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SID 67-318

APOLLO - LEM DOCKING DROGUE ASSEMBLY
 STATIC STRUCTURAL TEST

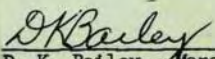
April 1967

TR 332015A
 CTR 02332015

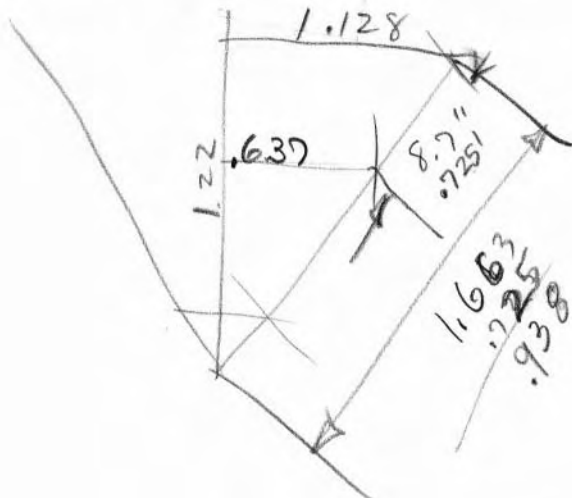
Contract NAS9-150, Exhibit I, Paragraph 5.5.12

Structural Testing Group
 Laboratories & Test

Approved by


 D. K. Bailey - Manager
 Laboratories & Test

NORTH AMERICAN AVIATION, INC.
 SPACE and INFORMATION SYSTEMS DIVISION



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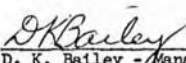
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TR 332015A
CTR 02332015

Contract NAS9-150, Exhibit I, Paragraph 5.5.12

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F O R E W O R D

Static structural tests were performed on the Apollo LEM docking drogue assembly to ultimate loads beginning on January 11, 1967 and ending on February 15, 1967.

The test was conducted by the Structures Test Group of Laboratories and Test at the Space and Information Systems Division of North American Aviation, Incorporated, at Downey, California.

The test was performed in accordance with TR 332015 Revision "A", written by the Apollo Engineering Structures group, to certify the S/C 101 Structural system as required by Certification Test Requirements (CTR 02332015). This report is the final test report as required by Exhibit I, paragraph 5.5.12 of Contract NAS 9-150.

TECHNICAL REPORT INDEX/ABSTRACT

ACCESSION NUMBER				DOCUMENT SECURITY CLASSIFICATION Unclassified			
TITLE OF DOCUMENT APOLLO - LEM DOCKING DROGUE ASSEMBLY STATIC STRUCTURAL TEST							LIBRARY USE ONLY
AUTHOR(S) Marozick, R. B.				Originating Agency - Research & Engineering Laboratories & Test			
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DESCRIPTIVE TERMS Apollo - LEM Docking Drogue Assembly							

ABSTRACT

The static structural tests were performed to demonstrate that the Apollo - LEM docking drogue assembly will sustain limit design loads without yielding and ultimate design loads without failure.

Limit loads were applied without yielding and ultimate loads were applied without failure.

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R E F E R E N C E S

- (a) TR 332015
- (b) IL 696-206-67-010, G. C. Sakai to C. G. Wickham,
dated 2/13/67
- (c) Laboratory Notebook M 243701, Pages M 243714
through M 243725 and M 243740

I N T R O D U C T I O N

The first requirement of the Apollo - LEM docking drogue assembly during the docking maneuvers of the Apollo mission is to withstand, structurally, the forces induced by the Apollo probe in its initial impact with the LEM vehicle.

This test program was conducted to verify the structural integrity of the Apollo - LEM docking assembly when subjected to the design ultimate probe tip impact forces. The purpose of the test program was successfully achieved by forcing a dummy probe tip against the drogue surface at four defined points.

I. DESCRIPTION OF TEST SPECIMEN

The test article was an Apollo - LEM docking drogue assembly (V28-575201), Serial Number 06362YAT5606.

II. TEST CONDITIONS

The test load was the maximum resultant probe tip impact load applied normal to the face of the drogue. The TR defined a limit load of 2380 pounds increased by a temperature factor of 1.15 to make the applied limit load 2737 pounds. The ultimate load factor was 1.35, making the applied ultimate load 3695 pounds. This load was applied four times, once to each of the locations indicated in Figure 1. Applying the load to point (A) was defined as Test Condition (T.C.) IA. Applying the load to point (B) was T.C. IB, and so on. In compliance with Reference (b), T.C. IA was repeated with the load increased to 150 percent of limit load, 4,106 pounds.

III. TEST SETUP

The drogue assembly was mounted in a test fixture equipped with six simulated LEM interface fittings. The six fittings permitted the drogue to be rotated in 60 degree increments relative to the hydraulic loading cylinder. The hydraulic cylinder could be positioned linearly parallel to an element of the inner surface of the drogue; thus, any of the four load points of Figure 1 could be aligned under the loading tip. Figures 2 and 3 show the drogue in two positions which use all six support fittings. Figures 4 and 5 show the strain gage locations on the drogue and Figure 6 shows how deflection measurements were taken, using four dial indicators.

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III. TEST SETUP (Continued)

Figures 7 and 8 show the loading probe tip in two typical positions.

All channels of instrumentation were electrically connected to a 100-channel recorder. The dial indicators shown in Figure 6 were manually read and recorded.

IV. TEST PROCEDURE

The test conditions were performed in alphabetical order of load points, Figure 1. Thus, the drogue and loading cylinder were initially positioned to apply load at point "A", Figure 7. The load was applied in 10 percent increments to 130 percent and the final increment took the load to 135 percent or ultimate load. Decreasing load was read at 100, 50 percent and zero return. The drogue was then repositioned as shown in Figure 2 and the loading assembly moved to the position of Figure 8 for loading at point "B". The load was applied similar to the procedure for T.C. IA. Tests at points "c" and "D" followed in that order. In compliance with Reference (b), T.C. IA was repeated to 150 percent of limit load, following the combined probe and drogue tests reported in SID 67-317.

V. TEST RESULTS

The required test data are presented graphically as Appendix A. Visual inspection of the drogue face after the tests showed light indentations at several load points, indicating partial crushing of the honeycomb core. These areas were inspected and measured by N.A.A. Inspection personnel. The inspection results are listed in Table 1.

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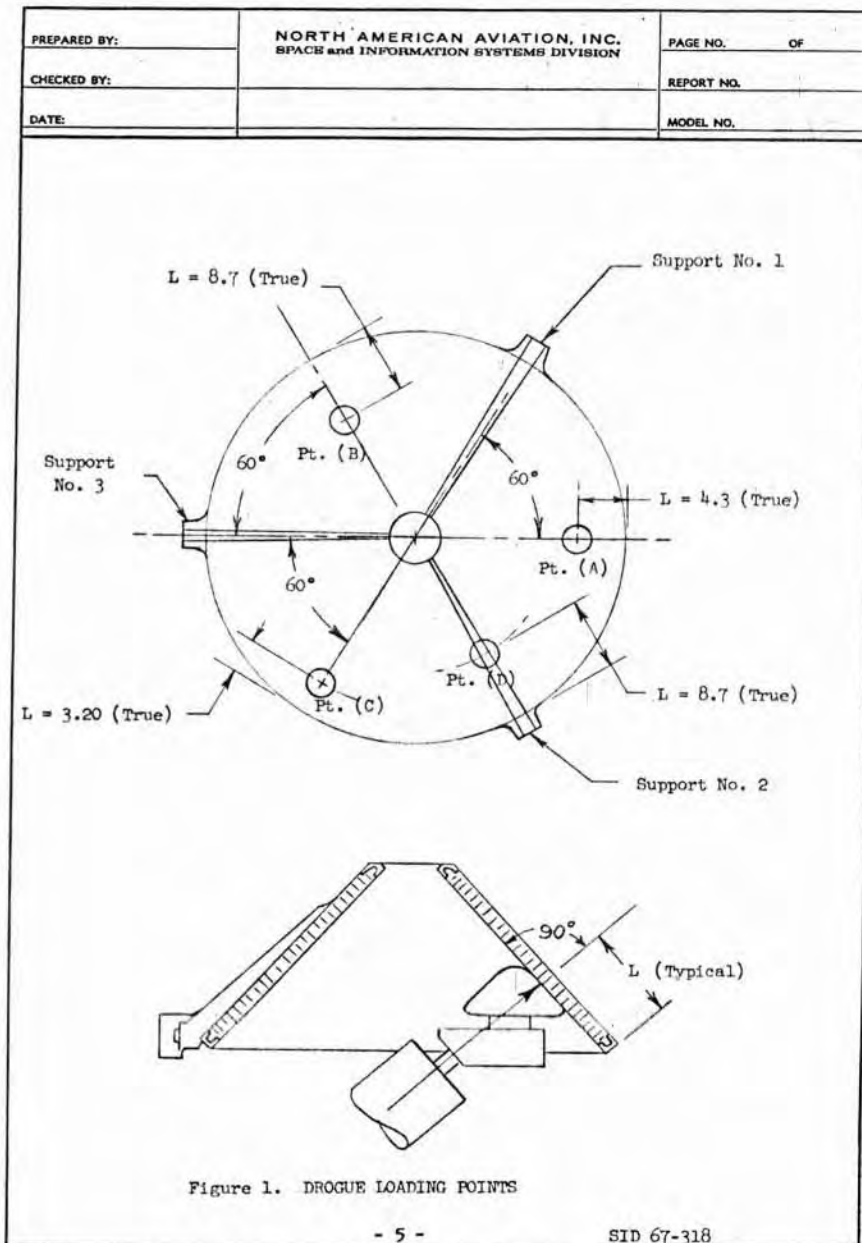
V. TEST RESULTS (Continued)

The loads applied to the drogue in this test series simulate the initial contact made by the probe during docking maneuvers. Following the first series of four tests, this same drogue was subjected to the subsequent-to-capture-latch loads as reported in SID 67-317. Then T.C. IA was repeated to 150 percent limit load. Since the drogue survived all these tests without further indications of yielding or failure, this specimen demonstrated its capability to perform the complete docking maneuver, and the indentations defined in Table 1 are not considered to be structural failures.

VI. CONCLUSIONS

The tests were performed in accordance with TR 332015A, Reference (a). The applied test loads were current and satisfactory.

Because the test article sustained 100 percent of ultimate load without failure, the test satisfied the requirements of CTR 02332015, and in conjunction with the satisfactory completion of test requirements set forth in CTR 02332077 complete the certification of the LEM docking drogue assembly. Therefore, the flight constraints against the related structures of Spacecraft 101 and subsequent Block II spacecraft will be removed.



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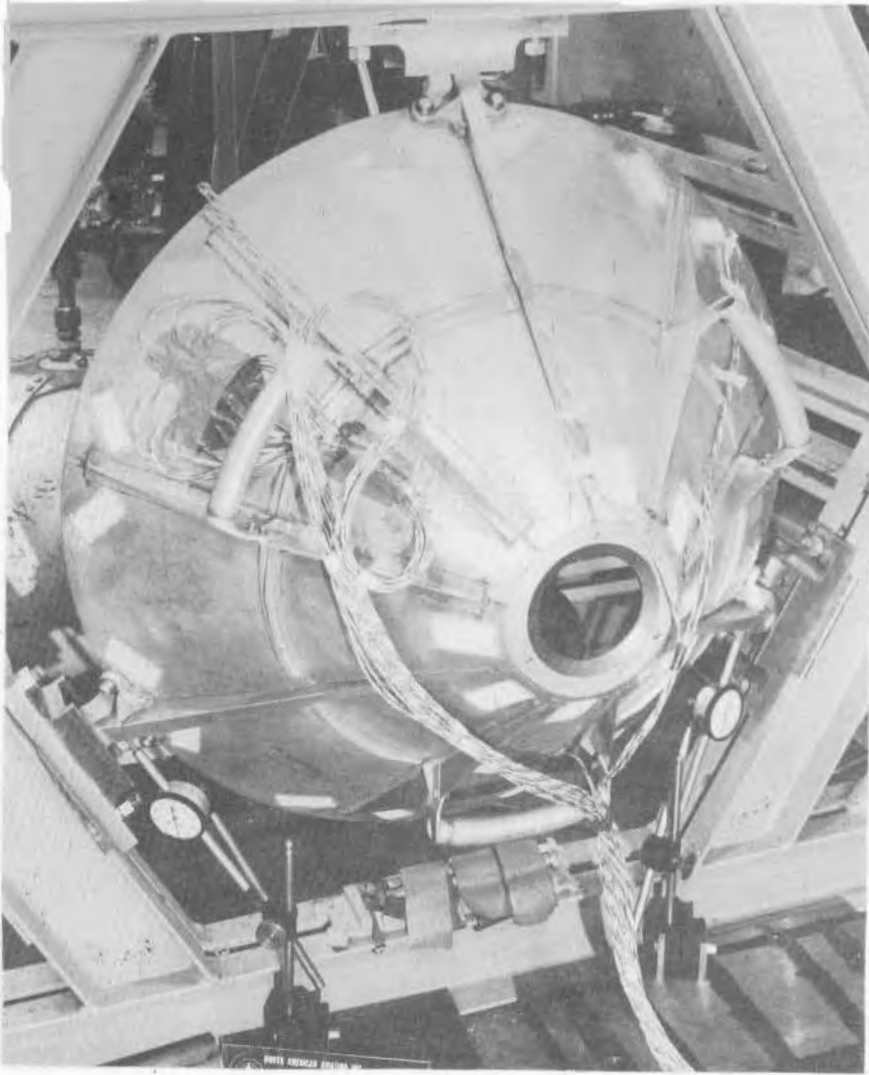


Figure 2. DROGUE SUPPORT ORIENTATION FOR TEST CONDITION IC

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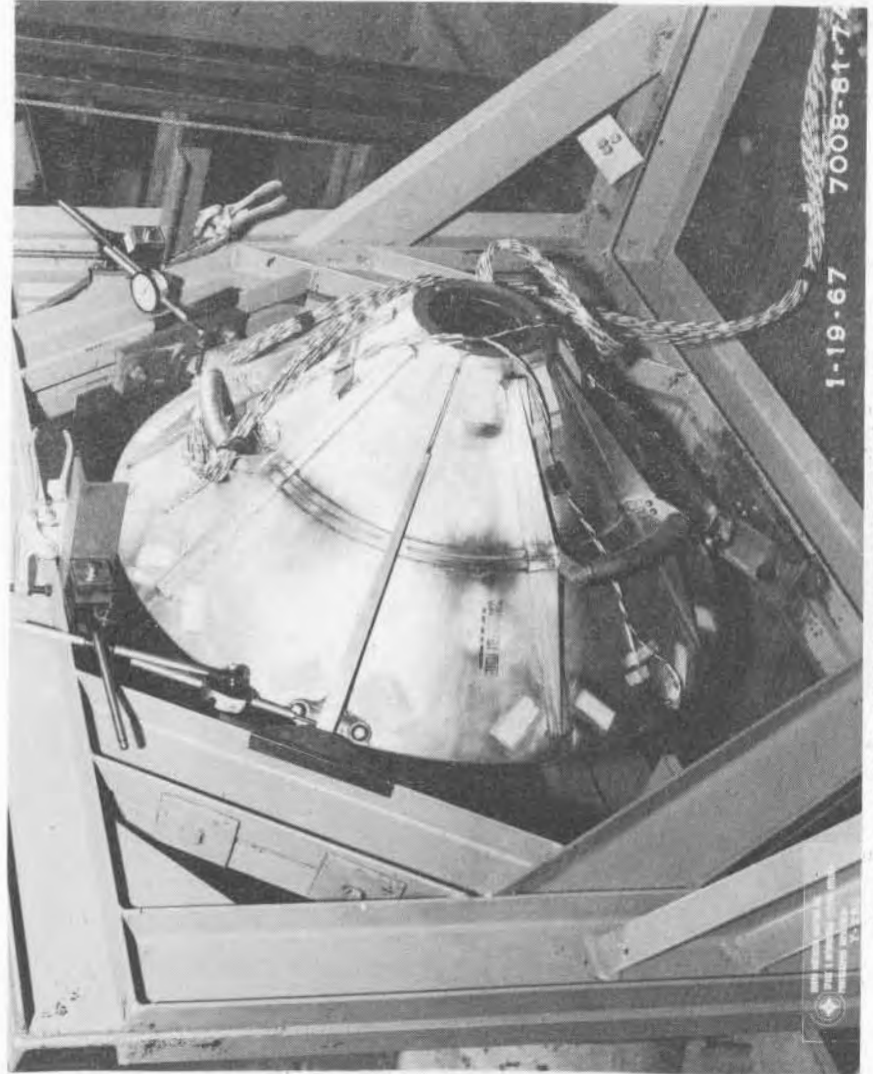


Figure 3. DROGUE SUPPORT ORIENTATION FOR TEST CONDITION ID

- 7 -

SID 67-318

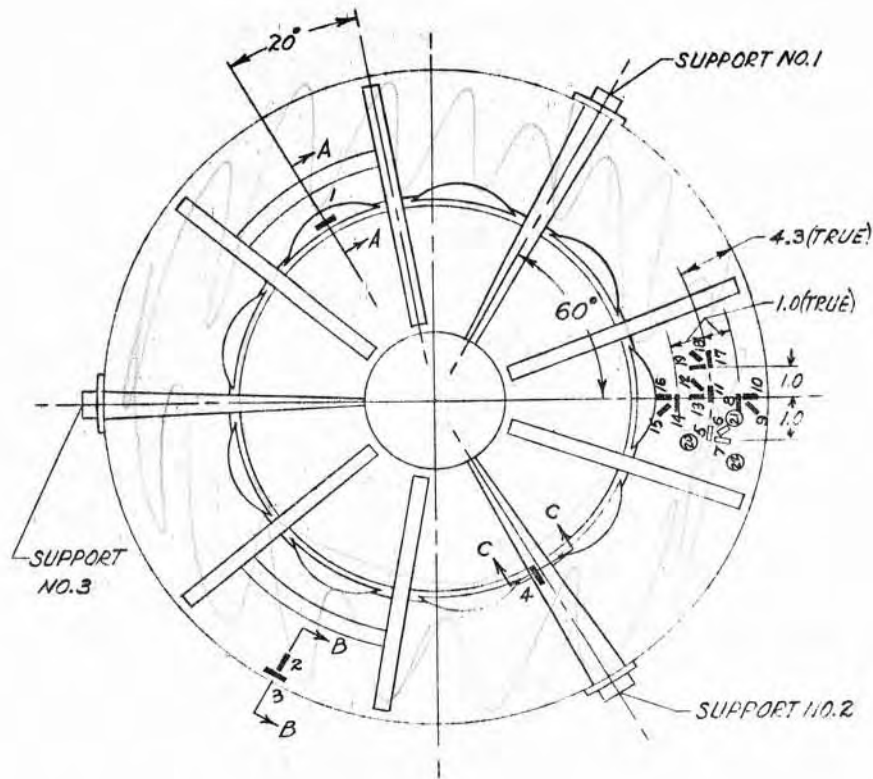


Figure 4. STRAIN GAGE LOCATIONS

1. Rosette orientation and location

- Coded gages are on outside face sheet
 - Coded gages are back-to-back with 20 21 22 on inside face sheet
- Axial gage orientation on Figure 5

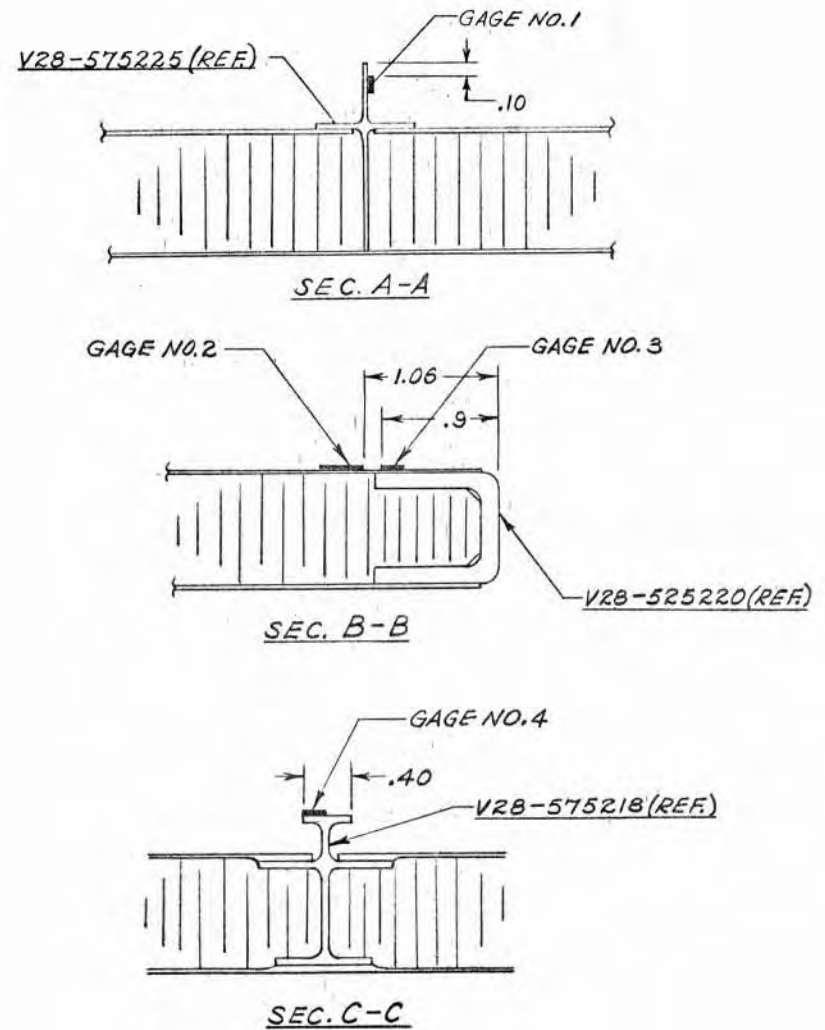
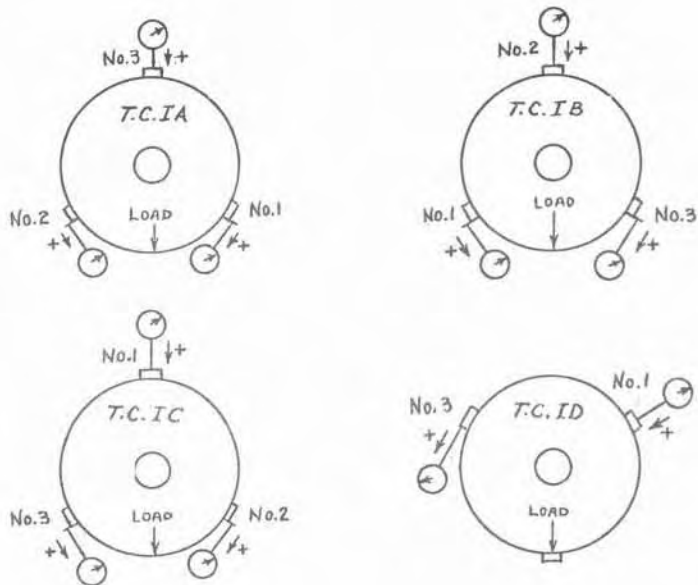


Figure 5. AXIAL STRAIN GAGE LOCATIONS



No. 4 ON T.C. IA, IB, IC
 No. 2 ON T.C. ID

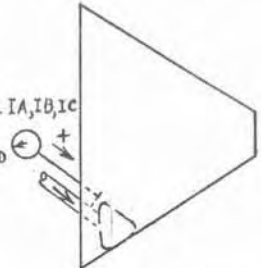
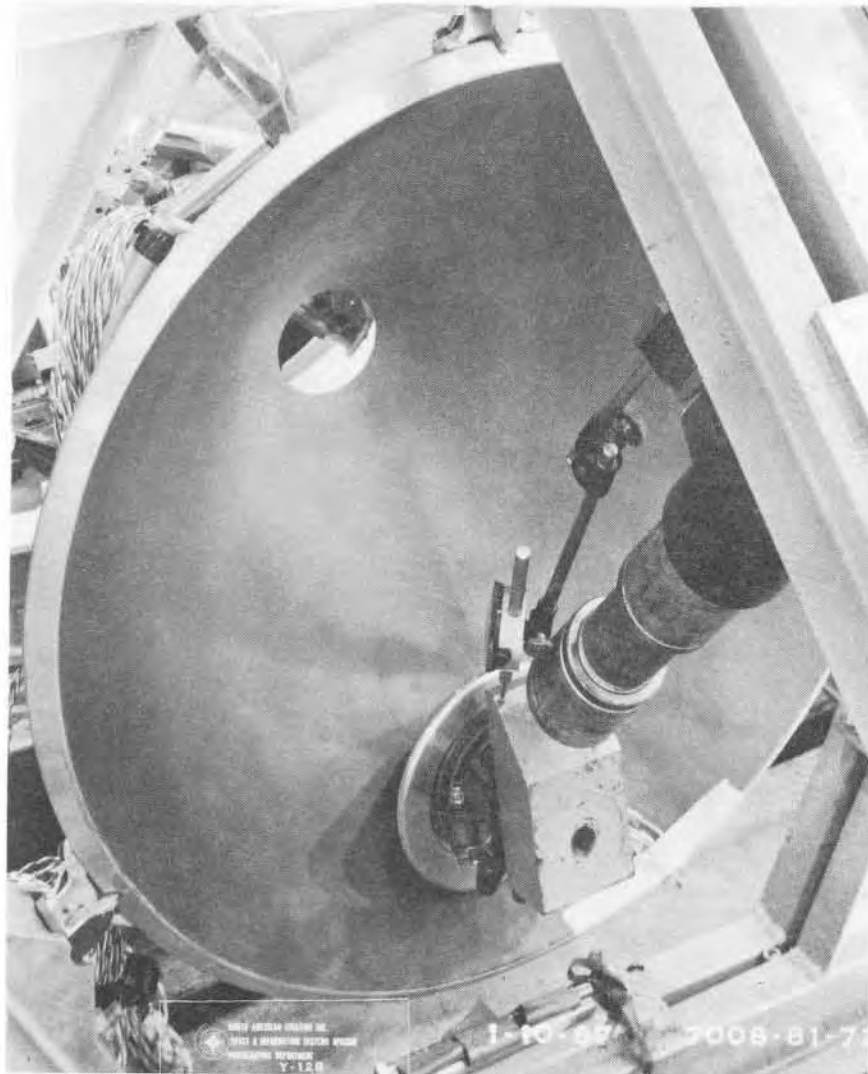


Figure 6. DIAL INDICATOR ORIENTATION AND IDENTIFICATION



7008-81-727C

Figure 7. LOADING SETUP FOR TEST CONDITION IA

7008-81-740B

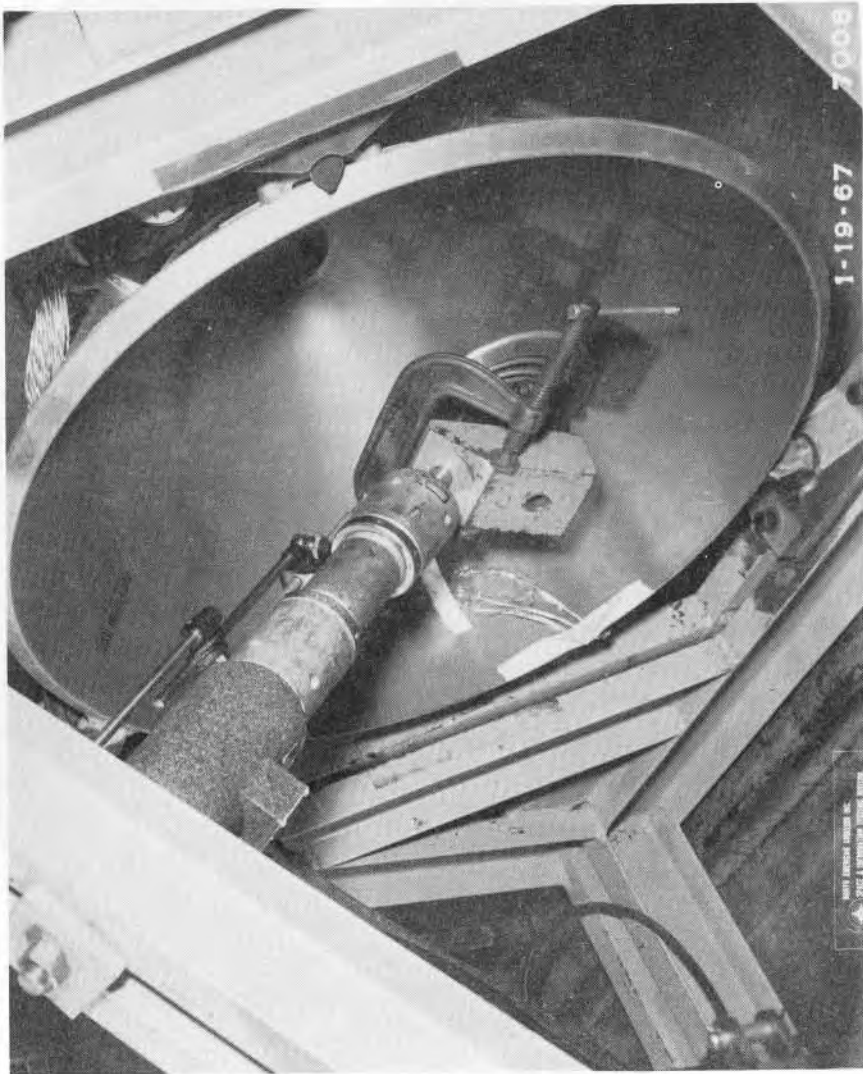


Figure 8. LOADING SETUP FOR TEST CONDITION ID

TABLE I

INDENTATIONS MEASURED AT LOAD POINTS AFTER TESTING

Load Point	Indentation Depth	Indentation Area
A	.000 to 0.10	2 in. diameter
B	.000 to 0.010	1½ in. diameter
C	.000 to 0.125	in. long x 2 in. wide
D	no indentation	

A P P E N D I X A

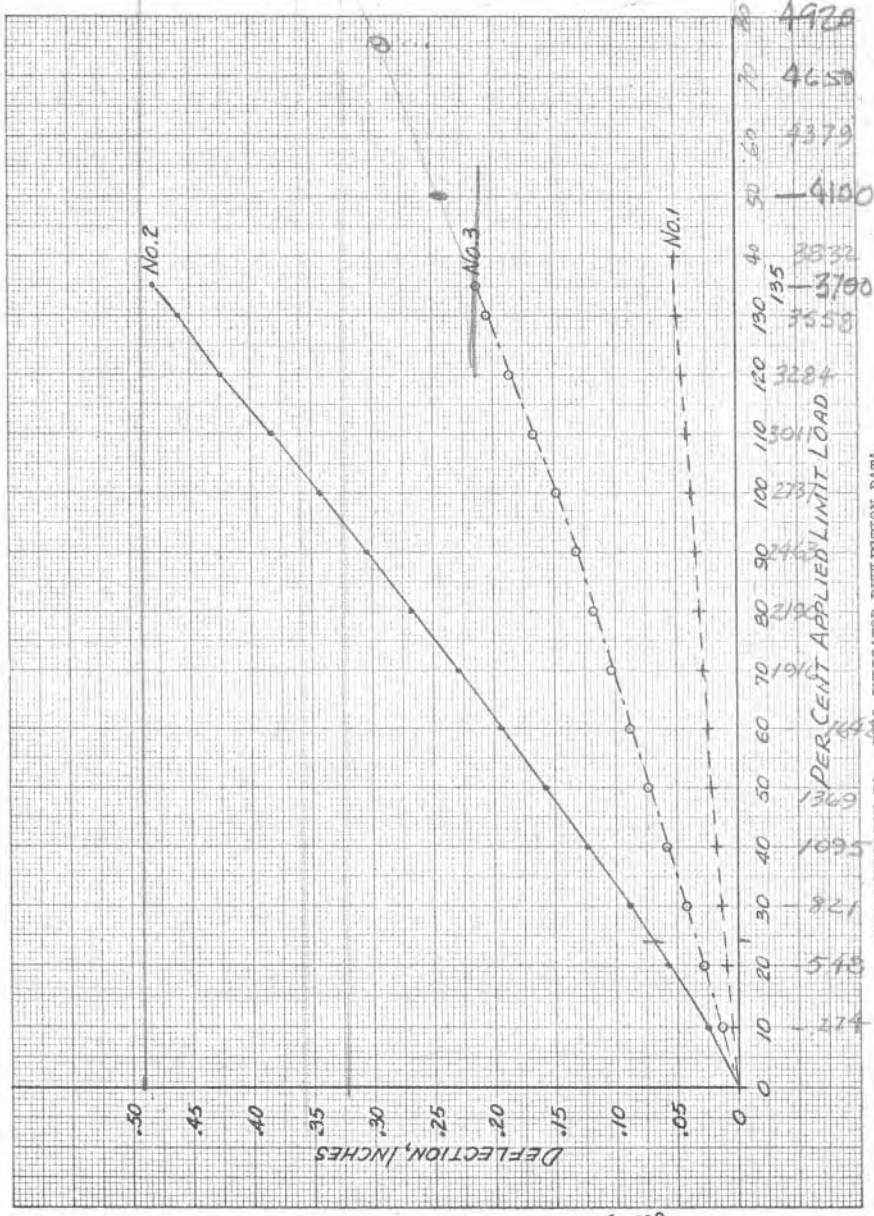
TEST CONDITION IA: DIAL INDICATOR DEFLECTION DATA

SID 67-318

2967-107

10 X 10 TO 1/2 INCH (1 X 10 INCH)

Serial No. 2757



① Limit average
② Maximum D

5200
5470
5740
6020

4920
4650
4379
4100
3822
3700
3558
3284
3011
273
246
219
191
164
1369
1095
821
548
274

PERCENT APPLIED LIMIT LOAD

TEST CONDITION IA: NEAL INDICATOR DEFLECTION DATA

T.C.I-A

M.A.A.

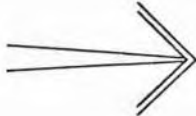
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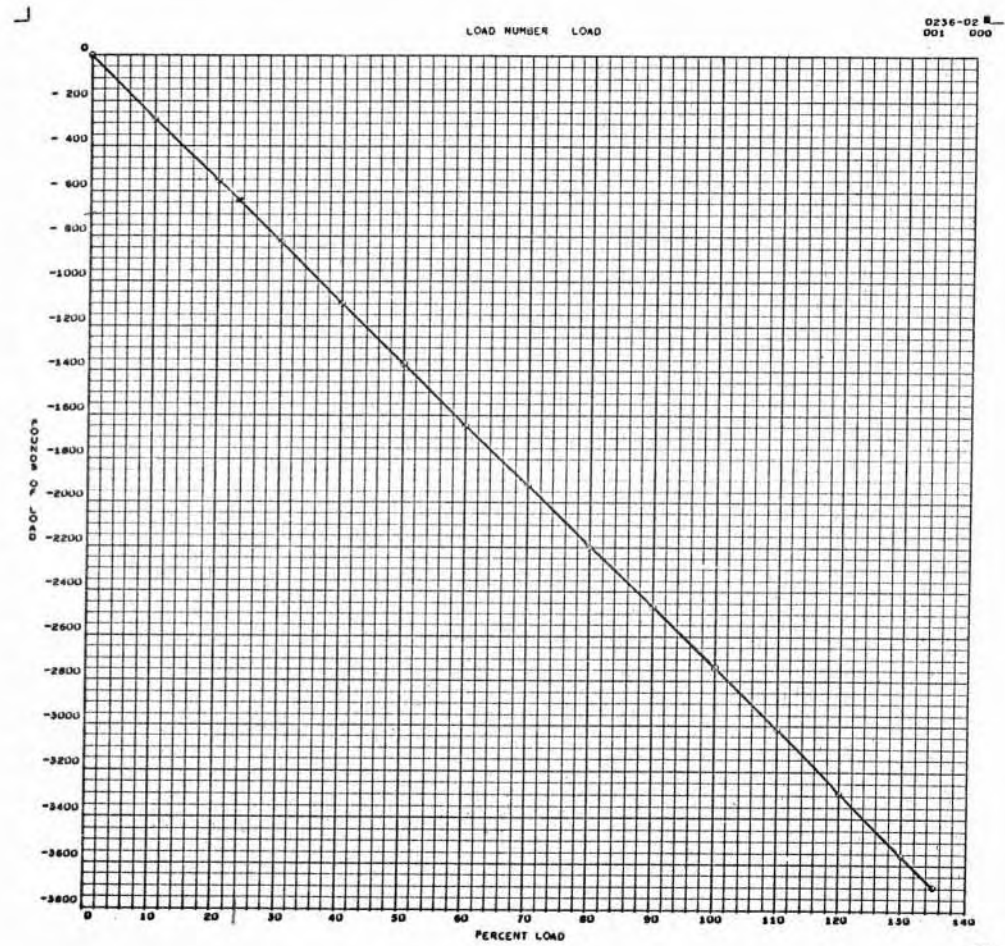
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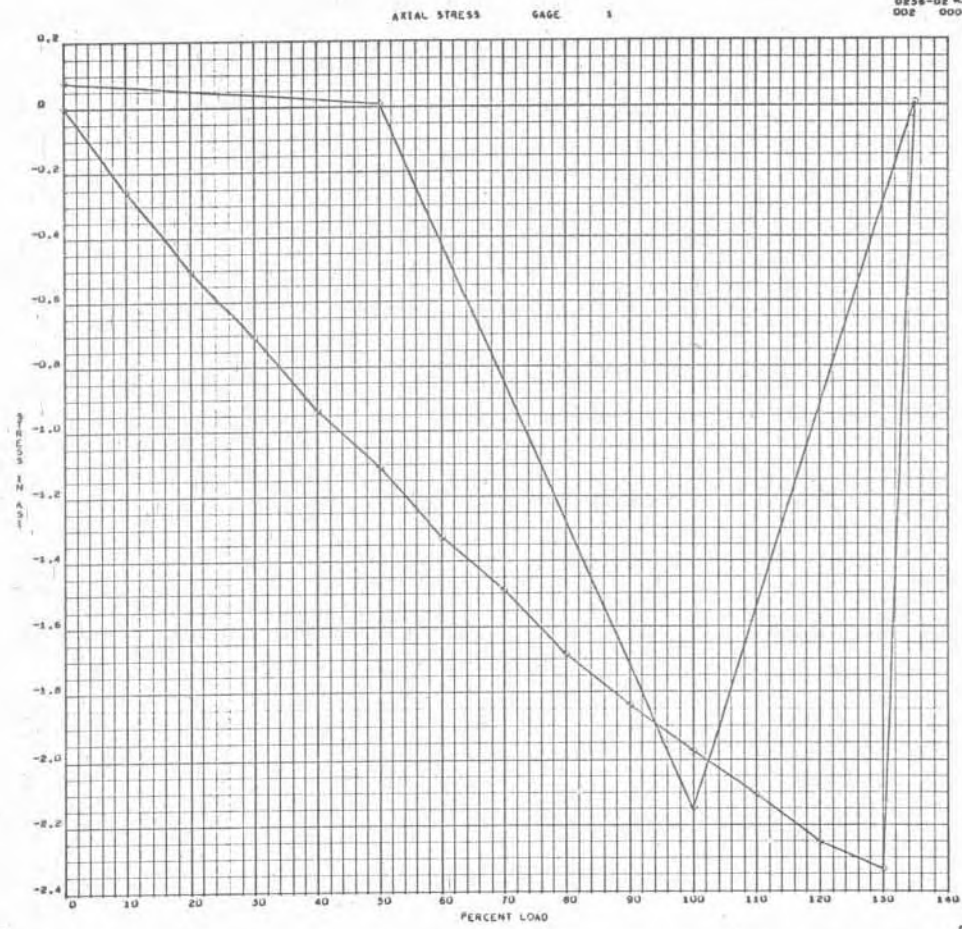
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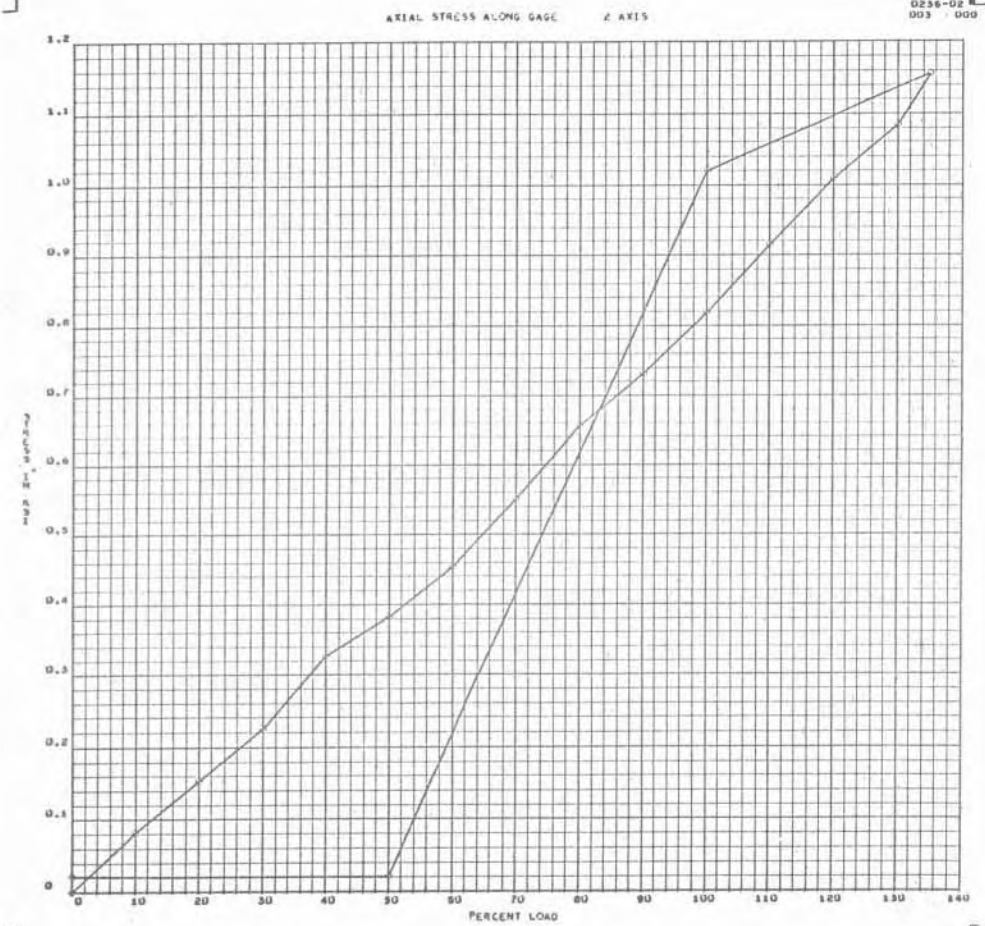
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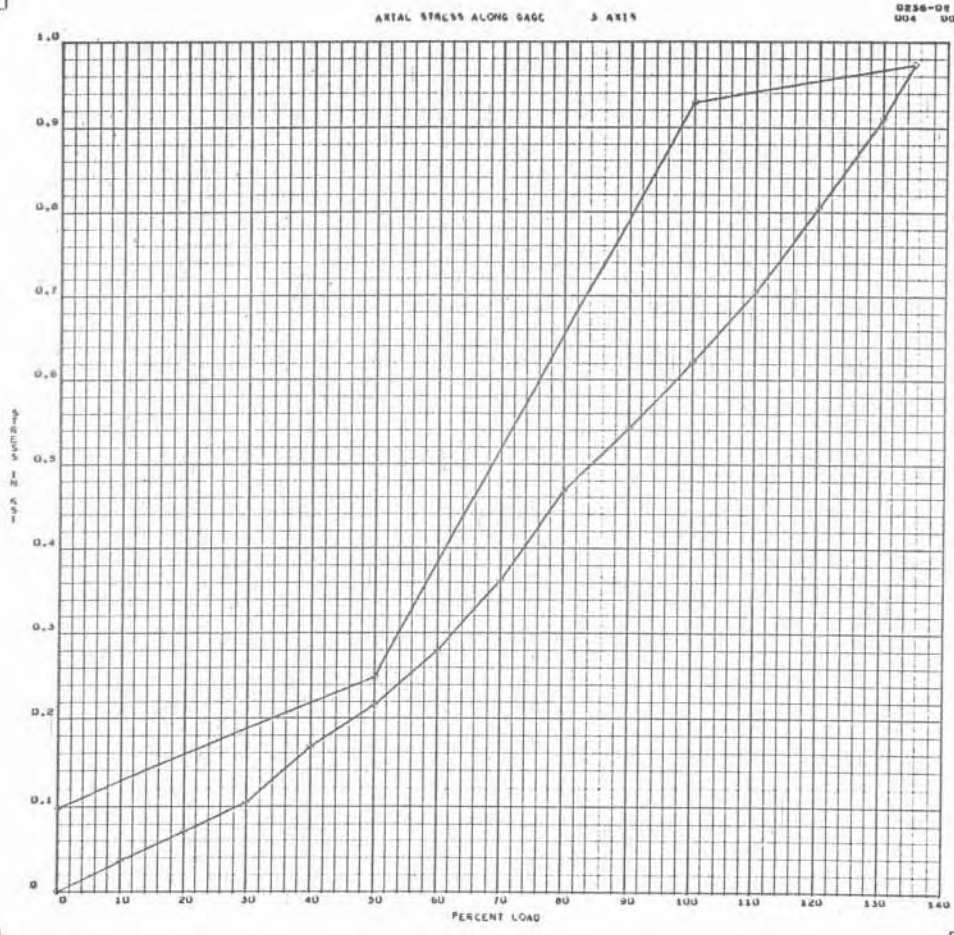
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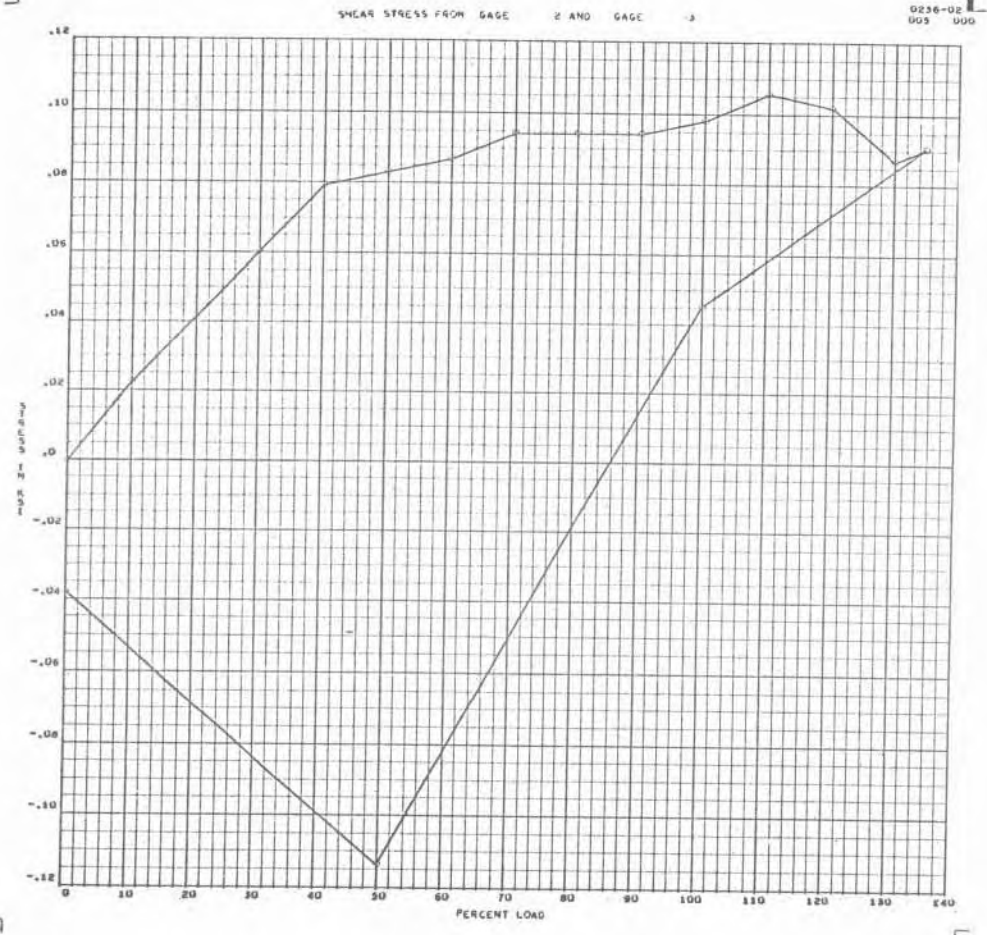


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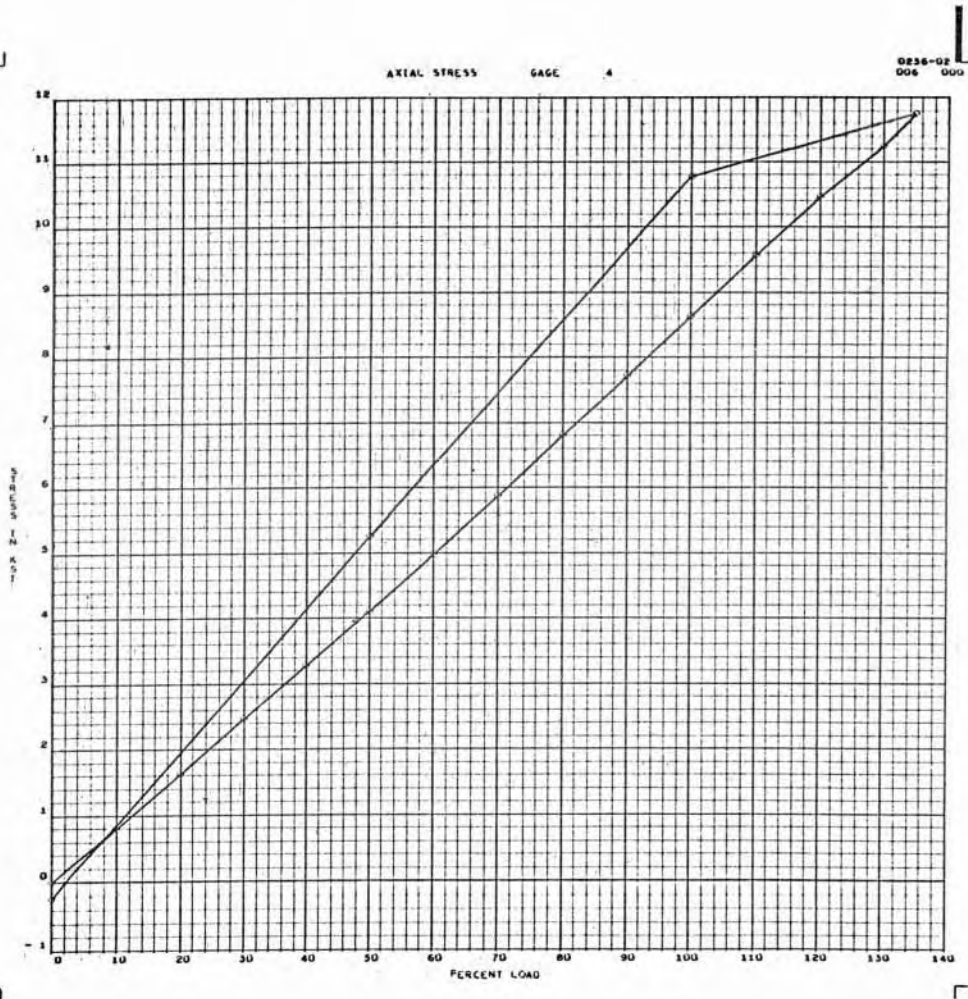
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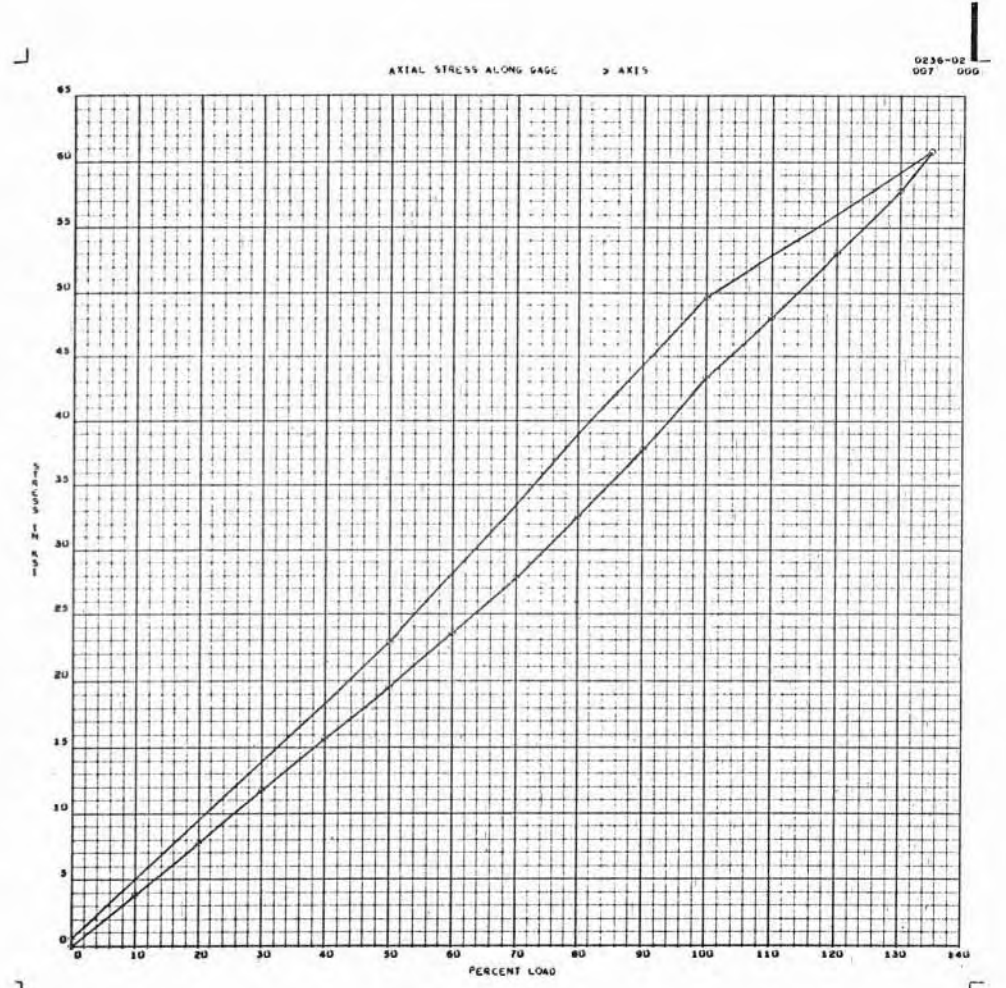


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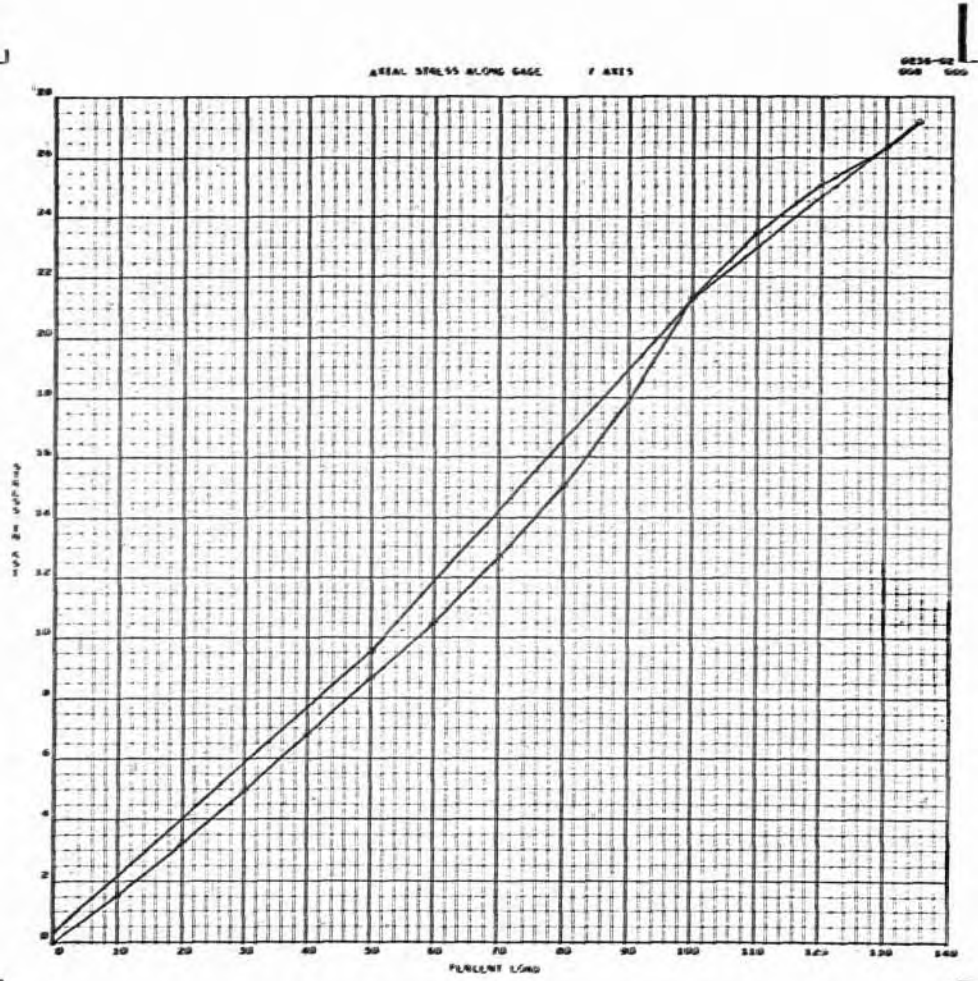
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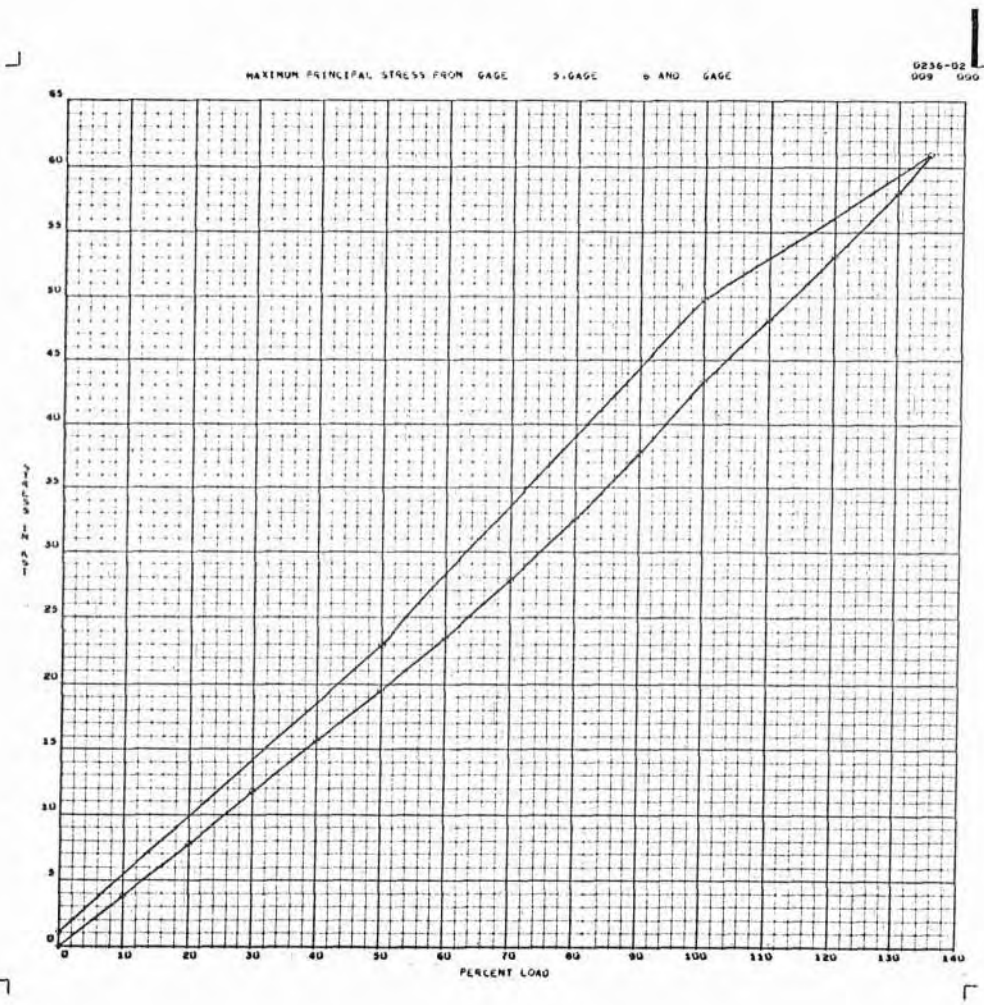


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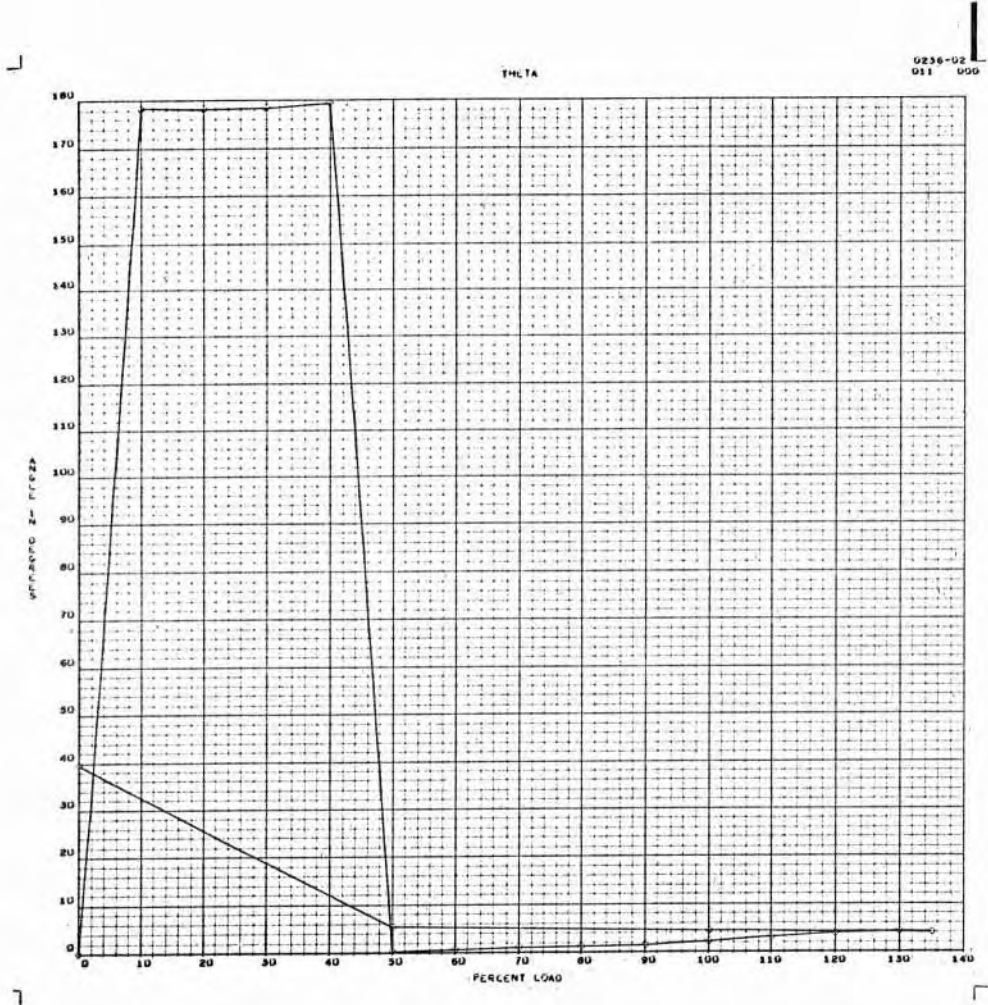
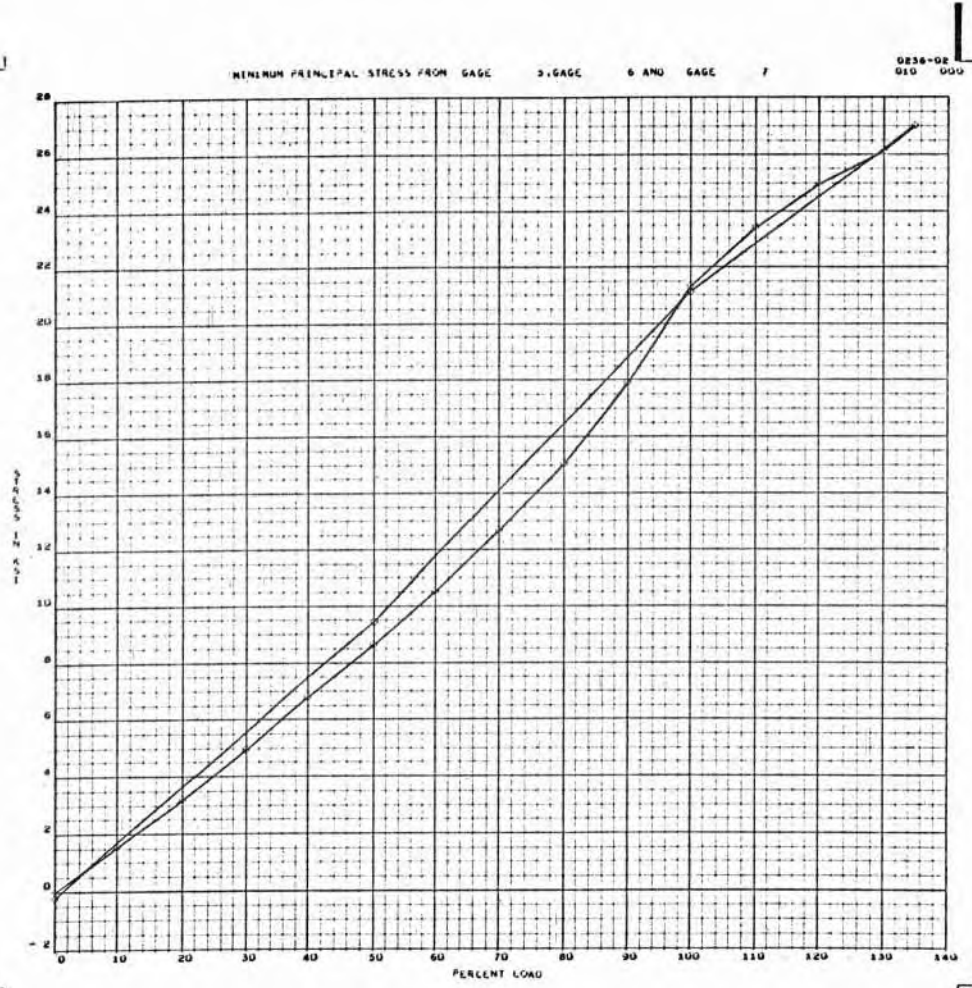
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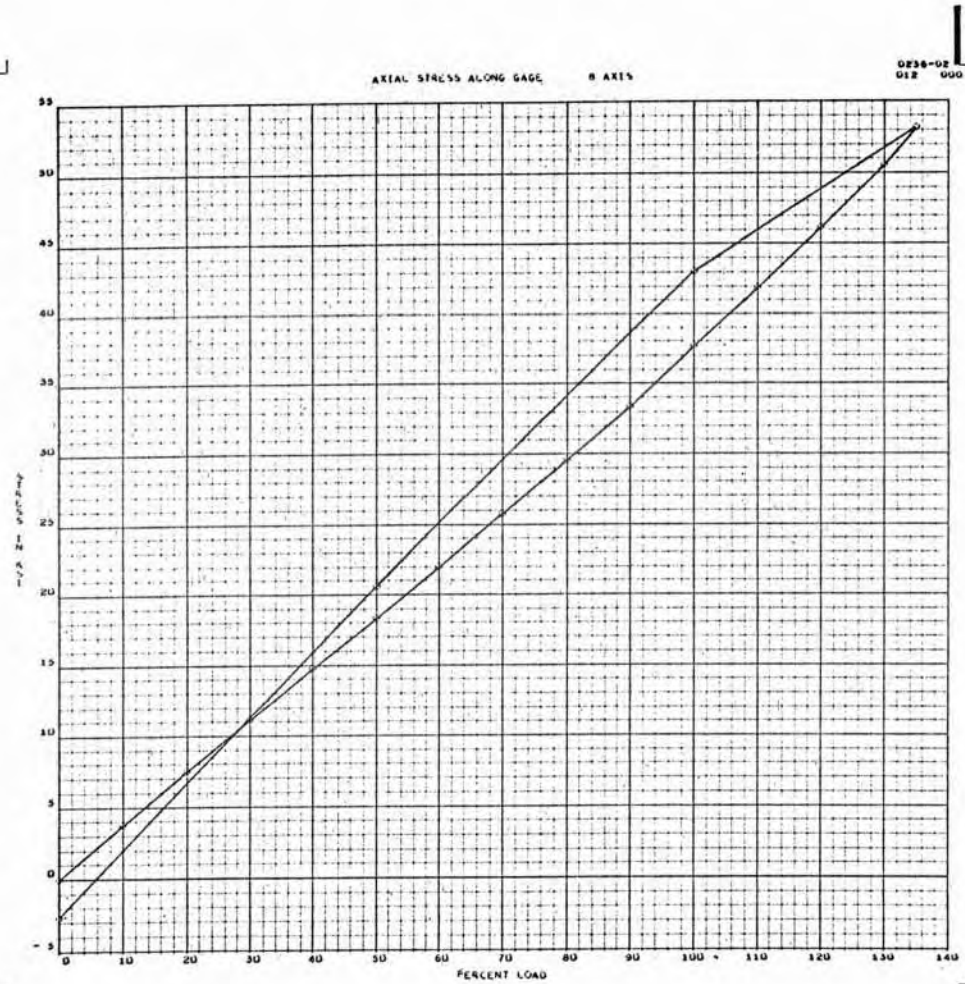


