COLUMN CREEP OF
75S-T6 ALUMINUM ALLOY

Thesis by

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SUMMARY

This thesis is a report of the results of the column phase of a three part experimental investigation of short time creep properties of light metal alloys under conditions of high loadings and elevated temperatures. The other parts of the investigation were concerned with creep properties of these alloys in tension and in compression. The former is described by R. J. Kauffman; the latter by R. C. Thatcher (Refs. 11 and 12).

Creep characteristics of 75S-T6 aluminum alloy columns having various effective slenderness ratios were investigated at 450°F and 550°F. Of primary interest was the region of applied stresses near the maximum stresses which these columns would sustain. Lateral creep deflection of the column midpoint was measured. Coincident with this measurement, time to failure of the column was also measured. Columns tested at 550°F had rectangular cross sections and had effective slenderness ratios of 25.5, 39.9, 48.6 and 57.2. Columns tested at 450°F. had rectangular cross sections and had effective slenderness ratios of 25.5, 48.6 and 57.2.

Testing equipment was designed and constructed for the investigation. A constant load was applied to the specimen by means of a lever arm having a ten to one mechanical advantage. The specimen was heated in an electric oven. The oven was maintained at temperature by automatic electrical control.

It was found that 75S-T6 aluminum alloy columns having effective slenderness ratios of 25.5 to 57.2 are suitable for short time (0 - 10 min.) use at 450°F and 550°F.

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I. INTRODUCTION

Creep in metals under stress at high temperatures is of widespread interest. The trend of aircraft toward high speeds of flight has introduced the problem of aerodynamic heating. For example, a temperature rise of 270°F due to compressibility is reported in reference 1. Jet propulsion has also created the need of more effective alloys for high temperature service.

Quite often it is possible to avoid the problem of structural difficulties caused by creep by imposing low working stresses on the structure. This is the inefficient solution to the problem, however, since the result is increased weight. Aeronautical engineering is particularly concerned with the problem of creep because a weight penalty cannot be accepted in many applications.

The literature on the subject of creep is varied. Fundamental studies relating to the origin and nature of creep have been conducted at the University of California and are reported in references 2 and 3. The National Advisory Committee for Aeronautics has summarized, in reference 4, numerous theories relating to creep phenomena and the extent of current knowledge on the subject. This report gives a list of 199 references as a bibliography of many of the published works in the field of creep. Marin, in reference 5, gives a survey of research in creep which includes a bibliography of 48 references.

In general, the application of creep knowledge to date has been concerned with the effect of creep at the end of a long time service period. The advent of high speed expendable missiles makes knowledge of short time, high stress creep characteristics of metals desirable. Short time here is defined in terms of minutes or seconds rather than hours of time. Knowledge of the short time creep characteristics of the material from which a unit is to be constructed will permit an efficient design where the service life of the unit is to be a matter of minutes. At present, no published work has considered this phase of the subject of creep.

Interest in the short time high stress creep characteristics of light metals such as aluminum and magnesium served as the motivating factor for starting an investigation of these creep characteristics. The investigation was divided into three parts; one dealing with tension; a second dealing with compression; and a third with columns in the intermediate slenderness ratio regime. The object of this paper is to report the results of the column phase of the investigation.

Column deflections and buckling loads for materials which do not creep have been considered and discussed for many years. Euler, (Ref. 6), obtained the theoretical critical load for ideal pin ended columns loaded below the proportional limit. There have been at least three major theories explaining the action of ideal columns loaded above the proportional limit. The first of these was proposed by Engesser over fifty years ago. The second theory is the reduced modulus theory of Considere, Engesser and von Karman. The third theory is that proposed by Shanley in reference 7 and additionally discussed by him in reference 8.

These theories are concerned with ideal columns, i.e. columns which are pin ended, which have no crookedness, which have homogeneity of material, and which have zero eccentricity of applied loading. The analysis given by these ideal theories must be extended to consider practical columns.

When a material creeps, the theories of column action mentioned above must be further modified to consider the reduction of the critical load which is caused by lateral creep deflections of the column.

Some theoretical work has been done in regard to column creep deflection. Marin, in reference 9, proposed a theory for creep deflection in bending in the form of a differential equation. A trial and error procedure or numerical integration must be used to solve the equation. Ness, in reference 10, expressed the creep deflection of the column in terms of a definite time integral containing Young's modulus and the viscosity coefficient.

Little experimental work has been done in column creep deflection, particularly at high temperature and high stress for a material. This investigation is intended to provide at least some experimental data of this type. It is not proposed to go into a discussion of the theoretical aspects of the problem of column creep but rather to present the data obtained in actual column tests. The basis for all column studies must be a reliable background of tests.

This investigation was conducted at the California Institute of Technology, Guggenheim Aeronautical Laboratory, Pasadena, California, during the period September 1951 to May 1952, under the supervision of Dr. E. E. Sechler and in cooperation with Ralph J. Kauffman, Lt. USN and Roland C. Thatcher, Lt. USN.

II. EQUIPMENT AND PROCEDURE

In the early stages of the investigation, it soon became evident to the author and his co-workers that equipment had to be designed and built to do the planned task of creep testing. Furthermore, no published data could be found to give a basis for judgment in problems which were likely to arise. It was decided to try to keep the machines for testing creep in tension, compression and columns as uniform and simple as possible to facilitate their subsequent manufacture.

An angle iron frame was designed to support a static load, a furnace and a 10 to 1 lever arm system. A constant load of a wide range of values could thereby be applied to the specimen. The range of loading was chosen as zero to 6,500 lbs. on the specimen. Fig. 1 is a photograph showing the assembled equipment. Knife edges in the lever arm serve as fulcrum points and a ball and socket joint in the lower shelf of the frame provide for automatic alignment of the load and specimen axes.

Heat for the specimen was desired to be available up to 550°F. Since fluctuation of temperature at a point and a gradient of temperature along the specimen are not desired but must be tolerated, it was decided to accept variations of $\pm$ 5°F at a point and a gradient of 10°F along the length of a six inch specimen. The time to achieve this heat was desired to be as short as possible.

Figs. 2 and 3 are detailed sketches of the oven as finally designed. Fig. 4 is a photograph showing the interior of the oven. Power to the oven is automatically controlled by a Sim-Ply-Trol Controlling Pyrometer actuating a power relay. The oven operates on 110 v a.c.

and reaches $550^{\circ}F.$ at the controlling thermocouple within the oven in twelve minutes starting from a cold oven. In order to achieve the acceptable gradient over the specimen, it was found necessary to add an auxiliary heating coil producing 250 watts to the bottom of the inside of the oven and to labyrinth the mating surfaces of the two halves of the oven. Fluctuation of temperature within the oven at a point was brought within the desired tolerances by increasing the rate of cycling of the Sim-Ply-Trol. Heat insulating joints were interposed into the loading system above and below the outside of the oven to reduce the flow of heat through the steel shafts which pierced the top and bottom of the oven.

As the basic loading system was tensile in nature, a reversing cage was designed to fit within the oven and to provide compressive loads to the specimen. Spherical seats were machined into the inside of the top and bottom of the cage into which spherically machined ends of the specimen were to fit. The radius of the seat was one inch, the radius of the end of the specimen was 3/4 inch. The reversing cage may be seen in Fig. 4.

Measurement of the lateral deflection of the column was achieved by means of a probe tapered at one end and intended to be held snugly against the mid-point of the column with soft iron wire. In the course of the investigation, the use of the iron wire was abandoned. The other end of the probe was drilled to receive the plunger of a Federal dial gauge. The dial gauge read to 0.001". The probe was made of transite to prevent transmission of heat from the specimen to the dial gauge. The probe passed through a 1 inch diameter hole cut into the furnace. The dial gauge was mounted on the outside of the furnace by means of an aluminum bracket; the surfaces of the bracket and the furnace wall being separated by a 1/4 inch layer of àsbestos. The dial gauge may be seen mounted on the furnace in Fig. 5.

Upon completion of the loading system, all elements were weighed with a spring balance scale so that the dead load imposed by the system on the specimen could be calculated. Each element was weighed to the nearest ounce. The loading system was assembled and the spacing between knife edges measured. Measurement was done with a scale reading to 0.01 inch. Assuming the worst possible combination of 0.01 inch errors in knife edge spacing and the worst combination of one ounce errors in weighing the parts of the loading system, the maximum error in load on the specimen due to knife edge spacing was calculated to be 0.37 percent. The maximum error due to weighing the parts of the loading system was calculated to be $\pm$ 1.25 lb. of load on the specimen.

The entire column creep testing machine was assembled and the oven calibrated. A 75S-T6 aluminum alloy specimen 1/2 inch diameter and 6.0 inches long with 3/4 inch radius spherical ends was fitted with thermocouples which were located 1/4 inch from each end, 1-1/2 inch from each end, and at the mid-point of the specimen. Calibration at 450^{o}F and 550^{o}F was performed with the specimen in place in the reversing cage. At 450^{o}F a 3^{o}F gradient existed between bottom and top of the specimen. At 550^{o}F the bottom and top of the specimen were each 1^{o}F cooler than the mid-point. During calibration, no measurable variation in temperature at a point was observed. Temperature was measured with iron-constantan thermocouples wired to the surface of the specimen and a Leeds and Northrup portable potentiometer.

III. TEST SPECIMENS

The experimental study of columns involves a consideration of many variables such as slenderness ratio, properties of material, crookedness, eccentricity of loading, shape of section, and end conditions some of which are difficult to control and all of which complicate the interpretation of results. In order to reduce the number and influence of these variables to a minimum so that attention may be focused principally on loading and slenderness ratio, the following facts are stated to apply to this investigation.

The material used for testing was 75S-T6 aluminum alloy, rolled, 5/8 inch diameter rod with the following properties:

Mechanical Properties	Value of Property
Modulus of elasticity in tension, psi.	10.27×10^6
Ultimate tensile strength, psi.	84,800
Tensile yield strength (0.2 percent offset), psi.	76,500
Elongation, percent in 2 inches.	10
Modulus of elasticity in compression, psi.	10.6×10^6
Compressive yield strength (0.2 percent offset), psi.	81,000

These properties were obtained by tension and compression tests conducted on the material in a Baldwin - Southwark Universal 300,000 lb. testing machine with a Tate-Emery Load Indicator. A Huggenberger strain gauge was used to measure strain. The tension stress - strain curve is given in Fig. 6. The compression stress strain curve is given in Fig. 7.

Specimens having various slenderness ratios were machined from the 75S-T6 round rod according to the following specifications:

$\frac{L}{\rho}$	thickness	width*	length	$\frac{L'}{\rho}$
41.5	0.3198"	0.4667"	3.835"	25.5
65.0	0.3198"	0.4667"	6.000"	39.9
80.0	0.2598"	0.4667"	6.000"	48.6
95.0	0.2188"	0.4667"	6.000"	57.2

In addition to having a rectangular cross section of the above dimensions, the specimens were machined with 3/4 inch radius spherical ends. Maximum variation from these dimensions was fixed at ± 0.001" in thickness, ± 0.005" in width and ± 0.001" in length. Actual variation from prescribed dimensions was usually much less in the specimens tested.

The crookedness of the various specimens was measured by placing thickness gauges between the specimens and a plane surface upon which they rested. Maximum variation at the mid-point of the columns having a slenderness ratio of 95 was 0.002". Columns having slenderness ratios less than 95 were practically flat.

Eccentricity of loading was overcome by the use of the spherical seats in the reversing cage and the spherical ends of the columns. The columns were easily centered in the cage for testing. Proper alignment of the specimens was [1] checked by visual reference to several of the parallel rods comprising the cage.

In order to obtain end fixity for the various columns tested, two columns of different slenderness ratios were separately placed in a Baldwin - Southwark Universal 300,000 lb. testing machine with a Tate - Emery Load Indicator with the ends of the reversing cage placed

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* During the investigation, column width was increased to 0.520".

between the top and bottom of the column and the respective cross-heads of the hydraulic machine. The columns had slenderness ratios of 50 and 95. They were 6.0" long with 3/4" radius spherical ends and were 0.4667" wide. The columns were uniformly loaded to buckling at a slow rate of loading. The proper value of tangent modulus was then obtained from Fig. 7 and the following equation solved for end fixity:

$$\sigma_{CR} = \frac{C \pi^2 E_t}{\left(\frac{L}{\rho}\right)^2}$$

where $\sigma_{CR} = \frac{P}{A}$ = critical stress of column

C = end fixity

E_t = tangent modulus corresponding to σ_{CR}

$\frac{L}{\rho}$ = slenderness ratio. For rectangular cross sections, this is $\frac{\sqrt{12} \times L}{t}$.

A straight line variation of end fixity was assumed to exist for the other columns tested in this investigation and the following values of end fixity were obtained:

Slenderness ratio	End Fixity	Effective Slenderness Ratio
41.5	2.580	25.5
65.0	2.650	39.9
80.0	2.700	48.6
95.0	2.744	57.2

75S-T6 aluminum alloy was chosen for testing because it is currently used in the aviation industry. Temperatures for test were chosen as 450°F, and 550°F to be consistent with the efforts of Lt. Thatcher and Lt. Kauffman (Ref. 11 and 12).

Each test consisted of mounting the specimen with probe and thermocouple in the cage in the furnace and affixing the probe to the dial gauge. The dial gauge was fixed at an arbitrary setting between the limits of its travel to enable it to track the column in either of the two directions that the column might deflect. Proper weights were applied to the loading system; the weights, weight holder and lever arm were supported by means of a small hydraulic jack. Fifty minutes after turning the power on, the ball in the lower shelf of the frame was lightly screwed up into its socket and an initial reading i.e. "unloaded" reading was obtained from the dial gauge. The load was then smoothly applied to the specimen by opening the valve slowly in the jack. The load was applied in about two seconds. When the specimen first supported the full load, zero time was declared, and "load-on" reading was obtained from the dial gauge. By means of a stop watch, data of creep of the column mid-point was obtained from the dial gauge in intervals of 10 seconds of time. Data was recorded continuously until the specimen failed to support the load and the weights fell to rest atop the jack stem which had been previously lowered a few inches to a new position below the zero time position.

