8	341037	0.76	0.11	0.18	0.18	3.48	4.57	0.14	0.03
	3x12	341038	0.76	0.11	0.18	0.18	3.48	4.57	0.14	0.03
	4x8	341039	0.70	0.10	0.16	0.19	3.66	4.74	0.14	0.04
	4x16	341040	0.63	0.08	0.14	0.18	3.51	4.40	0.15	0.03
	5x5	341041	0.70	0.08	0.16	0.17	3.48	4.42	0.14	0.03
	5x10	341042	0.72	0.10	0.15	0.19	3.45	4.45	0.15	0.03
	5x20	341043	0.80	0.11	0.18	0.18	3.45	4.54	0.15	0.03
	6x6	341044	0.65	0.09	0.17	0.17	3.30	4.46	0.14	0.04
	6x12	341045	0.70	0.10	0.16	0.19	3.66	4.74	0.14	0.04
	6x24	341046	0.72	0.10	0.16	0.17	3.55	4.60	0.15	0.02
	Limits*		0.40-0.8	0.30	0.40	0.10-0.30	2.9-3.7	3.8-4.8	0.10-0.25	0.10

* Federal Specification QQ-A-367g and Mil. Spec. MTL-A-22771C

† The Aluminum Association, "Aluminum Standards and Data", April 1968

} Maximum unless a range is shown.

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TABLE II

MECHANICAL PROPERTIES OF STRESS-RELIEVED 2014-T652 ALUMINUM ALLOY HAND FORGINGS
(F33615-68-C-1385)

SAMPLE CROSS- SECTIONAL NUMBER DIREC- TION, IN.	TENSILE	ELONG. IN 2 IN. OR 4D, %	RED. OF AREA, %	COMP. YIELD STRESS,* PSI	SHEAR ULT. STRESS, PSI	BEARING- EDGEWISE		
						ULT. STRESS, PSI	YIELD STRESS, PSI	e/D=2.0
								e/D=1.5
2x8 341007	L	11.5	30	69 200	44 200	101 000	122 500	87 800
	LT	6.0	9	70 300	43 600	101 000	130 100	89 300
	ST	9.4	34	68 700	---	---	---	---
2x12 341009	L	10.5	28	66 400	42 200	102 300	132 500	89 800
	LT	7.5	12	69 800	41 800	97 100	126 800	88 600
	ST	5.0	7	69 700	41 300	---	---	---
4x8 341009	L	12.5	29	66 400	40 400	89 300	123 700	85 500
	LT	7.5	12	65 100	40 600	90 700	121 700	87 200
	ST	2.5	4	69 300	39 900	---	---	---
4x16 341010	L	11.5	26	61 400	38 700	106 800	123 900	86 200
	LT	6.0	8	61 500	38 800	101 900	114 900	86 500
	ST	6.0	6	61 900	38 900	---	---	---
5x5 341011	L	12.0	28	65 300	41 800	85 200	117 300	85 900
	LT	4.0	5	62 500	40 700	87 200	118 400	85 900
	ST	2.0	4	66 500	41 200	---	---	---
5x10 341012	L	11.5	27	63 000	40 600	93 400	117 400	32 700
	LT	5.5	9	61 700	40 300	88 700	123 400	83 600
	ST	3.0	6	65 300	38 700	---	---	---
5x10 341013	L	11.5	24	61 200	38 800	90 100	113 500	79 000
	LT	5.0	7	63 500	38 400	86 600	117 500	79 000
	ST	3.7	7	62 800	37 300	---	---	---
6x6 341014	L	12.0	31	64 000	42 400	97 400	114 200	86 700
	LT	3.5	5	60 400	40 700	89 300	121 100	83 900
	ST	2.8	1	65 700	40 500	---	---	---
6x12 341015	L	11.0	27	60 300	40 200	91 100	120 100	81 600
	LT	3.5	6	61 900	38 600	87 700	119 000	80 600
	ST	3.5	2	61 900	38 700	---	---	---
6x24 341016	L	9.5	19	57 900	42 500	89 500	118 100	81 200
	LT	6.0	6	62 400	38 800	86 300	117 900	80 000
	ST	6.0	14	59 300	39 000	---	---	---

* OFFSET EQUALS 0.2 PER CENT

† OFFSET EQUALS 2 PER CENT OF PIN DIAMETER

‡ SPECIMENS AND FIXTURES CLEANED ULTRASONICALLY
§ L, LONGITUDINAL; LT, LONG TRANSVERSE; ST, SHORT TRANSVERSE

TABLE III

MECHANICAL PROPERTIES OF STRESS-RELIEVED 2024-T852 ALUMINUM ALLOY HAND FORGINGS
(F33615-68-C-1385)

SAMPLE CROSS- SECTIONAL NUMBER, DIREC- TION, SIZE, IN.	TENSILE				RED. OF AREA, %	COMP. YIELD STRESS,* PSI	SHEAR ULT. STRESS, PSI	BEARING† EDGEWISE			
	ULT. STR., PSI	YIELD STRESS,* PSI	ELONG. IN 2 IN. OR 4D, %	ULT. STRESS, PSI				YIELD STRESS, PSI	e/D=1.5 e/D=2.0		
										e/D=1.5 e/D=2.0	
2X 8 341017	L	70 800	64 600	7.0	28	70 200	42 700	97 700	133 100	95 500	116 300
	LT ST	72 300 67 400	63 800 64 000	9.0 1.6	17 3	72 700 74 600	41 800 ---	94 500	125 900	89 500	114 200
3X12 341018	L	72 200	66 700	5.5	18	70 000	42 400	94 900	123 400	93 700	109 300
	LT ST	73 700 68 100	69 000 64 400	3.0 1.0	---	75 800 72 200	42 000 40 200	94 500	126 100	93 500	113 300
4X 8 341019	L	68 900	61 100	9.0	26	62 200	40 500	91 900	117 900	82 500	100 500
	LT ST	70 400 65 700	63 200 57 200	5.0 3.2	8 4	63 500 65 500	39 500 38 600	88 800	119 400	82 800	101 000
4X10 341020	L	71 400	65 400	6.5	23	66 600	41 100	92 100	124 000	87 400	104 800
	LT ST	71 900 70 100	65 200 60 600	5.0 2.4	8 6	71 500 70 200	40 200 39 900	91 500	127 100	90 500	108 200
5X 5 341021	L	69 000	62 000	8.5	29	63 400	40 800	93 500	125 200	89 900	105 100
	LT ST	68 400 66 500	62 100 56 000	3.0 2.8	1 4	63 100 64 700	40 700 39 600	89 100	121 600	84 400	101 100
5X10 341022	L	68 400	61 000	8.5	25	63 000	40 300	89 100	114 300	87 700	96 800
	LT ST	69 100 66 100	61 500 59 800	6.0 1.5	8 4	64 800 68 400	39 700 38 800	89 500	120 200	85 100	99 600
5X20 341023	L	65 200	55 100	9.0	16	57 800	38 800	83 600	112 600	79 300	94 400
	LT ST	62 800 63 200	56 700 54 500	3.0 3.0	4 3	60 700 59 400	38 000 37 000	84 900	114 600	82 500	98 000
6X 6 341024	L	69 100	61 600	9.0	28	63 700	41 500	95 300	123 900	89 800	102 200
	LT ST	68 800 69 400	60 600 58 500	6.5 2.3	10 3	61 500 67 600	40 600 39 800	92 000	123 200	86 900	102 700
6X12 341025	L	67 000	58 700	8.0	22	59 700	39 600	84 700	117 100	82 400	190 500
	LT ST	67 400 65 300	60 200 55 100	3.2 2.9	4 3	63 500 63 000	38 400 37 400	85 700	113 400	81 400	95 700
6X24 341026	L	64 300	56 100	7.5	20	56 000	37 100	80 900	111 700	80 500	95 000
	LT ST	65 400 58 000	57 800 53 900	5.0 1.0	8 1	57 500 58 000	36 100 34 900	84 300	98 600	79 900	90 600

* OFFSET EQUALS 0.2 PER CENT

† OFFSET EQUALS 2 PER CENT OF PIN DIAMETER

SPECIMENS AND FEATURES CLEANED ULTRASONICALLY

§ L, LONGITUDINAL; LT, LONG TRANSVERSE; ST, SHORT TRANSVERSE

TABLE IV

MECHANICAL PROPERTIES OF STRESS-RELIEVED 7075-T7352 ALUMINUM ALLOY HAND FORGINGS
(F33615-68-C-1385)

SAMPLE CROSS- SECTIONAL NUMBER DIREC- TION\$	TENSILE			COMP.	SHEAR	BEARING# EDGEWISE		
	ULT. STRESS, PSI	YIELD STRESS,* PSI	ELONG. IN 2 IN. OR 4D, %			YIELD STRESS, PSI	ULT. STRESS, PSI	YIELD STRESS,† PSI
						e/D=1.5	e/D=2.0	e/D=1.5 e/D=2.0
2X 8	L	73 700	65 300	13.5	43	69 300	111 900	93 700
	LT	74 900	65 300	13.5	29	68 800	110 600	92 700
	ST	73 100	61 800	6.3	9	69 300	---	---
3X12	L	76 400	66 200	11.5	27	66 900	103 100	89 000
	LT	71 400	59 300	8.0	11	65 300	98 300	89 800
	ST	73 000	60 800	4.2	5	69 300	---	---
4X 8	L	68 400	57 300	15.0	42	60 200	95 100	83 500
	LT	65 100	53 000	10.0	17	57 600	98 500	81 400
	ST	64 500	50 600	6.4	10	57 500	---	---
4X16	L	70 000	59 500	13.0	34	59 600	95 300	82 900
	LT	67 600	55 200	12.0	25	59 700	94 200	82 600
	ST	64 800	52 500	6.4	7	58 600	---	---
5X 5	L	68 400	56 700	14.0	39	59 400	104 400	84 300
	LT	67 200	55 100	10.5	20	56 600	98 000	83 500
	ST	63 800	51 700	4.0	6	59 500	---	---
5X10	L	65 200	52 700	14.0	37	53 400	95 900	82 300
	LT	64 000	51 400	9.0	17	53 800	97 700	80 100
	ST	64 200	49 500	7.0	9	58 000	---	---
5X20	L	64 800	52 500	14.5	35	52 200	94 100	76 800
	LT	64 000	50 700	11.0	25	54 400	91 500	77 100
	ST	63 700	49 300	6.5	10	54 900	---	---
6X 6	L	62 400	51 100	15.0	44	54 000	99 300	82 100
	LT	63 800	52 100	10.0	23	53 000	97 400	81 600
	ST	63 400	49 700	8.0	14	55 300	---	---
6X12	L	63 300	52 600	12.5	34	50 300	98 700	80 000
	LT	63 400	50 900	9.0	14	51 200	95 000	79 400
	ST	60 800	49 800	6.5	9	54 400	---	---
6X24	L	65 800	55 400	12.5	34	51 400	93 700	76 000
	LT	62 100	50 300	9.5	16	52 300	85 600	71 600
	ST	62 600	49 200	6.5	10	53 800	---	---

* OFFSET EQUALS 0.2 PER CENT

† OFFSET EQUALS 2 PER CENT OF PIN DIAMETER

SPECIMENS AND FIBURES CLEANED ULTRASONICALLY

\$ L, LONGITUDINAL; LT, LONG TRANSVERSE; ST, SHORT TRANSVERSE

TABLE V

MECHANICAL PROPERTIES OF STRESS-RELIEVED 7079-T6S2 ALUMINUM ALLOY HAND FORGINGS
(F33615-68-C-1385)