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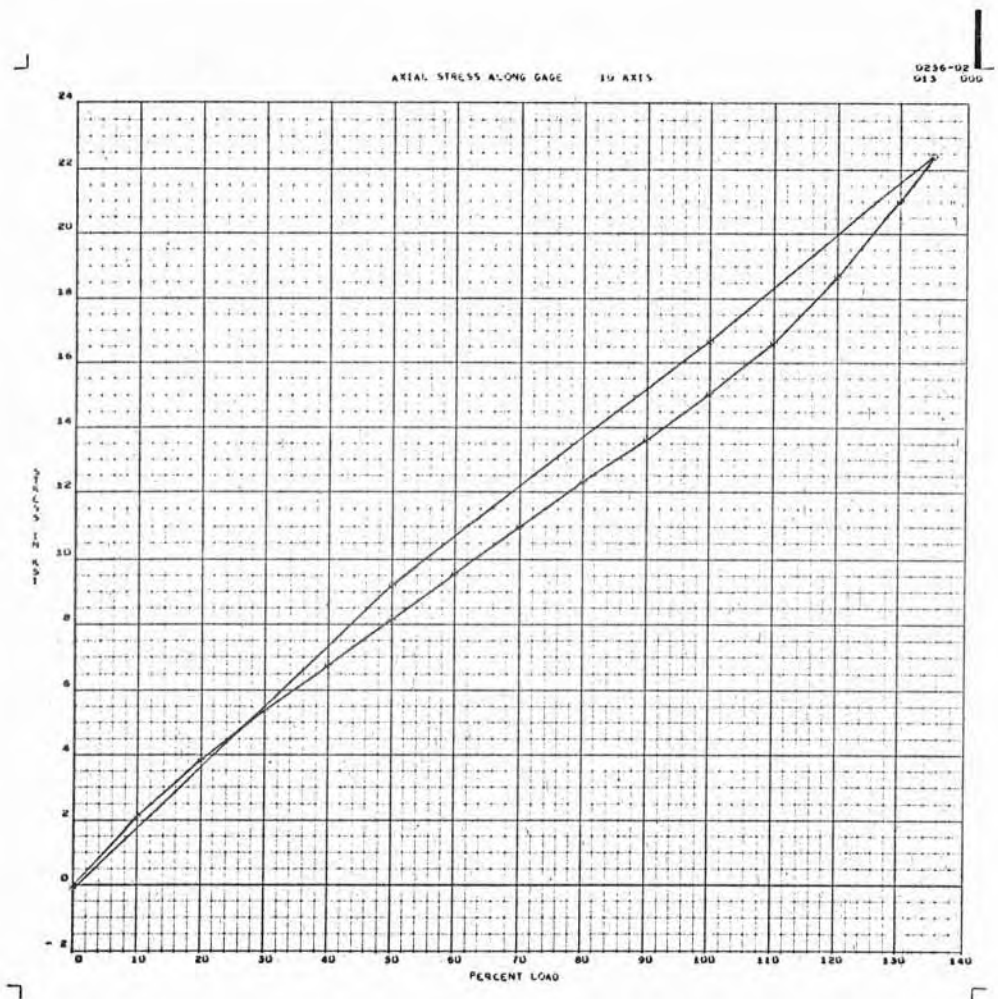


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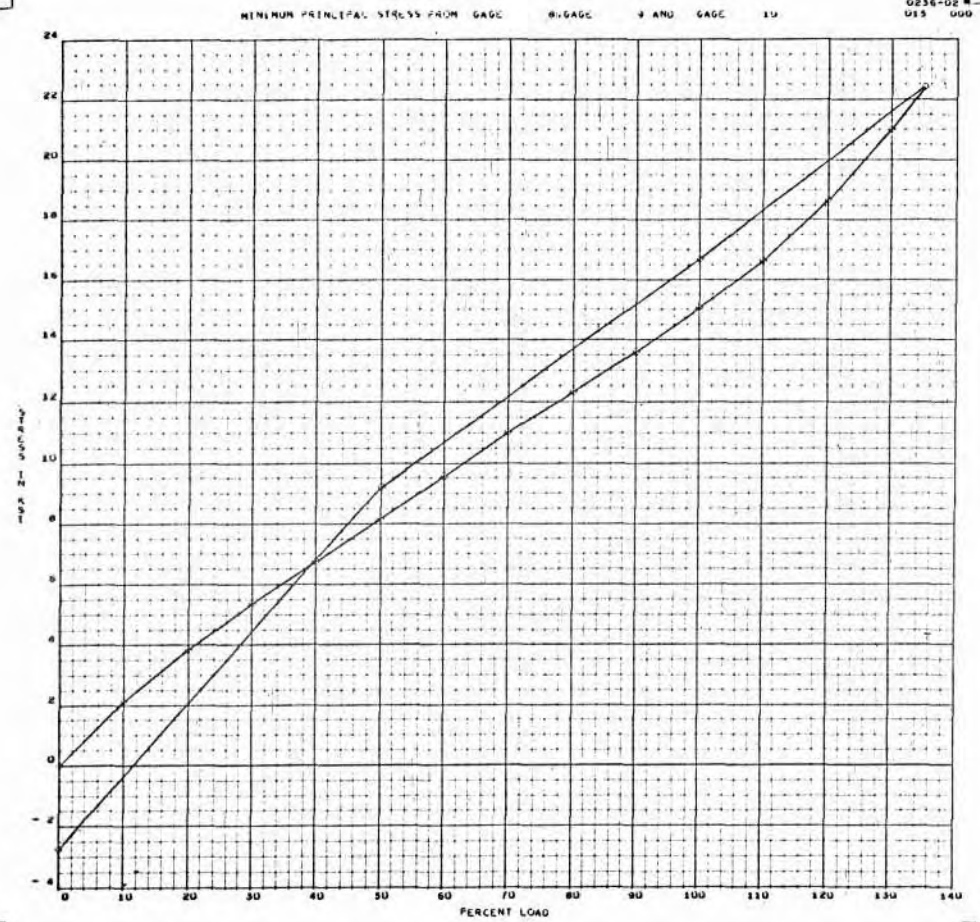
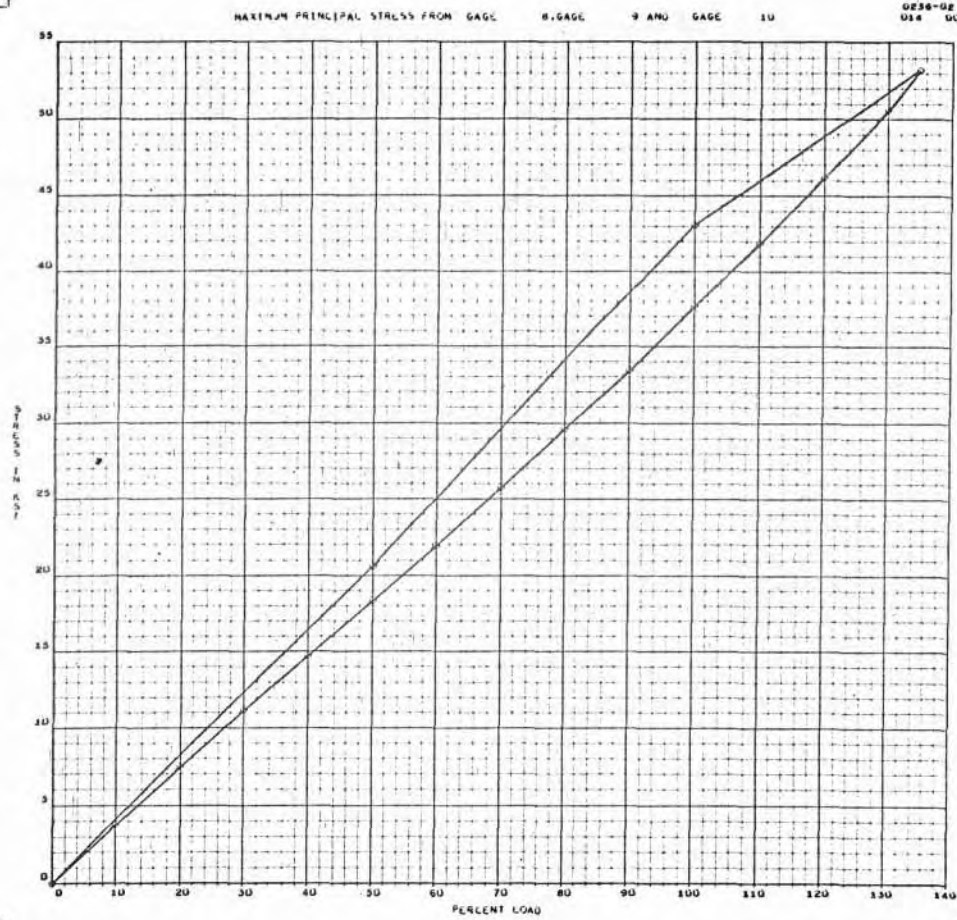




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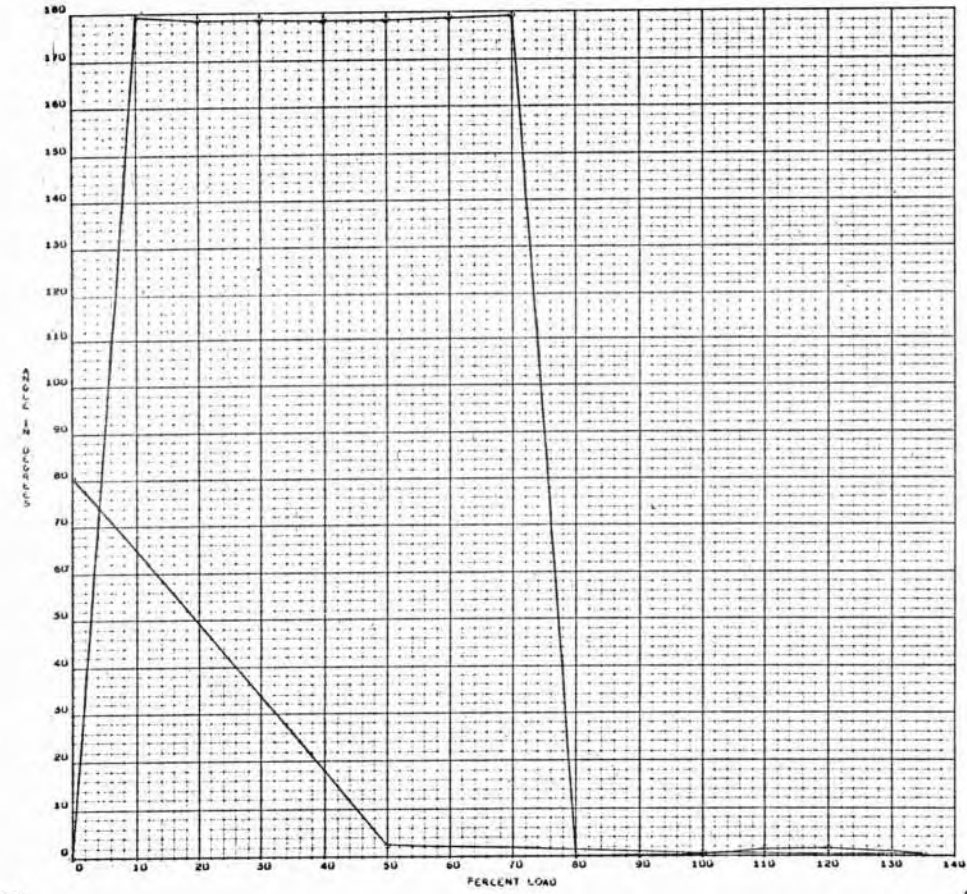


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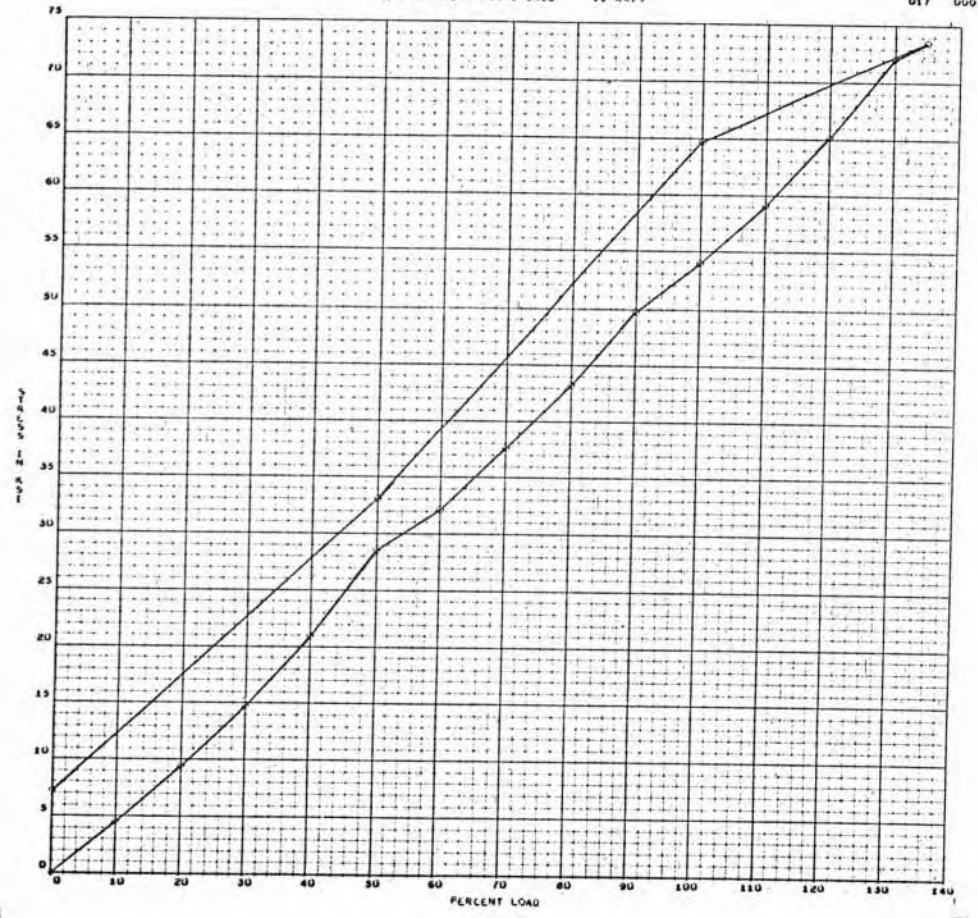


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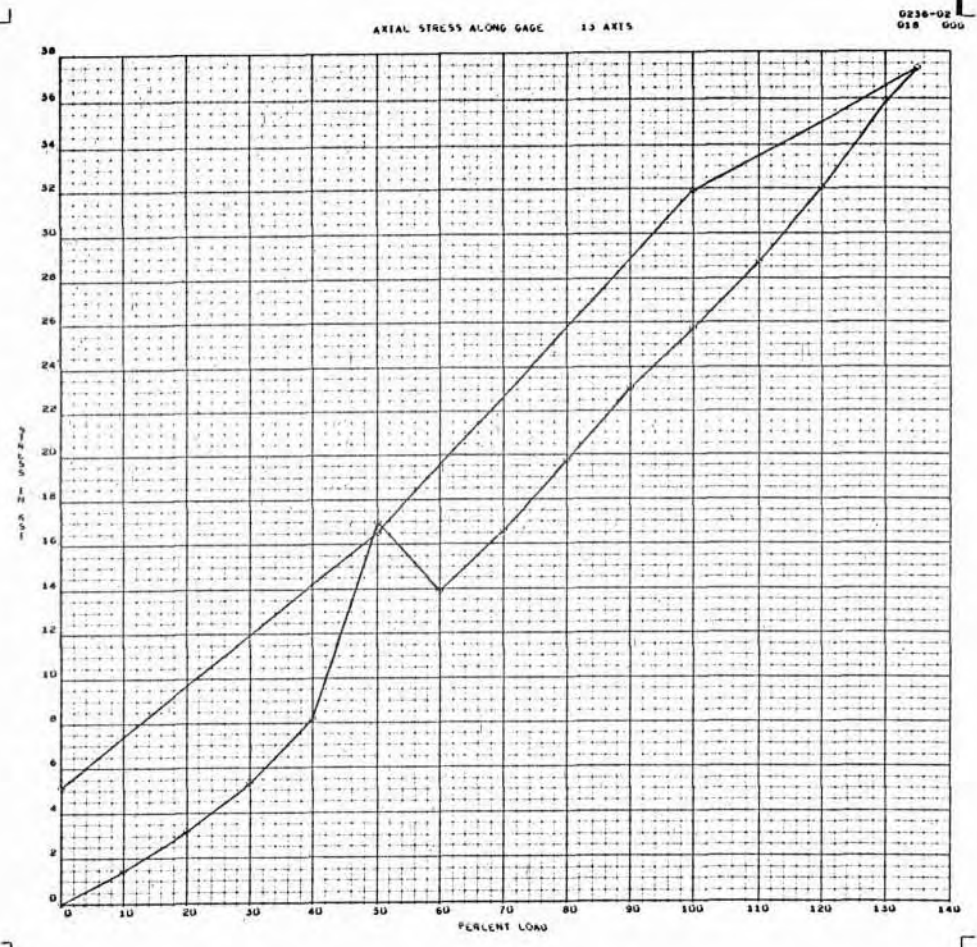
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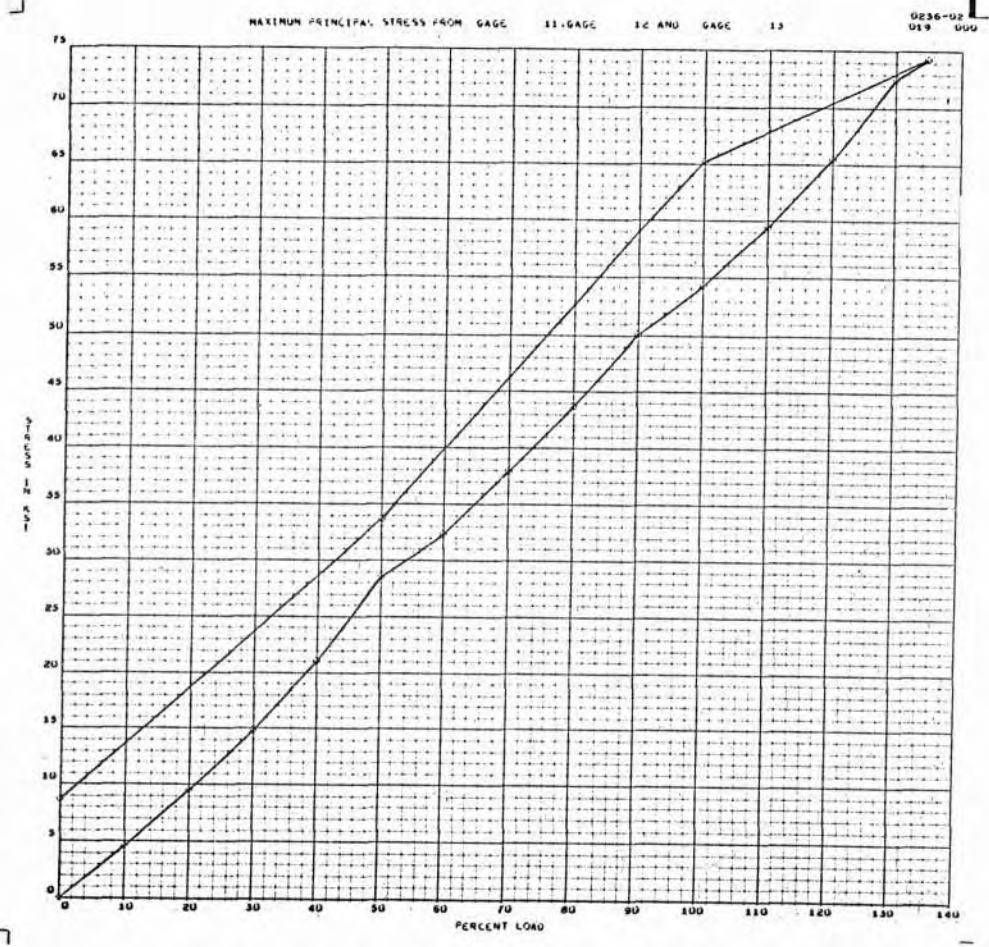


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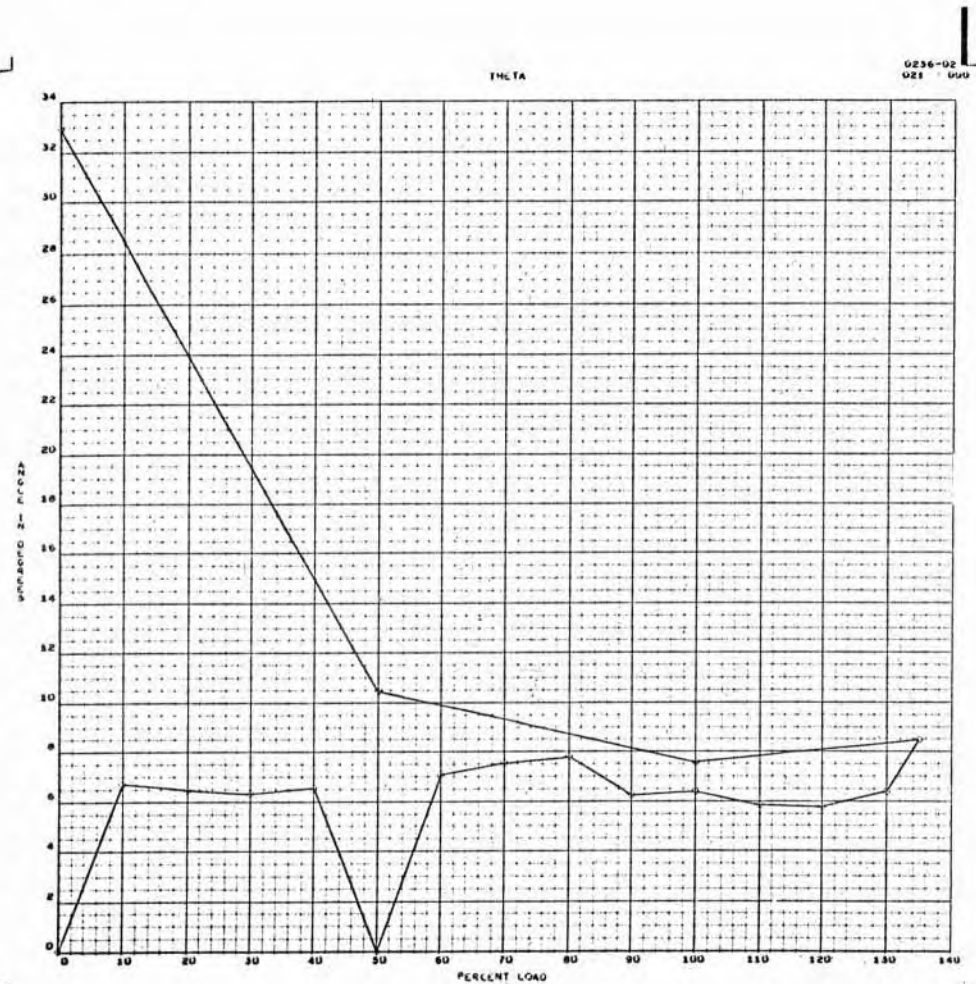
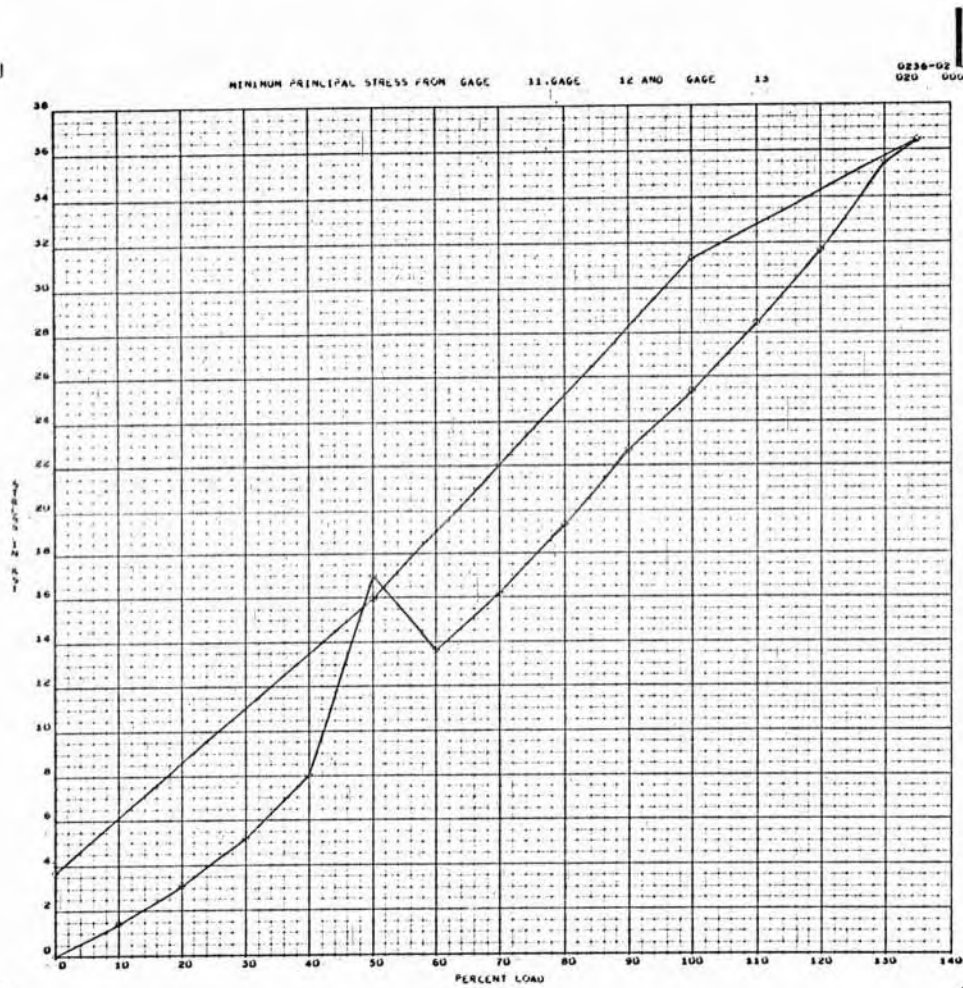
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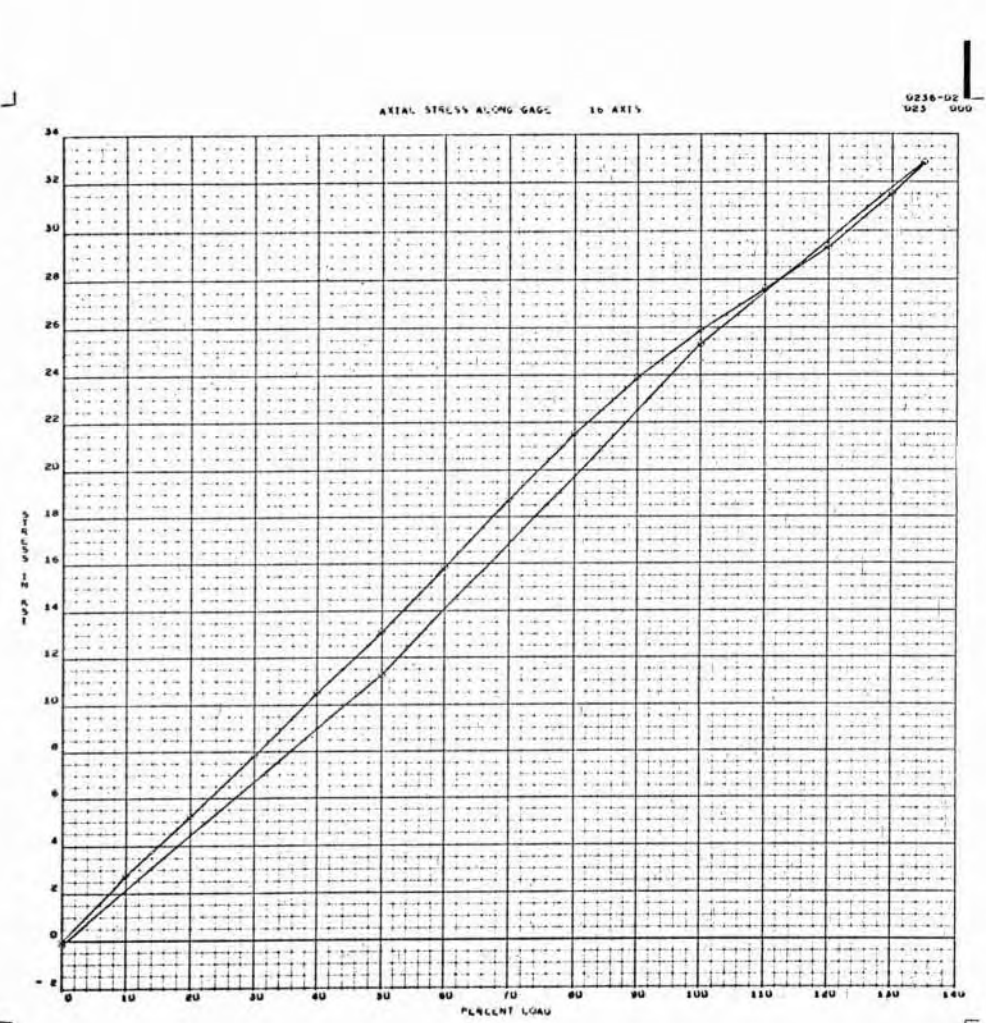
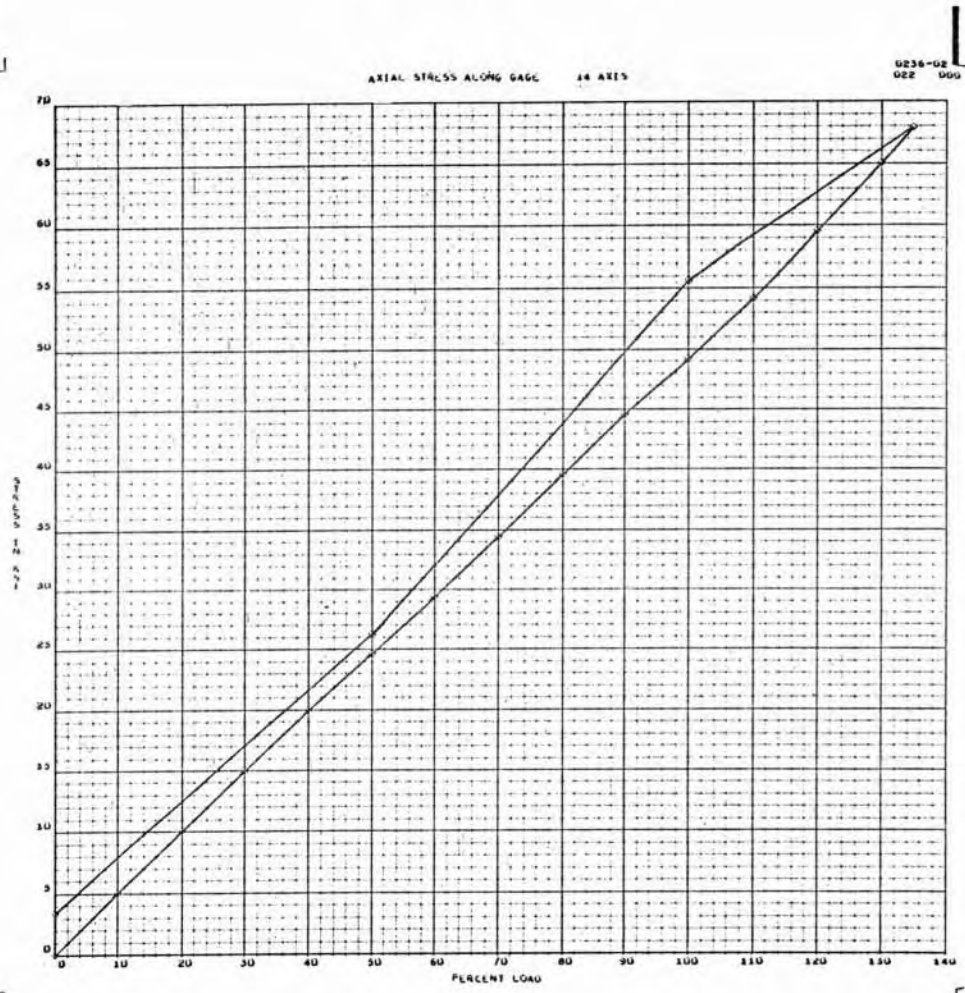


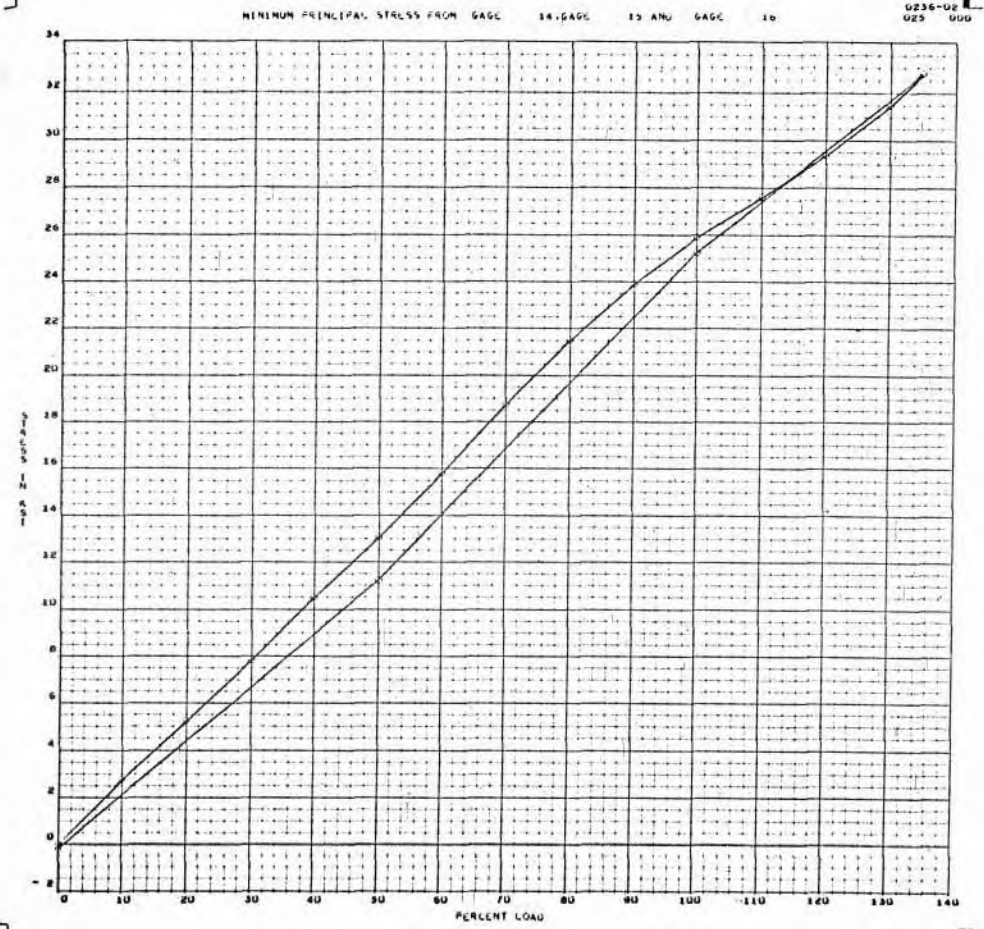
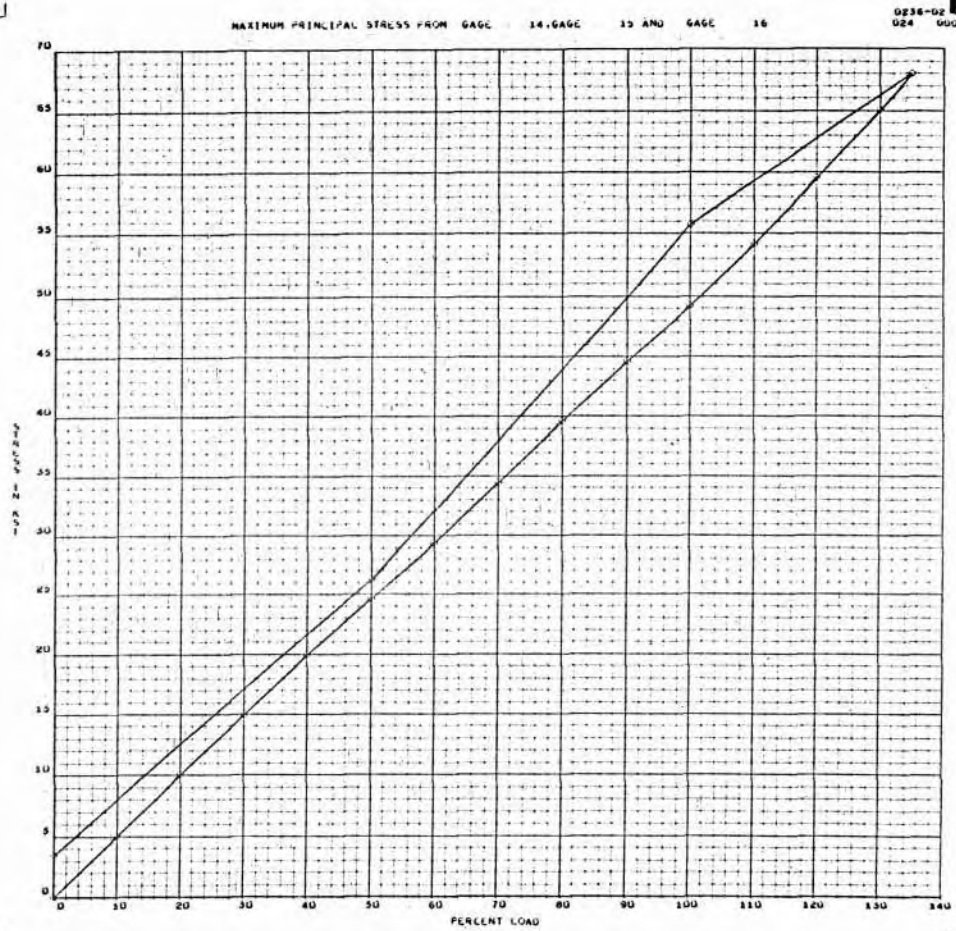
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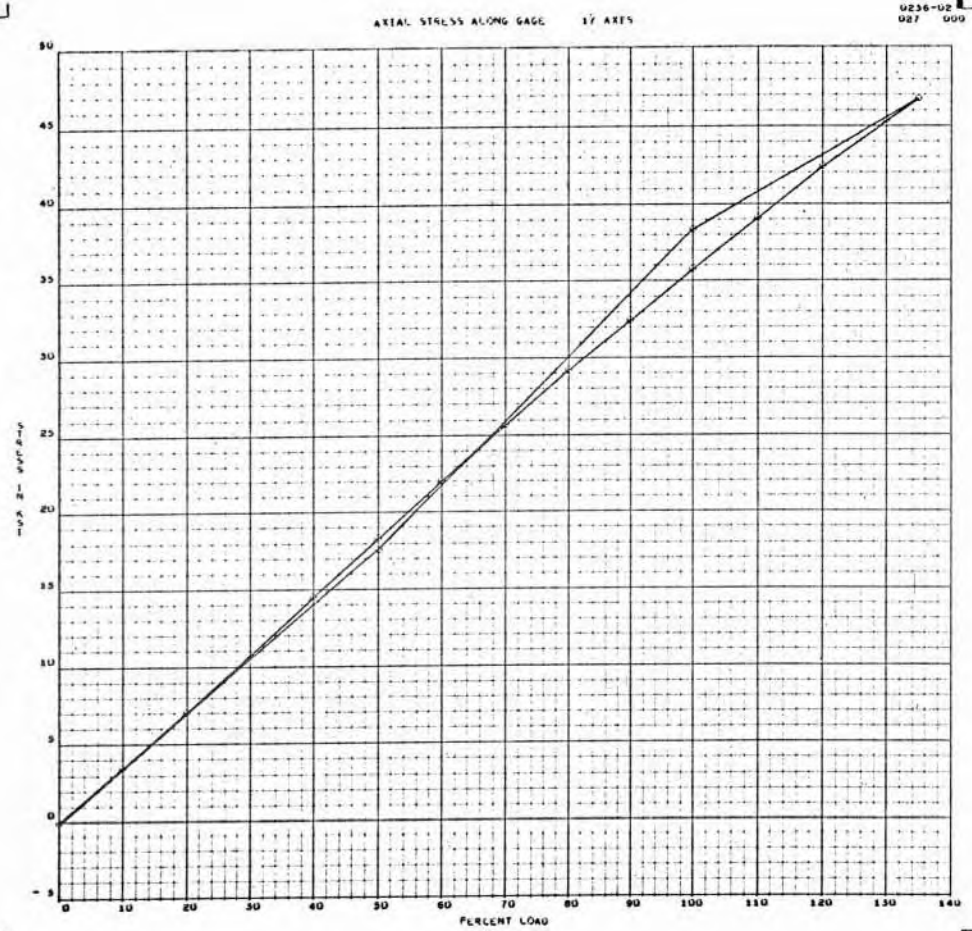
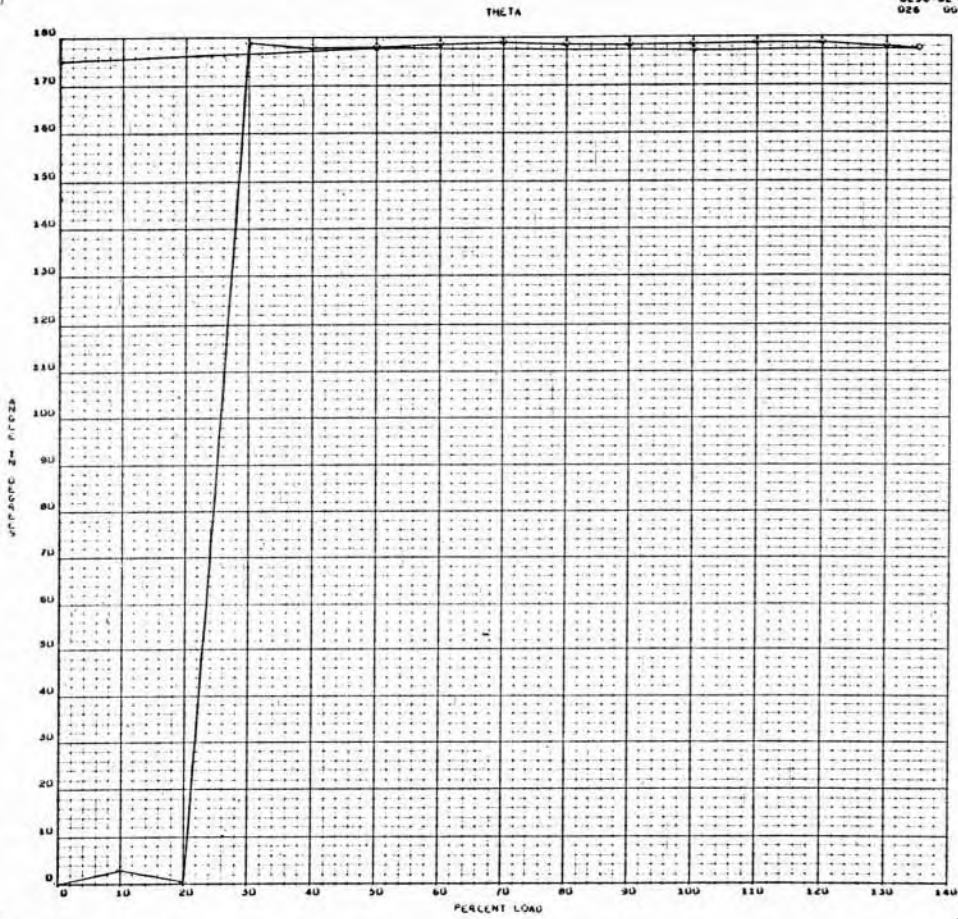


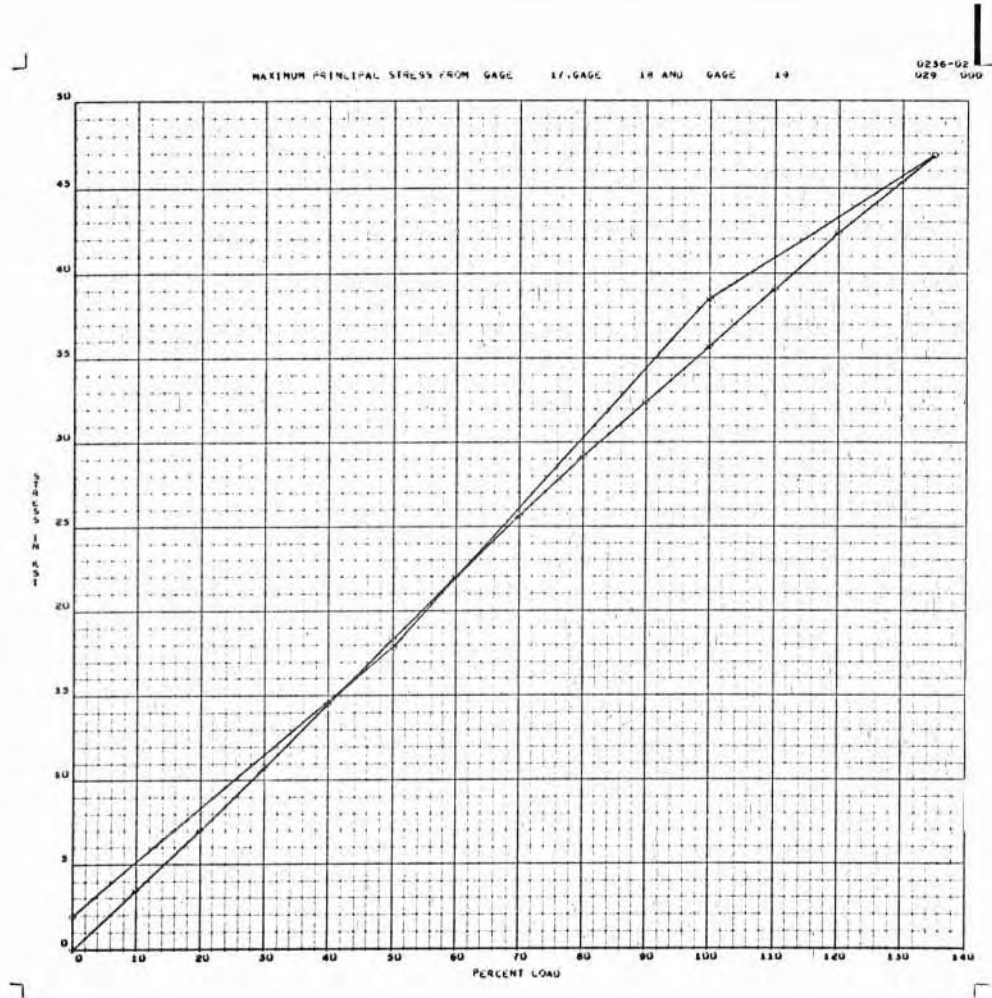
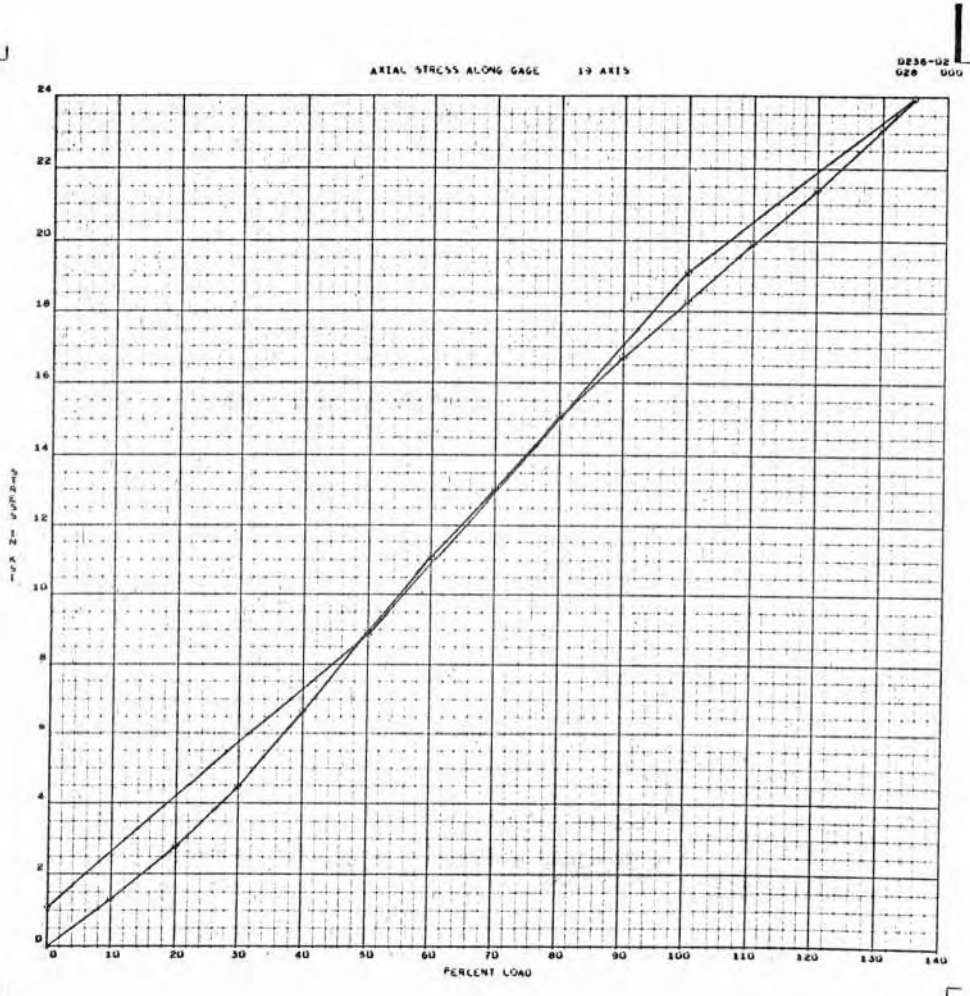
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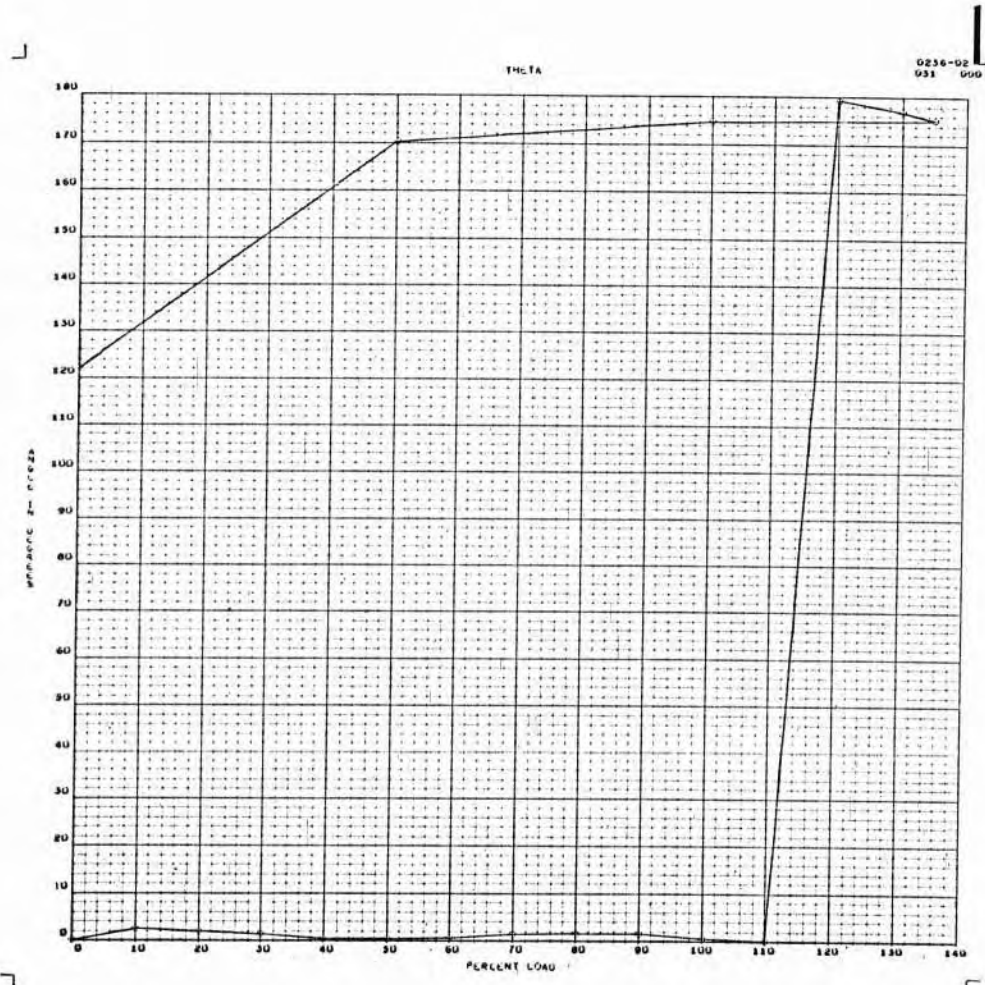
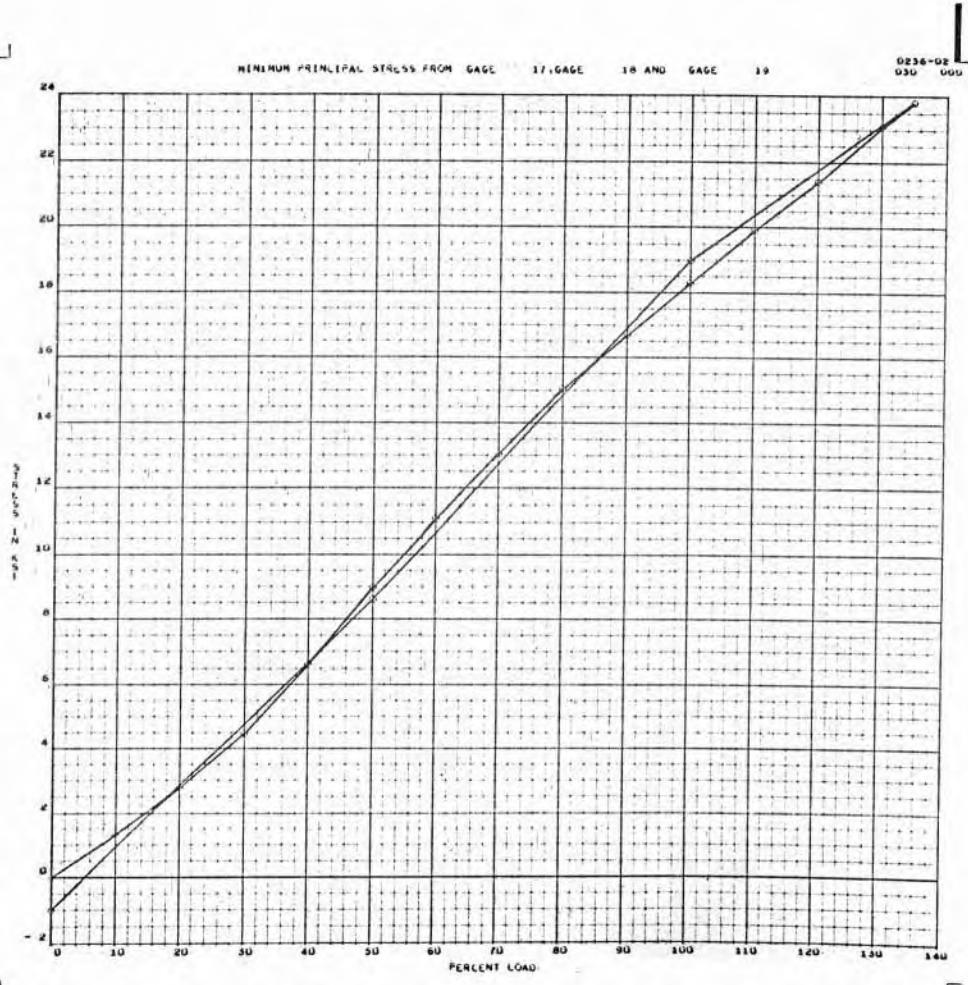


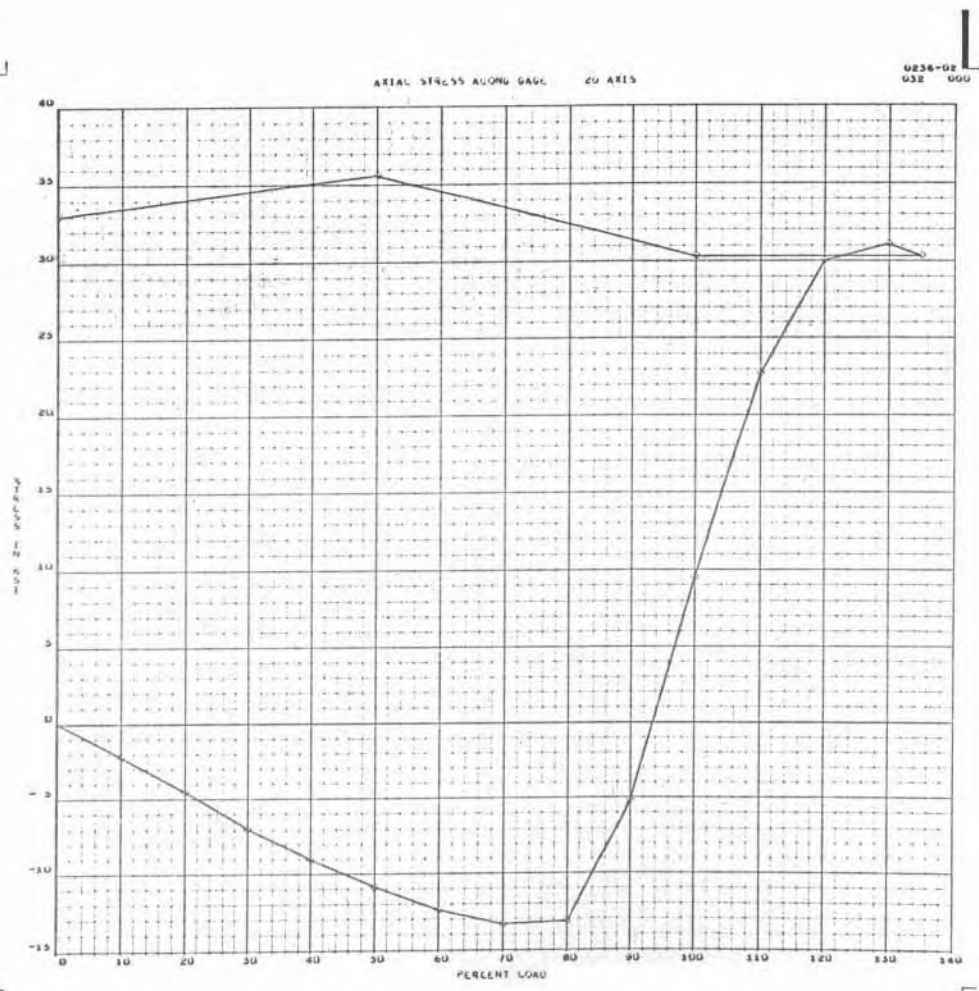




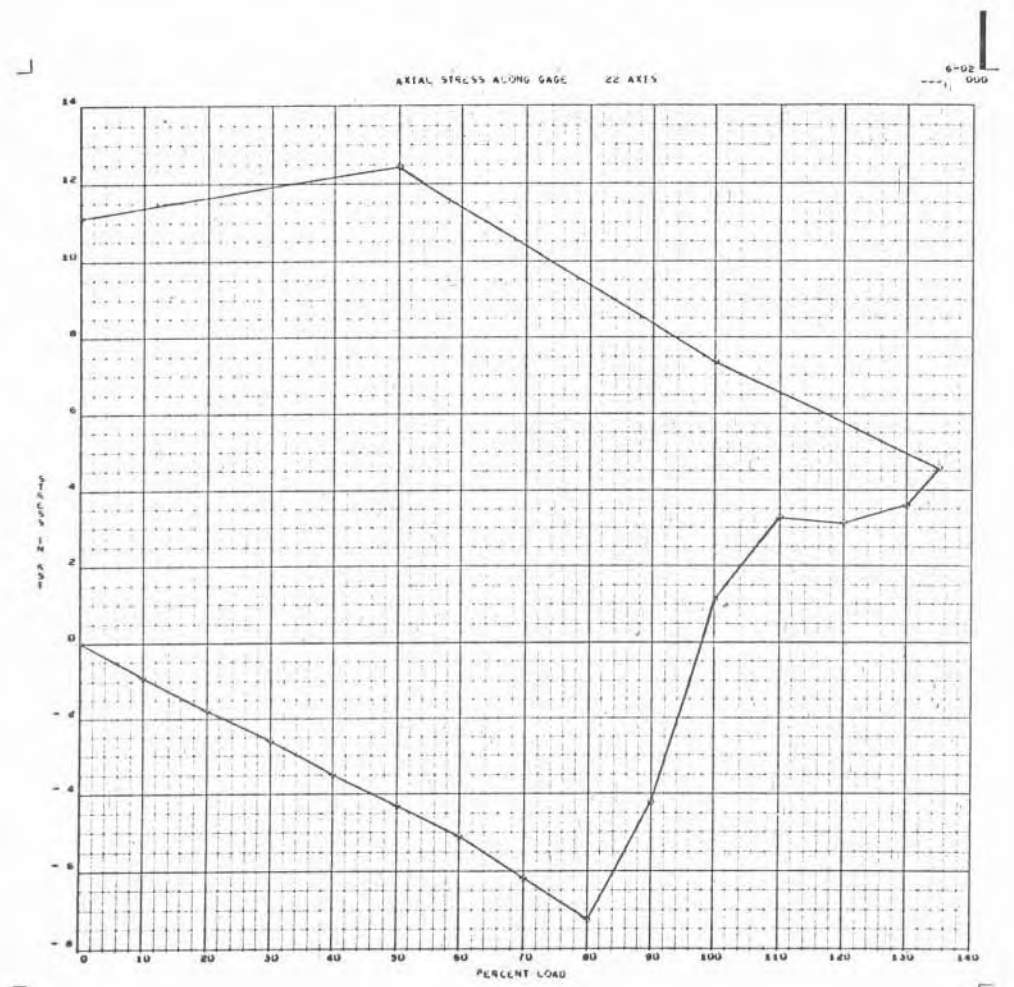








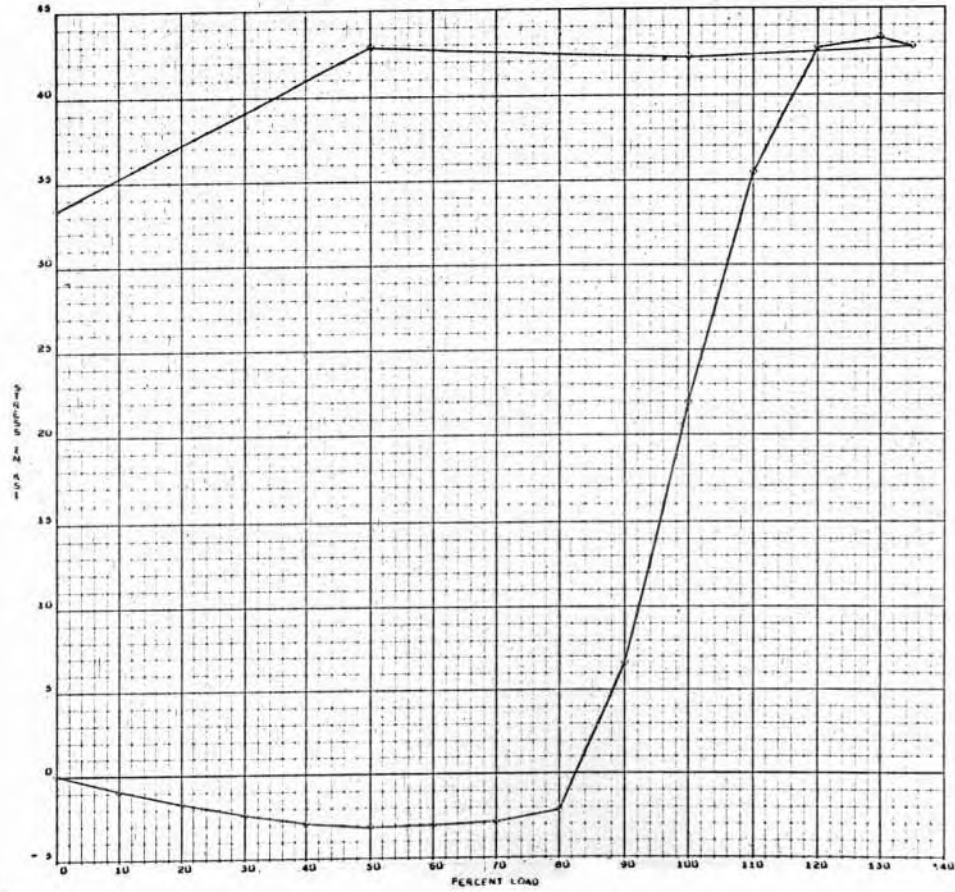
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MAXIMUM PRINCIPAL STRESS FROM GAGE 20, GAGE 21 AND GAGE 22

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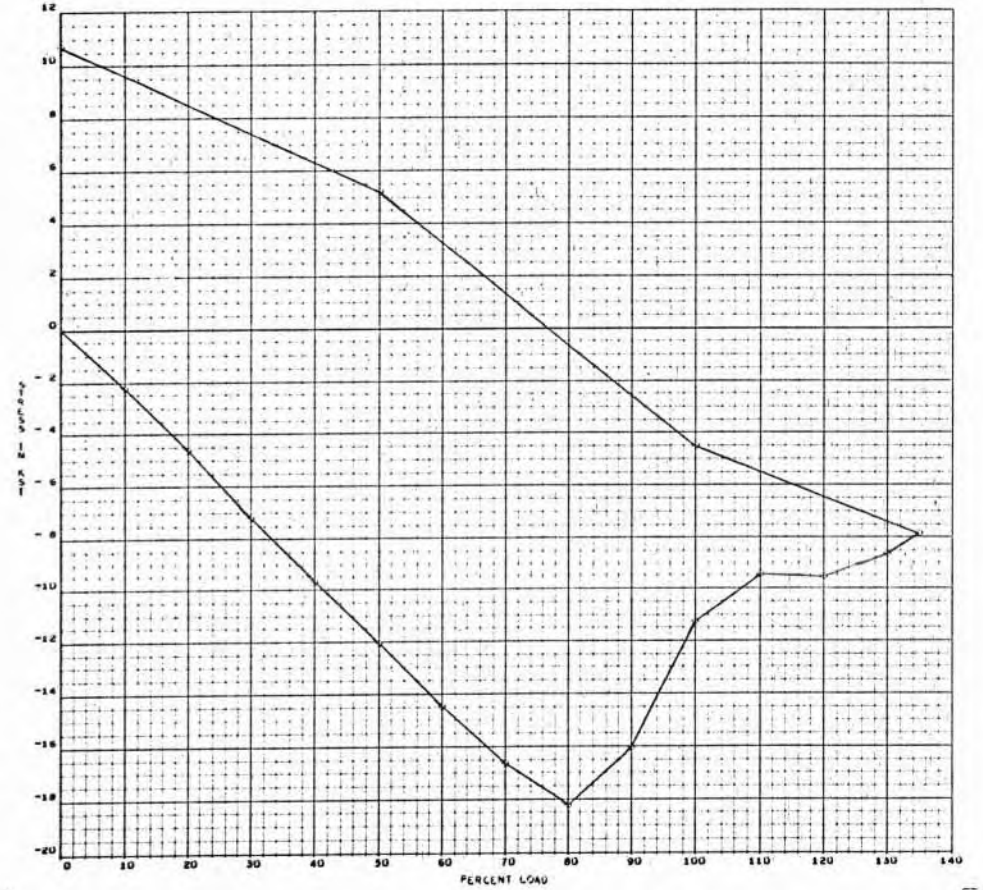


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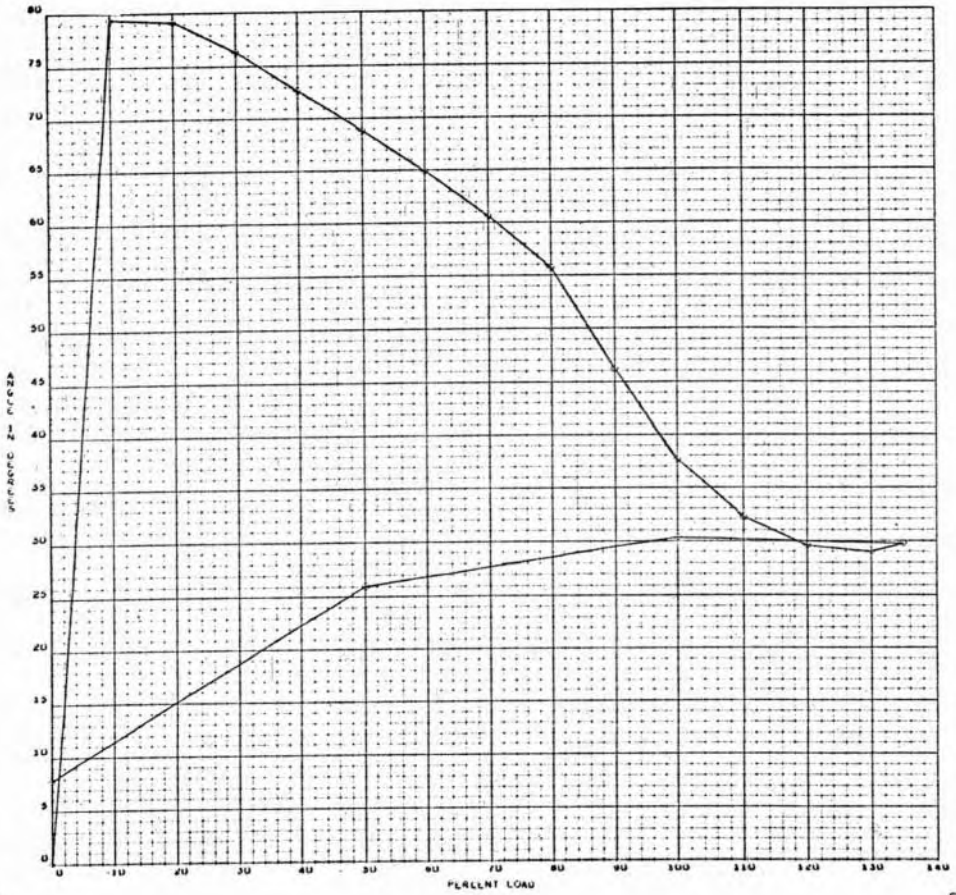