The specimen took 20 to 25 minutes to reach 98 percent of final temperature on its surface. Thirty minutes after this time, testing took place. Temperature on the surface of the specimen was observed by means of an iron-constantan thermocouple wired to the surface of the specimen. Control of the oven was maintained by a thermocouple located on the reversing cage midway between its top and bottom.

IV. RESULTS AND DISCUSSION

A total of 68 columns were tested; forty of them at 550°F and the rest at 450°F. Graphs showing lateral deflection creep of the column mid-point vs. time in seconds at 550°F and 450°F are plotted in Figs. 8 through 14. Creep curves are plotted to as large a scale as practical in order to magnify the trend of creep with change in applied stress. Creep deflection is shown to the nearest 0.0001 inch; an estimated accuracy, since a dial gauge reading to 0.001 inches was used. The time abscissa of each graph is terminated at 6 minutes; interest of the investigation being directed to the region of high stresses and temperatures. Curves of applied stress vs. time to failure at 450°F and 550°F are given on Figs. 15 and 16. The direction of the curves which do not evidence experimental points near their ends is established by data shown on Figs. 8 through 14 but which could not be plotted on Figs. 15 and 16. The curve for effective slenderness ratio of 57.2 at 450°F on Fig. 16 is an exception to this statement. In this case, however, a column having an effective slenderness ratio of 57.2 was tested at an applied stress of 7,500 psi at 450°F. At the end of two hours of time the column had not failed. Crossplots of applied stress vs. effective slenderness ratio for various times to failure at 450° and 550°F were obtained from Figs. 15 and 16 and are shown on Figs. 17 and 18.

It may be observed that all creep curves in Figs. 8 through 14 are referred to the origin. Consistent difficulty was realized in obtaining sensible intercepts during the investigation. In fact, frequently at zero time when the column fully supported the applied load, creep of the column mid-point caused the initial direction of motion of the dial gauge to reverse. The reason for this was not found. Factors in the design of test equipment which would contribute to lateral motion of the specimen during loading were investigated and corrected. Sway braces were installed to restrict the lever arm and appended weights to motion in the vertical plane only. Wedges were inserted around the loading system support shaft where it passed through the upper plate of the test stand. The ball which fitted into the socket in the lower shelf of the test stand was snugly screwed into position prior to loading. These measures were non-corrective. Rotation of the cage during loading was ruled out since the shafts supporting the upper and lower ends of the reversing cage were machined with identical threads. The torque induced on one end of the cage due to the load on the thread at that end would be cancelled by an equal and opposite torque induced by the threads at the other end of the cage. Rotation of the specimen during loading was discounted since reversal of direction of motion of the dial gauge occurred with the specimen securely fastened to the end of the probe with soft iron wire. In the event that a satisfactory explanation of this phenomenon is discovered at a later date making it possible to correct the recorded creep data to a suitable sequence of intercept values, laboratory data for the curves shown in Figs. 8 through 14 are given in Tables I through XXVII along with the corresponding data by which all curves are referred to the origin. In plotting the creep curves, creep was considered to start at the time the specimen fully supported the applied load.

A greater number of tests were conducted than those for which data is given. Another phenomenon developed in this investigation which contributed to a large amount of scatter and for which no satisfactory explanation has as yet been found. The single probe system which was used for measuring the column deflection, required that the column deflect in the direction of the axis of the probe and coincident dial gauge plunger. To insure this taking place, rectangular cross section columns were used. However, the columns did not consistently behave as expected. Many of them deflected at right angles to the intended direction as well as in the desired direction. This action took place, to varying degrees at 450^{o} and 550^{o}F in all effective slenderness ratios except that of 48.6. It occurred more frequently at 550^{o}F. The columns most affected were those having an effective slenderness ratio of 39.9. An interesting observation in connection with this double bending was that when its magnitude was greatest, the time to failure of the columns so affected was increased over the time to failure of columns which had the same stress and which bent in the intended direction only.

Inspection of columns tested, placed suspicion upon the soft iron wire used to fix the free end of the probe to the column mid-point. The wire indented the corners of the column cross section slightly. Thereafter, the wire was omitted and the probe was supported by a transite slide placed in the hole in the furnace wall through which the probe passed. Contact against the specimen mid-point was maintained by the addition of a light spring coiled around the dial gauge plunger. This spring amplified the spring in the mechanism of the dial gage and forced the probe to maintain contact with the surface of the specimen. The additional spring was not strong enough to influence the bending of the column because subsequent tests showed that the column deflected against the spring force as well as with it. In addition to changing the manner of maintaining contact between the column mid-point and the probe end, the column width was increased to 0.520 inches. The number of cases of double bending diminished but did not disappear. Throughout the investigation, 24 columns deflected in this manner.

Since the major part of the scatter in the experimental data obtained, involved columns which bent doubly, these tests were considered as unreliable. The data shown on Figs. 8 through 16 represent those obtained from columns which deflected in one plane only and those which best fit together. This resulted in not using the data from ten columns which deformed in the desired plane. The inevitable loss of data occurred also in several cases; losses due to an acute need of coordinated teamwork in operating experimental equipment and in recording data. Novice experimentalists at work must always pay this price.

No direct attempt was made to prove reproducibility of data. However, as a result of the difficulty experienced with double bending, tests were re-run to validate the trend of data as it accumulated. Columns which deformed properly presented a neat array of experimental evidence as shown by Figs. 8 through 16. Test data presented in these figures is not large in quantity but it is a reasonable representation of short time maximum loading creep characteristics of 75S-T6 columns.

V. CONCLUSIONS AND RECOMMENDATIONS

The results of this investigation permit the following conclusions:

1. 75S-T6 aluminum alloy columns have zero time to failure strengths, at 550°F which increase from 5,500 psi for an effective slenderness ratio of 57.2 to 9,550 psi for an effective slenderness ratio of 25.5. At 450°F, 75S-T6 columns have zero time to failure strengths which increase from 10,400 psi for an effective slenderness ratio of 57.2 to 17,600 psi for an effective slenderness ratio of 25.5. Zero time to failure strength is the maximum stress that a column will sustain when loaded at a relatively rapid rate. Shock or impact loading is not considered. Columns in the range of effective slenderness ratios 57.2 to 25.5 have approximately 50 percent of the maximum strength at 550°F that they have at 450°F.

2. The stress for which 75S-T6 aluminum alloy columns having effective slenderness ratios of 57.2 to 25.5 may be designed while still realizing a useful life in short time applications at 450°F and 550°F is an appreciable percentage of the maximum stress that these columns will sustain at these temperatures. For example, at 550°F a 75S-T6 column having an effective slenderness ratio of 39.9 will fail in 7 minutes if subjected to an applied stress of 5,500 psi. This stress is 65.5 percent of the maximum stress that the column will sustain. Other columns at 550°F in the range of effective slenderness ratios of 25.5 to 57.2 will fail in seven minutes under applied stresses which are higher than 65.5 percent of maximum. At 450°F, 75S-T6 columns in this same range of effective

slenderness ratios will withstand applied stresses, for seven minutes, which are 75 percent or better of maximum.

3. Contrary to widespread belief, 75S-T6 aluminum alloy may be useful in short time high stress, elevated temperature column applications in the range of effective slenderness ratios 57.2 to 25.5. An example of such use is one wherein a load due to acceleration is applied for a short time to a column which has been serving in a body under uniform low level stress for a half hour at elevated temperatures.

In the interest of additional experimental investigation of column creep, the following recommendations are offered:

It is suggested that other light metals be tested at elevated temperatures in order to obtain comparative creep data among several alloys. It is further suggested that the effect of variables on column creep be studied in the laboratory. Factors contributing to the scatter of elevated temperature column creep tests are varied and may well be important. Additional testing of columns at elevated temperatures would serve to evaluate them. It is felt that non-symmetrical deformation of a column about the plane through its mid-point and perpendicular to its axis is a critical item. This type of deformation occurred during the investigation and seemed to be coincident with premature failure of the column. Whether such deformation is due only to inconsistencies in material and variation of physical dimensions along the length of the column, or is due to something else is worthwhile knowing. Investigation of the phenomenon of double bending of rectangular columns would be of interest. It is due to factors such as machining stresses or testing technique or does it have to be planned for in design? Another point of possible interest is the relative importance of the rate at which a column is heated to its final temperature. Still another is the effect of loading rate on column creep and time to failure. Last, but nevertheless worthy of equal consideration is the question of shape factor and its influence on column creep properties.

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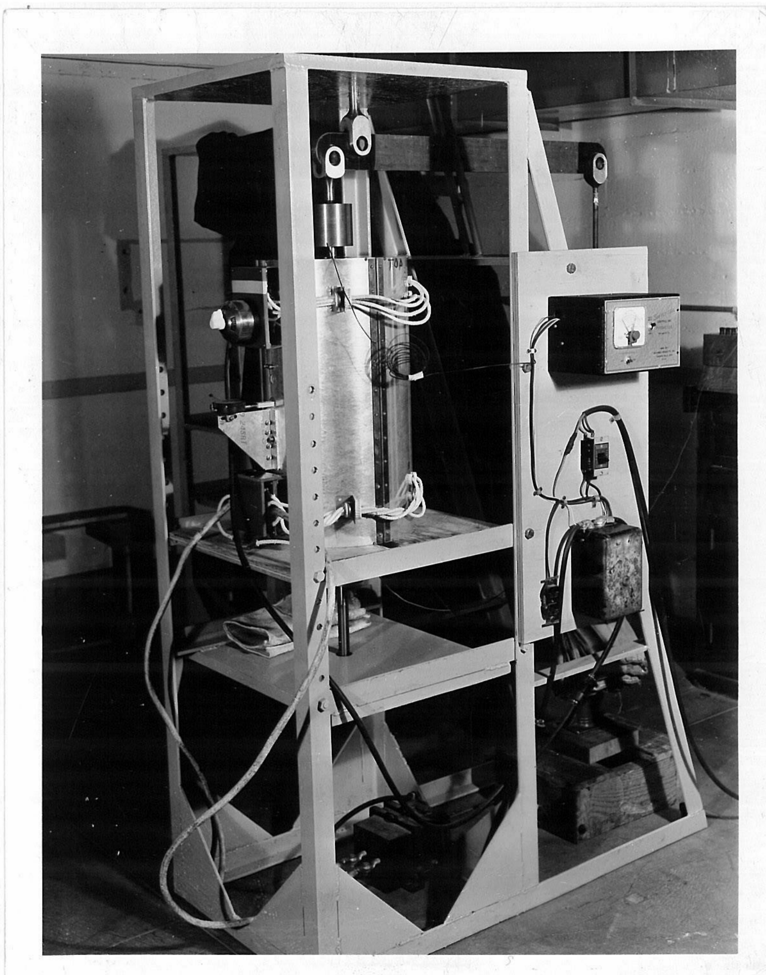
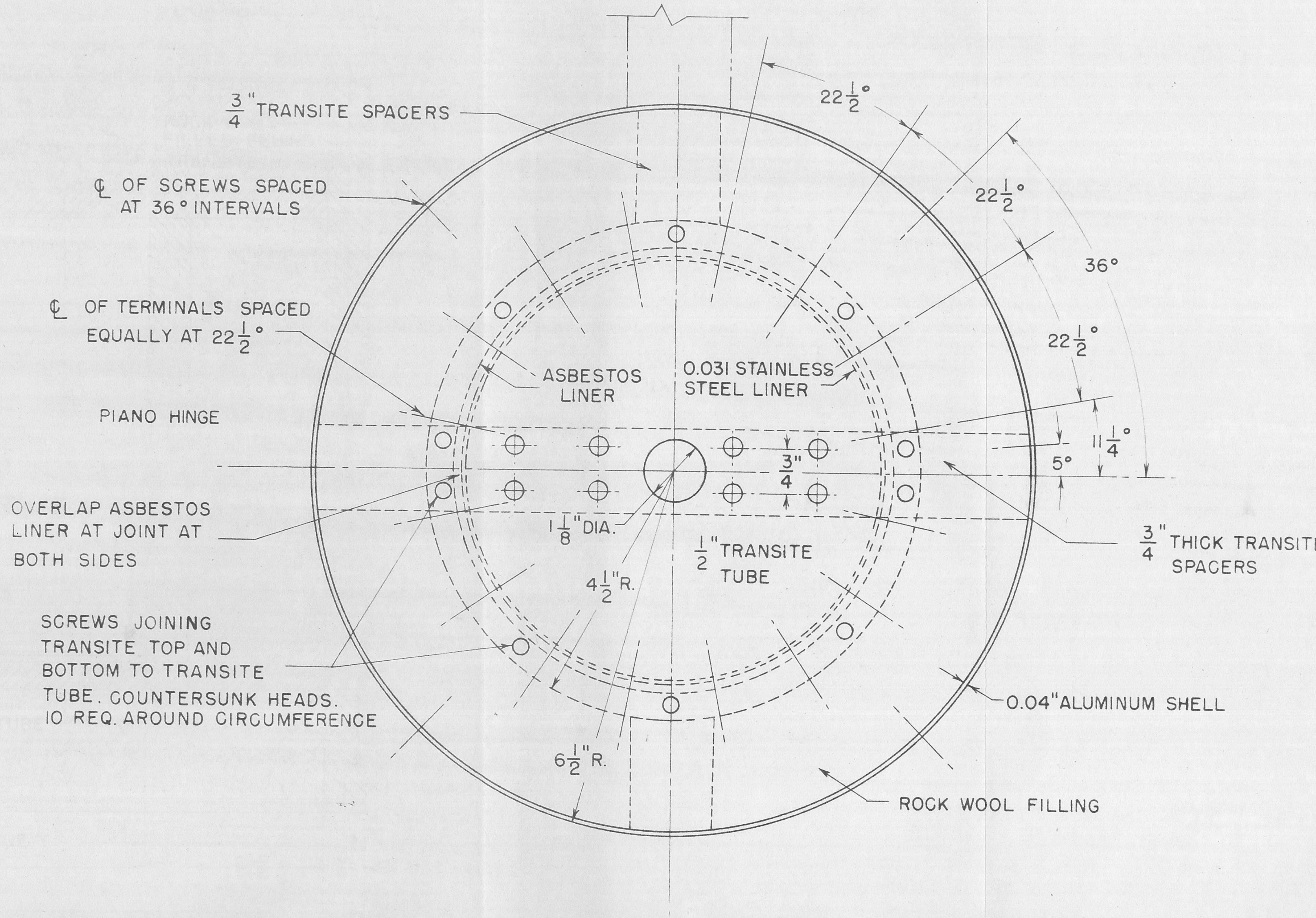


