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13. ABSTRACT

This report contains the results of an investigation of joint shear strengths using solid rivet fasteners lubricated with lauric acid.

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BEARING STRENGTHS						
LUBRICATION						

Ib.



DEPARTMENT OF THE NAVY
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WARMINSTER, PA. 18974

AIR VEHICLE TECHNOLOGY DEPARTMENT

REPORT NO. NADC-72055-VT

4 APRIL 1972

EFFECT OF LUBRICATION ON THE JOINT BEARING
STRENGTH OF RIVETED LAP JOINTS

FINAL REPORT
AIRTASK NO. A05-530/202-1/200000000
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This report contains the results of an investigation of joint shear strengths using solid rivet fasteners lubricated with lauric acid.

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EVALUATION AND DISCUSSION

INTRODUCTION

The yield and ultimate shear strength of joints fabricated from various metals using solid rivet fasteners lubricated with lauric acid is reported herein. The results of the investigations showing a reduction of material bearing strength when pins and threaded fasteners were lubricated with lauric acid have been reported in references (a) and (b) respectively.

TEST PROCEDURE

Joint yield and ultimate strengths were determined in accordance with reference (c), using a Tinius Olsen Universal Testing Machine, Model Super "L" UTM Serial 54984-3, and a Baldwin Extensometer, Model TSMD Serial 1029 (Figures 1 and 2). All the rivets and sheet material were initially cleaned ultrasonically in chloroethene V.G.S.A. 1192A. Tests were performed on the clean riveted lap joint specimens, and the yield and ultimate strength was recorded. To determine the effect of lubrication, rivets were then coated with lauric acid ($\text{CH}_3(\text{CH}_2)_{10}\text{COOH}$) and specimens fabricated. The tests were repeated. The test specimens were .063 inches thick, and the rivet holes in the specimens were within a tolerance range of .253 to .257 inches. The installation requirements to form the flat driven heads on the rivets used in the test were in accordance with reference (d).

The four materials used in this investigation included aluminum (2024-T3 Sheet-Heats 1-2), magnesium (AZ31B-H24 Sheet), and steel (PH15-7 Mo Sheet). Rivets of the following types and the driving pressures that were required to form the fastener heads in the lap joints are shown below:

<u>Type</u>	<u>Material</u>	<u>Driving Pressure</u>
MS20470D8-6	Aluminum	12,000 lbs.
MS20470B8-6	Magnesium	9,000 lbs.
NAS1198-8-6	Steel	22,000 lbs.

DISCUSSION

All specimens were subjected to the joint shear test specified in reference (c). One half of the ultrasonically cleaned specimens were tested with rivets that had been lubricated with lauric acid. Careful control of all significant parameters was exercised to determine any effect upon the lap joints' bearing yield and bearing ultimate strength produced by lubrication of the rivets.

Joint yield strength was determined from load deflection curves using the second modulus method for hole filling fasteners in accordance with reference (c). The bearing yield loads are shown on the load deflection charts, Figures 3 through 82. The joint bearing yield and bearing ultimate strength was calculated by dividing the applicable load carried by the bearing area. The results obtained are shown in Tables I through VIII. The average strength of the lap joint specimens tested with lubricated rivets was consistently lower than those of the specimens tested with non-lubricated rivets, Table IX.

CONCLUSIONS

It is concluded that joints fabricated with lubricated rivets, like those fabricated with lubricated threaded fasteners, have lower bearing yield and bearing ultimate joint strengths than when fabricated with clean fasteners.

RECOMMENDATIONS

It is recommended that this effect be considered in the preparation of MIL-HDBK-5 since the reductions are not the same for hole filling fasteners (rivets), non-hole filling fasteners (bolts), and sheet materials.

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R E F E R E N C E S

- (a) NAVAIRDEVCON Report No. NADC-MA-7007 of 31 Dec 1970, Effect of Lubrication on the Bearing Strength of Various Metallic Materials
- (b) NAVAIRDEVCON Report No. NADC-MA-7162 of 27 Sep 1971, Effect of Lubrication on the Joint Bearing Strength of Metal Joints
- (c) MIL-STD-1312 Notice 1 - Test 4, Joint Shear Strength
- (d) NAVAIR 01-1A-8 Technical Manual Structural Hardware

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ALUMINUM
2024-T3
HEAT-1
(ALCOA)

NOT LUBRICATED			LUBRICATED		
SPECIMEN NO.	BEARING YIELD STRENGTH (PSI)	BEARING ULTIMATE STRENGTH (PSI)	SPECIMEN NO.	BEARING YIELD STRENGTH (PSI)	BEARING ULTIMATE STRENGTH (PSI)
1-A	101,269	138,095	4-AW	93,650	106,031
2-A	101,587	135,238	3-AW	91,746	111,111
3-A	101,587	136,507	5-AW	91,746	114,920
5-A	101,904	136,825	2-AW	92,063	116,825
7-A	98,412	136,825	6-AW	90,793	118,095
AVG.	100,951	136,698		91,999	113,346

NOTE:

8.8% decrease in bearing yield strength when lubricated.

17.0% decrease in bearing ultimate strength when lubricated.

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ALUMINUM
2024-T3
HEAT-2
(HARVEY)

NOT LUBRICATED			LUBRICATED		
SPECIMEN NO.	BEARING YIELD STRENGTH (PSI)	BEARING ULTIMATE STRENGTH (PSI)	SPECIMEN NO.	BEARING YIELD STRENGTH (PSI)	BEARING ULTIMATE STRENGTH (PSI)
2-H	103,174	136,507	12-HW	90,476	111,746
3-H	107,396	137,142	14-HW	89,841	113,333
4-H	108,888	137,777	18-HW	90,158	115,555
7-H	106,349	139,047	11-HW	87,619	117,460
1-H	99,682	145,396	16-HW	93,333	119,682
AVG.	105,097	139,173		90,285	115,555

NOTE:

14.0% decrease in bearing yield strength when lubricated.

16.9% decrease in bearing ultimate strength when lubricated.

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MAGNESIUM
H-5070
(DOW)

NOT LUBRICATED			LUBRICATED		
SPECIMEN NO.	BEARING YIELD STRENGTH (PSI)	BEARING ULTIMATE STRENGTH (PSI)	SPECIMEN NO.	BEARING YIELD STRENGTH (PSI)	BEARING ULTIMATE STRENGTH (PSI)
3-D	66,349	86,349	15-DL	60,317	83,809
1-D	71,428	88,571	18-DL	63,492	83,492
6-D	72,063	88,888	17-DL	60,372	84,444
7-D	65,714	89,523	10-DL	66,031	87,301
11-D	65,079	90,476	16-DL	61,904	86,031
AVG.	68,126	88,761		62,423	85,015

NOTE:

8.3% decrease in bearing yield strength when lubricated.

4.2% decrease in bearing ultimate strength when lubricated.

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MAGNESIUM
7546
AZ31B

NCT LUBRICATED			LUBRICATED		
SPECIMEN NO.	BEARING YIELD STRENGTH (PSI)	BEARING ULTIMATE STRENGTH (PSI)	SPECIMEN NO.	BEARING YIELD STRENGTH (PSI)	BEARING ULTIMATE STRENGTH (PSI)
2-M	67,619	82,539	4-ML	58,412	79,047
5-M	68,571	85,079	1-ML	58,095	81,904
3-M	68,253	85,714	8-ML	57,142	81,904
4-M	68,888	86,984	6-ML	60,317	81,904
10-M	69,841	88,253	5-ML	59,365	82,539
AVG.	68,634	85,713		58,666	81,459

NOTE:

14.5% decrease in bearing yield strength when lubricated.

4.9% decrease in bearing ultimate strength when lubricated.

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MAGNESIUM
C-70065
(DOW)

NOT LUBRICATED			LUBRICATED		
SPECIMEN NO.	BEARING YIELD STRENGTH (PSI)	BEARING ULTIMATE STRENGTH (PSI)	SPECIMEN NO.	BEARING YIELD STRENGTH (PSI)	BEARING ULTIMATE STRENGTH (PSI)
D-2	60,317	82,222	13-DL	55,555	77,142
D-1	60,317	82,857	16-DL	55,873	78,412
D-5	60,634	83,492	10-DL	55,873	78,730
D-7	63,492	84,126	12-DL	57,142	79,882
D-8	60,634	85,398	11-DL	56,825	80,000
AVG.	61,078	83,619		56,253	78,833

NOTE:

7.8% decrease in bearing yield strength when lubricated.

5.7% decrease in bearing ultimate strength when lubricated.

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STEEL
870255

NOT LUBRICATED			LUBRICATED		
SPECIMEN NO.	BEARING YIELD STRENGTH (FSI)	BEARING ULTIMATE STRENGTH (PSI)	SPECIMEN NO.	BEARING YIELD STRENGTH (PSI)	BEARING ULTIMATE STRENGTH (PSI)
SA-4	126,666	229,841	SAL-8	104,761	205,714
SA-9	133,650	234,920	SAL-1	104,761	204,444
SA-2	133,333	228,571	SAL-4	93,650	195,873
SA-5	126,984	228,253	SAL-6	101,587	182,539
SA-6	139,682	225,079	SAL-9	107,936	208,888
AVG.	132,063	229,332		102,539	199,491

NOTE:

22.3% decrease in bearing yield strength when lubricated.

13.0% decrease in bearing ultimate strength when lubricated.

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STEEL
851064

NOT LUBRICATED			LUBRICATED		
SPECIMEN NO.	BEARING YIELD STRENGTH (PSI)	BEARING ULTIMATE STRENGTH (PSI)	SPECIMEN NO.	BEARING YIELD STRENGTH (PSI)	BEARING ULTIMATE STRENGTH (PSI)
SB-3	101,587	208,571	SBL-9	111,111	193,650
SB-5	120,634	213,650	SBL-3	117,460	196,190
SB-4	129,841	214,920	SBL-7	104,761	199,365
SB-2	123,809	215,555	SBL-4	111,111	187,619
SB-7	128,571	215,873	SBL-5	117,460	187,619
AVG.	120,888	213,713		112,380	192,888

NOTE:

7.0% decrease in bearing yield strength when lubricated.

9.7% decrease in bearing ultimate strength when lubricated.