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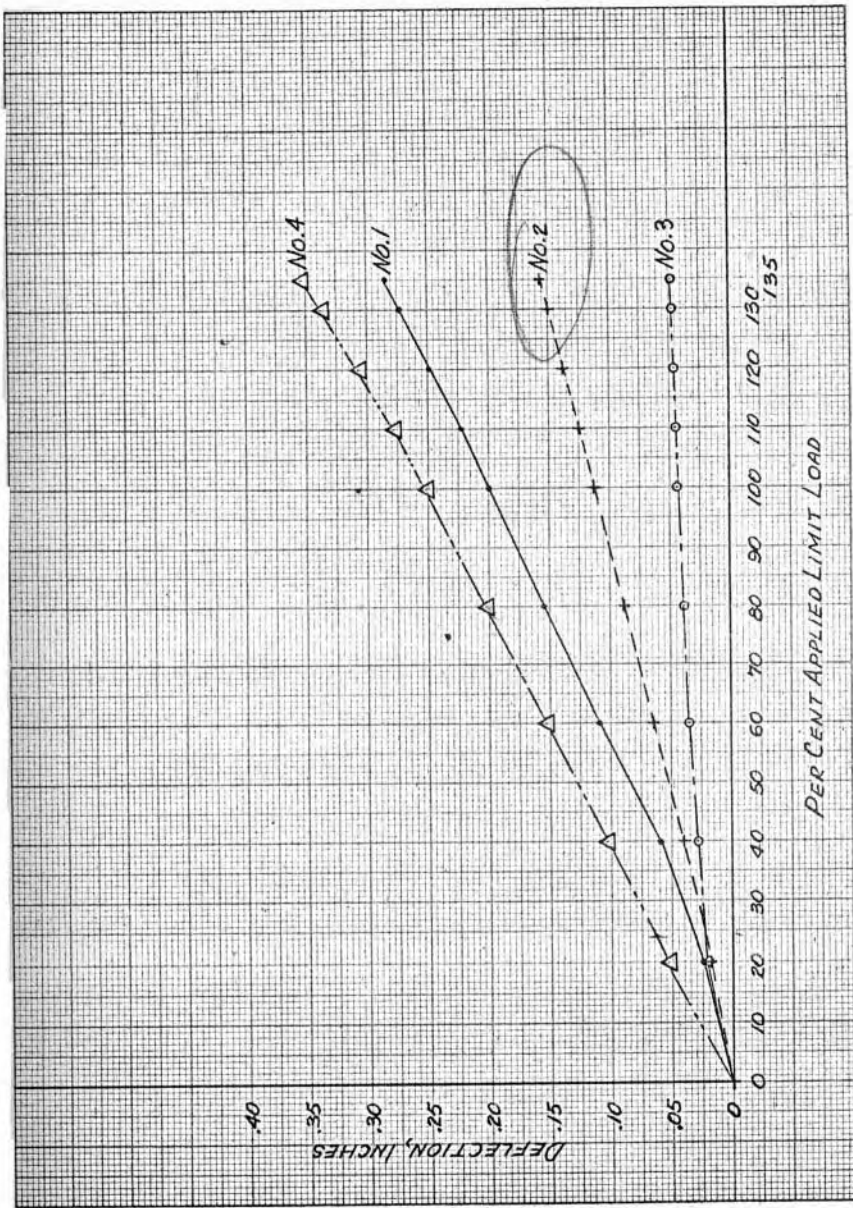
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APPENDIX A

TEST CONDITION IB

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TEST CONDITION 1B

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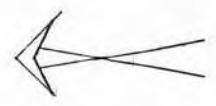
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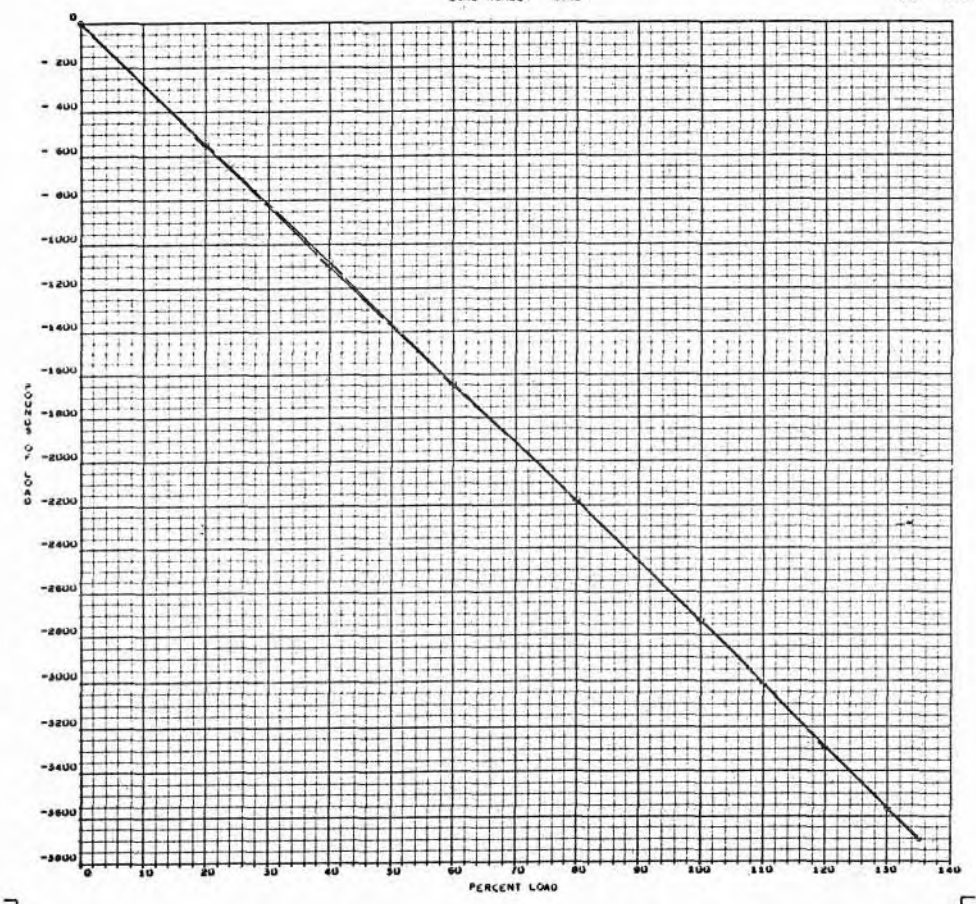
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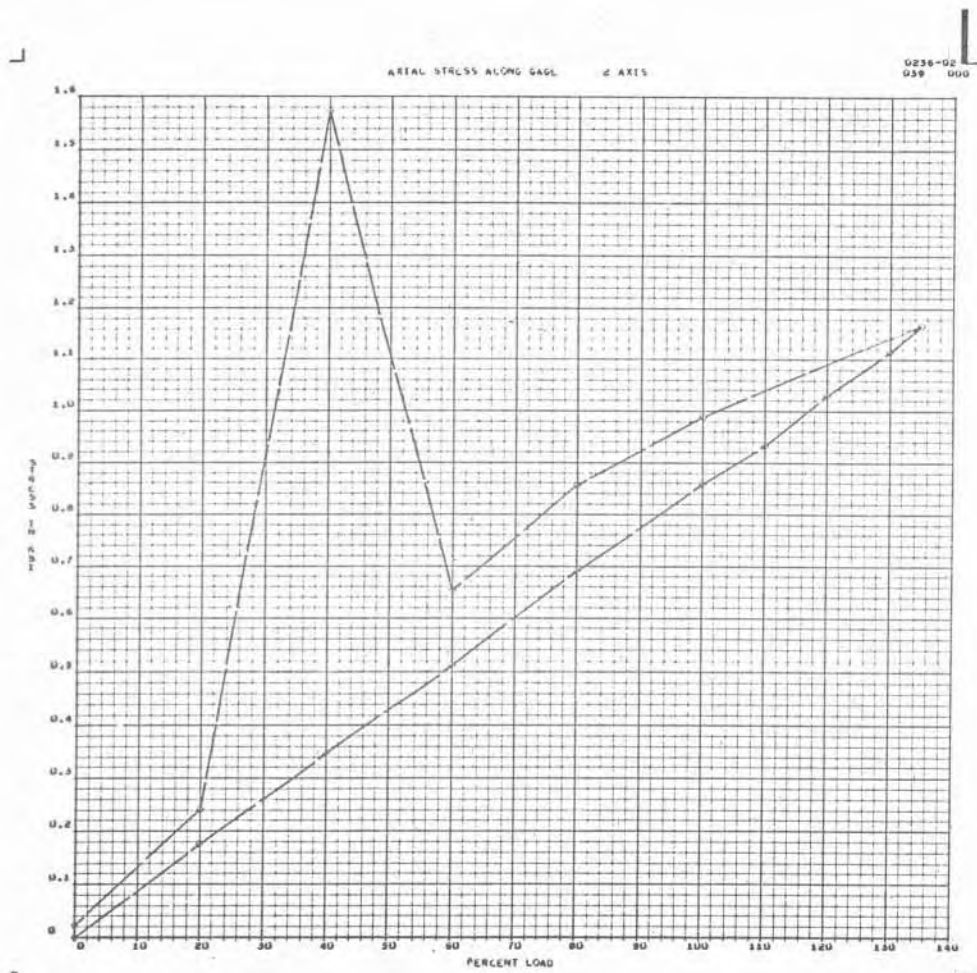
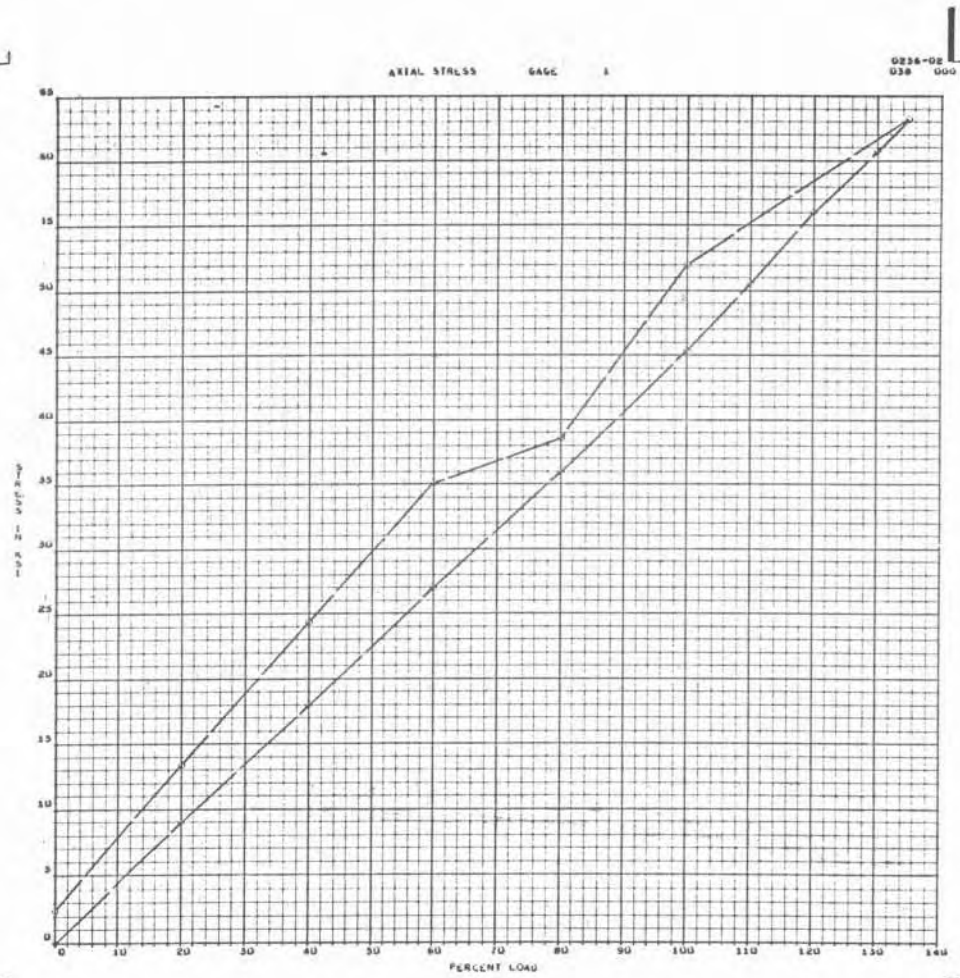
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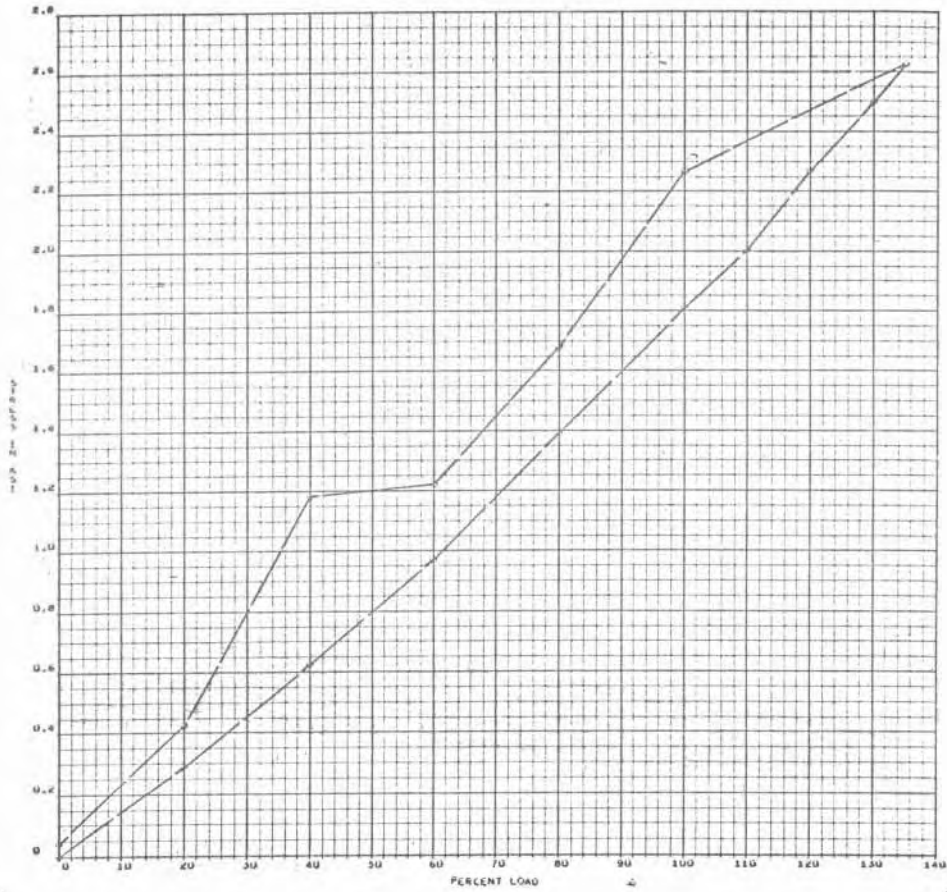
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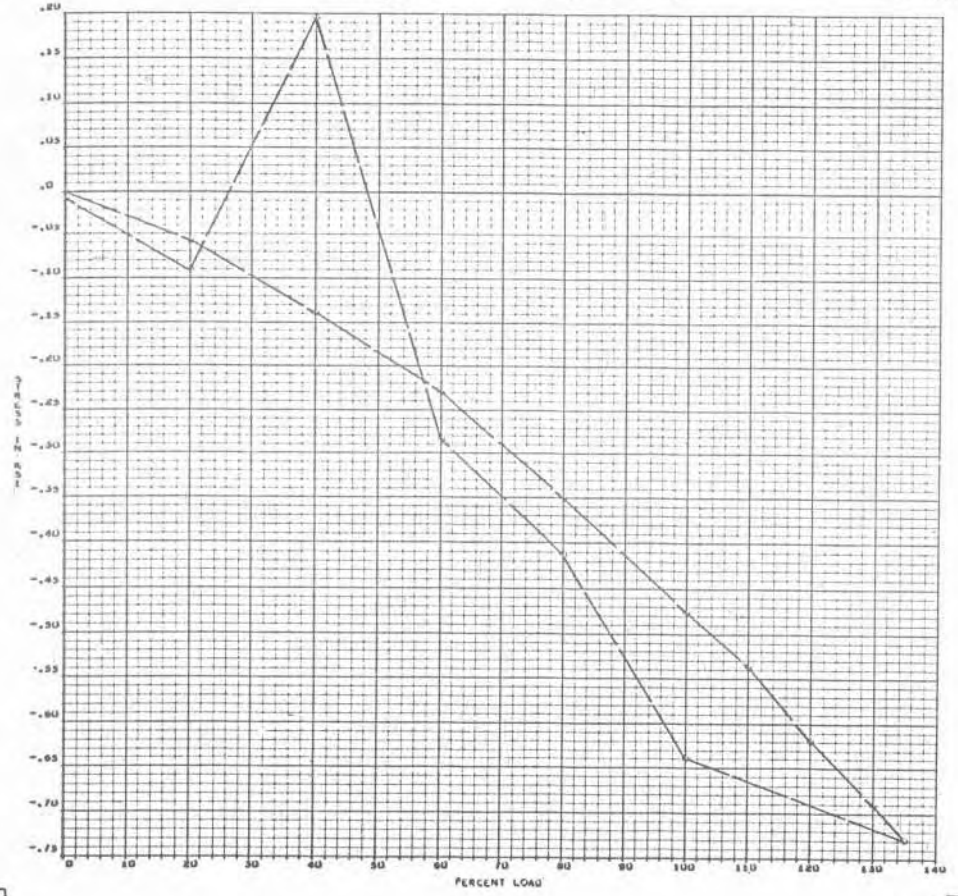
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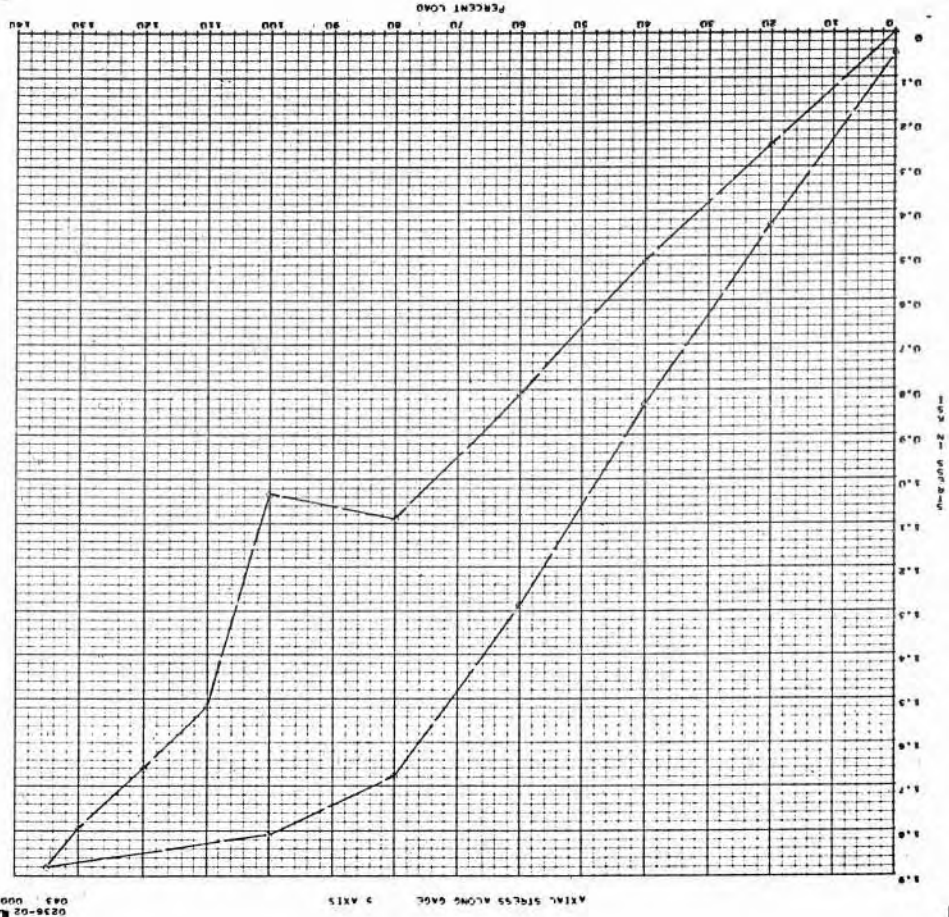
0236-02
040 000



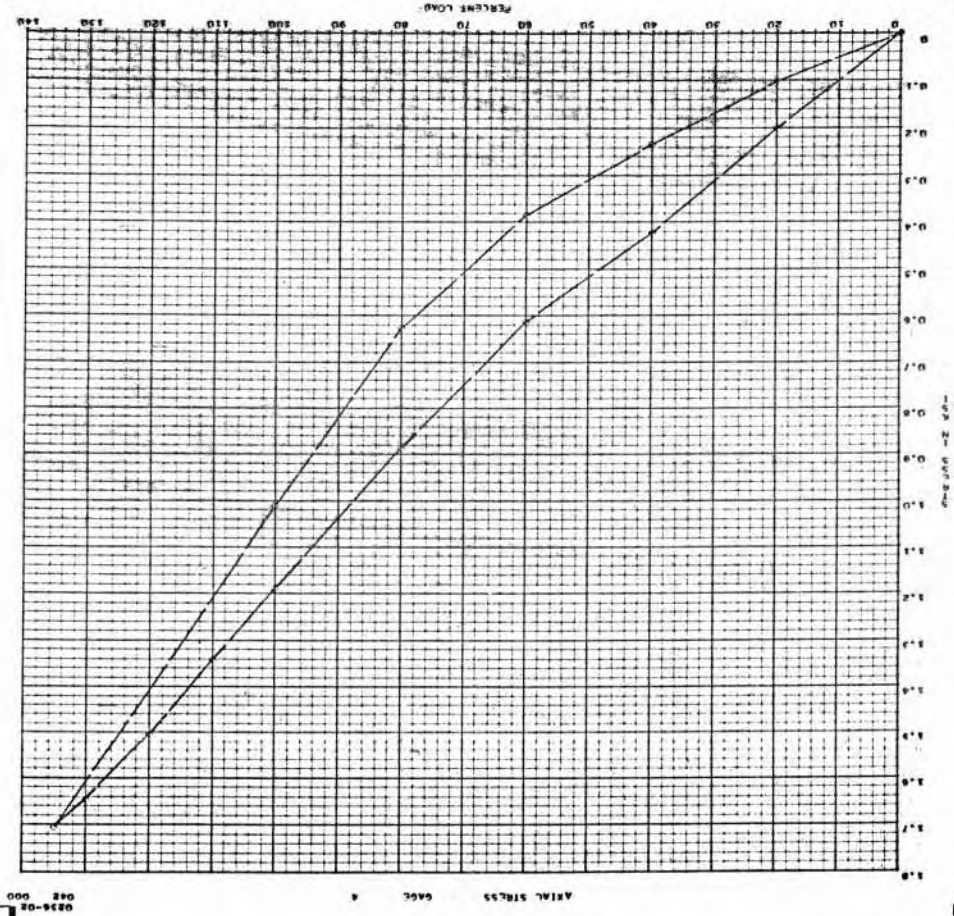
SHEAR STRESS FROM GAGE 2 AND GAGE 3

0236-02
041 000

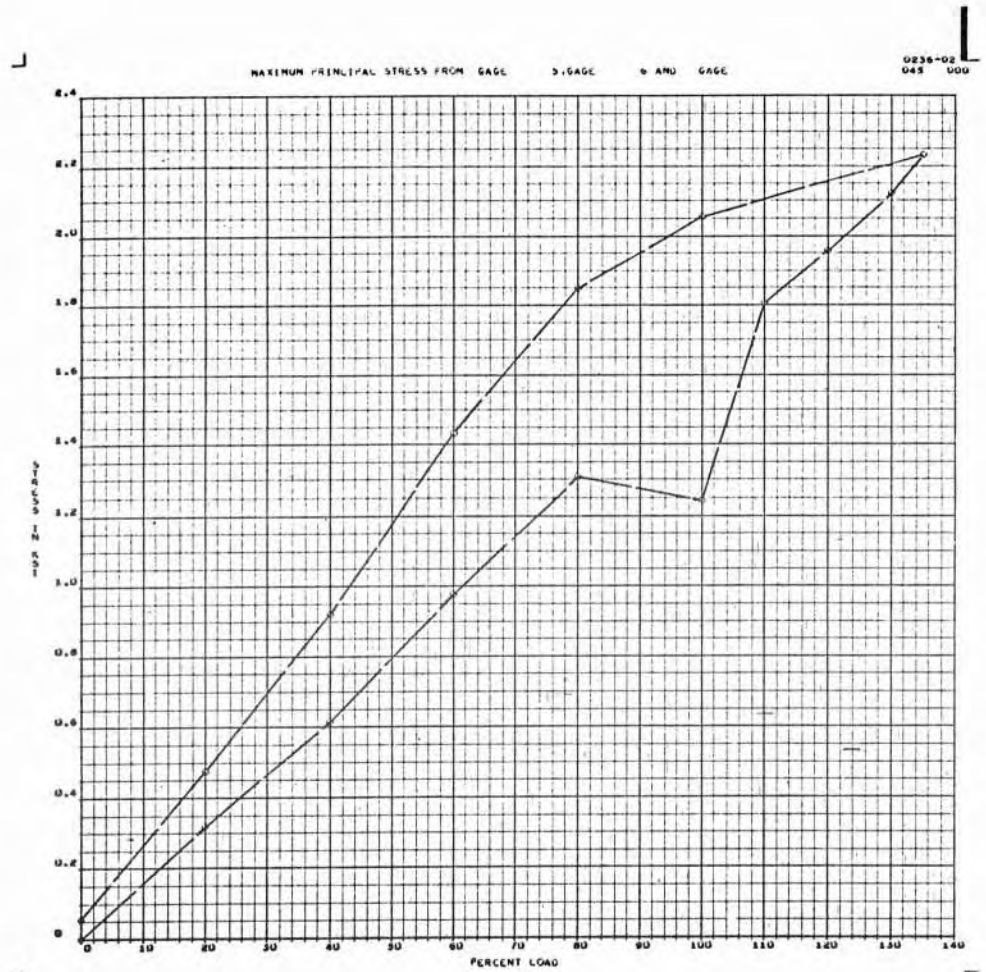
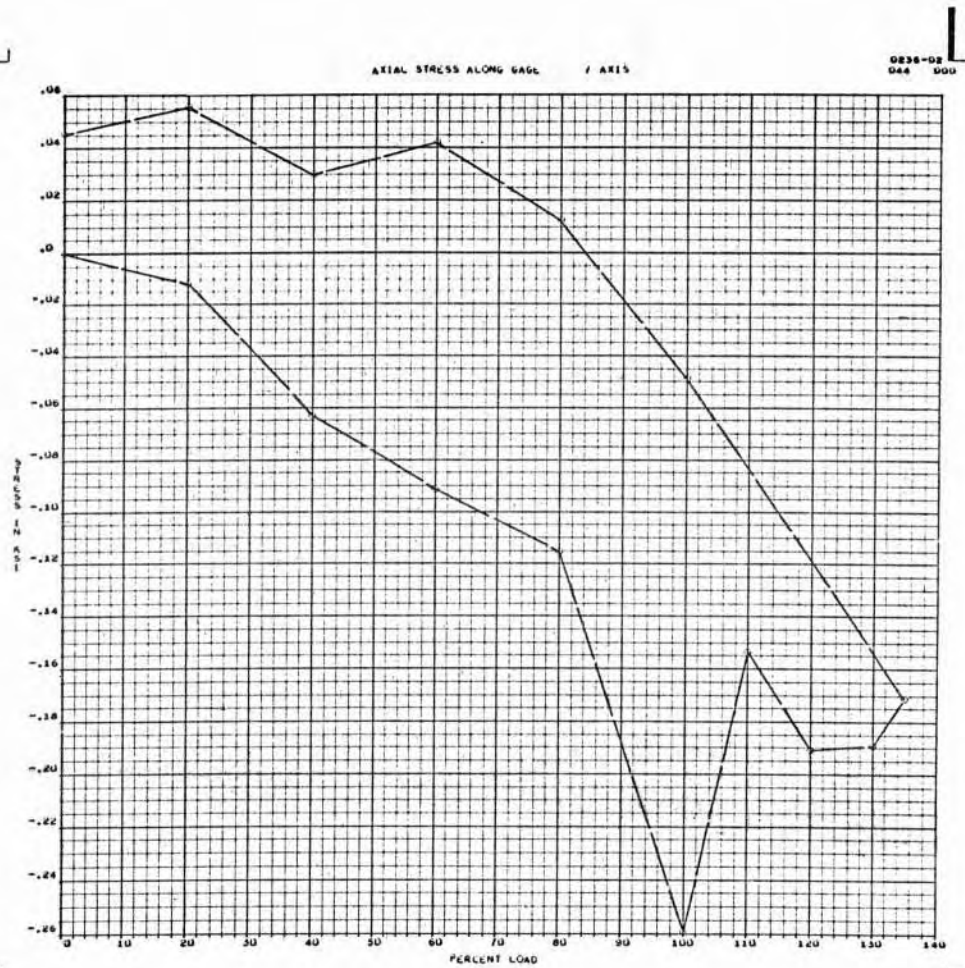


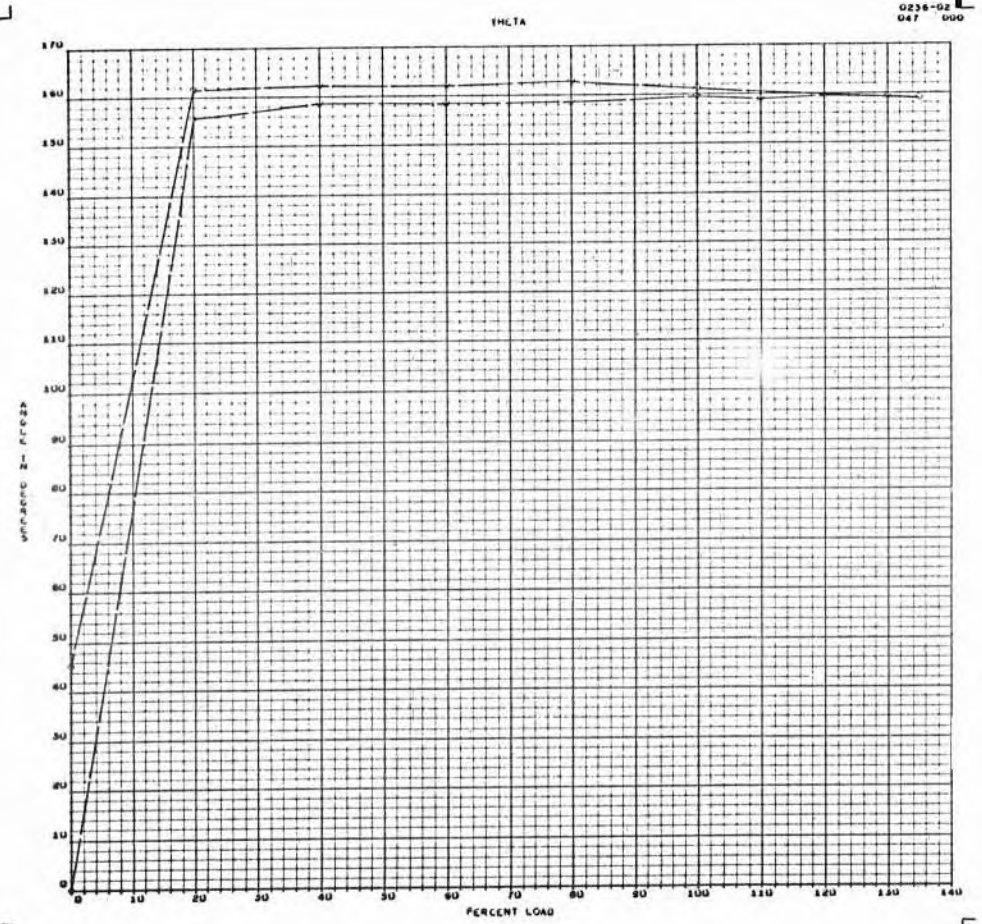
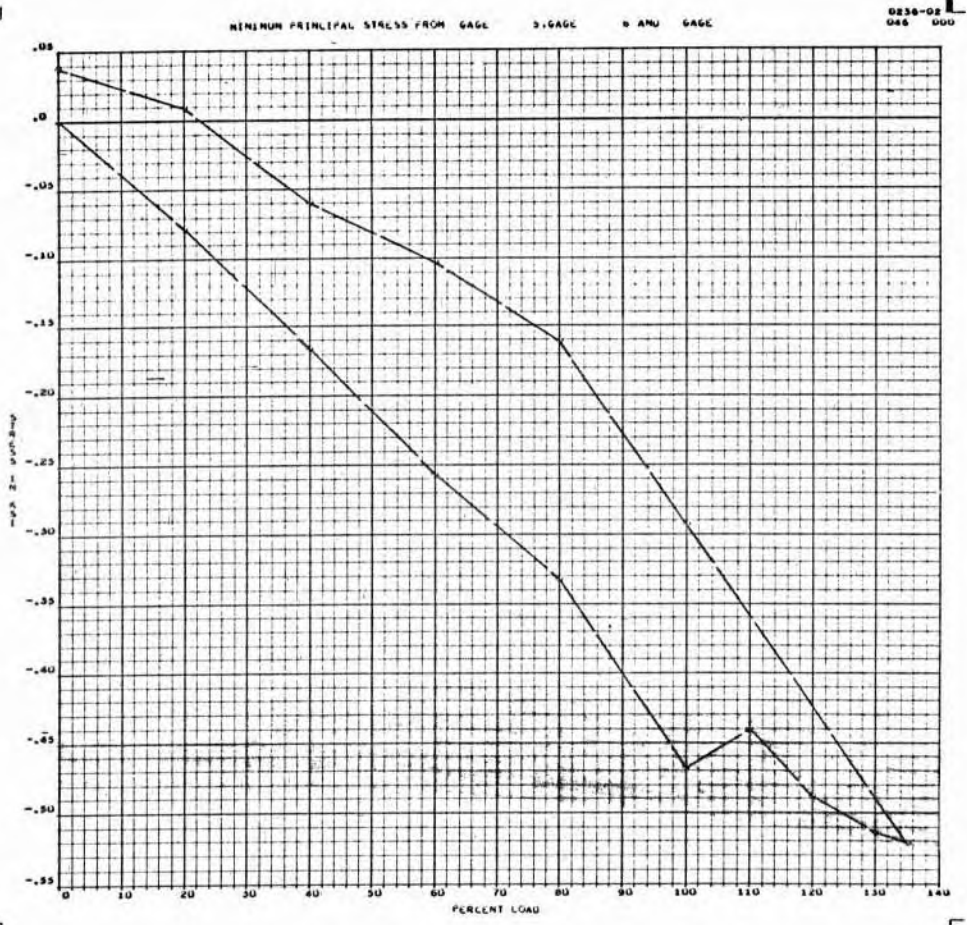


0236-02
043 000



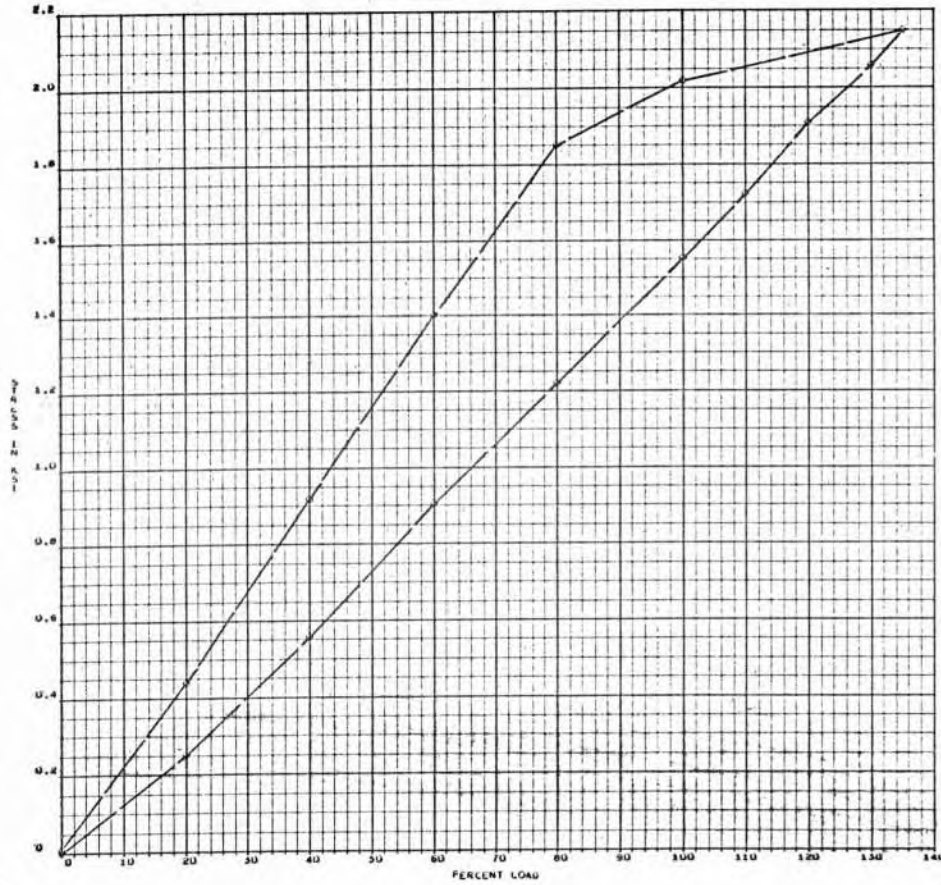
0236-02
042 000





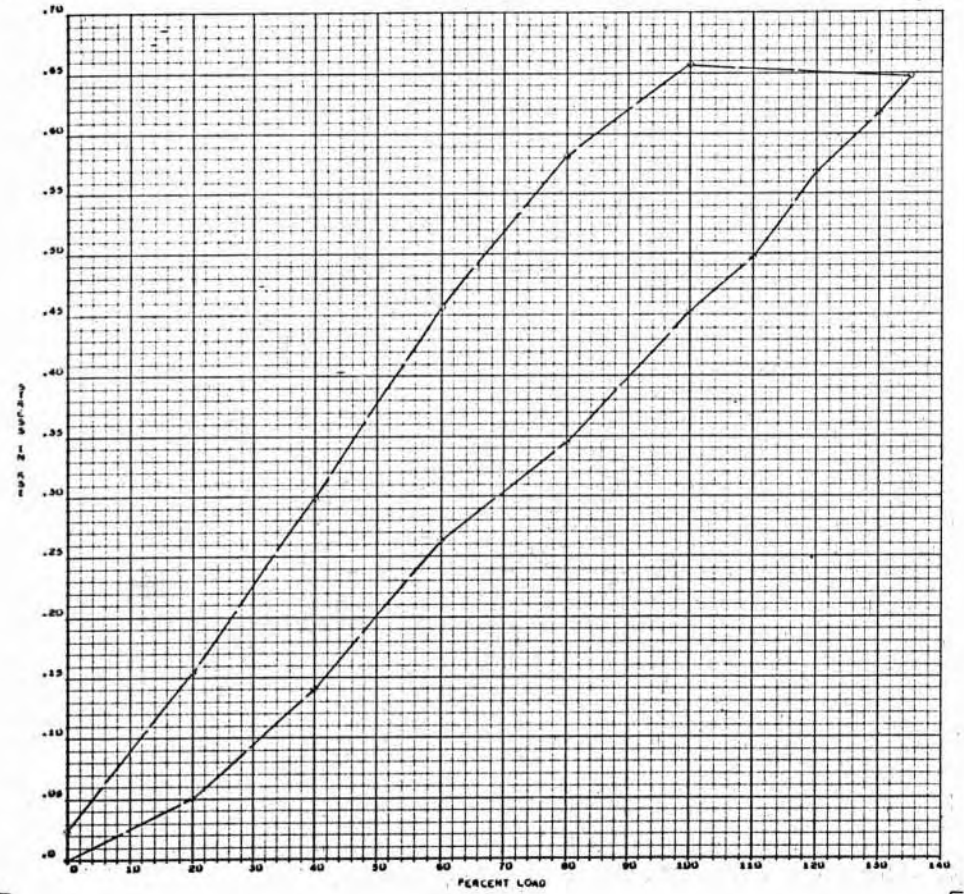
AXIAL STRESS ALONG GAGE 8 AXIS

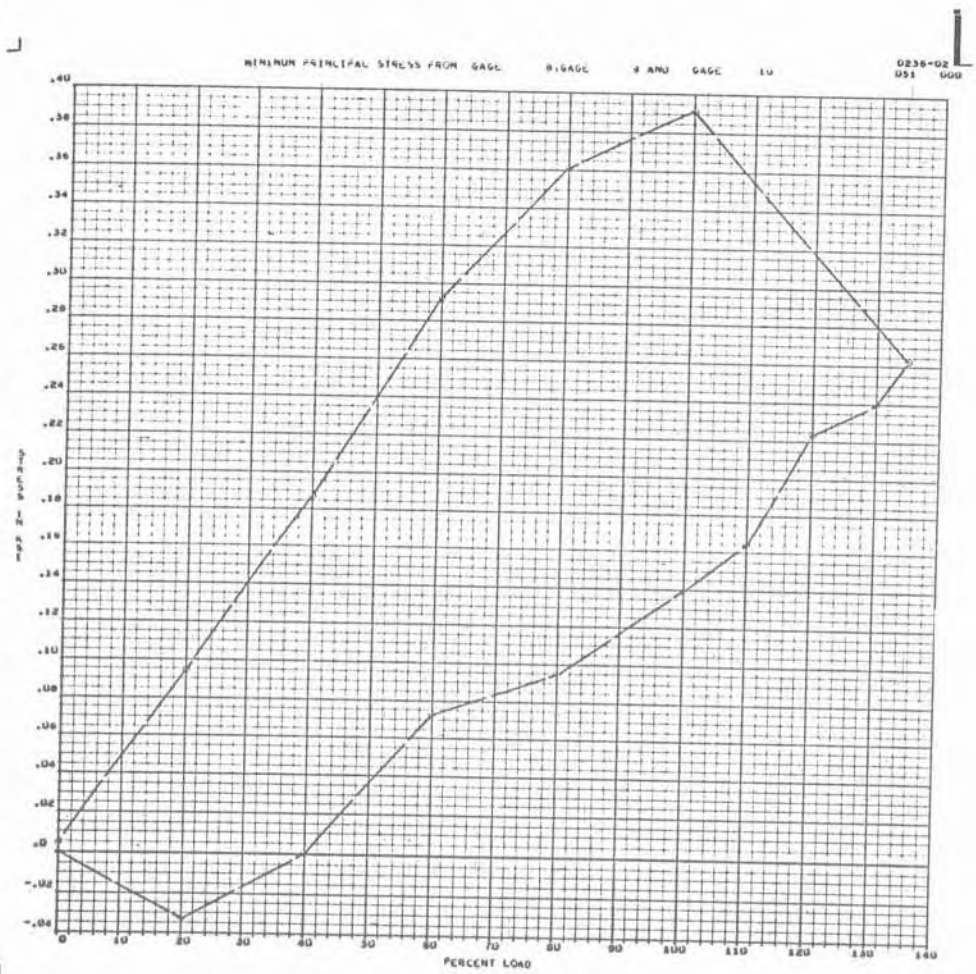
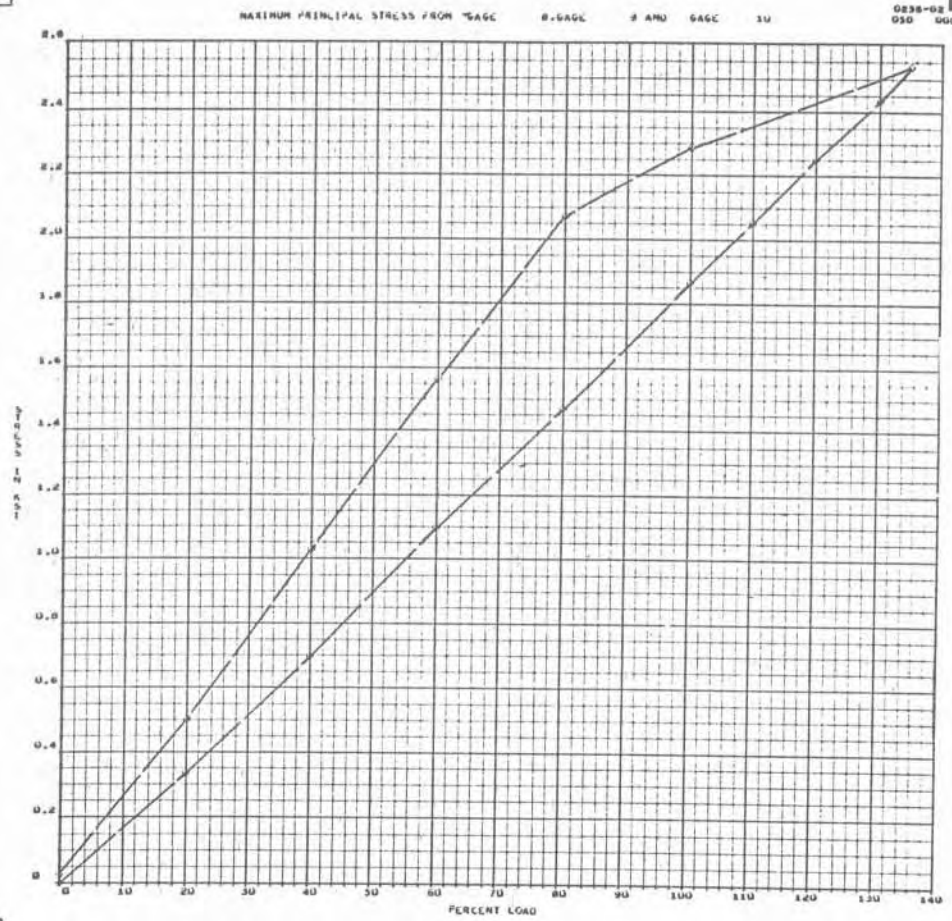
0236-02
048 000

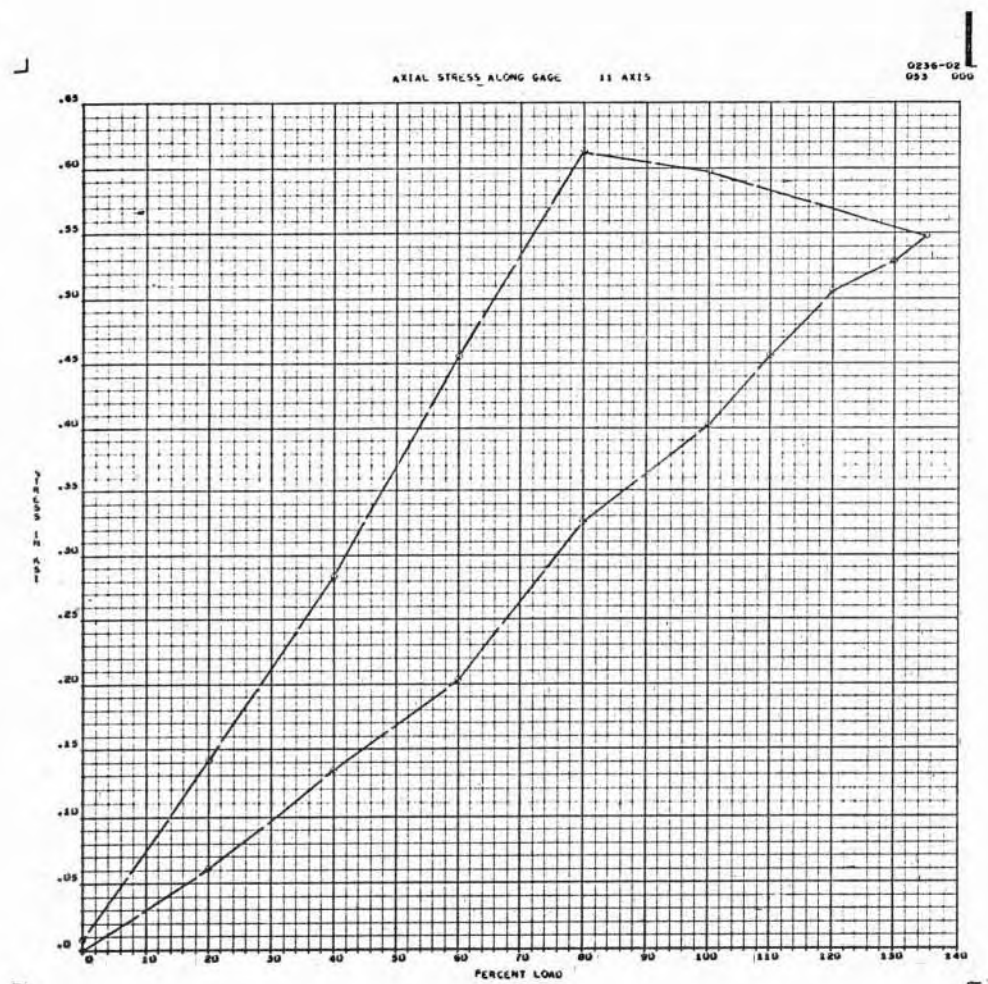
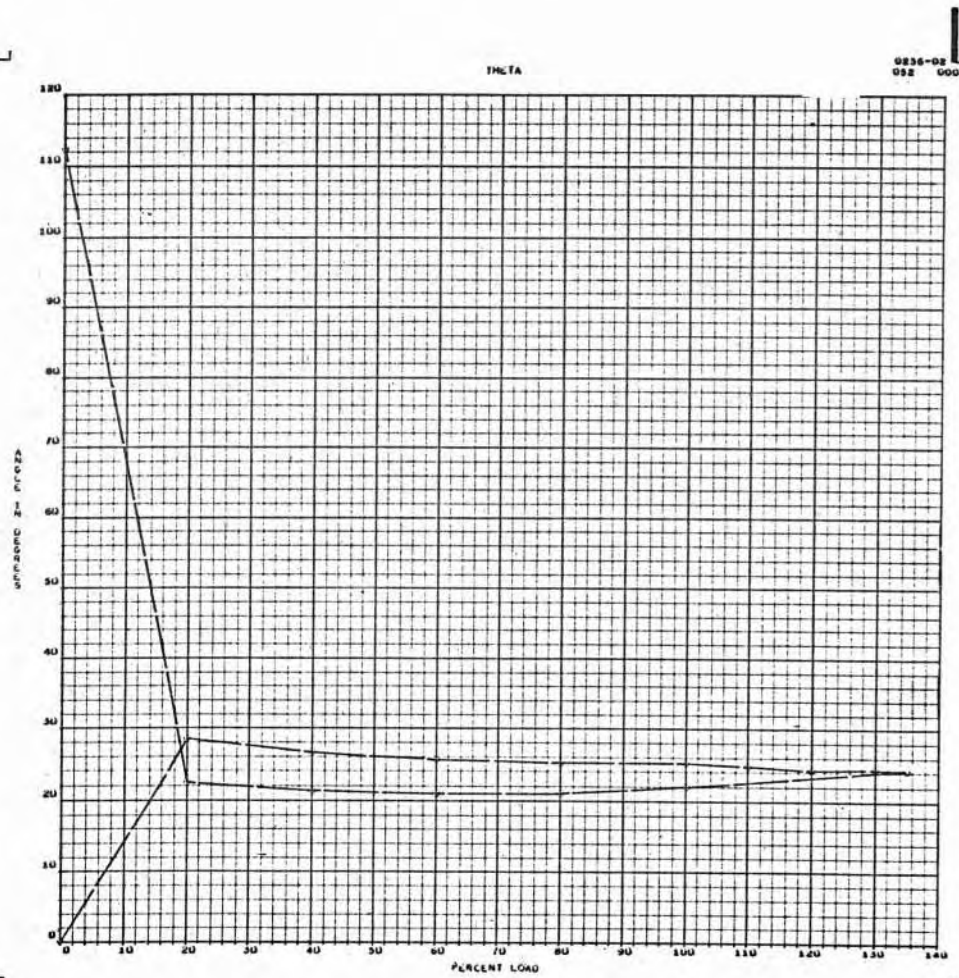


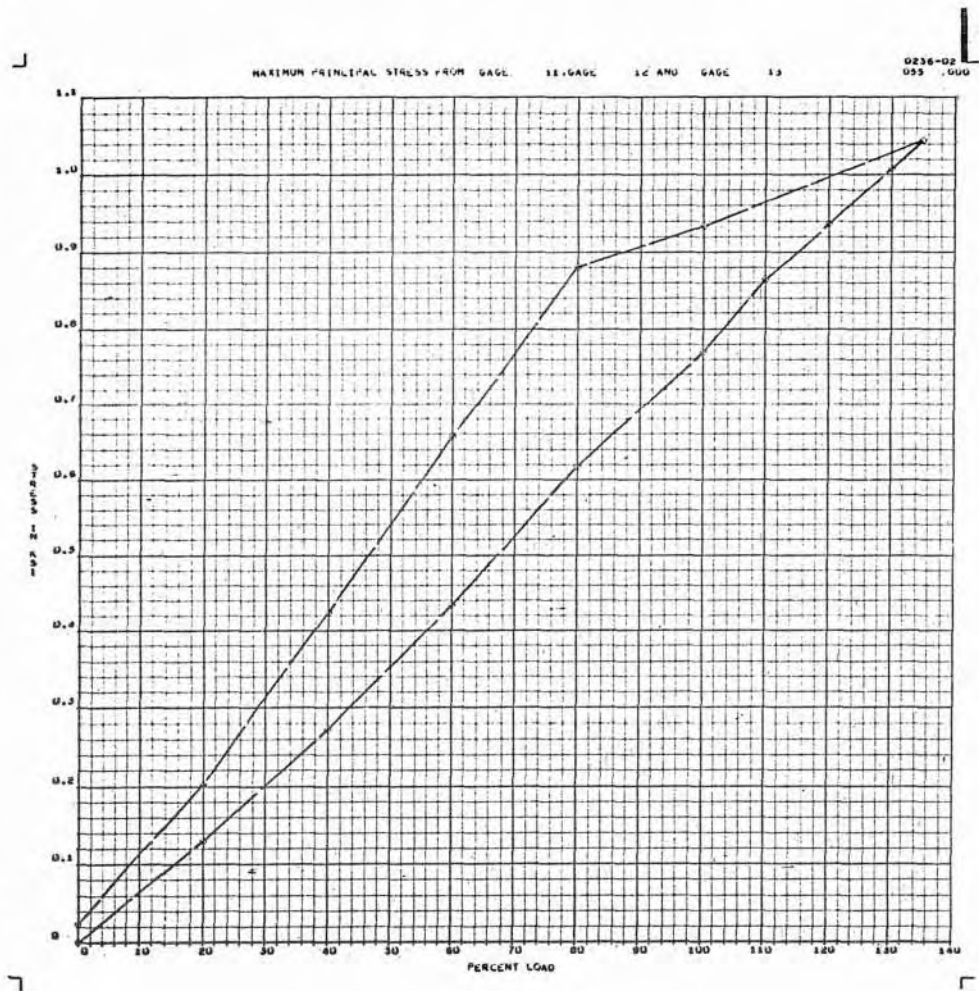
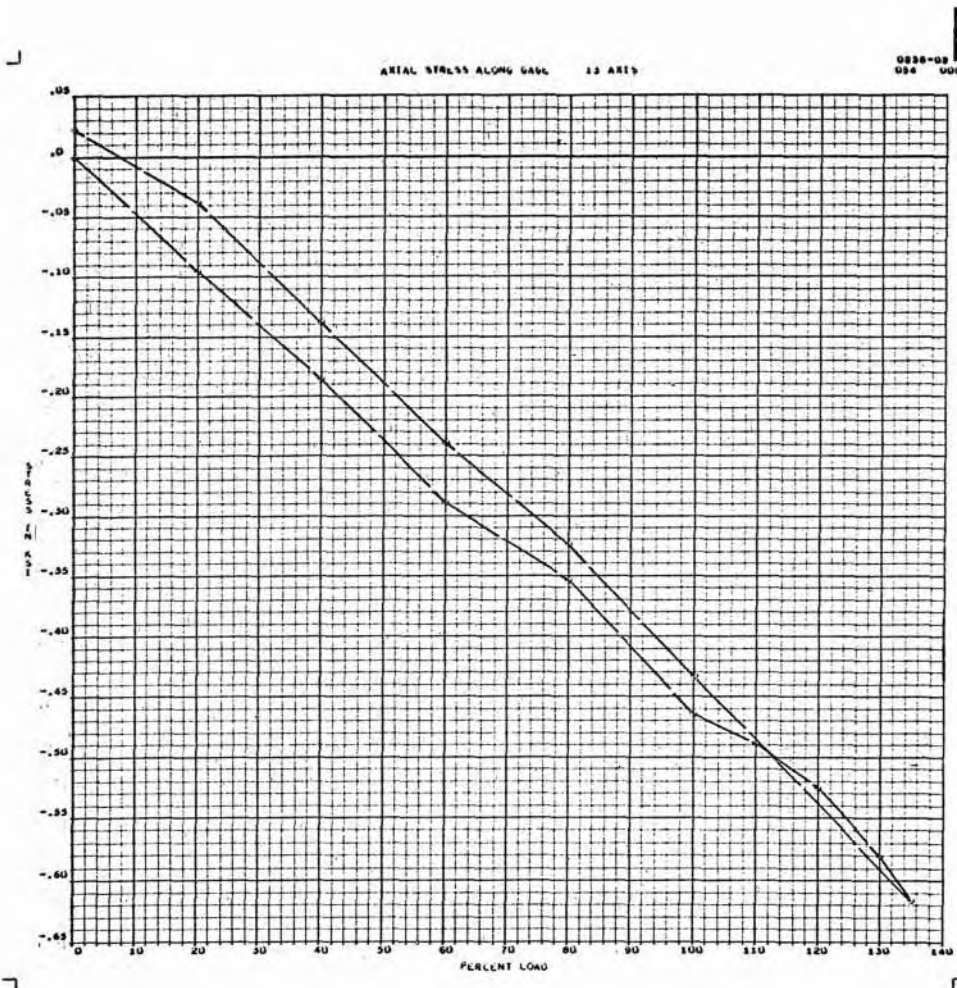
AXIAL STRESS ALONG GAGE 19 AXIS

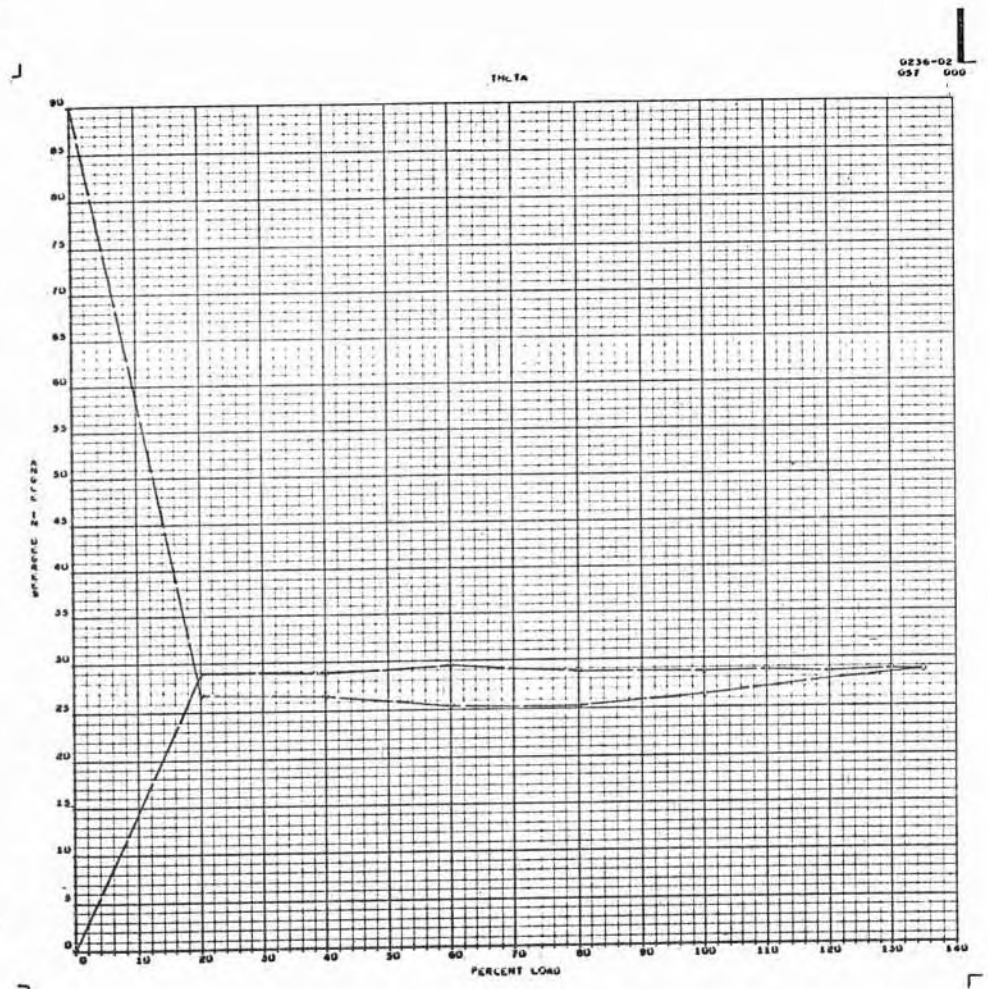
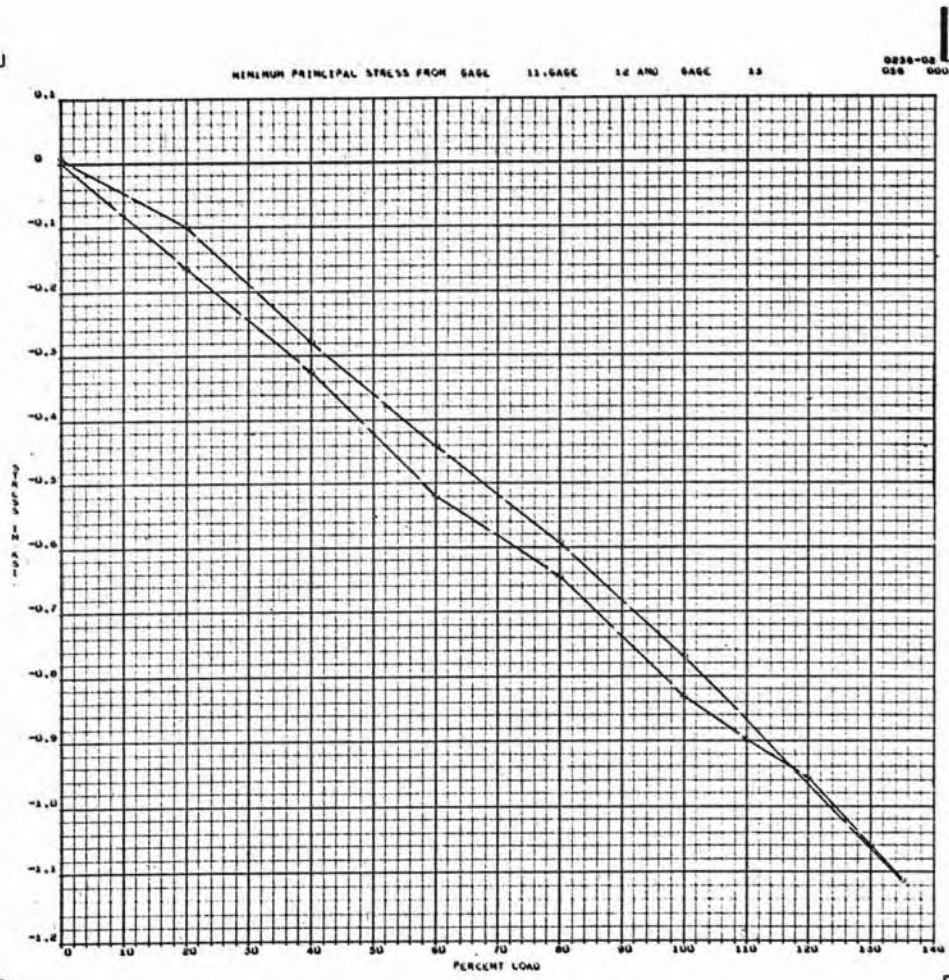
0236-02
049 000

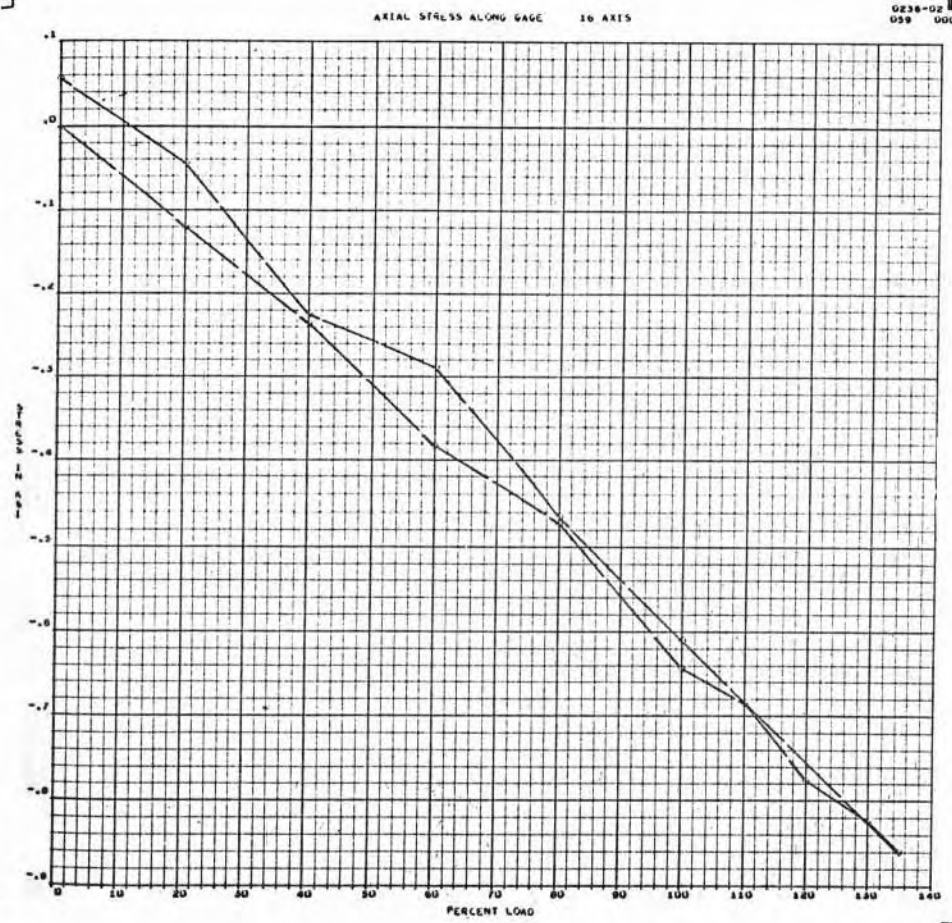
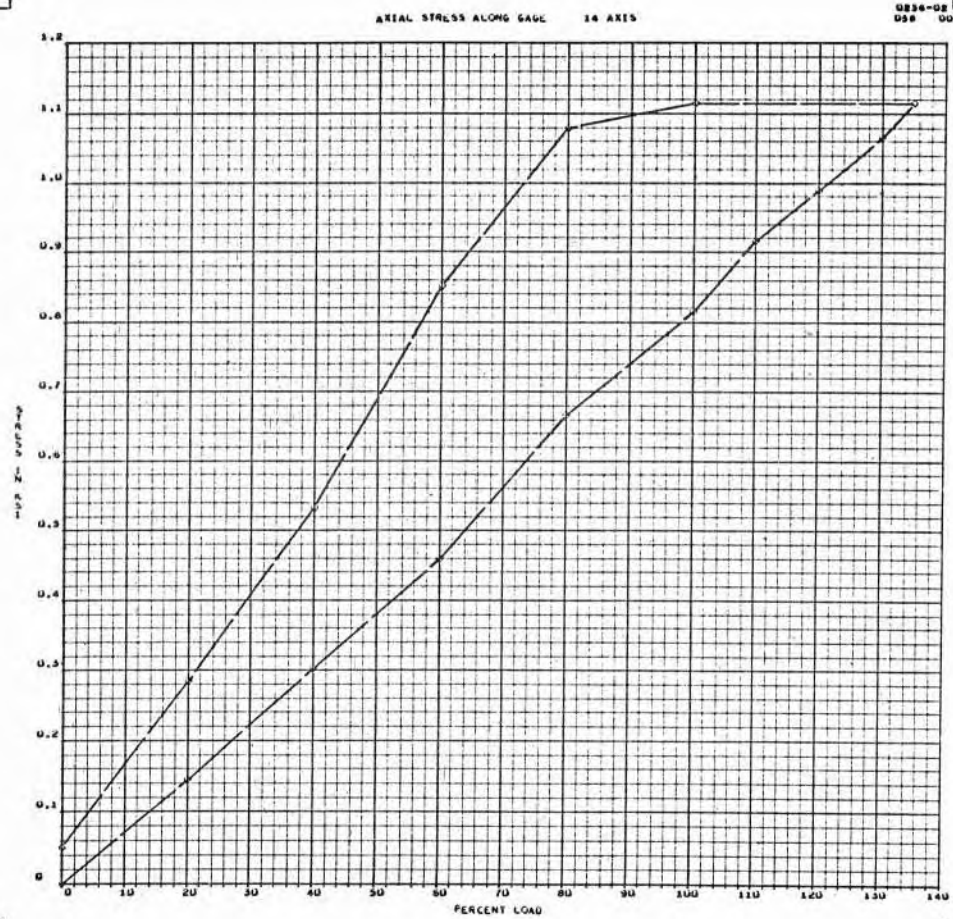