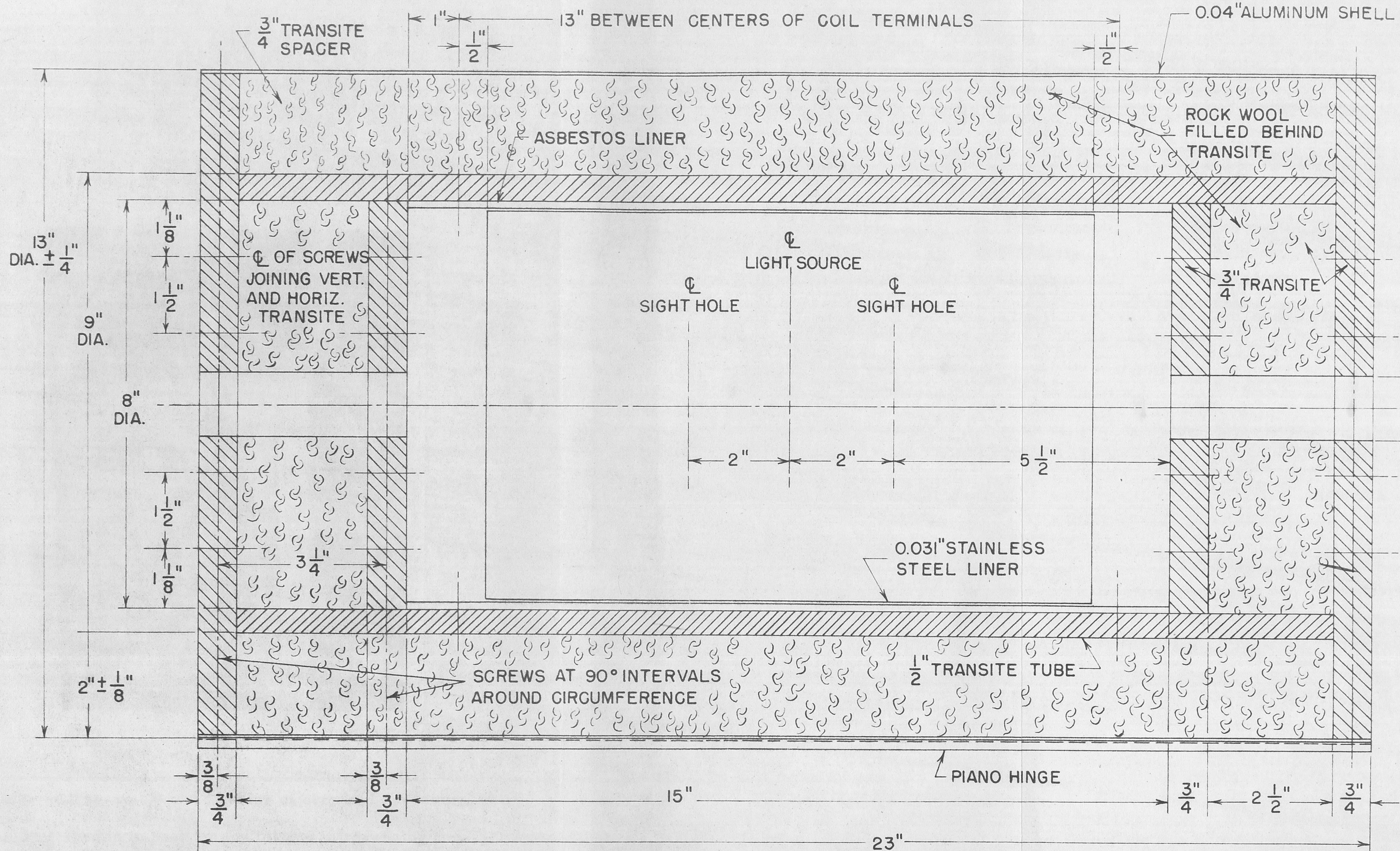
Fig. 1 Creep Test Equipment



TOP VIEW

CREEP TEST FURNACE

FIG. 2



NOTES:

1. FURNACE TO BE BUILT IN TWO HALVES. USE $\frac{3}{4}$" TRANSITE SHEET AT DIVIDING LINE TO CLOSE IN ROCK WOOL FILLER.
2. STAINLESS STEEL LINER TO BE FITTED WITH OVERSIZE HOLES AT FASTENING POINTS TO ALLOW FOR EXPANSION.
3. MANNER OF SCREWING TRANSITE TOGETHER IS IDENTICAL AT TOP AND BOTTOM OF FURNACE.

FRONT VIEW
CREEP TEST FURNACE

FIG. 3

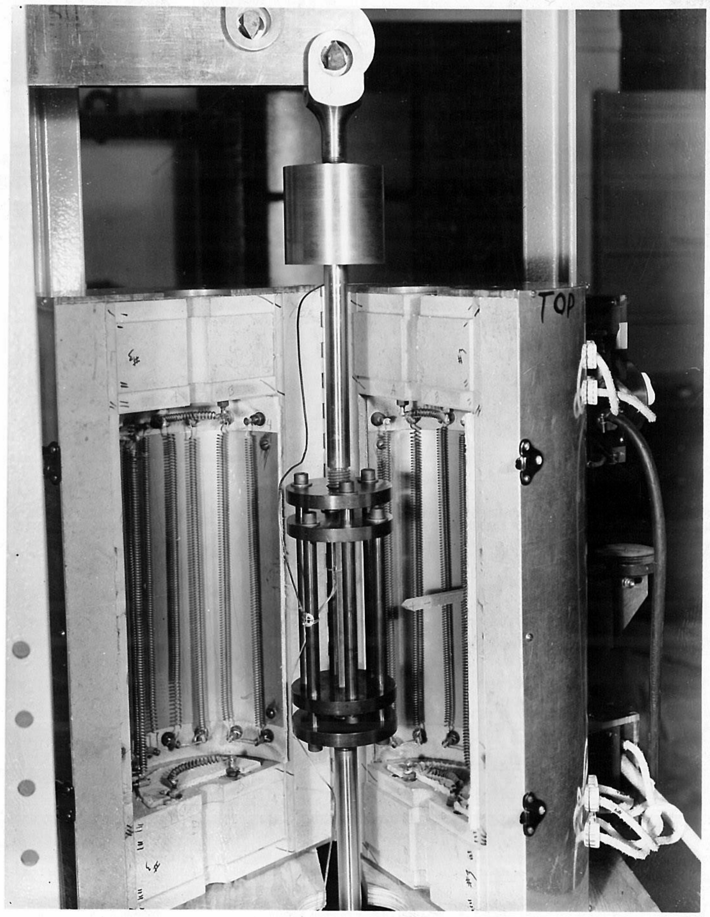


Fig. 4 Close-up view of interior of oven and reversing cage. Specimen is in position for testing in reversing cage.

Fig. 5 Close-up view of exterior of furnace showing dial gauge in position for measuring column deflection.

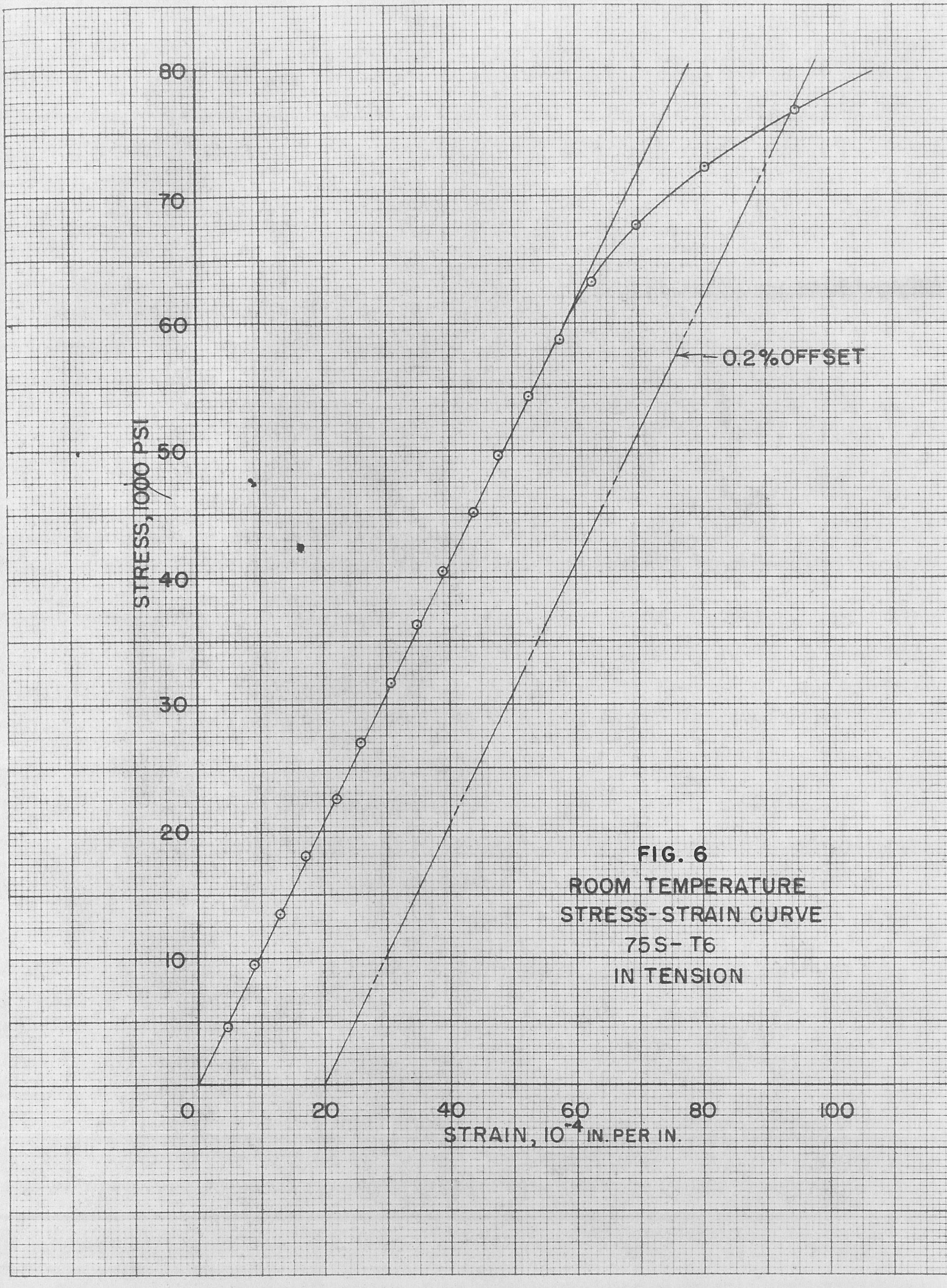


FIG. 6
ROOM TEMPERATURE
STRESS-STRAIN CURVE
75S-T6
IN TENSION

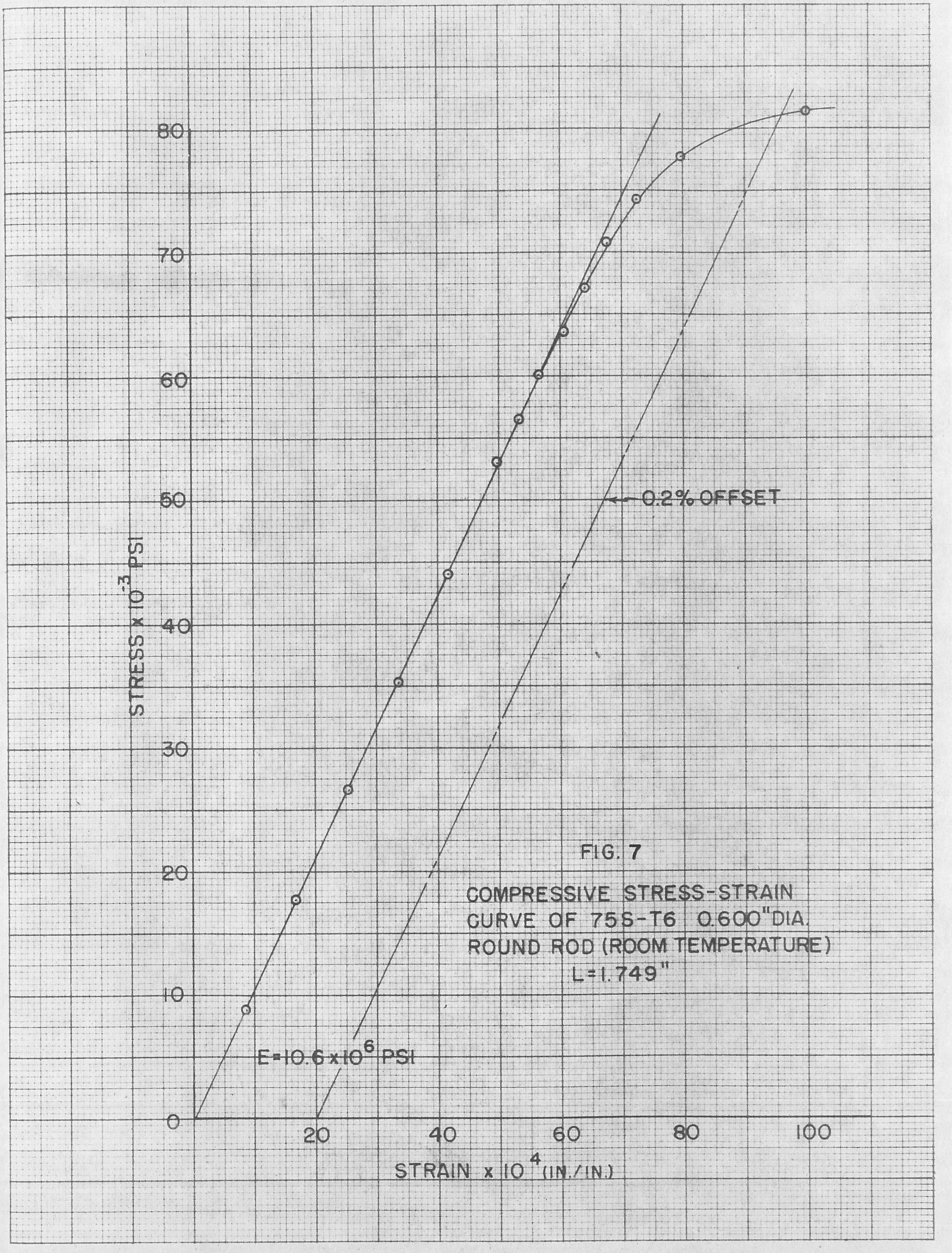


FIG. 7

COMPRESSIVE STRESS-STRAIN CURVE OF 75S-T6 0.600" DIA. ROUND ROD (ROOM TEMPERATURE)