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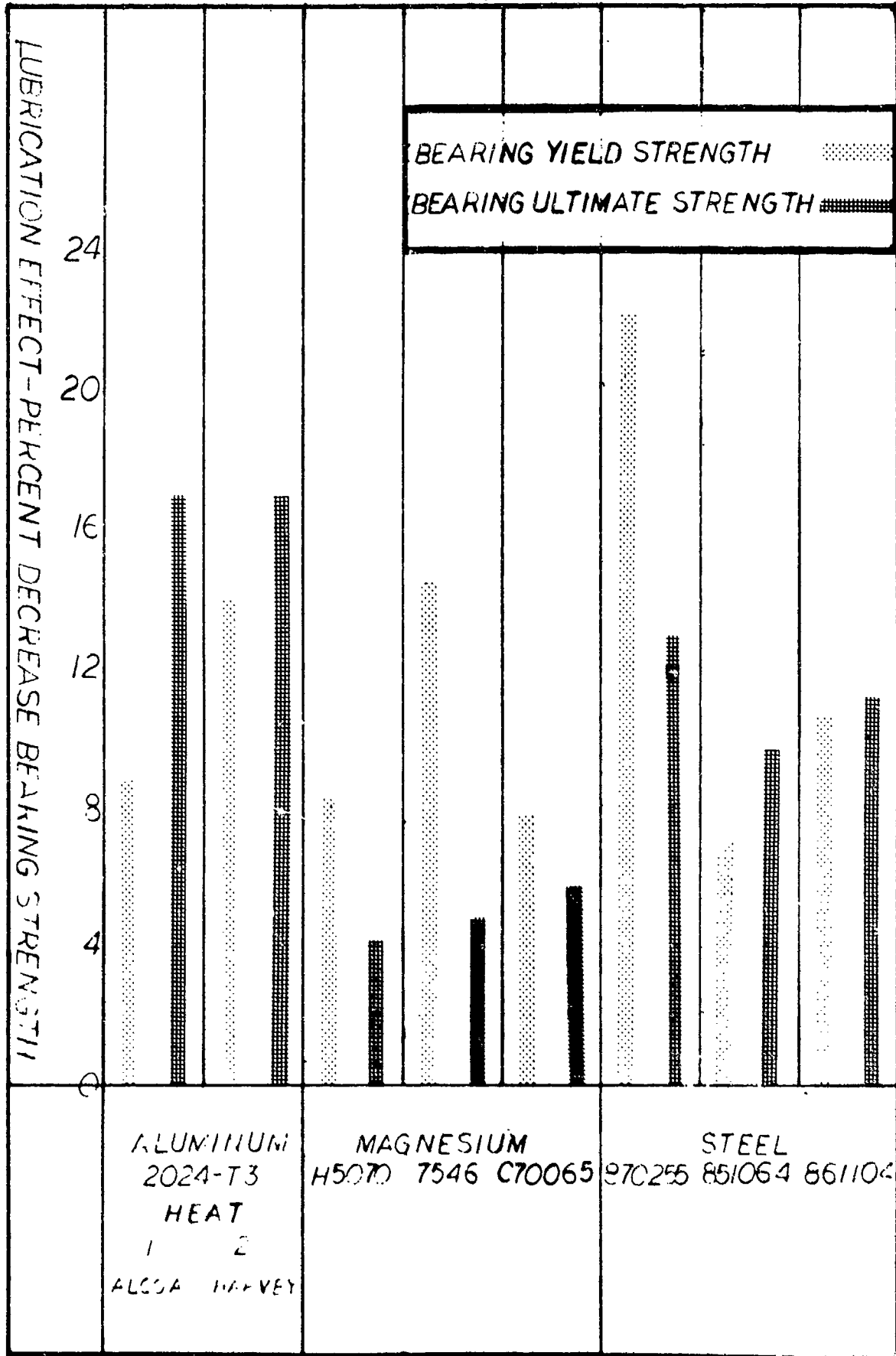
STEEL
861104

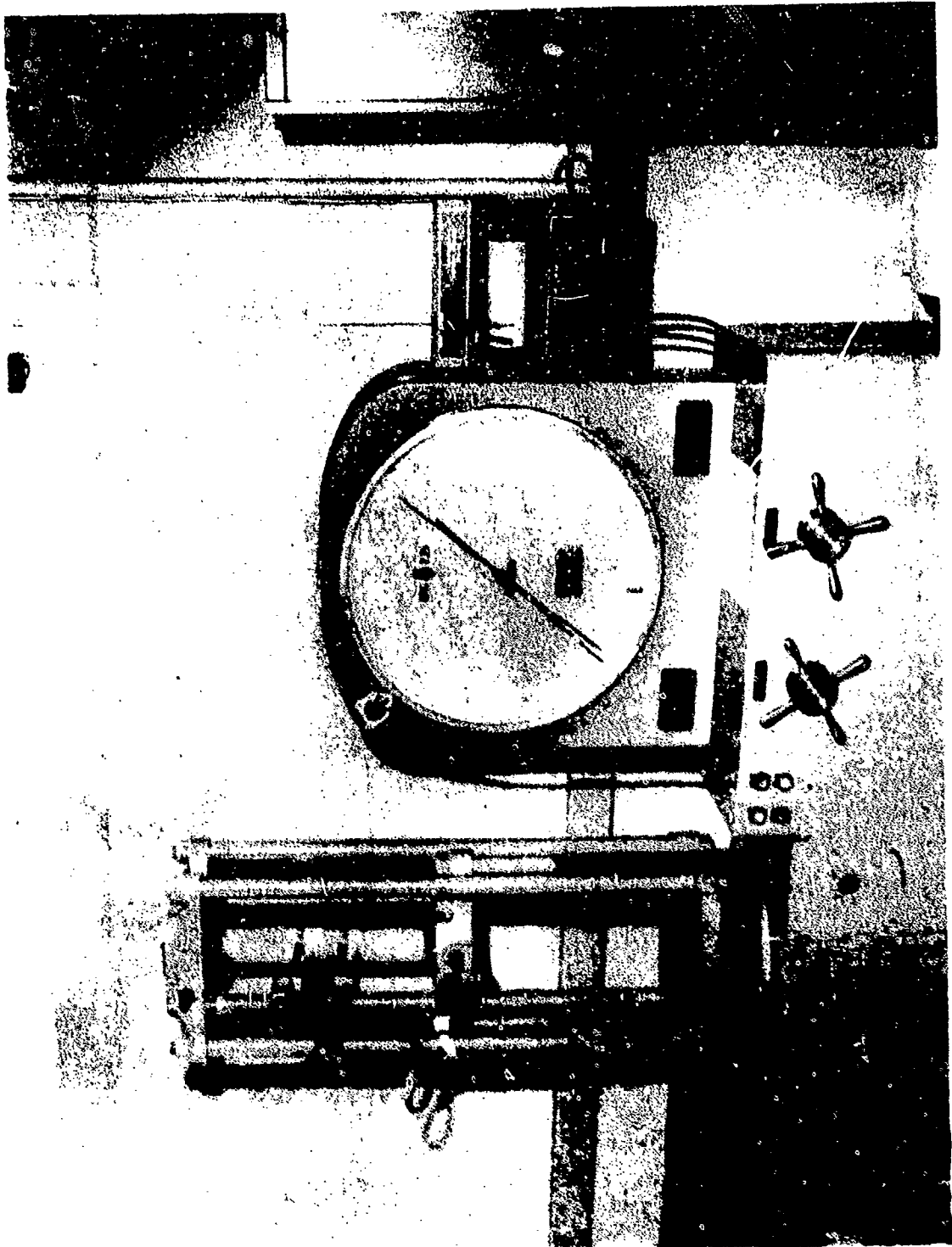
NOT LUBRICATED			LUBRICATED		
SPECIMEN NO.	BEARING YIELD STRENGTH (PSI)	BEARING ULTIMATE STRENGTH (PSI)	SPECIMEN NO.	BEARING YIELD STRENGTH (PSI)	BEARING ULTIMATE STRENGTH (PSI)
SC-6	117,460	215,555	SCL-18	114,285	196,190
SC-4	123,174	216,507	SCL-12	104,761	193,015
SC-7	120,634	219,047	SCL-15	107,936	191,111
SC-3	125,396	219,047	SCL-17	111,111	186,349
SC-5	128,235	226,349	SCL-11	111,111	205,079
AVG.	123,047	219,301		109,840	194,348

NOTE:


10.7% decrease in bearing yield strength when lubricated.

11.3% decrease in bearing ultimate strength when lubricated.