SAMPLE CROSS- SECTIONAL NUMBER DIREC- TION §	SIZE, IN.	TENSILE			RED. OF AREA, %	COMP. YIELD STRESS,* PSI	SHEAR ULT. STRESS, PSI	REAPING ‡				
		ULT. STRESS. PSI	YIELD STRESS,* PSI	ELONG. IN 2 IN. OR 4D, %				EDGEWISE		PSI		
								ULT. STRESS, PSI	e/D=1.5	YIELD STRESS, PSI	e/D=2.0	e/D=1.5
2X 8	341037	L	78 600	71 000	14.0	34	73 300	48 700	115 100	154 700	99 100	114 400
		LT	76 100	64 900	12.0	20	73 200	46 500	114 500	149 100	98 000	113 400
		ST	76 000	63 700	7.8	10	74 200	---	---	---	---	---
3X12	341038	L	77 500	68 700	13.0	26	71 300	46 400	113 200	148 800	94 800	112 900
		LT	76 100	65 700	12.0	26	70 700	46 100	116 800	149 100	97 900	114 600
		ST	73 700	61 400	8.0	11	71 800	45 400	---	---	---	---
4X 8	341039	L	78 800	69 600	11.0	21	72 800	48 900	111 600	148 300	99 400	115 200
		LT	77 500	66 500	11.5	24	72 900	48 200	117 100	148 700	102 300	117 200
		ST	74 300	62 800	5.0	6	73 200	47 300	---	---	---	---
4X16	341040	L	77 900	68 000	12.0	22	70 100	46 600	113 600	145 900	95 200	110 300
		LT	74 600	63 000	9.5	18	66 800	45 700	107 500	144 400	94 010	105 700
		ST	74 000	62 900	7.9	17	70 600	44 900	---	---	---	---
5X 5	341041	L	75 600	67 600	13.0	27	69 700	47 900	112 600	149 900	94 400	108 900
		LT	72 900	63 000	8.5	12	67 000	45 900	105 200	143 600	92 100	107 800
		ST	71 300	59 500	7.0	10	68 400	46 300	---	---	---	---
5X10	341042	L	76 100	68 000	13.0	27	68 800	45 700	108 200	140 900	92 800	107 000
		LT	74 100	62 600	10.5	19	69 300	45 900	108 300	141 300	94 300	109 100
		ST	73 000	61 300	5.5	5	72 200	44 400	---	---	---	---
5X20	341043	L	76 900	65 600	13.0	24	67 000	46 200	104 600	135 900	91 800	106 400
		LT	73 300	61 400	11.0	19	65 700	46 400	103 300	136 900	89 800	105 400
		ST	71 300	58 300	6.0	7	68 300	44 000	---	---	---	---
6X 6	341044	L	73 600	63 800	15.0	37	68 900	48 400	112 200	148 100	95 600	115 400
		LT	72 600	61 400	9.0	16	69 700	47 900	111 000	146 000	96 700	109 400
		ST	71 700	61 800	8.5	14	67 100	47 300	---	---	---	---
6X12	341045	L	75 200	65 700	11.0	25	67 500	46 300	109 000	139 300	93 800	107 500
		LT	72 800	62 100	7.5	12	66 200	45 500	104 000	140 700	92 300	107 600
		ST	72 400	58 800	6.0	7	69 300	44 700	---	---	---	---
6X24	341046	L	73 900	63 900	12.0	22	63 300	43 800	94 300	128 300	85 200	98 100
		LT	69 100	57 500	10.0	22	62 900	42 000	87 700	123 300	83 300	97 200
		ST	69 300	58 100	4.5	6	67 300	42 000	---	---	---	---

* OFFSET EQUALS 0.2 PER CENT

† OFFSET EQUALS 2 PER CENT OF PIN DIAMETER

‡ SPECIMENS AND FEATURES CLEANED ULTRASONICALLY

§ L, LONGITUDINAL; LT, LONG TRANSVERSE; ST, SHORT TRANSVERSE

TABLE VI

SPECIFIED MINIMUM VALUES FOR STRESS-RELIEVED ALUMINUM ALLOY HAND FORGINGS†
(P33615-68-C-1385)

Alloy and Temper	Thickness, in.	Longitudinal			Long-Transverse			Short-Transverse			Specification
		Ultimate Tensile Stress, psi	Tensile Yield Stress, psi	Elong. in 4D, %	Ultimate Tensile Stress, psi	Tensile Yield Stress, psi	Elong. in 4D, %	Ultimate Tensile Stress, psi	Tensile Yield Stress, psi	Elong. in 4D, %	
2014-T652	Up thru 2.000	55 000	56 000	8	65 000	56 000	3	---	---	---	MIL-A-22771C QQ-A-367g
	2.001-3.000	64 000	56 000	8	64 000	55 000	3	62 000	52 000	2	
	3.001-4.000	63 000	55 000	8	63 000	55 000	3	61 000	51 000	2	
	4.001-5.000	62 000	54 000	7	62 000	54 000	2	60 000	50 000	1	
2024-T852	5.001-6.000	61 000	53 000	7	61 000	53 000	2	59 000	50 000	1	None
	All	---	---	-	---	---	-	---	---	-	
	Up thru 3.000	66 000	54 000	7	64 000	52 000	4	61 000	50 000	3	
	3.001-4.000	64 000	53 000	7	63 000	50 000	3	60 000	48 000	2	
7075-T7352	4.001-5.000	62 000	51 000	7	61 000	48 000	3	58 000	46 000	2	MIL-A-22771C
	5.001-6.000	61 000	49 000	6	59 000	46 000	3	57 000	44 000	2	
	Up thru 2.000	72 000	63 000	9	71 000	61 000	5	---	---	---	
	2.001-3.000	72 000	62 000	9	70 000	60 000	5	67 000	55 000	3	
7079-T652	3.001-4.000	71 000	61 000	9	70 000	59 000	5	67 000	55 000	3	MIL-A-22771C QQ-A-367g
	4.001-5.000	70 000	60 000	9	69 000	58 000	4	66 000	54 000	3	
	5.001-6.000	69 000	59 000	9	68 000	56 000	4	65 000	53 000	3	
		69 000	59 000	9	68 000	56 000	4	65 000	53 000	3	

† Maximum cross-sectional area of 256 sq. in.

* Offset equals 0.2 per cent.

RATIOS AND (2) THE TENSILE, COMPRESSIVE, SHEAR AND WEARING PROPERTIES
 OF STRESS-RELIEVED ALUMINUM ALLOY HAND FORGINGS
 (F13615-68-C-1385)

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(FBI-DOJ-USA)

* Student's t -test showed no significant difference between error means for I, and 17 directions and F -test showed no significant difference in variability for 5 and 17 directions.

TABLE I
STATISTICAL ANALYSIS OF TENSILE AND COMPRESSIVE, SHEAR AND TORSION MECHANICAL PROPERTIES
OF STRESS-RELIEVED 7075-T7352 BOND FORMING

(1956)5-68-C-1385

Part No.	Tensile			Shear			Torsion			Compression			Tension			Tension		
	Test (L)	Test (T)	Test (S)	Test (L)	Test (T)	Test (S)	Test (L)	Test (T)	Test (S)	Test (L)	Test (T)	Test (S)	Test (L)	Test (T)	Test (S)	Test (L)	Test (T)	Test (S)
1.16	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1.17	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1.18	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1.19	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1.20	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1.21	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1.22	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1.23	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1.24	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1.25	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1.26	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1.27	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1.28	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1.29	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1.30	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1.31	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1.32	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1.33	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1.34	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1.35	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1.36	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1.37	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1.38	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1.39	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1.40	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1.41	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1.42	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1.43	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1.44	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1.45	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1.46	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1.47	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1.48	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1.49	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1.50	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1.51	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1.52	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1.53	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1.54	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1.55	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1.56	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1.57	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1.58	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1.59	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1.60	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1.61	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1.62	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1.63	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1.64	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1.65	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1.66	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1.67	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1.68	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1.69	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1.70	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1.71	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1.72	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1.73	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1.74	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1.75	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1.76	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1.77	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1.78	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1.79	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1.80	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1.81	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1.82	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1.83	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1.84	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1.85	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1.86	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1.87	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1.88	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1.89	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1.90	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1.91	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1.92	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1.93	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1.94	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1.95	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1.96	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1.97	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1.98	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1.99	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
2.00	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

* Student's t-test showed no significant difference between average ratios for L and T directions and F-test showed no significant difference in variability for L and T directions.
** Student's t-test showed no significant difference between average ratios for L and T directions and F-test showed no significant difference in variability for L and T directions.

TABLE XI
STATISTICAL ANALYSIS OF 100% AND 50% COMPARATIVE GEAR AND FINGER BEARING PROPERTIES
OF LITHIUM-BATTERY 100% AND 50% BEARING
(P350-000-010)

P350-000-010	100% BEARING				50% BEARING				100% BEARING				50% BEARING				100% BEARING				50% BEARING			
	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
n	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10	10
R	1.03	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
f _R	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Min	1.017	1.075	1.130	1.185	1.240	1.295	1.350	1.405	1.460	1.515	1.570	1.625	1.680	1.735	1.790	1.845	1.900	1.955	2.010	2.065	2.120	2.175	2.230	2.285

* Student's t-test showing significant difference between 100% and 50% bearing properties for 100% and 50% bearing properties is variability for 100% and 50% bearing properties.

TABLE XII

RATIOS FOR COMPUTING DESIGN MECHANICAL PROPERTIES
OF STRESS-RELIEVED 2014-T652 HAND FORGINGS

Ratio	Thickness, in.				
	≤2.000	2.001- 3.000	3.001- 4.000	4.001- 5.000	5.001- 6.000
$F_{cy}(L)/F_{ty}(L)$	1.011	1.011	1.011	1.011	1.011
$F_{cy}(LT)/F_{ty}(LT)$	1.035	1.035	1.035	1.035	1.035
$F_{cy}(ST)/F_{ty}(ST)$	1.111	1.111	1.111	1.111	1.111
$F_{su}/F_{tu}(LT)$	0.586	0.586	0.586	0.586	0.586
$F_{bru}/F_{tu}(LT)$					
$e/D = 1.5$	1.357	1.357	1.357	1.357	1.357
$e/D = 2.0$	1.768	1.768	1.768	1.768	1.768
$F_{bry}/F_{ty}(LT)$					
$e/D = 1.5$	1.382	1.382	1.382	1.382	1.382
$e/D = 2.0$	1.621	1.621	1.621	1.621	1.621

TABLE XIII
RATIOS FOR COMPUTING DESIGN MECHANICAL PROPERTIES
OF STRESS-RELIEVED 2024-T852 HAND FORGINGS

Ratios	Thickness, in.				
	≤2.000	2.001-3.000	3.001-4.000	4.001-5.000	5.001-6.000
$F_{cy}(L)/F_{ty}(L)$	1.066	1.052	1.038	1.024	1.010
$F_{cy}(LT)/F_{ty}(LT)$	1.121	1.093	1.066	1.039	1.011
$F_{cy}(ST)/F_{ty}(ST)$	1.118	1.118	1.118	1.118	1.118
$F_{su}/F_{tu}(LT)$	0.551	0.551	0.551	0.551	0.551
$F_{bru}/F_{tu}(LT)$					
$e/D = 1.5$	1.290	1.290	1.290	1.290	1.290
$e/D = 2.0$	1.705	1.705	1.705	1.705	1.705
$F_{bry}/F_{ty}(LT)$					
$e/D = 1.5$	1.372	1.372	1.372	1.372	1.372
$e/D = 2.0$	1.625	1.625	1.625	1.625	1.625