L=1.749"

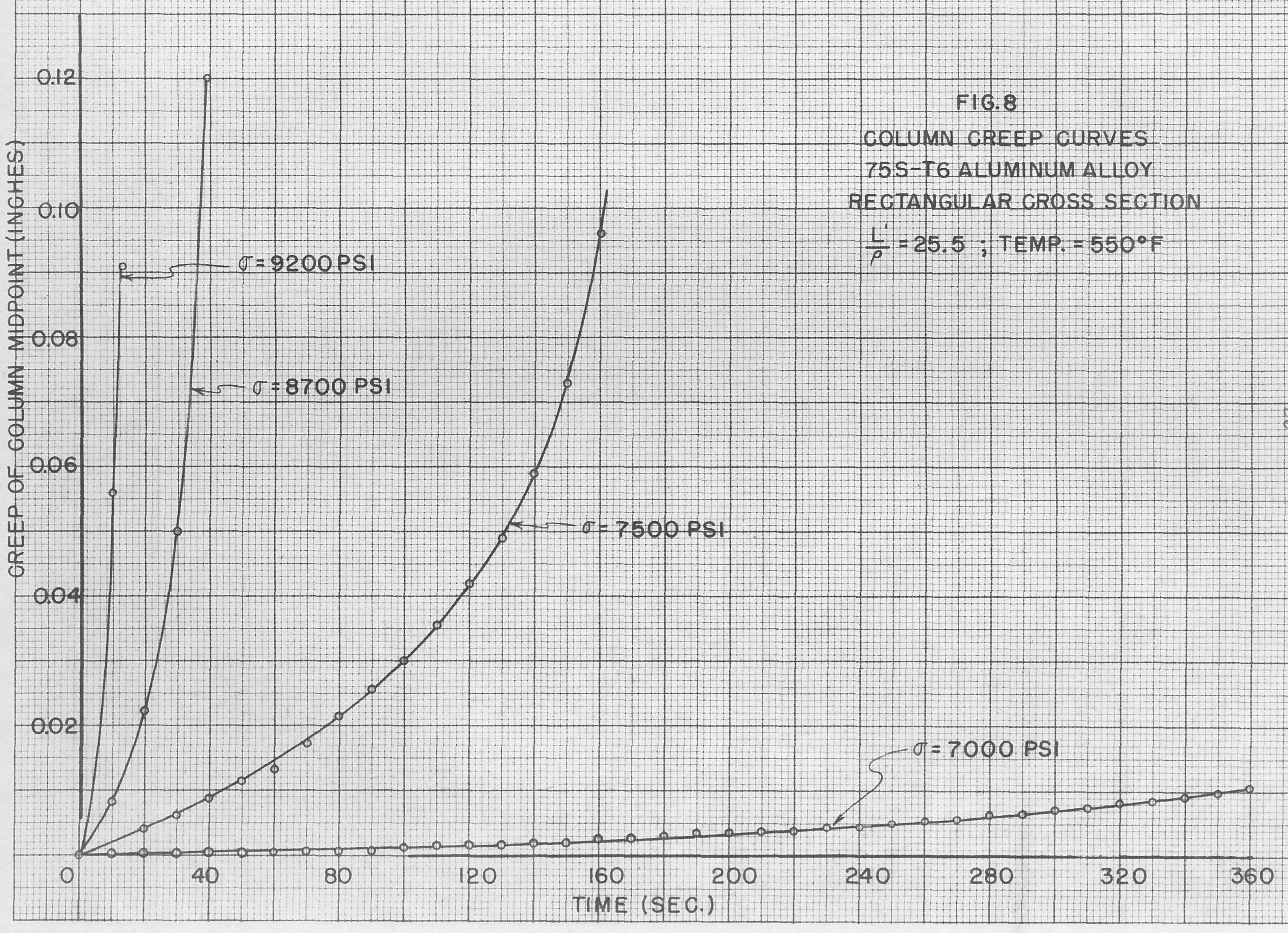


FIG. 8
COLUMN CREEP CURVES
75S-T6 ALUMINUM ALLOY
RECTANGULAR CROSS SECTION
$\frac{L'}{\rho} = 25.5$; TEMP. = 550°F

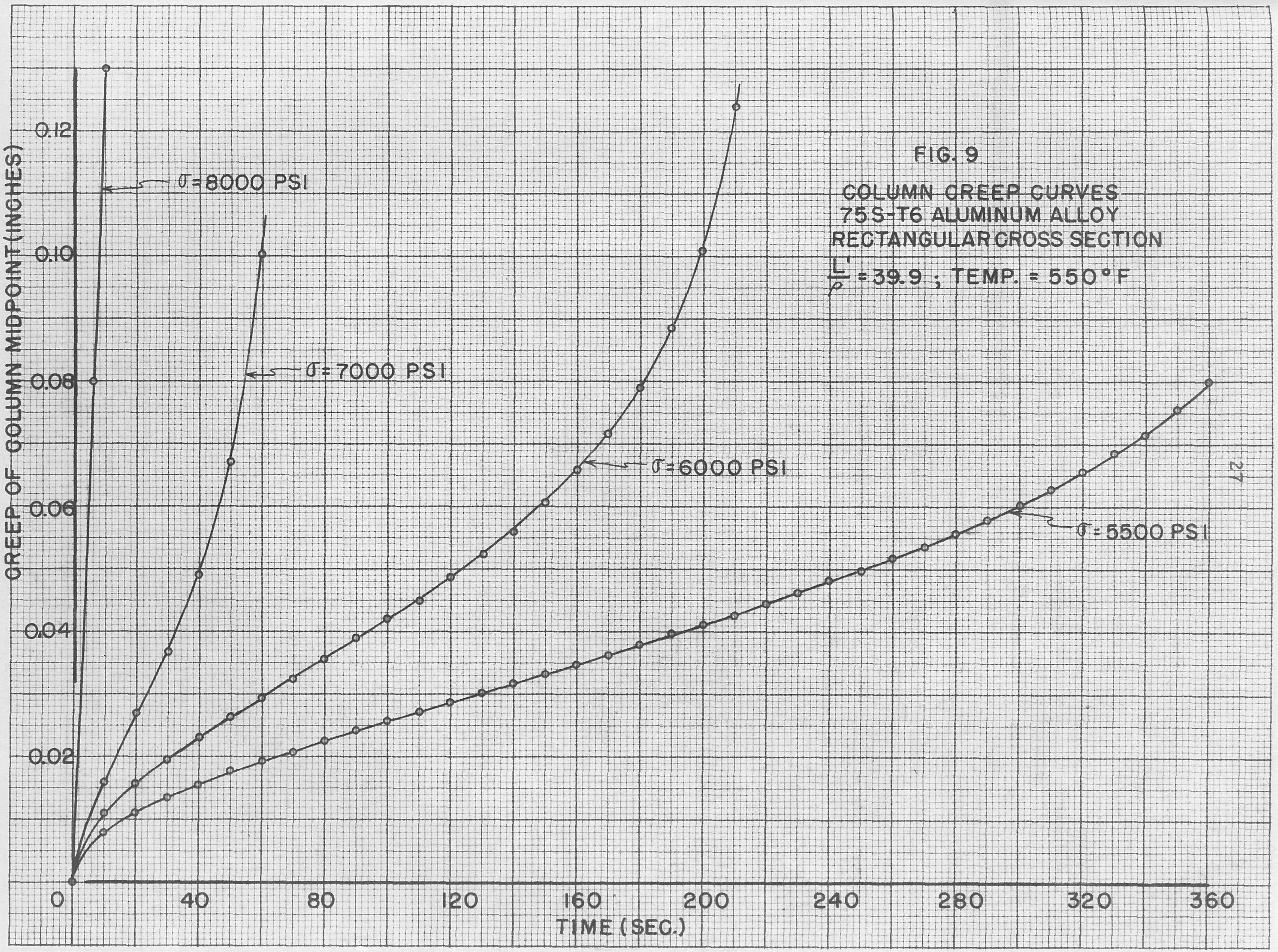


FIG. 9
COLUMN CREEP CURVES
75S-T6 ALUMINUM ALLOY
RECTANGULAR CROSS SECTION
L'/ρ = 39.9 ; TEMP. = 550°F
σ = 8000 PSI
σ = 7000 PSI
σ = 6000 PSI
σ = 5500 PSI
CREEP OF COLUMN MIDPOINT (INCHES)
0.12
0.10
0.08
0.06
0.04
0.02
0
40
80
120
160
200
240
280
320
360
TIME (SEC.)

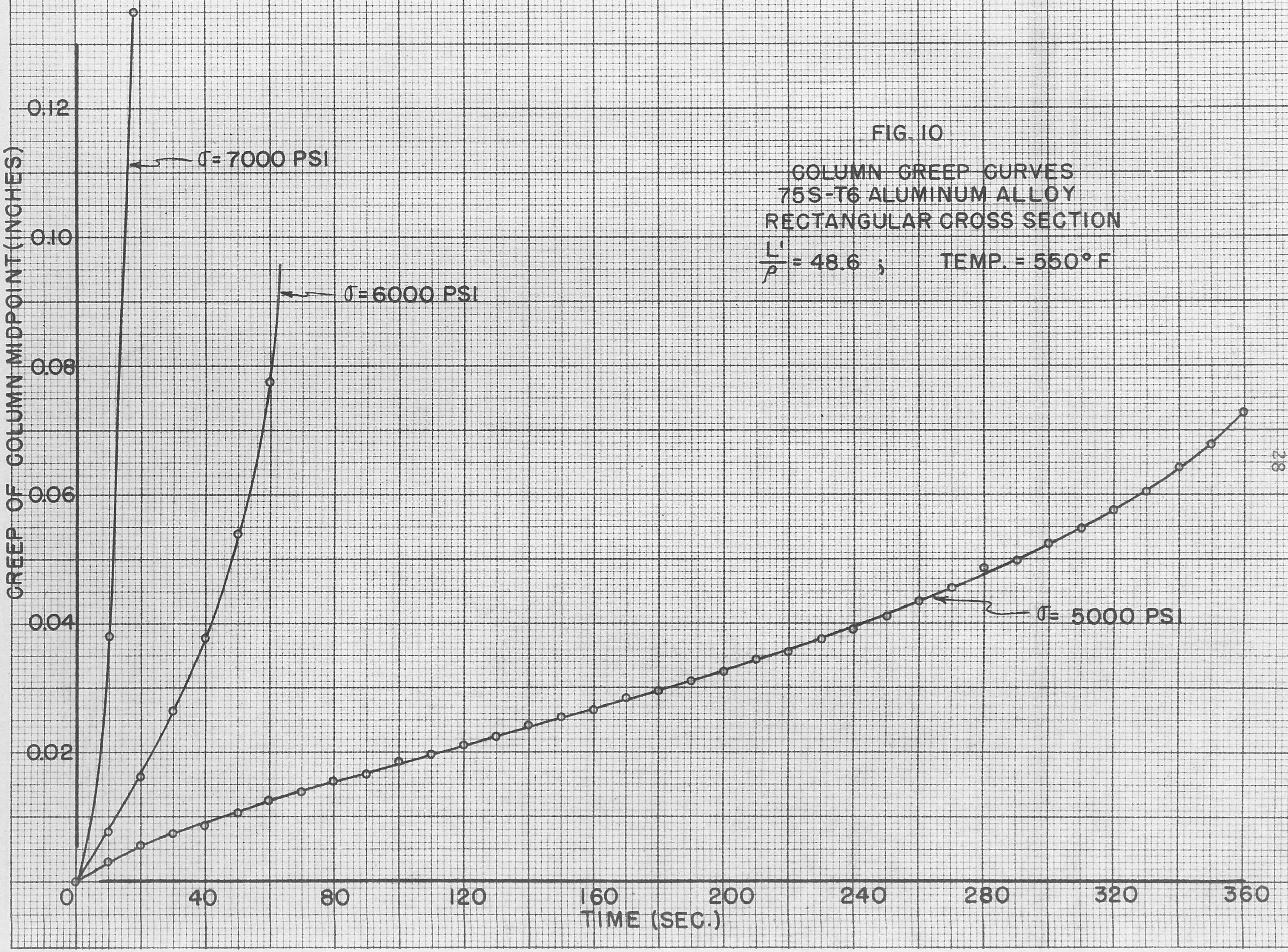
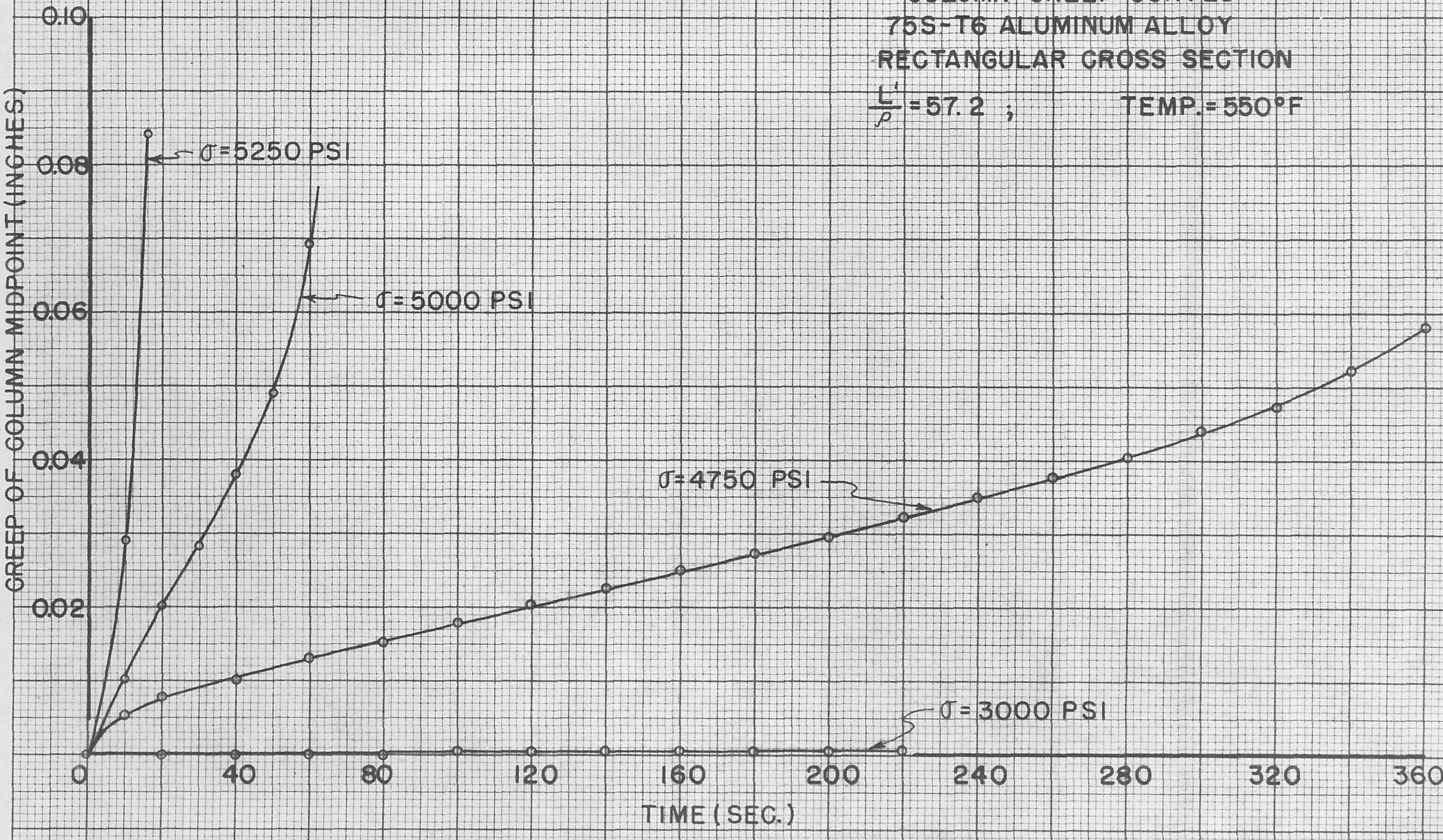