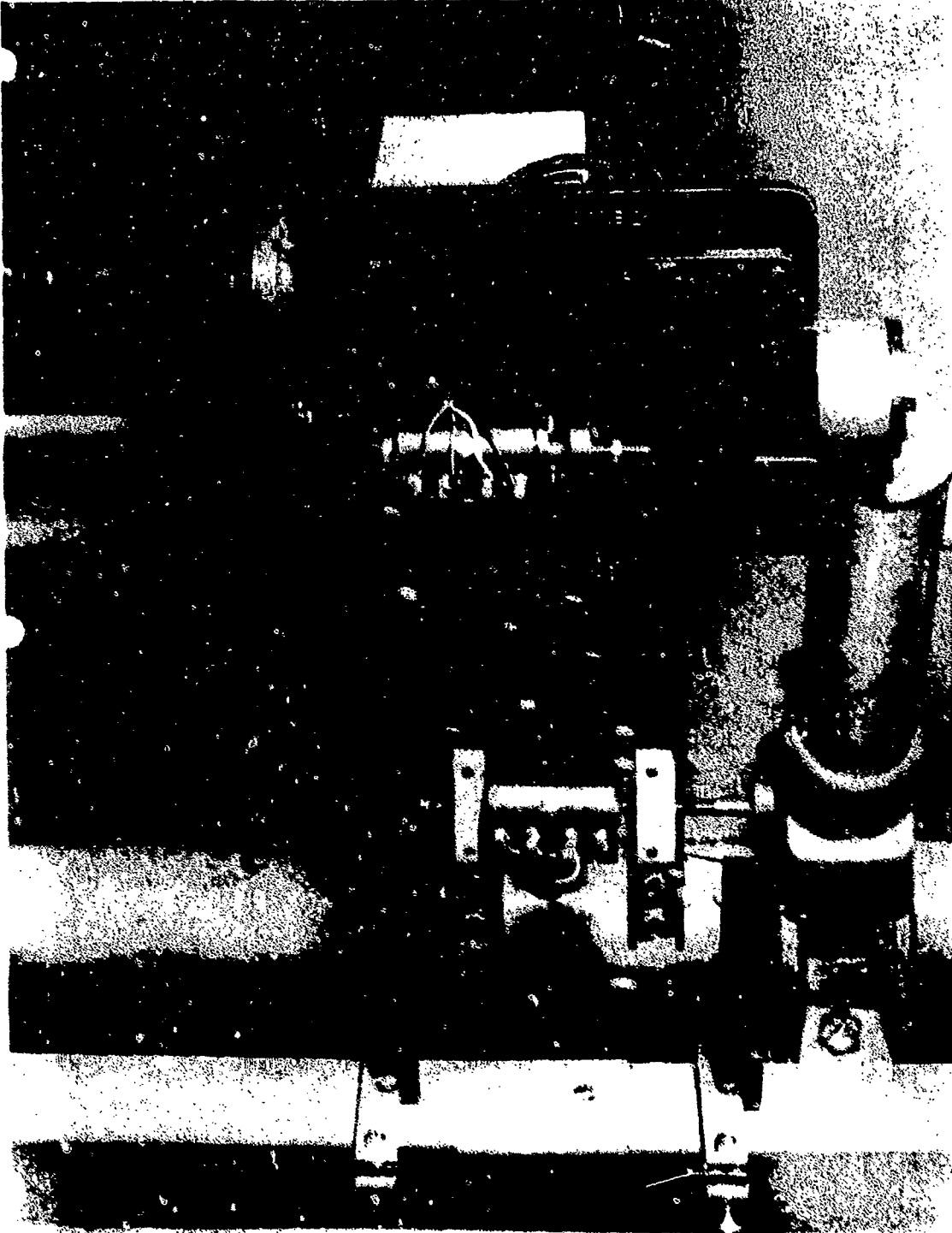





TINIUS OLSEN 60,000 LB. UNIVERSAL TESTING MACHINE

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TEST FIXTURE

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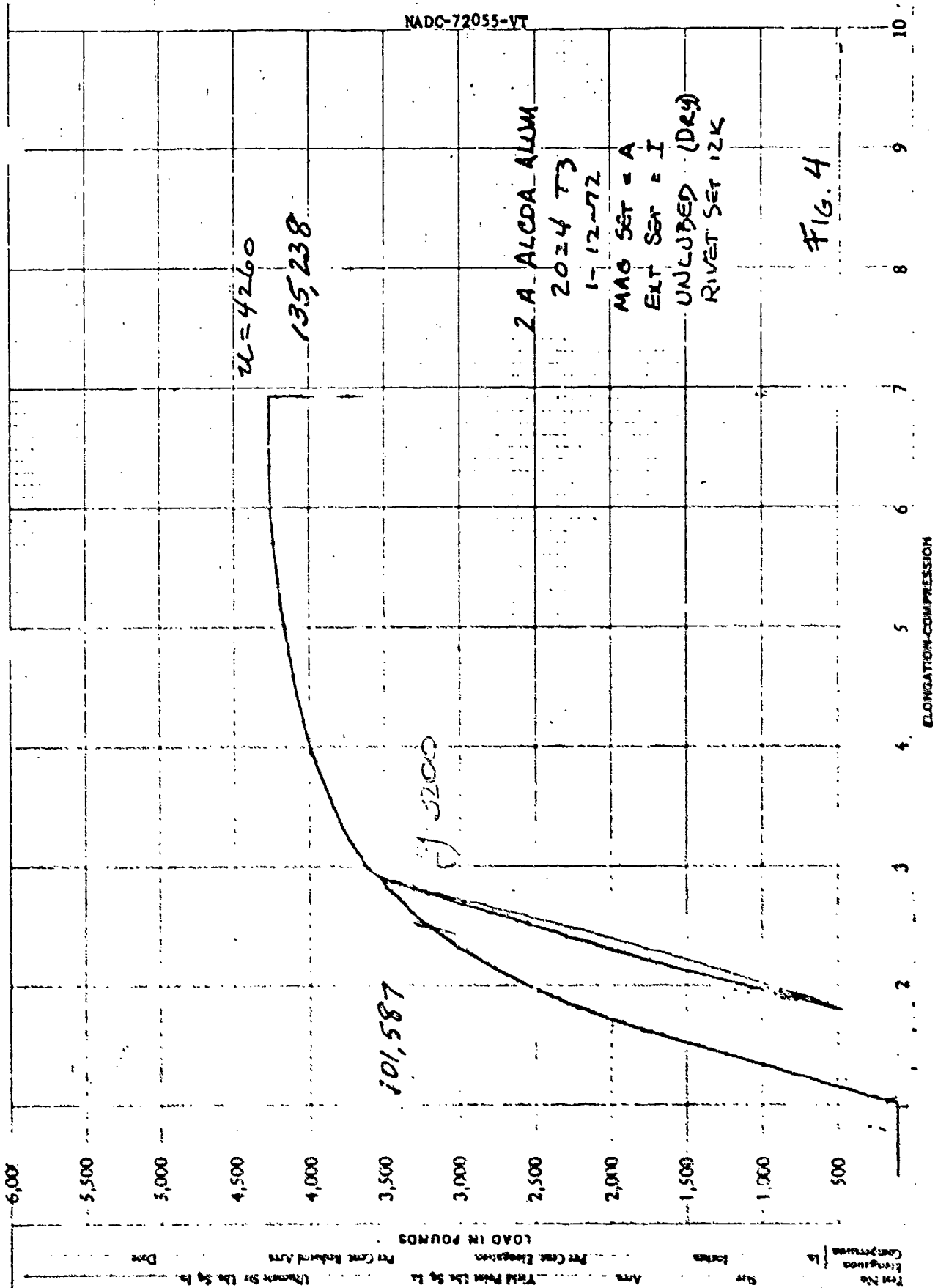


FIGURE 4

ELONGATION-COMPRESSION

LOAD IN POUNDS

Yield Point 101,587

91

Per Cent Elongation

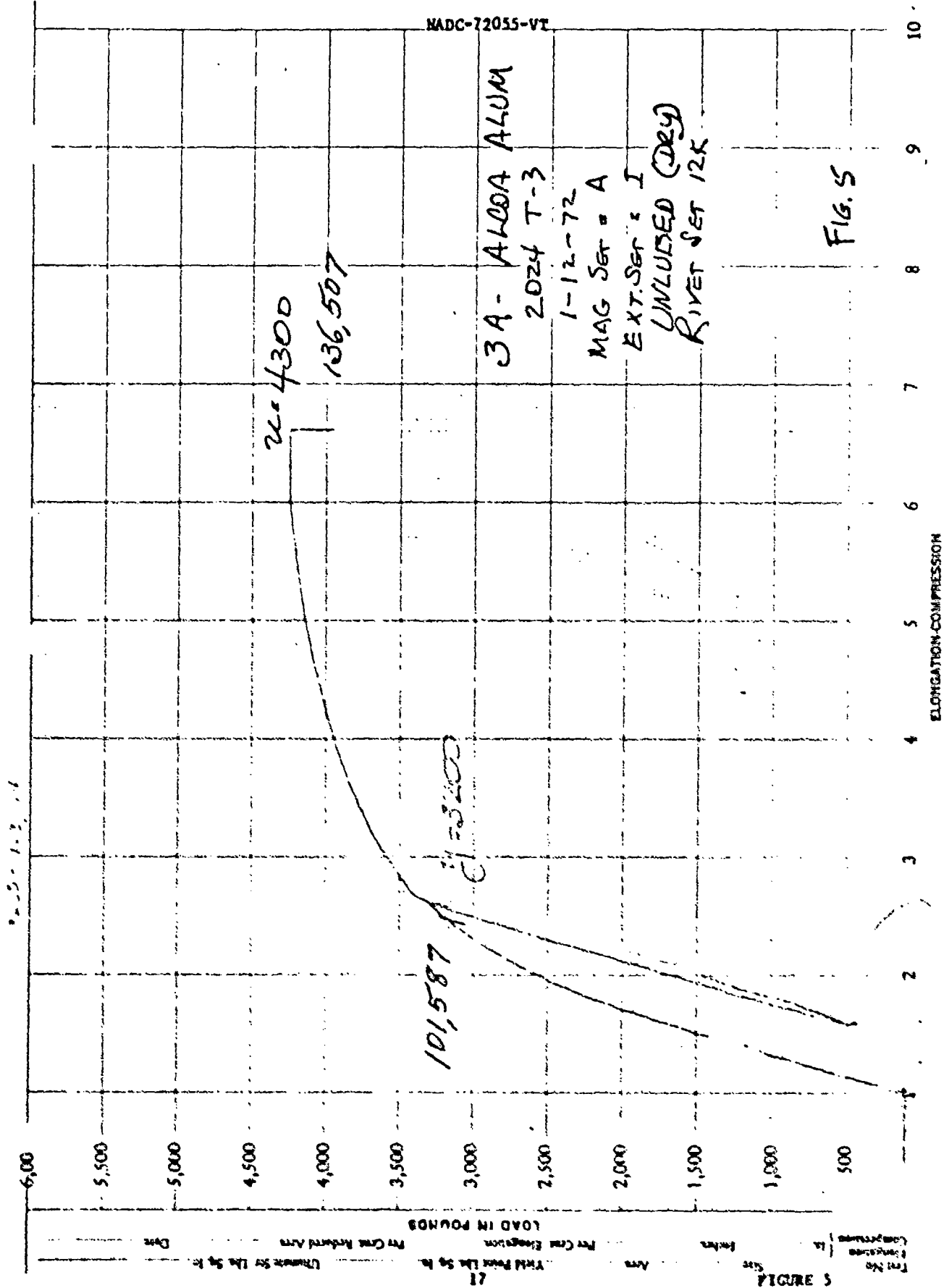
Per Cent Reduction Area

Date

Test No

Elongation

Compression



MADC-72055-VT

FIG. 5

5 AREA
 Test No. _____
 Test Pressure _____
 Test Length _____
 Area _____
 Yield Point Load _____
 Per Cent Elongation _____
 Per Cent Reduction Area _____
 Date _____