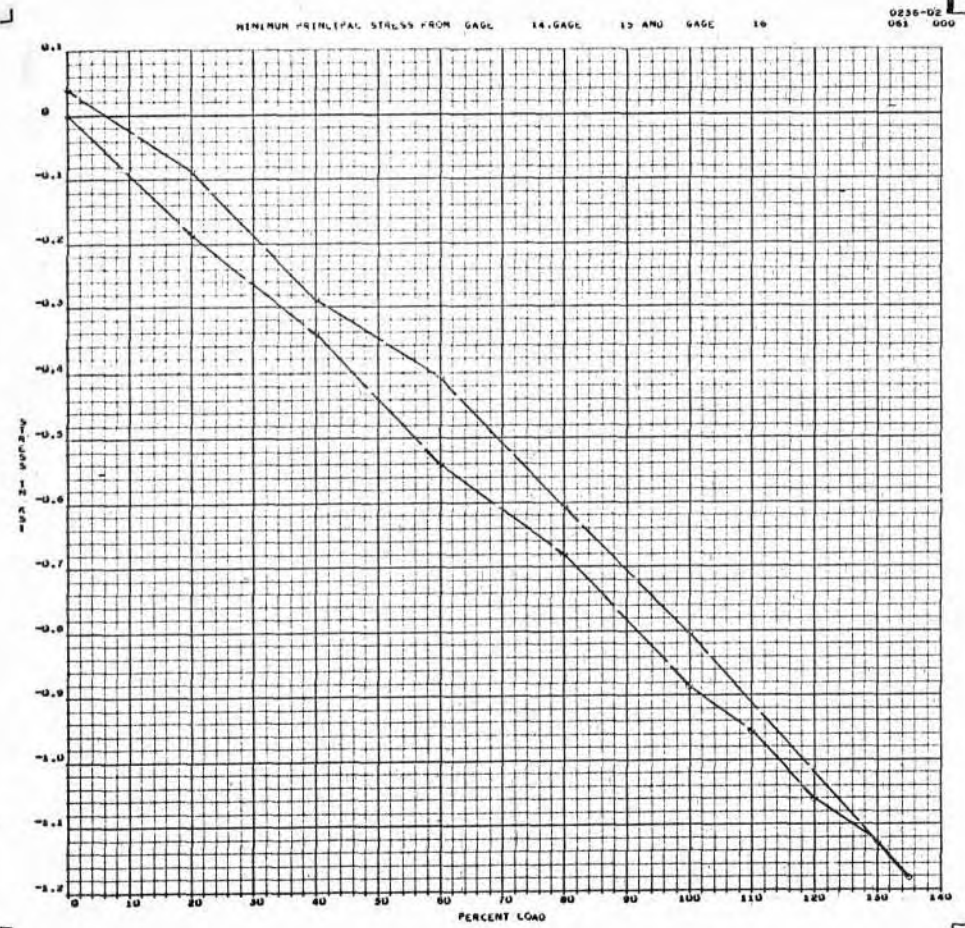
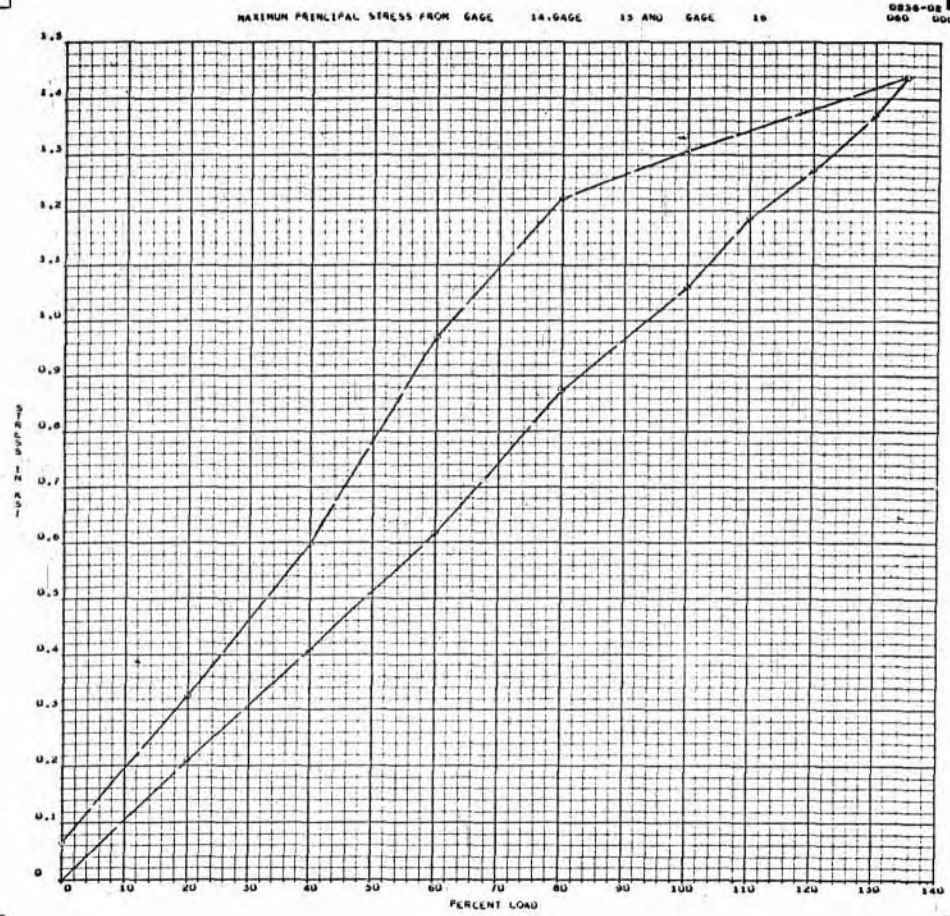


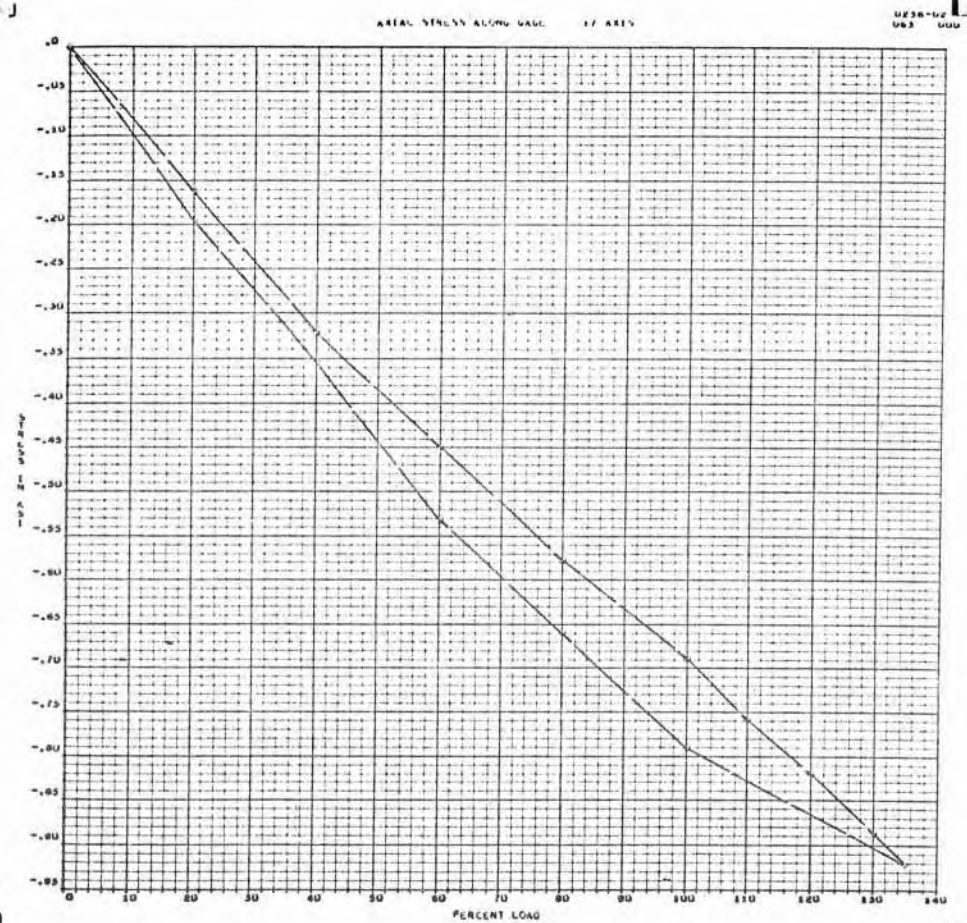
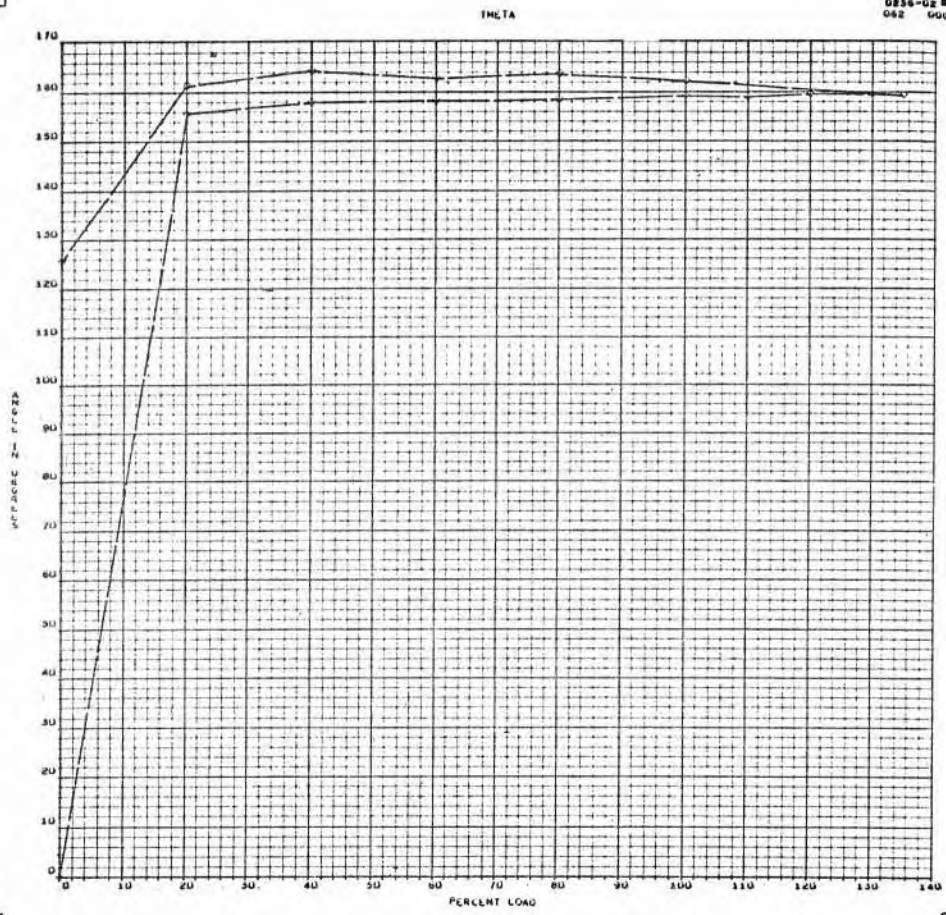






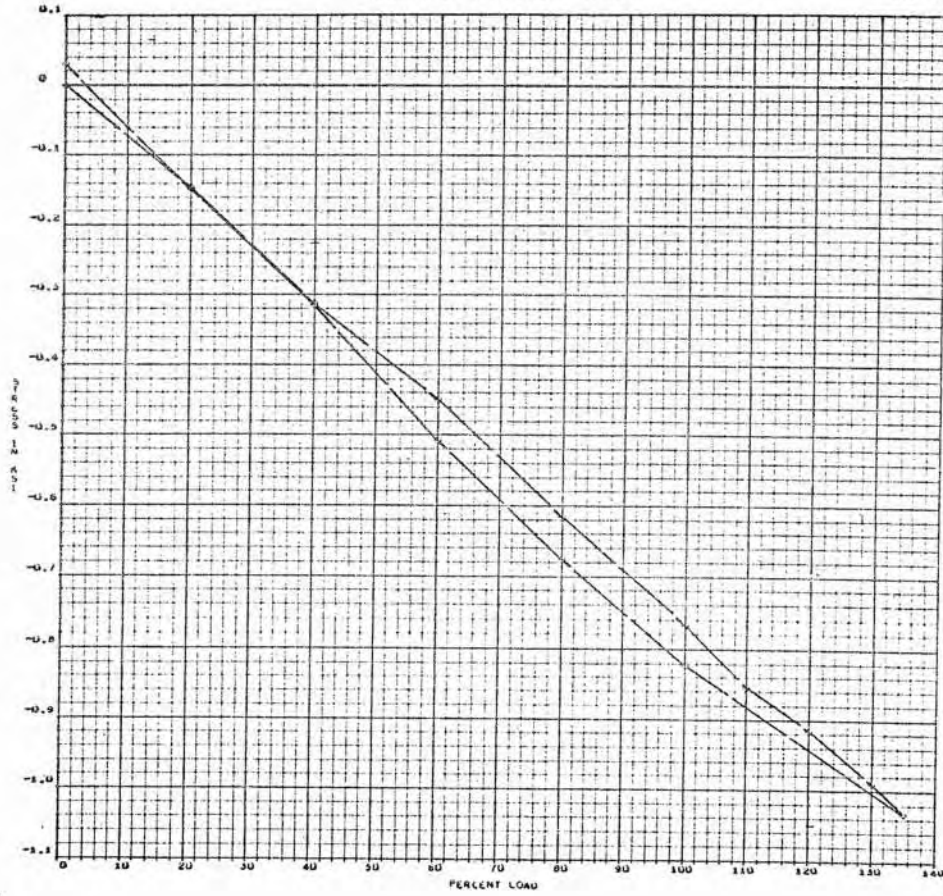






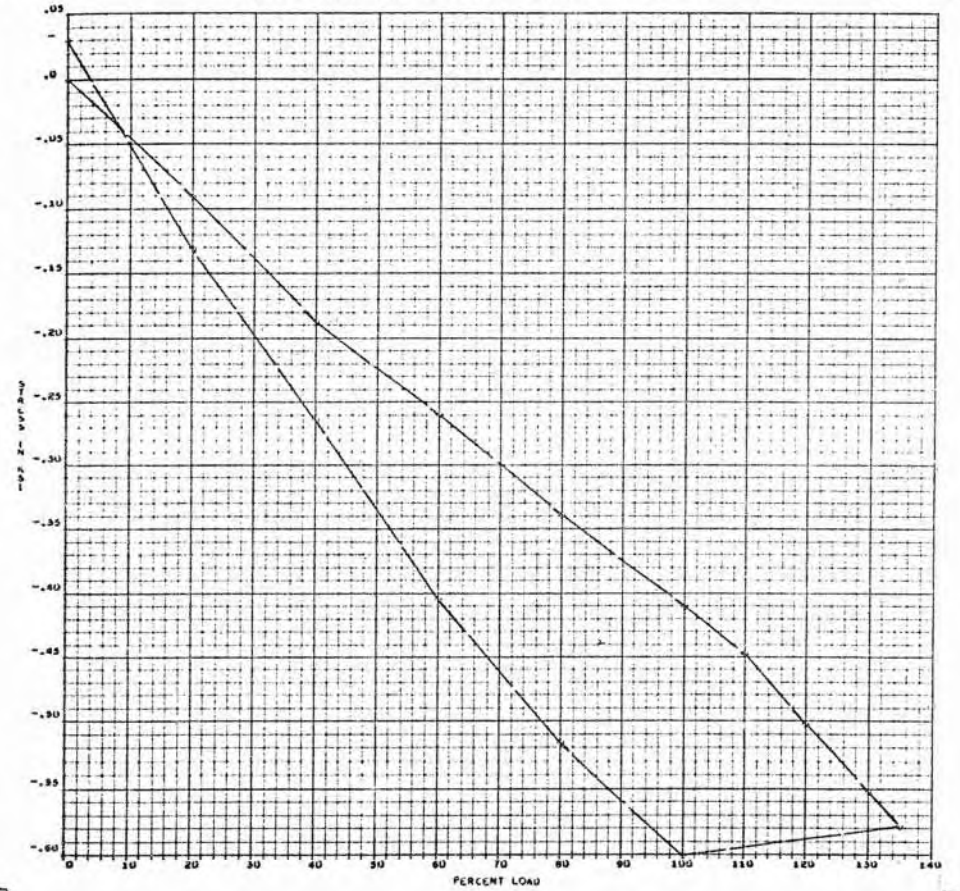
AXIAL STRESS ALONG GAGE 19 AXIS

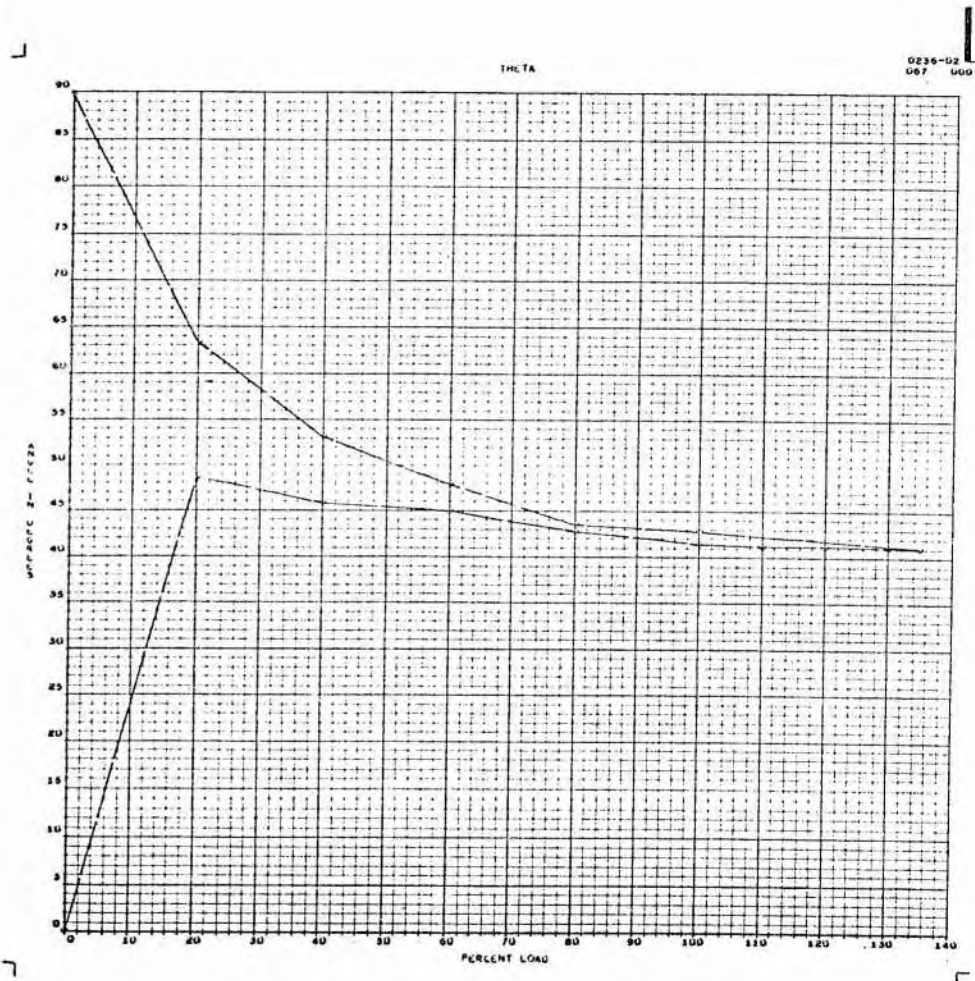
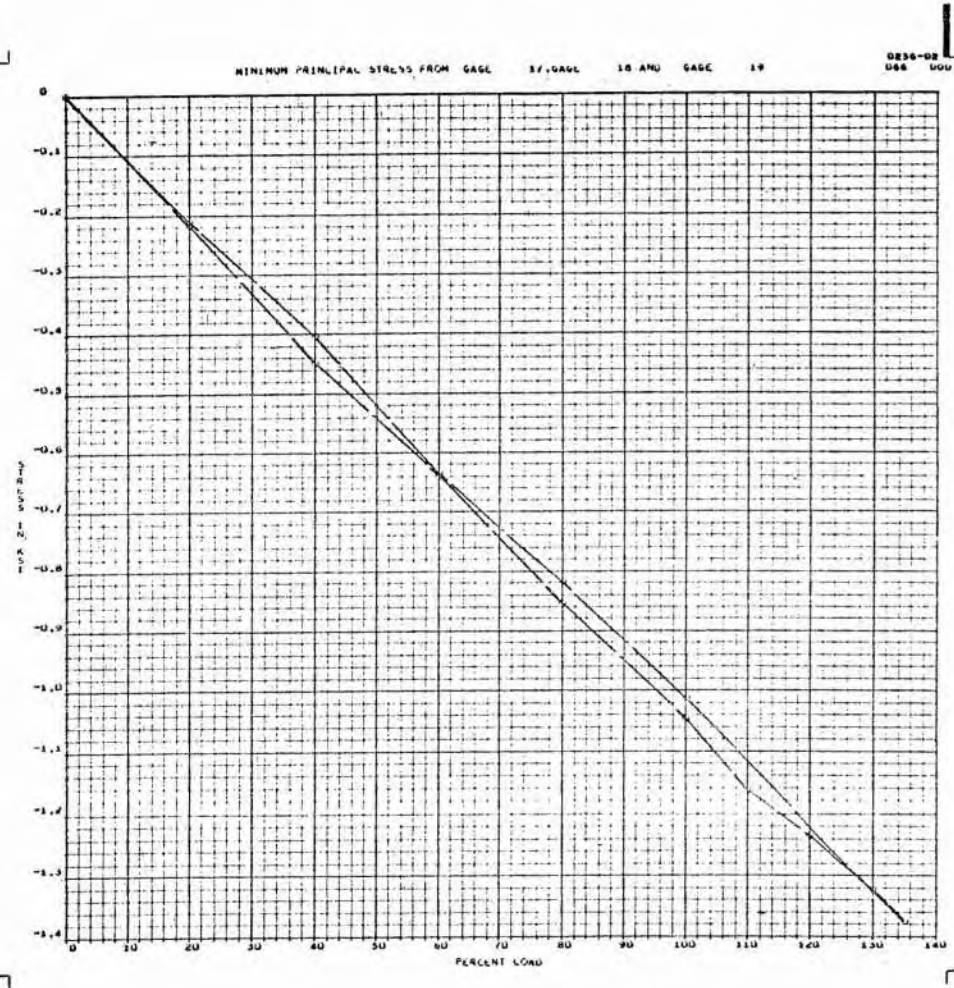
0236-02
064 UGU

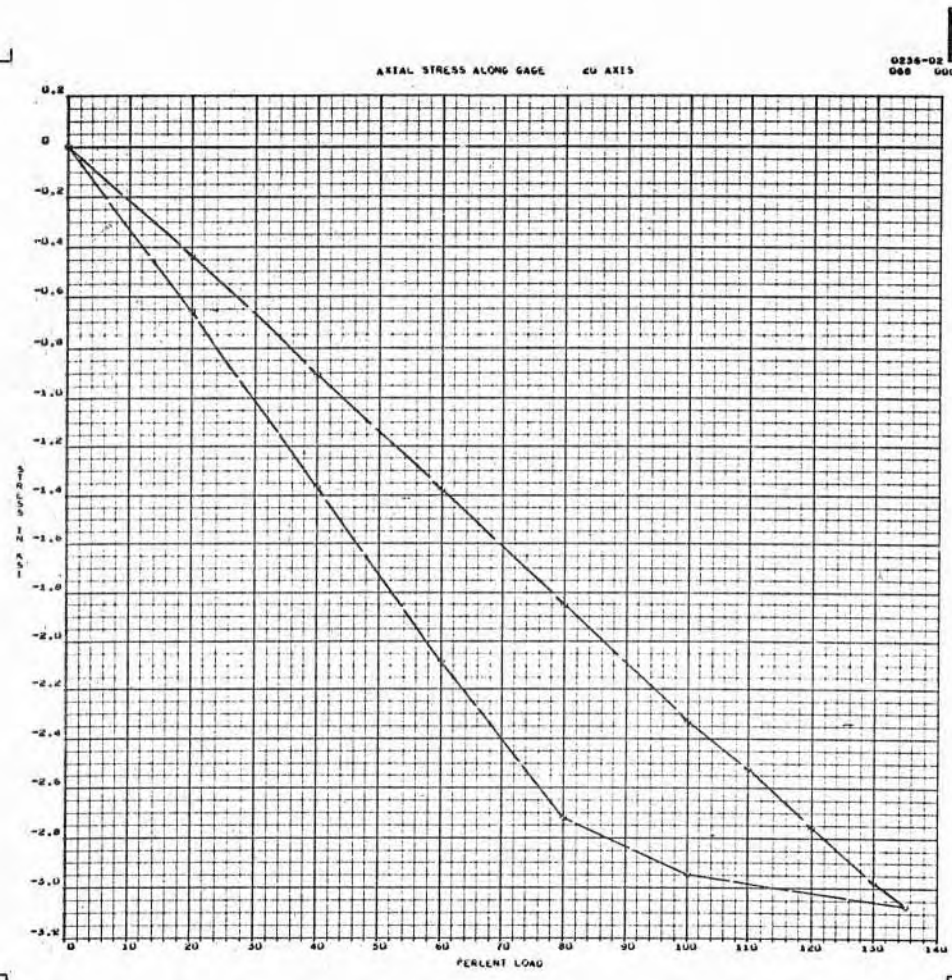


MAXIMUM PRINCIPAL STRESS FROM GAGE 17, GAGE 18 AND GAGE 19

0236-02
065 UGU

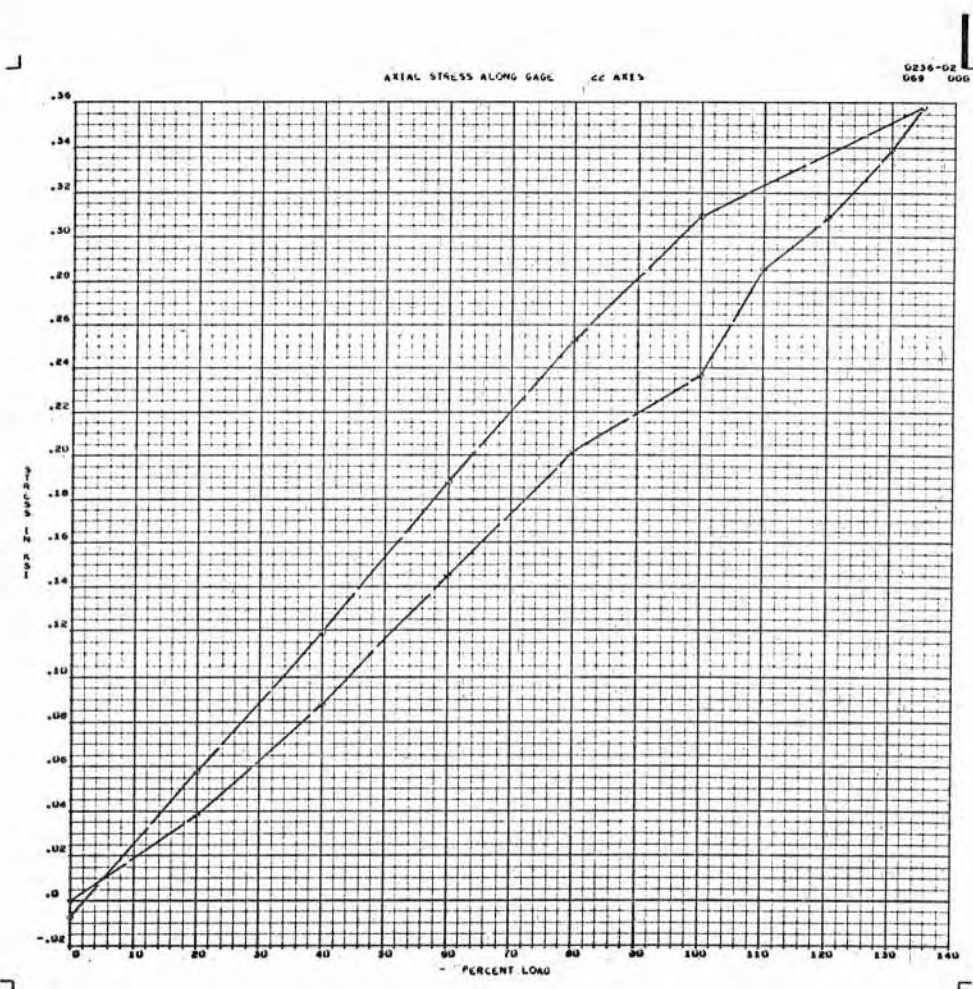






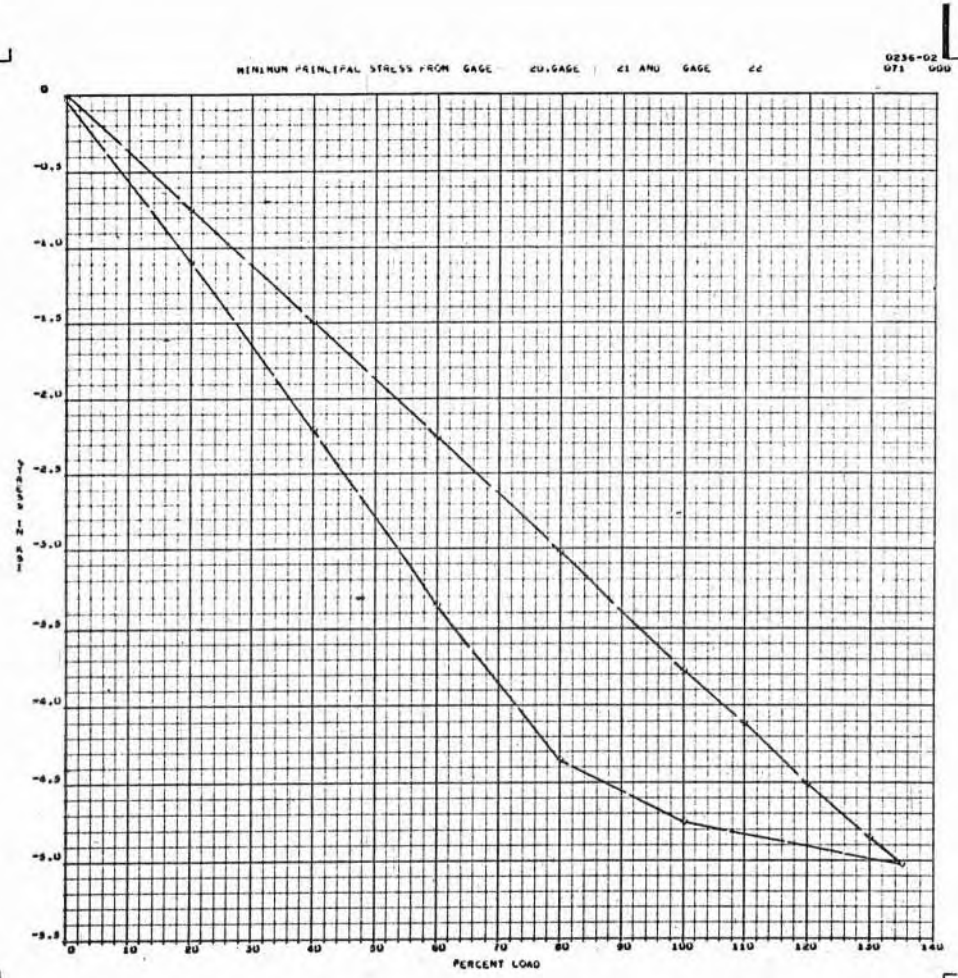
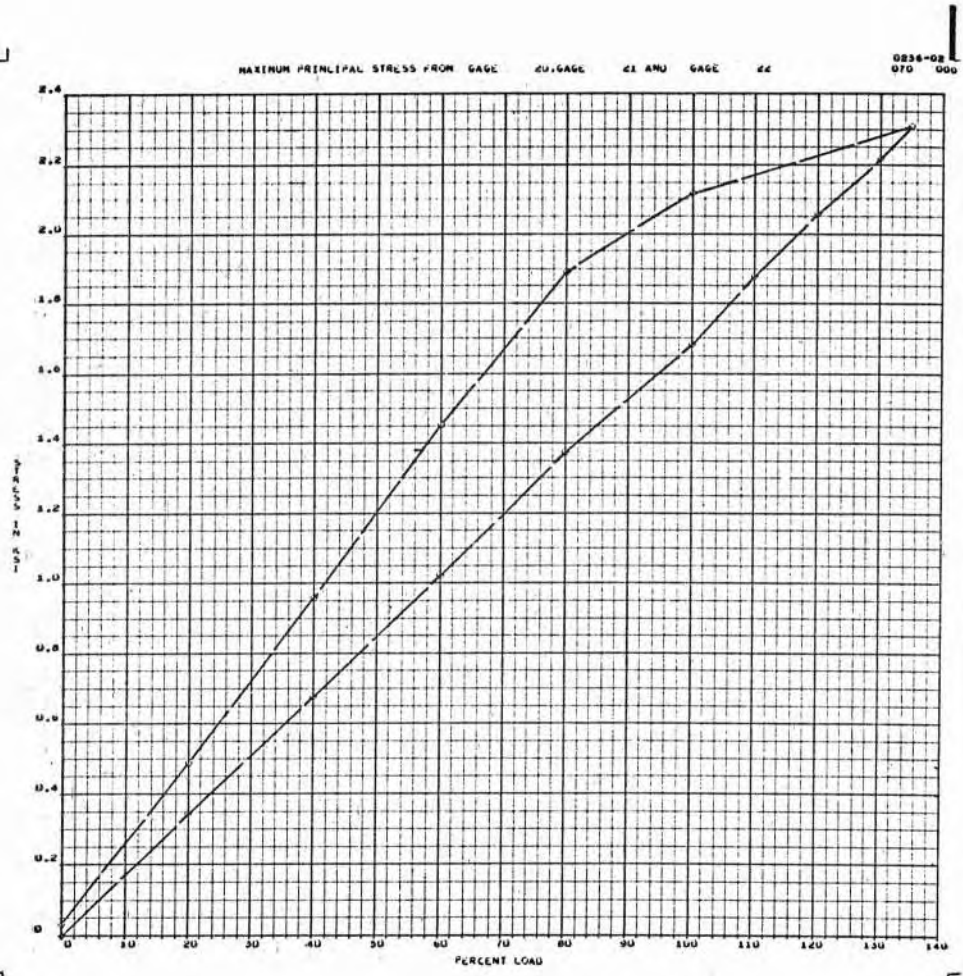
- A 72 -

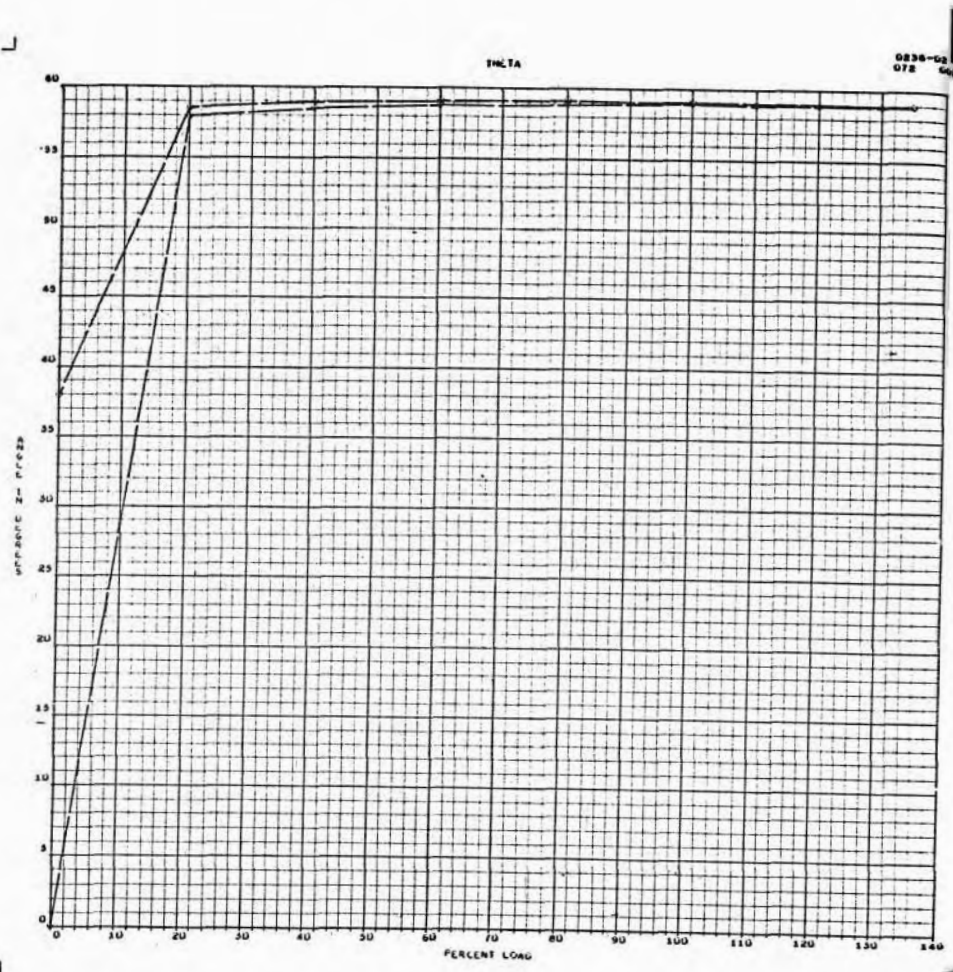
SID 67-318



- A 73 -

SID 67-318





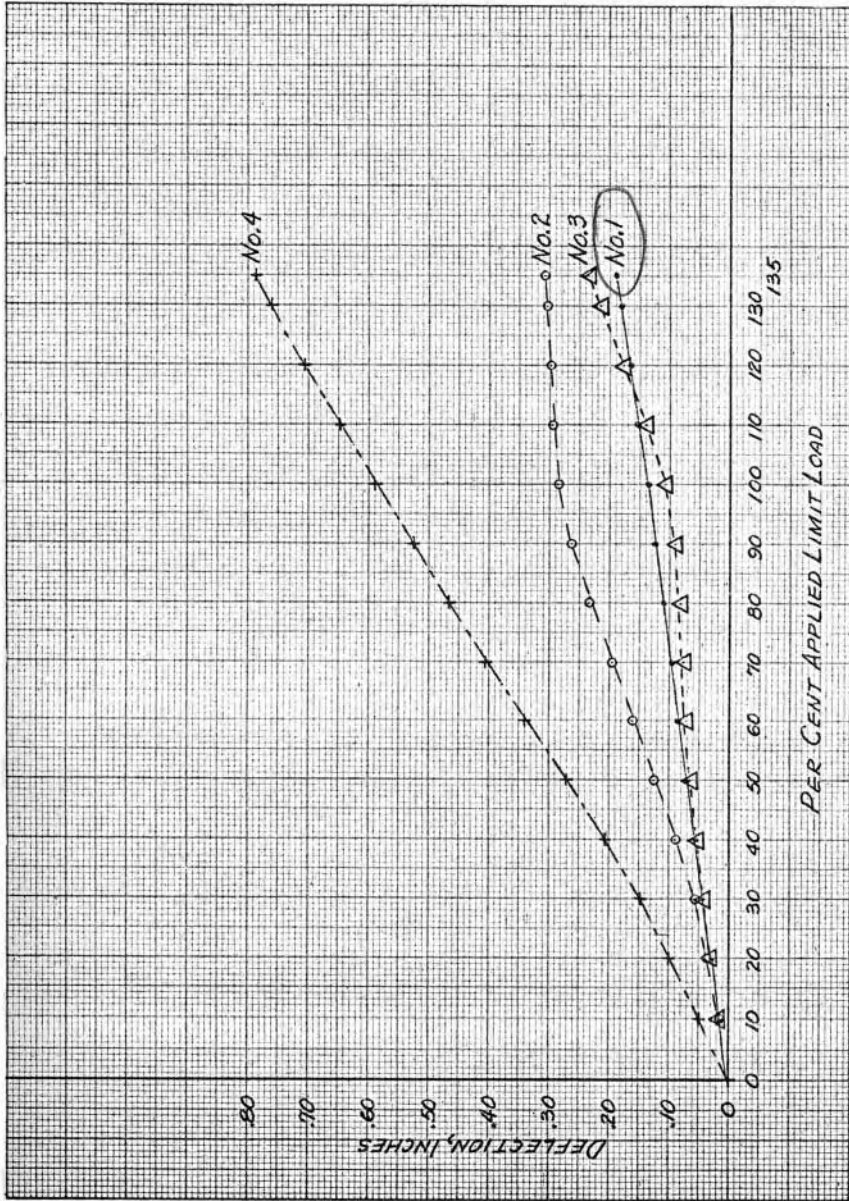
APPENDIX A

TEST CONDITION IC

SID 67-318

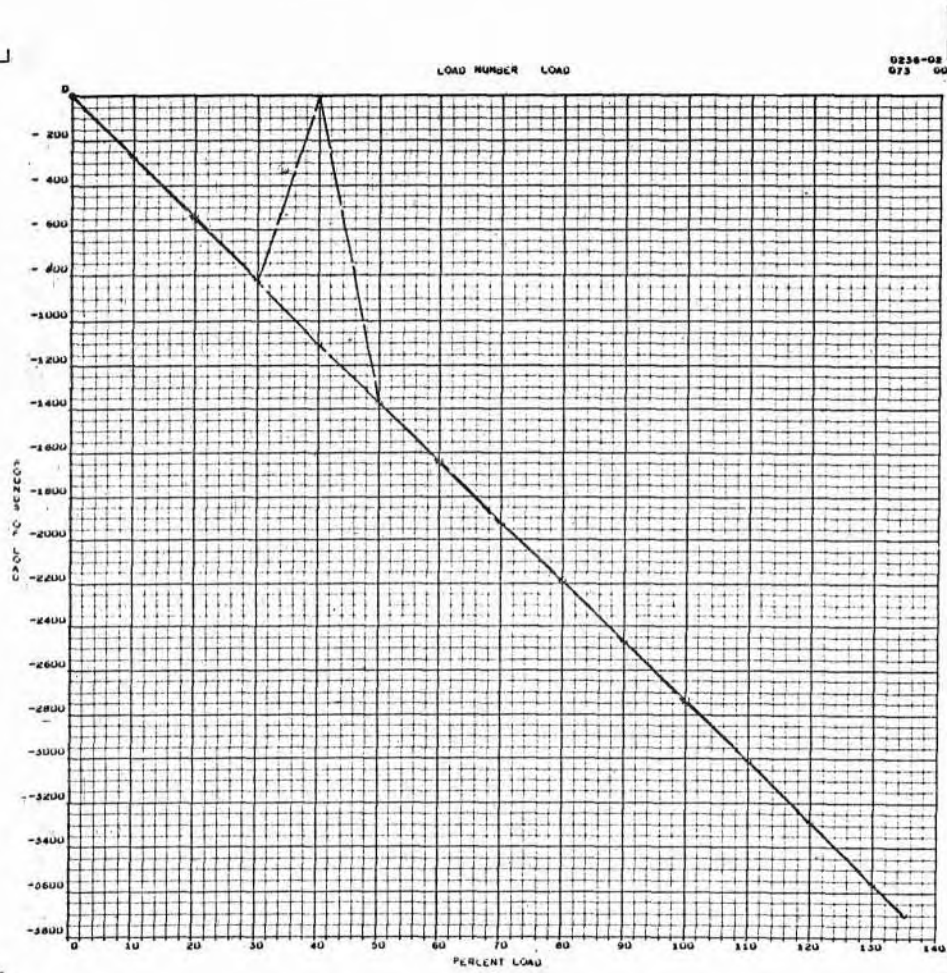
100% = 27.37

$\frac{12}{9} = 1.33$



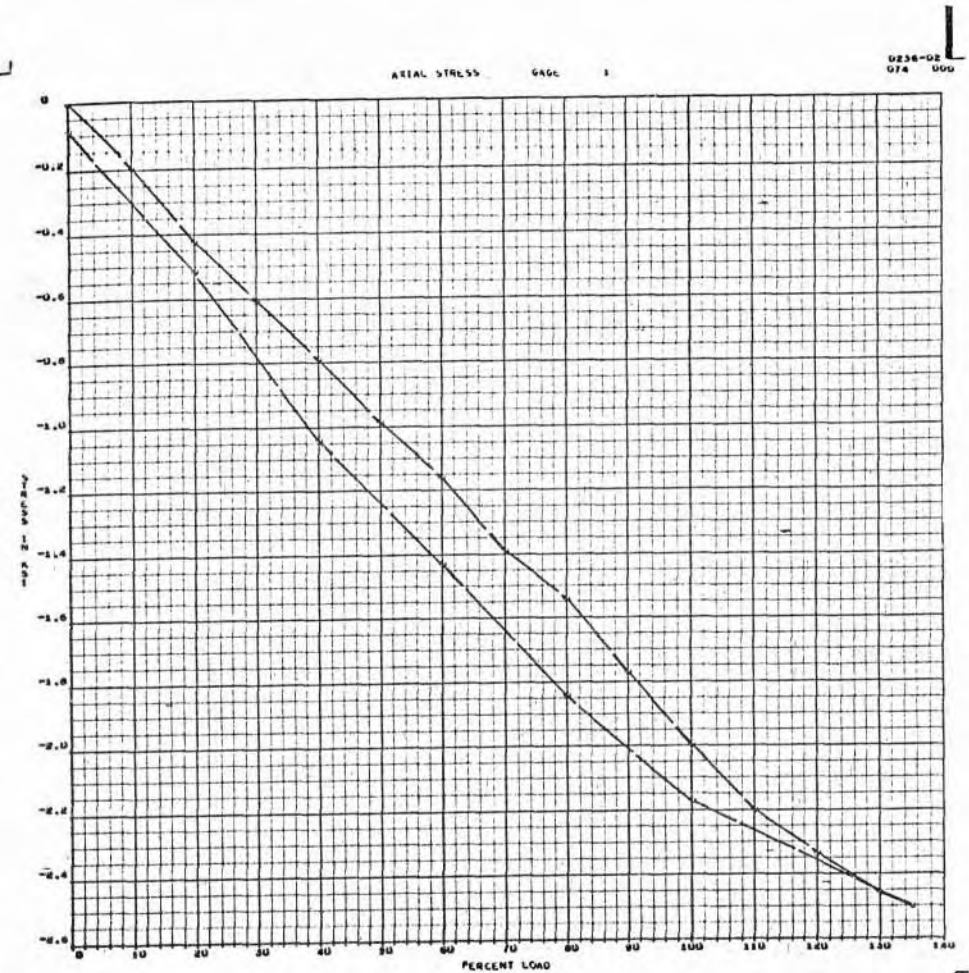
TEST CONDITION IC

T.C. IC



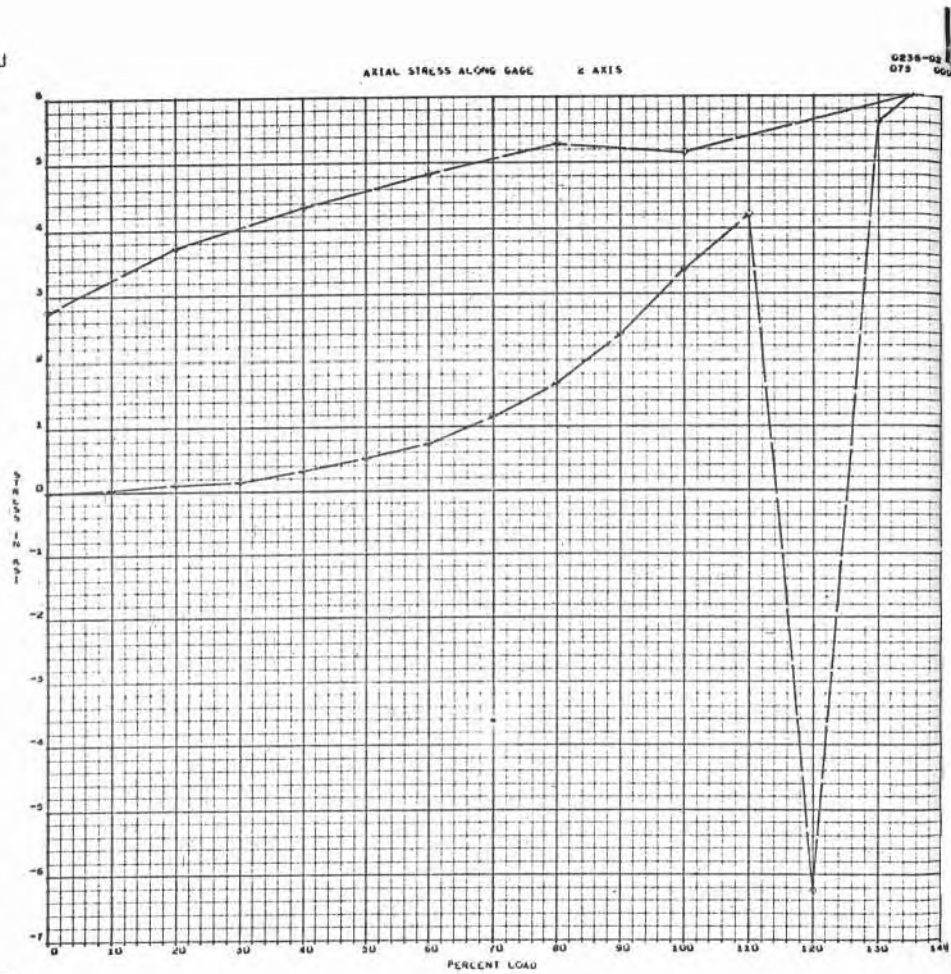
- A 78 -

SID 67-318



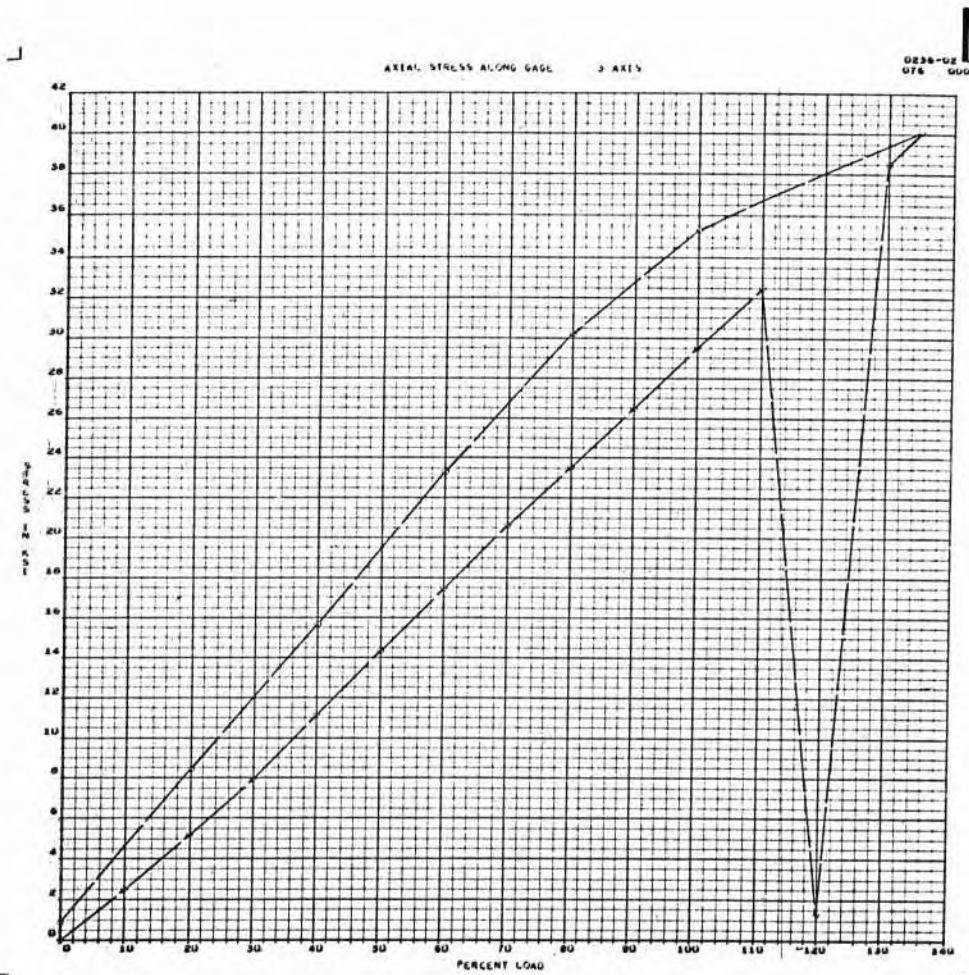
- A 79 -

SID 67-318



- A 80 -

SID 67-318

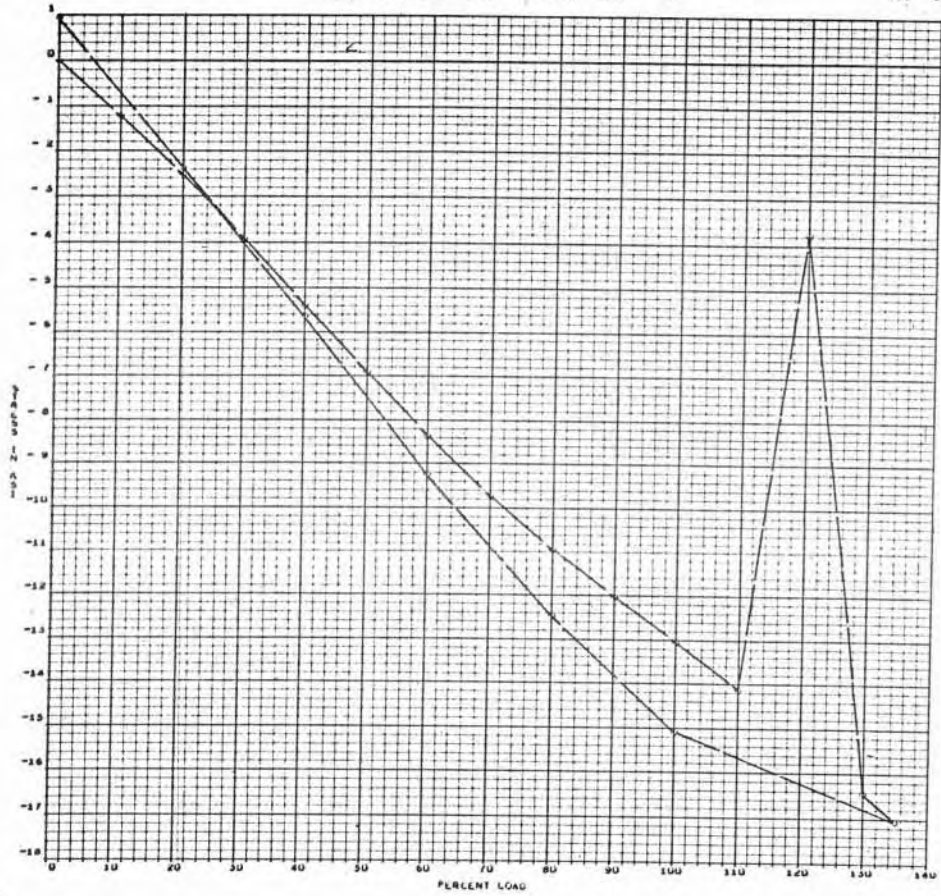


- A 81 -

SID 67-318

SHEAR STRESS FROM GAGE 2 AND GAGE 3

0238-02
077 000

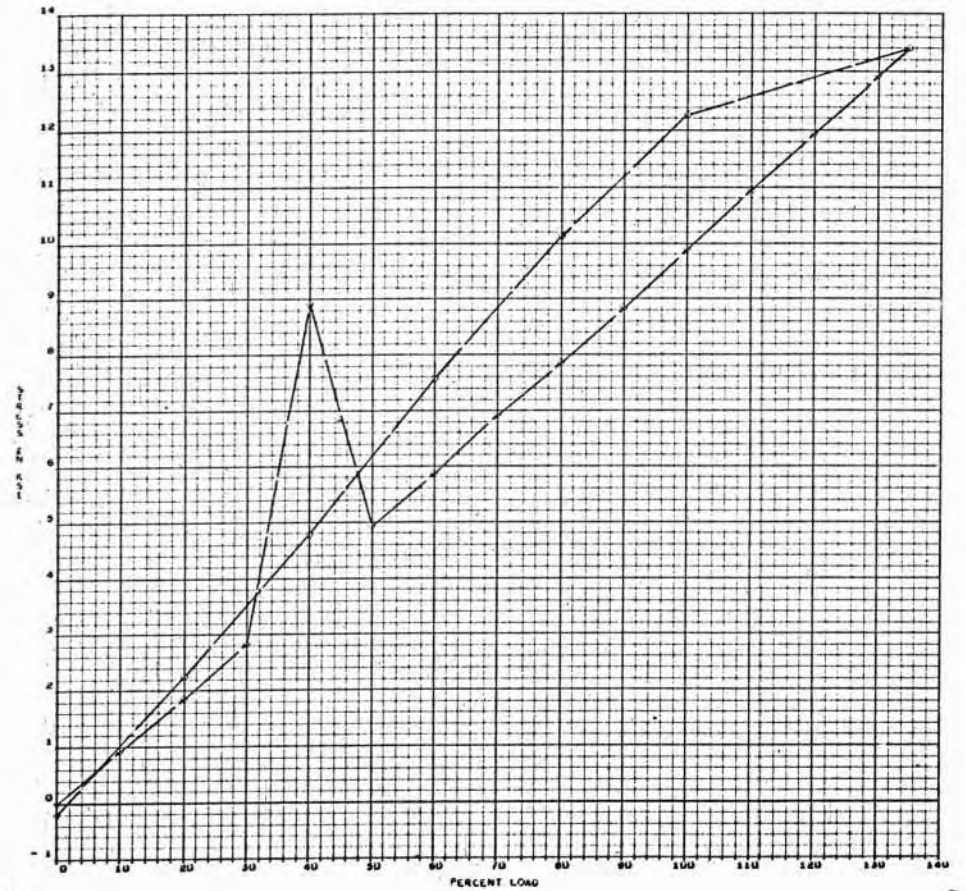


- A 82 -

SID 67-318

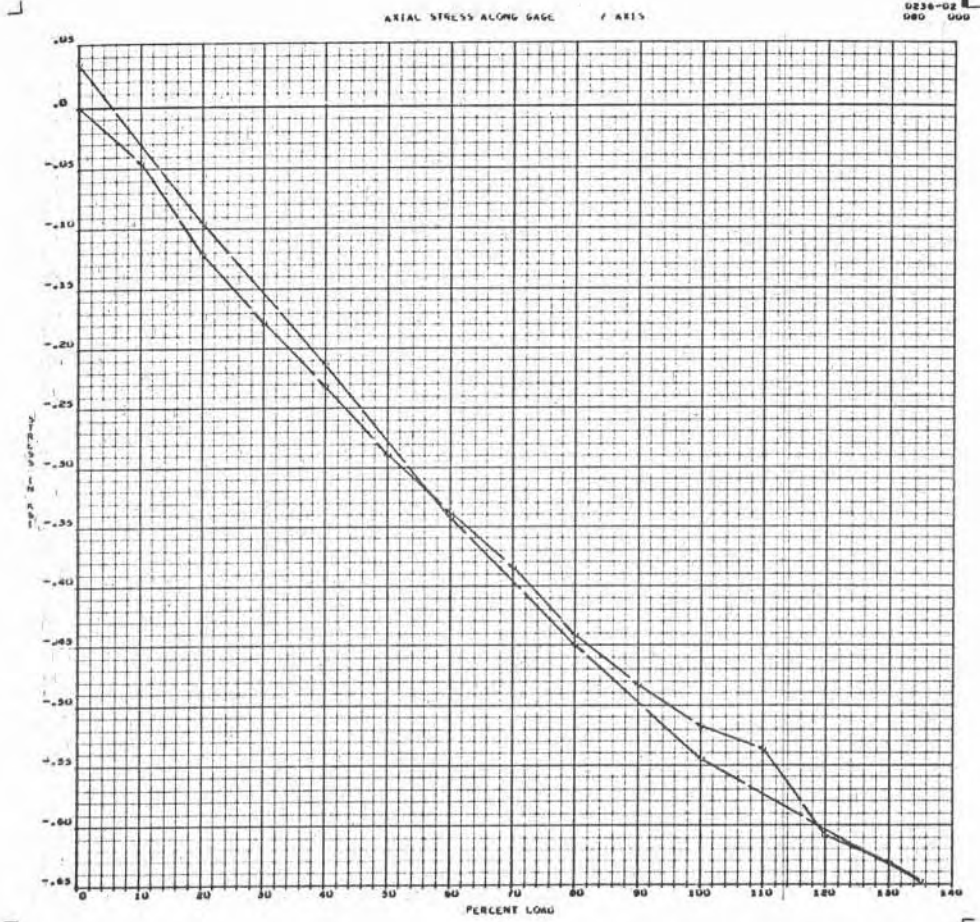
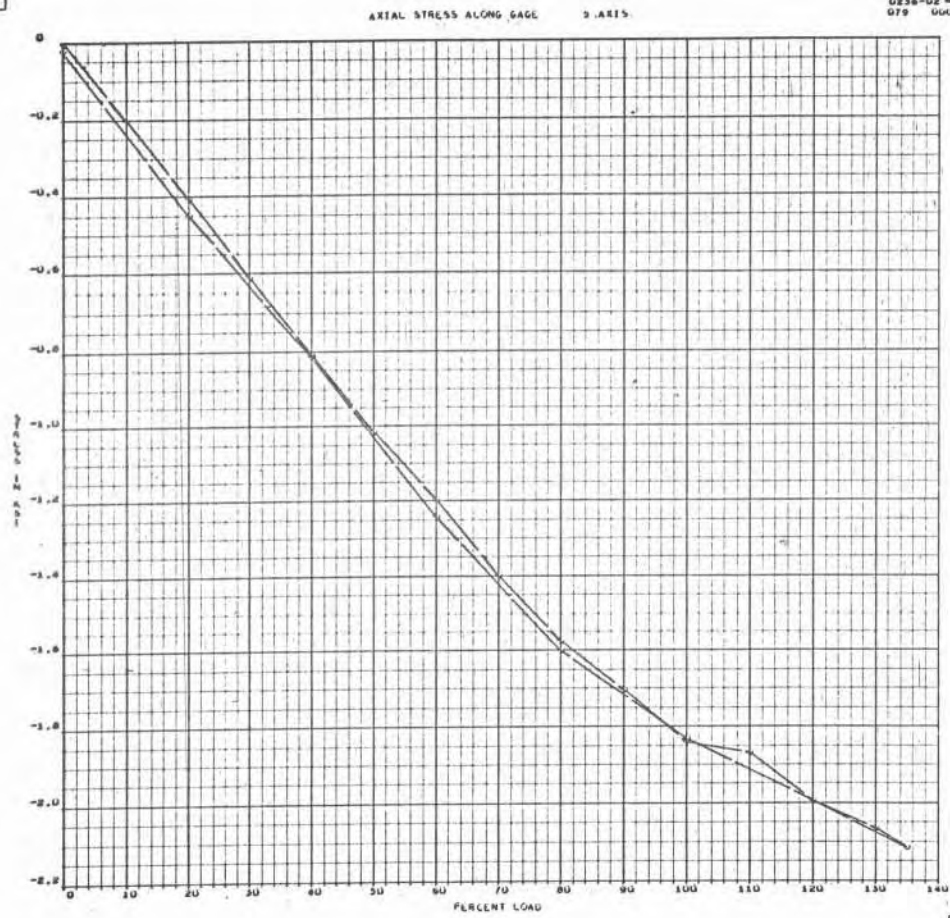
AXIAL STRESS GAGE 4

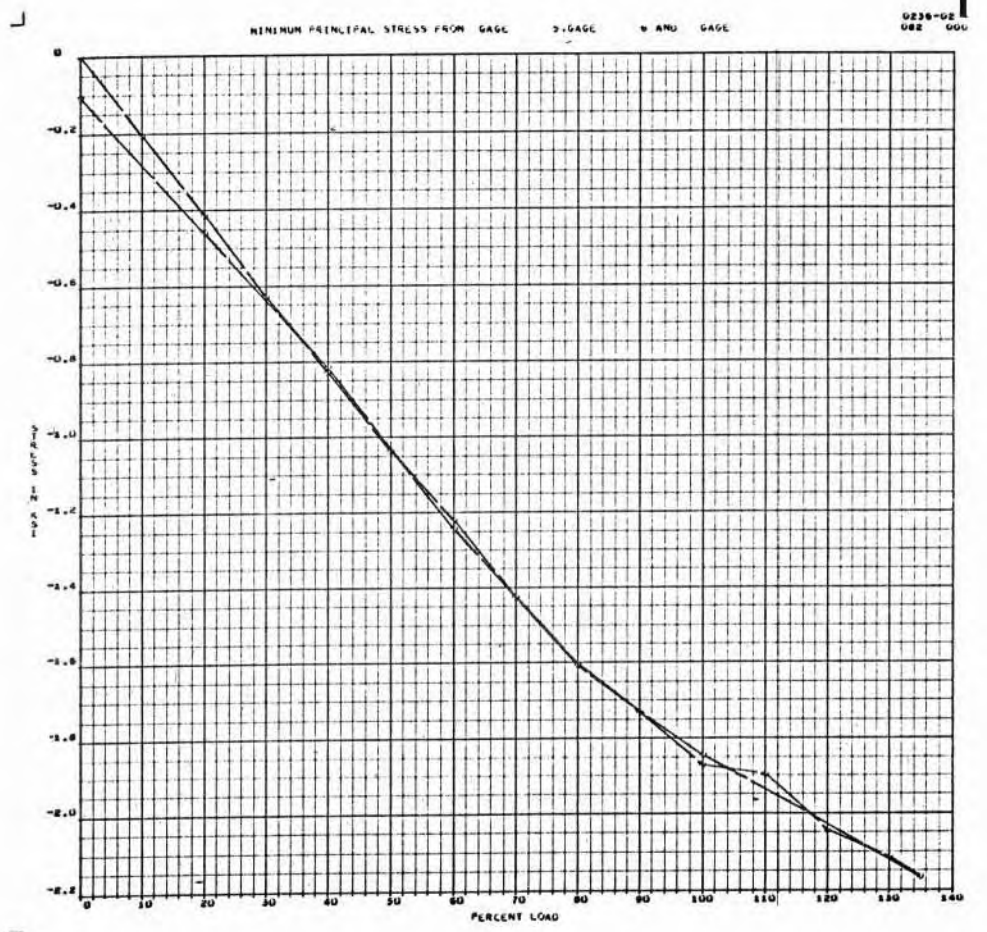
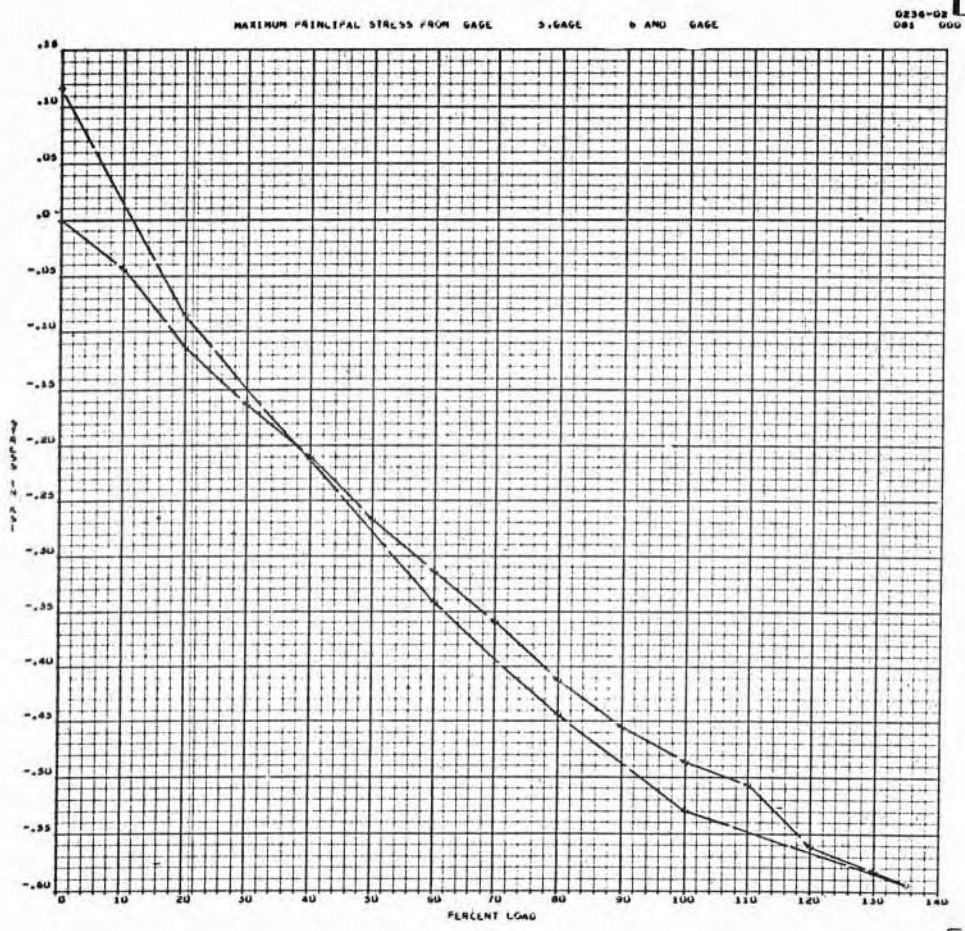
0238-02
078 000