TABLE XIV

RATIOS FOR COMPUTING DESIGN MECHANICAL PROPERTIES
OF STRESS-RELIEVED 7075-T7352 HAND FORGINGS

Ratio	Thickness, in.				
	<2.000	2.001- 3.000	3.001- 4.000	4.001- 5.000	5.001- 6.000
$F_{cy}(L)/F_{ty}(L)$	0.988	0.988	0.988	0.988	0.988
$F_{cy}(LT)/F_{ty}(LT)$	1.036	1.036	1.036	1.036	1.036
$F_{cy}(ST)/F_{ty}(ST)$	1.109	1.109	1.109	1.109	1.109
$F_{su}/F_{tu}(LT)$	0.597	0.597	0.597	0.597	0.597
$F_{bru}/F_{tu}(LT)$					
$e/D=1.5$	1.455	1.455	1.455	1.455	1.455
$e/D=2.0$	1.898	1.898	1.898	1.898	1.898
$F_{brv}/F_{ty}(LT)$					
$e/D=1.5$	1.501	1.501	1.501	1.501	1.501
$e/D=2.0$	1.694	1.694	1.694	1.694	1.694

TABLE XV
RATIOS FOR COMPUTING DESIGN MECHANICAL PROPERTIES
OF STRESS-RELIEVED 7079-T652 HAND FORGINGS

Ratio	Thickness, in.				
	<2.000	2.001- 3.000	3.001- 4.000	4.001- 5.000	5.001- 6.000
$F_{cy}(L)/F_{ty}(L)$	1.017	1.017	1.017	1.017	1.017
$F_{cy}(LT)/F_{ty}(LT)$	1.075	1.075	1.075	1.075	1.075
$F_{cy}(ST)/F_{ty}(ST)$	1.138	1.138	1.138	1.138	1.138
$E_{su}/F_{tu}(LT)$	0.601	0.601	0.601	0.601	0.601
$F_{bru}/F_{tu}(LT)$					
$e/D = 1.5$	1.439	1.439	1.439	1.439	1.439
$e/D = 2.0$	1.909	1.909	1.909	1.909	1.909
$F_{bry}/F_{ty}(LT)$					
$e/D = 1.5$	1.485	1.485	1.485	1.485	1.485
$e/D = 2.0$	1.719	1.719	1.719	1.719	1.719

TABLE XVI

COMPUTED DESIGN MECHANICAL PROPERTIES OF 2014-T652 ALUMINUM ALLOY HAND FORGINGS

Alloy Form Condition Thickness, in. Basis	2014 Hand Forgings†				
	T652				
	≤ 2.000 S	2.001-5.000 S	5.001-4.000 S	4.001-5.000 S	5.001-6.000 S
Mechanical Properties:					
F_{tu} , ksi	65	64	63	62	61
LT	65	64	63	62	61
ST	--	62	61	60	59
F_{ty} , ksi					
L	56	56	55	54	53
LT	56	55	55	54	53
ST	--	52	51	50	50
$F_{0.2}$, ksi					
L	56	56	55	54	53
LT	57(+1)	56(+1)	56(+1)	55(+1)	54(+1)
ST	--	57(*)	56(*)	55(*)	55(*)
F_{su} , ksi	38(-2)	37(-2)	37(-2)	36(-2)	36(-2)
F_{bru} , ksi					
e/D=1.5	88(-3)	87(-3)	85(-3)	84(-3)	83(-2)
e/D=2.0	115(-2)	113(-2)	111(-2)	110(-2)	108(-2)
F_{bry} , ksi					
e/D=1.5	77(-1)	76(-2)	76(-1)	74(-2)	73(-1)
e/D=2.0	91(+1)	89(-1)	89(+1)	87(+1)	85(+1)
e, per cent:					
L	8	8	8	7	7
LT	3	3	3	2	2
ST	-	2	2	1	1
E, 10^6 psi	10.5				
E_c , 10^6 psi	10.8(+0.1)				
G, 10^6 psi	4.0				

Note: Numbers in parenthesis are differences from values in MIL-HDBK-5A, February 1966.

* No values shown in MIL-HDBK-5A, February 1966

† Maximum cross-sectional area of 256 sq in.

TABLE XVII

TENTATIVE COMPUTED DESIGN MECHANICAL PROPERTIES* OF 2024-T852 ALUMINUM ALLOY HAND FORGINGS

Alloy Form Condition Thickness, in. Units	2024 Hand Forgings†				
	T852				
	≤ 2.000	2.001-3.000	3.001-4.000	4.001-5.000	5.001-6.000
Mechanical Properties:					
F _{tu} , ksi					
L	64	64	64	62	60
LT	61	61	61	59	57
ST	--	59	59	57	55
F _{ty} , ksi					
L	54	54	54	53	52
LT	52	52	52	51	50
ST	--	50	50	49	48
F _{cy} , ksi					
L	58	57	56	54	52
LT	58	57	55	53	51
ST	--	56	56	55	54
F _{su} , ksi	34	34	34	32	31
F _{bu} , ksi					
e/D=1.5	79	79	79	76	73
e/D=2.0	104	104	104	101	97
F _{br} , ksi					
e/D=1.5	71	71	71	70	69
e/D=2.0	84	84	84	83	81
e, per cent:					
L	4	4	4	4	4
LT	2	2	2	2	2
ST	--	1	1	1	1
E, 10 ⁶ psi	10.5 10.8 4.0				
E _c , 10 ⁶ psi					
G, 10 ⁶ psi					

* No values shown in MIL-HDBK-5A, February 1966.
† Maximum cross-sectional area of 256 sq in.

TABLE XVIII

COMPUTED DESIGN MECHANICAL PROPERTIES* OF 7075-T7352 ALUMINUM ALLOY HAND FORGINGS

Alloy Form Condition Thickness, in. Basis	7075 Hand Forgings†				
	T7352				
	≤ 2.000	2.001-3.000	3.001-4.000	4.001-5.000	5.001-6.000
	S	S	S	S	S
Mechanical Properties:					
F_{tu} , ksi					
L	66	66	64	62	61
LT	64	64	63	61	59
ST	--	61	61	58	57
F_{ty} , ksi					
L	54	54	53	51	49
LT	52	52	50	48	46
ST	--	50	48	46	44
F_{cy} , ksi					
L	53	53	52	50	48
LT	54	54	52	50	48
ST	--	55	53	51	49
F_{su} , ksi	38	38	37	36	35
F_{bru} , ksi					
e/D=1.5	93	93	92	89	86
e/D=2.0	121	121	119	116	112
F_{brv} , ksi					
e/D=1.5	78	78	75	72	69
e/D=2.0	88	88	84	81	78
e, per cent:					
L	7	7	7	7	6
LT	4	4	3	3	3
ST	--	3	2	2	2
E, 10^6 psi			10.0		
E_c , 10^6 psi			10.4		
G, 10^6 psi			3.8		

* No values in MIL-HDBK-5A, February 1966.
† Maximum cross-sectional area of 256 sq in.

TABLE XIX

COMPUTED DESIGN MECHANICAL PROPERTIES OF 7079-T652 ALUMINUM ALLOY HAND FORGINGS

Alloy Form Condition Thickness, in. Basis	7079 Hand Forgings†				
	T652				
	2,000	2,001-3,000	3,001-4,000	4,001-5,000	5,001-6,000
	S	S	S	S	S
Mechanical Properties:					
F_{tu} , ksi					
L	72	72	71	70	69
LT	71	70	70	69	68
ST	--	67	67	66	66
F_{ty} , ksi					
L	63	62	61	60	59
LT	61	60	59	58	56
ST	--	55	55	54	53
F_{oy} , ksi					
L	64(-2)	63(-2)	62(-2)	61(-2)	60(-2)
LT	65(*)	64(*)	63(*)	62(*)	60(*)
ST	--	62(*)	62(*)	61(*)	60(*)
F_{su} , ksi	43	42(-1)	42(-1)	41(-1)	41
F_{bru} , ksi					
e/D=1.5	102(*)	100(*)	100(*)	99(*)	98(*)
e/D=2.0	135(*)	133(*)	133(*)	132(*)	130(*)
F_{bry} , ksi					
e/D=1.5	90(*)	89(*)	87(*)	86(*)	83(*)
e/D=2.0	105(*)	103(*)	101(*)	99(*)	96(*)
e, per cent:					
L	9	9	9	9	9
LT	5	5	5	4	4
ST	--	3	3	3	3
E, 10^6 psi	10.0(-0.3)				
E_c , 10^6 psi	10.4(-0.1)				
G, 10^6 psi	3.8(-0.1)				

Note: Numbers in parenthesis are differences from values in MIL-HDBK-5A, February 1966.

* No values shown in MIL-HDBK-5A, February 1966

† Maximum cross-sectional area of 256 sq in.

TABLE 11

RESULTS OF TENSILE AND COMPRESSIVE STRESS-STRAIN AND MODULUS OF ELASTICITY TESTS
(P-1611-13-C-129)

Alloy	Temp., °F.	Long Transverse				Short Transverse				Compressive			
		Yield Stress, 10 ⁵ psi	Tensile Stress, 10 ⁵ psi	Modulus of Elasticity, 10 ⁵ psi	Elongation, %	Yield Stress, 10 ⁵ psi	Tensile Stress, 10 ⁵ psi	Modulus of Elasticity, 10 ⁵ psi	Elongation, %	Yield Stress, 10 ⁵ psi	Tensile Stress, 10 ⁵ psi	Modulus of Elasticity, 10 ⁵ psi	Elongation, %
7075-T6	70	81.5	100.0	10.41	7.0	81.5	100.0	10.41	7.0	81.5	100.0	10.41	7.0
	100	81.5	100.0	10.41	7.0	81.5	100.0	10.41	7.0	81.5	100.0	10.41	7.0
	150	81.5	100.0	10.41	7.0	81.5	100.0	10.41	7.0	81.5	100.0	10.41	7.0
	200	81.5	100.0	10.41	7.0	81.5	100.0	10.41	7.0	81.5	100.0	10.41	7.0
7075-T6	250	81.5	100.0	10.41	7.0	81.5	100.0	10.41	7.0	81.5	100.0	10.41	7.0
	300	81.5	100.0	10.41	7.0	81.5	100.0	10.41	7.0	81.5	100.0	10.41	7.0
	350	81.5	100.0	10.41	7.0	81.5	100.0	10.41	7.0	81.5	100.0	10.41	7.0
	400	81.5	100.0	10.41	7.0	81.5	100.0	10.41	7.0	81.5	100.0	10.41	7.0
7075-T6	450	81.5	100.0	10.41	7.0	81.5	100.0	10.41	7.0	81.5	100.0	10.41	7.0
	500	81.5	100.0	10.41	7.0	81.5	100.0	10.41	7.0	81.5	100.0	10.41	7.0
	550	81.5	100.0	10.41	7.0	81.5	100.0	10.41	7.0	81.5	100.0	10.41	7.0
	600	81.5	100.0	10.41	7.0	81.5	100.0	10.41	7.0	81.5	100.0	10.41	7.0
7075-T6	650	81.5	100.0	10.41	7.0	81.5	100.0	10.41	7.0	81.5	100.0	10.41	7.0
	700	81.5	100.0	10.41	7.0	81.5	100.0	10.41	7.0	81.5	100.0	10.41	7.0
	750	81.5	100.0	10.41	7.0	81.5	100.0	10.41	7.0	81.5	100.0	10.41	7.0
	800	81.5	100.0	10.41	7.0	81.5	100.0	10.41	7.0	81.5	100.0	10.41	7.0