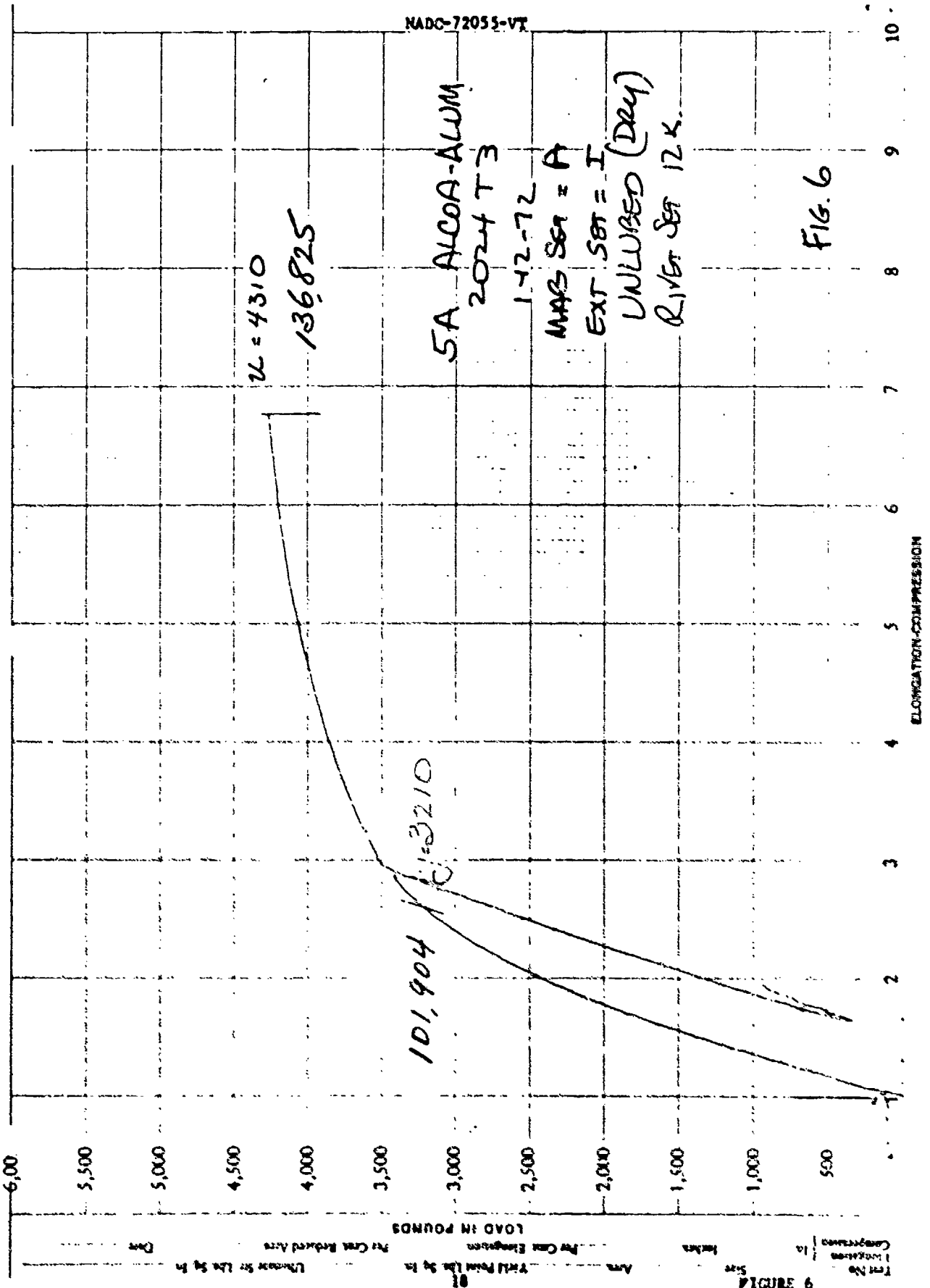


FIGURE 9

FIG. 6

ELONGATION-COMPRESSION

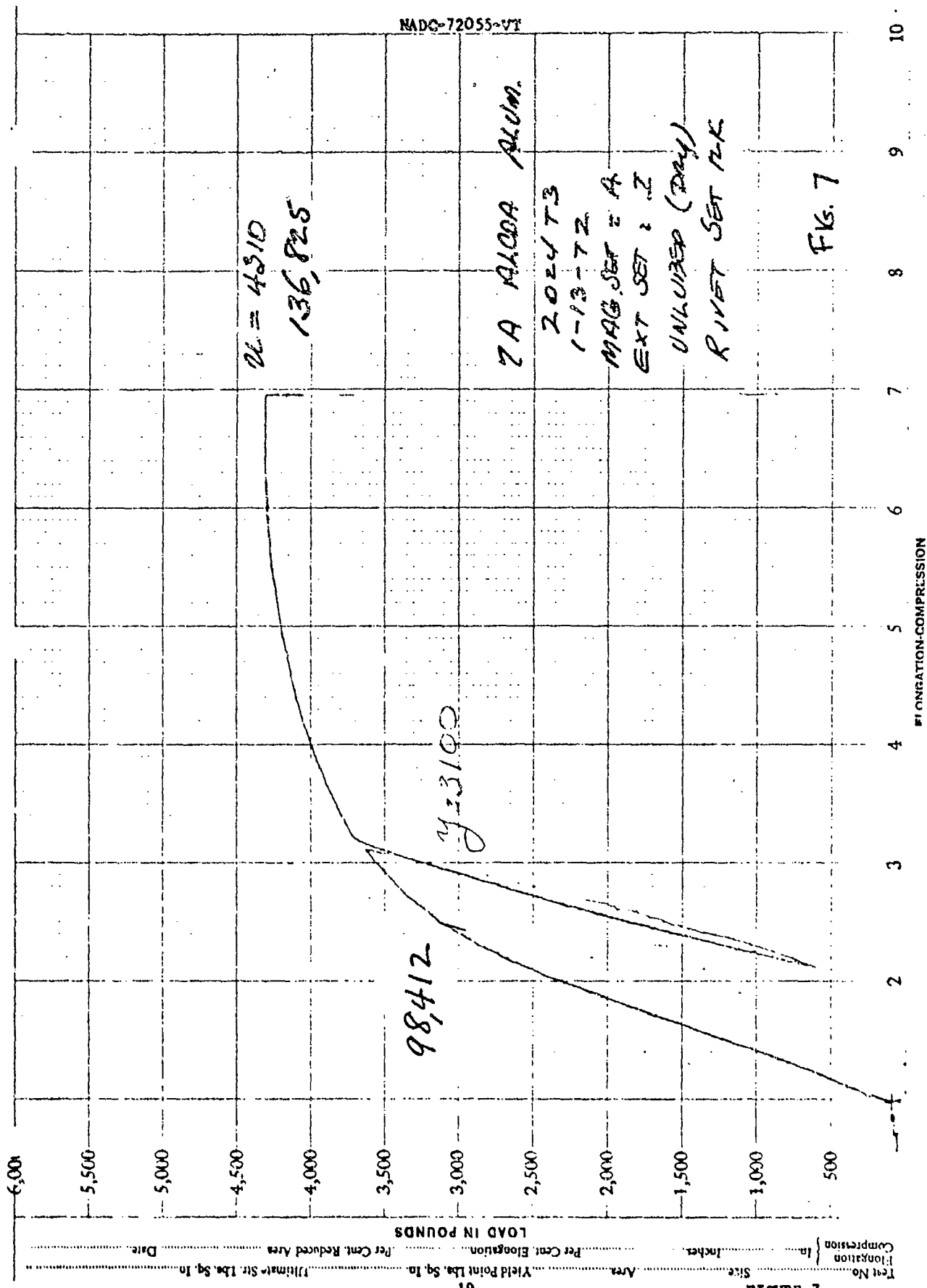


FIG. 7

61

Yield Point Lbs. Sq. In. Ultimate Str. Lbs. Sq. In. Date

Area Size Inches Per Cent. Elongation Per Cent. Reduced Area

Test No. Elongation Compression

FIGURE 7

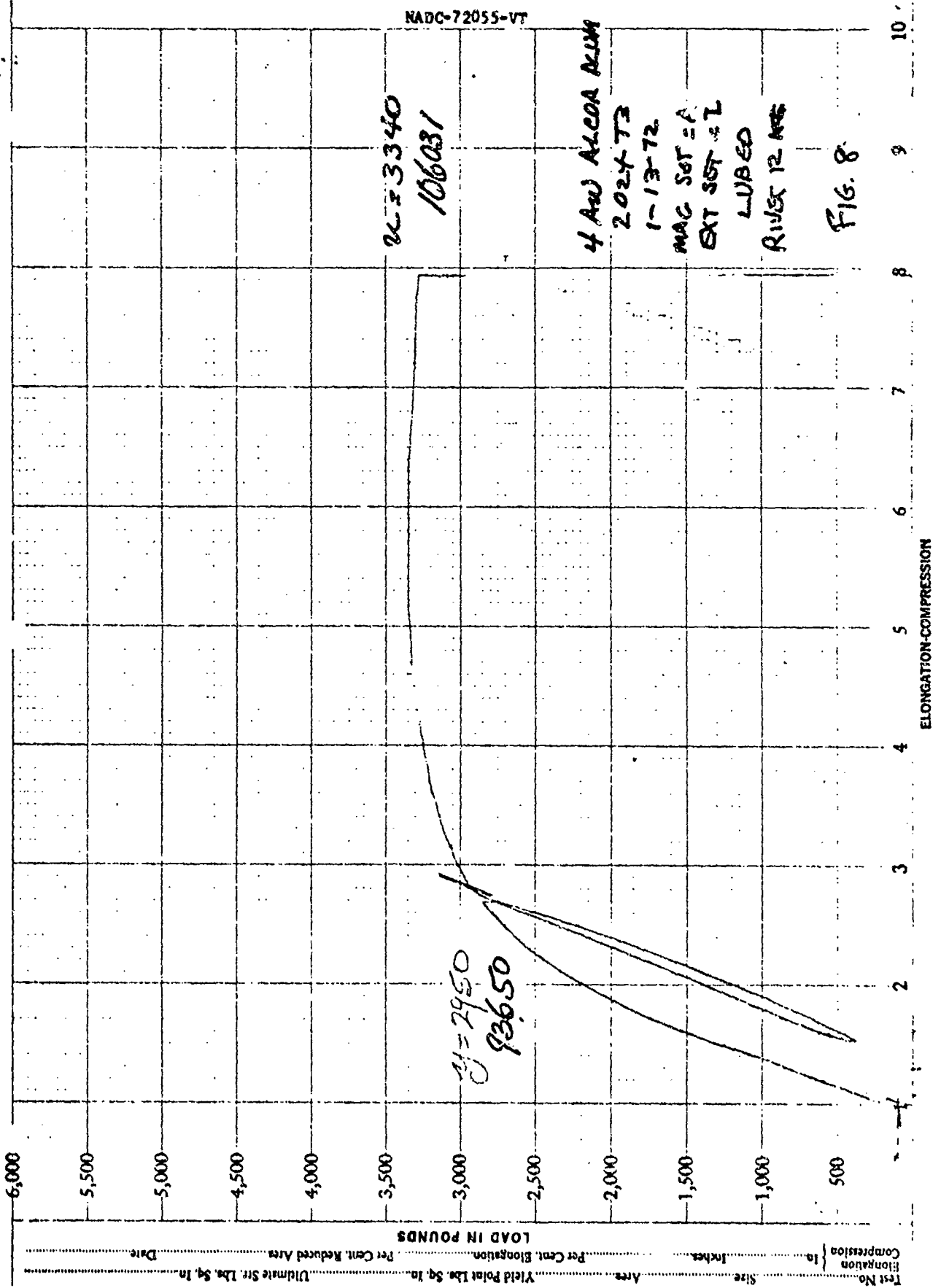