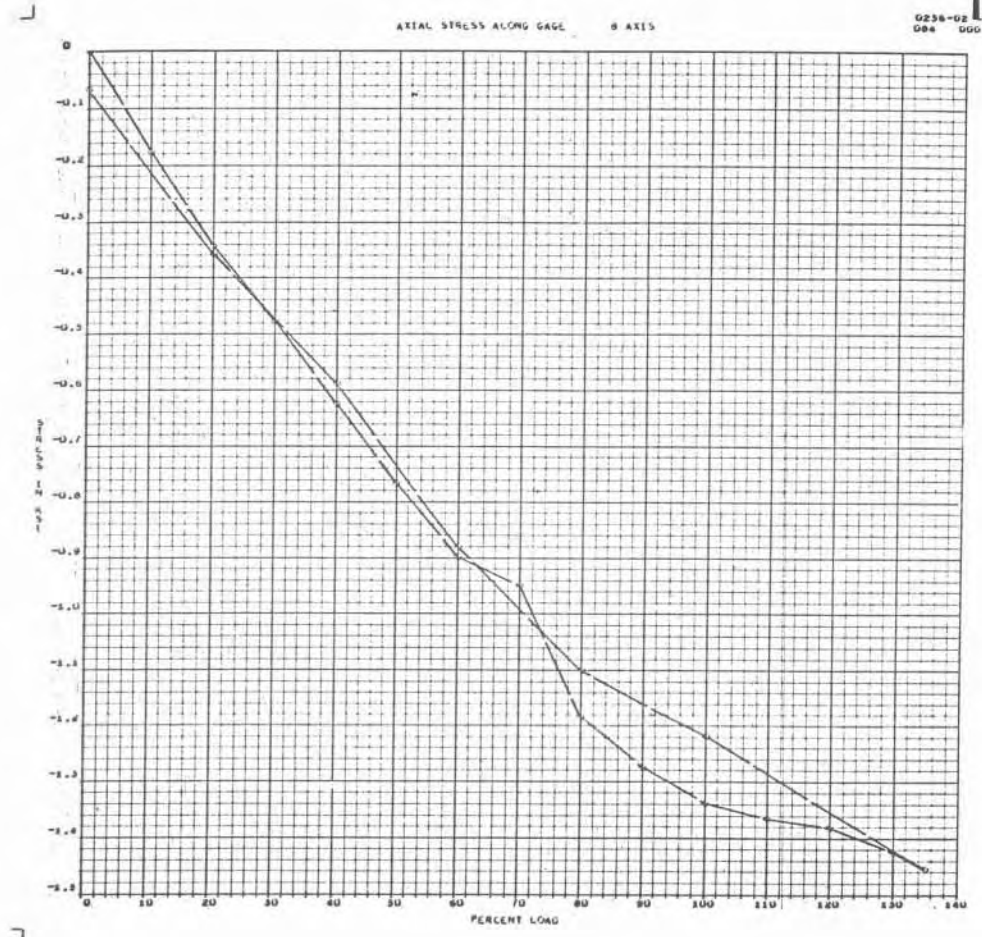
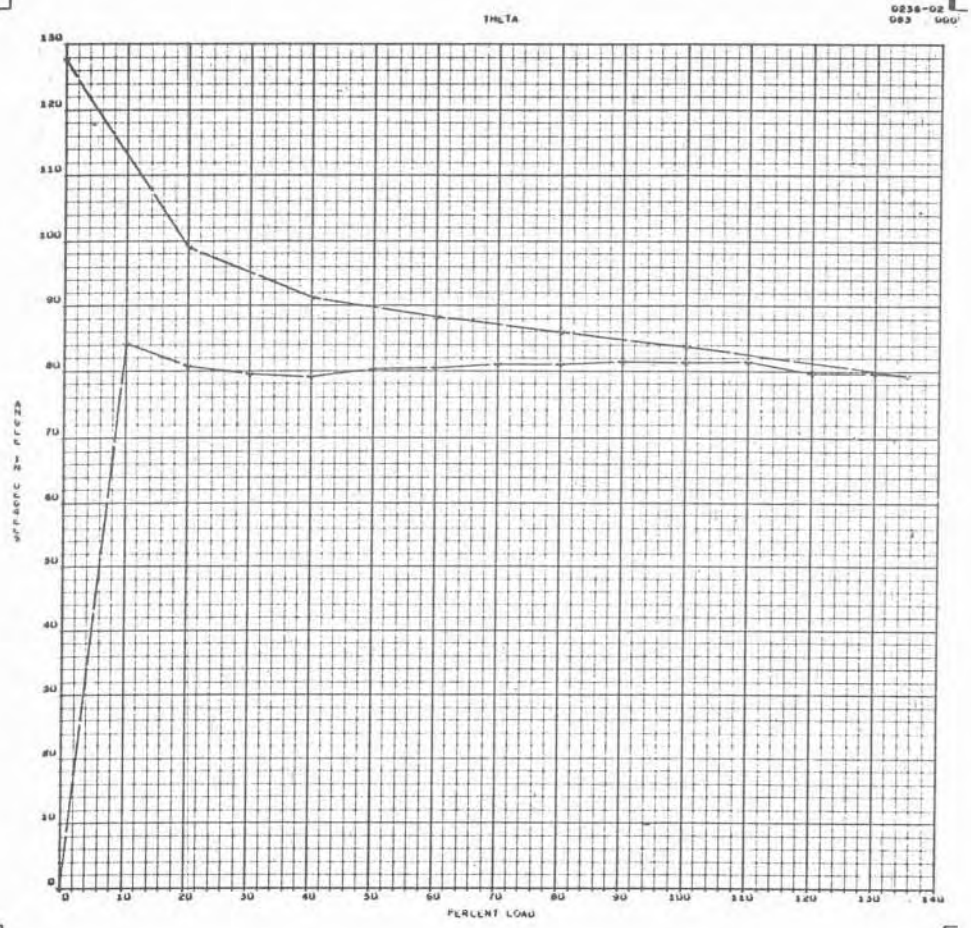


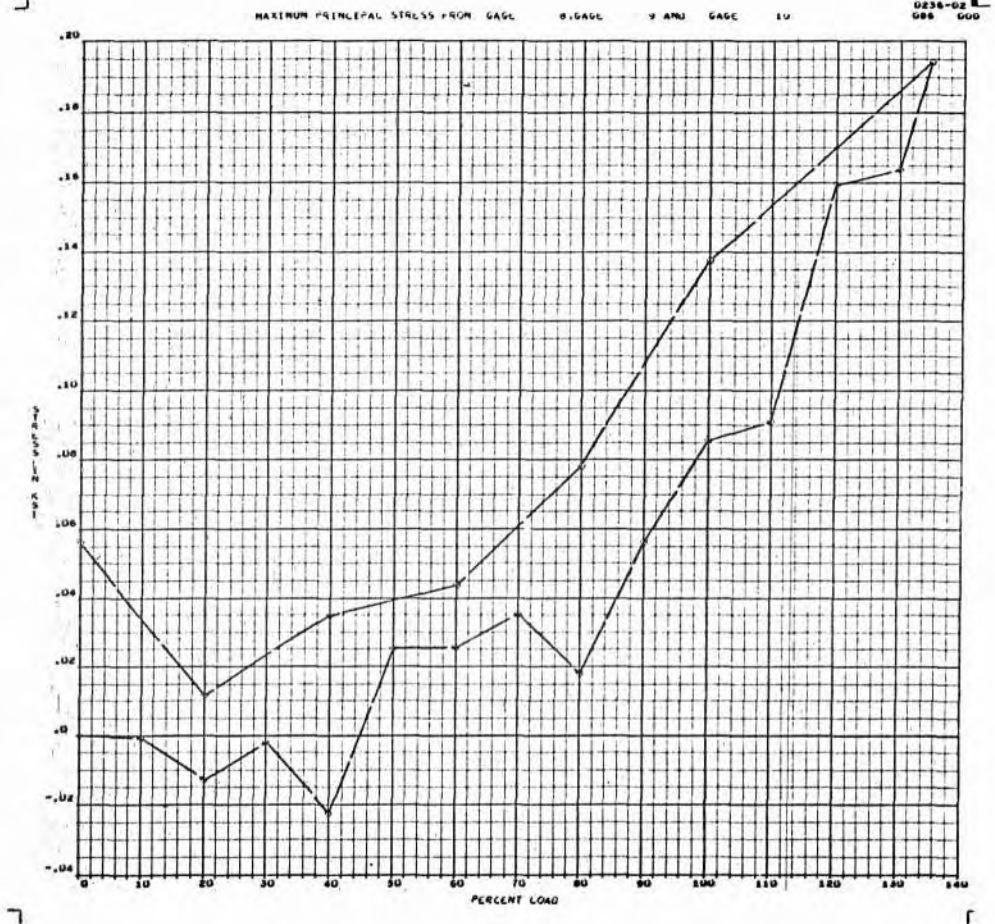
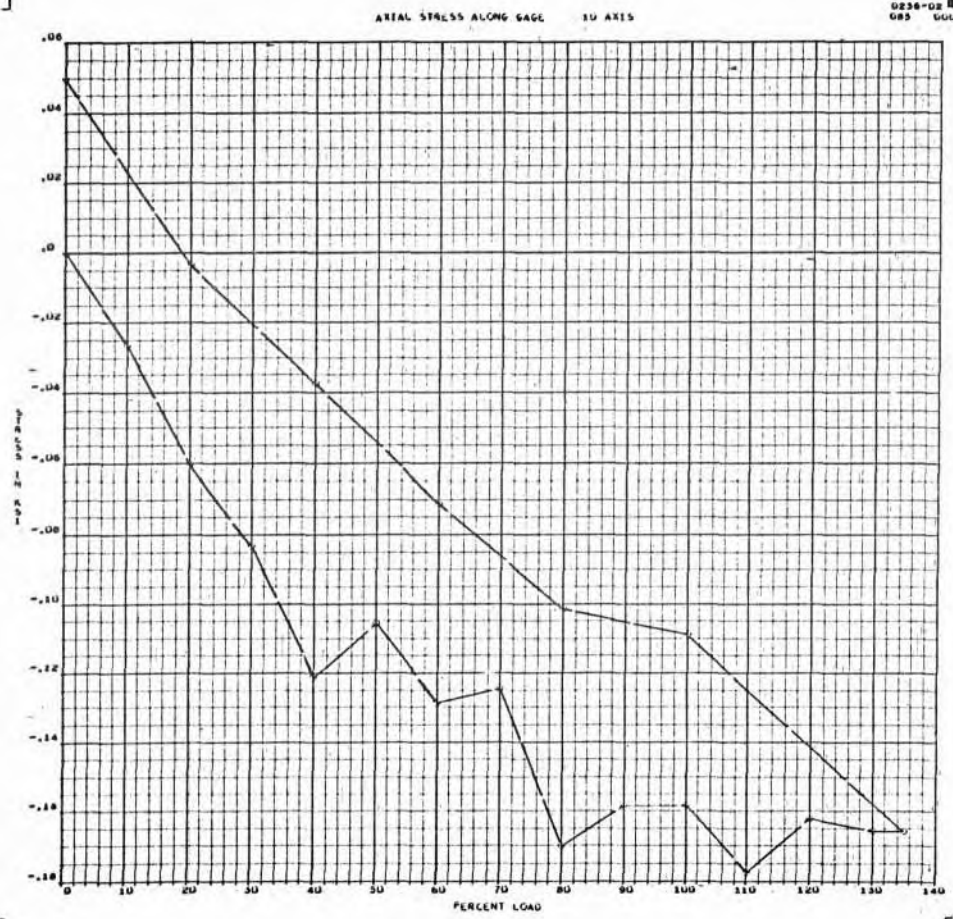
- A 83 -

SID 67-318



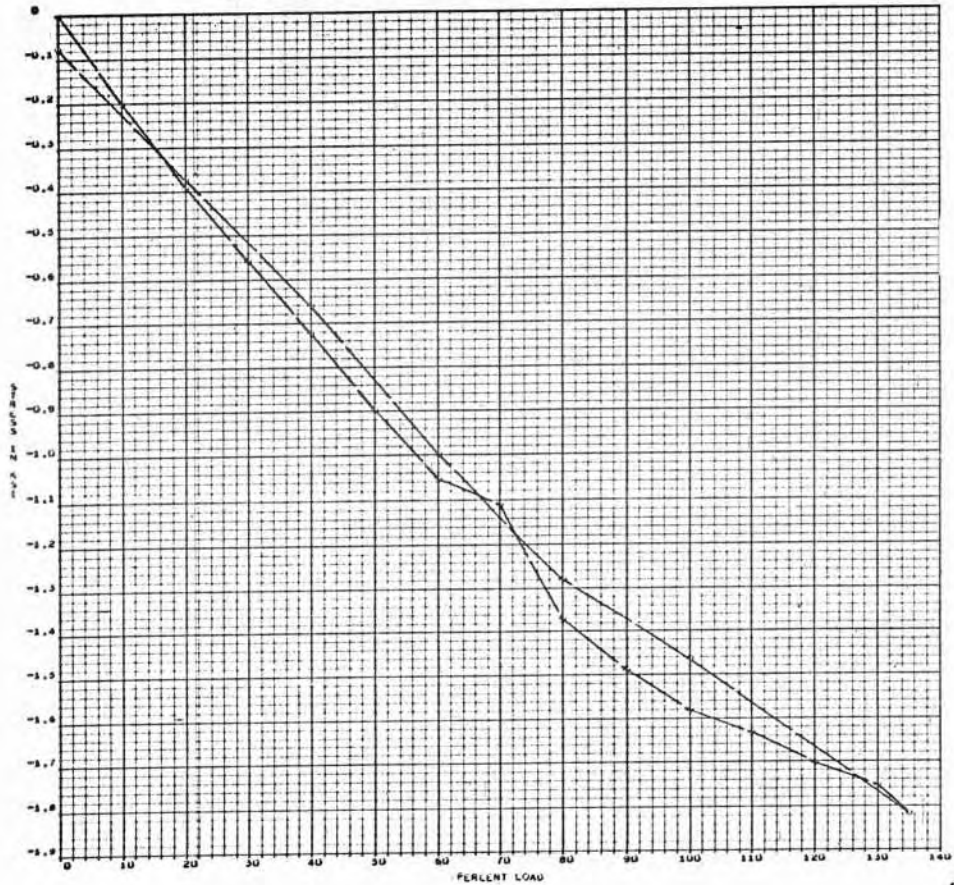






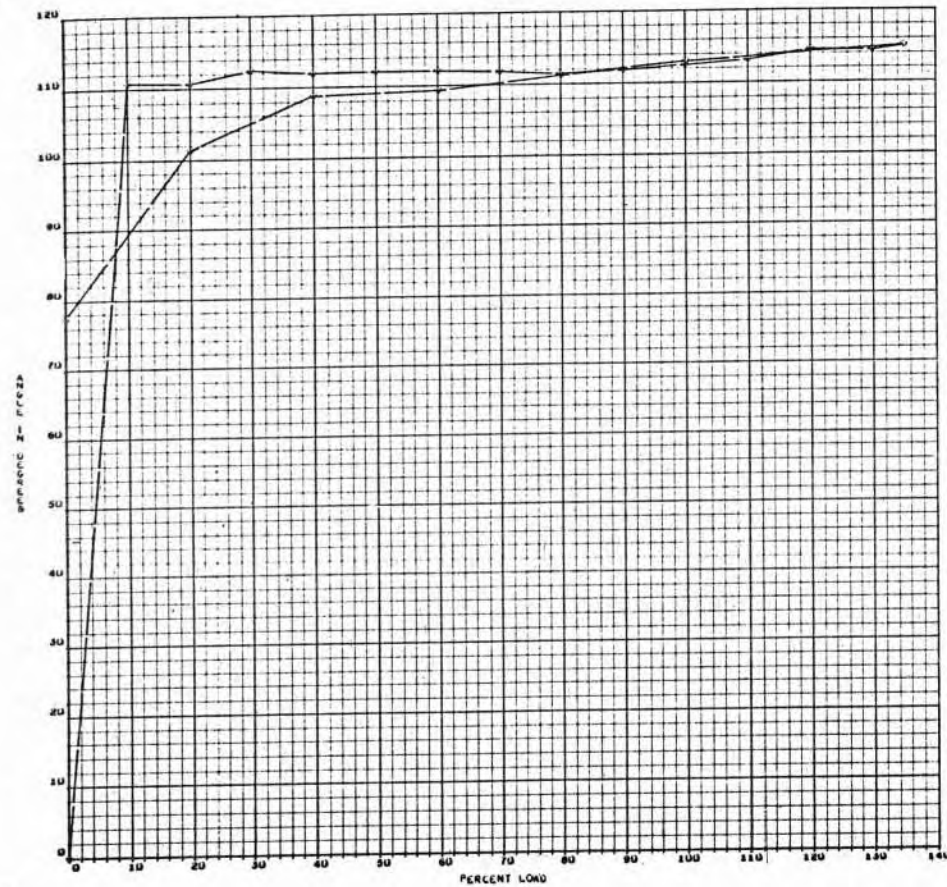
MINIMUM PRINCIPAL STRESS FROM GAGE 8, GAGE 9 AND GAGE 10

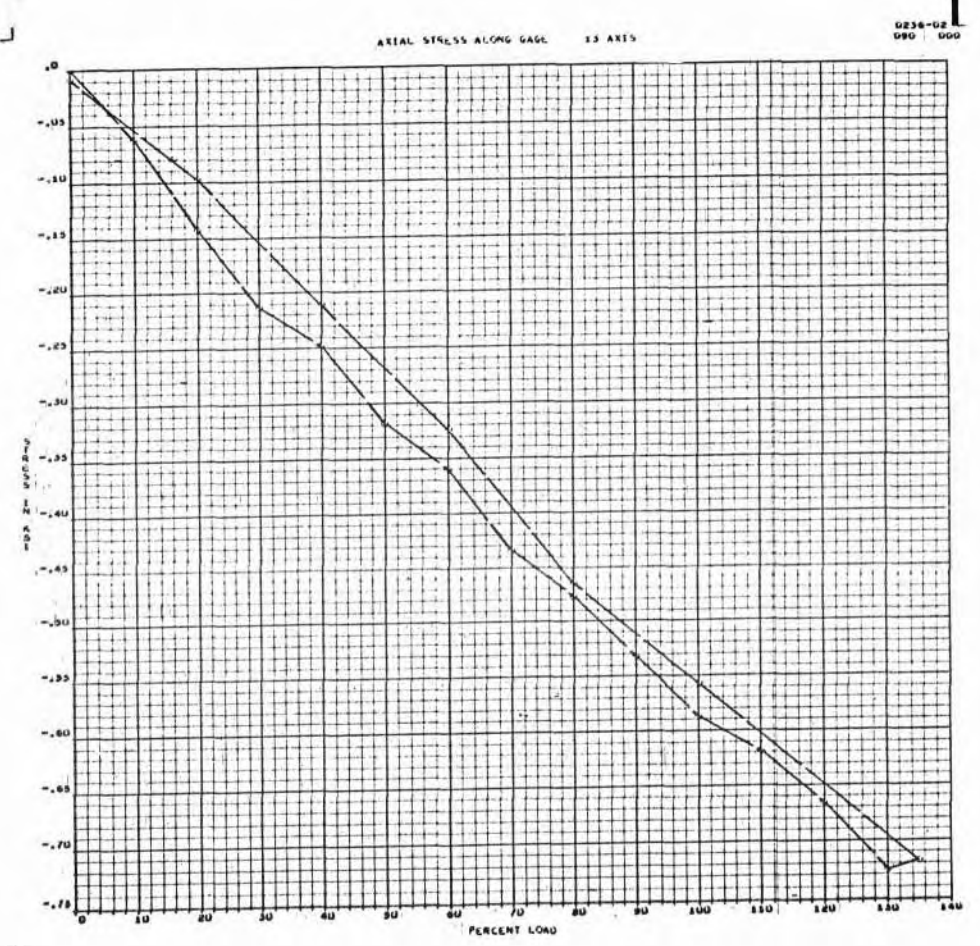
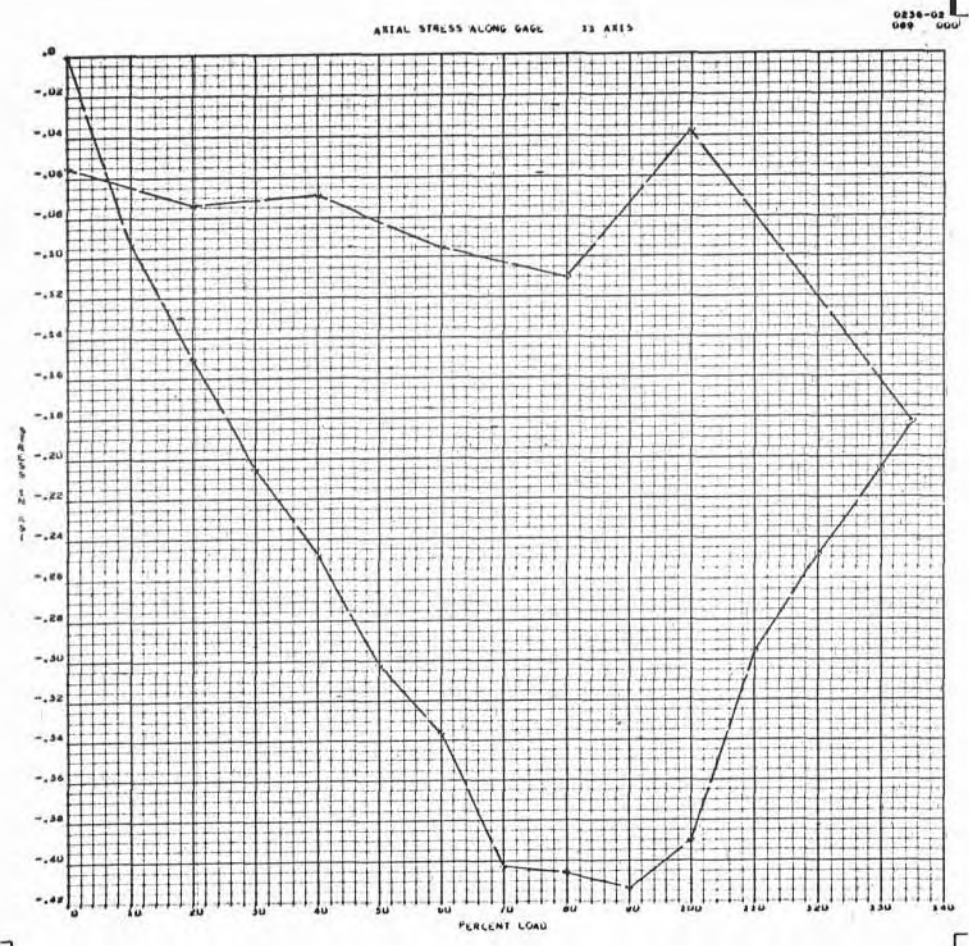
0238-02
087 000

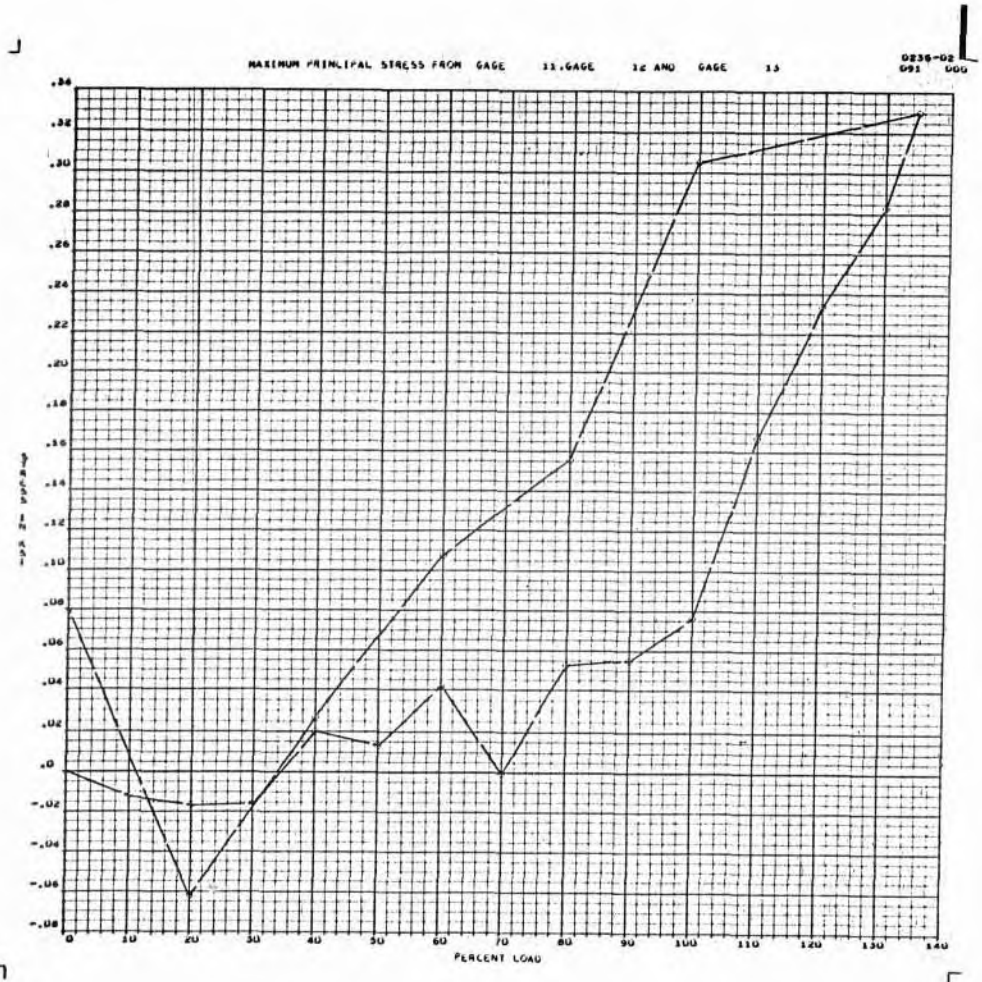


THETA

0238-02
088 000

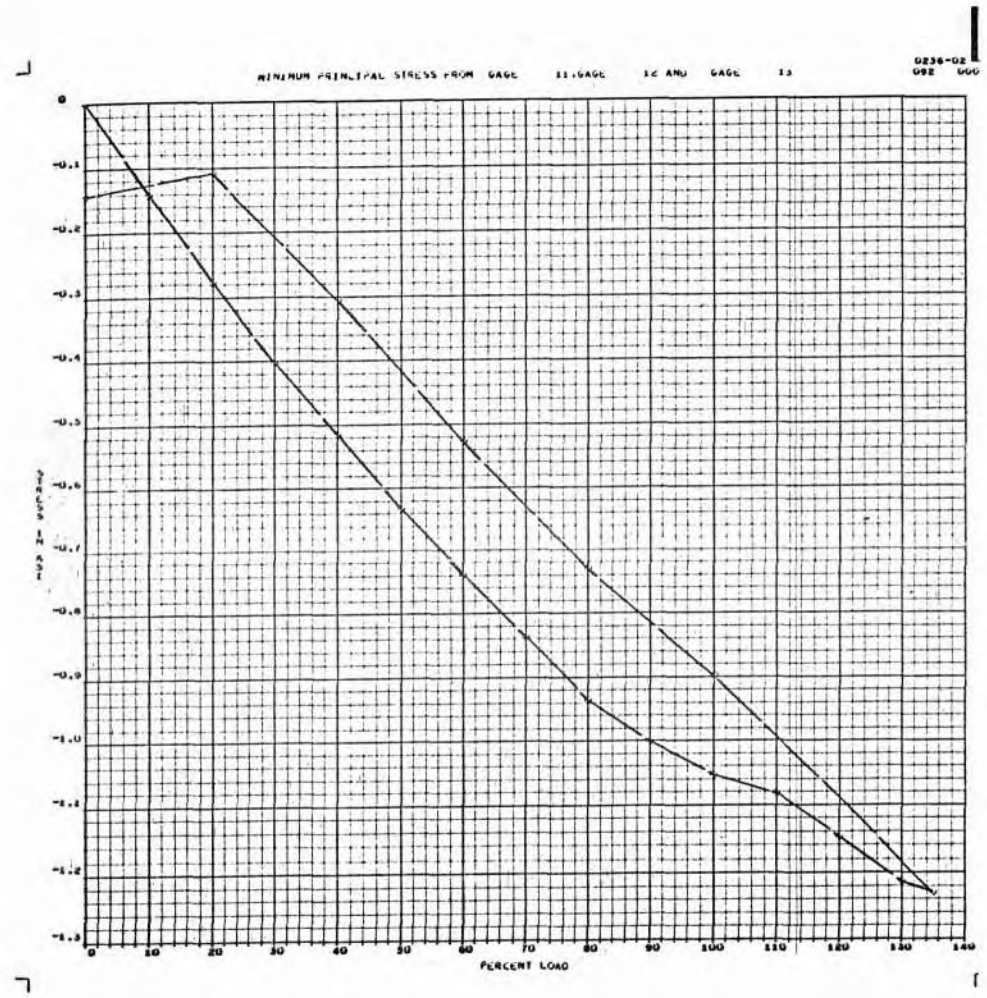






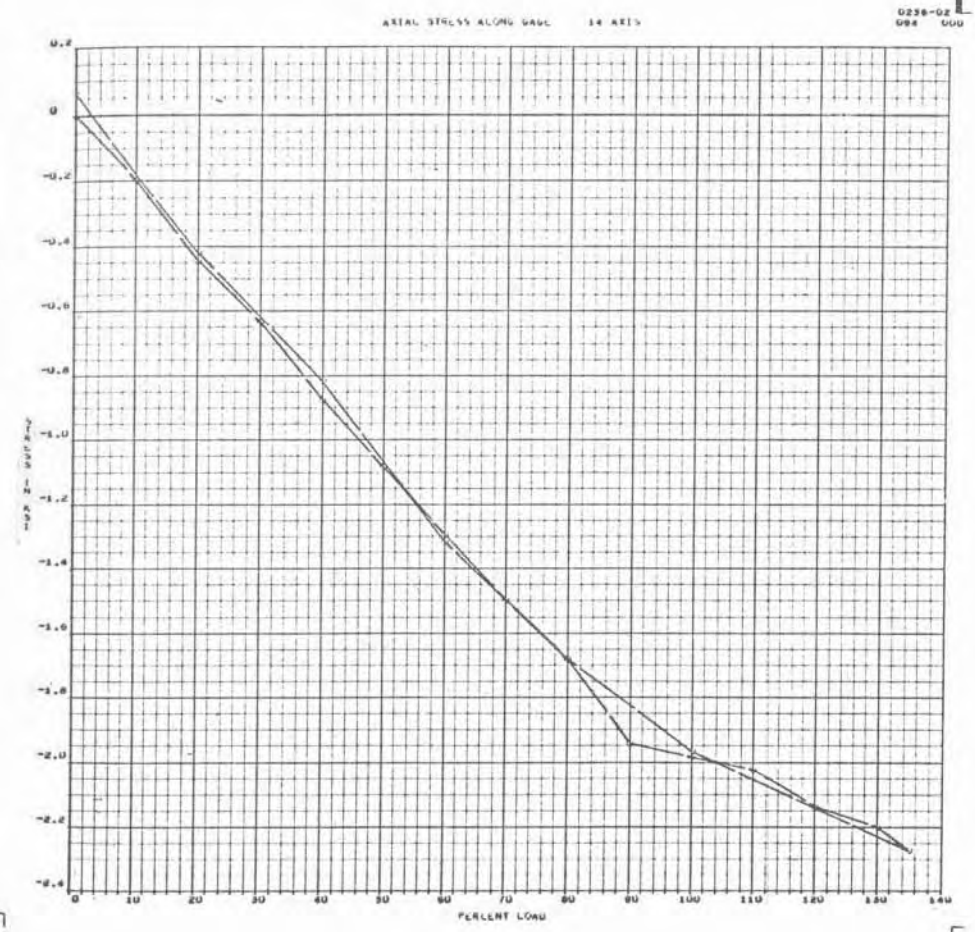
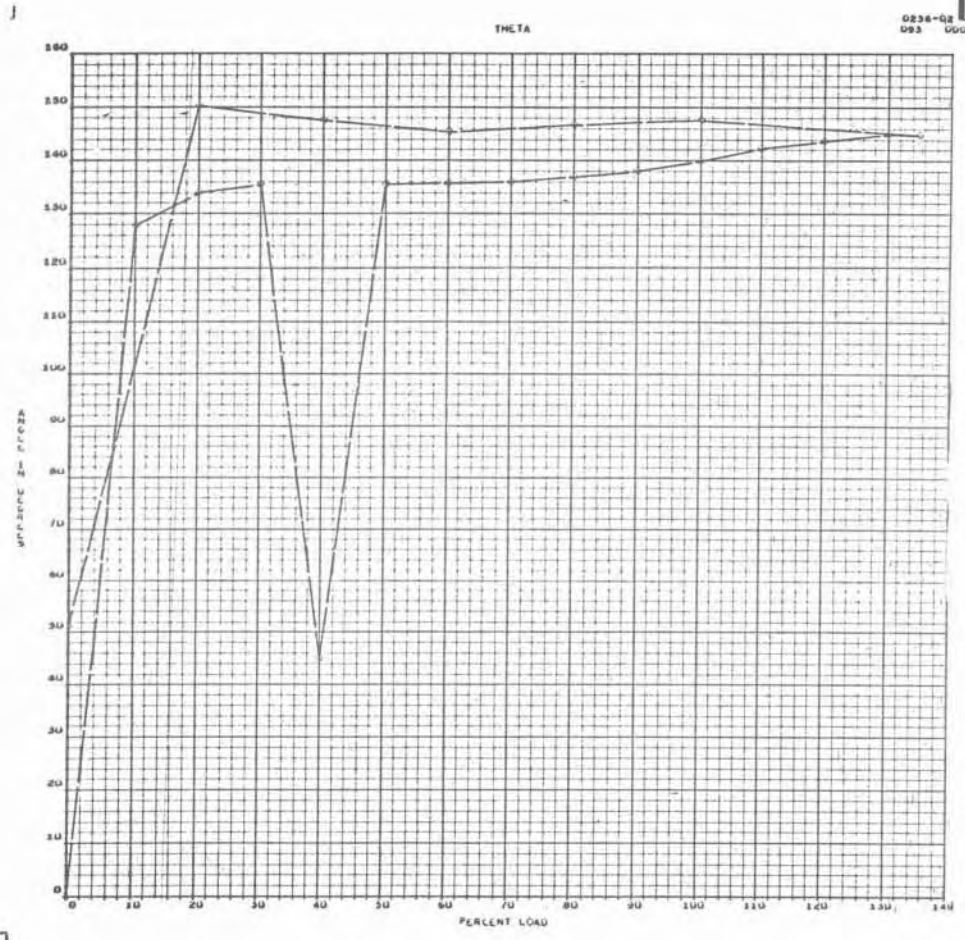
- A 96 -

SID 67-318



- A 97 -

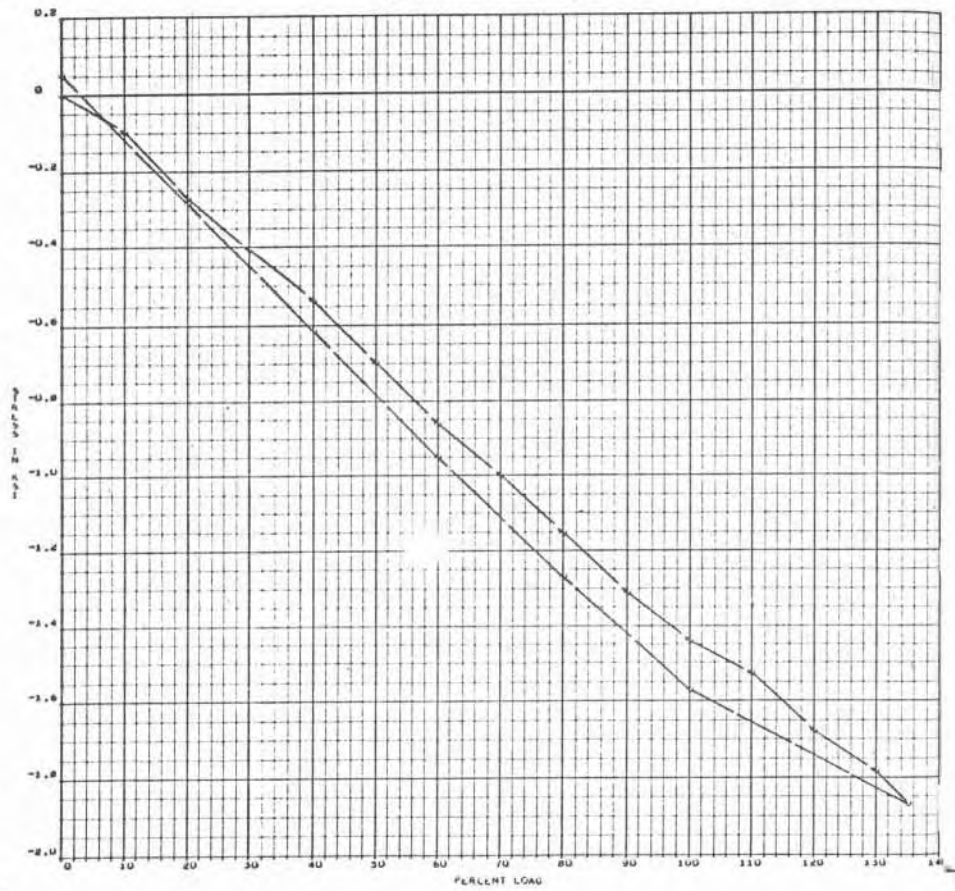
SID 67-318



J

AXIAL STRESS ALONG GAGE 10 AXIS

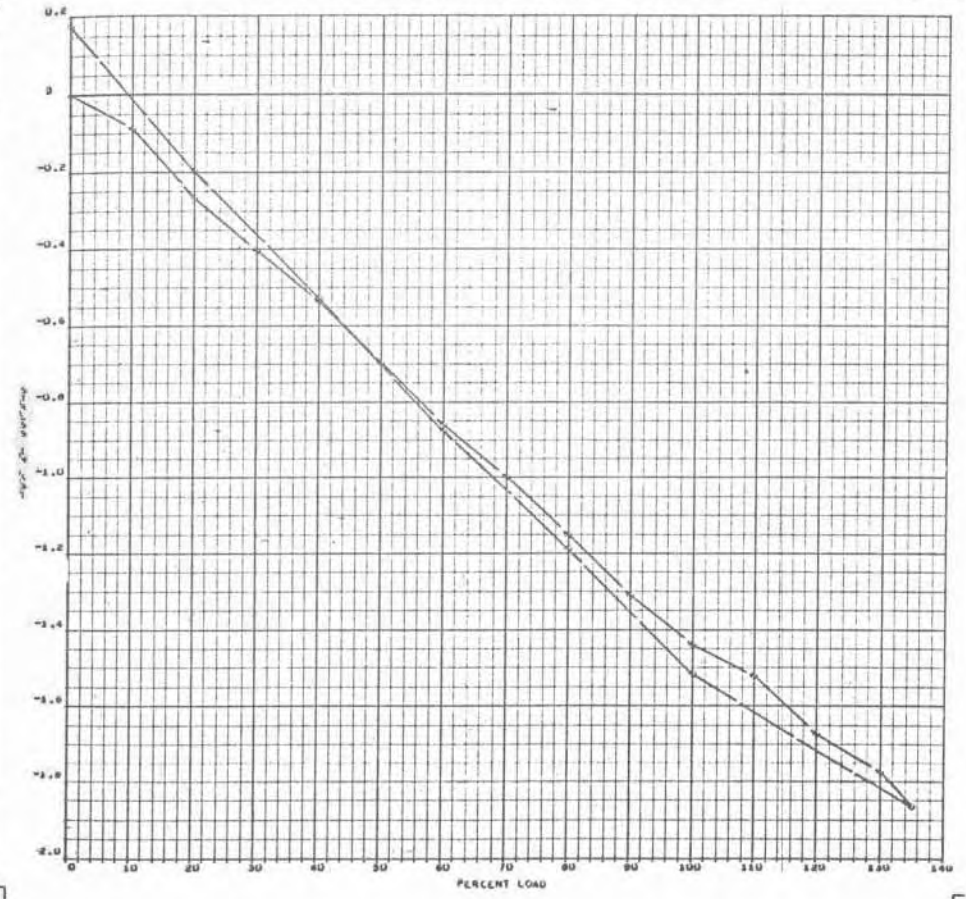
0236-02
093 000

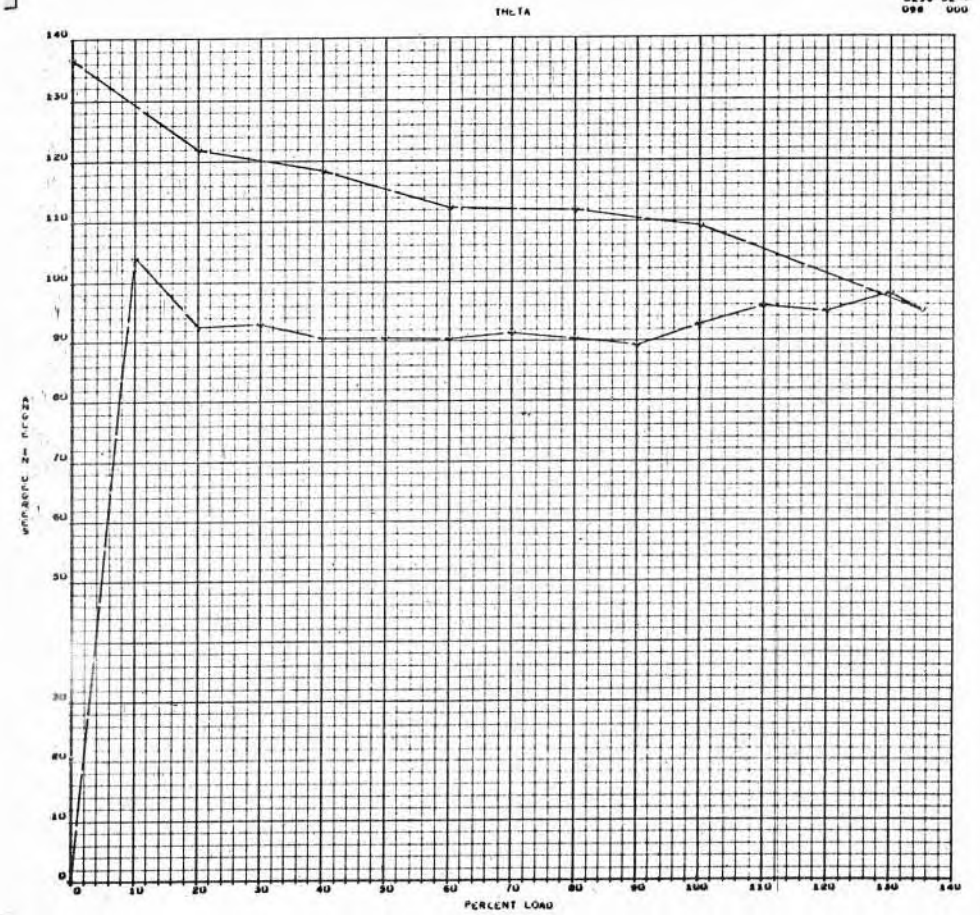
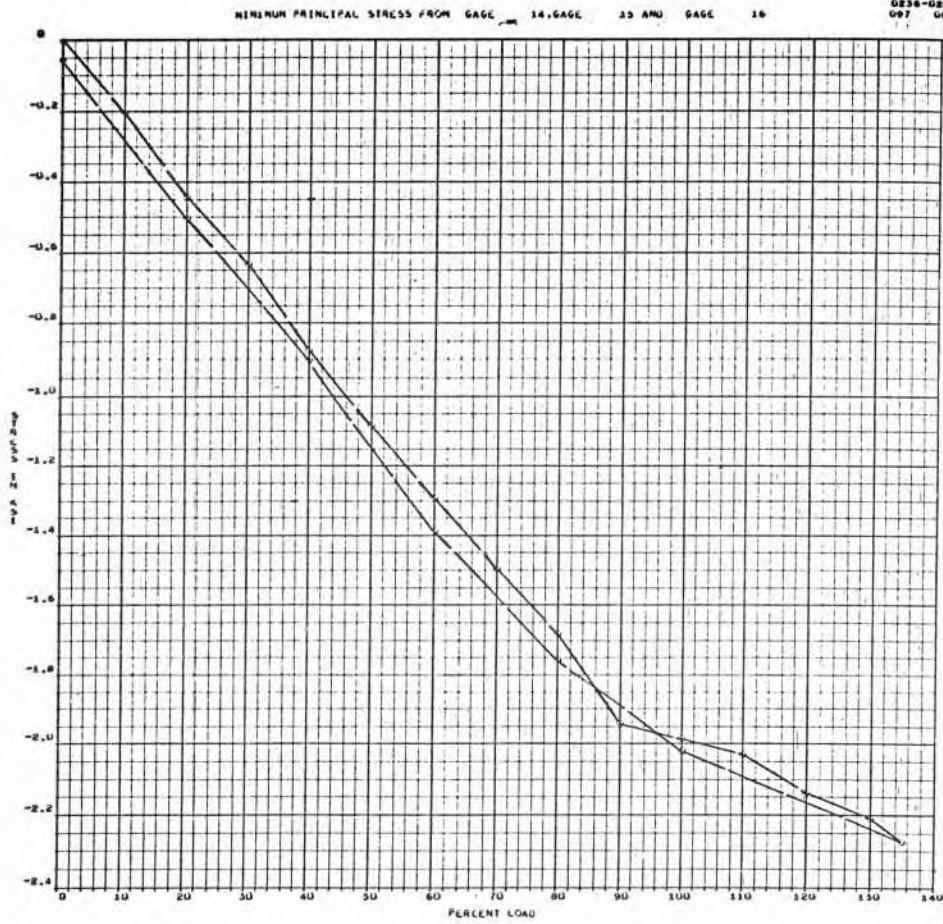


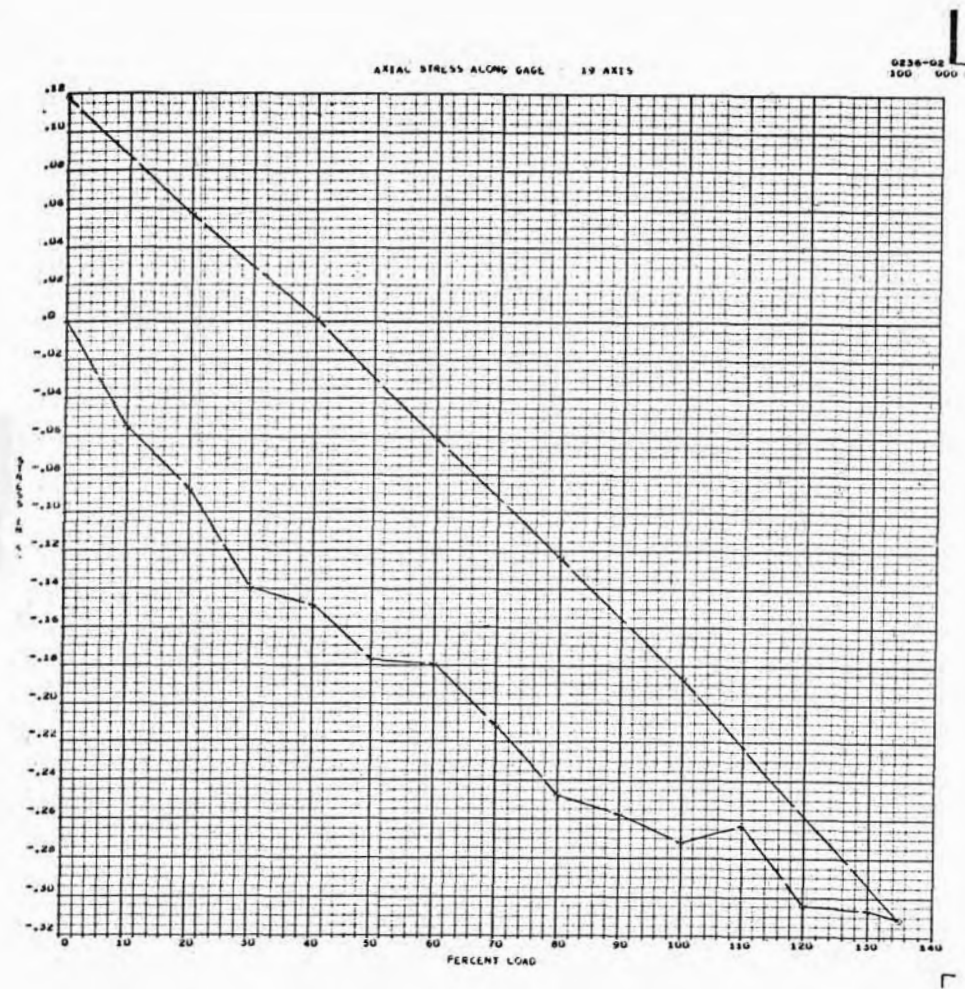
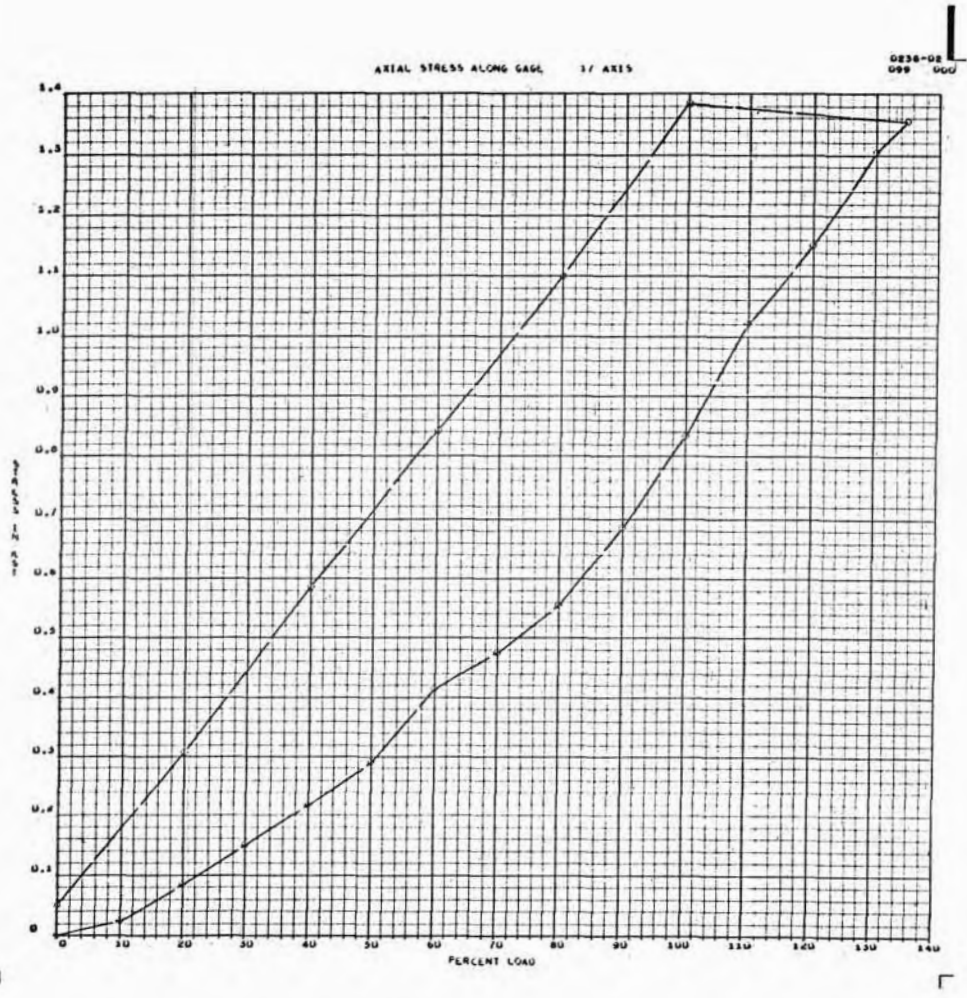
7

MAXIMUM PRINCIPAL STRESS FROM GAGE 14, GAGE 15 AND GAGE 16

0236-02
098 000

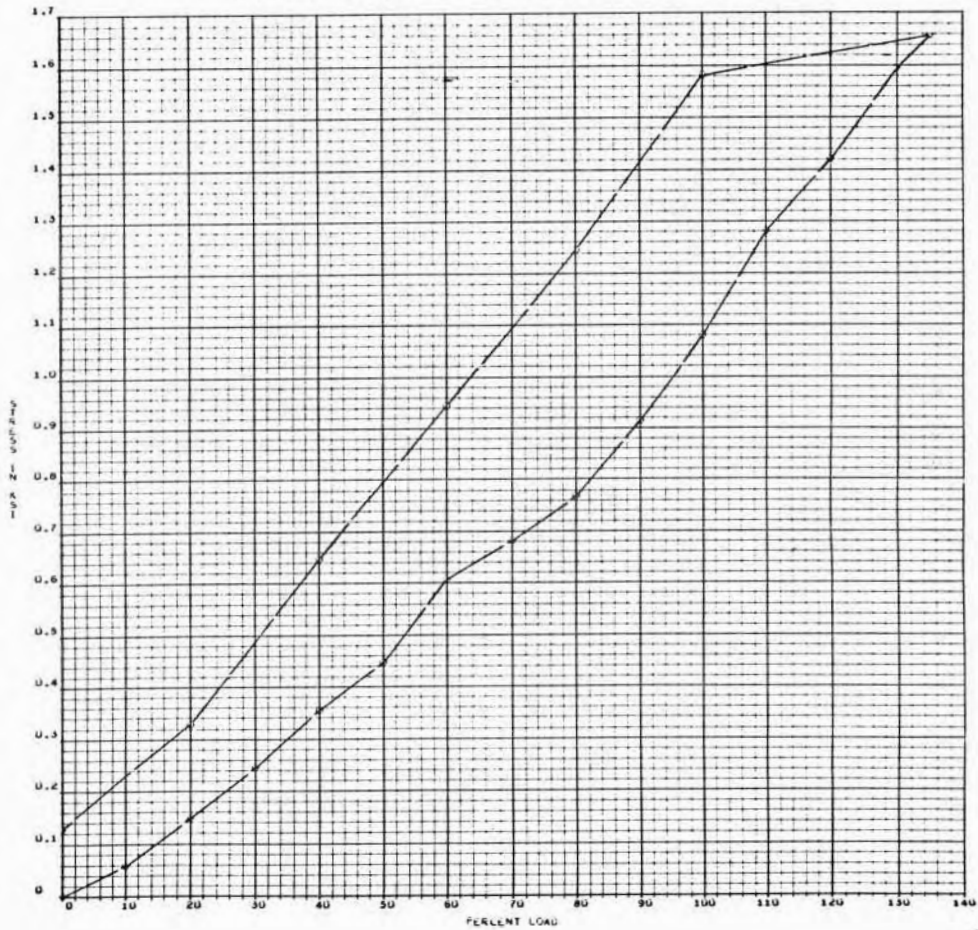






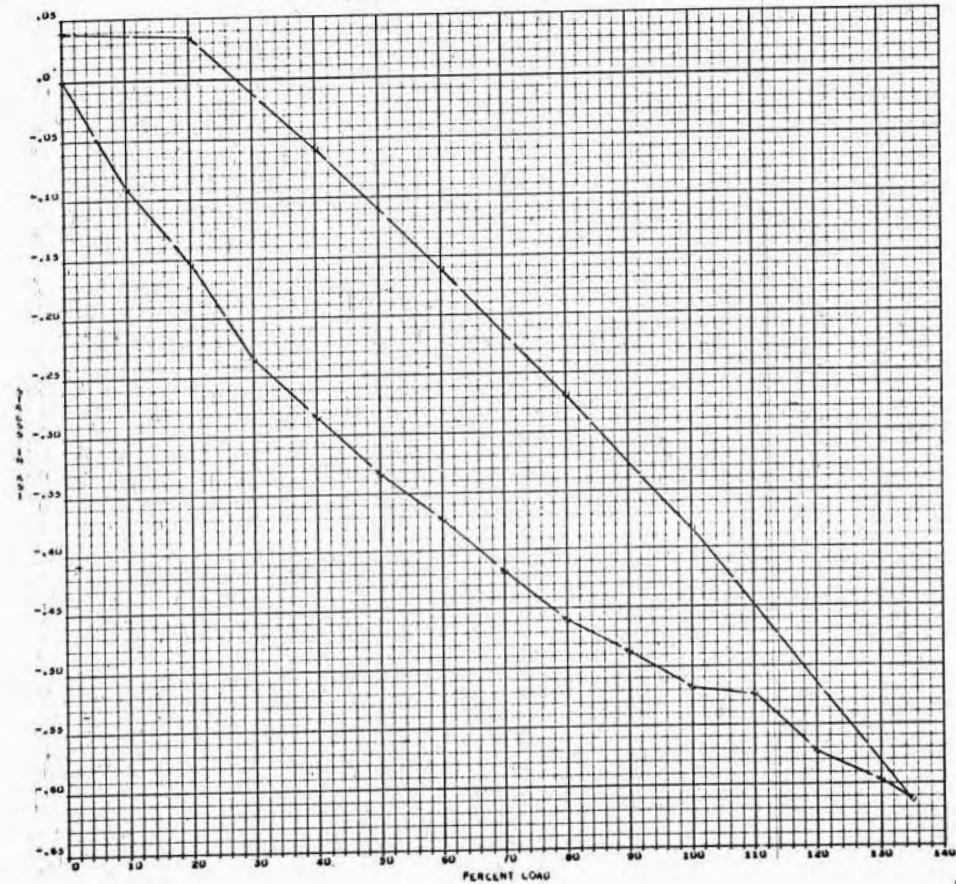
MAXIMUM PRINCIPAL STRESS FROM GAGE 17, GAGE 18 AND GAGE 19

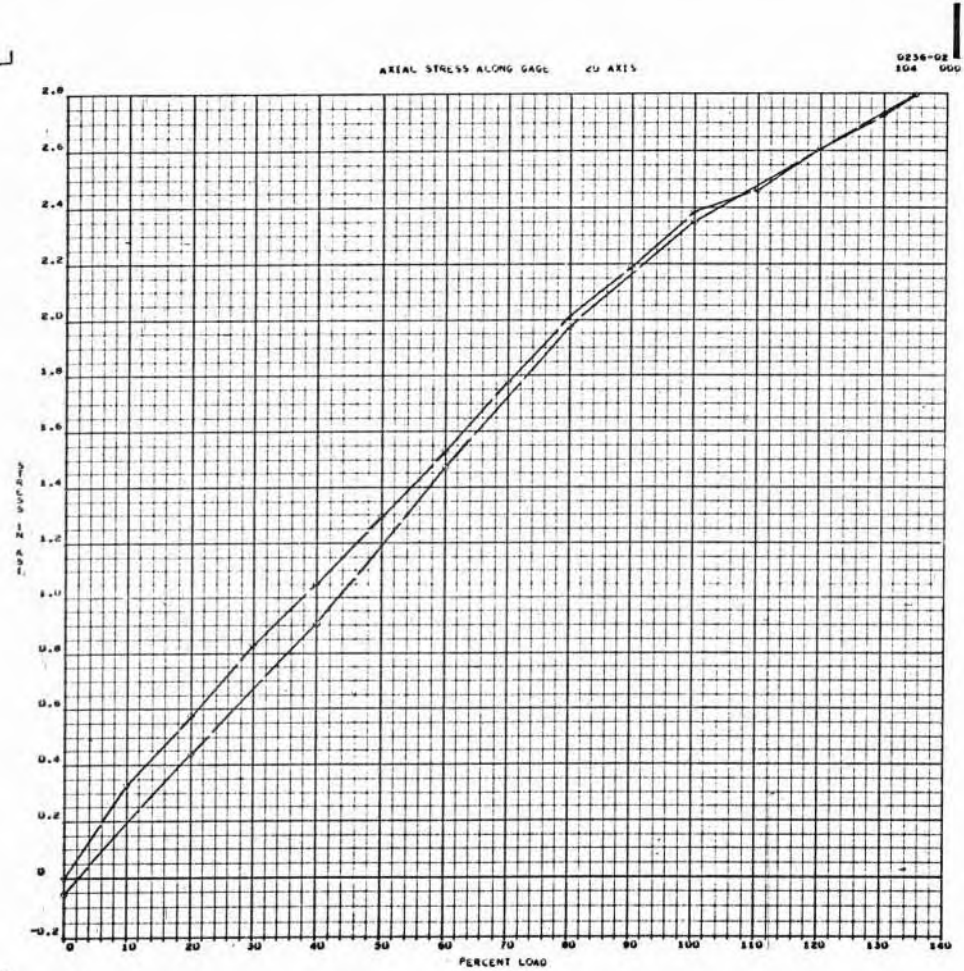
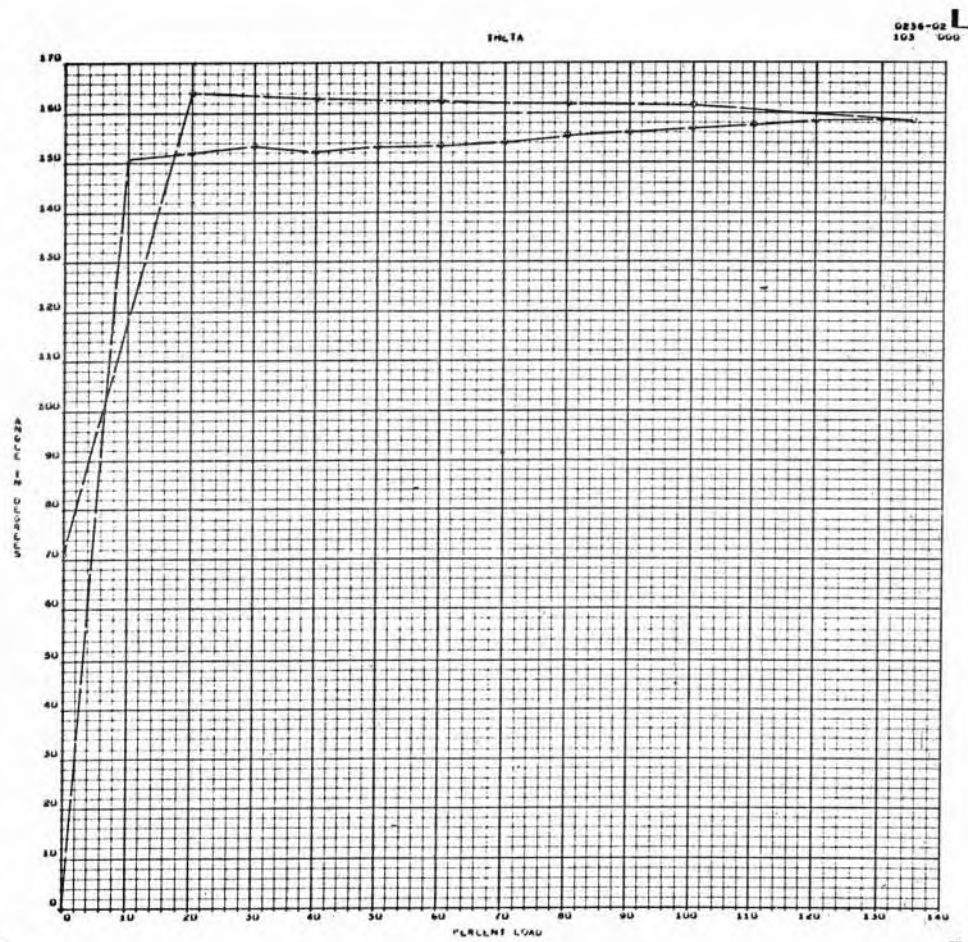
0236-02
101 500

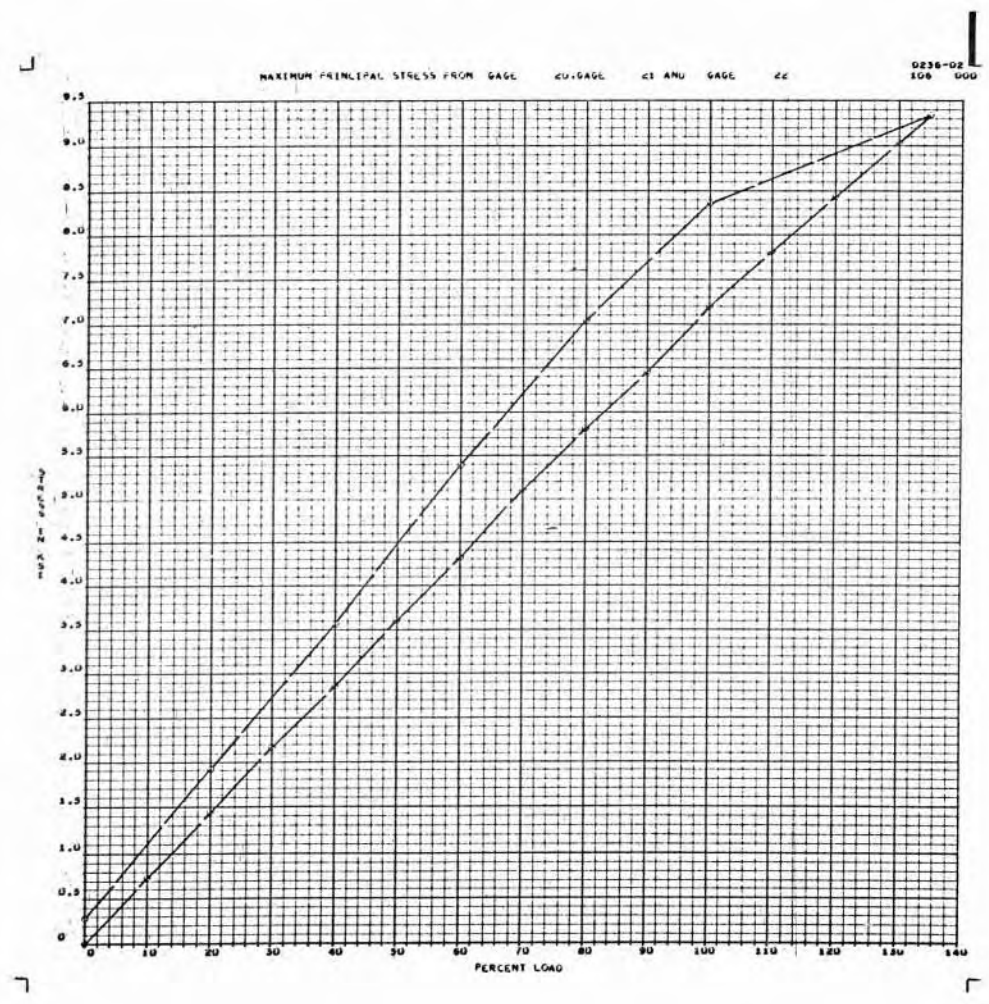
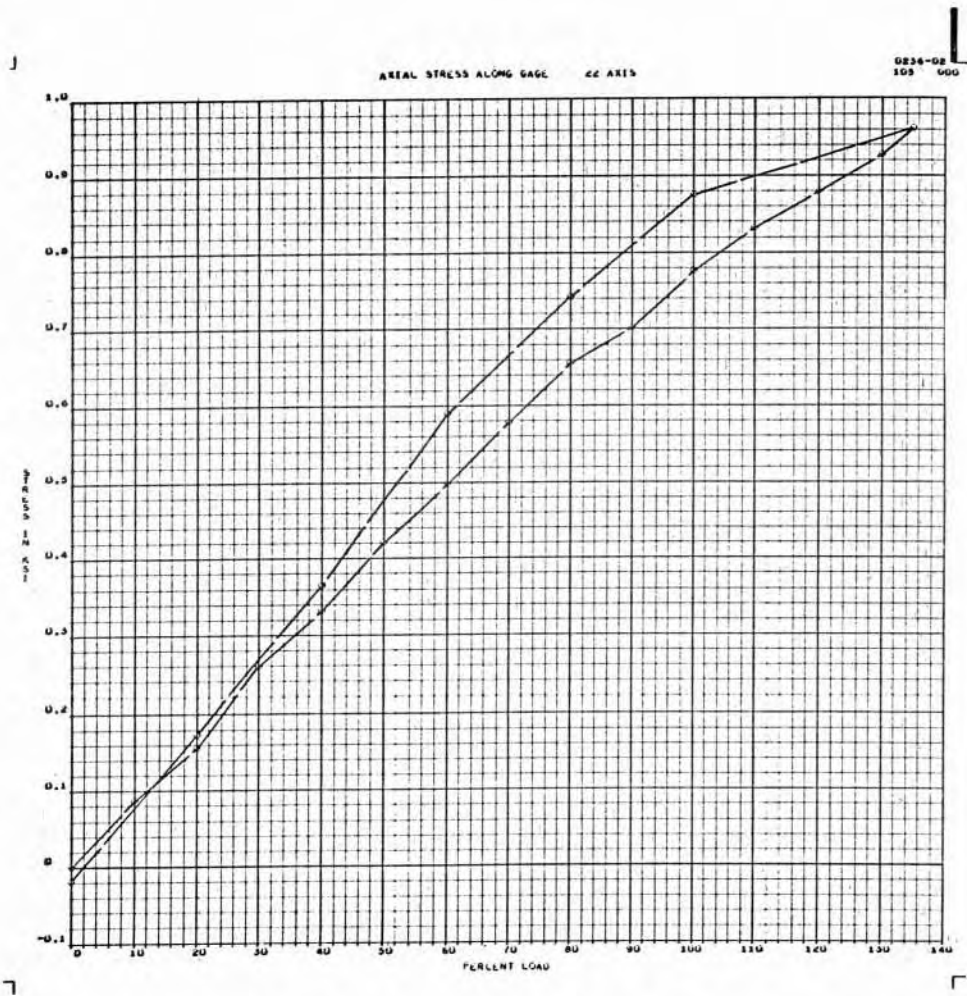


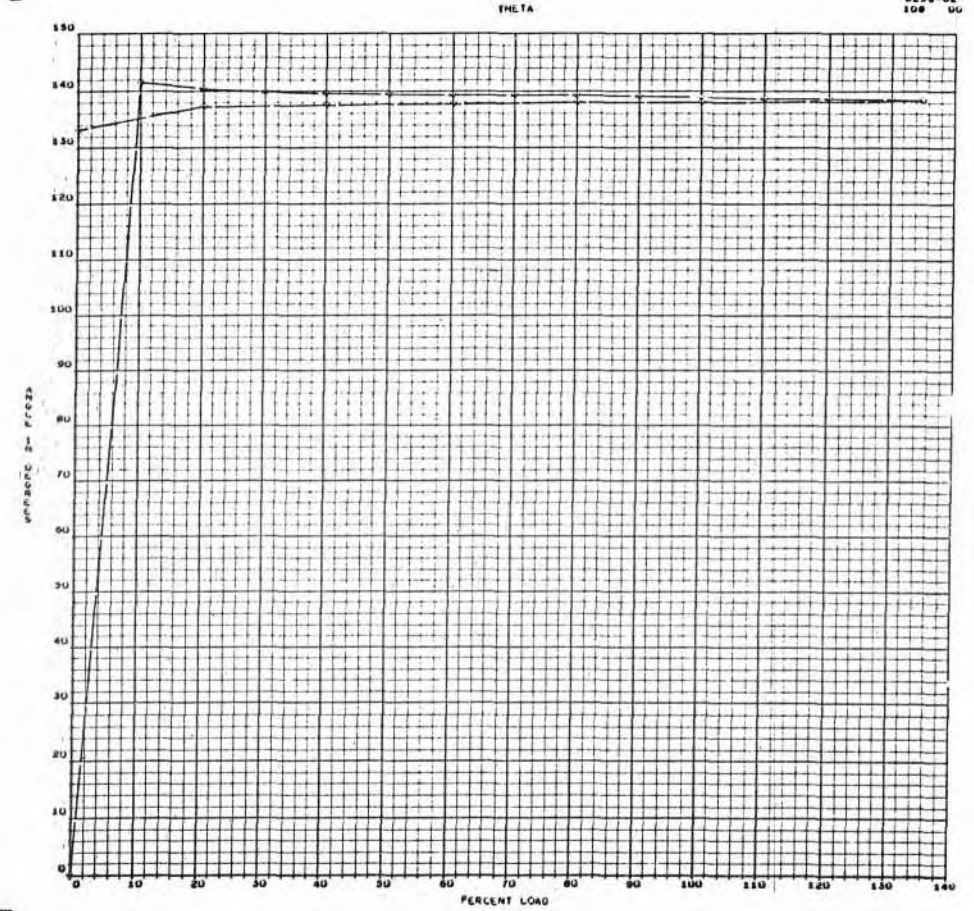
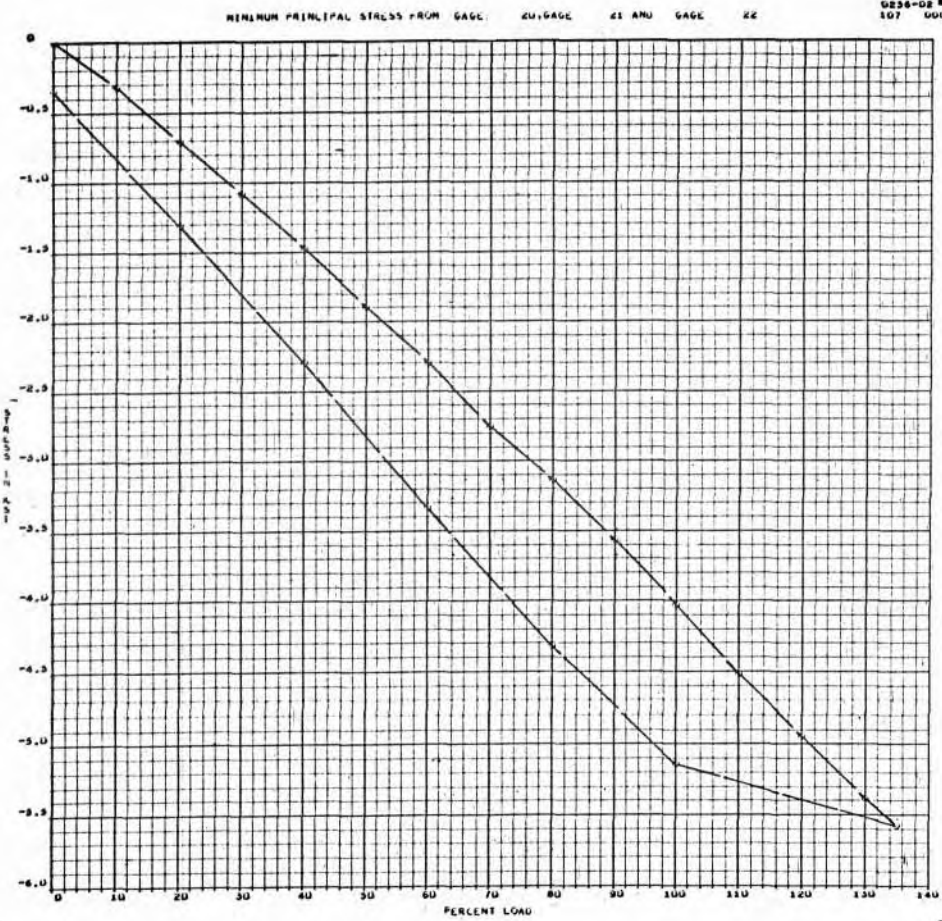
MINIMUM PRINCIPAL STRESS FROM GAGE 17, GAGE 18 AND GAGE 19

0236-02
102 500





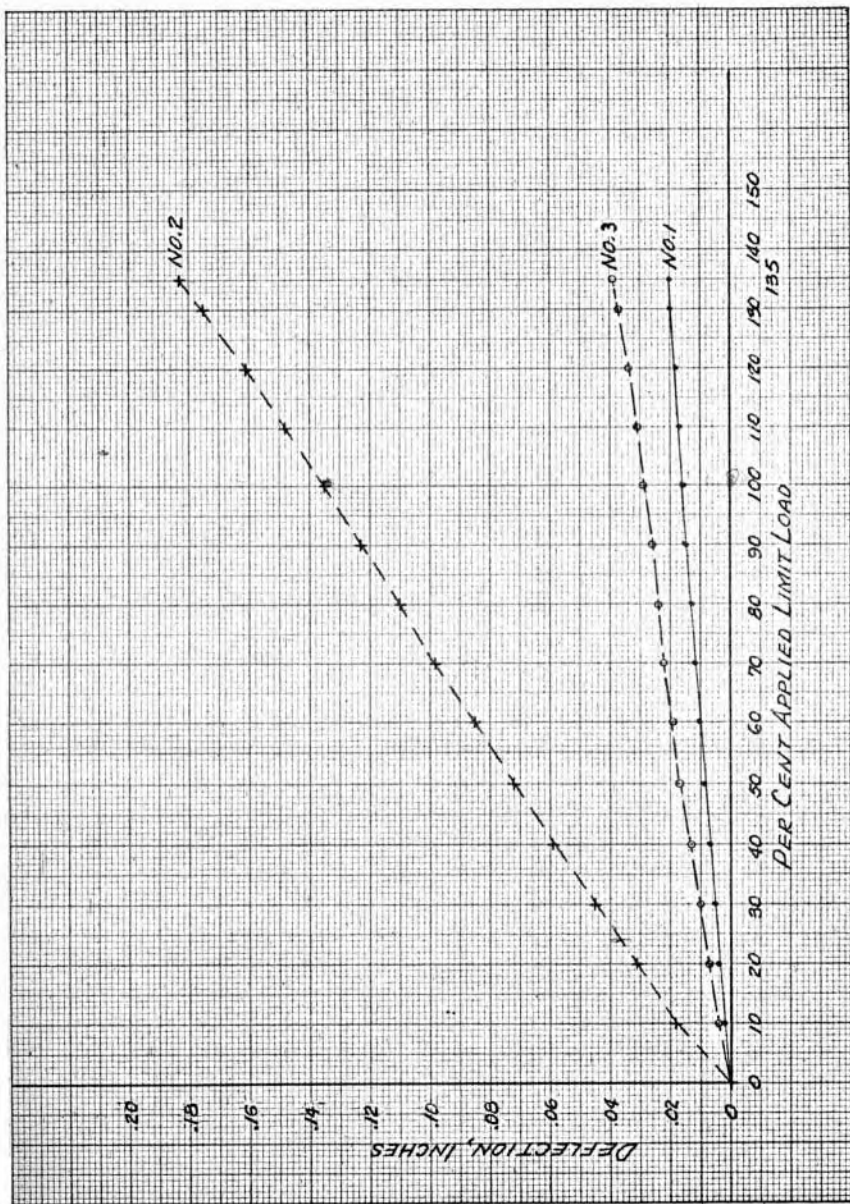




APPENDIX A

TEST CONDITION ID

$\frac{1036}{2} = 0.12$



TEST CONDITION ID

T.C. I-D

S.A.A.