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TABLE XXI

AVERAGE* MODULUS VALUES OF 2 TO 6-IN. THICK STRESS-RELIEVED ALUMINUM ALLOY HAND FORGINGS
(P33615-68-C-1385)

Alloy and Temper	Average Modulus of Elasticity Values, 10 ⁶ psi					
	Tension		Short-Transverse		Compression	
	Longitudinal	Long-Transverse	Longitudinal	Short-Transverse	Longitudinal	Short-Transverse
2014-T652	10.40	10.49	10.40		10.74	10.77
2024-T352	10.49	10.50	10.45		10.75	10.75
7075-T7352	10.04	10.13	10.11		10.37	10.48
7079-T652	9.94	9.96	10.00		10.30	10.35
Averages						
2014 and 2024	10.44	10.50	10.42		10.74	10.76
7075 and 7079	9.99	10.04	10.06		10.34	10.42

AVERAGES, † ALL DIRECTIONS

Series	Modulus, psi	
	Tension	Compression
2000	10 500 000	10 800 000
7000	10 000 000	10 400 000

* For each L and LT - 5 samples; for ST - 3 samples.
† Values rounded to nearest 100 000 psi.

TABLE XII

RESULTS OF NOTCH-BEND FATIGUE STRESS TESTS
OF STRESS-RELIEVED ALUMINUM ALLOY BARE FORTRESS

(75615-68-C-136)

Specimen Size, in.	Fracture Surface Area, sq. in.	Type See Fig. 5	Specimen		Fatigue Pre-Cracking		At 5 Per Cent Second Offset		Meaningful E_{10}	Fracture Appearance Following
			Weld Length (ft.)	Stress Intensity, E_{10} per ft.	Cycles	Crack Length (in.)	E_{10} , psi	Stress, psi		
2x2	34.1x7	3	1.501	0.7501	156,000	0.086	2,450	28,000	Yes	Yes
		3	1.500	0.7510	159,000	0.178	2,450	28,000	Yes	Yes
		3	1.501	0.7502	223,000	0.173	1,600	19,500	Yes	Yes
		3	1.501	0.7502	223,000	0.173	1,600	19,500	Yes	Yes
3x12	34.1x6	4	2.000	0.774	121,000	0.053	3,070	28,000	Yes	Yes
		4	2.001	0.774	121,000	0.053	3,070	28,000	Yes	Yes
		4	2.002	0.774	68,000	1.085	2,450	28,000	Yes	Yes
		4	2.002	0.774	68,000	1.085	2,450	28,000	Yes	Yes
4x5	34.1x7	5	3.003	1.500	93,000	1.171	1,600	19,500	Yes	Yes
		5	3.003	1.500	93,000	1.171	1,600	19,500	Yes	Yes
		5	3.003	1.500	93,000	1.171	1,600	19,500	Yes	Yes
		5	3.003	1.500	93,000	1.171	1,600	19,500	Yes	Yes
5x20	34.1x10	5	3.003	1.500	93,000	1.171	1,600	19,500	Yes	Yes
		5	3.003	1.500	93,000	1.171	1,600	19,500	Yes	Yes
		5	3.003	1.500	93,000	1.171	1,600	19,500	Yes	Yes
		5	3.003	1.500	93,000	1.171	1,600	19,500	Yes	Yes
6x24	34.1x16	6	4.003	2.000	68,000	1.171	1,600	19,500	Yes	Yes
		6	4.003	2.000	68,000	1.171	1,600	19,500	Yes	Yes
		6	4.003	2.000	68,000	1.171	1,600	19,500	Yes	Yes
		6	4.003	2.000	68,000	1.171	1,600	19,500	Yes	Yes

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TABLE XIII (Continued)

RESULTS OF NOTCH-BEND FRACTURE TOUGHNESS TESTS
OF STRESS-RELIEVED ALUMINUM ALLOY BARE FORDING

(734615-68-C-1385)

Alloy and Temper	Sample	Direction and Number	Specimen		Fatigue Pre-Cracking		Crack		K _{ISCC}		Meaningful K _{IC}	Fracture Appearance
			Thickness, in.	Width (W), in.	Thick-ness (B), in.	Max. Load (P), lb	Stress Intensity, K _I , psi/in.	Cycles	Longitudinal (a), in.	Transverse (b), in.		
7015-T7352	341027	WT ₁	3	1.428	0.7510	251	800	78 000	0.722	0.607	Yes	23
		WT ₂	3	1.501	0.7538	251	8100	84 000	0.747	0.597	Yes	18
		WT ₃	3	1.501	0.7515	251	8100	147 000	0.748	0.586	Yes	23
		WT ₄	3	1.501	0.7505	251	8100	147 000	0.745	0.586	Yes	10
		WT ₅	3	1.501	0.7514	251	8100	147 000	0.745	0.586	Yes	5
	341028	WT ₁	4	1.998	0.9738	524	7100	116 000	0.725	0.530	Yes	40
		WT ₂	4	1.998	0.9738	524	7100	116 000	0.725	0.530	Yes	40
		WT ₃	4	1.998	0.9738	524	7100	116 000	0.725	0.530	Yes	18
		WT ₄	4	1.998	0.9738	524	7100	116 000	0.725	0.530	Yes	5
		WT ₅	4	1.998	0.9738	524	7100	116 000	0.725	0.530	Yes	5
5425	341029	WT ₁	5	3.003	1.5000	1262	12 500	229 000	1.577	0.823	Yes	10
		WT ₂	5	3.003	1.5000	1262	12 500	229 000	1.577	0.823	Yes	5
		WT ₃	5	3.003	1.5000	1262	12 500	229 000	1.577	0.823	Yes	5
		WT ₄	5	3.003	1.5000	1262	12 500	229 000	1.577	0.823	Yes	5
		WT ₅	5	3.003	1.5000	1262	12 500	229 000	1.577	0.823	Yes	5
	341030	WT ₁	5	3.003	1.5000	1262	12 500	229 000	1.577	0.823	Yes	10
		WT ₂	5	3.003	1.5000	1262	12 500	229 000	1.577	0.823	Yes	5
		WT ₃	5	3.003	1.5000	1262	12 500	229 000	1.577	0.823	Yes	5
		WT ₄	5	3.003	1.5000	1262	12 500	229 000	1.577	0.823	Yes	5
		WT ₅	5	3.003	1.5000	1262	12 500	229 000	1.577	0.823	Yes	5
6424	341031	WT ₁	6	4.003	2.0020	2500	15 500	143 000	2.203	1.626	Yes	10
		WT ₂	6	4.003	2.0020	2500	15 500	143 000	2.203	1.626	Yes	20
		WT ₃	6	4.003	2.0020	2500	15 500	143 000	2.203	1.626	Yes	0
		WT ₄	6	4.003	2.0020	2500	15 500	143 000	2.203	1.626	Yes	0
		WT ₅	6	4.003	2.0020	2500	15 500	143 000	2.203	1.626	Yes	0
	341032	WT ₁	6	4.003	2.0020	2500	15 500	143 000	2.203	1.626	Yes	0
		WT ₂	6	4.003	2.0020	2500	15 500	143 000	2.203	1.626	Yes	0
		WT ₃	6	4.003	2.0020	2500	15 500	143 000	2.203	1.626	Yes	0
		WT ₄	6	4.003	2.0020	2500	15 500	143 000	2.203	1.626	Yes	0
		WT ₅	6	4.003	2.0020	2500	15 500	143 000	2.203	1.626	Yes	0

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TABLE XIII

SUMMARY OF MEANINGFUL K_{Ic} VALUES FOR STRESS-RELIEVED ALUMINUM ALLOY HAND FORGINGS

(F33615-63-C-1235)

Alloy and Temper	Sample Test-Specimen Size, in.	Longitudinal (LW)		Long-Transverse (WL)		Short-Transverse (TL)	
		Number of Meaningful Tests	Thickness, K_{Ic} , psi√in.†	Number of Meaningful Tests	Thickness, K_{Ic} , psi√in.†	Number of Meaningful Tests	Thickness, K_{Ic} , psi√in.†
2014-T652	2x8	3	25 400	3	0.75	---	---
	2x12	3	26 600	3	1.00	---	---
	4x12	3	34 100	3	1.50	3	0.25
	8x8	3	29 200	3	1.50	3	0.50
	Average	---	26 500	3	2.00	3	0.50
2014-T6510	Extrusion†	---	30 100	---	---	---	---
2014-T652	2x8	3	24 200	3	0.75	---	---
	2x12	3	22 500	3	1.00	---	---
	4x12	3	27 300	---	---	3	0.25
	8x8	3	27 100	3	1.50	2	0.50
	Average	3	26 900	3	2.00	3	0.50
2014-T6510	Extrusion†	---	29 000	---	---	---	---
7075-T7302	2x8	3	31 400	3	0.75	---	---
	2x12	3	31 400	3	1.00	---	---
	4x12	3	32 700	3	1.50	3	0.25
	8x8	3	34 200	3	1.50	3	0.50
	Average	3	32 500	3	2.00	3	0.50
7075-T7310	Extrusion†	---	34 200	---	---	---	---
7075-T652	2x8	3	26 000	1	0.75	---	---
	2x12	3	27 400	3	1.00	---	---
	4x12	3	26 600	1	1.50	3	0.25
	8x8	3	26 100	3	1.50	3	0.50
	Average	3	26 100	3	2.00	3	0.50
7075-T6510	Extrusion†	---	30 300	---	---	---	---

† Meanings of values are given in Table VIII.

† Average values are based on a minimum number of specimens (3 specimens for longitudinal, 3 specimens for long-transverse, 3 specimens for short-transverse).

TABLE XXIV

RESULTS OF LONG-TRANSVERSE AXIAL-STRESS FATIGUE TESTS
OF STRESS-RELIEVED ALUMINUM ALLOY HAND FORGINGS (R=0.0)
(F33615-68-C-1385)

Alloy and Temper	Sample		Cycles to Failure		
	Size, in.	Number	Maximum Stress, psi		
			60 000	40 000	35 000
2014-T652	2x8	341007	34 200	4 358 100	10 264 500*
	4x8	341009	17 700	1 032 800	6 252 200
	5x10	341012	18 900	230 000	10 017 300*
	6x12	341015	7 700	142 200	14 323 200*
	Log-Mean Fatigue Life		17 200	619 400	---
2024-T852	2x8	341017	22 600	252 900	10 029 500*
	4x8	341019	12 700	180 700	19 845 700*
	5x10	341022	14 300	90 200	17 189 300*
	6x12	341015	7 200	93 600	14 882 400*
	Log-Mean Fatigue Life		13 700	140 200	---
7075-T7352			Maximum Stress, psi		
			60 000	45 000	38 000
	2x8	341027	28 100	4 084 800	14 882 600*
	4x8	341029	4 700	82 400	1 455 800
	5x10	341032	9 800	51 100	105 800
7075-T7352	6x12	341035	3 600	38 600	93 000
	Log-Mean Fatigue Life		3 300	160 500	---
7079-T652	2x8	341037	22 200	109 800	720 500
	4x8	341039	22 700	61 400	11 607 400*
	5x10	341042	19 200	75 500	162 700
	6x12	341045	11 400	40 200	146 400
	Log-Mean Fatigue Life		18 100	66 900	---

* Specimen did not fail.