FIG. 10

COLUMN CREEP CURVES
75S-T6 ALUMINUM ALLOY
RECTANGULAR CROSS SECTION
$\frac{L'}{\rho} = 48.6$; TEMP. = 550° F

FIG. 11

COLUMN CREEP CURVES
75S-T6 ALUMINUM ALLOY
RECTANGULAR CROSS SECTION
$\frac{L'}{\rho} = 57.2$; TEMP. = 550°F



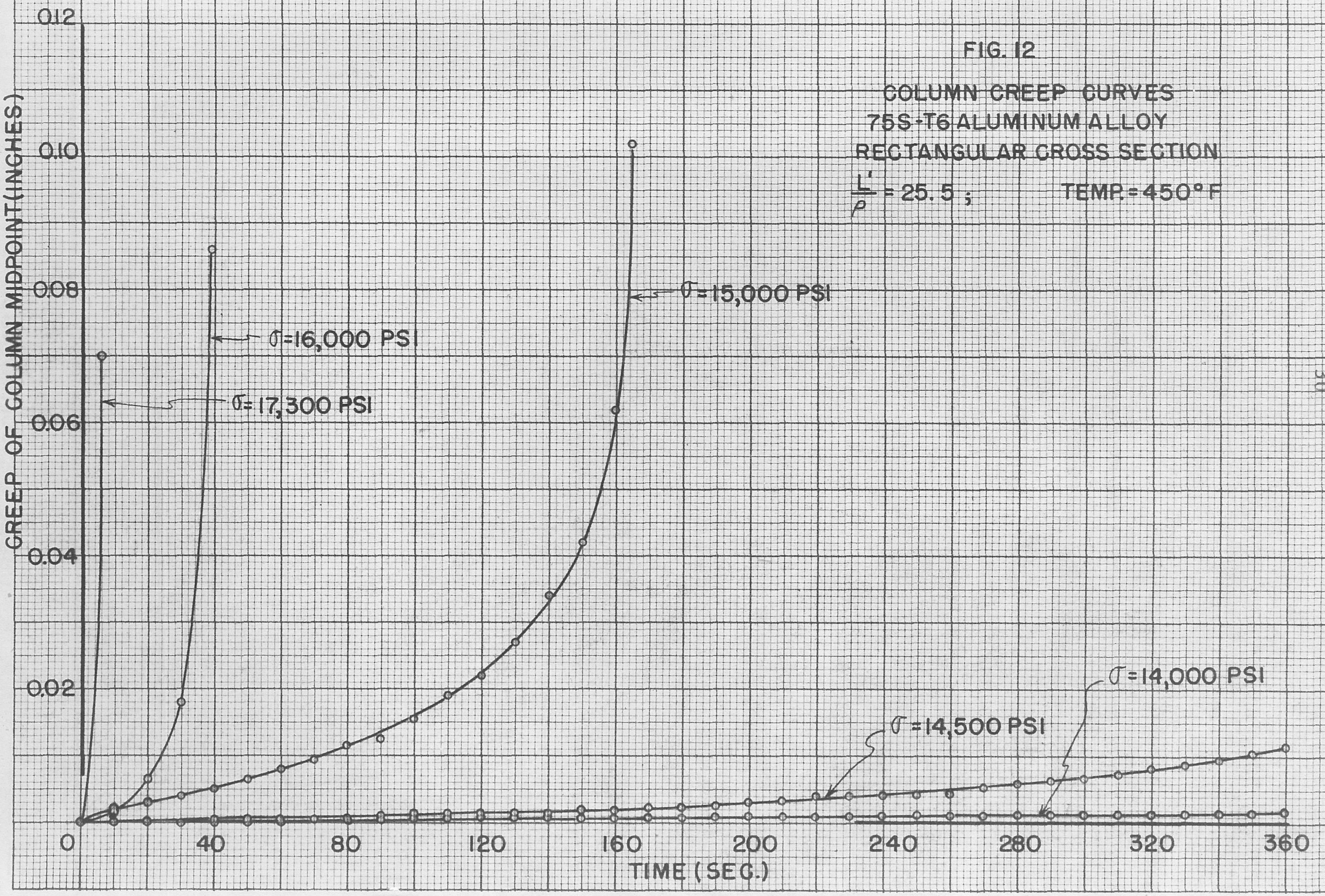


FIG. 12
COLUMN CREEP CURVES
75S-T6 ALUMINUM ALLOY
RECTANGULAR CROSS SECTION
L'/ρ = 25.5 ; TEMP. = 450° F
σ = 17,300 PSI
σ = 16,000 PSI
σ = 15,000 PSI
σ = 14,500 PSI
σ = 14,000 PSI
CREEP OF COLUMN MIDPOINT (INCHES)
0.12
0.10
0.08
0.06
0.04
0.02
0
40
80
120
160
200
240
280
320
360
TIME (SEC.)