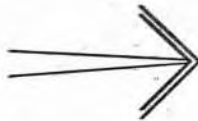
SCHE TO KISSINGDALET 84

DEPT-GROUP 098 232

0236-02

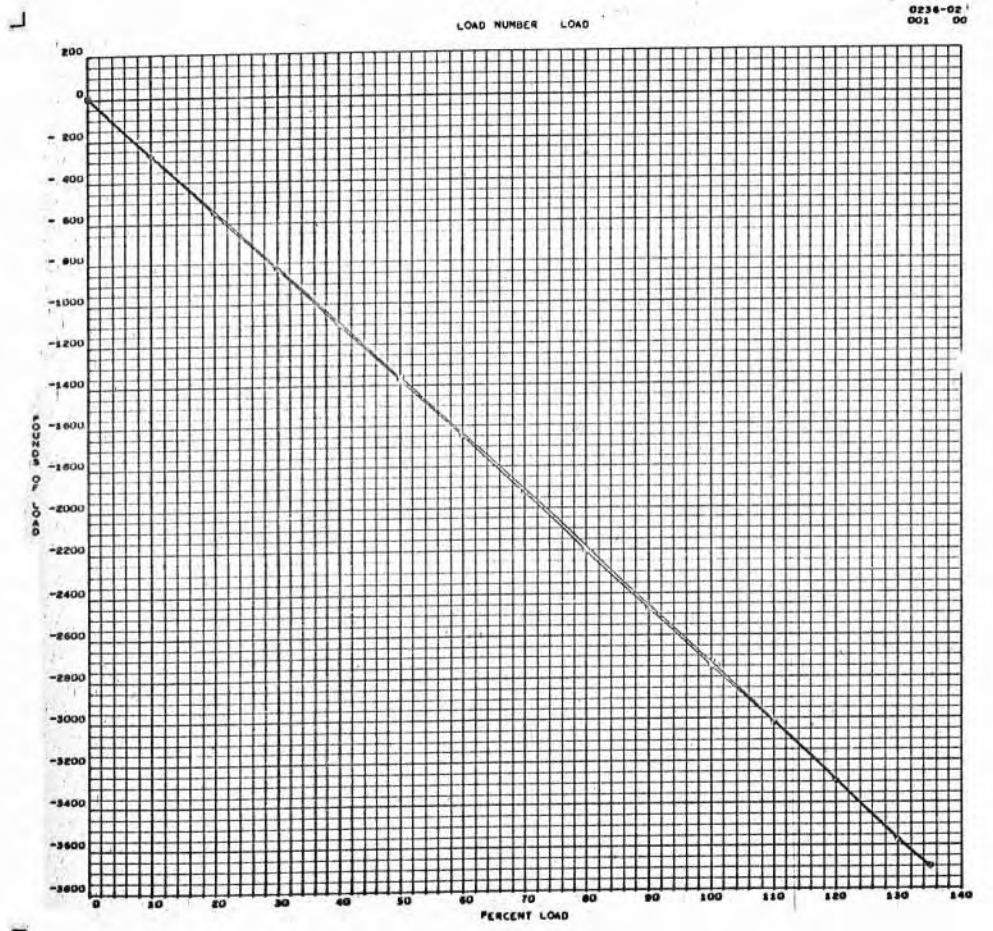
BOX NO. 101

DATE 02/02/67



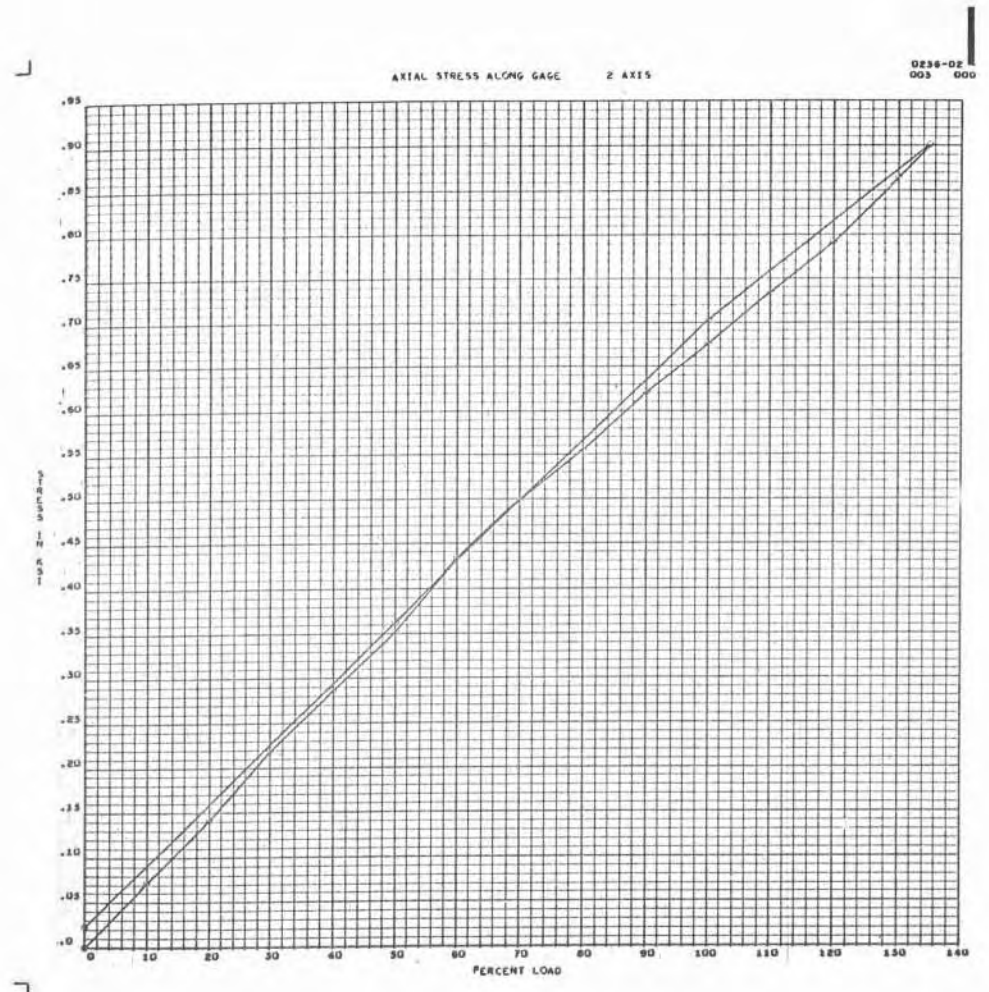
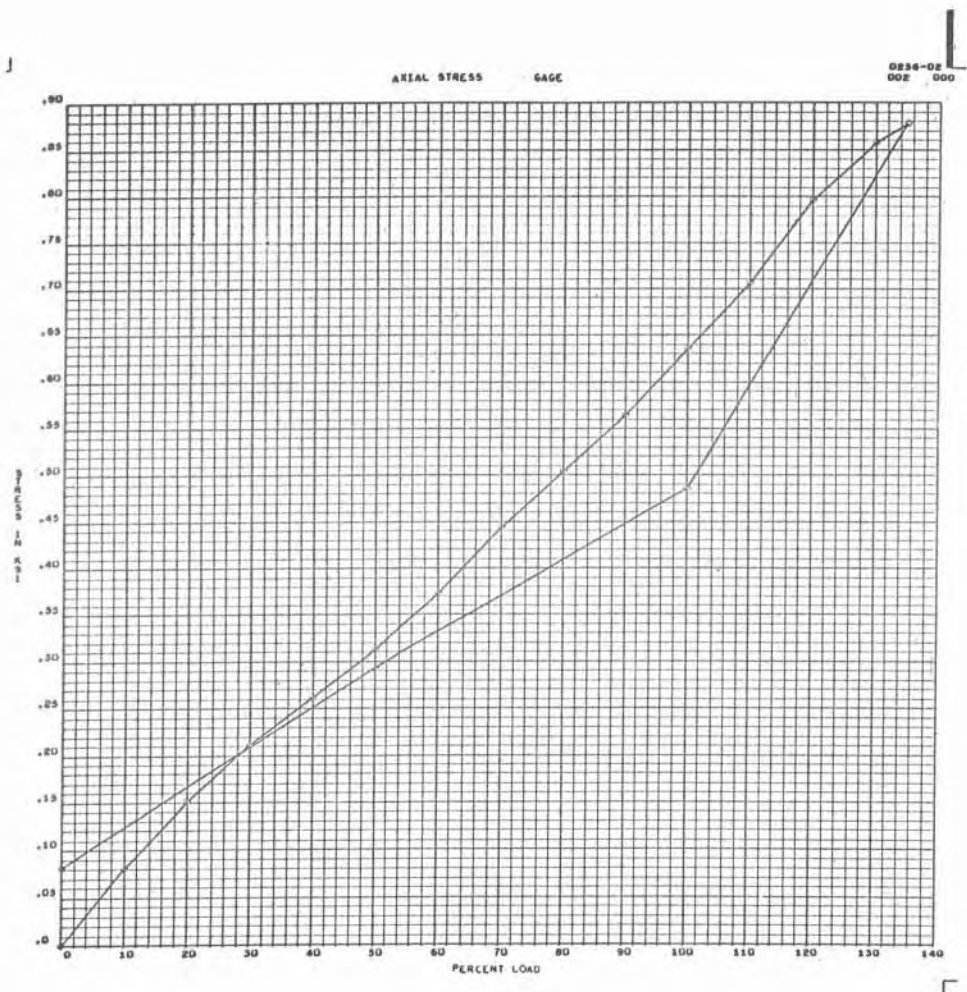
- A 115 -

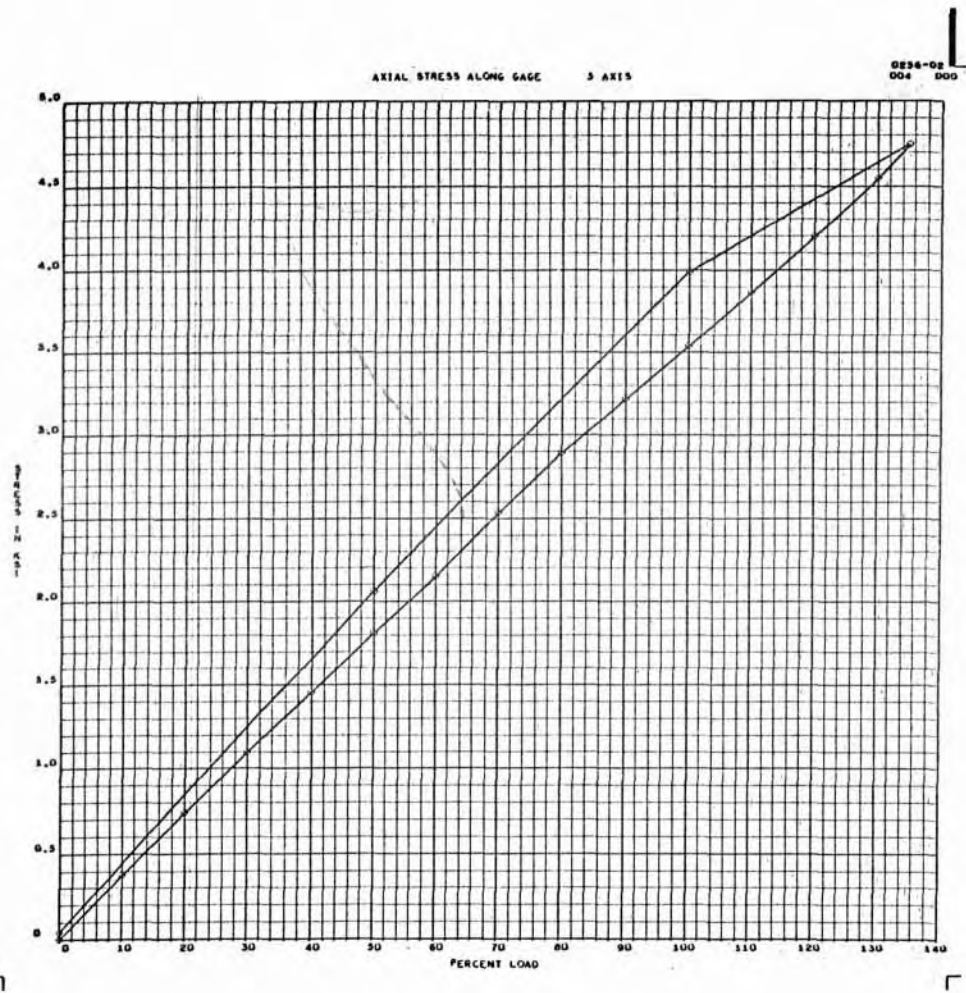
SID 67-318



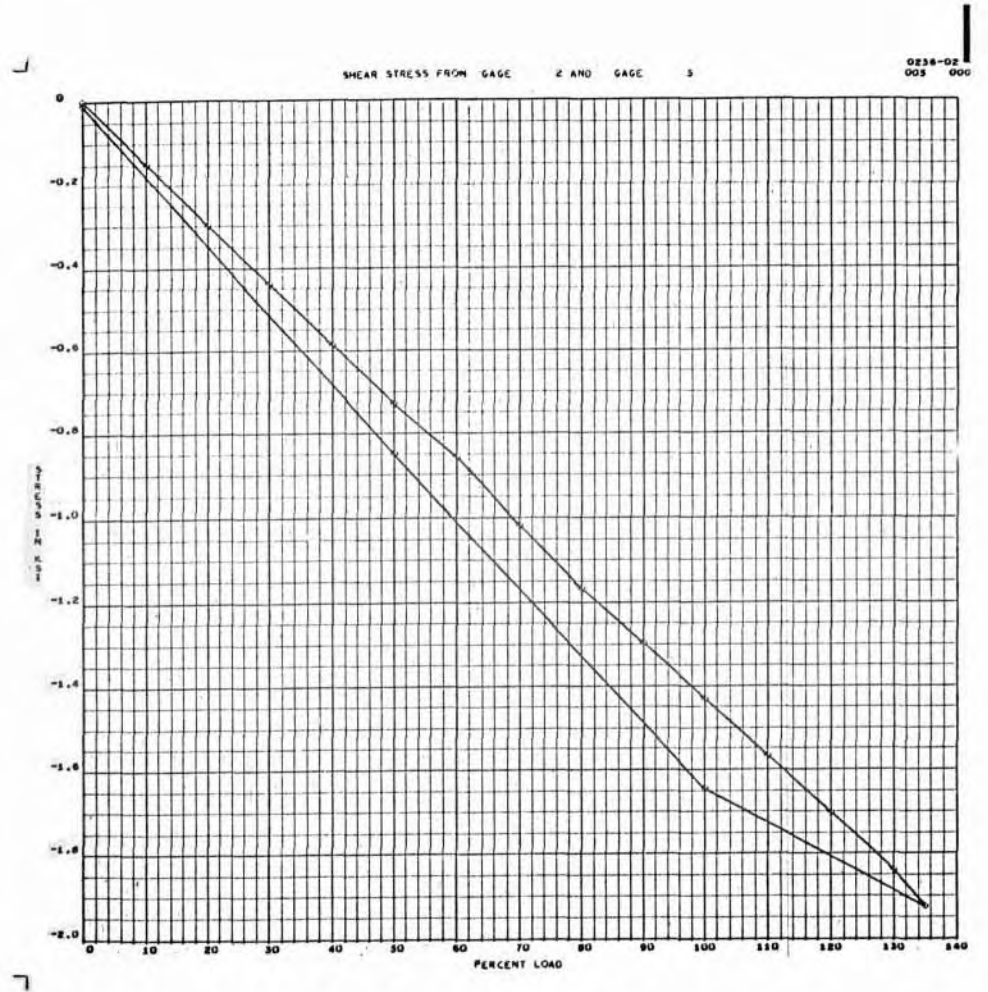
- A 116 -

SID 67-318

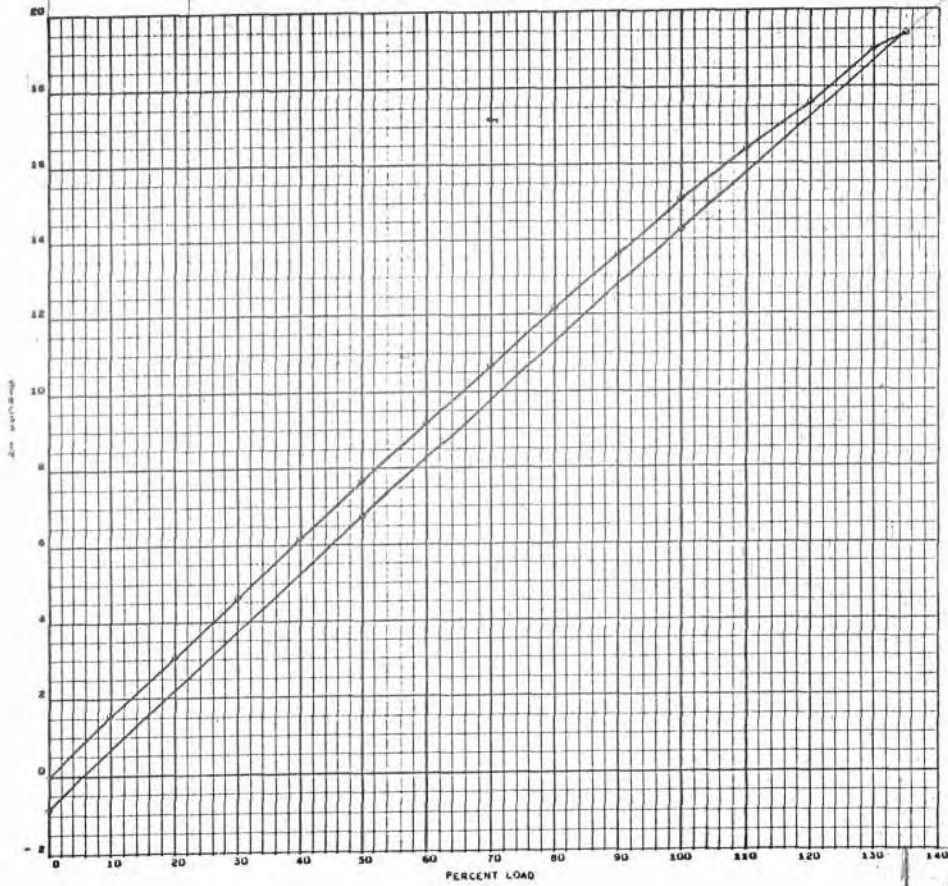




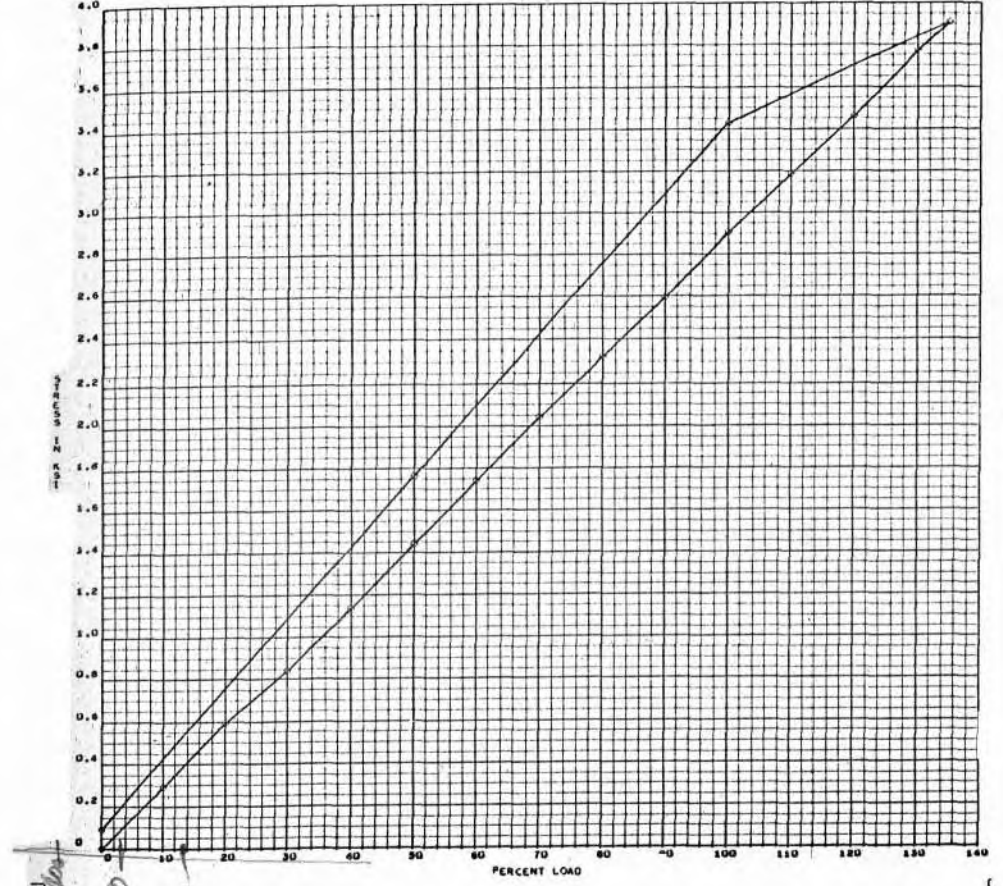
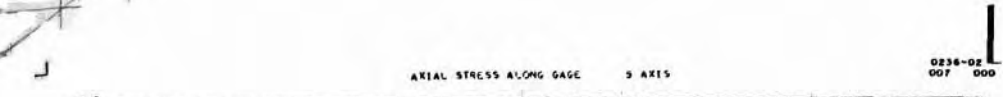
- A 119 - SID 67-318



- A 120 - SID 67-318



3700

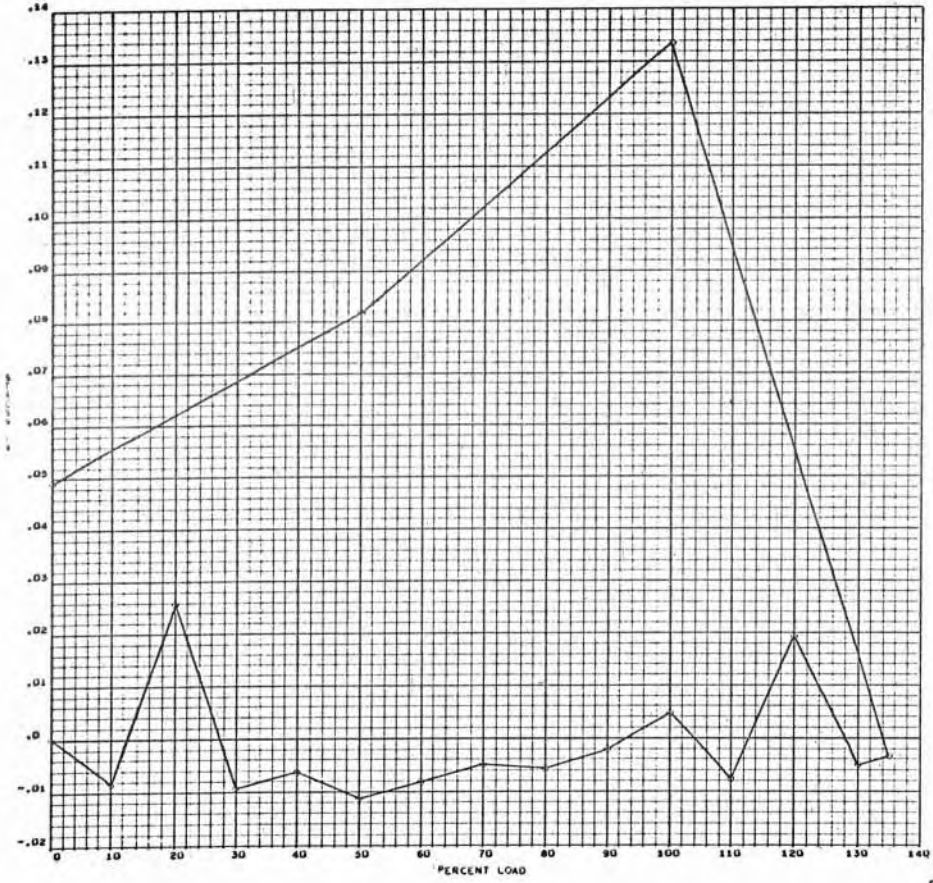


4100
4650
4970

150 = 4100
160 = 4400
170 = 4650
180 = 4930

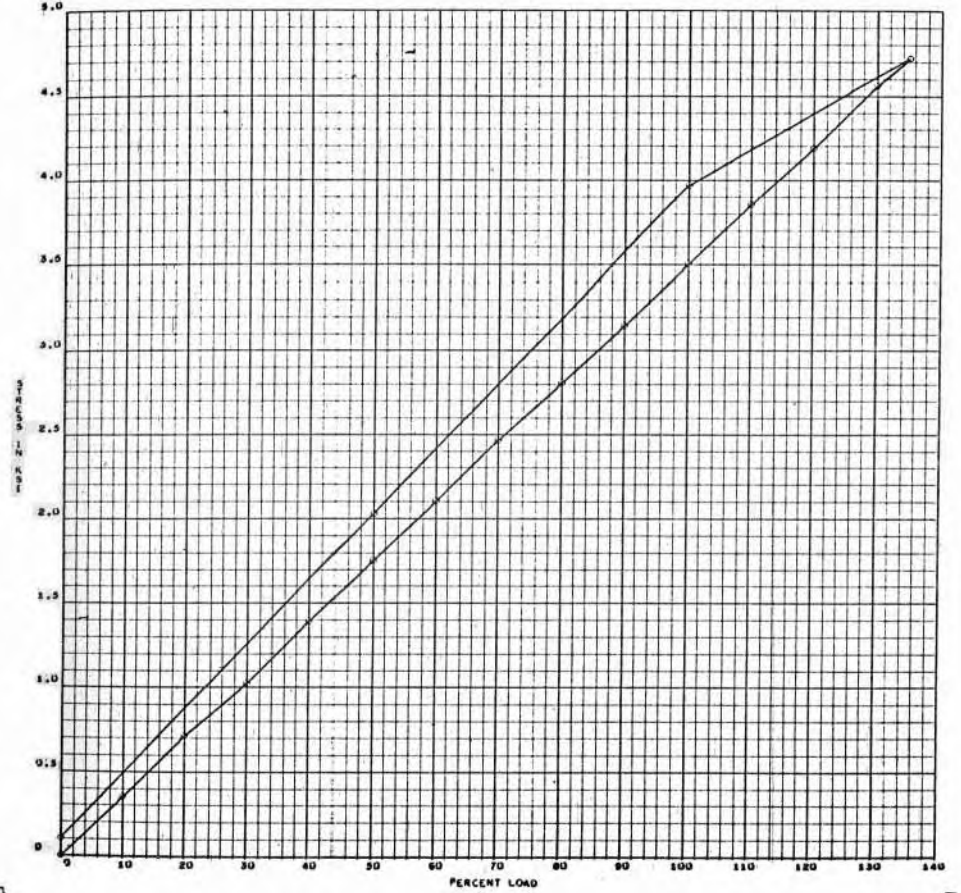
0238-02
008 000

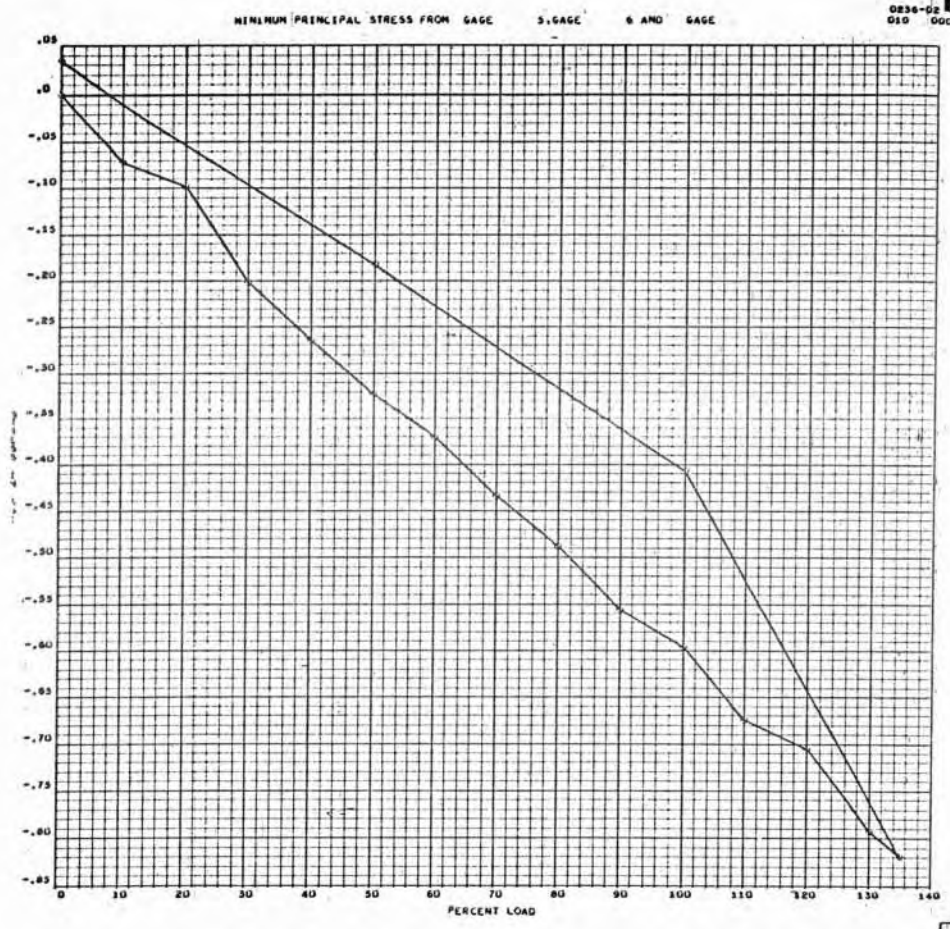
AXIAL STRESS ALONG GAGE 7 AXIS



0238-02
009 000

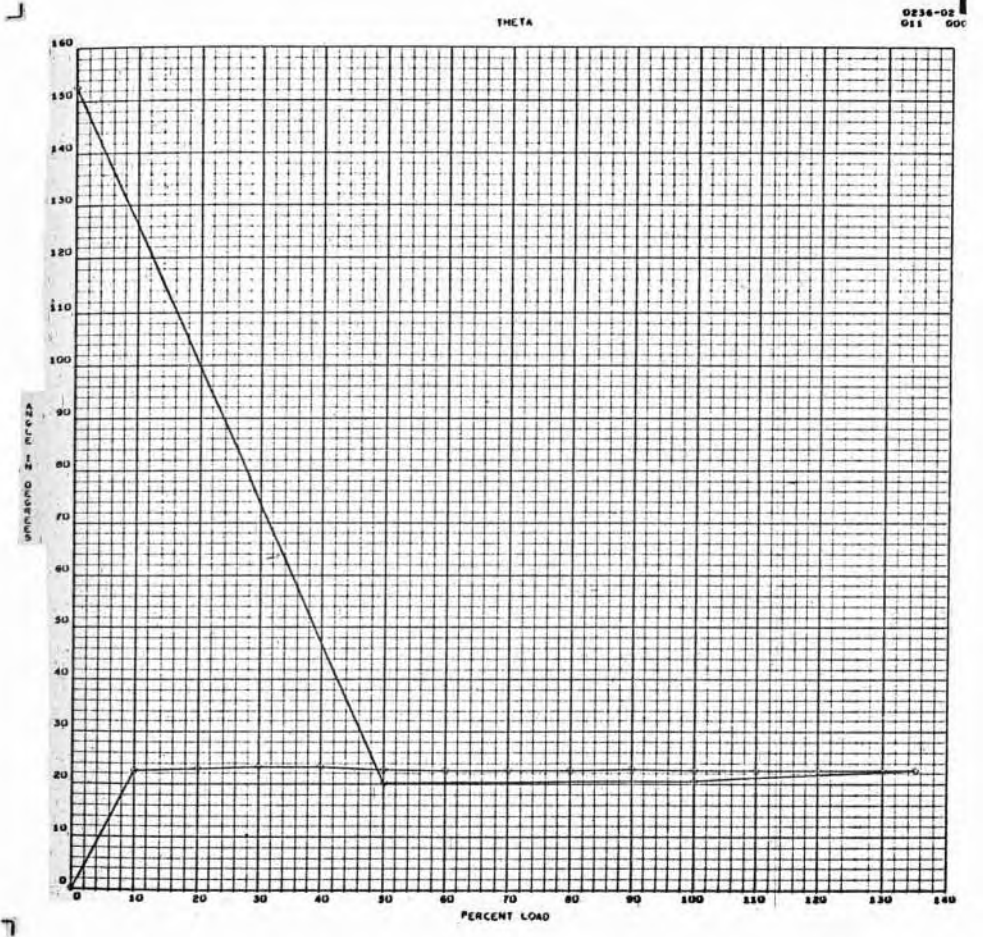
MAXIMUM PRINCIPAL STRESS FROM GAGE 5, GAGE 6 AND GAGE





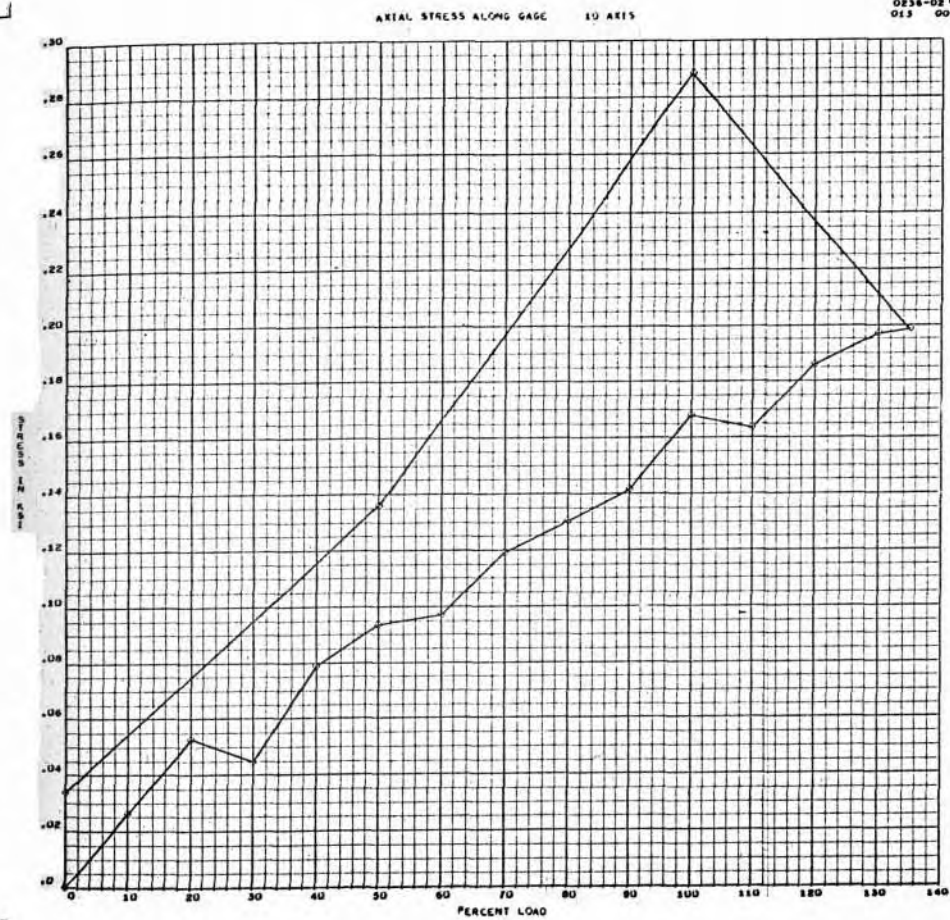
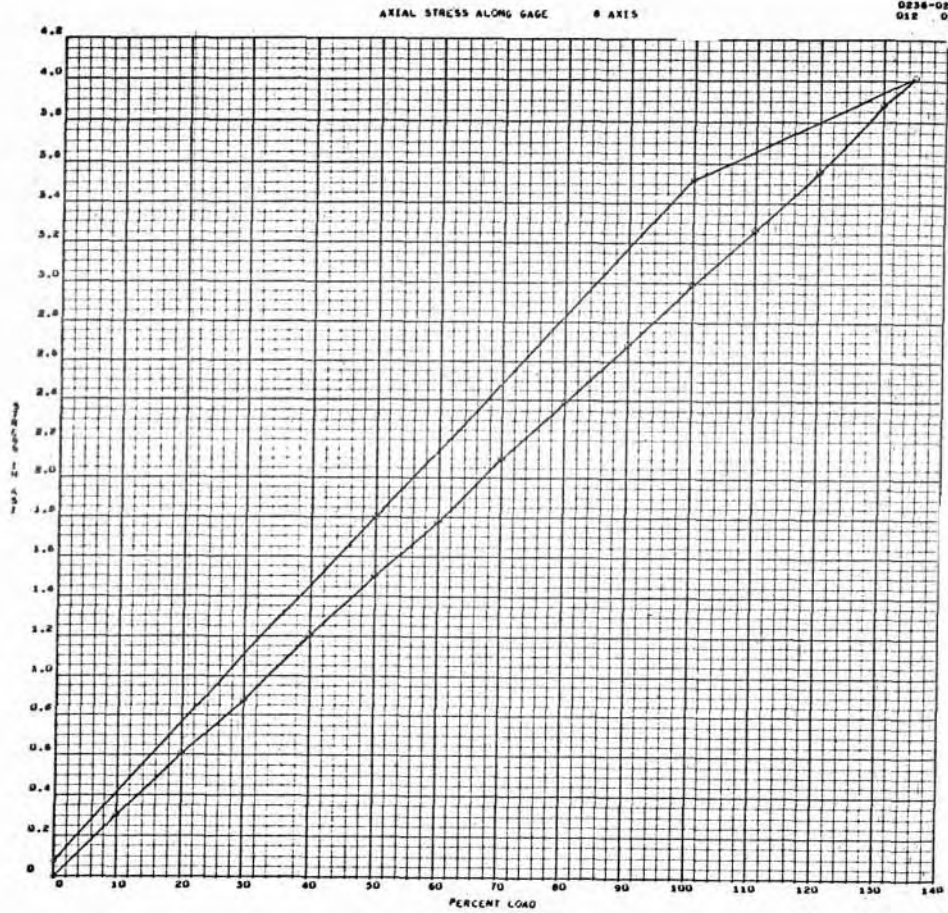
- A 125 -

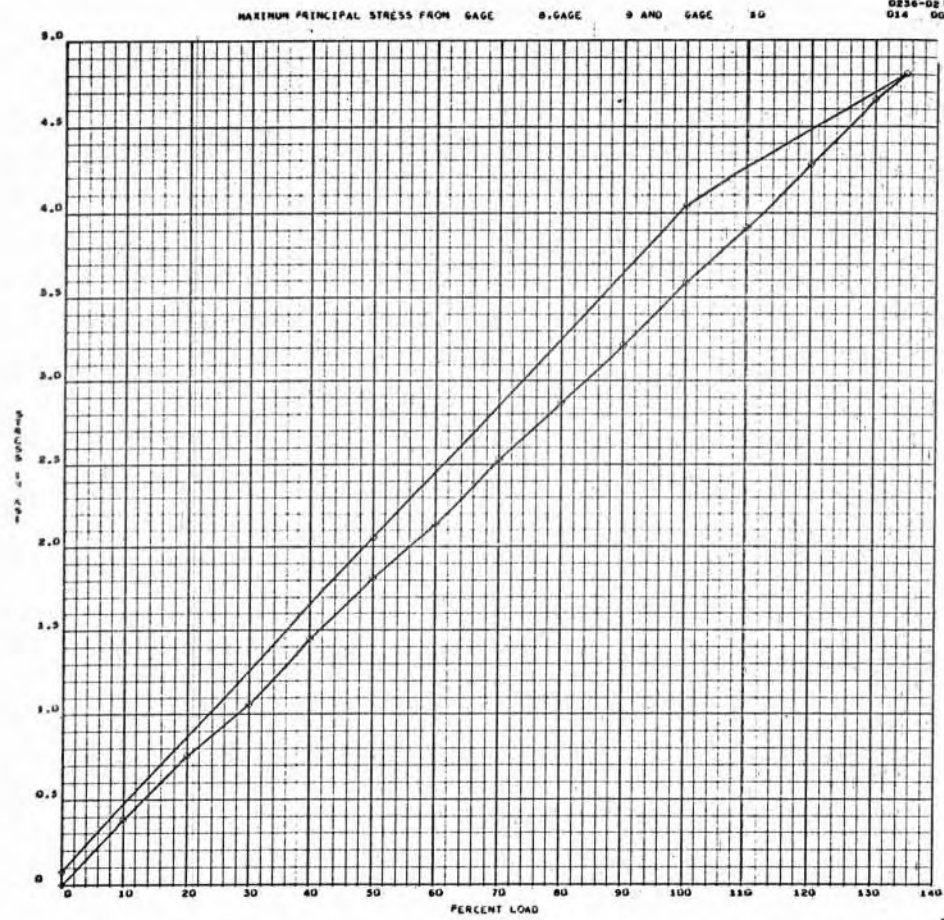
SID 67-318



- A 126 -

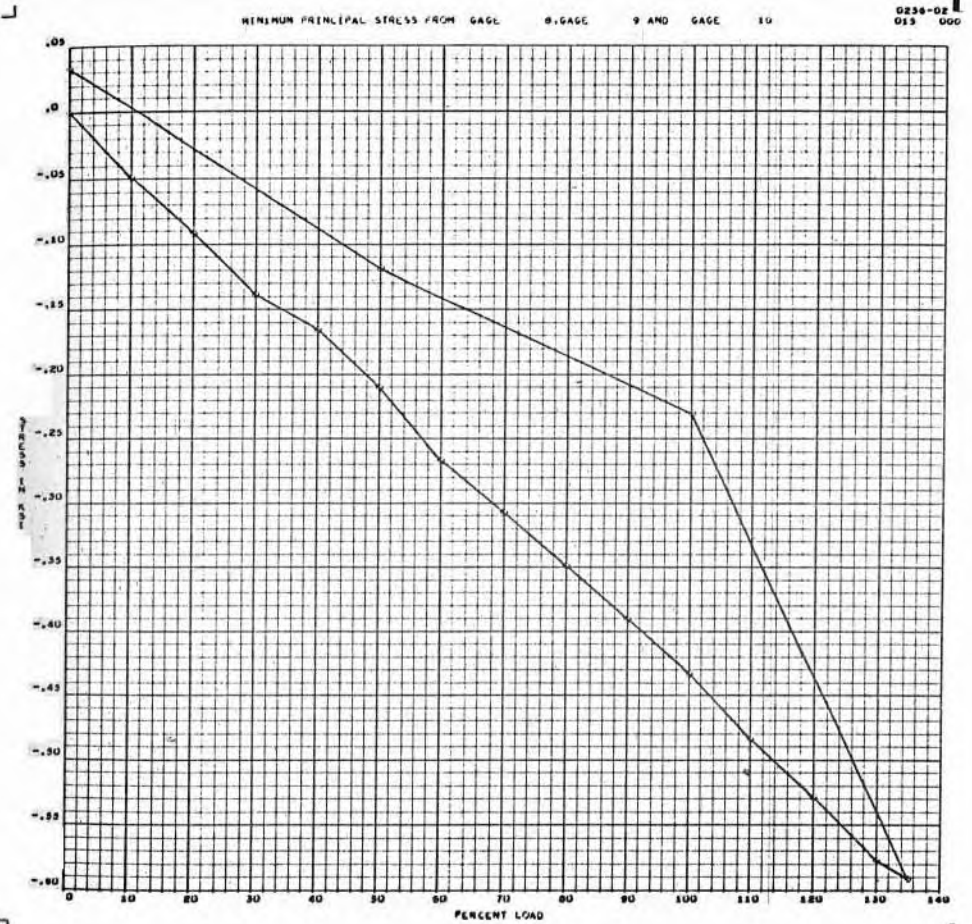
SID 67-318





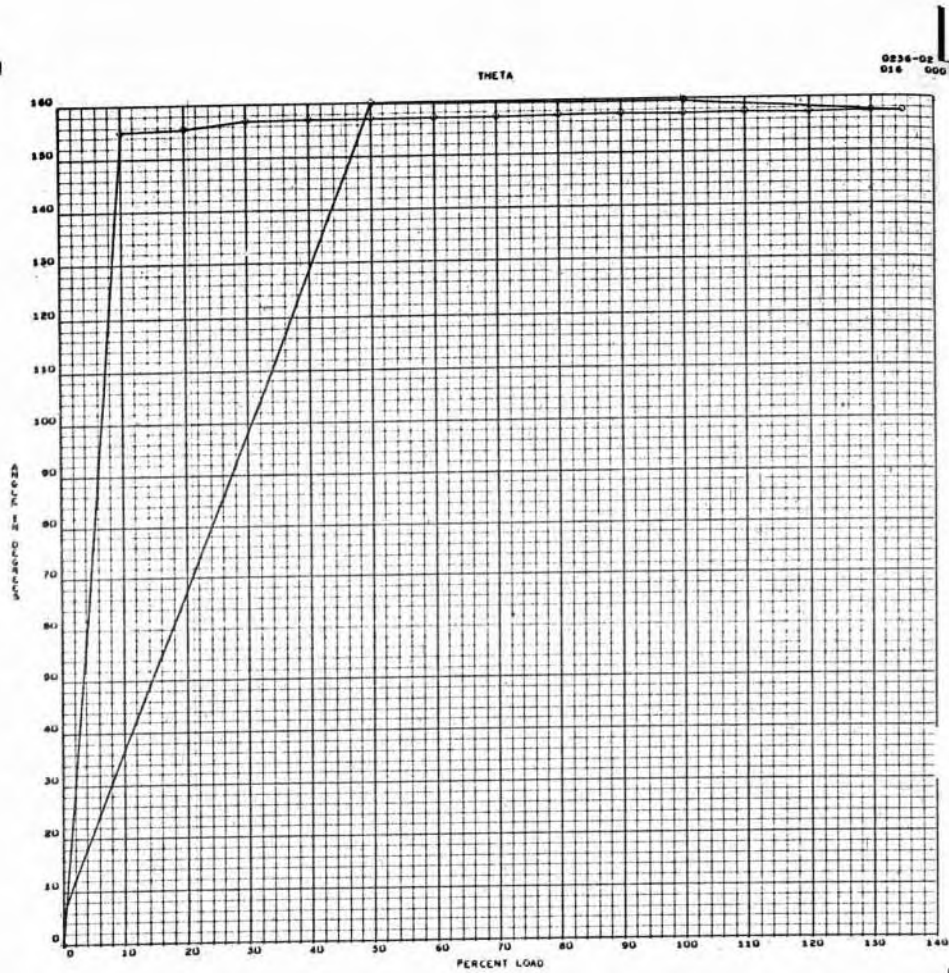
- A 129 -

SID 67-318



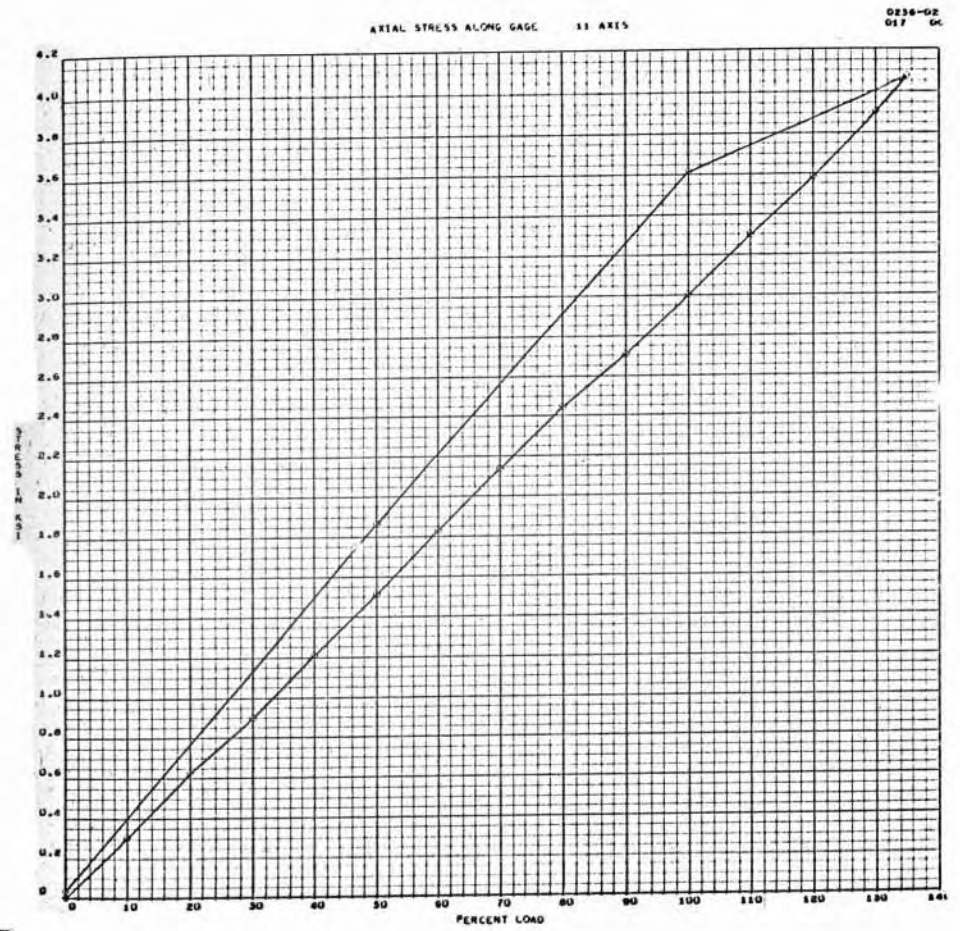
- A 130 -

SID 67-318



- A 131 -

SID 67-318

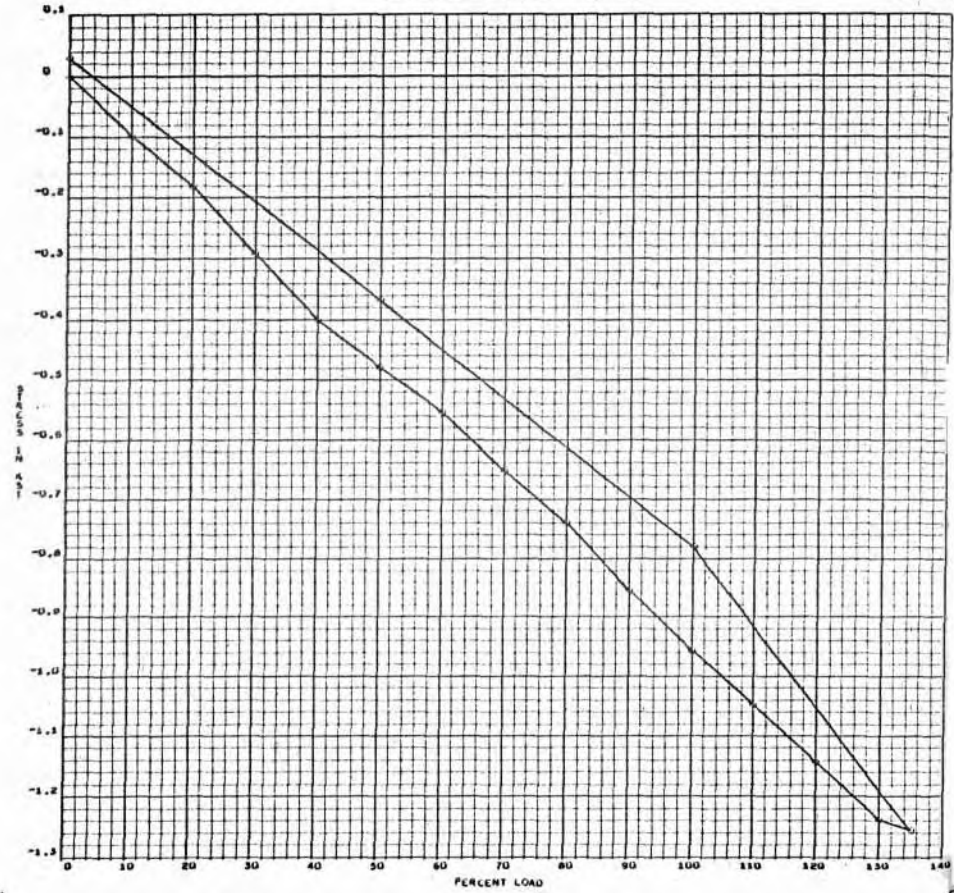


- A 132 -

SID 67-318

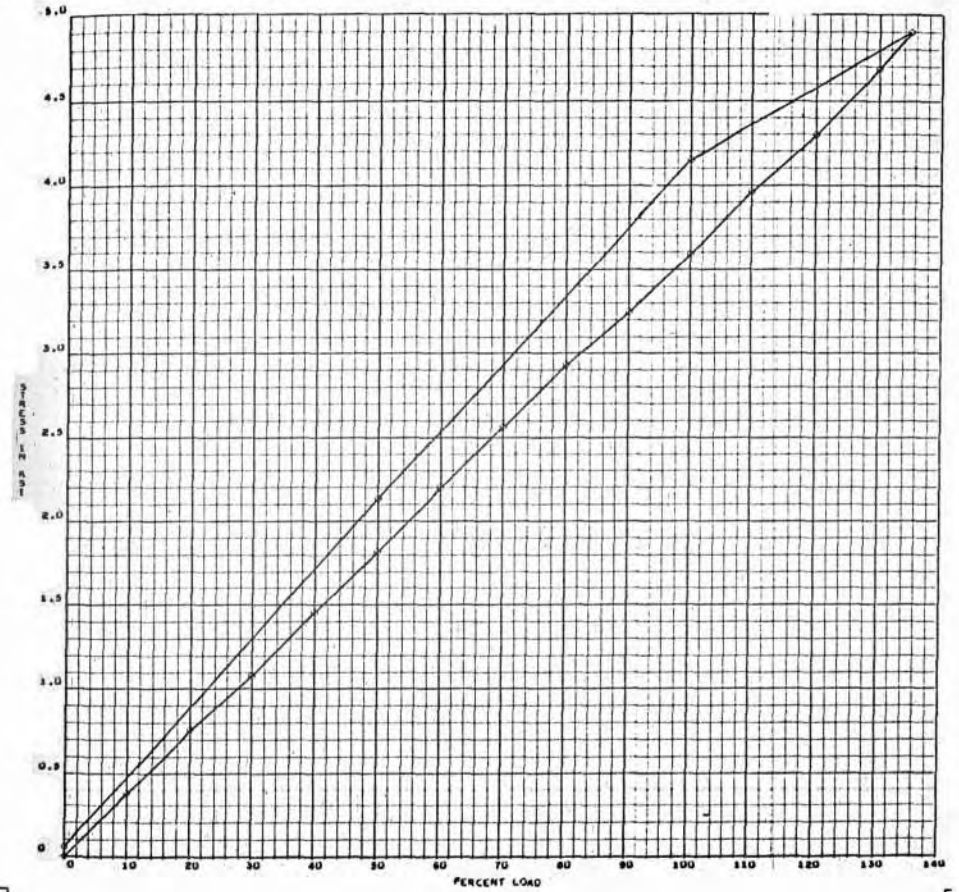
AXIAL STRESS ALONG GAGE 13 AXIS

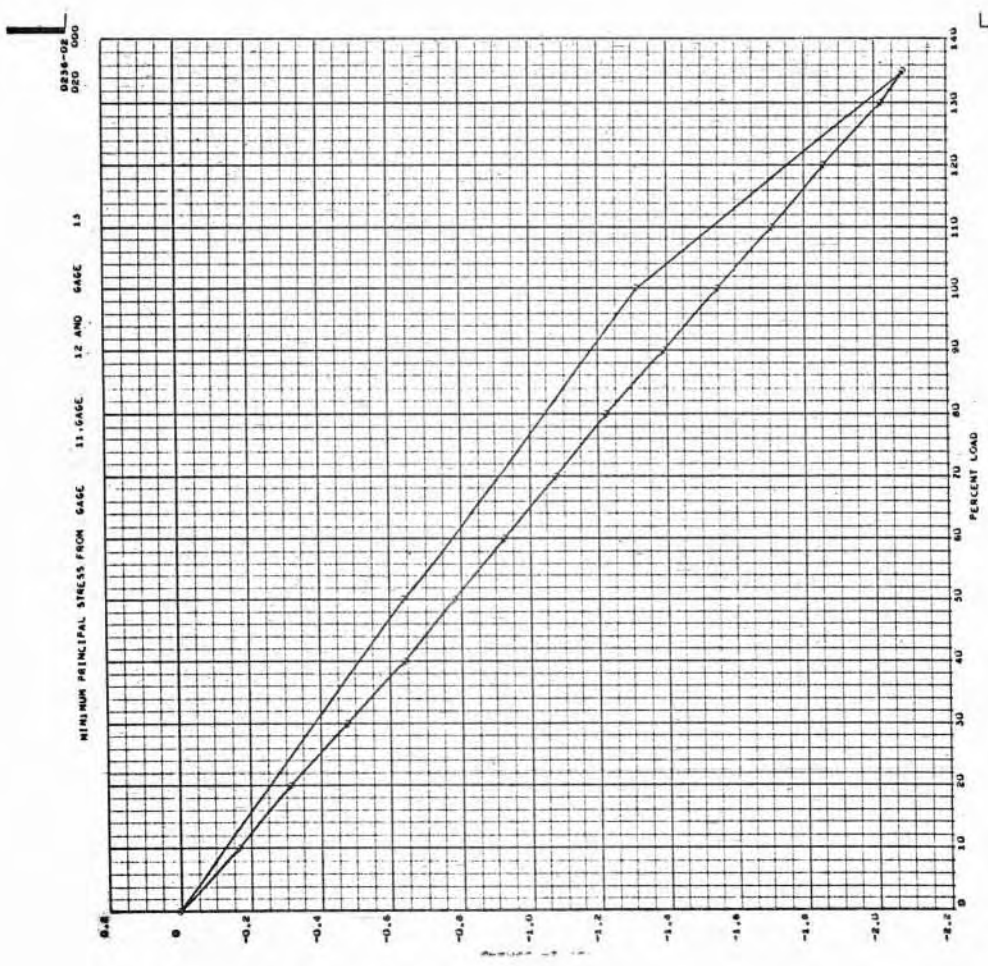
0236-02
019 000



MAXIMUM PRINCIPAL STRESS FROM GAGE 11, GAGE 12 AND GAGE 13

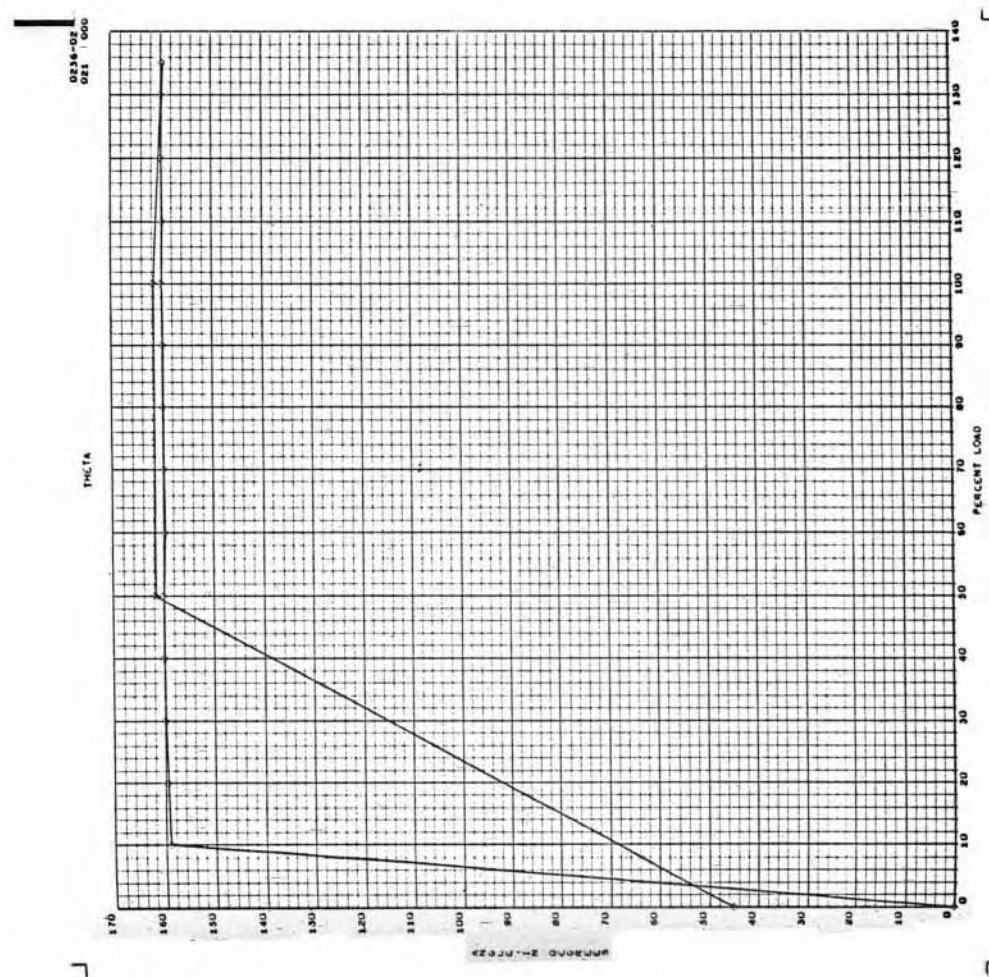
0236-02
019 000





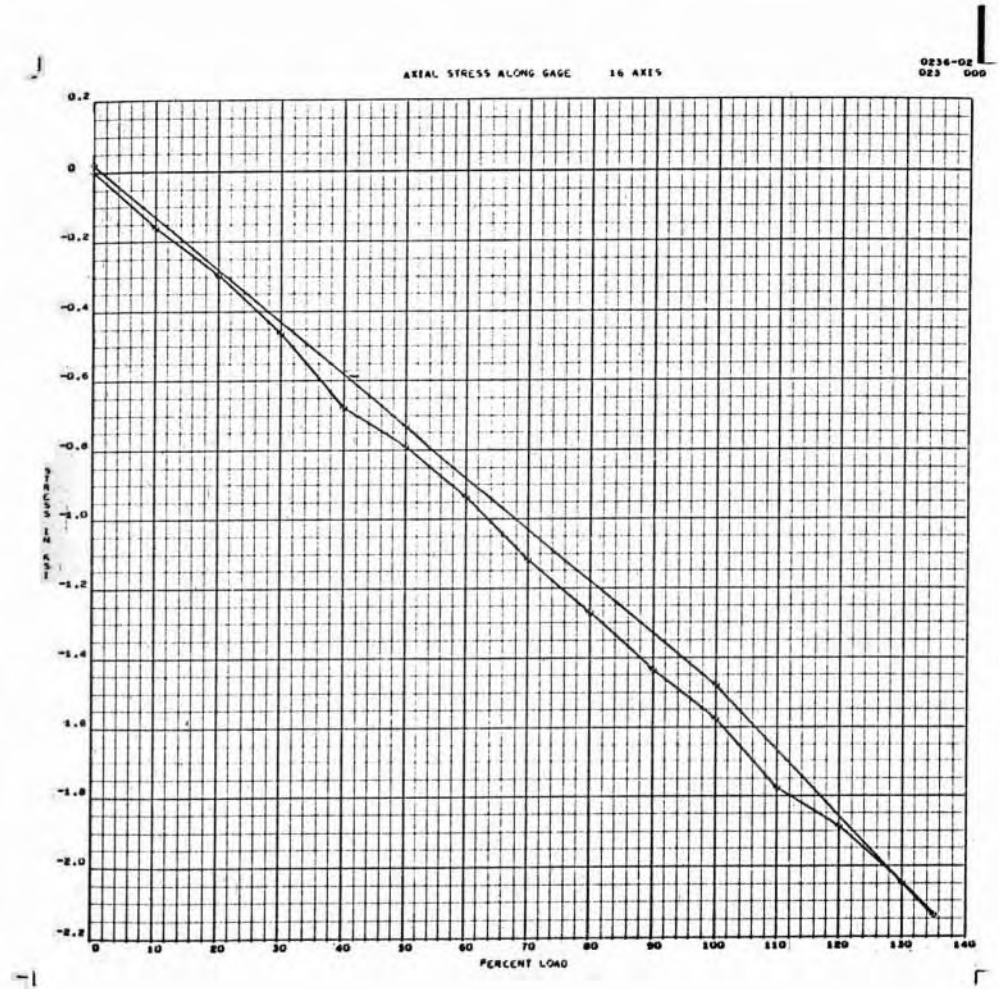
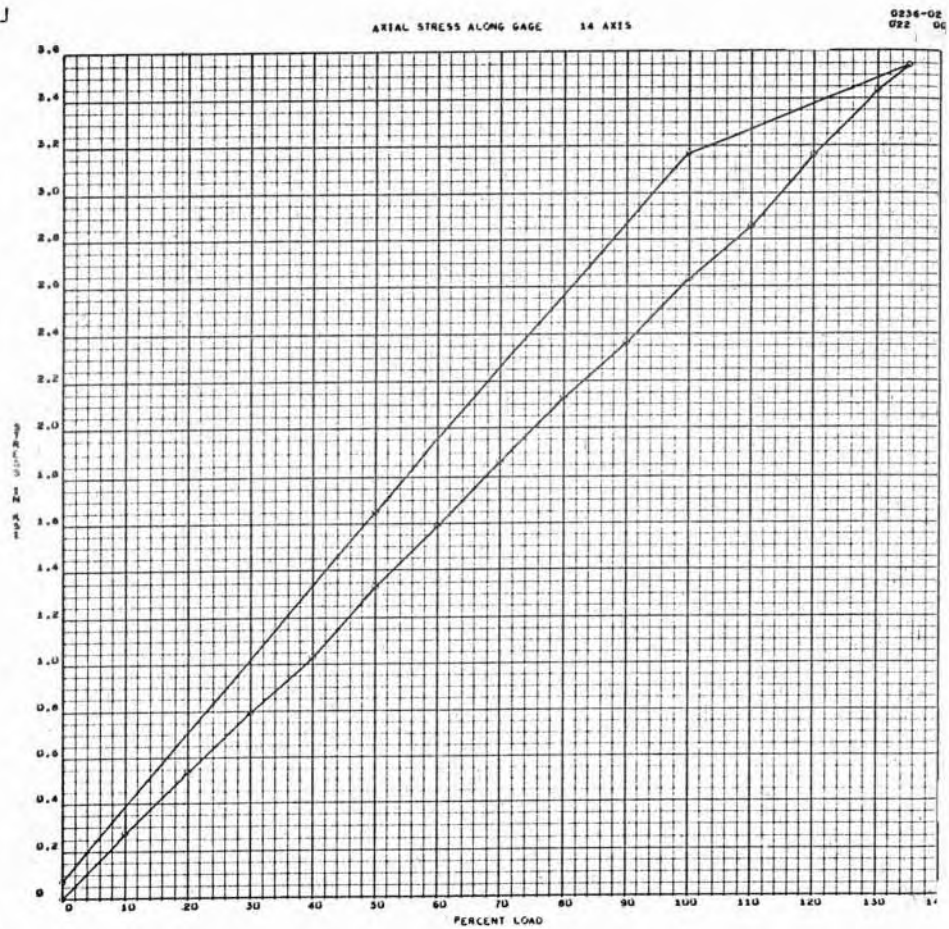
- A 135 -