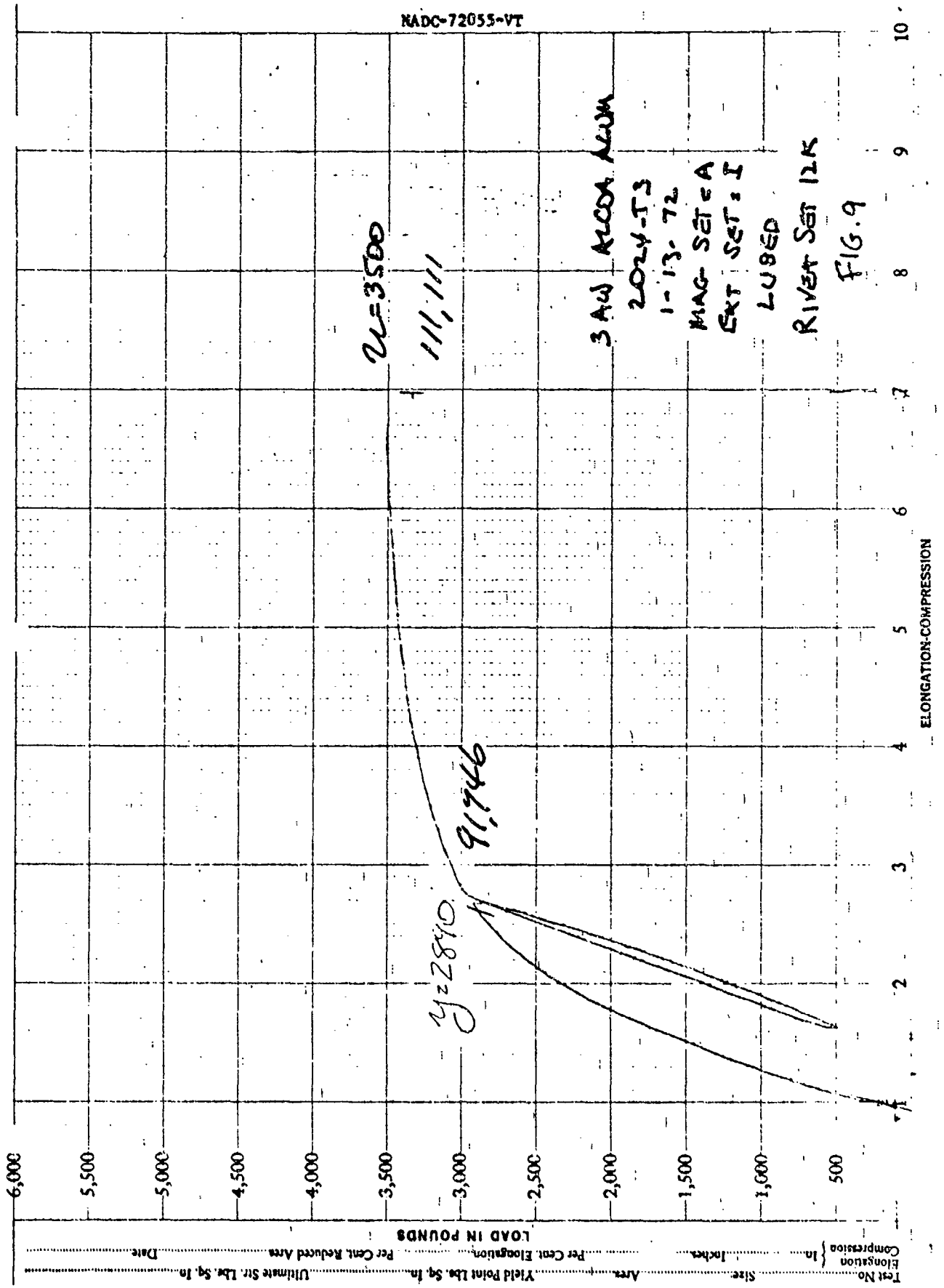
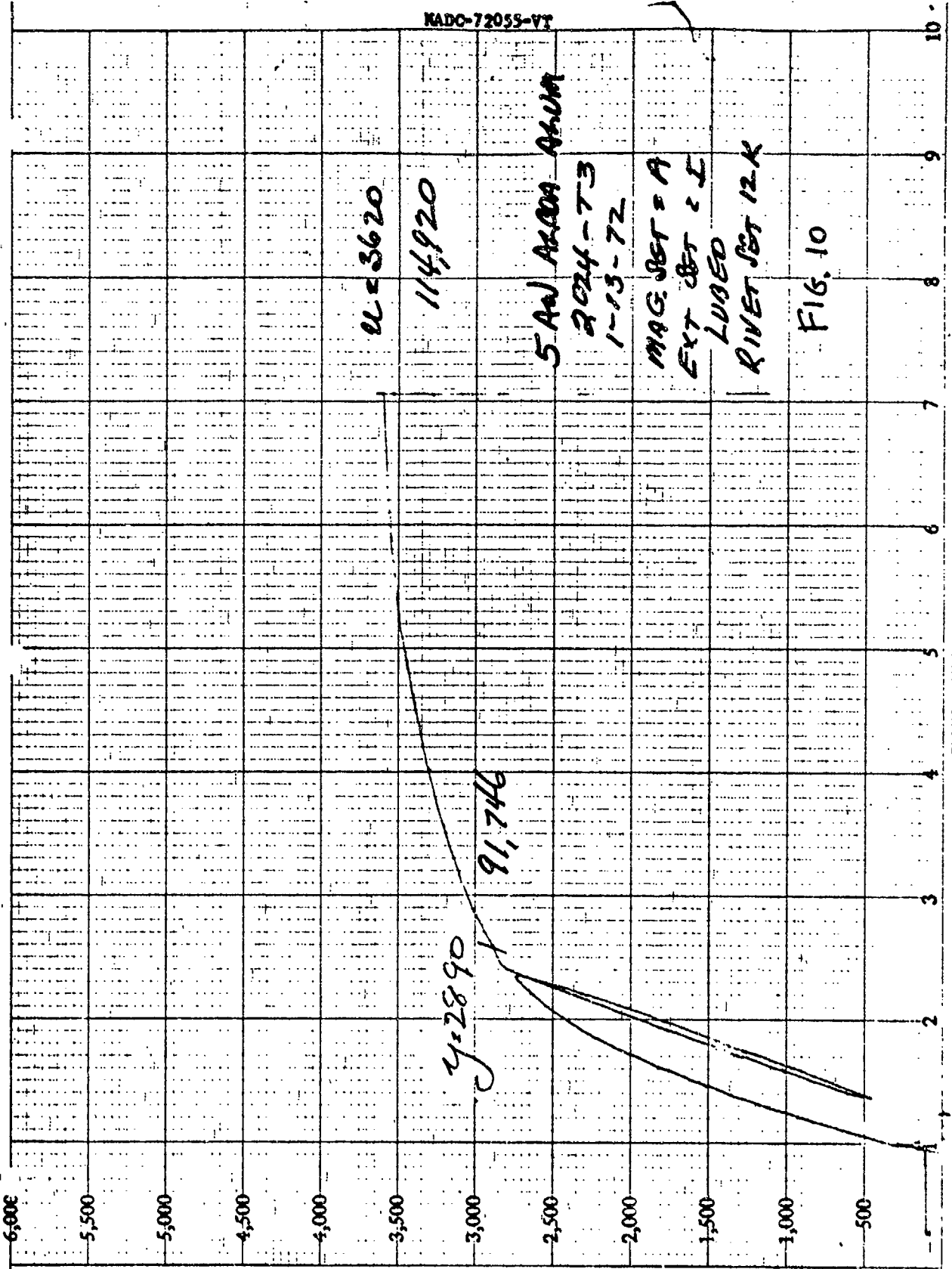


FIGURE 8

20

Test No. _____
 Elongation _____
 Compression _____
 Size _____
 Area _____
 Yield Point Lbs. Sq. In. _____
 Per Cent. Elongation _____
 Per Cent. Reduced Area _____
 Ultimate Str. Lbs. Sq. In. _____
 Date _____