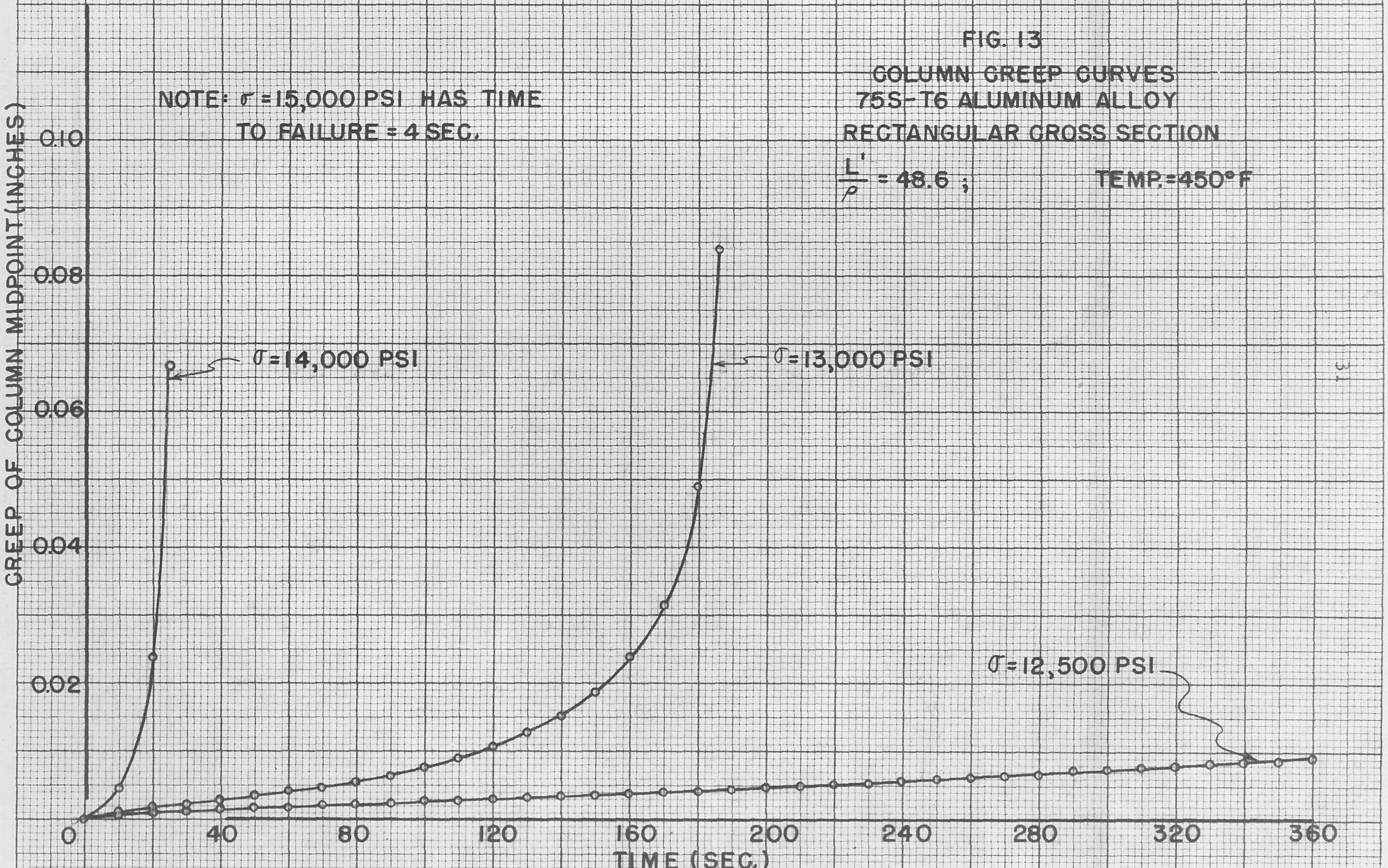


FIG. 13
COLUMN CREEP CURVES
75S-T6 ALUMINUM ALLOY
RECTANGULAR CROSS SECTION
$\frac{L'}{\rho} = 48.6$; TEMP. = 450°F

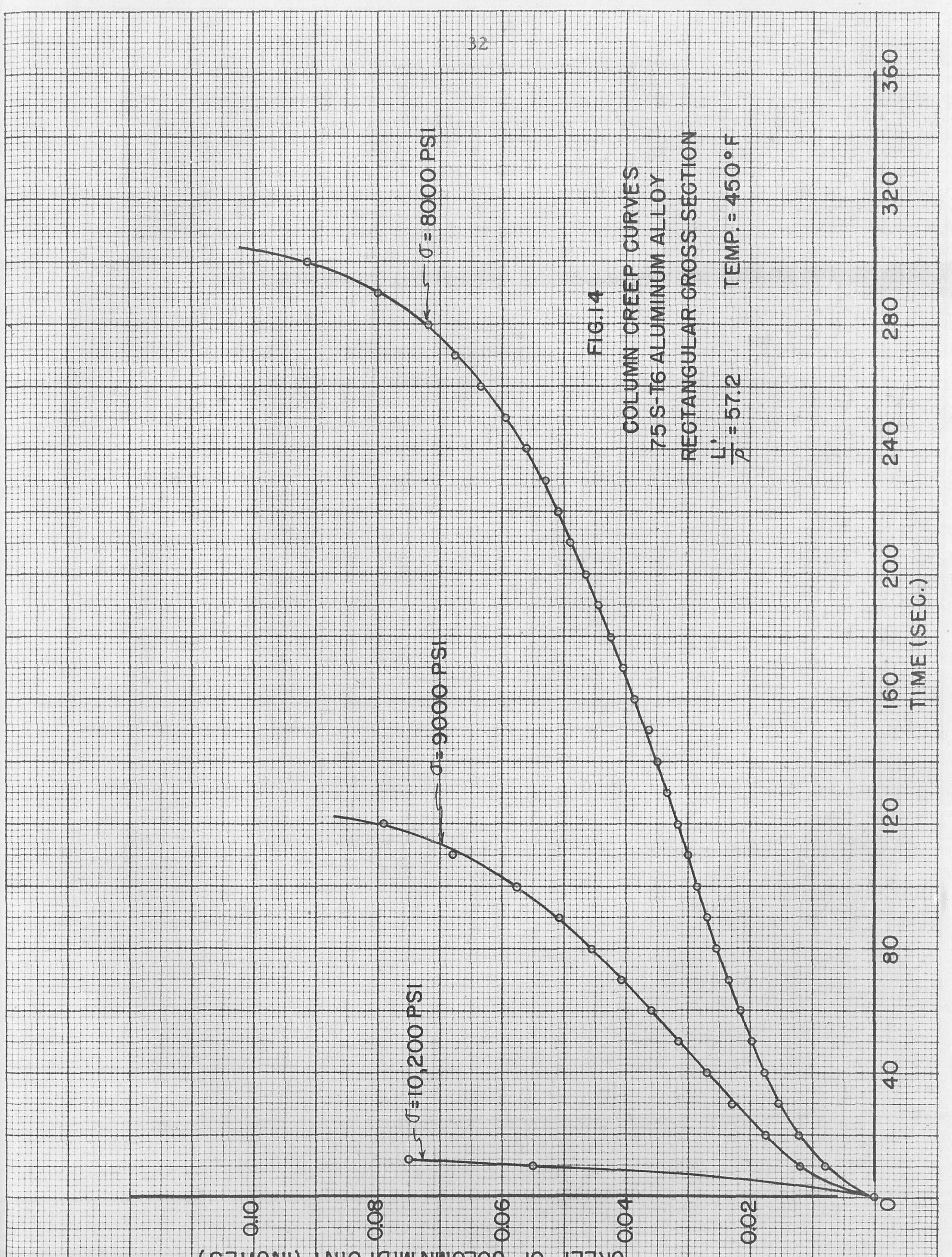


FIG.14

COLUMN CREEP CURVES

75 S-T6 ALUMINUM ALLOY

RECTANGULAR CROSS SECTION

$\frac{L'}{\rho} = 57.2$ TEMP. = 450° F

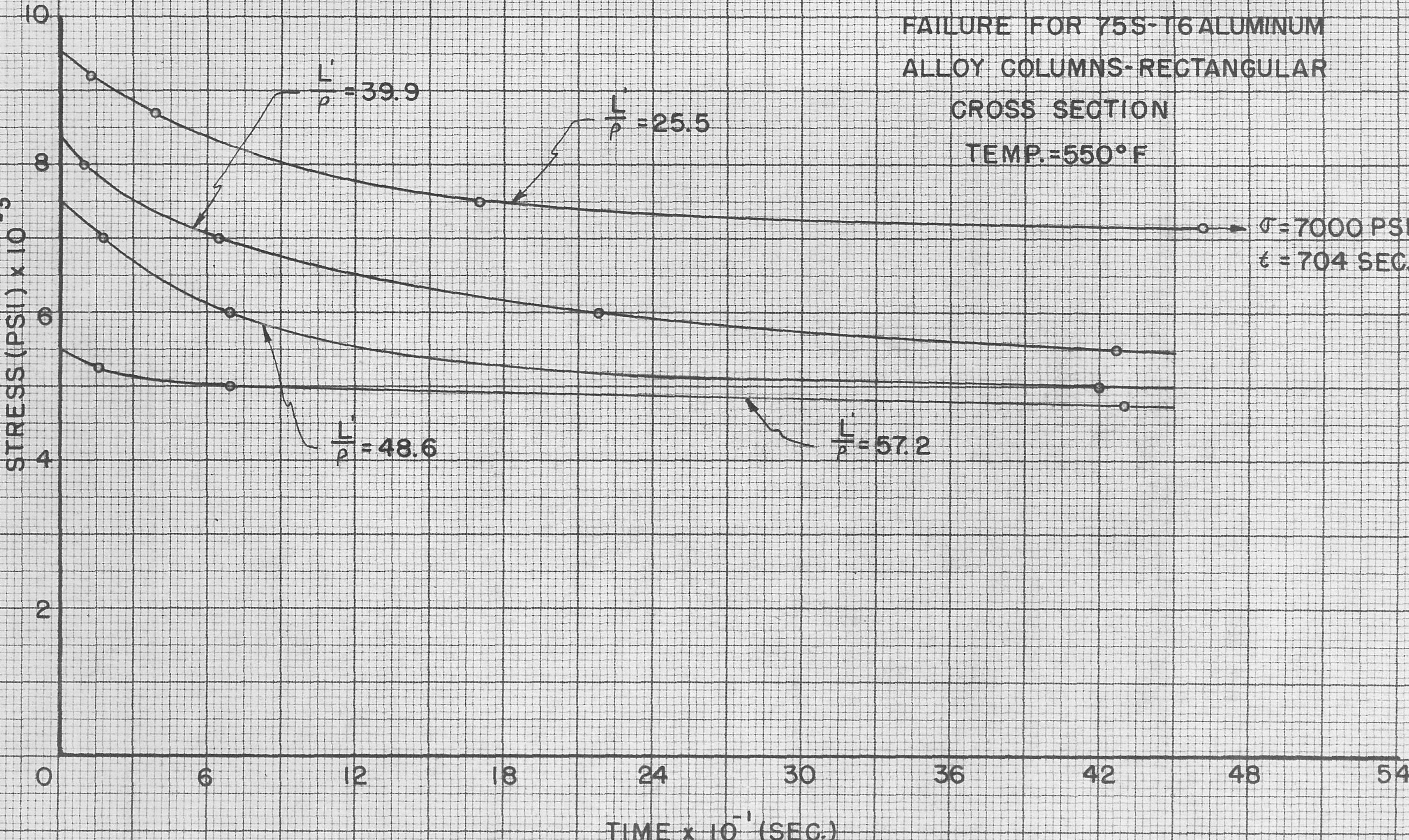


FIG. 15

APPLIED STRESS vs TIME TO FAILURE FOR 75S-T6 ALUMINUM ALLOY COLUMNS-RECTANGULAR CROSS SECTION

TEMP. = 550°F

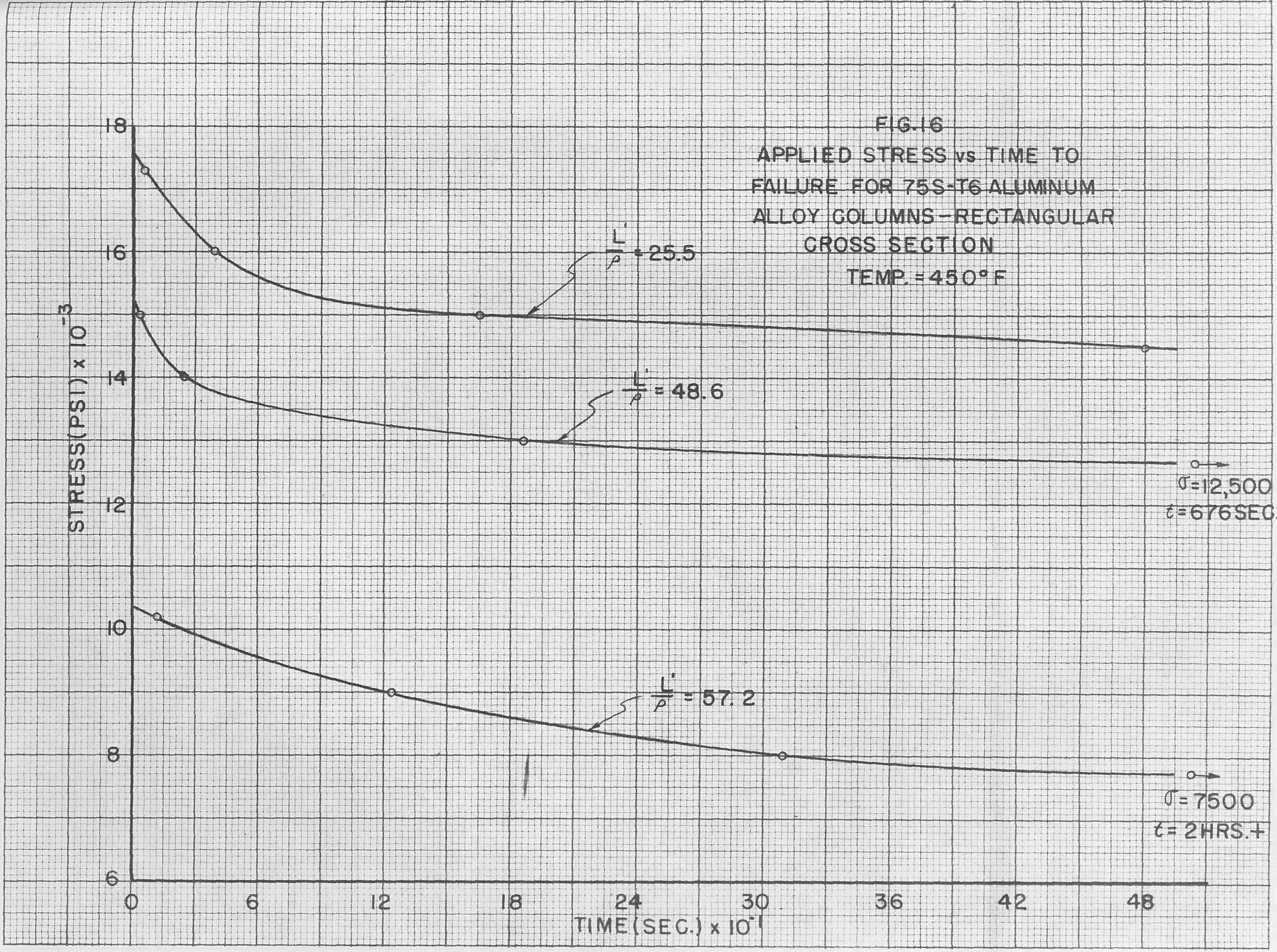


FIG.16
APPLIED STRESS vs TIME TO FAILURE FOR 75S-T6 ALUMINUM ALLOY COLUMNS - RECTANGULAR CROSS SECTION
TEMP. = 450° F

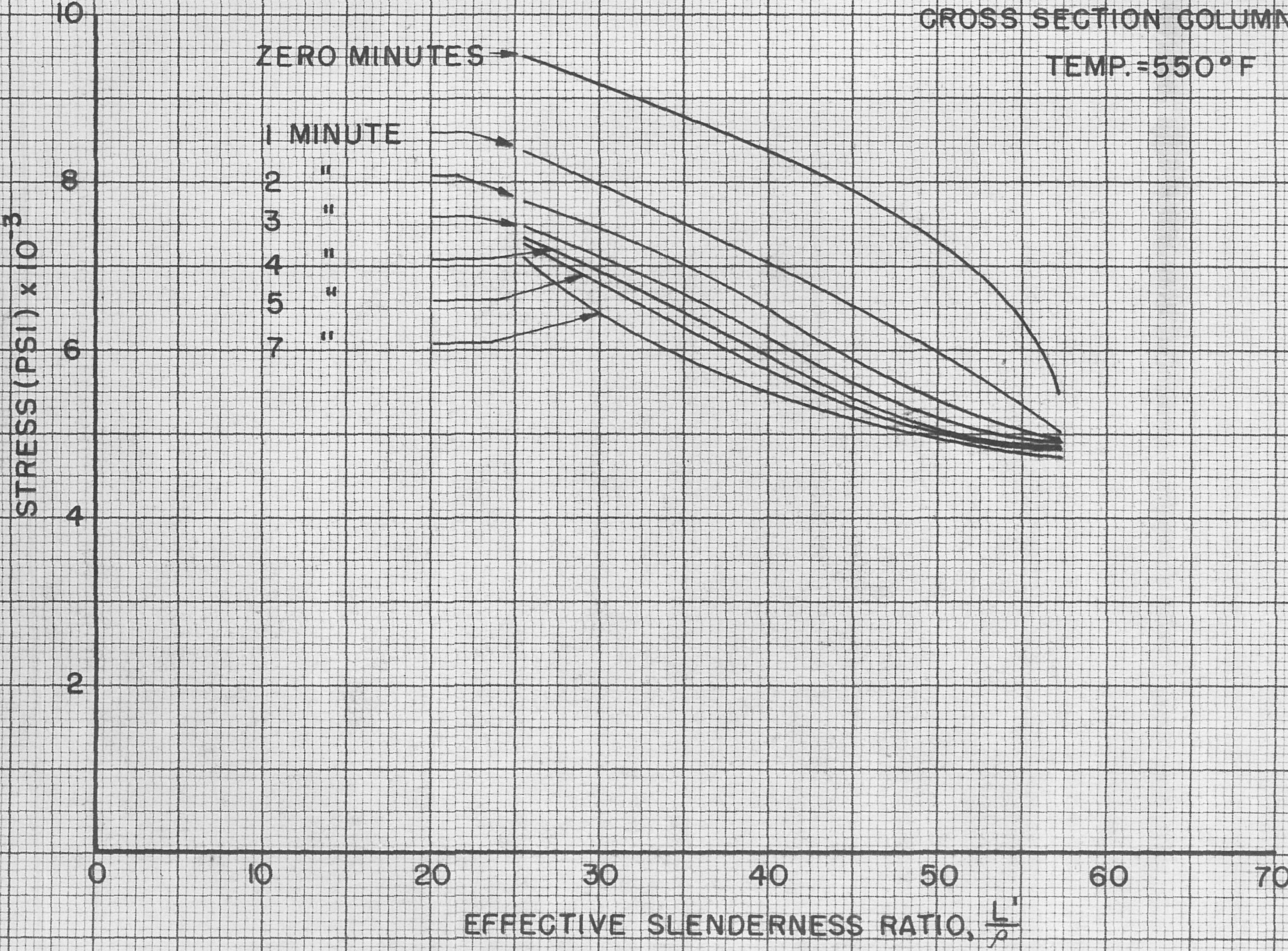


FIG. 17

TIME TO FAILURE FOR 75S-T6 ALUMINUM ALLOY RECTANGULAR CROSS SECTION COLUMNS

TEMP. = 550°F

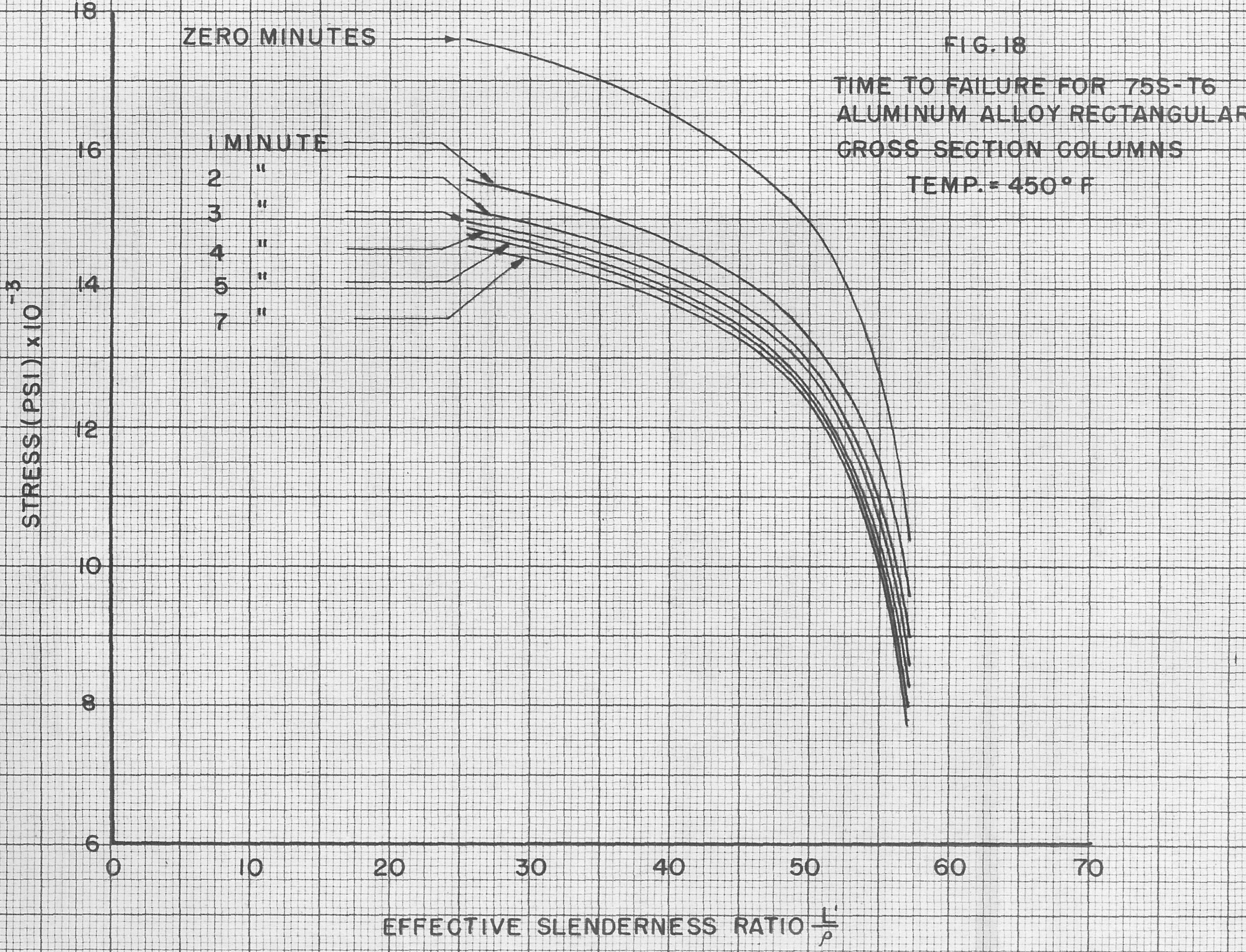


FIG. 18

TIME TO FAILURE FOR 75S-T6 ALUMINUM ALLOY RECTANGULAR CROSS SECTION COLUMNS

TEMP. = 450° F

TABLE I

COLUMN CREEP DATA

Material: 75S-T6

Effective Slenderness Ratio: 25.5

Temperature: 550°F

Applied Stress: 9200 psi

Time (seconds)	Dial Gage (inches)	Creep (inches)
unloaded	0.2011	
load on	0.2290	0.0000
10	0.2850	0.0560
13	0.3200	0.0910

TABLE II

COLUMN CREEP DATA

Material: 75S-T6

Effective Slenderness Ratio: 25.5

Temperature: 550°F

Applied Stress: 8700 psi

Time (seconds)	Dial Gage (inches)	Creep (inches)
unloaded	0.1965	
load on	0.2400	0.0000
10	0.2481	0.0081
20	0.2621	0.0221
30	0.2900	0.0500
39	0.3600	0.1200

TABLE III

COLUMN CREEP DATA

Material: 75S-T6

Effective Slenderness Ratio: 25.5

Temperature: 550°F

Applied Stress: 7500 psi

Time (seconds)	Dial Gage (inches)	Creep (inches)
unloaded	0.1140	
load on	0.1260	0.0000
10	0.1240	0.0020
20	0.1220	0.0040
30	0.1990	0.0061
40	0.1172	0.0088
50	0.1145	0.0115
60	0.1129	0.0131
70	0.1086	0.0174
80	0.1045	0.0215
90	0.1005	0.0255
100	0.0960	0.0300
110	0.0905	0.0355
120	0.0840	0.0420
130	0.0770	0.0490
140	0.0670	0.0590
150	0.0530	0.0730
160	0.0300	0.0960
170	0.9700	0.1560

TABLE IV

COLUMN CREEP DATA

Material: 75S-T6

Effective Slenderness Ratio: 25.5

Temperature: 550°F

Applied Stress: 7000 psi

Time (seconds)	Dial Gage (inches)	Creep (inches)	Time (seconds)	Dial Gage (inches)	Creep (inches)
unloaded	0.0895		370	0.0781	0.0114
load on	0.0895	0.0000	380	0.0778	0.0117
10	0.0892	0.0003	390	0.0765	0.0130
20	0.0892	0.0003	400	0.0760	0.0135
30	0.0892	0.0003	410	0.0749	0.0146
40	0.0891	0.0004	420	0.0739	0.0156
50	0.0891	0.0004	430	0.0729	0.0166
60	0.0890	0.0005	440	0.0719	0.0176
70	0.0889	0.0006	450	0.0709	0.0186
80	0.0888	0.0007	460	0.0697	0.0198
90	0.0887	0.0008	470	0.0685	0.0210
100	0.0883	0.0012	480	0.0675	0.0220
110	0.0880	0.0015	490	0.0661	0.0234
120	0.0878	0.0017	500	0.0650	0.0245
130	0.0877	0.0018	510	0.0638	0.0257
140	0.0876	0.0019	520	0.0620	0.0275
150	0.0875	0.0020	530	0.0605	0.0290
160	0.0871	0.0024	540	0.0589	0.0306
170	0.0868	0.0027	550	0.0571	0.0324
180	0.0865	0.0030	560	0.0552	0.0343
190	0.0861	0.0034	570	0.0532	0.0363
200	0.0860	0.0035	580	0.0512	0.0383
210	0.0858	0.0037	590	0.0482	0.0413
220	0.0856	0.0039	600	0.0459	0.0436
230	0.0852	0.0043	610	0.0430	0.0465
240	0.0849	0.0046	620	0.0398	0.0497
250	0.0845	0.0050	630	0.0359	0.0536
260	0.0841	0.0054	640	0.0315	0.0580
270	0.0838	0.0057	650	0.0260	0.0635
280	0.0832	0.0063	660	0.0199	0.0696
290	0.0830	0.0065	670	0.0120	0.0775
300	0.0824	0.0071	680	0.0005	0.0890
310	0.0820	0.0075	690	0.9840	0.1055
320	0.0813	0.0082	700	0.9470	0.1425
330	0.0809	0.0086	704	0.9000	0.1895
340	0.0804	0.0091			
350	0.0796	0.0099			
360	0.0790	0.0105			

TABLE V

COLUMN CREEP DATA

Material: 75S-T6

Effective Slenderness Ratio: 39.9

Temperature: 550°F

Applied Stress: 8000 psi

Time (seconds)	Dial Gage (inches)	Creep (inches)
unloaded	0.2681	
load on	0.2700	0.0000
6	0.1900	0.0800
10	0.1400	0.1300

TABLE VI

COLUMN CREEP DATA

Material: 75S-T6

Effective Slenderness Ratio: 39.9

Temperature: 550°F

Applied Stress: 7000 psi

Time (seconds)	Dial Gage (inches)	Creep (inches)