Table XXV

SCOPE OF CORROSION TESTS OF STRESS-RELIEVED ALUMINUM
ALLOY HAND FORGINGS

Part A : Stress-Corrosion Tests: Number of Specimens Per Stress-Level

Stress Levels	26 Weeks Exposure				12 Weeks Exposure			
	Longitudinal*		Long. Transverse*		Long. Transverse*		Short Transverse†	
	All Four Alloy-Tempers	2014-T652 7079-T652	2024-T852 7075-T652	2014-T652 7079-T652	2014-T652 7079-T652	2024-T852 7075-T652	2014-T652 7079-T652	7075-T652
75% Y.S.	3	3	3	---	---	3	3	3
50% Y.S.	---	3	---	---	---	---	---	---
22.5 KSI	---	---	---	3	3	---	---	---
15.0 KSI	---	---	---	3	3	---	---	---
7.5 KSI	---	---	---	2	2	---	2	2
Unstressed	2	2	2	2	2	2	2	2

* Longitudinal and long-transverse tensile specimens, 0.437-in. diameter, from 2X8, 4X16 and 6X24-in. forgings.

+ Short-transverse tensile specimens, 0.125-in. diameter, from 2X8, 3X12, 4X16, 5X20 and 6X24-in. forgings.

Part B : Exfoliation Tests : Number of Panels ++

Forging Size, In.	2014-T652	2024-T852	7075-T652	7079-T652
2X8	2	2	2	2
6X24	2	2	2	2

++ Panels 4X6 in. with 6 in. dimension in longitudinal direction.

TABLE XXVI

RESULTS OF STRESS-CORROSION TESTS OF LONGITUDINAL AND LONG-TRANSVERSE SPECIMENS
TRIPPLICATE 0.437-IN. DIAMETER TENSION SPECIMENS STRESSED IN DIRECT TENSION*

Exposure : 3.5% NaCl Solution by Alternate Immersion **

Alloy & Temper.	Forging Size, In.	Sample Number	Longitudinal Specimens		Long-Transverse Specimens			
			Stressed 75 Y.S.		Stressed 75 Y.S.		Stressed 50 Y.S.	
			F/N+	Days	F/N+	Days	F/N+	Days
2014-T652	2x3	341007	0/3	OK - 182	3/3	8,59,64	0/3	OK - 182
	4x1.6	341010	0/3	OK - 182	2/3	59,60,182 [#]	0/3	OK - 182
	6x2.4	341016	0/3	OK - 182	2/3	23,113 (1-OK-182)	0/3	OK - 182
2024-T352	2x3	341017	0/3	OK - 182	0/3	OK - 182	---	---
	4x1.6	341020	0/3	OK - 182	0/3	OK - 182	---	---
	6x2.4	341025	0/3	OK - 182	0/3	OK - 182	---	---
7075-T735C	2x3	341027	0/3	OK - 182	0/3	OK - 182	---	---
	4x1.6	341030	0/3	OK - 182	0/3	OK - 182	---	---
	6x2.4	341036	0/3	OK - 182	0/3	OK - 182	---	---
7079-T652	2x3	341037	0/3	OK - 182	3/3	27,59,64	0/3	OK - 182
	4x1.6	341040	0/3	OK - 182	3/3	20,26,182 [#]	0/3	OK - 182
	6x2.4	341046	0/3	OK - 182	0/3	OK - 182	0/3	OK - 182

* Duplicate unstressed specimens (longitudinal and long-transverse) were also exposed for each alloy. (Table XXVII)

+ F/N denotes number of specimens failed over number exposed.

Specimen failed outside the reduced section, beneath the protective coating used to isolate all parts of the stressing frame.

** Specimens from the 2, 3 and 5-in. thick forgings were exposed during months of November through May; specimens from the 4 and 6-in. forgings exposed during April through October.

Table XVII

PER CENT REDUCTION IN TENSILE STRENGTH BY CORROSION OF LONGITUDINAL
AND LONG-TRANSVERSE SPECIMENS, 0.427-IN. DIAMETER*

Exposure: 3.5% NaCl Solution by Alternate Immersion - 182 Days**

Alloy & Temper	Forging Size, in.	Sample Number	Longitudinal Specimens		Long-Transverse Specimens		
			Unstressed	Stressed 75% Y.S.	Unstressed	Stressed 75% Y.S.	Stressed 50% Y.S.
2014-T652	2X6	341007	5	8	1	+	29
	4X16	341010	6	8	19	+	28
	6X24	341016	5	6	18	27 [#]	17
2024-T352	2X6	341017	1	0	7	7	--
	4X16	341020	7	4	23	15	--
	6X24	341026	6	4	19	15	--
7075-T7552	2X6	341027	0	1	10	13	--
	4X16	341030	7	8	8	11	--
	6X24	341035	0	0	1	2	--
7075-T652	2X6	341037	2	1	0	+	17
	4X16	341040	2	4	1	+	20
	6X24	341046	3	3	1	3	3

* Results are average values for tensile tests of duplicate unstressed and triplicate stressed specimens unless otherwise noted.

+ No value obtained since all specimens failed in stress-corrosion test.

Value for tensile test of single specimen which did not fail in stress-corrosion test.

** Specimens from the 2, 3 and 5-in. thick forgings were exposed during months of November through May; specimens from the 4 and 6-in. forgings exposed during April through October.

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Table XVIII

RESULTS OF STRESS-CORROSION TESTS OF SHORT-TRANSVERSE SPECIMENS
TRIP-LITE 0.125-IN. DIAMETER TENSION SPECIMENS STRESSED IN DIRECT TENSION*

Alloy & Temper	Forging Size, In.	Sample Number	Exposure: 3.5% NaCl solution by Alternate Immersion #4				Stressed 15.0 ksi Y/N [†] Days	Stressed 22.5 ksi Y/N [†] Days	Stressed 7.5 ksi Y/N [†] Days
			Stressed 75% Y.S. Y/N [†] Days	Stressed 50% Y.S. Y/N [†] Days	Stressed 22.5 ksi Y/N [†] Days	Stressed 15.0 ksi Y/N [†] Days			
2024-T652	2x8	341007**	---	---	0/3	OK - 84	0/3	OK - 84	0/3
	3x12	341008	---	---	3/3	6,8,8	1/3	84(2-OK-84)	0/3
	4x16	341010	---	---	3/3	4,4,4	1/3	6(2-OK-84)	0/3
	5x20	341013	---	---	0/3	OK - 84	0/3	OK - 84	0/3
	6x24	341016	---	---	3/3	4,5,5	3/3	10,13,21	0/3
	2x3	341017	14,84,84 [#]	0/3	OK - 84	---	---	---	---
2024-T652	3x12	341013	OK - 84	0/3	OK - 84	---	---	---	---
	4x16	341020	3,3,4	2/3	19,61 (1-OK-84)	---	---	---	---
	5x20	341021	OK - 84	0/3	OK - 84	---	---	---	---
	6x24	341026	24,20,33	0/3	OK - 84	---	---	---	---
	2x8	341027	OK - 84	---	---	---	---	---	---
	3x12	341028**	8,8,8	---	---	---	---	---	---
7075-T652	4x16	341030	64 ^{††} (2-OK-84)	---	---	---	---	---	---
	5x20	341033	OK - 84	---	---	---	---	---	---
	6x24	341036	OK - 84	---	---	---	---	---	---
	2x8	341037**	---	---	0/3	OK - 84	0/3	OK - 84	0/3
	3x12	341038	---	---	0/3	OK - 84	0/3	OK - 84	0/3
	4x16	341040	---	---	3/3	3,4,4	1/3	4,4,4	3/3
7075-T652	5x20	341043	---	---	2/3	15,27 (1-OK-84)	0/3	OK - 84	0/3
	6x24	341046	---	---	3/3	5,5,5	2/3	13,84(1-OK-84)	0/3

* Duplicate untreated specimens were also exposed in each instance. (Table XIII)
† 2/4 denotes failure of specimen failed over number exposed.
†† Specimen failed outside the gage length section, beneath the protective coating used to isolate all parts of the stressing frame.
** Specimens were pretreated to confirm their test results (see Table XII)
†† Failure not typical of stress-corrosion cracking.
‡ Specimens from 2, 3, and 5-in. diameter forgings were exposed during months of November through February; specimens from 4 and 6-in. forgings exposed during April through July.

Table XIX

P22 C20T RESISTION IN TENSILE STRENGTH BY CORROSION OF SHORT-TRANSVERSE SPECIMENS, 0.125-IN. DIAMETER

Exposure: 3.5% NaCl Solution by Alternate Immersion **

Alloy & Temper	Forging Size, In.	Sample Number	Distressed	Stressed 15% Y.S.	Stressed 50% Y.S.	Stressed 72.5 ksi	Stressed 15.0 ksi	Stressed 7.5 ksi
2014-T652	2.0	341007	8	---	---	21	17	9
	3.0	341008	9	---	---	---	25 ^g	21
	4.0	341010	37	---	---	+	56 ^g	65
	5.0	341013	11	---	---	23	14	9
	6.0	341016	20	---	---	+	+	23
	2.0	341017	13	+	17	---	---	---
	3.0	341018	9	8	9	---	---	---
	4.0	341020	40	+	+	---	---	---
	5.0	341023	8	6	3	---	---	---
	6.0	341025	40	+	30	---	---	---
7075-T652	2.0	341027	3	7	---	---	---	---
	3.0	341028	8	+	---	---	---	---
	4.0	341030	16	53 ^g	---	---	---	---
	5.0	341033	8	11	---	---	---	---
	6.0	341036	8	26	---	---	---	---
	2.0	341037	4	---	---	5	0	2
	3.0	341038	3	---	---	0	0	2
	4.0	341040	19	---	---	+	+	+
	5.0	341043	3	---	---	1 ^g	0	1
	6.0	341046	12	---	---	+	34 ^g	16

* Results are average values for tensile tests of duplicate unstressed and triplicate stressed specimens unless otherwise noted.

+ No value obtained since all specimens failed in stress-corrosion test, or were damaged in handling.

g Results are average values for tensile tests of specimens (1 or 2) that did not fail in stress-corrosion test.

** Specimens tested 2 1/2 and 5 1/2 hours. All specimens were exposed during entire of treatment through specimens from 1 and 2 in. forging size including April through July.