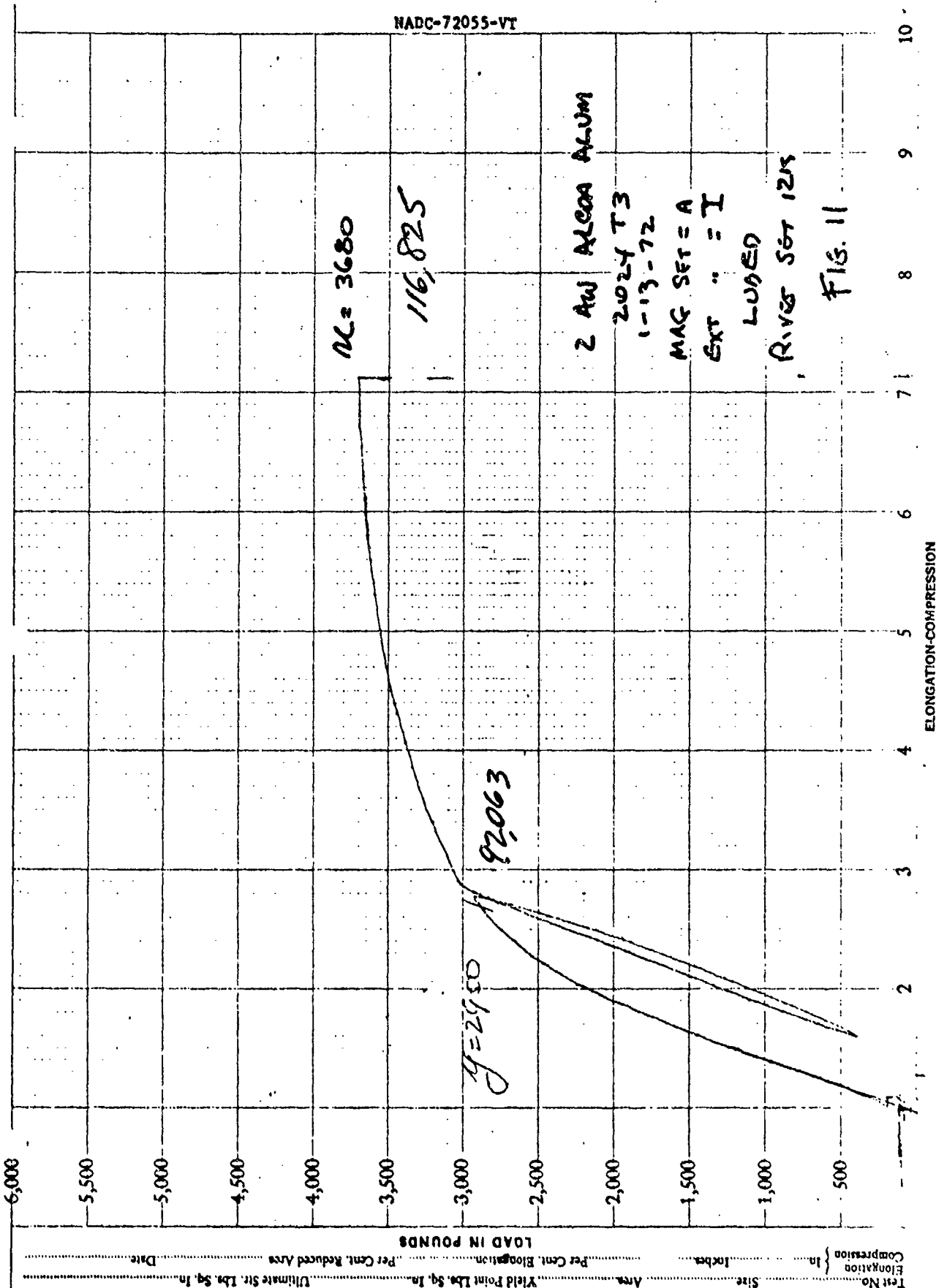




Test No. _____
 Elongation _____
 Compression _____
 In _____
 Locks _____
 Area _____
 Yield Point Lbs. Sq. In. _____
 Ultimate Str. Lbs. Sq. In. _____
 Date _____
 Per Cent. Elongation _____
 Per Cent. Reduced Area _____

FIGURE 10

ELONGATION-COMPRESSION



Test No. _____
Elongation _____ in _____
Compression _____ in _____
Area _____
Yield Point _____ Lbs. Sq. In. _____
Ultimate Str. _____ Lbs. Sq. In. _____
Per Cent. Elongation _____
Per Cent. Reduced Area _____
Date _____

FIGURE 11

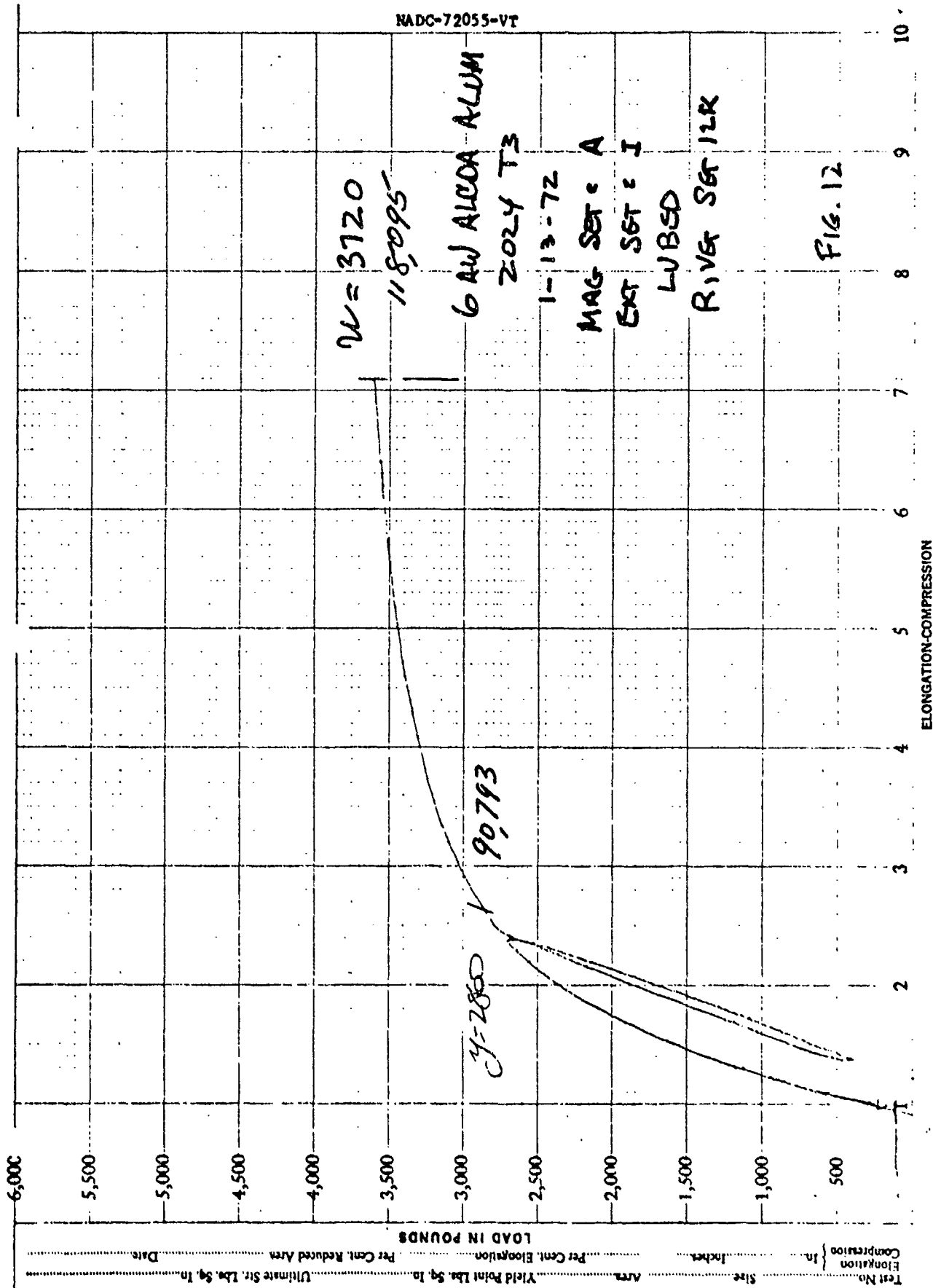
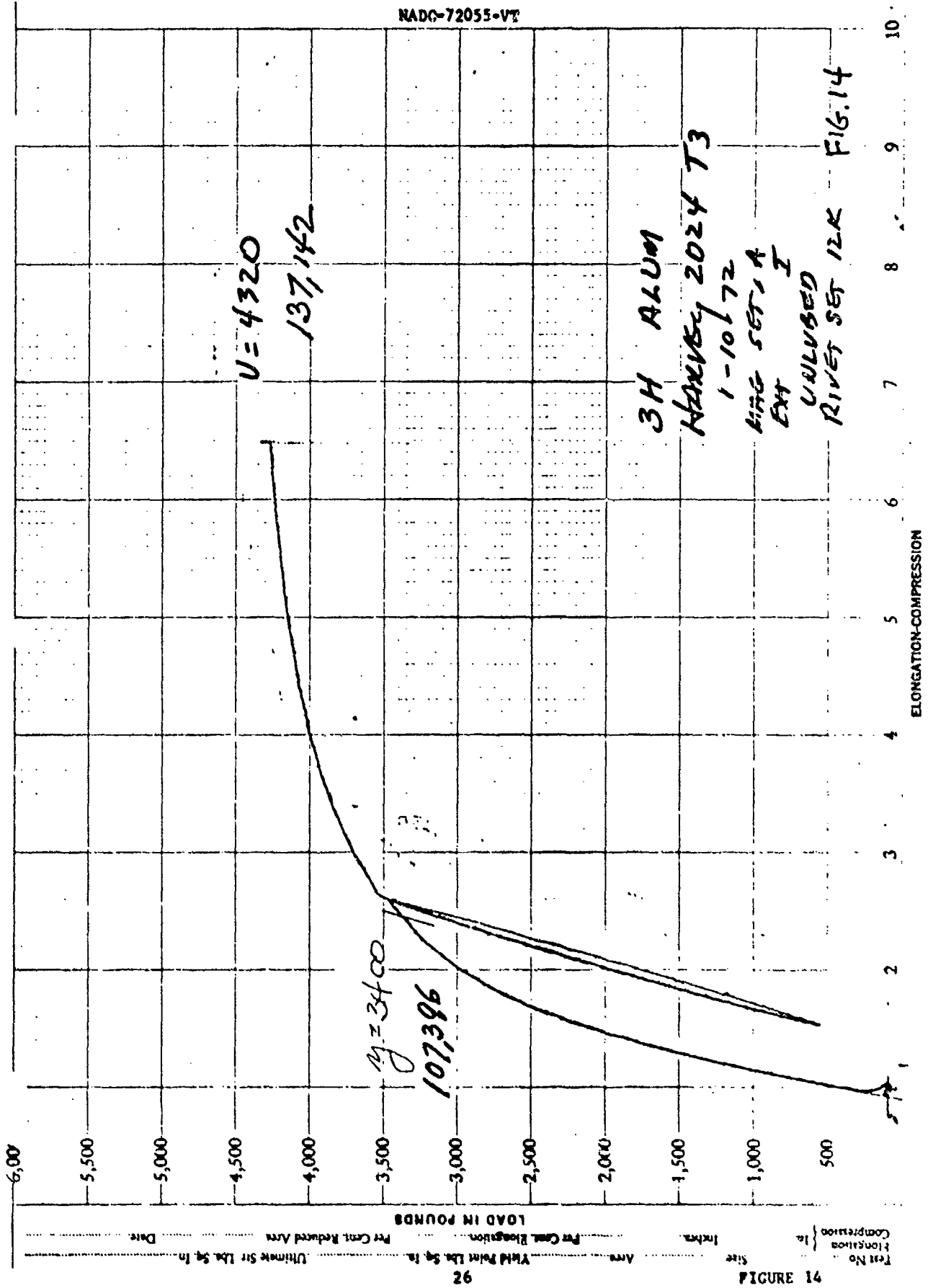