unloaded	0.2668	
load on	0.2980	0.0000
10	0.3140	0.0160
20	0.3250	0.0270
30	0.3349	0.0369
40	0.3471	0.0491
50	0.3651	0.0671
60	0.4000	0.1020
65	0.4600	0.1620

TABLE VII

COLUMN CREEP DATA

Material: 75S-T6

Effective Slenderness Ratio: 39.9

Temperature: 550°F

Applied Stress: 6000 psi

Time (seconds)	Dial Gage (inches)	Creep (inches)
unloaded	0.1885	
load on	0.2310	0.0000
10	0.2420	0.0110
20	0.2469	0.0159
30	0.2506	0.0196
40	0.2541	0.0231
50	0.2573	0.0263
60	0.2604	0.0294
70	0.2635	0.0325
80	0.2668	0.0358
90	0.2700	0.0390
100	0.2730	0.0420
110	0.2760	0.0450
120	0.2798	0.0488
130	0.2832	0.0522
140	0.2870	0.0560
150	0.2916	0.0606
160	0.2970	0.0660
170	0.3026	0.0716
180	0.3100	0.0790
190	0.3196	0.0886
200	0.3320	0.1010
218	0.4100	0.1790
210	0.3550	0.1240

TABLE VIII

COLUMN CREEP DATA

Material: 75S-T6

Effective Slenderness Ratio: 39.9

Temperature: 550°F

Applied Stress: 5500 psi

Time (seconds)	Dial Gage (inches)	Creep (inches)	Time (seconds)	Dial Gage (inches)	Creep (inches)
unloaded	0.1880		220	0.2745	0.0445
load on	0.2300	0.0000	230	0.2761	0.0461
10	0.2380	0.0080	240	0.2781	0.0481
20	0.2412	0.0112	250	0.2799	0.0499
30	0.2435	0.0135	260	0.2818	0.0518
40	0.2456	0.0156	270	0.2837	0.0537
50	0.2479	0.0179	280	0.2858	0.0558
60	0.2493	0.0193	290	0.2880	0.0580
70	0.2509	0.0209	300	0.2902	0.0602
80	0.2525	0.0225	310	0.2929	0.0629
90	0.2541	0.0241	320	0.2955	0.0655
100	0.2558	0.0258	330	0.2986	0.0686
110	0.2571	0.0271	340	0.3015	0.0715
120	0.2589	0.0289	350	0.3055	0.0755
130	0.2601	0.0301	360	0.3100	0.0800
140	0.2618	0.0318	370	0.3149	0.0849
150	0.2632	0.0332	380	0.3206	0.0906
160	0.2649	0.0349	390	0.3279	0.0979
170	0.2662	0.0362	400	0.3370	0.1070
180	0.2680	0.0380	410	0.3506	0.1206
190	0.2699	0.0399	420	0.3750	0.1450
200	0.2712	0.0412	427	--	--
210	0.2729	0.0429			

TABLE IX

COLUMN CREEP DATA

Material: 75S-T6

Effective Slenderness Ratio: 48:6

Temperature: 550^{o}F

Applied Stress: 7000 psi

Time (seconds)	Dial Gage (inches)	Creep (inches)
unloaded	0.2050	
load on	0.2500	0.0000
10	0.2880	0.0380
18	0.3850	0.1350

TABLE X

COLUMN CREEP DATA

Material: 75S-T6

Effective Slenderness Ratio: 48.6

Temperature: 550^{o}F

Applied Stress: 6000 psi

Time (seconds)	Dial Gage (inches)	Creep (inches)
unloaded	0.0930	
load on	0.1360	0.0000
10	0.1282	0.0078
20	0.1198	0.0162
30	0.1095	0.0265
40	0.0981	0.0379
50	0.0820	0.0540
60	0.0585	0.0775
69	0.9900	0.1460

TABLE XI

COLUMN CREEP DATA

Material: 75S-T6

Effective Slenderness Ratio: 48.6

Temperature: 550°F

Applied Stress: 5000 psi

Time (seconds)	Dial Gage (inches)	Creep (inches)
unloaded	0.0965	
load on	0.1085	0.0000
10	0.1055	0.0030
20	0.1030	0.0055
30	0.1012	0.0073
40	0.0999	0.0086
50	0.0978	0.0107
60	0.0960	0.0125
70	0.0946	0.0139
80	0.0931	0.0154
90	0.0918	0.0167
100	0.0900	0.0185
110	0.0889	0.0196
120	0.0873	0.0212
130	0.0860	0.0225
140	0.0843	0.0242
150	0.0830	0.0255
160	0.0818	0.0267
170	0.0802	0.0283
180	0.0791	0.0294
190	0.0775	0.0310
200	0.0760	0.0325
210	0.0741	0.0344
220	0.0729	0.0356
230	0.0710	0.0375
240	0.0695	0.0390
250	0.0675	0.0410
260	0.0651	0.0434
270	0.0632	0.0453
280	0.0610	0.0475
290	0.0589	0.0496
300	0.0563	0.0522
310	0.0538	0.0547
320	0.0511	0.0574
330	0.0482	0.0603
340	0.0445	0.0640
350	0.0408	0.0677
360	0.0359	0.0726
370	0.0310	0.0775
380	0.0240	0.0845
390	0.0155	0.0930
400	0.0020	0.1065
410	0.9750	0.1335
420	0.9300	0.1785

TABLE XII

COLUMN CREEP DATA

Material: 75S-T6

Effective Slenderness Ratio: 57.2

Temperature: 550°F

Applied Stress: 5250 psi

Time (seconds)	Dial Gage (inches)	Creep (inches)
unloaded	0.5146	
load on	0.5360	0.0000
10	0.5650	0.0290
16	0.6200	0.0840

TABLE XIII

COLUMN CREEP DATA

Material: 75S-T6

Effective Slenderness Ratio: 57.2

Temperature: 550°F

Applied Stress: 5000 psi

Time (seconds)	Dial Gage (inches)	Creep (inches)
unloaded	0.6240	
load on	0.6320	0.0000
10	0.6420	0.0100
20	0.6520	0.0200
30	0.6600	0.0280
40	0.6700	0.0380
50	0.6810	0.0490
60	0.7015	0.0695
70	0.8700	0.1385