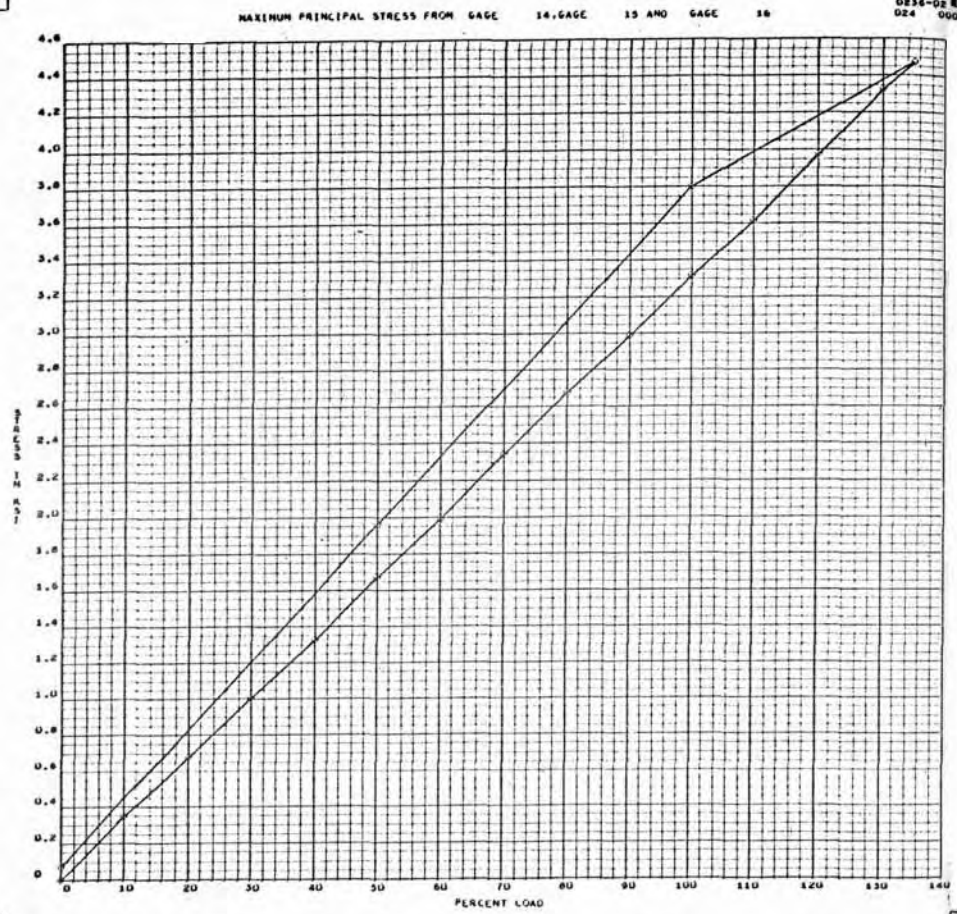
SID 67-318



- A 136 -

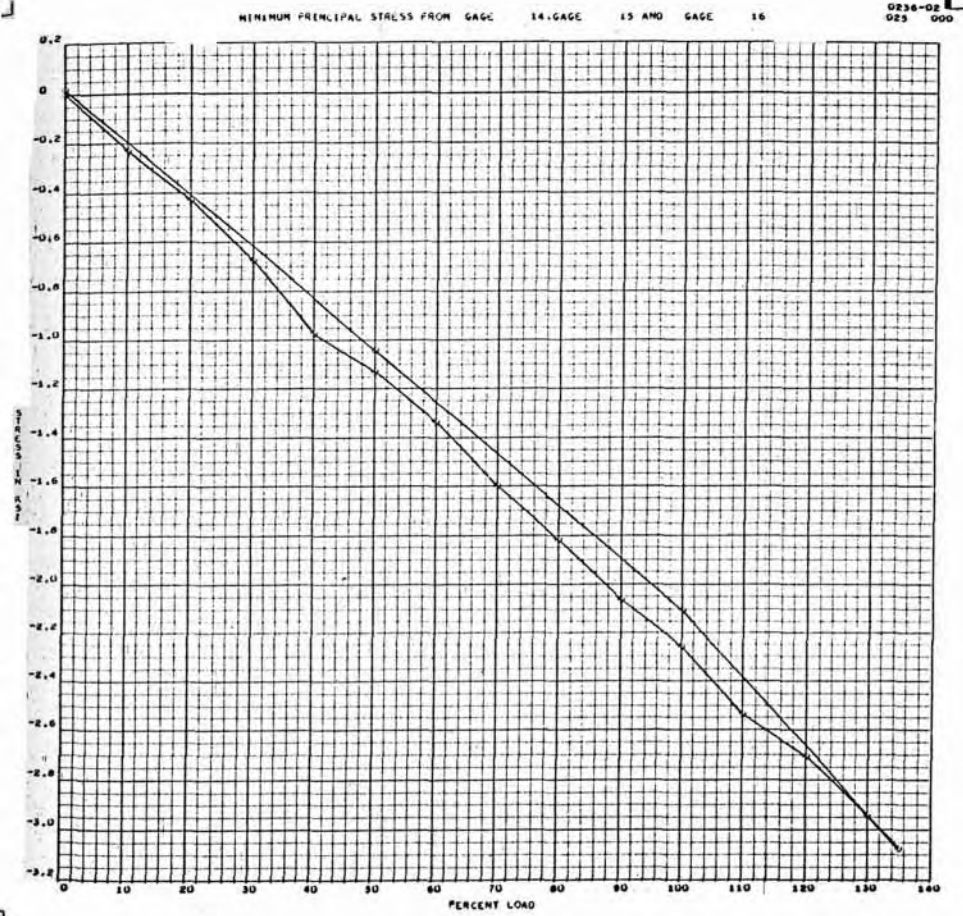
SID 67-318





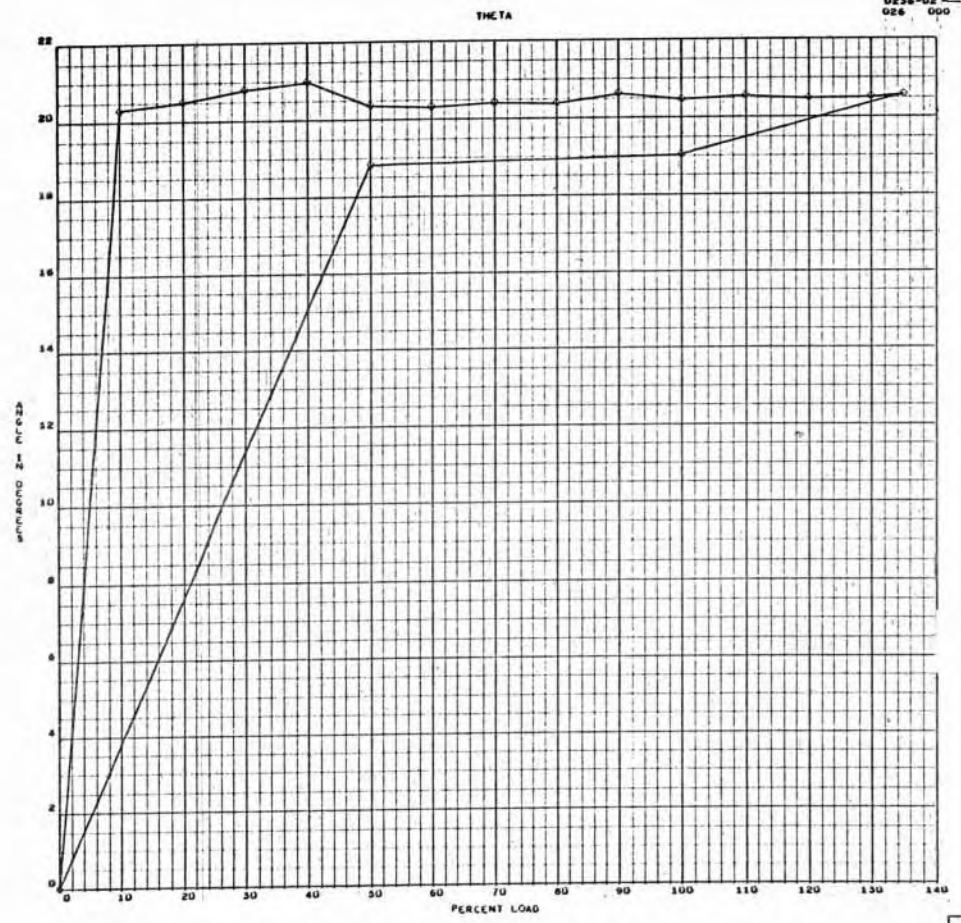
- A 139 -

SID 67-318



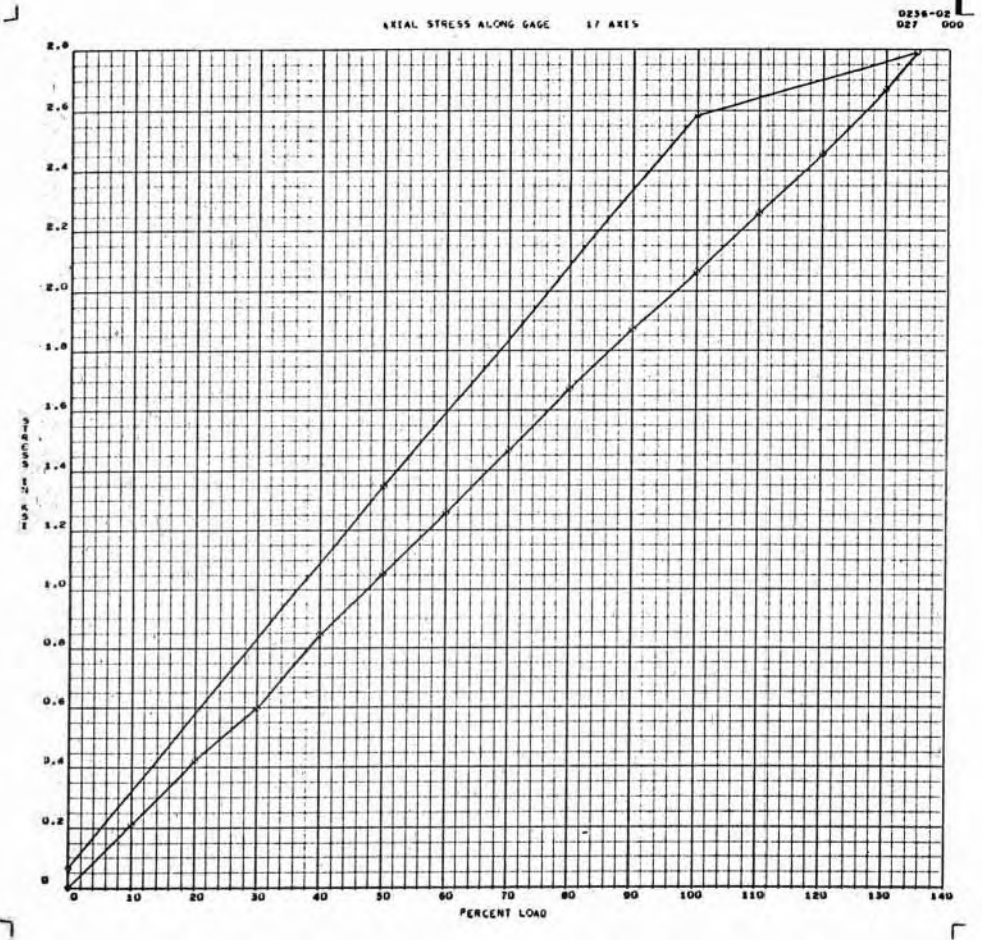
- A 140 -

SID 67-318



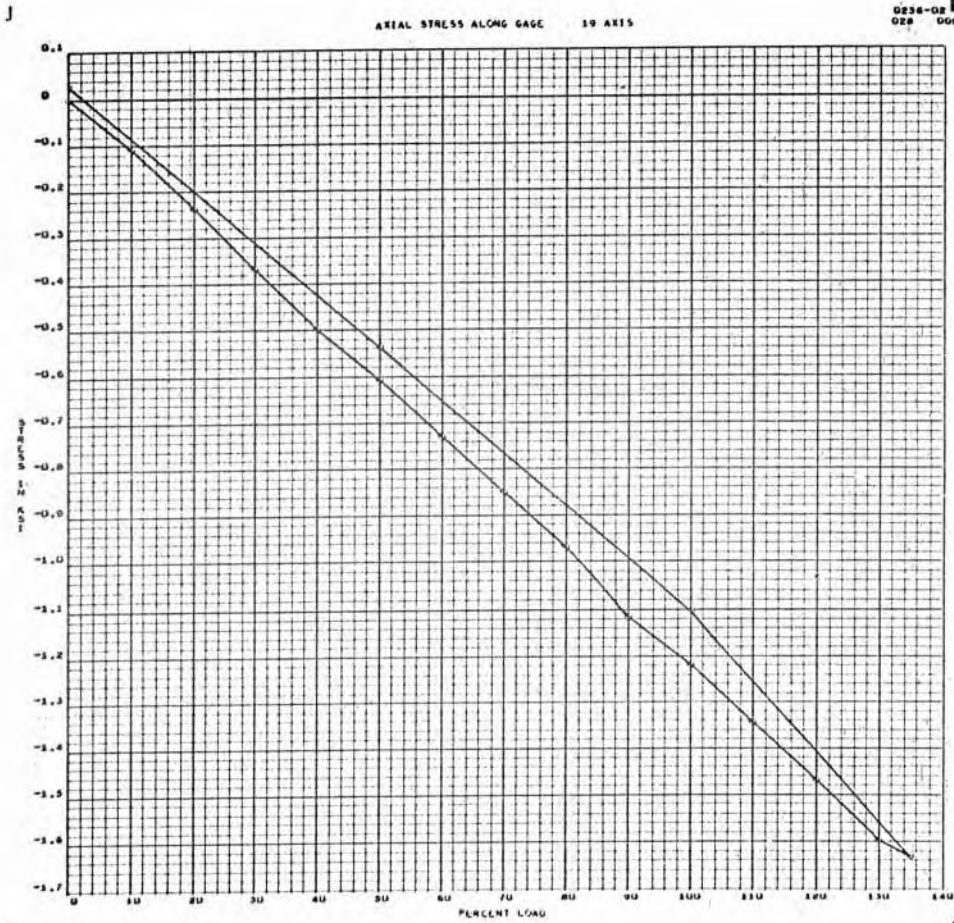
- A 141 -

SID 67-318



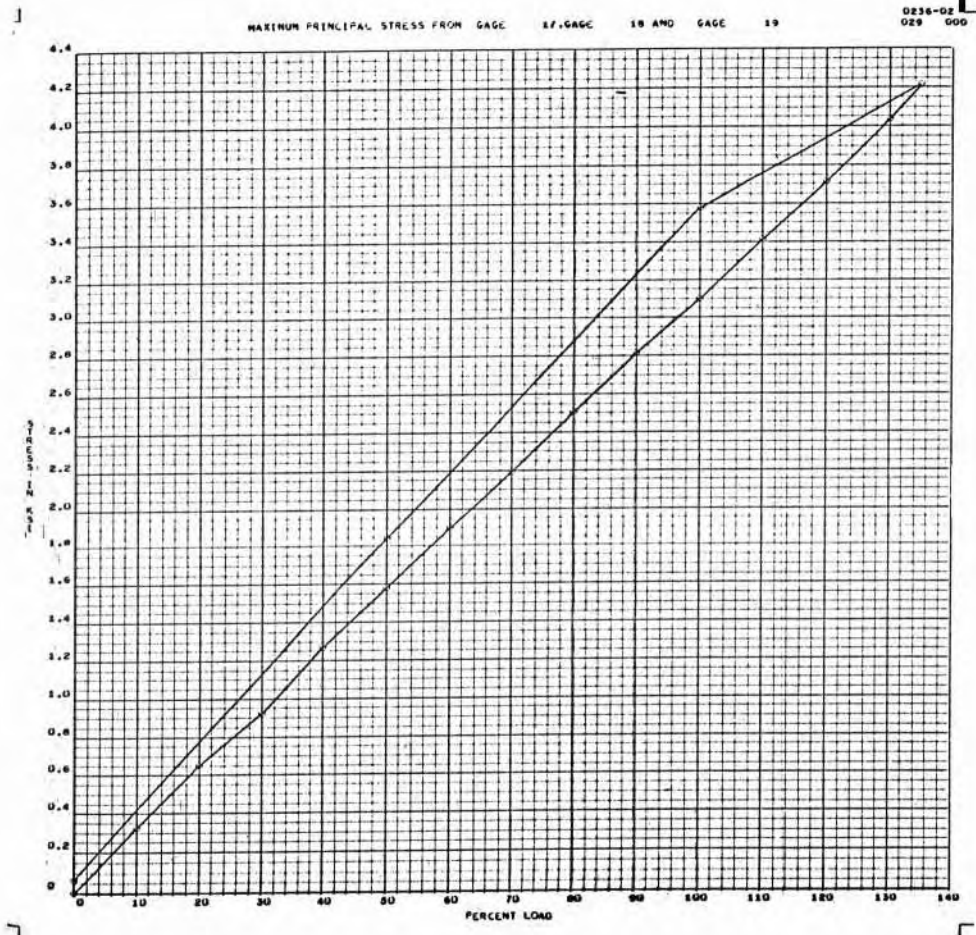
- A 142 -

SID 67-318



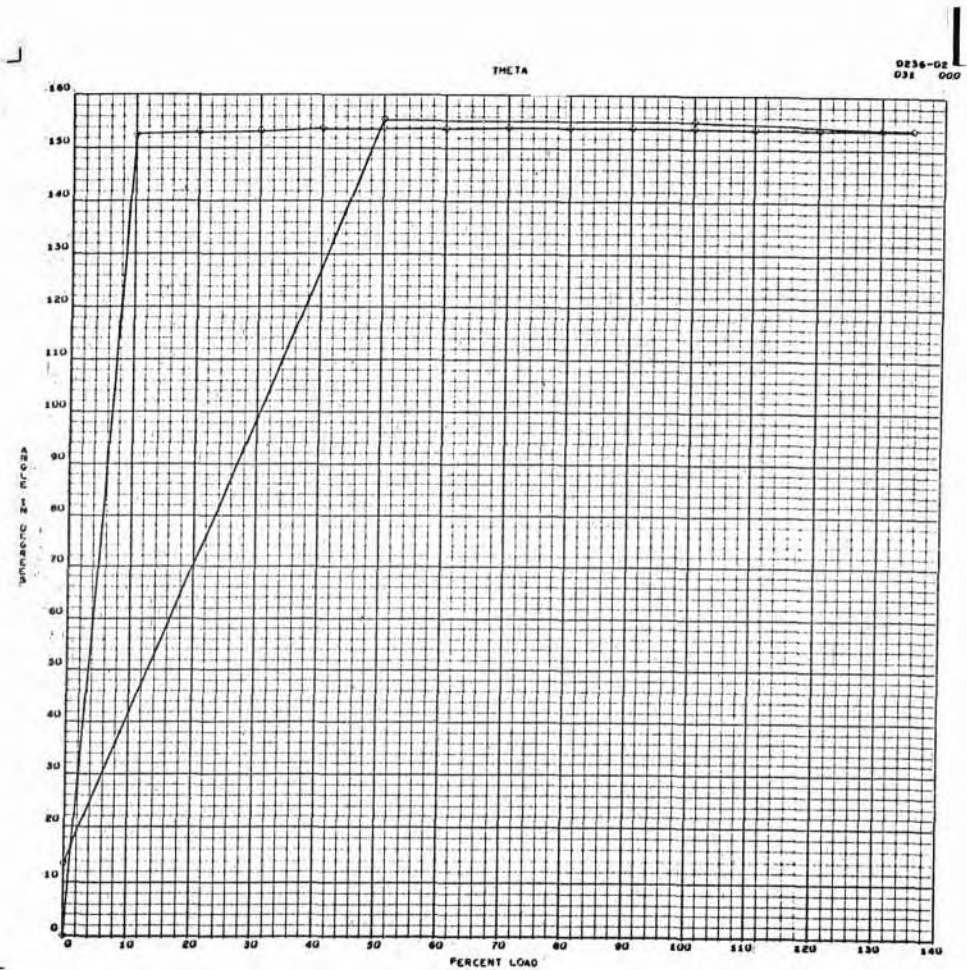
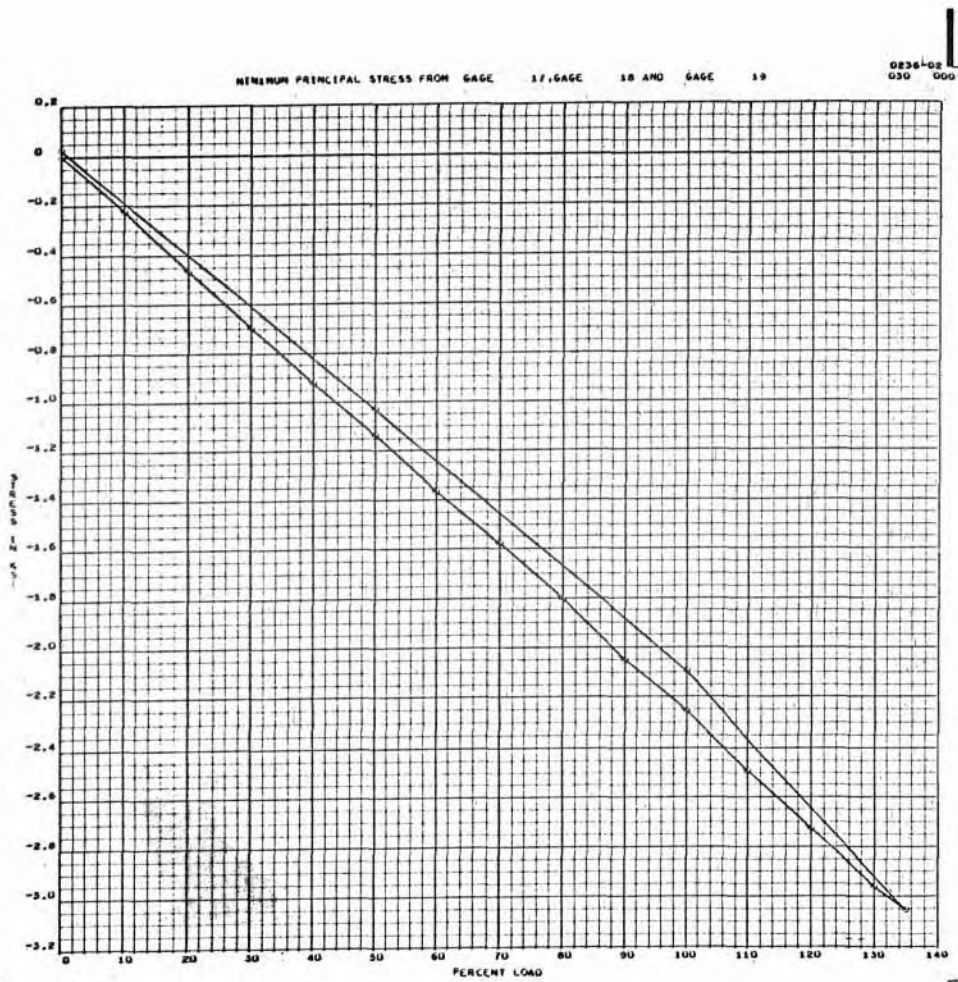
- A 143 -

SID 67-318



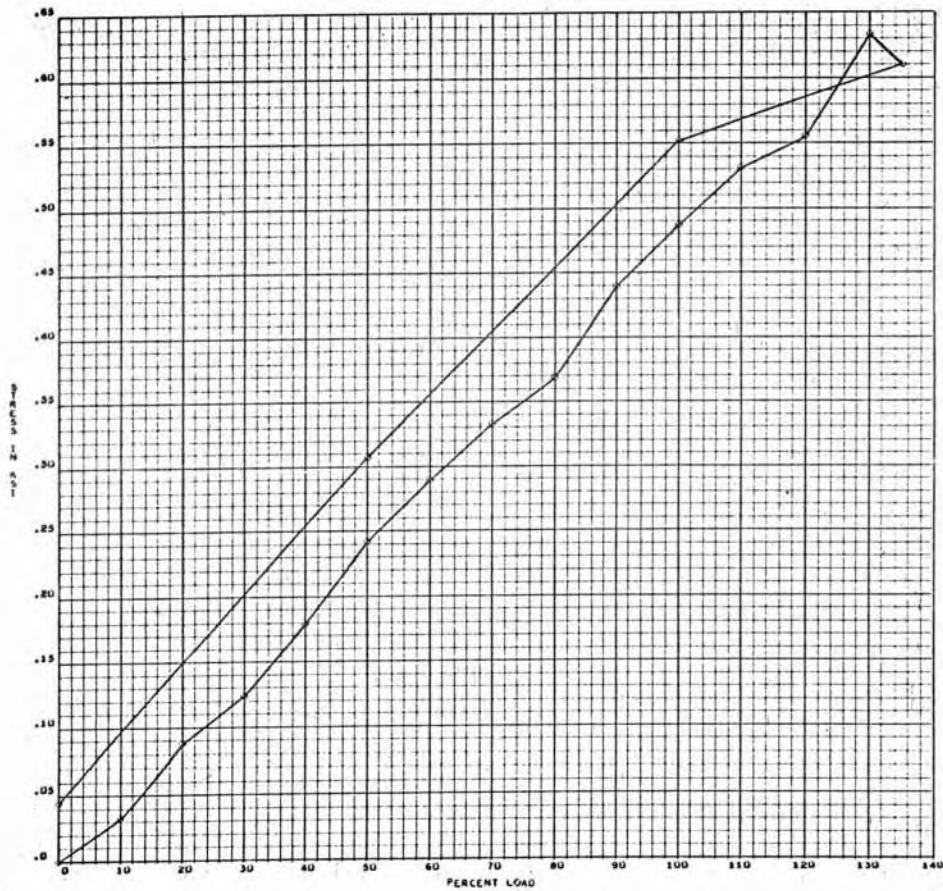
- A 144 -

SID 67-318



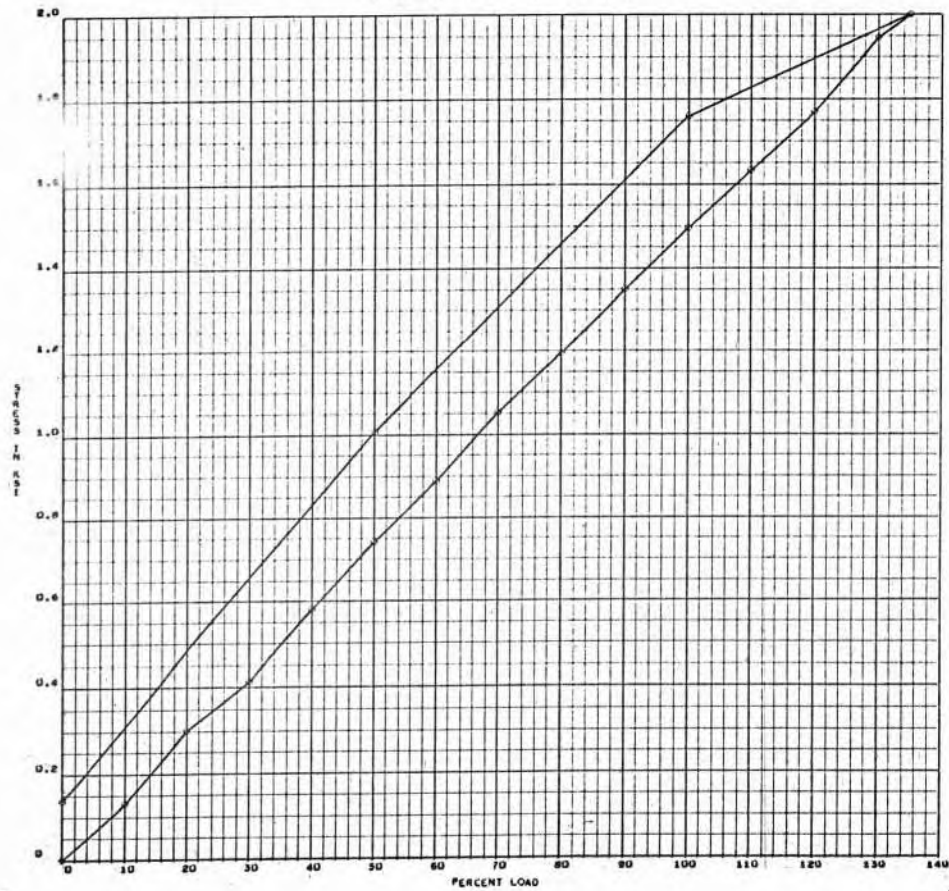
0238-02
032 000

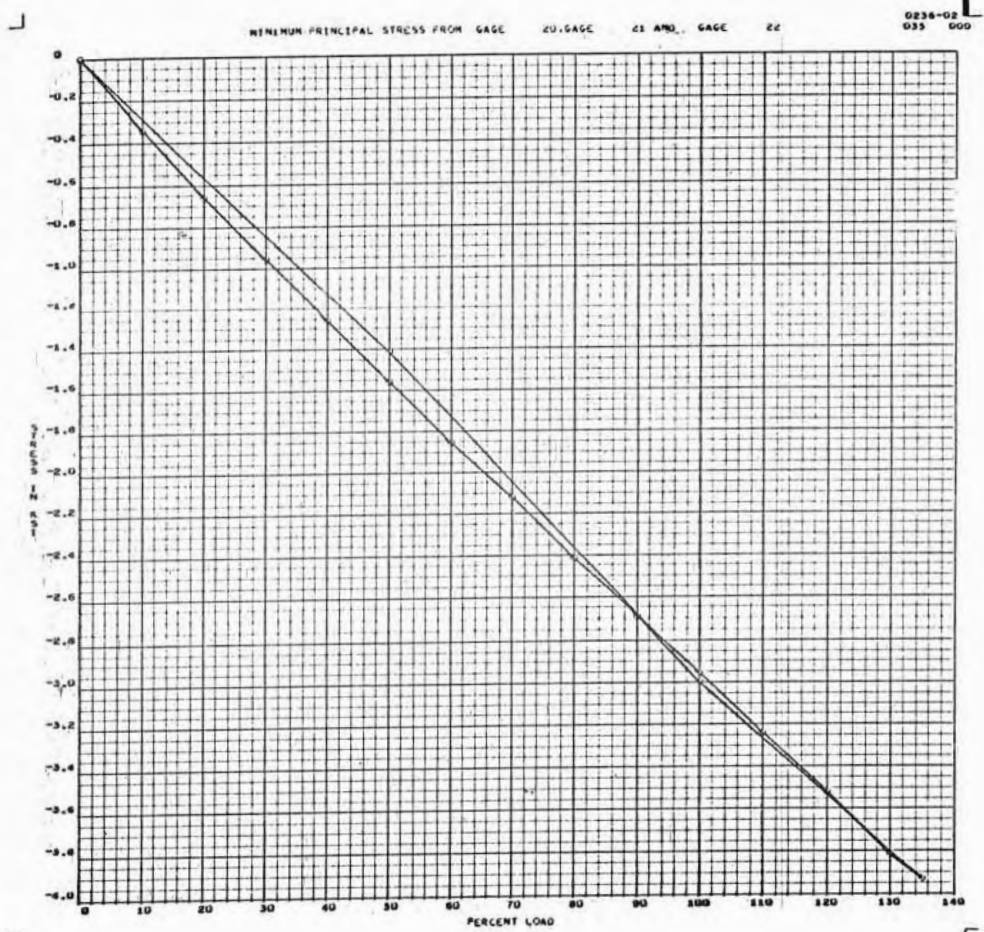
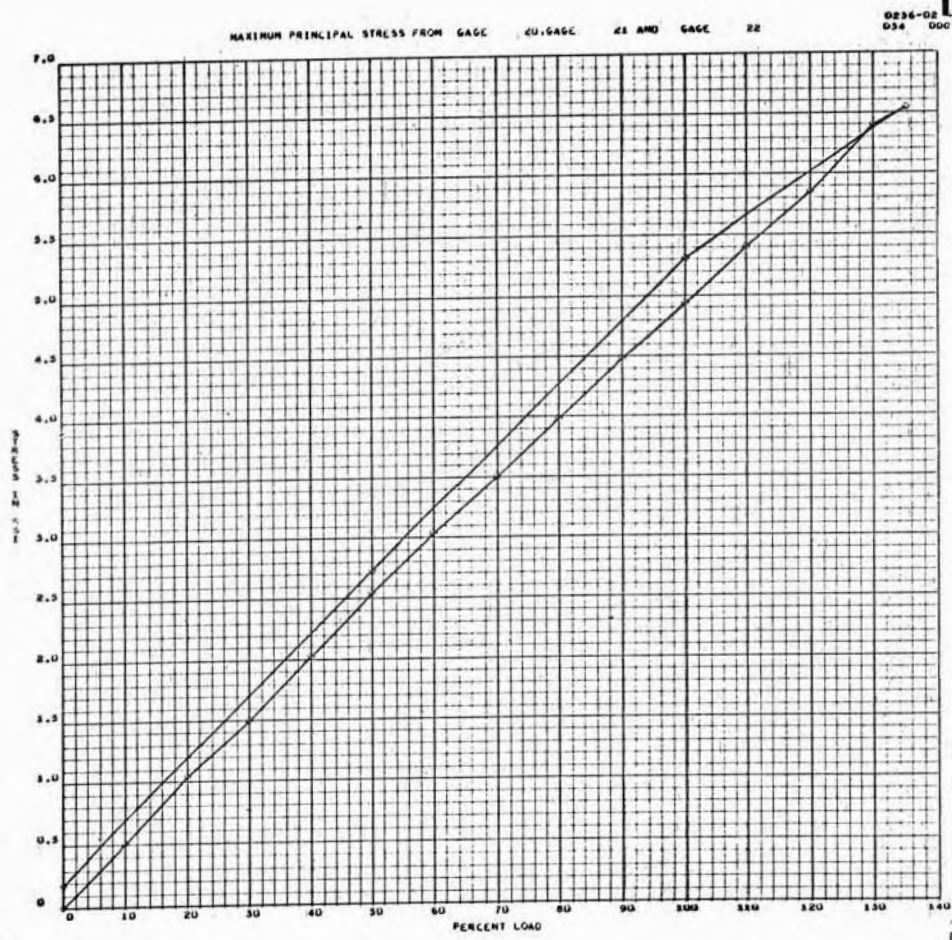
AXIAL STRESS ALONG GAGE ZU AXIS

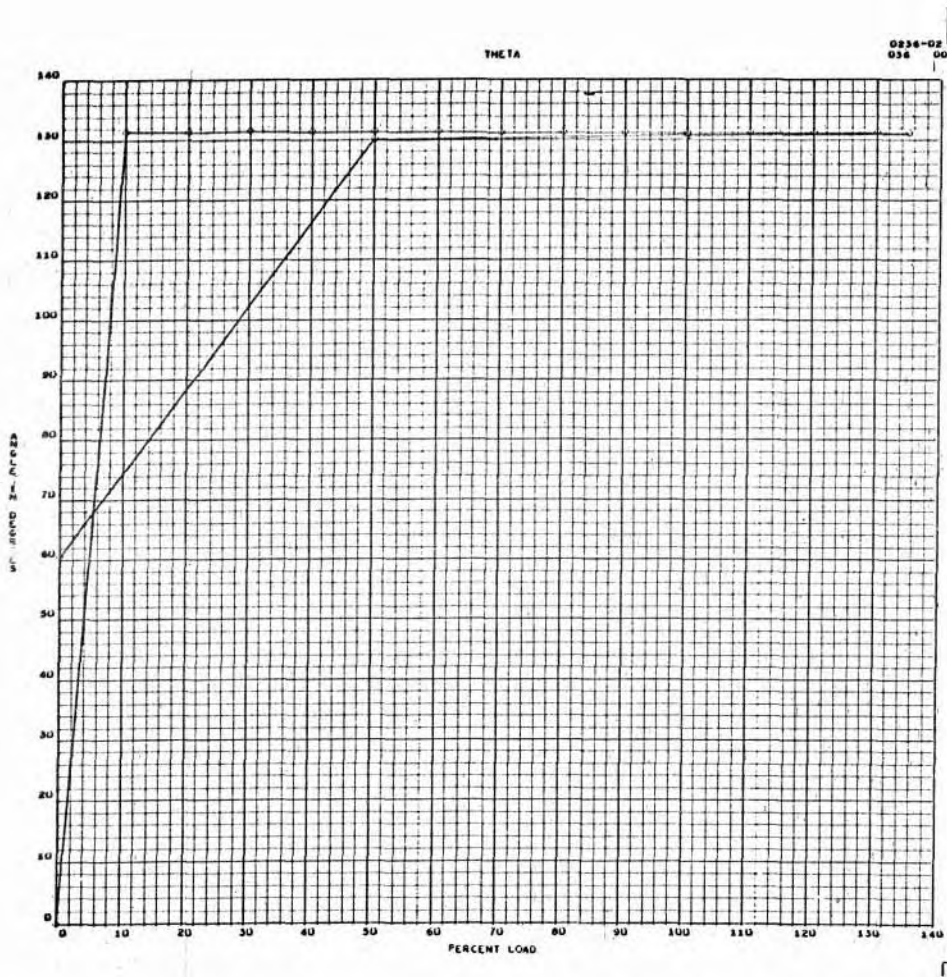


0238-02
033 000

AXIAL STRESS ALONG GAGE Z2 AXIS



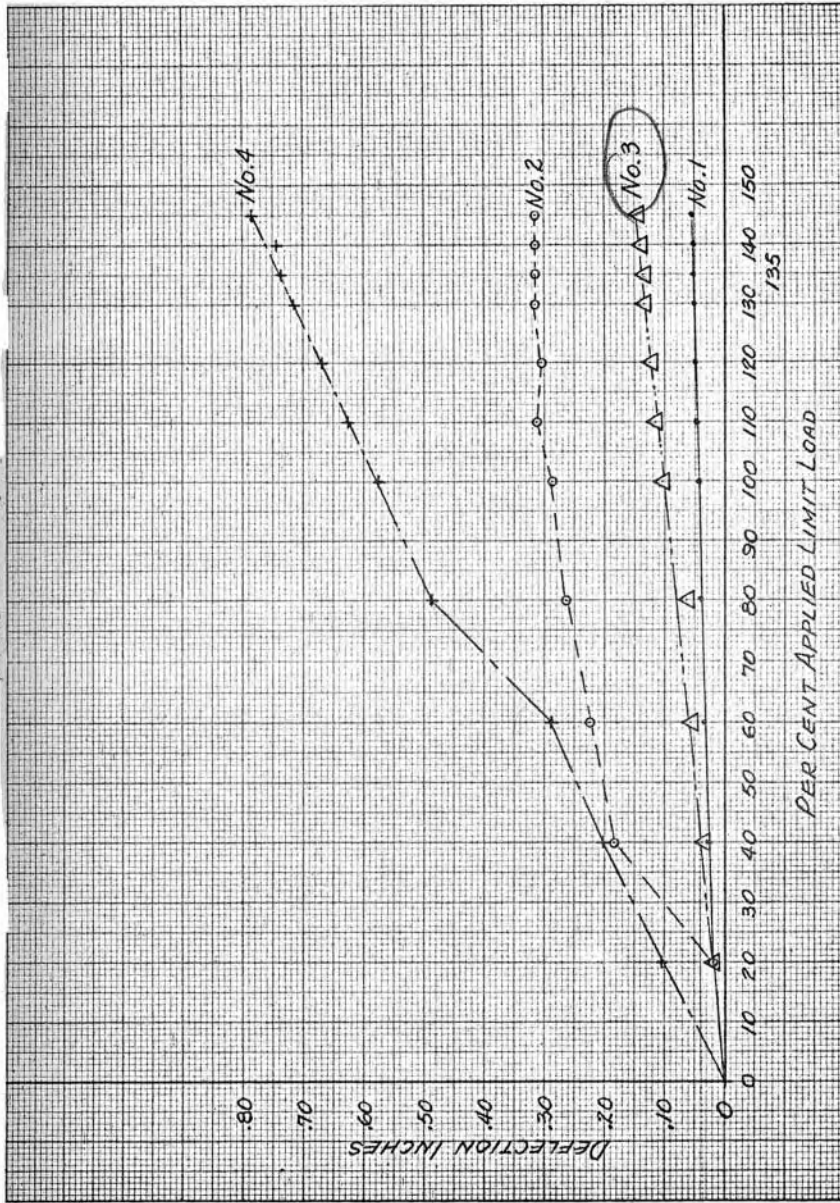




APPENDIX A

TEST CONDITION IA 150 PERCENT

10018-2735



PER CENT APPLIED LIMIT LOAD

TEST CONDITION IA - 150 PERCENT

N.A.A.

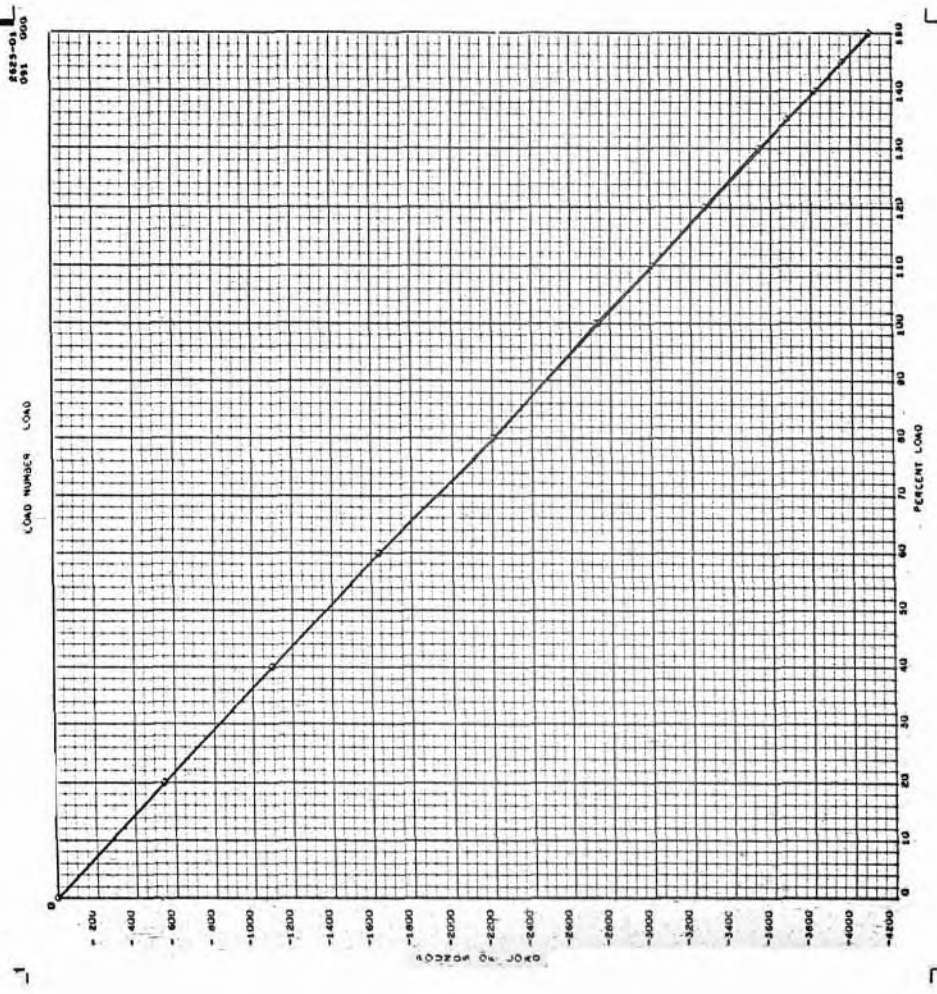
SEND TO RUMBERMOUNT B1

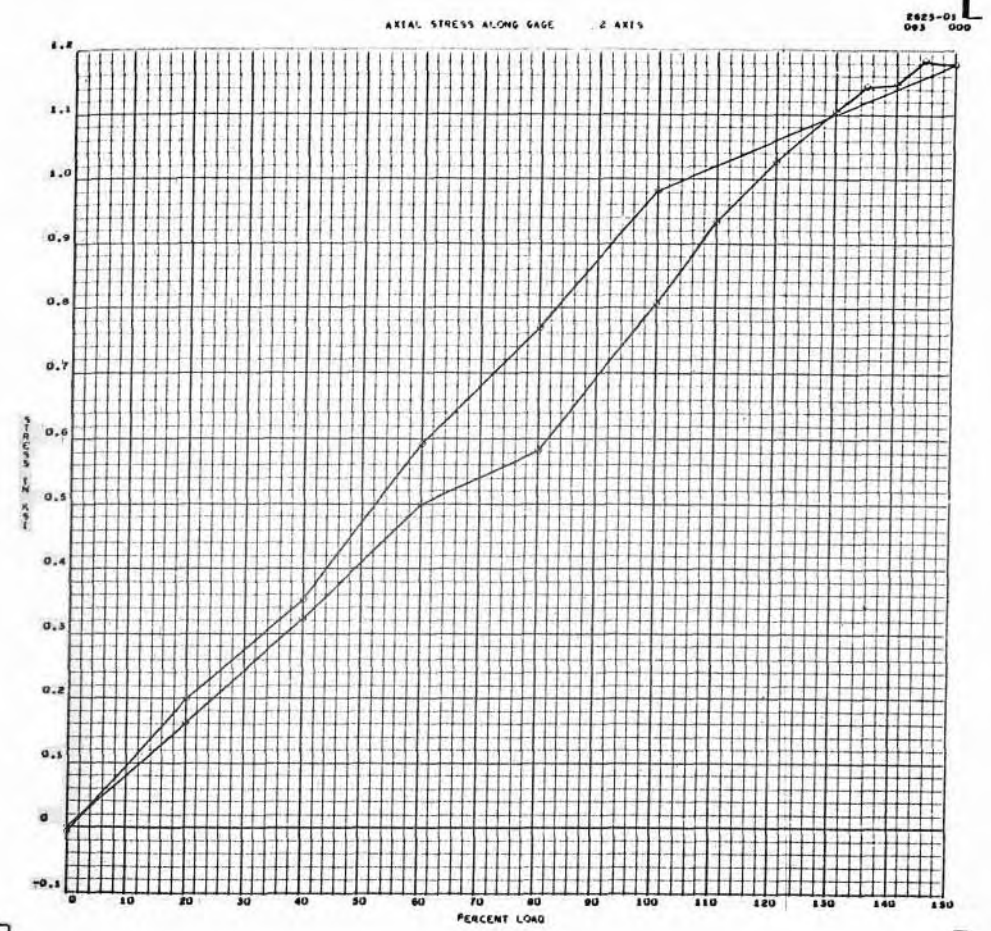
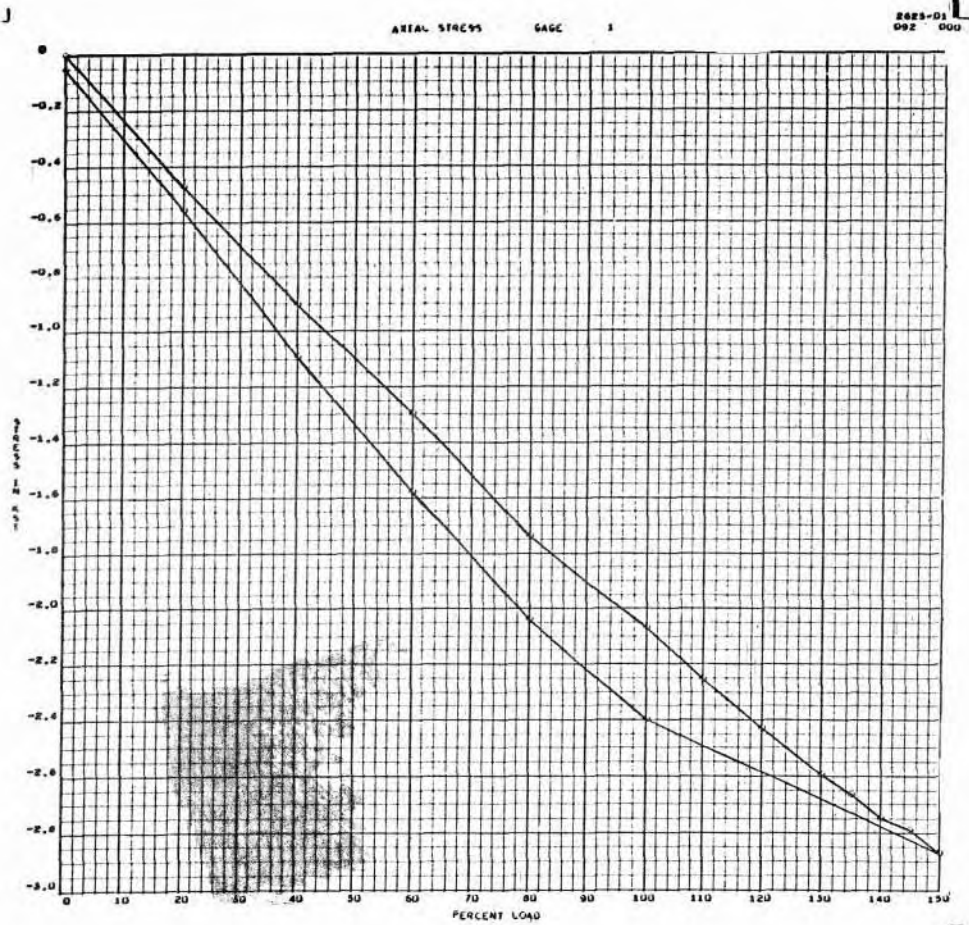
DEPT-GROUP U98 432

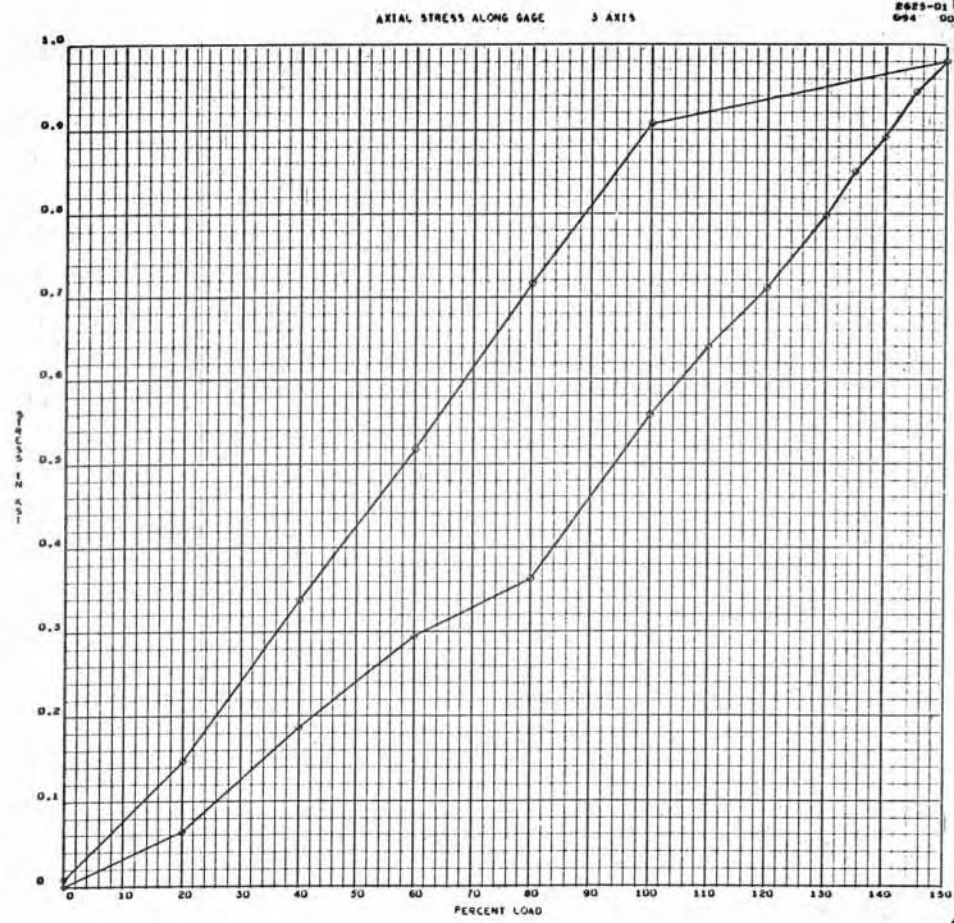
0236-02

BOX NO. 101

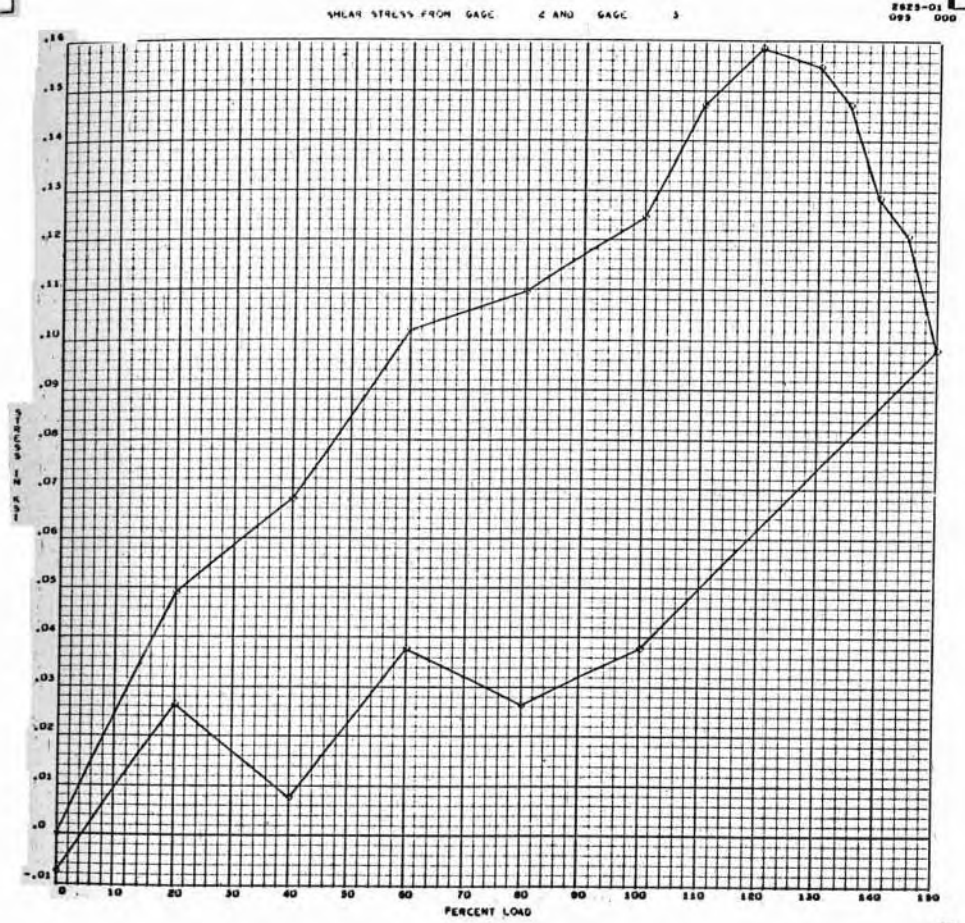
DATE 02/02/67



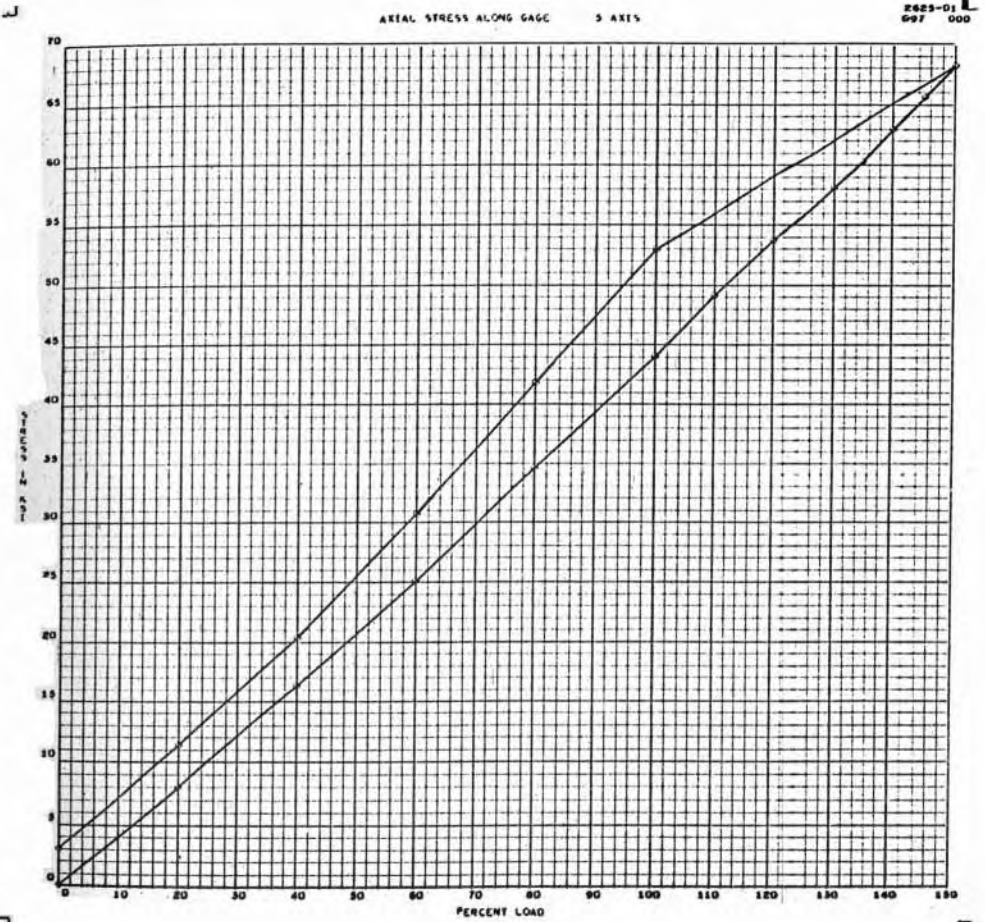
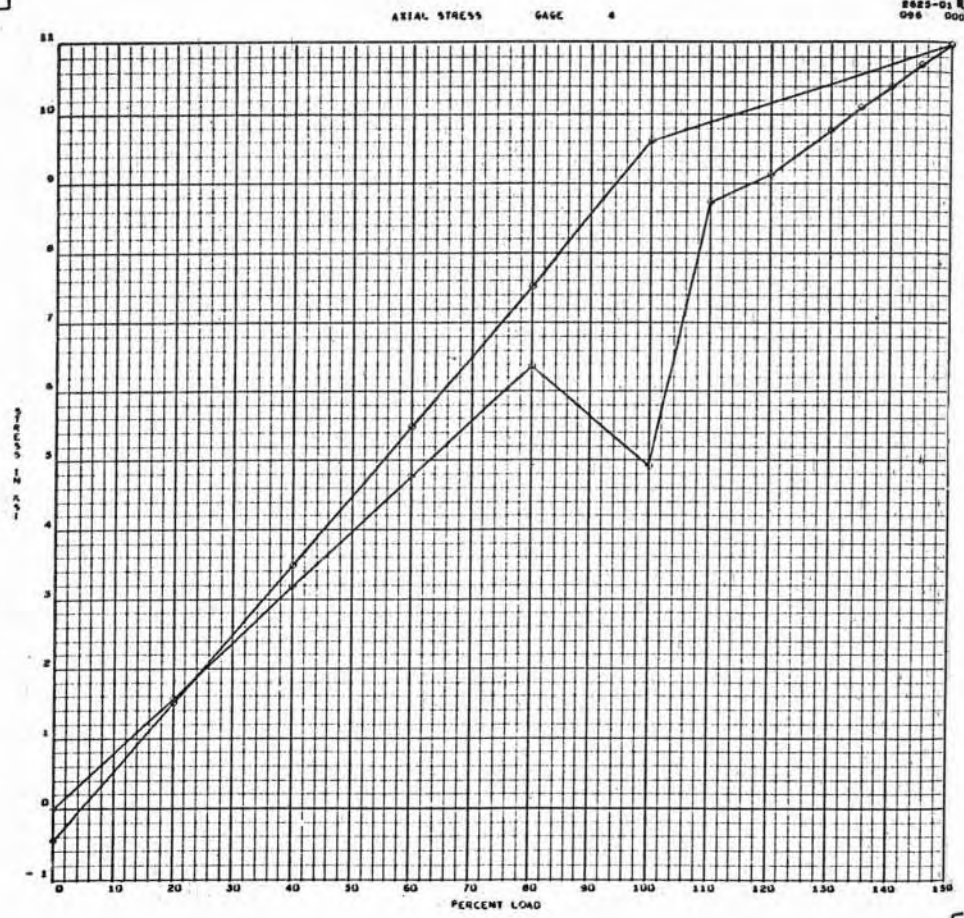