FIGURE 12

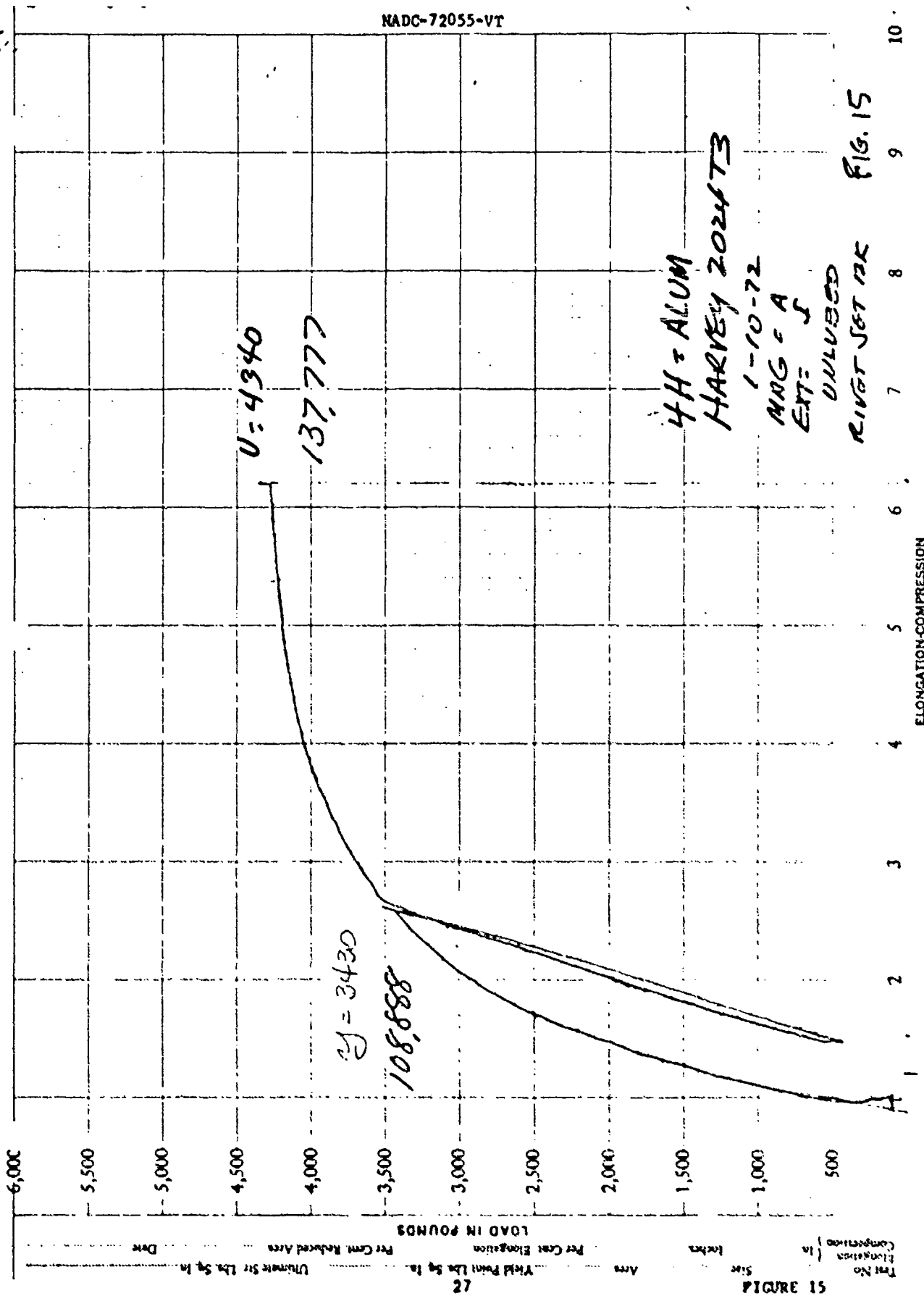
Test No. _____ Size _____ In. _____
 Elongation _____ In. _____
 Compression _____ In. _____
 Area _____ Per Cent. Elongation _____
 Yield Point Lbs. Sq. In. _____
 Ultimate Str. Lbs. Sq. In. _____
 Per Cent. Reduced Area _____
 Date _____



3H ALUM
 HARVEY 2024 T3
 1-10-72
 FIG SET 1 A
 EXT
 UNLUBED
 RIVET SET 12K FIG. 14

92
 Yield Point Lbs. Sq. In. Ultimate Str. Lbs. Sq. In. Date
 Per Cent Elongation Per Cent Reduced Area
 Test No. Elongation in. Compression in. Size in. Area in. Sq. In.