TABLE XXI
RESULTS OF SUPPLEMENTARY STRESS-CORROSION TESTS OF SHEAR-TENSILE SPECIMENS
TRIPLICATES 0.125-IN. DIAMETER TENSILE SPECIMENS STRESSED
IN DISSOLUTIVE

Alloy & Temper.	Forging Size, in.	Sample Number	Applied Stress, ksi (75% Y.S.)	Initial Test Results			Supplementary Test Results		
				P/N	Days	Loss in %	P/N	Days	Loss in %
7075-T732	3C2	341025	45	3/3	8,9,8	---	3/3	7, 15, 15	---
			40 ^d	---	---	---	3/3	7, 15, 27	---
			35	---	---	---	3/3	4, 28, 30	---
			30	---	---	---	2/3	7, 25 71-OK-84)	14 ^{***}
			0	---	---	9	---	---	19 ^{***}
2014-T632	2C	341077	22.5	0/3	OK - 84	21	3/3	4, 10, 10	---
			15.0	0/3	OK - 84	17	3/3	10, 28, 34	---
			7.5	0/3	OK - 84	9	0/3	OK - 84	66
			0	---	---	8	---	---	35
			22.5	0/3	OK - 84	5	3/3	10, 10, 11	---
7075-T732	2C	341037	15.0	0/3	OK - 84	0	0/3	OK - 84	11
			7.5	0/3	OK - 84	2	0/3	OK - 84	11
			0	---	---	4	---	---	9

* Duplicate unstressed specimens were also exposed in each instance.

+ P/N denotes number of specimens failed over number exposed.

Federal Specification for 7075-T73 prohibits further satisfactory completion of 30 days exposure at 75% of minimum longitudinal yield strength. Application of criteria to 7075-T732 forging would require completion of 30-day test at a stress of 30.7 ksi.

** Replicate groups of unstressed specimens showed 13 and 13 per cent reduction in strength after 4 and 8 weeks exposure, respectively.

*** Tests were initiated in November, 1964, and terminated in February, 1965.

Tests were initiated in July, 1969, and terminated in October, 1969.

... Results are average values for tensile tests of duplicate unstressed and triplicate stressed specimens unless otherwise noted.

... Value for tensile test of single specimen which did not fail in stress corrosion test.

TABLE XXXI

SCHEDULE OF FATIGUE-CRACK-PROPAGATION TESTS
HAHD FORGINGS OF 6x24-IN. CROSS SECTION

Specimen Orientation (Fig. 42)	Type of Notch*	Length of Specimen, in.	Environment**	Rate of Cycling, cpm	Maximum Gross Tensile Stresses to Propagate Cracks, ksi†		
					2014-T652	2024-T652	7075-T7352
LT (E)	Mill	24	Ambient	310	8.2, 12.5		
LT (E)	Sharp	24	Ambient	310	8.2, 12.5		
LT (E)	Sharp	6	Ambient	310	8.2, 12.5		
LT (E)	Sharp	24	Ambient	310	8.2 to 12.5††		
LT (E)	Sharp	24	Ambient	310	12.5 to 8.2††		
LT (E)	Elox	24	Ambient	310		8.2, 12.5, 17.5	8.2, 12.5, 17.5
LT (E)	Elox	24	Ambient	310		8.2	8.2
L (E)	Elox	24	Ambient	310		8.2	8.2
L (E)	Elox	24	Ambient	310		8.2, 12.5	8.2, 12.5
L (E)	Elox	24	Ambient	310		8.2, 12.5	8.2, 12.5
ST (L)	Elox	6	Ambient	310		8.2, 12.5	8.2, 12.5
ST (T)	Elox	6	Ambient	310		8.2	8.2
LT (E)	Elox	24	Dry	310		8.2	8.2
LT (E)	Elox	24	Humid	310		8.2	8.2
LT (E)	Elox	24	Salt-Fog	310		8.2	8.2
LT (E)	Elox	24	Salt-Fog	18		8.2	8.2

*See Figures 41, 43, 44 and 45 for specimen details.

**Ambient refers to uncontrolled, laboratory environment. Relative humidities were measured during progress of tests.

Environments described as Dry, Humid and Salt-fog, were achieved within the specimen enclosure shown in Fig. 46. See text for details.

†Ratio of minimum to maximum gross stress, R, in test cycle = 1/3.

††Stress changed (increased or decreased) when crack length plus notch width totaled 1 in.

Most tests were made in duplicate; a few in triplicate.

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APPENDIX

CRACK PROPAGATION FOR CENTER-BOTCHED FATIGUE SPECIMENS
6" x 36" 2014-T652 Hard Polyimide
Long-Transverse Specimens, Geometrical Variables
Constant-Load Tests, Stress Ratio = 1/3

Wahltag:

Cycles - Number of cycles of crack propagation.
Fatigue Crack Length - measured on specimen surface.
Total Notch Length - 0.50-in. long each starter plus fatigue cracks.
Per cent Cracked - total notch length expressed as a per cent of gross width.
T - tensile thickness, in.

CRACK PROPAGATION FOR CENTER-NOTCHED FATIGUE SPECIMENS

6" x 10" 7011-7012 Heat Treating
Long-Transverse Specimens, Load Changes
Stress Ratio = 1/3

Notes:

Cycles = Number of cycles after crack propagation.
Fatigue Crack Length = measured on specimen surface.
Total Notch Length = 0.50-in. long crack starter plus fatigue cracks.
Per cent Cracked = total notch length expressed as a per cent of gross width.
T = specimen thickness, in.

TABLE XXXIV

CRACK PROPAGATION FOR CENTER-CRACKED FATIGUE SPECIMENS

6" x 24" 2024-T852 Hand Forging

Long-Transverse Specimens

Constant Load Tests, Stress Ratio = 1/3

341024 LTF

	FATIGUE CRACK		TOTAL	
	LENGTH (IN.)		NOTCH	PERCENT
CYCLES	AVG.	AVG.	LENGTH	CRACKED
	LEFT	RIGHT	(IN.)	
			T =	.7496 IN.
341024LTF12024I#52 - - - -			SIP =	8.2 KSI
0.	.155	.145	.500	16.65
22700.	.175	.170	.545	18.15
35300.	.210	.210	.620	20.65
78400.	.245	.245	.690	22.98
99200.	.280	.278	.758	25.24
116200.	.305	.315	.820	27.31
129800.	.340	.345	.885	29.47
144600.	.370	.380	.950	31.64
158100.	.410	.420	1.030	34.30
178800.	.475	.485	1.160	38.63
187400.	.510	.515	1.225	40.75
194300.	.555	.550	1.305	43.46
208800.	.615	.615	1.430	47.62
213700.	.660	.650	1.510	50.28
217400.	.695	.680	1.575	52.45
223100.	.730	.710	1.640	54.61
227000.	.765	.750	1.715	57.11
231300.	.825	.800	1.825	60.77
235400.	.890	.860	1.930	64.27
238400.	.985	.865	2.050	68.27
238800.	1.400	1.400	3.000	90.90

T = .7501 IN. 341024LTF32024I#52 - - - - - SIP = 8.2 KSI				
0.	.145	.155	.500	16.64
30300.	.180	.190	.570	18.99
62500.	.205	.215	.620	20.65
81400.	.240	.255	.695	23.15
101200.	.275	.280	.755	25.15
119900.	.305	.310	.815	27.15
137000.	.340	.350	.890	29.65
152000.	.385	.390	.975	32.48
165400.	.425	.430	1.055	35.14
174500.	.465	.475	1.140	37.97
187000.	.505	.515	1.220	40.64
194300.	.545	.555	1.300	43.30
204400.	.600	.610	1.410	46.97
211200.	.630	.645	1.475	49.13
219500.	.675	.700	1.575	52.47
227500.	.740	.760	1.700	56.63
232000.	.795	.820	1.815	60.46
235500.	.865	.875	1.940	64.62
237000.	.895	.910	2.005	66.79
237000.	1.400	1.400	3.000	90.93

CYCLES	FATIGUE CRACK LENGTH (IN.)		TOTAL NOTCH PERCENT CRACKED	
	AVG. LEFT	AVG. RIGHT		
	LENGTH (IN.)			
T = .7491 IN.				
341024LTF22024I#52 - - - - - SIP = 12.5 KSI				
0.	.150	.150	.500	16.67
16300.	.195	.195	.590	19.67
27800.	.250	.260	.690	23.00
36800.	.290	.280	.770	25.67
43100.	.345	.335	.880	29.33
48400.	.375	.375	.950	31.67
53500.	.420	.420	1.060	36.47
57400.	.470	.475	1.145	38.17
60400.	.495	.500	1.195	39.83
63400.	.535	.540	1.275	42.50
67800.	.595	.595	1.390	46.33
70800.	.650	.665	1.515	50.50
73300.	.725	.735	1.640	55.33
73300.	1.400	1.400	3.000	100.00

T = .7456 IN. 341024LTF42024I#52 - - - - - SIP = 12.5 KSI				
0.	.150	.150	.500	16.67
15300.	.200	.195	.595	19.83
29500.	.255	.250	.705	23.50
40300.	.320	.315	.835	27.41
45800.	.365	.365	.930	31.00
51500.	.415	.410	1.025	34.17
54400.	.455	.460	1.115	37.17
62200.	.505	.525	1.230	41.09
64800.	.545	.590	1.355	45.17
70200.	.640	.640	1.500	50.00
71100.	.690	.700	1.590	53.00
71100.	1.400	1.400	3.000	100.00

T = .7404 IN. 341024LTF62024I#52 - - - - - SIP = 12.5 KSI				
0.	.150	.150	.500	16.67
29900.	.190	.185	.575	19.15
58000.	.225	.215	.645	21.31
79900.	.255	.255	.710	23.66
10500.	.315	.320	.835	27.41
11700.	.385	.400	.905	32.80
11700.	1.400	1.400	3.000	90.90

T = .7504 IN. 341024LTF82024I#52 - - - - - SIP = 12.5 KSI				
0.	.140	.160	.500	16.64
1900.	.145	.145	.500	16.71
3000.	.245	.245	.600	22.27
5300.	.245	.205	.700	25.27
5300.	1.400	1.400	3.000	90.47

Notes:

Cycles - Number of cycles of crack propagation.

Fatigue Crack Length - measured on specimen surface.

Total Notch Length - 0.20-in. long crack starter plus fatigue cracks.

Per cent Cracked - total notch length expressed as a per cent of gross width.

T - specimen thickness, in.