TABLE XIV

COLUMN CREEP DATA

Material: 75S-T6

Effective Slenderness Ratio: 57.2

Temperature: 550°F

Applied Stress: 4750 psi

Time (seconds)	Dial Gage (inches)	Creep (inches)	Time (seconds)	Dial Gage (inches)	Creep (inches)
unloaded	0.5021		220	0.5530	0.0321
load on	0.5209	0.0000	230	0.5541	0.0332
10	0.5260	0.0051	240	0.5555	0.0346
20	0.5287	0.0078	250	0.5568	0.0359
30	0.5292	0.0083	260	0.5583	0.0374
40	0.5308	0.0099	270	0.5598	0.0389
50	0.5321	0.0112	280	0.5611	0.0402
60	0.5336	0.0127	290	0.5628	0.0419
70	0.5349	0.0140	300	0.5645	0.0436
80	0.5361	0.0152	310	0.5663	0.0454
90	0.5375	0.0166	320	0.5682	0.0473
100	0.5388	0.0179	330	0.5704	0.0495
110	0.5400	0.0191	340	0.5730	0.0521
120	0.5411	0.0202	350	0.5755	0.0546
130	0.5421	0.0212	360	0.5785	0.0576
140	0.5433	0.0224	370	0.5818	0.0609
150	0.5444	0.0235	380	0.5853	0.0644
160	0.5457	0.0248	390	0.5902	0.0693
170	0.5469	0.0260	400	0.5961	0.0752
180	0.5481	0.0272	410	0.6050	0.0841
190	0.5492	0.0283	420	0.6210	0.1001
200	0.5502	0.0293	430	0.6851	0.1642
210	0.5518	0.0309			

TABLE XV

COLUMN CREEP DATA

Material: 75S-T6

Effective Slenderness Ratio: 57.2

Temperature: 550°F

Applied Stress: 3000 psi

Time (seconds)	Dial Gage (inches)	Creep (inches)
unloaded	0.0040	
load on	0.0010	
10	0.0010	0.0000
20	0.0010	0.0000
30	0.0010	0.0000
40	0.0010	0.0000
50	0.0010	0.0000
60	0.0010	0.0000
70	0.0010	0.0000
80	0.0010	0.0000
90	0.0015	0.0005
100	0.0016	0.0006
110	0.0016	0.0006
120	0.0017	0.0007
130	0.0017	0.0007
140	0.0018	0.0008
150	0.0018	0.0008
160	0.0018	0.0008
170	0.0018	0.0008
180	0.0018	0.0008
190	0.0018	0.0008
200	0.0018	0.0008
210*	0.0018	0.0008

* Test stopped at this point because of small creep rate.

TABLE XVI

COLUMN CREEP DATA

Material: 75S-T6

Effective Slenderness Ratio: 25.5

Temperature: 450°F

Applied Stress: 17,300 psi

Time (seconds)	Dial Gage (inches)	Creep (inches)
unloaded	0.1122	
load on	0.1400	0.0000
6	0.0700	0.0700

TABLE XVII

COLUMN CREEP DATA

Material: 75S-T6

Effective Slenderness Ratio: 25.5

Temperature: 450°F

Applied Stress: 16,000 psi

Time (seconds)	Dial Gage (inches)	Creep (inches)
unloaded	0.1080	
load on	0.1260	0.0000
10	0.1245	0.0015
20	0.1195	0.0065
30	0.1080	0.0180
39	0.0400	0.0860

TABLE XVIII

COLUMN CREEP DATA

Material: 75S-T6

Effective Slenderness Ratio: 25.5

Temperature: 450°F

Applied Stress: 15,000 psi

Time (seconds)	Dial Gage (inches)	Creep (inches)
unloaded	0.1081	
load on	0.1220	0.0000
10	0.1200	0.0020
20	0.1190	0.0030
30	0.1180	0.0040
40	0.1170	0.0050
50	0.1155	0.0065
60	0.1140	0.0080
70	0.1127	0.0093
80	0.1105	0.0115
90	0.1095	0.0125
100	0.1065	0.0155
110	0.1030	0.0190
120	0.1000	0.0220
130	0.0950	0.0270
140	0.0880	0.0340
150	0.0800	0.0420
160	0.0600	0.0620
165	0.0200	0.1020

TABLE XIX

COLUMN CREEP DATA

Material: 75S-T6

Effective Slenderness Ratio: 25.5

Temperature: 450°F

Applied Stress: 14,500 psi

Time (seconds)	Dial Gage (inches)	Creep (inches)	Time (seconds)	Dial Gage (Inches)	Creep (inches)
unloaded	0.1020		240	0.1193	0.0042
load on	0.1235	0.0000	250	0.1192	0.0043
10	0.1235	0.0000	260	0.1189	0.0046
20	0.1235	0.0000	270	0.1182	0.0053
30	0.1235	0.0000	280	0.1175	0.0060
40	0.1230	0.0005	290	0.1172	0.0063
50	0.1229	0.0006	300	0.1166	0.0069
60	0.1229	0.0006	310	0.1162	0.0073
70	0.1229	0.0006	320	0.1152	0.0083
80	0.1226	0.0009	330	0.1147	0.0088
90	0.1224	0.0011	340	0.1138	0.0097
100	0.1221	0.0014	350	0.1130	0.0105
110	0.1220	0.0015	360	0.1118	0.0117
120	0.1220	0.0015	370	0.1106	0.0129
130	0.1219	0.0016	380	0.1090	0.0145
140	0.1219	0.0016	390	0.1075	0.0160
150	0.1215	0.0020	400	0.1060	0.0175
160	0.1215	0.0020	410	0.1040	0.0195
170	0.1212	0.0023	420	0.1015	0.0220
180	0.1211	0.0024	430	0.0985	0.0250
190	0.1209	0.0026	440	0.0946	0.0289
200	0.1203	0.0032	450	0.0893	0.0342
210	0.1201	0.0034	460	0.0821	0.0414
220	0.1195	0.0040	470	0.0690	0.0545
230	0.1194	0.0041	480	0.0000	0.1235

TABLE XX

COLUMN CREEP DATA

Material: 75S-T6

Effective Slenderness Ratio: 25.5

Temperature: 450°F

Applied Stress: 14,000 psi

Time (seconds)	Dial Gage (inches)	Creep (inches)	Time (seconds)	Dial Gage (inches)	Creep (inches)
unloaded	0.1135		340	0.1305	0.0015
load on	0.1290	0.0000	350	0.1306	0.0016
10	0.1290	0.0000	360	0.1308	0.0018
20	0.1290	0.0000	370	0.1308	0.0018
30	0.1290	0.0000	380	0.1309	0.0019
40	0.1290	0.0000	390	0.1310	0.0020
50	0.1291	0.0001	400	0.1310	0.0020
60	0.1292	0.0002	410	0.1311	0.0021
70	0.1296	0.0006	420	0.1312	0.0022
80	0.1296	0.0006	480	0.1320	0.0030
90	0.1297	0.0007	* 540	0.1341	0.0051
100	0.1298	0.0008	600	0.1380	0.0090
110	0.1299	0.0009	610	0.1399	0.0109
120	0.1299	0.0009	620	0.1399	0.0109
130	0.1299	0.0009	630	0.1411	0.0121
140	0.1299	0.0009	640	0.1422	0.0132
150	0.1299	0.0009	650	0.1441	0.0151
160	0.1299	0.0009	660	0.1460	0.0170
170	0.1299	0.0009	670	0.1481	0.0191
180	0.1299	0.0009	680	0.1505	0.0215
190	0.1300	0.0010	690	0.1536	0.0246
200	0.1300	0.0010	700	0.1575	0.0285
210	0.1300	0.0010	710	0.1630	0.0340
220	0.1300	0.0010	720	0.1700	0.0410
230	0.1300	0.0010	730	0.1860	0.0570
240	0.1301	0.0011	740	0.2100	0.0810
250	0.1301	0.0011	744	0.2500	0.1210
260	0.1301	0.0011			
270	0.1301	0.0011			
280	0.1301	0.0011			
290	0.1302	0.0012			
300	0.1302	0.0012			
310	0.1302	0.0012			
320	0.1303	0.0013			
330	0.1304	0.0014			

* Readings 1 min. apart due to slow creep rate.

TABLE XXI

COLUMN CREEP DATA

Material: 75S-T6

Effective Slenderness Ratio: 48.6

Temperature: 450°F

Applied Stress: 15,000 psi

Time (seconds)	Dial Gage (inches)	Creep (inches)
unloaded	0.1551	
load on	0.1000	0.0000
4	--	--

TABLE XXII

COLUMN CREEP DATA

Material: 75S-T6

Effective Slenderness Ratio: 48.6

Temperature: 450°F

Applied Stress: 14,000 psi

Time (seconds)	Dial Gage (inches)	Creep (inches)
unloaded	0.1550	
load on	0.1968	0.0000
10	0.1922	0.0046
20	0.1730	0.0238
25	0.1300	0.0668

TABLE XXIII

COLUMN CREEP DATA

Material: 75S-T6

Effective Slenderness Ratio: 48.6

Temperature: 450°F

Applied Stress: 13,000 psi

Time (seconds)	Dial Gage (inches)	Creep (inches)
unloaded	0.1920	
load on	0.2240	0.0000
10	0.2229	0.0011
20	0.2221	0.0019
30	0.2219	0.0021
40	0.2212	0.0028
50	0.2205	0.0035
60	0.2199	0.0041
70	0.2191	0.0049
80	0.2183	0.0057
90	0.2175	0.0065
100	0.2162	0.0078
110	0.2150	0.0090
120	0.2132	0.0108
130	0.2111	0.0129
140	0.2089	0.0151
150	0.2051	0.0189
160	0.2001	0.0239
170	0.1925	0.0315
180	0.1750	0.0490
186	0.1400	0.0840

TABLE XXIV

COLUMN CREEP DATA

Material: 75S-T6

Effective Slenderness Ratio: 48.6

Temperature: 450°F

Applied Stress: 12,500 psi

Time (seconds)	Dial Gage (inches)	Creep (inches
unloaded	0.1088	
load on	0.1390	0.0000
10	0.1382	0.0008
20	0.1380	0.0010
30	0.1378	0.0012
40	0.1375	0.0015
50	0.1372	0.0018
60	0.1371	0.0019
70	0.1369	0.0021
80	0.1368	0.0022
90	0.1366	0.0024
100	0.1362	0.0028
110	0.1361	0.0029
120	0.1360	0.0030
130	0.1359	0.0031
140	0.1355	0.0035
150	0.1353	0.0037
160	0.1351	0.0039
170	0.1350	0.0040
180	0.1349	0.0041
190	0.1345	0.0045
200	0.1342	0.0048
210	0.1340	0.0050
220	0.1339	0.0051
230	0.1337	0.0053
240	0.1332	0.0058
250	0.1330	0.0060
260	0.1328	0.0062
270	0.1325	0.0065
280	0.1321	0.0069
290	0.1319	0.0071
300	0.1317	0.0073
310	0.1312	0.0078
320	0.1310	0.0080
330	0.1308	0.0082
340	0.1304	0.0086
350	0.1301	0.0089
360	0.1299	0.0091
370	0.1294	0.0096
380	0.1289	0.0101
390	0.1285	0.0105
400	0.1280	0.0110
410	0.1275	0.0115

Time (seconds)	Dial Gage (inches)	Creep (inches)
420	0.1271	0.0119
430	0.1268	0.0122
440	0.1260	0.0130
450	0.1255	0.0135
460	0.1249	0.0141
470	0.1247	0.0143
480	0.1237	0.0153
490	0.1229	0.0161
500	0.1221	0.0169
510	0.1212	0.0178
520	0.1205	0.0185
530	0.1198	0.0192
540	0.1186	0.0204
550	0.1175	0.0215
560	0.1163	0.0227
570	0.1150	0.0240
580	0.1138	0.0252
590	0.1121	0.0269
600	0.1108	0.0282
610	0.1086	0.0304
620	0.1061	0.0329
630	0.1035	0.0355
640	0.1000	0.0390
650	0.0950	0.0440
660	0.0875	0.0515
670	0.0730	0.0660
676	0.0400	0.0990

TABLE XXV

COLUMN CREEP DATA

Material: 75S-T6

Effective Slenderness Ratio: 57.2

Temperature: 450°F

Applied Stress: 10,200 psi

Time (seconds)	Dial Gage (inches)	Creep (inches)
unloaded	0.1192	
load on	0.1250	0.0000
10	0.0700	0.0550
12	0.0500	0.0750

TABLE XXVI

COLUMN CREEP DATA

Material: 75S-T6

Effective Slenderness Ratio: 57.2

Temperature: 450°F

Applied Stress: 9000 psi

Time (seconds)	Dial Gage (inches)	Creep (inches)
unloaded	0.2000	
load on	0.2160	0.0000
10	0.2040	0.0120
20	0.1985	0.0175
30	0.1930	0.0230
40	0.1890	0.0270
50	0.1845	0.0315
60	0.1800	0.0360
70	0.1751	0.0409
80	0.1706	0.0454
90	0.1651	0.0509
100	0.1583	0.0577
110	0.1480	0.0680
120	0.1270	0.0890
124	0.0700	0.1460

TABLE XXVII

COLUMN CREEP DATA

Material: 75S-T6

Effective Slenderness Ratio: 57.2

Temperature: 450°F

Applied Stress: 8000 psi

Time (seconds)	Dial Gage (inches)	Creep (inches)	Time (seeonds)	Dial Gage (inches)	Creep (inches)
unloaded	0.1849		160	0.1523	0.0387
load on	0.1910	0.0000	170	0.1505	0.0405
10	0.1830	0.0080	180	0.1485	0.0425
20	0.1788	0.0122	190	0.1465	0.0445
30	0.1755	0.0155	200	0.1445	0.0465
40	0.1731	0.0179	210	0.1420	0.0490
50	0.1715	0.0195	220	0.1400	0.0510
60	0.1693	0.0217	230	0.1380	0.0530
70	0.1674	0.0236	240	0.1349	0.0561
80	0.1656	0.0254	250	0.1315	0.0595
90	0.1640	0.0270	260	0.1275	0.0635
100	0.1624	0.0286	270	0.1235	0.0675
110	0.1610	0.0300	280	0.1190	0.0720
120	0.1592	0.0318	290	0.1110	0.0800
130	0.1575	0.0335	300	0.0995	0.0915
140	0.1560	0.0350	309	0.0500	0.1410
150	0.1545	0.0365			