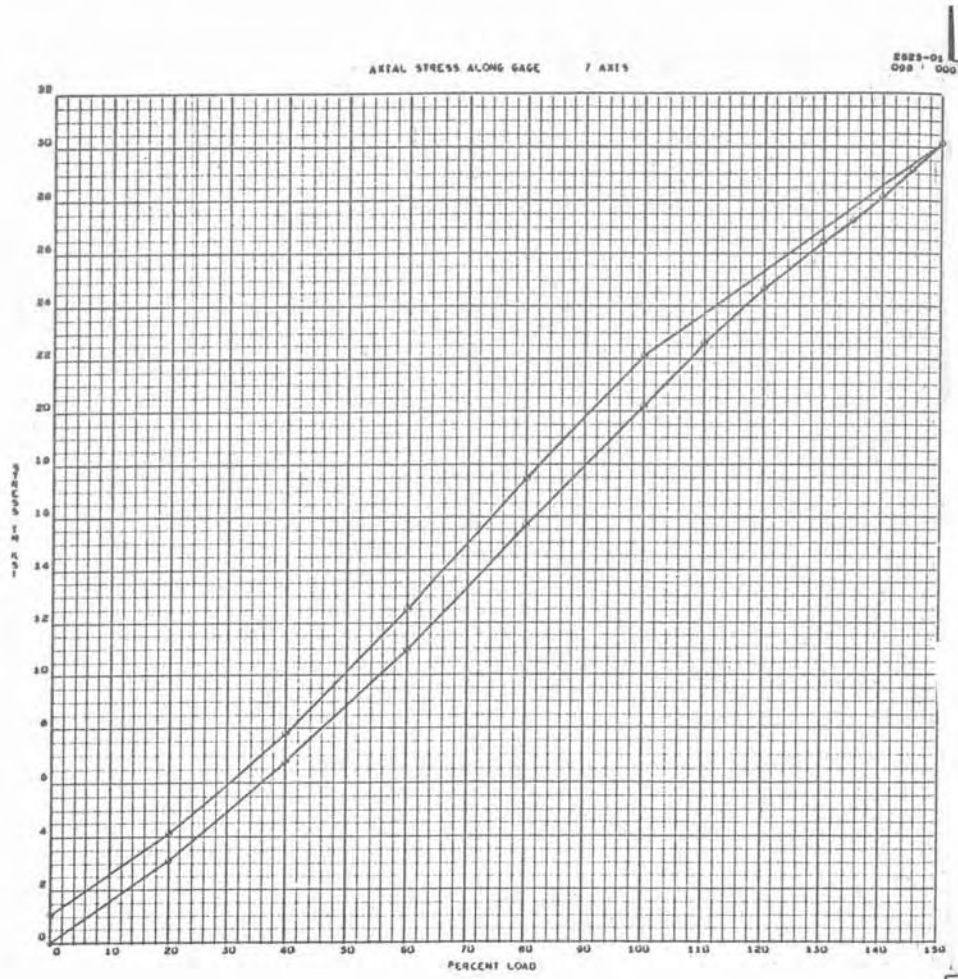


- A 157 - SID 67-318



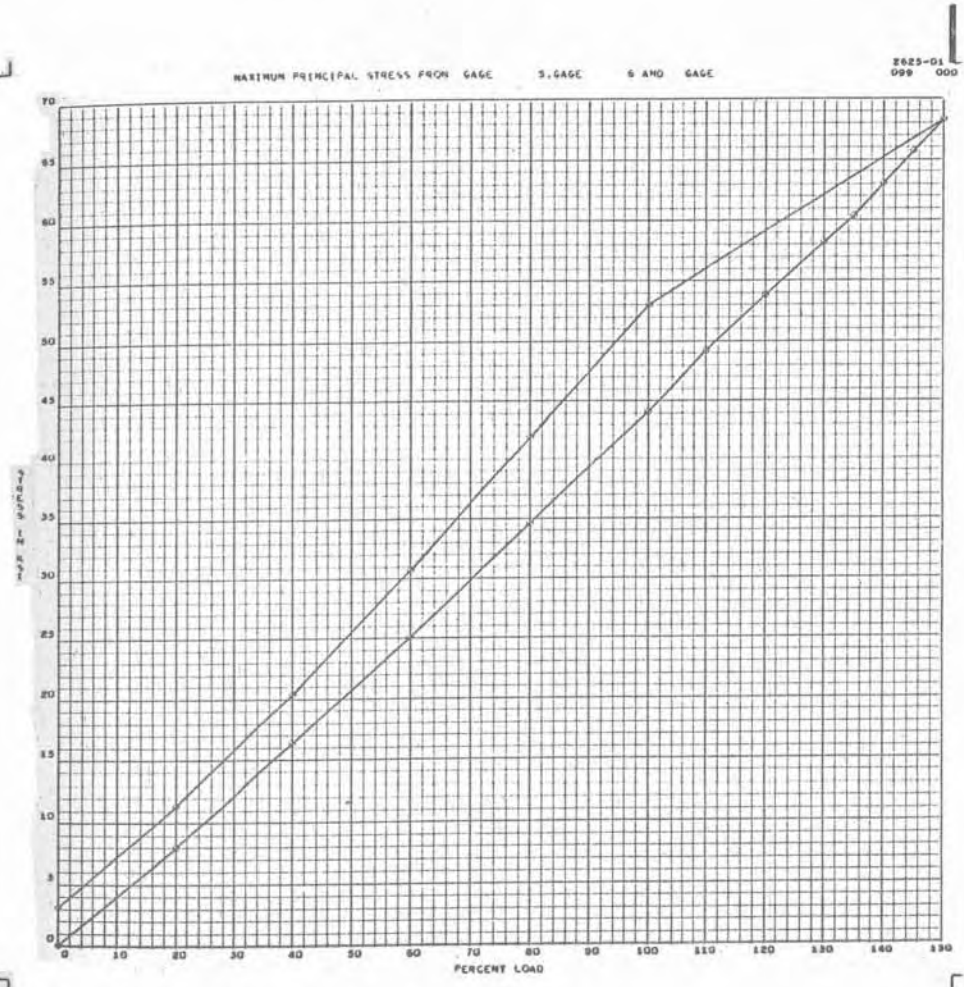
- A 158 - SID 67-318





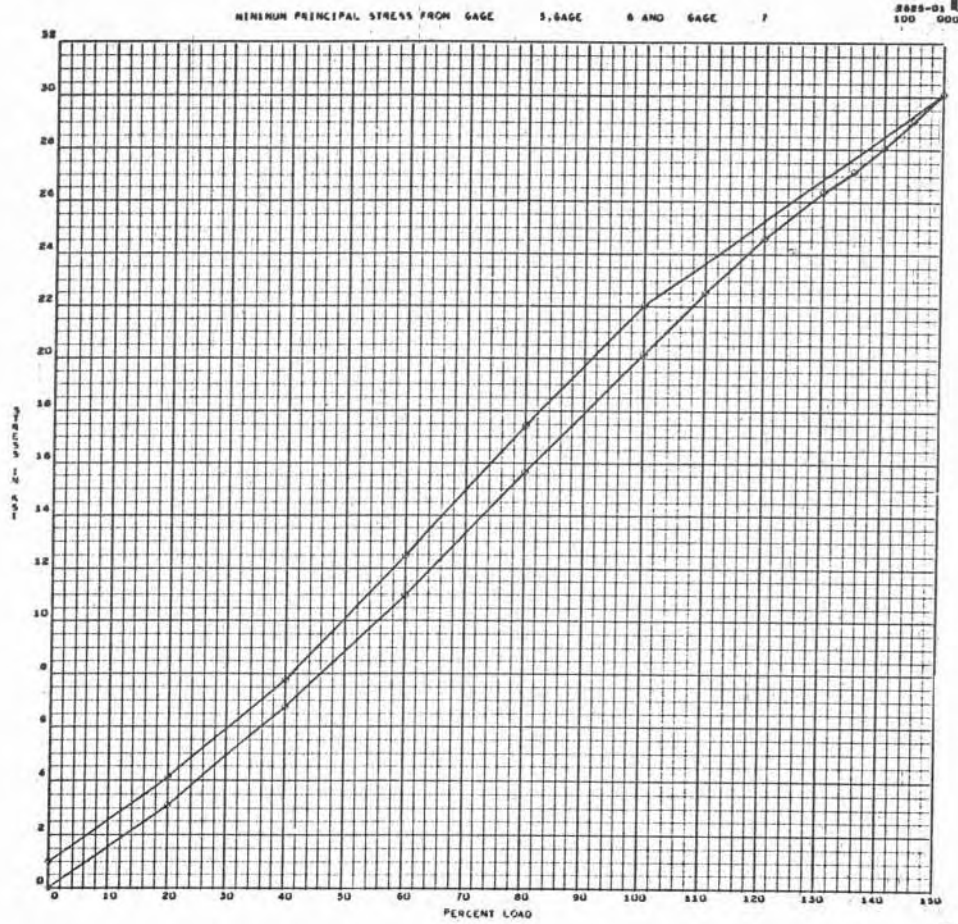
- A 161 -

SID 67-318



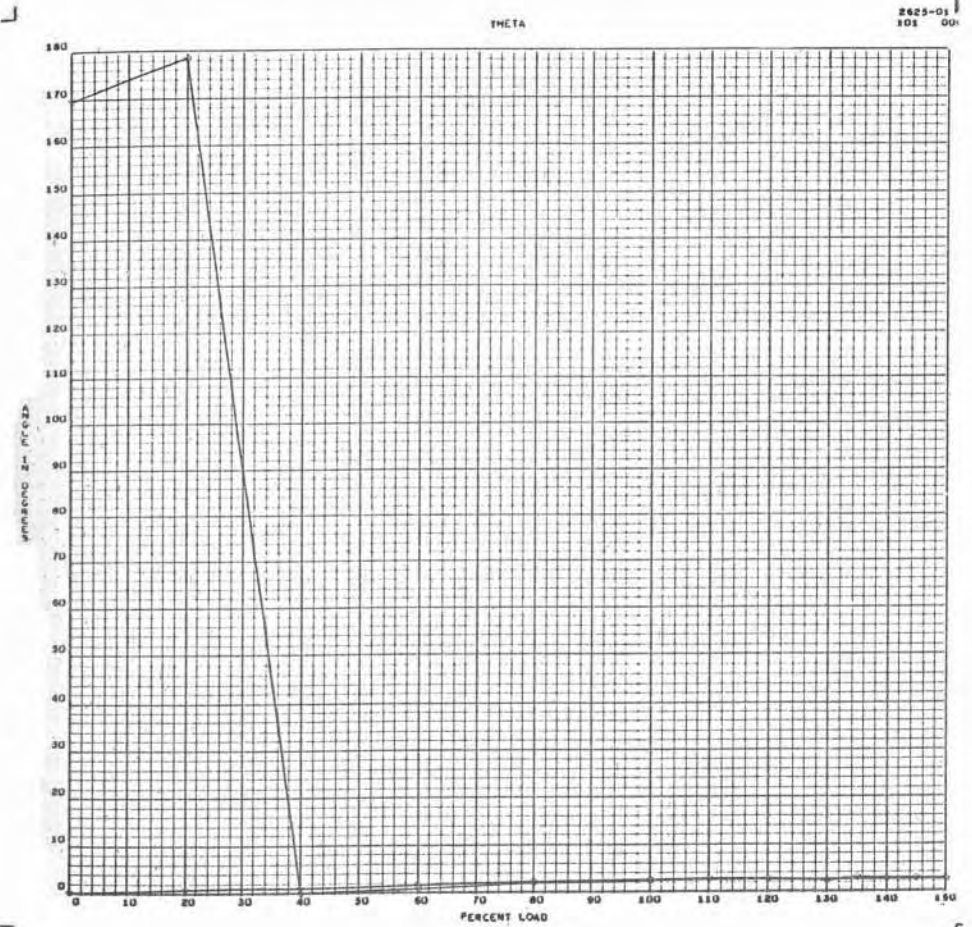
- A 162 -

SID 67-318



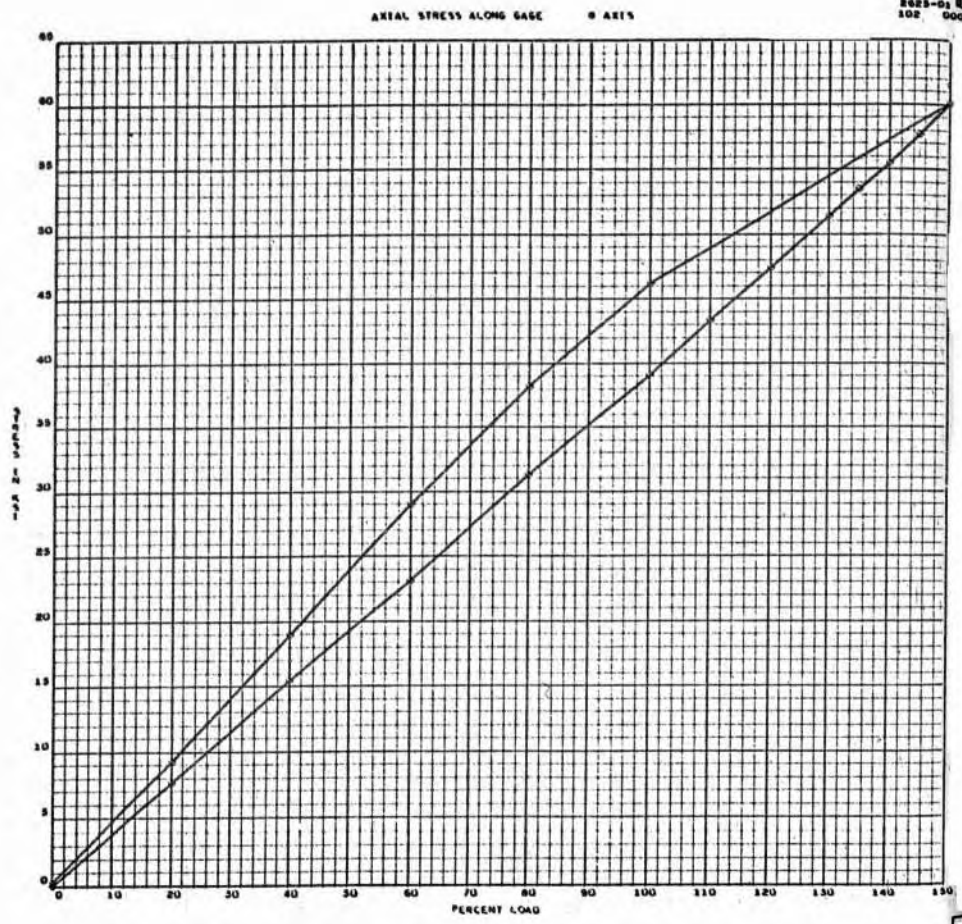
- A 163 -

SID 67-318



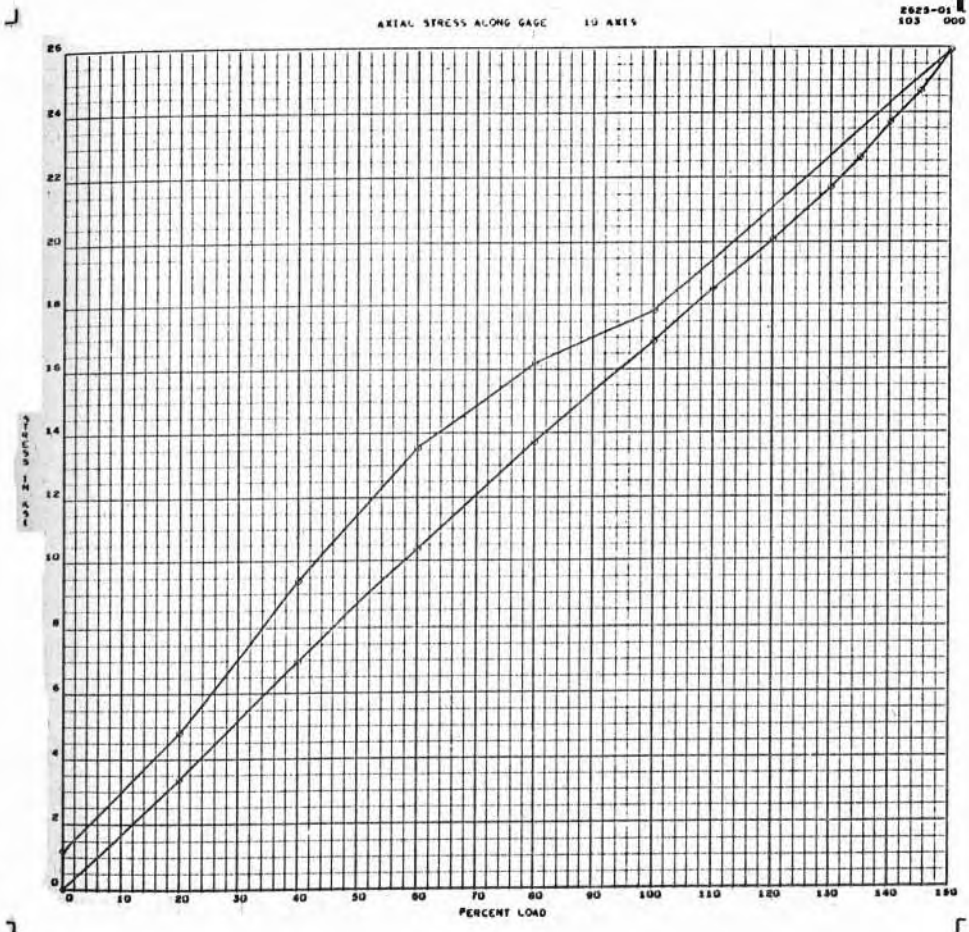
- A 164 -

SID 67-318



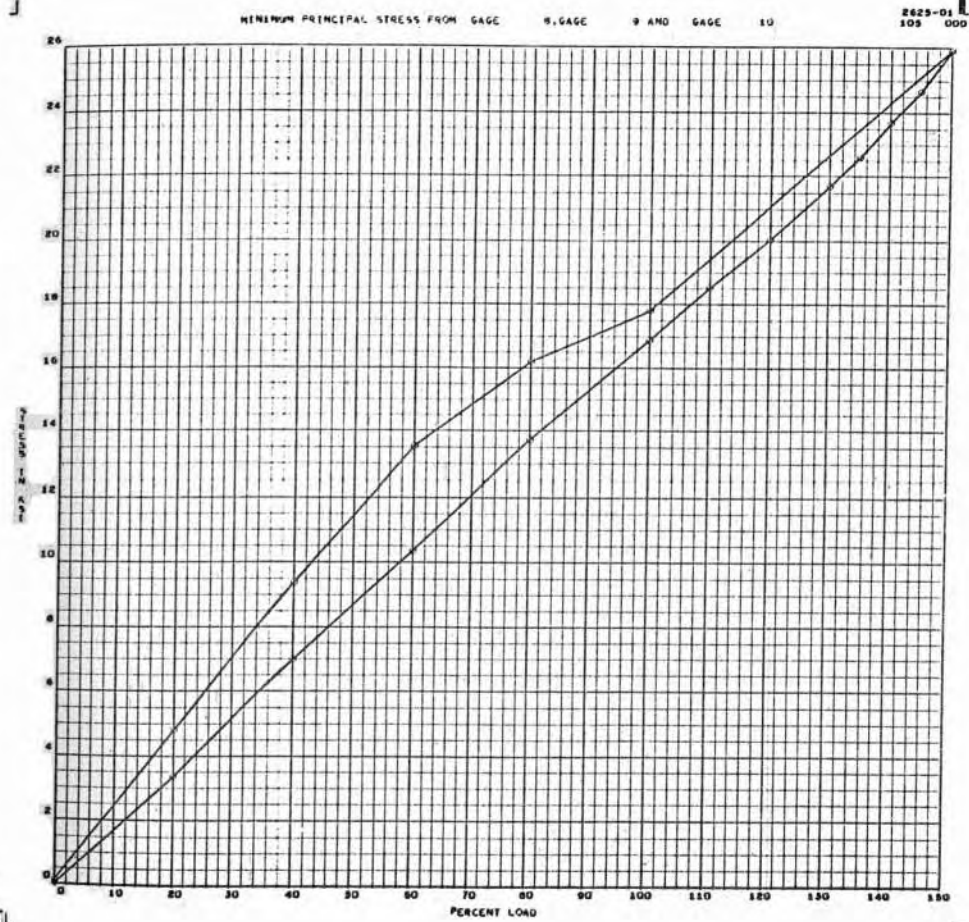
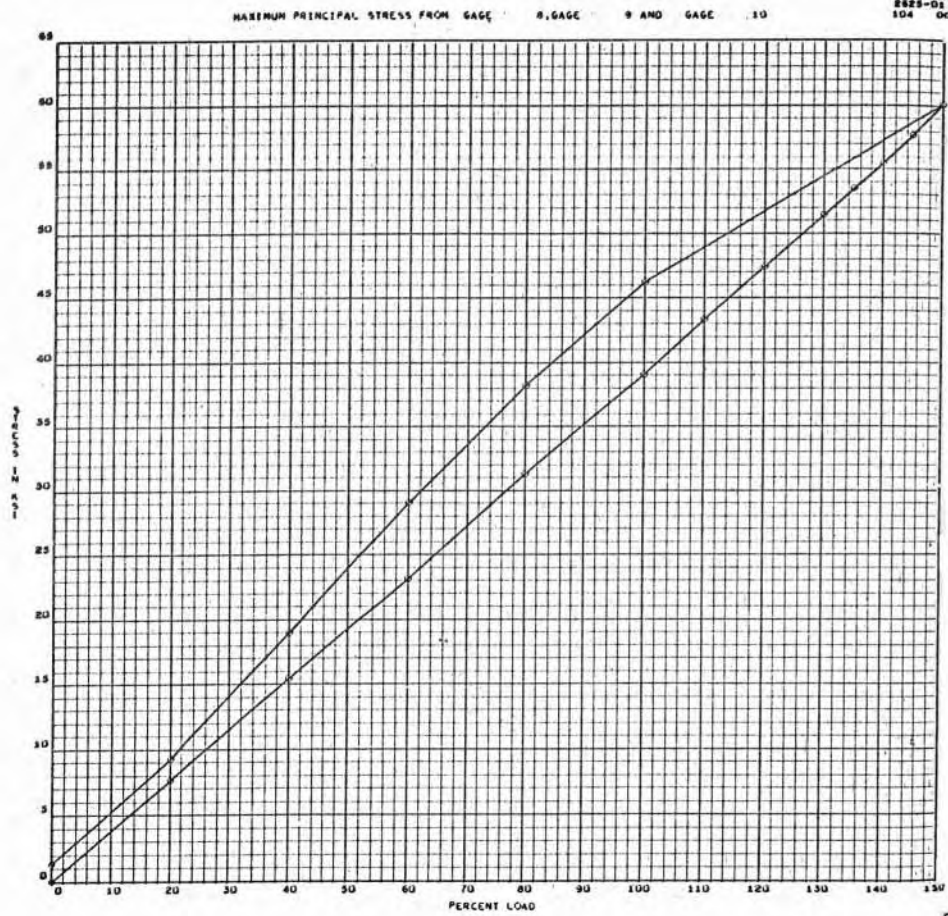
- A 165 -

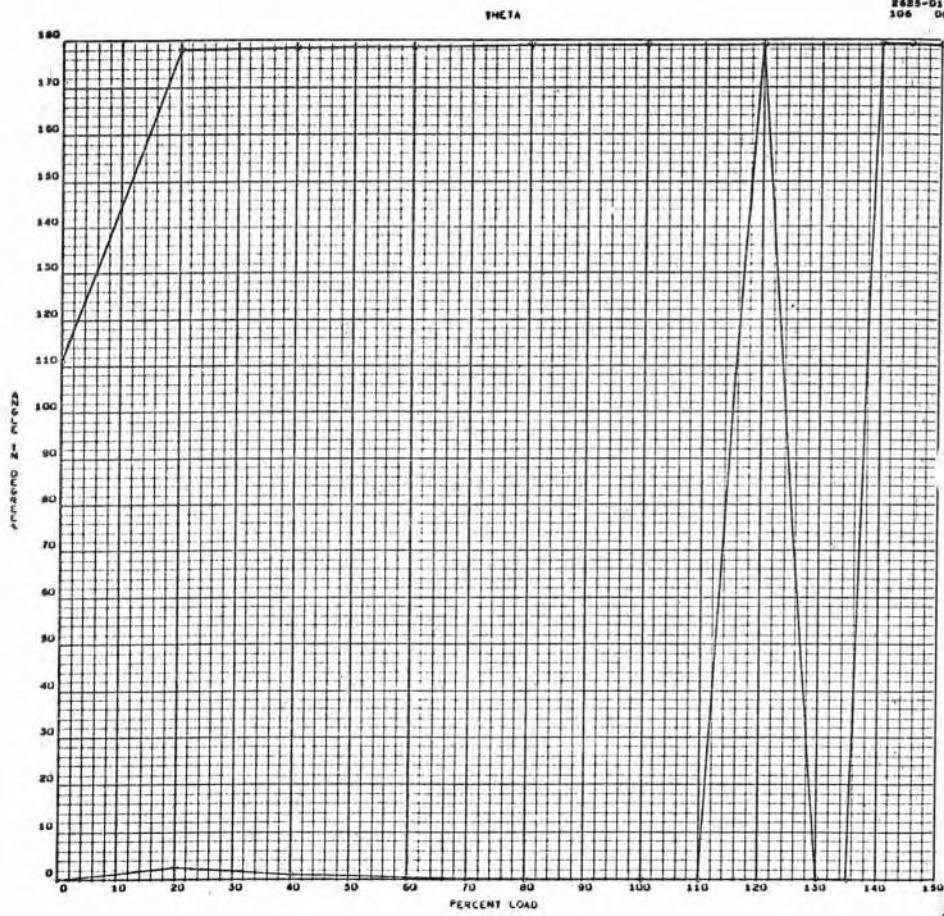
SID 67-318



- A 166 -

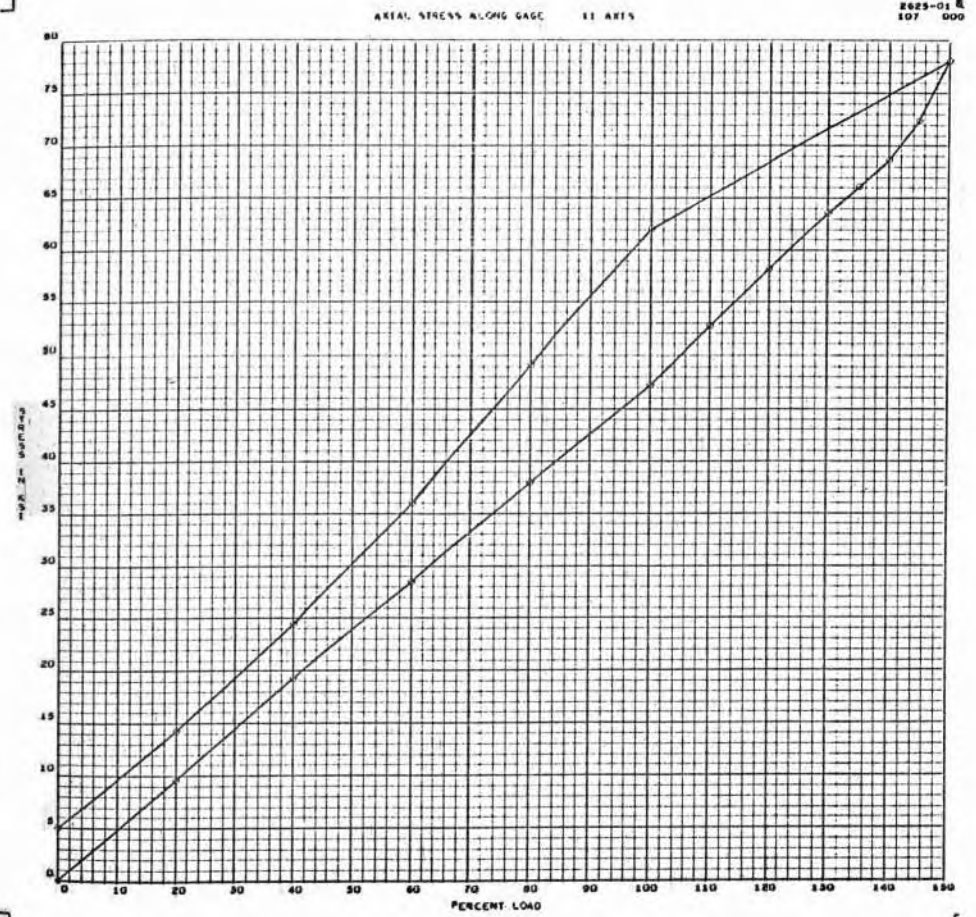
SID 67-318





- A 169 -

SID 67-318

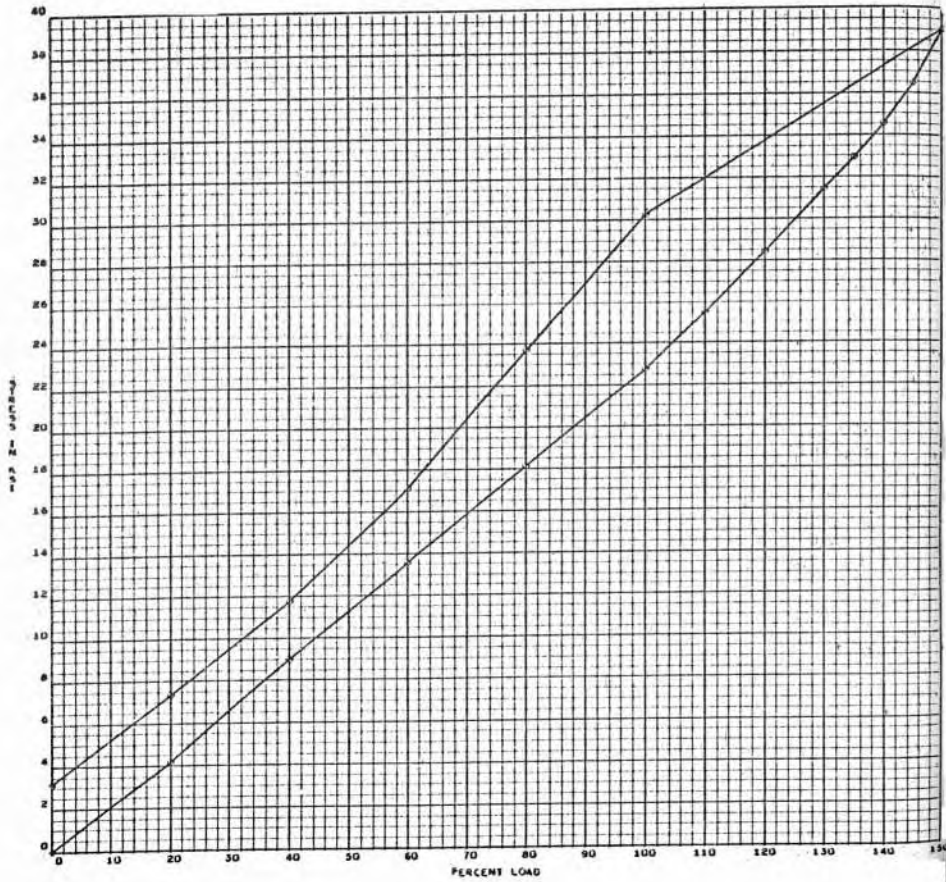


- A 170 -

SID 67-318

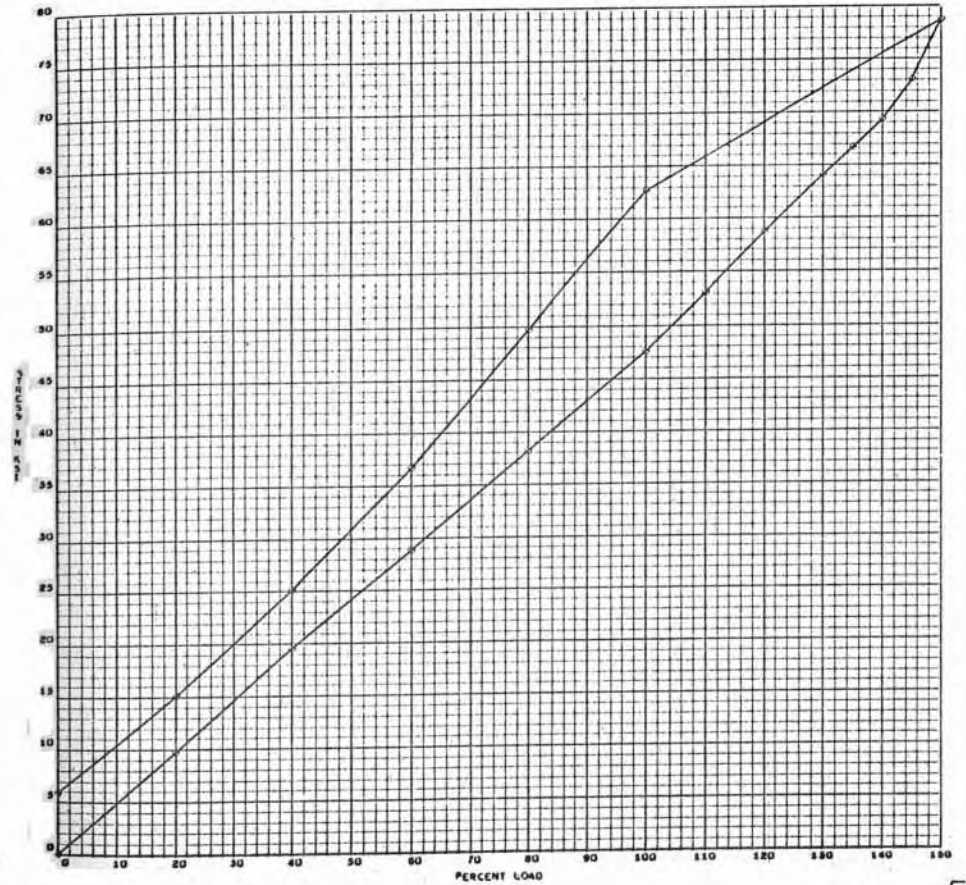
AXIAL STRESS ALONG GAGE 13 ARTS

8023-01
108
000



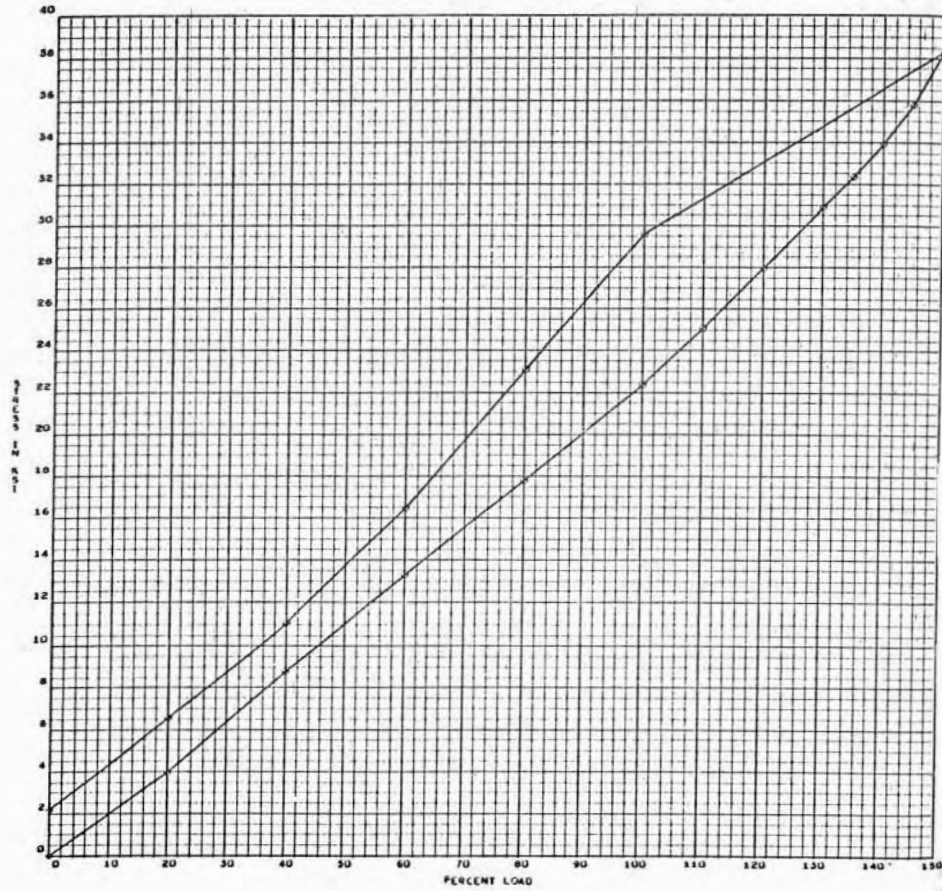
MAXIMUM PRINCIPAL STRESS FROM GAGE 11, GAGE 12 AND GAGE 13

8023-01
108
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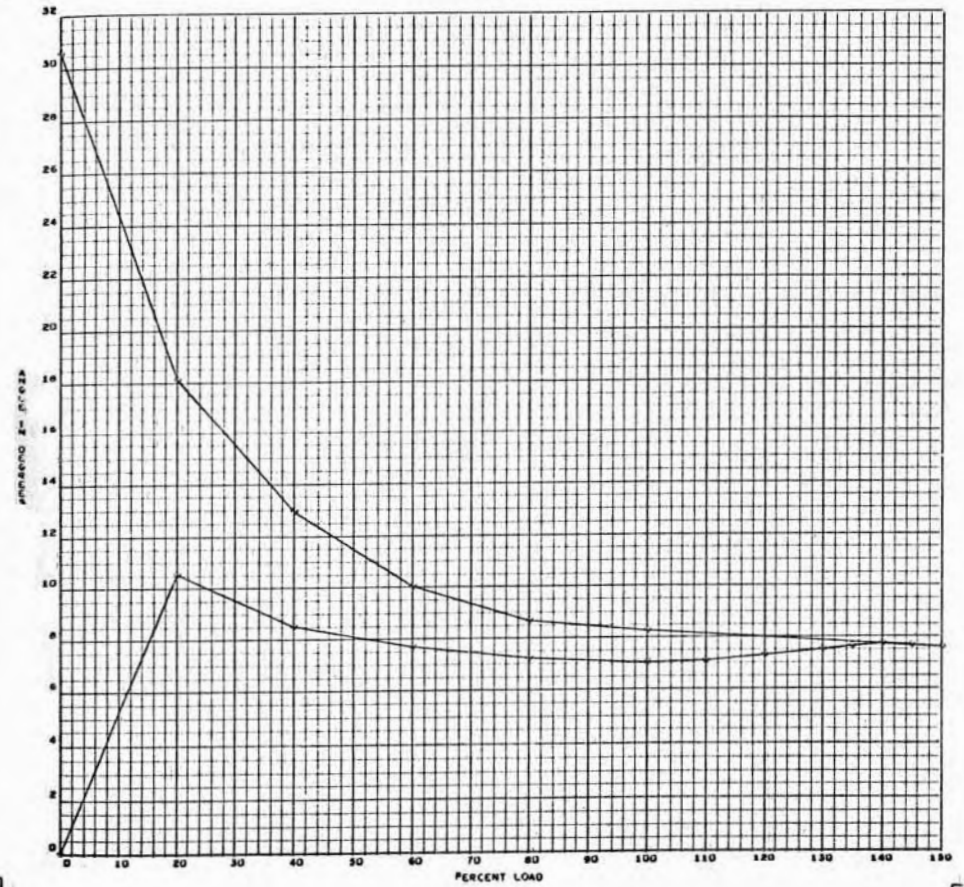
MINIMUM PRINCIPAL STRESS FROM GAGE 11, GAGE 12 AND GAGE 13

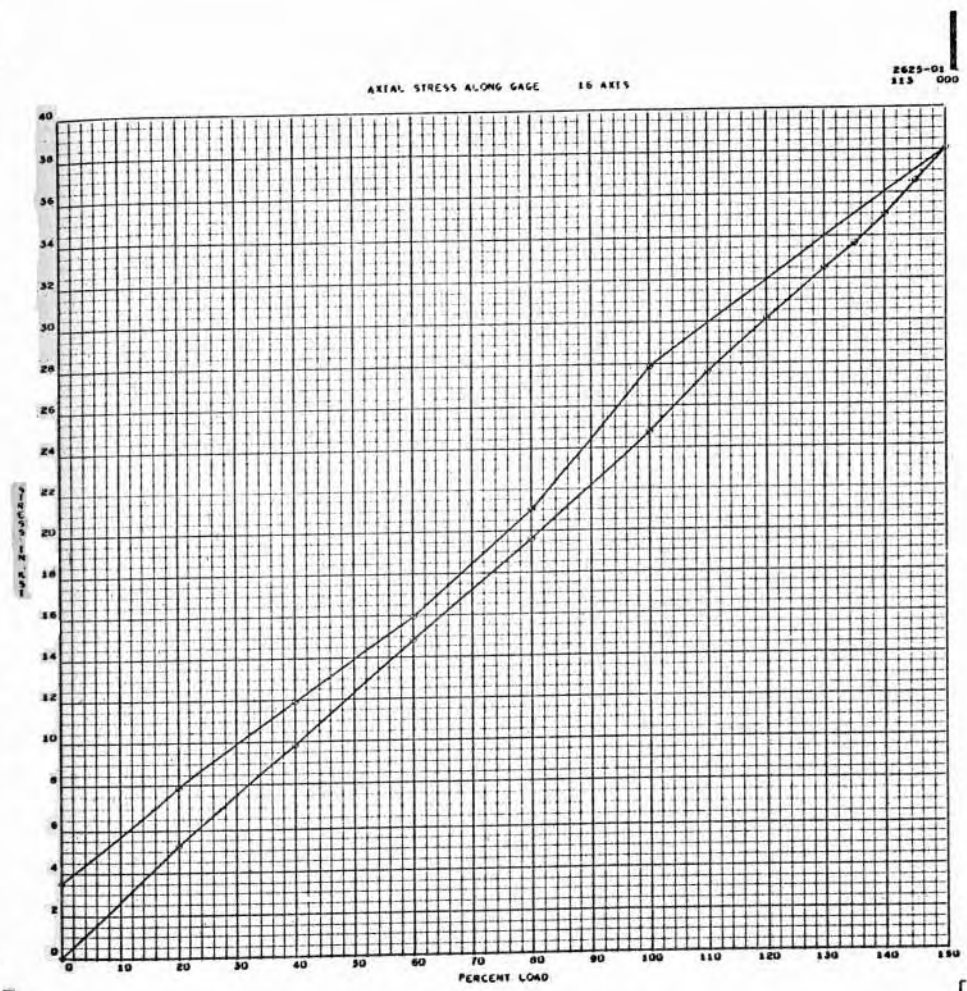
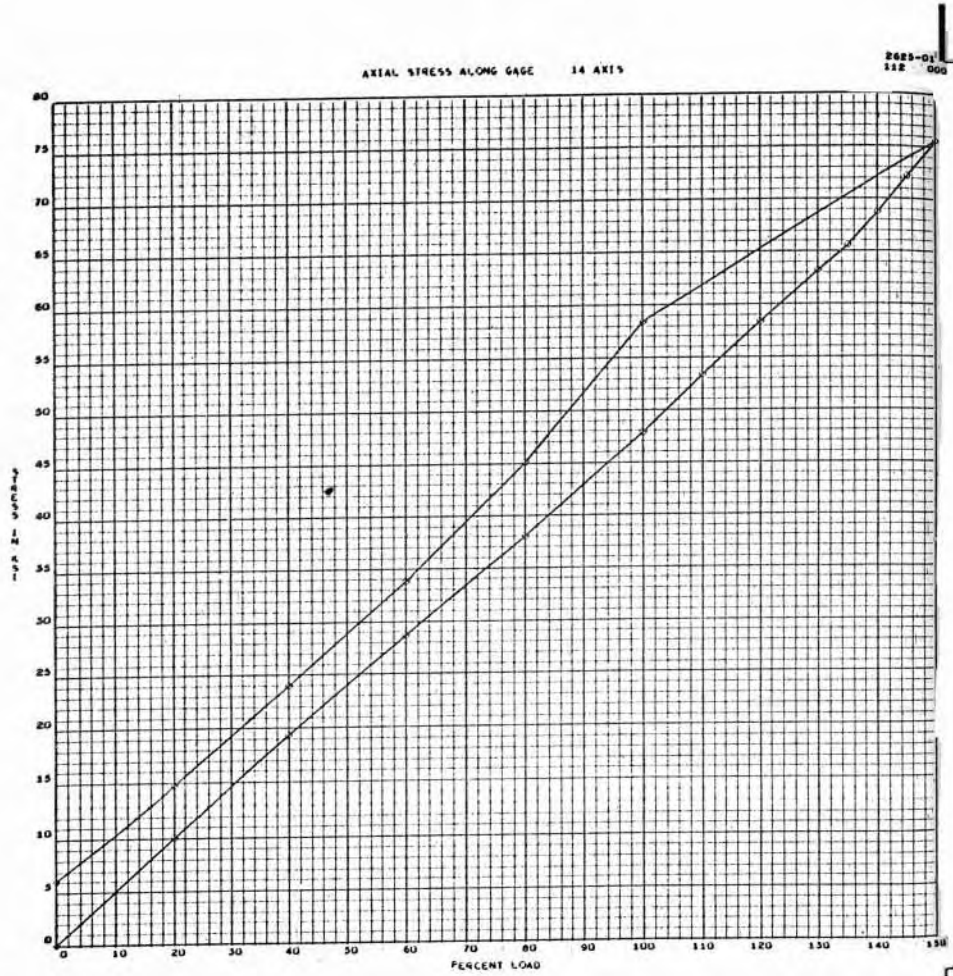
8825-01
111 000

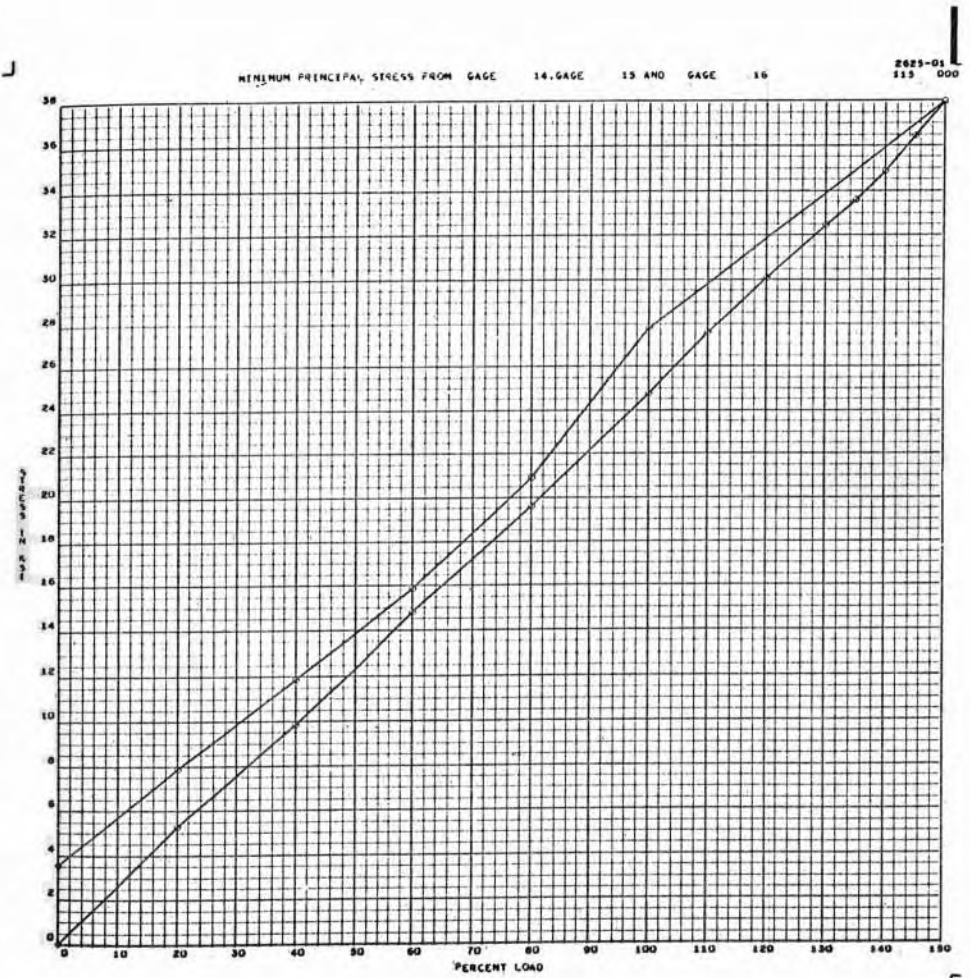
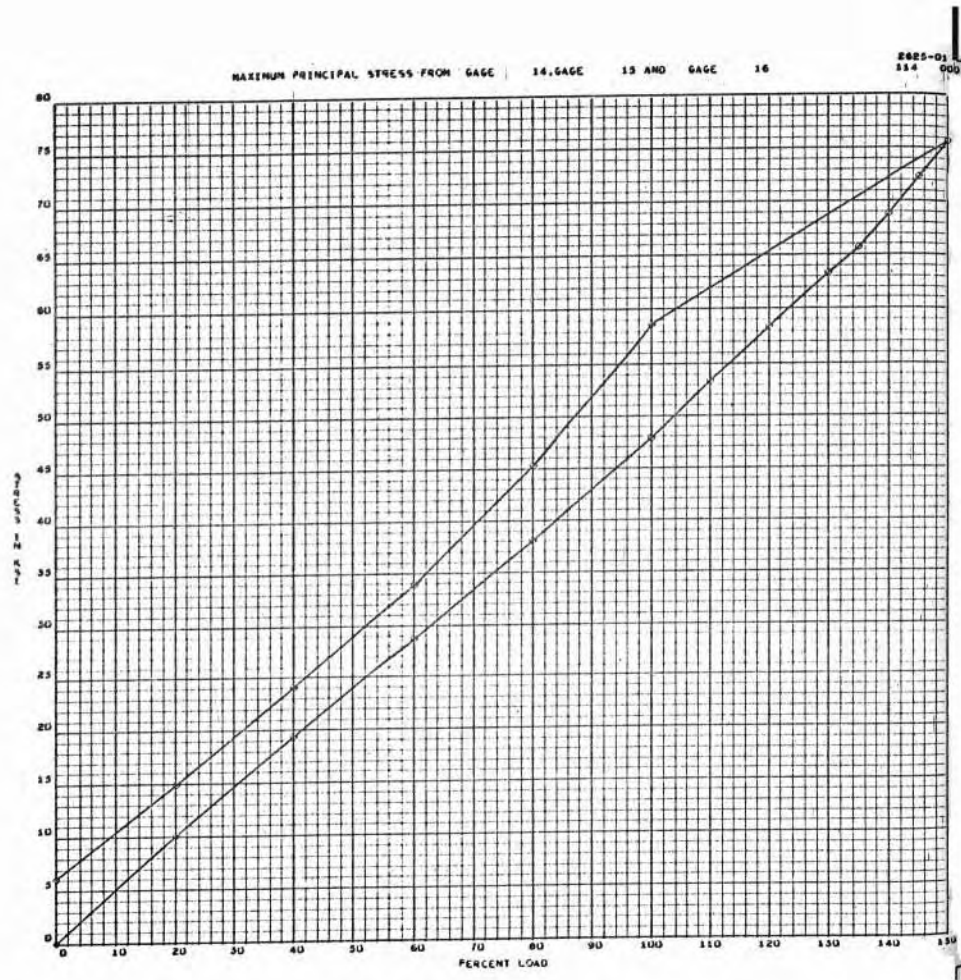


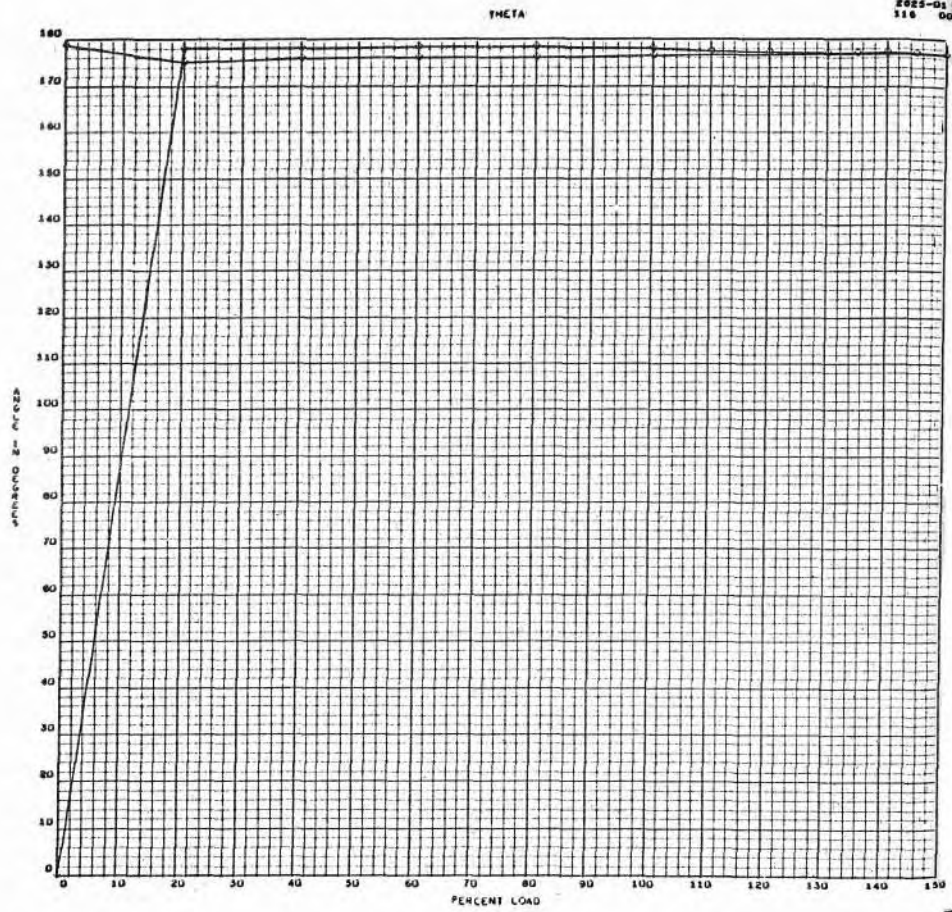
THETA

8825-01
111 000



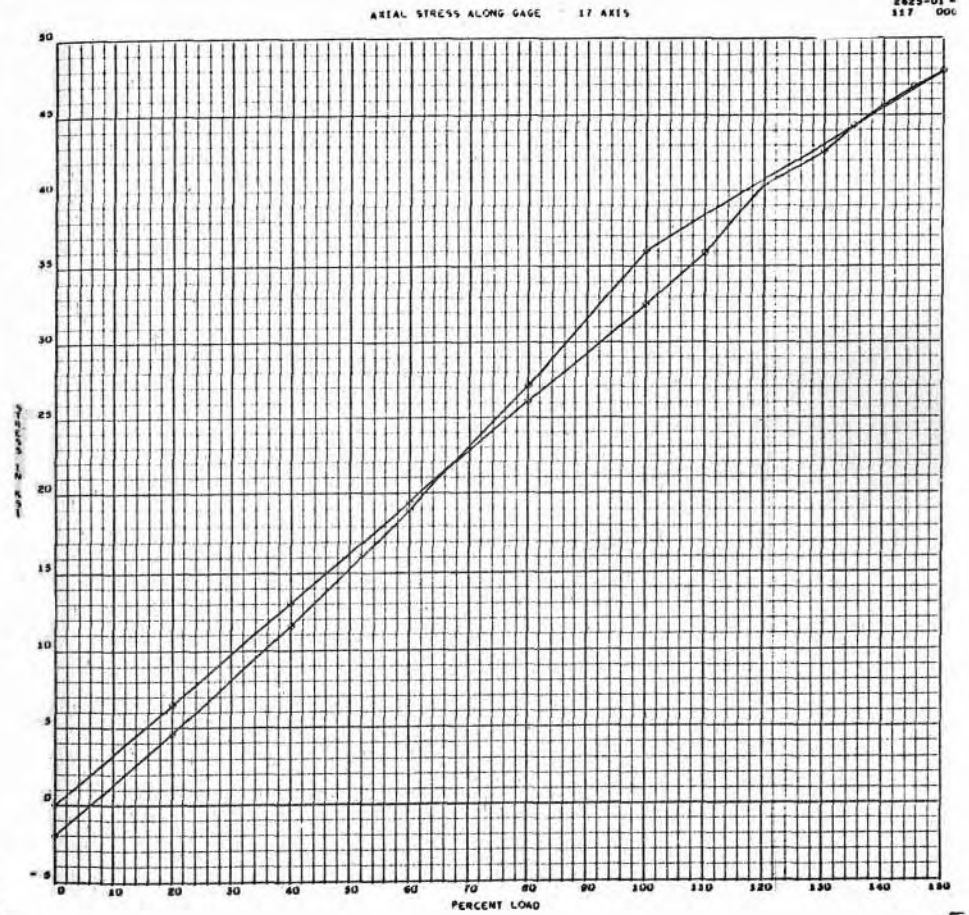






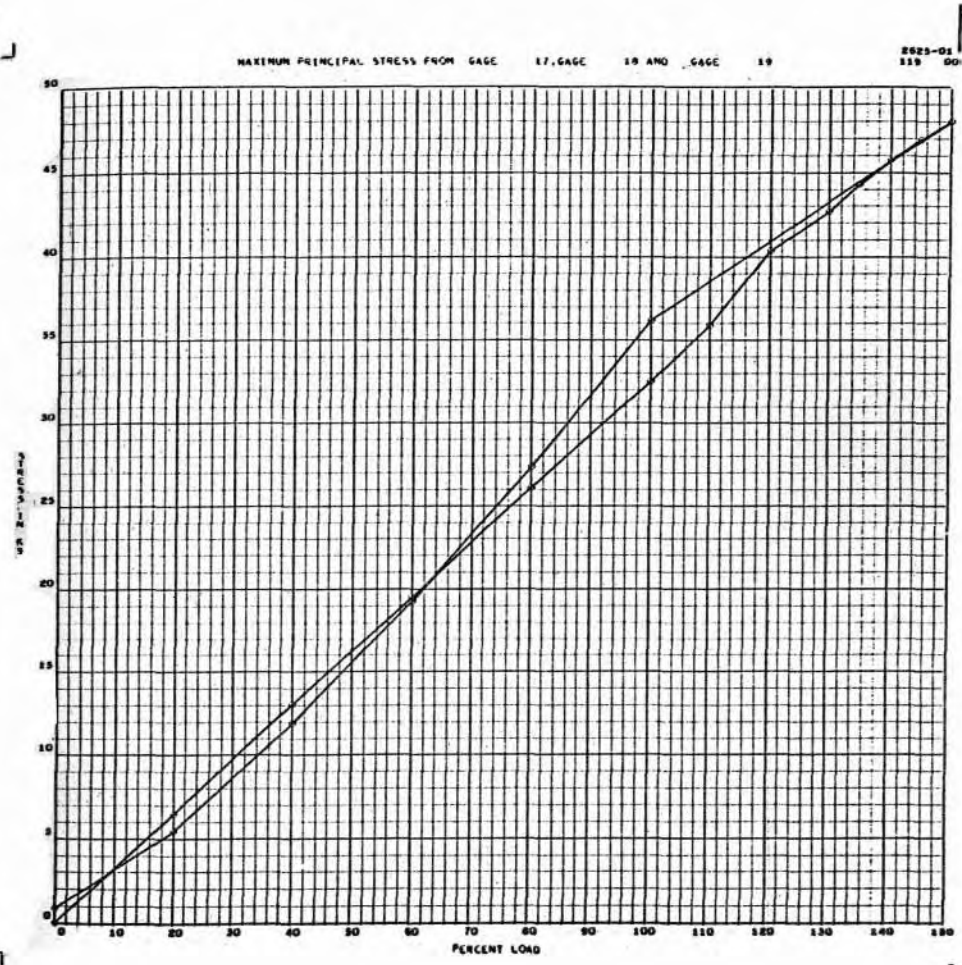
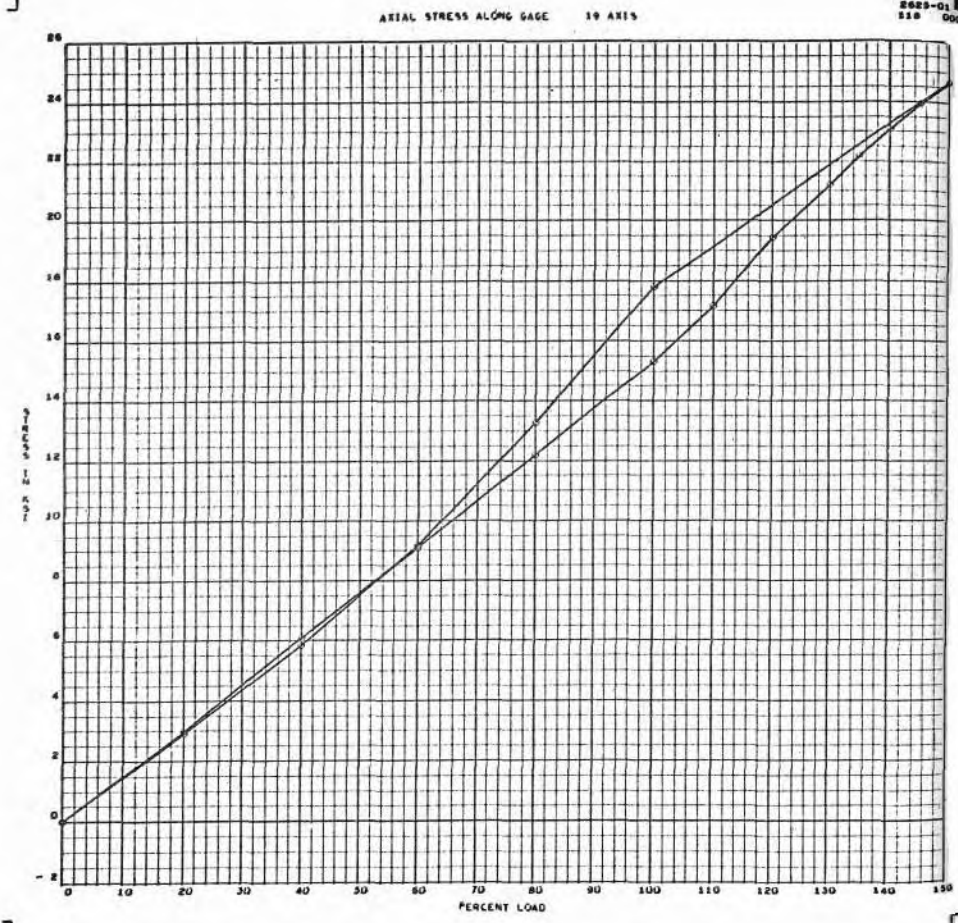
- A 179 -

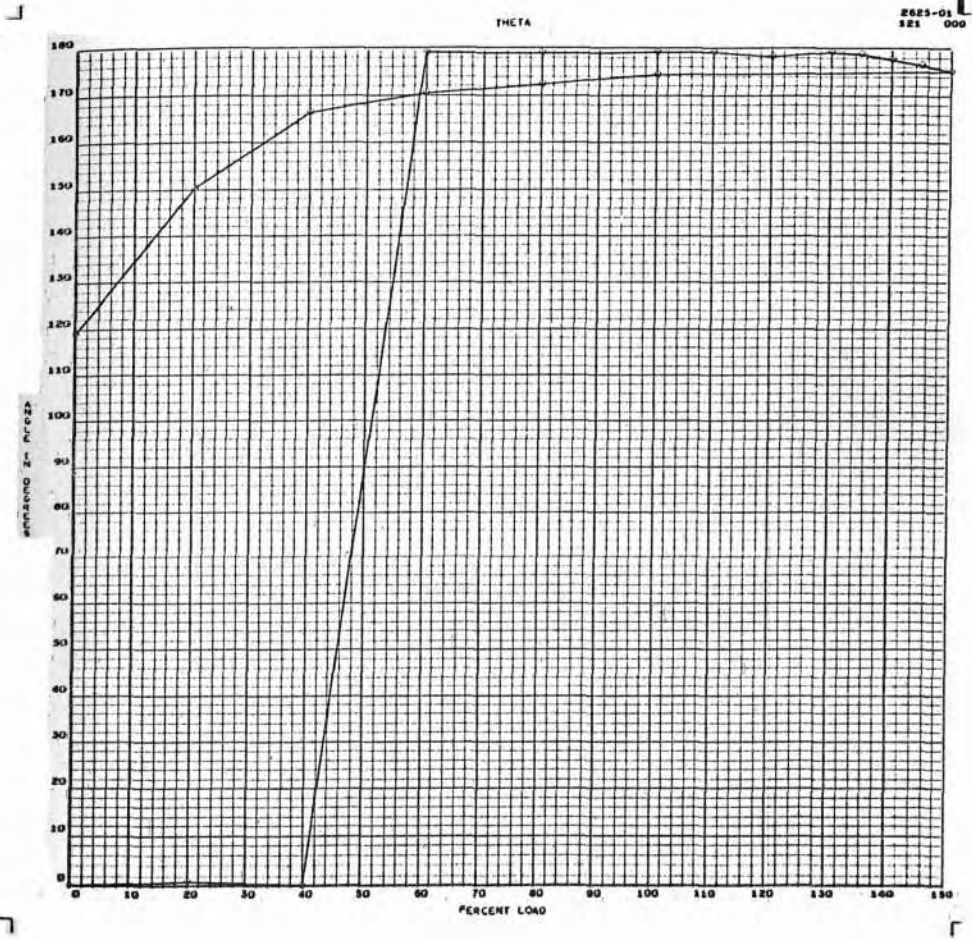
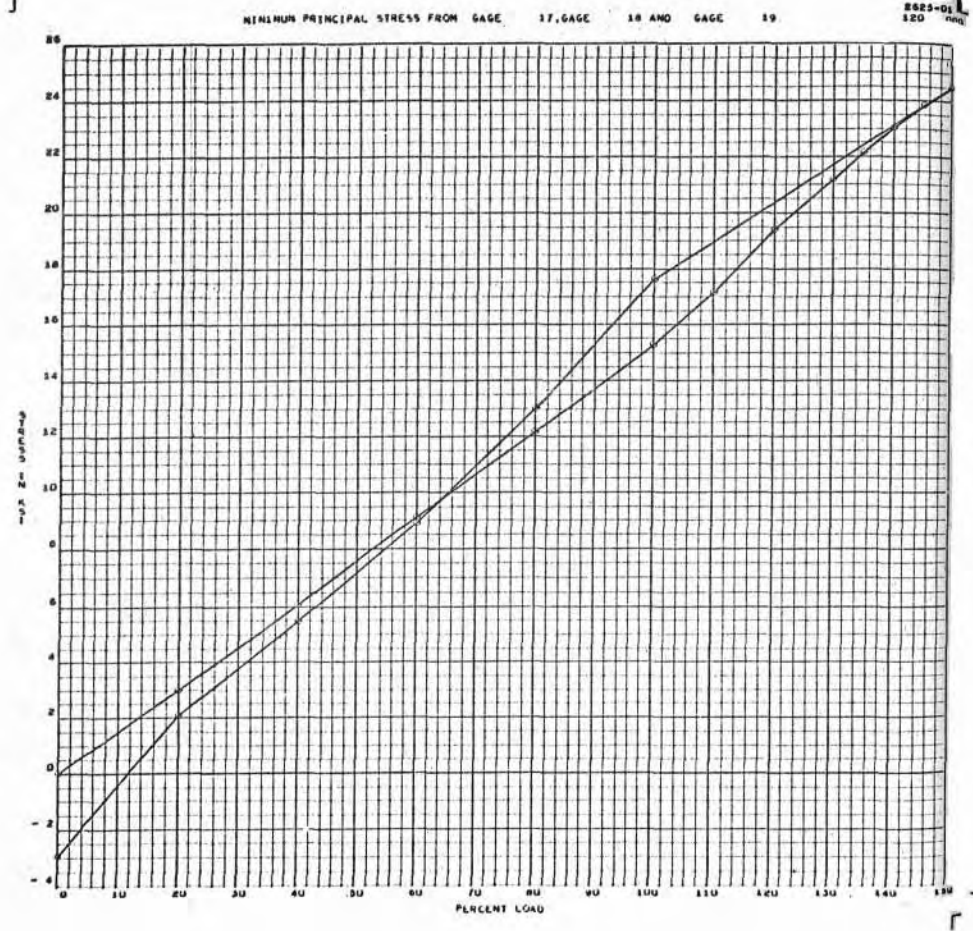
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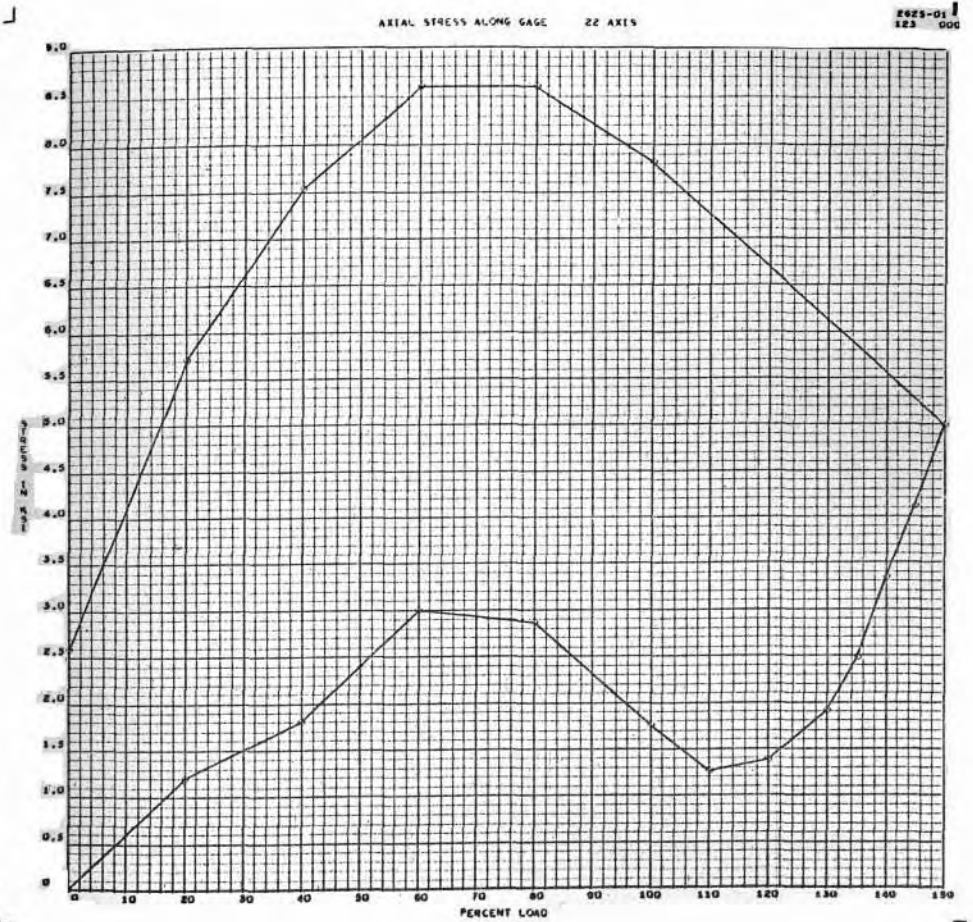
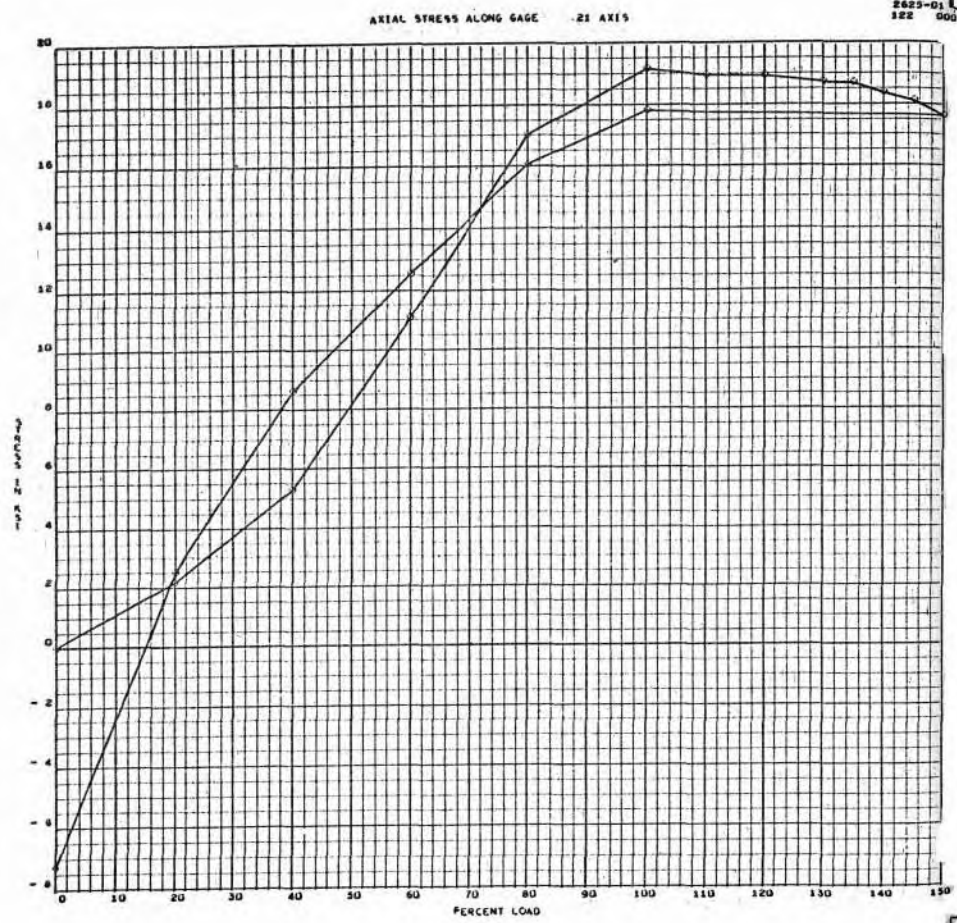


A 180 -

SID 67-318







SHEAR STRESS FROM GAGE 21 AND GAGE 22

1683-01
24 000