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TABLE XXXV

CRACK PROPAGATION FOR CENTER-CRACKED FATIGUE SPECIMENS

6 x 24" 7075-T7352 Band Forging
Longitudinal and Grain-Runout Specimens
Constant-Load Tests, Stress Ratio = 1/3

301034/1					301034/2					301034/3				
CYCLES LEFT	FATIGUE CRACK LENGTH (IN.)		TOTAL NOTCH DEPTH (IN.)	PERCENT CRACKED	CYCLES LEFT	FATIGUE CRACK LENGTH (IN.)		TOTAL NOTCH DEPTH (IN.)	PERCENT CRACKED	CYCLES LEFT	FATIGUE CRACK LENGTH (IN.)		TOTAL NOTCH DEPTH (IN.)	PERCENT CRACKED
	LEFT	RIGHT				LEFT	RIGHT				LEFT	RIGHT		
T = .7448 IN.														
301034/1 20251732					301034/2 20251732					301034/3 20251732				
S10-0.8-2 R51					S10-0.8-2 R51					S10-0.8-2 R51				
0.	.160	.160	.400	16.64	0.	.154	.154	.400	16.44	0.	.154	.154	.400	16.44
22100.	.160	.160	.400	17.90	22100.	.154	.154	.400	16.44	22100.	.154	.154	.400	16.44
44200.	.160	.160	.400	18.15	44200.	.154	.154	.400	16.44	44200.	.154	.154	.400	16.44
66300.	.160	.160	.400	18.37	66300.	.154	.154	.400	16.44	66300.	.154	.154	.400	16.44
88400.	.160	.160	.400	18.55	88400.	.154	.154	.400	16.44	88400.	.154	.154	.400	16.44
110500.	.160	.160	.400	18.69	110500.	.154	.154	.400	16.44	110500.	.154	.154	.400	16.44
132600.	.160	.160	.400	18.80	132600.	.154	.154	.400	16.44	132600.	.154	.154	.400	16.44
154700.	.160	.160	.400	18.89	154700.	.154	.154	.400	16.44	154700.	.154	.154	.400	16.44
176800.	.160	.160	.400	18.96	176800.	.154	.154	.400	16.44	176800.	.154	.154	.400	16.44
198900.	.160	.160	.400	19.01	198900.	.154	.154	.400	16.44	198900.	.154	.154	.400	16.44
221000.	.160	.160	.400	19.05	221000.	.154	.154	.400	16.44	221000.	.154	.154	.400	16.44
243100.	.160	.160	.400	19.08	243100.	.154	.154	.400	16.44	243100.	.154	.154	.400	16.44
265200.	.160	.160	.400	19.10	265200.	.154	.154	.400	16.44	265200.	.154	.154	.400	16.44
287300.	.160	.160	.400	19.12	287300.	.154	.154	.400	16.44	287300.	.154	.154	.400	16.44
309400.	.160	.160	.400	19.14	309400.	.154	.154	.400	16.44	309400.	.154	.154	.400	16.44
331500.	.160	.160	.400	19.15	331500.	.154	.154	.400	16.44	331500.	.154	.154	.400	16.44
353600.	.160	.160	.400	19.16	353600.	.154	.154	.400	16.44	353600.	.154	.154	.400	16.44
375700.	.160	.160	.400	19.17	375700.	.154	.154	.400	16.44	375700.	.154	.154	.400	16.44
397800.	.160	.160	.400	19.18	397800.	.154	.154	.400	16.44	397800.	.154	.154	.400	16.44
419900.	.160	.160	.400	19.19	419900.	.154	.154	.400	16.44	419900.	.154	.154	.400	16.44
442000.	.160	.160	.400	19.20	442000.	.154	.154	.400	16.44	442000.	.154	.154	.400	16.44
464100.	.160	.160	.400	19.21	464100.	.154	.154	.400	16.44	464100.	.154	.154	.400	16.44
486200.	.160	.160	.400	19.22	486200.	.154	.154	.400	16.44	486200.	.154	.154	.400	16.44
508300.	.160	.160	.400	19.23	508300.	.154	.154	.400	16.44	508300.	.154	.154	.400	16.44
530400.	.160	.160	.400	19.24	530400.	.154	.154	.400	16.44	530400.	.154	.154	.400	16.44
552500.	.160	.160	.400	19.25	552500.	.154	.154	.400	16.44	552500.	.154	.154	.400	16.44
574600.	.160	.160	.400	19.26	574600.	.154	.154	.400	16.44	574600.	.154	.154	.400	16.44
596700.	.160	.160	.400	19.27	596700.	.154	.154	.400	16.44	596700.	.154	.154	.400	16.44
618800.	.160	.160	.400	19.28	618800.	.154	.154	.400	16.44	618800.	.154	.154	.400	16.44
640900.	.160	.160	.400	19.29	640900.	.154	.154	.400	16.44	640900.	.154	.154	.400	16.44
663000.	.160	.160	.400	19.30	663000.	.154	.154	.400	16.44	663000.	.154	.154	.400	16.44
685100.	.160	.160	.400	19.31	685100.	.154	.154	.400	16.44	685100.	.154	.154	.400	16.44
707200.	.160	.160	.400	19.32	707200.	.154	.154	.400	16.44	707200.	.154	.154	.400	16.44
729300.	.160	.160	.400	19.33	729300.	.154	.154	.400	16.44	729300.	.154	.154	.400	16.44
751400.	.160	.160	.400	19.34	751400.	.154	.154	.400	16.44	751400.	.154	.154	.400	16.44
773500.	.160	.160	.400	19.35	773500.	.154	.154	.400	16.44	773500.	.154	.154	.400	16.44
795600.	.160	.160	.400	19.36	795600.	.154	.154	.400	16.44	795600.	.154	.154	.400	16.44
817700.	.160	.160	.400	19.37	817700.	.154	.154	.400	16.44	817700.	.154	.154	.400	16.44
839800.	.160	.160	.400	19.38	839800.	.154	.154	.400	16.44	839800.	.154	.154	.400	16.44
861900.	.160	.160	.400	19.39	861900.	.154	.154	.400	16.44	861900.	.154	.154	.400	16.44
884000.	.160	.160	.400	19.40	884000.	.154	.154	.400	16.44	884000.	.154	.154	.400	16.44
906100.	.160	.160	.400	19.41	906100.	.154	.154	.400	16.44	906100.	.154	.154	.400	16.44
928200.	.160	.160	.400	19.42	928200.	.154	.154	.400	16.44	928200.	.154	.154	.400	16.44
950300.	.160	.160	.400	19.43	950300.	.154	.154	.400	16.44	950300.	.154	.154	.400	16.44
972400.	.160	.160	.400	19.44	972400.	.154	.154	.400	16.44	972400.	.154	.154	.400	16.44
994500.	.160	.160	.400	19.45	994500.	.154	.154	.400	16.44	994500.	.154	.154	.400	16.44
1016600.	.160	.160	.400	19.46	1016600.	.154	.154	.400	16.44	1016600.	.154	.154	.400	16.44
1038700.	.160	.160	.400	19.47	1038700.	.154	.154	.400	16.44	1038700.	.154	.154	.400	16.44
1060800.	.160	.160	.400	19.48	1060800.	.154	.154	.400	16.44	1060800.	.154	.154	.400	16.44
1082900.	.160	.160	.400	19.49	1082900.	.154	.154	.400	16.44	1082900.	.154	.154	.400	16.44
1105000.	.160	.160	.400	19.50	1105000.	.154	.154	.400	16.44	1105000.	.154	.154	.400	16.44
1127100.	.160	.160	.400	19.51	1127100.	.154	.154	.400	16.44	1127100.	.154	.154	.400	16.44
1149200.	.160	.160	.400	19.52	1149200.	.154	.154	.400	16.44	1149200.	.154	.154	.400	16.44
1171300.	.160	.160	.400	19.53	1171300.	.154	.154	.400	16.44	1171300.	.154	.154	.400	16.44
1193400.	.160	.160	.400	19.54	1193400.	.154	.154	.400	16.44	1193400.	.154	.154	.400	16.44
1215500.	.160	.160	.400	19.55	1215500.	.154	.154	.400	16.44	1215500.	.154	.154	.400	16.44
1237600.	.160	.160	.400	19.56	1237600.	.154	.154	.400	16.44	1237600.	.154	.154	.400	16.44
1259700.	.160	.160	.400	19.57	1259700.	.154	.154	.400	16.44	1259700.	.154	.154	.400	16.44
1281800.	.160	.160	.400	19.58	1281800.	.154	.154	.400	16.44	1281800.	.154	.154	.400	16.44
1303900.	.160	.160	.400	19.59	1303900.	.154	.154	.400	16.44	1303900.	.154	.154	.400	16.44
1326000.	.160	.160	.400	19.60	1326000.	.154	.154	.400	16.44	1326000.	.154	.154	.400	16.44
1348100.	.160	.160	.400	19.61	1348100.	.154	.154	.400	16.44	1348100.	.154	.154	.400	16.44
1370200.	.160	.160	.400	19.62	1370200.	.154	.154	.400	16.44	1370200.	.154	.154	.400	16.44
1392300.	.160	.160	.400	19.63	1392300.	.154	.154	.400	16.44	1392300.	.154	.154	.400	16.44
1414400.	.160	.160	.400	19.64	1414400.	.154	.154	.400	16.44	1414400.	.154	.154	.400	16.44
1436500.	.160	.160	.400	19.65	1436500.	.154	.154	.400	16.44	1436500.	.154	.154	.400	16.44
1458600.	.160	.160	.400	19.66	1458600.	.154	.154	.400	16.44	1458600.	.154	.154	.400	16.44
1480700.	.160	.160	.400	19.67	1480700.	.154	.154	.400	16.44	1480700.	.154	.154	.400	16.44
1502800.	.160	.160	.400	19.68	1502800.	.154	.154	.400	16.44	1502800.	.154	.154	.400	16.44
1524900.	.160	.160	.400	19.69	1524900.	.154	.154	.400	16.44	1524900.	.154	.154	.400	16.44
1547000.	.160	.160	.400	19.70	1547000.	.154	.154	.400	16.44	1547000.	.154	.154	.400	16.44
1569100.	.160	.160	.400	19.71	1569100.	.154	.154	.400	16.44	1569100.	.154	.154	.400	16.44
1591200.	.160	.160	.400	19.72	1591200.	.154	.154	.400	16.44	1591200.	.154	.154	.400	16.44
1613300.	.160	.160	.400	19.73	1613300.	.154	.154	.400	16.44	1613300.	.154	.154	.400	16.44
1635400.	.160	.160	.400	19.74	1635400.	.154	.154	.400	16.44	1635400.	.154	.154	.400	16.44
1657500.	.160	.160	.400	19.75	1657500.	.154	.154	.400	16.44					

CRACK PROPAGATION FOR CENTER-CRACKED FATIGUE SPECIMENS
6" x 24" 7075-T7352 Hand Forgings
Short-Transverse and Long-Transverse Specimens
Constant-Load Tests, Stress Ratio = 1/1

Notes

Cycles = Number of cycles of crack propagation.
Fatigue Crack Length = measured on specimen surface.
Total Notch Length = 3.75-in. long crack starter plus fatigue cracks.
Per cent Cracked = total notch length expressed as a per cent of gross width.
t = specimen thickness, in.

TABLE XXXVII

CRACK PROPAGATION FROM CENTER-NOTCHED FATIGUE SPECIMENS
 6" x 24" 7075-T7352 Hand Forging
 Long-Transverse Specimens, Controlled Environment
 Constant-Load Tests, Stress Ratio = 1/1

30130 LITE LOW HUMIDITY						30130 LITE SALT SPRAY					
CYCLES	FATIGUE CRACK		TOTAL	NOTCH PERCENT		CYCLES	FATIGUE CRACK		TOTAL	NOTCH PERCENT	
	LENGTH (IN.)	AVG. LENGTH (IN.)		RIGHT	LEFT		LENGTH (IN.)	AVG. LENGTH (IN.)		RIGHT	LEFT
Y = .7422 IN.						Y = .7400 IN.					
30130 LITE 7075-T7352						30130 LITE 7075-T7352					
0	.155	.145	.550	16.45		0	.150	.150	.550	16.45	
17100	.190	.195	.575	17.15		11700	.180	.185	.575	17.15	
36600	.250	.250	.600	17.50		21500	.195	.195	.595	17.31	
60000	.310	.310	.630	17.97		41300	.255	.260	.645	17.16	
77600	.355	.355	.673	18.16		51700	.305	.305	.700	17.30	
90200	.400	.375	.675	17.67		70200	.360	.355	.715	16.44	
101200	.440	.425	.705	18.13		75200	.400	.395	.705	17.17	
112000	.515	.490	.735	18.13		82000	.435	.435	.735	17.67	
117000	.580	.520	.750	18.20		97500	.465	.460	.750	17.70	
126700	.635	.575	.7610	18.05		100000	.470	.460	.755	18.05	
129200	.675	.570	.765	18.12		109500	.515	.505	.765	18.05	
136100	.735	.605	.7820	18.05		122500	.560	.550	.770	18.05	
139700	.785	.650	.785	17.70		130000	.570	.560	.770	18.05	
144800	.840	.695	.785	17.60		140000	.570	.560	.770	18.05	
150000	.890	.740	.785	18.05		147000	.570	.560	.770	18.05	
153600	.940	.810	.785	18.27		156000	.570	.560	.770	18.05	
153600	.995	.860	.785	17.76		160000	.565	.560	.770	18.05	
159500	1.070	.930	.785	17.60		160000	1.030	1.030	.770	18.05	
166200	1.125	1.000	.785	18.20		171000	1.125	1.125	.770	18.05	
166200	1.400	1.400	.785	18.00		171000	1.400	1.400	.770	18.05	
Y = .7411 IN.						Y = .7400 IN.					
30130 LITE 7075-T7352						30130 LITE 7075-T7352					
0	.155	.145	.550	16.45		0	.150	.150	.550	16.45	
30600	.190	.190	.580	17.15		20100	.185	.185	.575	17.00	
72600	.275	.275	.600	17.50		36700	.215	.215	.595	17.15	
90200	.345	.345	.630	17.97		47000	.255	.255	.645	17.16	
116000	.395	.355	.670	17.97		56000	.295	.295	.670	17.16	
126000	.435	.405	.680	17.77		67000	.345	.345	.695	17.17	
140000	.485	.455	.710	18.05		77600	.405	.405	.715	17.17	
150000	.535	.505	.720	18.05		87100	.460	.460	.730	18.05	
156600	.585	.545	.730	18.20		97500	.510	.510	.730	18.05	
165200	.630	.595	.730	18.05		100000	.510	.505	.730	18.05	
171000	.670	.630	.730	18.20		109500	.560	.550	.730	18.05	
176000	.710	.670	.730	18.05		121000	.610	.605	.730	18.05	
177000	.750	.705	.730	18.05		130000	.660	.650	.730	18.05	
187000	.800	.760	.730	18.05		140000	.710	.705	.730	18.05	
197000	.850	.810	.730	18.05		150000	.760	.750	.730	18.05	
207000	.900	.860	.730	18.05		160000	.810	.800	.730	18.05	
217000	.950	.910	.730	18.05		170000	.860	.850	.730	18.05	
227000	1.000	.960	.730	18.05		180000	.910	.900	.730	18.05	
237000	1.050	1.010	.730	18.05		190000	.960	.950	.730	18.05	
247000	1.100	1.060	.730	18.05		200000	1.010	1.000	.730	18.05	
257000	1.150	1.110	.730	18.05		210000	1.060	1.050	.730	18.05	
267000	1.200	1.160	.730	18.05		220000	1.110	1.100	.730	18.05	
277000	1.250	1.210	.730	18.05		230000	1.160	1.150	.730	18.05	
287000	1.300	1.260	.730	18.05		240000	1.210	1.200	.730	18.05	
297000	1.350	1.310	.730	18.05		250000	1.260	1.250	.730	18.05	
307000	1.400	1.360	.730	18.05		260000	1.310	1.300	.730	18.05	
317000	1.450	1.410	.730	18.05		270000	1.360	1.350	.730	18.05	
327000	1.500	1.460	.730	18.05		280000	1.410	1.400	.730	18.05	
337000	1.550	1.510	.730	18.05		290000	1.460	1.450	.730	18.05	
347000	1.600	1.560	.730	18.05		300000	1.510	1.500	.730	18.05	
357000	1.650	1.610	.730	18.05		310000	1.560	1.550	.730	18.05	
367000	1.700	1.660	.730	18.05		320000	1.610	1.600	.730	18.05	
377000	1.750	1.710	.730	18.05		330000	1.660	1.650	.730	18.05	
387000	1.800	1.760	.730	18.05		340000	1.710	1.700	.730	18.05	
397000	1.850	1.810	.730	18.05		350000	1.760	1.750	.730	18.05	
407000	1.900	1.860	.730	18.05		360000	1.810	1.800	.730	18.05	
417000	1.950	1.910	.730	18.05		370000	1.860	1.850	.730	18.05	
427000	2.000	1.960	.730	18.05		380000	1.910	1.900	.730	18.05	
437000	2.050	2.010	.730	18.05		390000	1.960	1.950	.730	18.05	
447000	2.100	2.060	.730	18.05		400000	2.010	2.000	.730	18.05	
457000	2.150	2.110	.730	18.05		410000	2.060	2.050	.730	18.05	
467000	2.200	2.160	.730	18.05		420000	2.110	2.100	.730	18.05	
477000	2.250	2.210	.730	18.05		430000	2.160	2.150	.730	18.05	
487000	2.300	2.260	.730	18.05		440000	2.210	2.200	.730	18.05	
497000	2.350	2.310	.730	18.05		450000	2.260	2.250	.730	18.05	
507000	2.400	2.360	.730	18.05		460000	2.310	2.300	.730	18.05	
517000	2.450	2.410	.730	18.05		470000	2.360	2.350	.730	18.05	
527000	2.500	2.460	.730	18.05		480000	2.410	2.400	.730	18.05	
537000	2.550	2.510	.730	18.05		490000	2.460	2.450	.730	18.05	
547000	2.600	2.560	.730	18.05		500000	2.510	2.500	.730	18.05	
557000	2.650	2.610	.730	18.05		510000	2.560	2.550	.730	18.05	
567000	2.700	2.660	.730	18.05		520000	2.610	2.600	.730	18.05	
577000	2.750	2.710	.730	18.05		530000	2.660	2.650	.730	18.05	
587000	2.800	2.760	.730	18.05		540000	2.710	2.700	.730	18.05	
597000	2.850	2.810	.730	18.05		550000	2.760	2.750	.730	18.05	
607000	2.900	2.860	.730	18.05		560000	2.810	2.800	.730	18.05	
617000	2.950	2.910	.730	18.05		570000	2.860	2.850	.730	18.05	
627000	3.000	2.960	.730	18.05		580000	2.910	2.900	.730	18.05	
637000	3.050	3.010	.730	18.05		590000	2.960	2.950	.730	18.05	
647000	3.100	3.060	.730	18.05		600000	3.010	3.000	.730	18.05	
657000	3.150	3.110	.730	18.05		610000	3.060	3.050	.730	18.05	
667000	3.200	3.160	.730	18.05		620000	3.110	3.100	.730	18.05	
677000	3.250	3.210	.730	18.05		630000	3.160	3.150	.730	18.05	
687000	3.300	3.260	.730	18.05		640000	3.210	3.200	.730	18.05	
697000	3.350	3.310	.730	18.05		650000	3.260	3.250	.730	18.05	
707000	3.400	3.360	.730	18.05		660000	3.310	3.300	.730	18.05	
717000	3.450	3.410	.730	18.05		670000	3.360	3.350	.730	18.05	
727000	3.500	3.460	.730	18.05		680000	3.410	3.400	.730	18.05	
737000	3.550	3.510	.730	18.05		690000	3.460	3.450	.730	18.05	
747000	3.600	3.560	.730	18.05		700000	3.510	3.500	.730	18.05	
757000	3.650	3.610	.730	18.05		710000	3.560	3.550	.730	18.05	
767000	3.700	3.660	.730	18.05		720000	3.610	3.600	.730	18.05	
777000	3.750	3.710	.730	18.05		730000	3.660	3.650	.730	18.05	
787000	3.800	3.760	.730	18.05		740000	3.710	3.700	.730	18.05	
797000	3.850	3.810	.730	18.05		750000	3.760	3.750	.730	18.05	
807000	3.900	3.860	.730	18.05		760000	3.810	3.800	.730	18.05	
817000	3.950	3.910	.730	18.05		770000	3.860	3.850	.730	18.05	
827000	4.000	3.960	.730	18.05		780000	3.910	3.900	.730	18.05	
837000	4.050	4.010	.730	18.05		790000	3.960	3.950	.730	18.05	
847000	4.100	4.060	.730	18.05		800000	4.010	4.000	.730	18.05	
857000	4.150	4.110	.730	18.05		810000	4.060	4.050	.730	18.05	
867000	4.200	4.160	.730	18.05		820000	4.110	4.100	.730	18.05	
877000	4.250	4.210	.730	18.05		830000	4.160	4.150	.730	18.05	
887000	4.300	4.260	.730	18.05		840000	4.210	4.200	.730	18.05	
897000	4.350	4.310	.730	18.05		850000	4.260	4.250	.730	18.05	
907000	4.400	4.360	.730	18.05		860000	4.310	4.300	.730	18.05	
917000	4.450	4.410	.730	18.05		870000					

STAGE PROPERTIES FOR CRYSTAL-CRAKED POLYMER SPECIMENS
 6" x 24" T679-T692 Hand Forging
 Longitudinal and Transverse Specimens
 Constant-load Tests, Stress Ratio = 1/3

Notes:

Cycles - Number of spikes of stress propagation.
Petiole Girth Length - measured on stem surface.
Total Vein Length - 0.75-in. long each starter plus Petiole girth.
Per Cent Cracked - total vein length expressed as a per cent of gross width.
W - maximum thickness, in.

6" x 10" 1075-7013 Lead Pencil
Lead-Encased and Short-Encased Type
(Constant Lead Ratio, Stress Ratio = 1/3)

cycles - Number of cycles of stress propagation.
 Fatigue Crack Length - measured on specimen surface.
 Total Width Length - 3.75-in long stress starter plate Fatigue crack
 Per Cent Cracked - total notch length expressed as a per cent of stress width
 ? - specimen thickness, in.

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13. ABSTRACT The tensile, compressive, shear, bearing, fracture-toughness, axial-stress fatigue, resistance to stress-corrosion cracking and fatigue-crack propagation rates have been determined for a total of 40 lots of 2014-T652, 2024-T852, 7075-T7352 and 7079-T652 stress-relieved aluminum alloy hand forgings ranging in thickness from 2 through 6 in. Tables of computed design mechanical properties and typical and minimum stress-strain and compressive tangent-modulus curves were prepared. Average values of plane-strain stress-intensity factor, K_{Ic} , at 5 per cent secant offset were determined. Log-mean fatigue-life values were calculated. The forgings of all four alloys have a high resistance to exfoliation and a high resistance to stress-corrosion cracking when stressed in the longitudinal direction relative to the grain flow pattern. In the long and short-transverse test directions, the resistance to SCC varied markedly with respect to alloy and temper, with 7075-T7352 being outstanding, 2024-T852 rating second, and 2014-T652 or 7079-T652 rating third. The rate of fatigue crack propagation was found to vary with the seven orientations tested and to be substantially faster in a humid atmosphere than in a dry atmosphere. For tests in a salt fog atmosphere, it was demonstrated that a slower rate of loading caused a faster rate of propagation per cycle. At the lower stress intensities the alloys rate in the following decreasing order of resistance to crack propagation: 2014-T652, 2024-T852, 7075-T7352 and 7079-T652.		

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