FIGURE 14



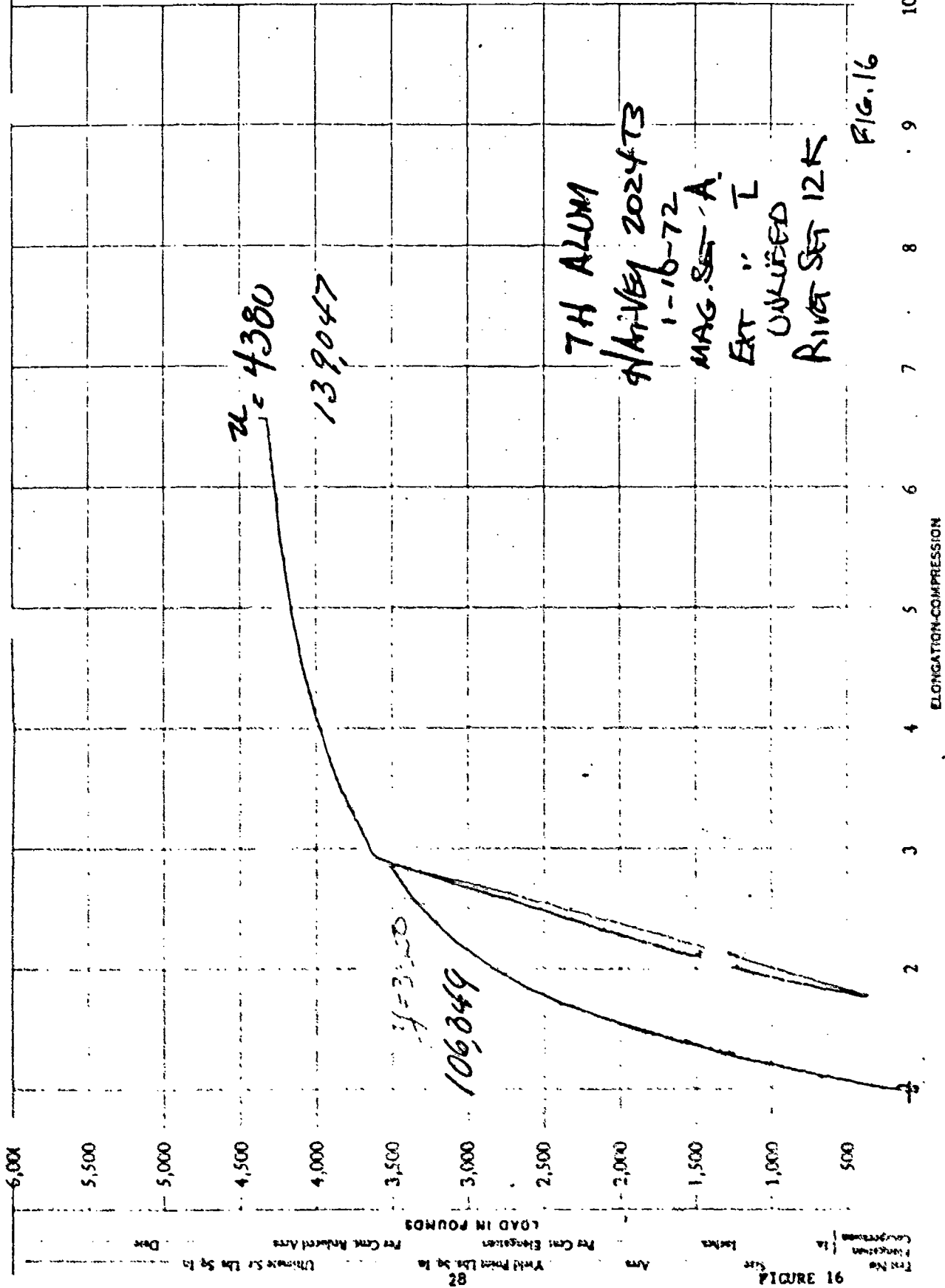


FIG. 16

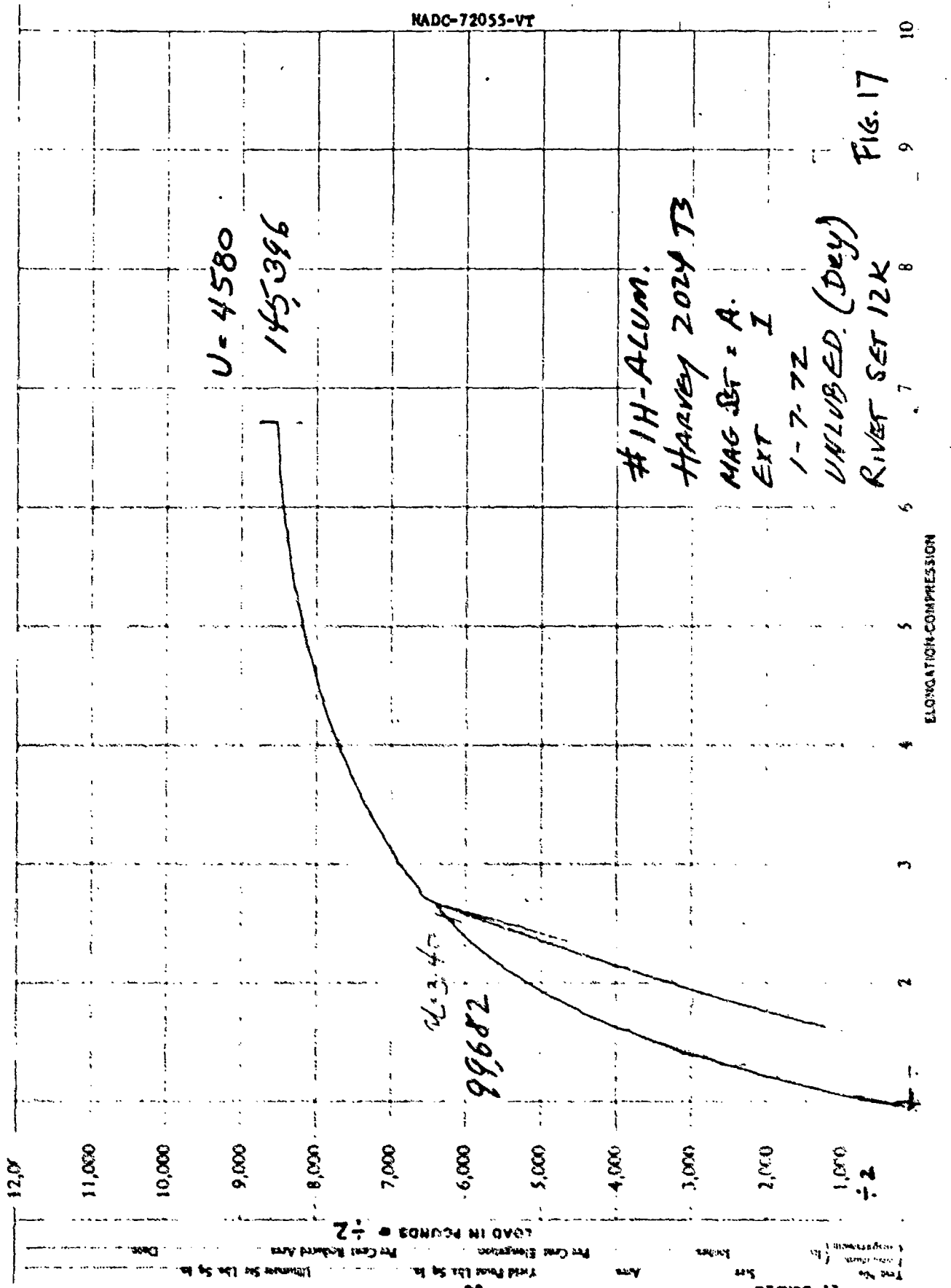


FIG. 17

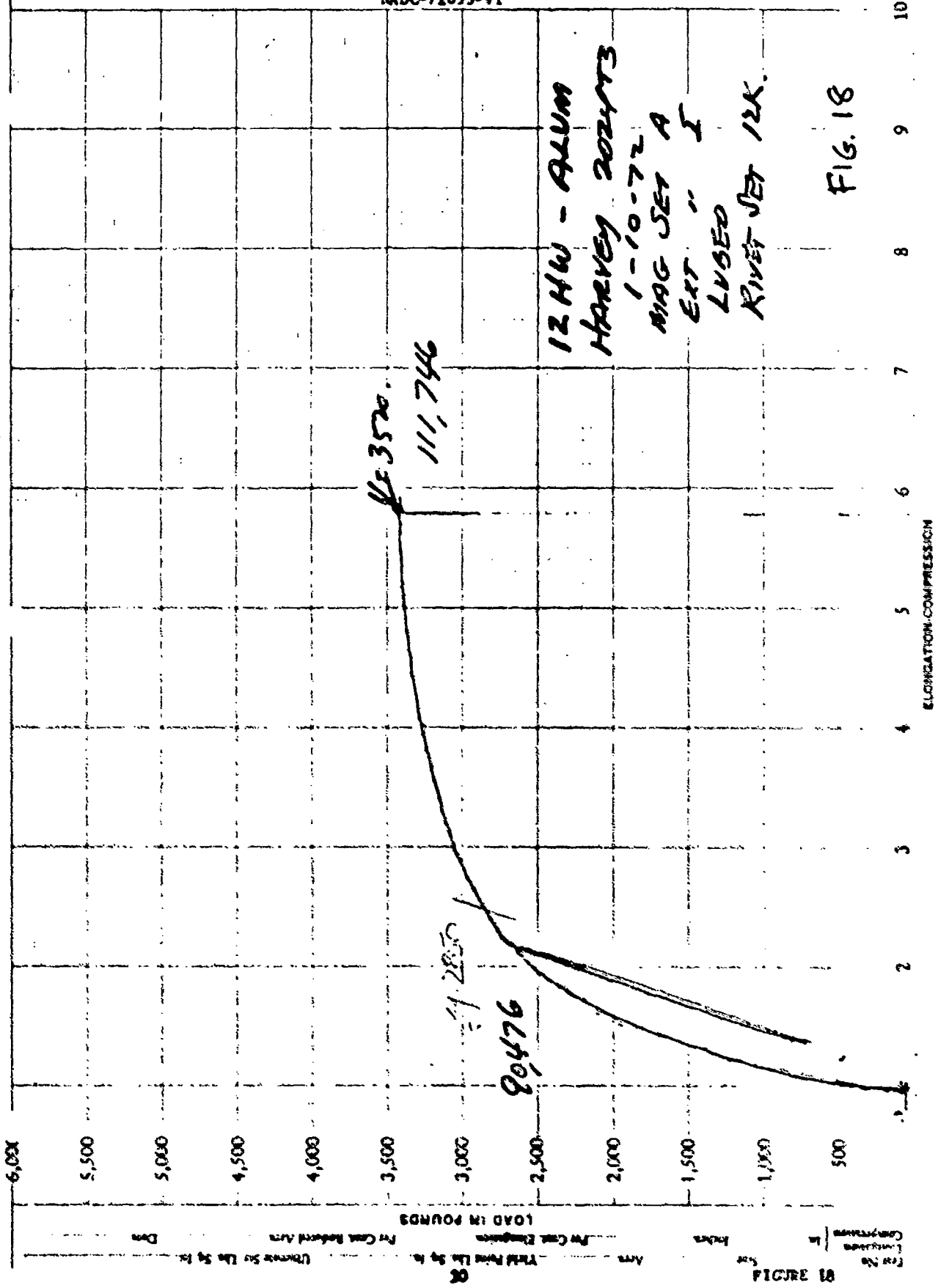


FIG. 18

FIGURE 18
 Rivet No. _____
 Elongation-Compression _____ in
 Load _____ lbs
 Area _____ sq in
 Yield Point _____ lbs sq in
 Tensile _____ lbs sq in
 Elongation _____ %
 Per Cent Elongation _____
 Per Cent Reduction Area _____
 Dia _____

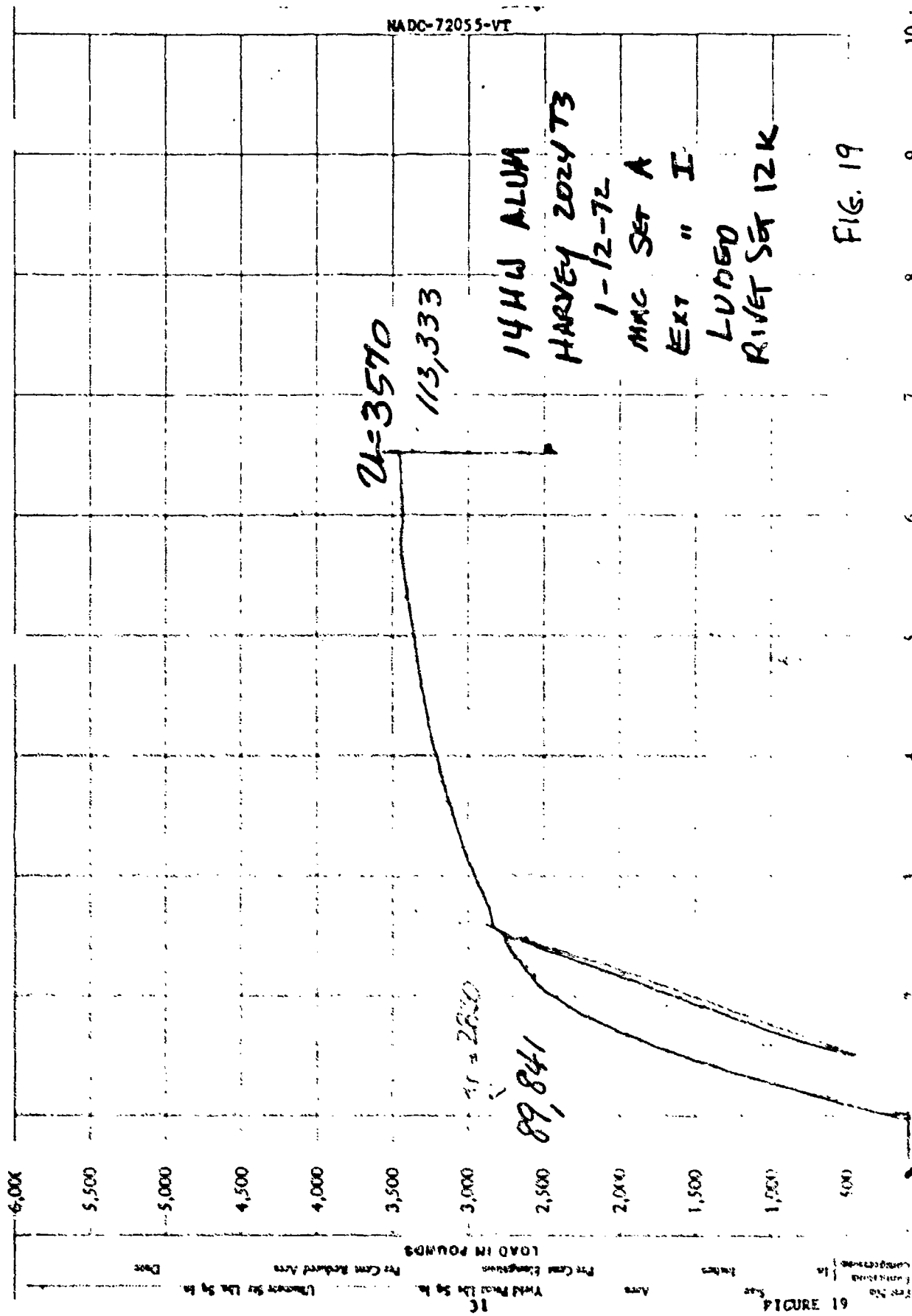


FIG. 19

FIGURE 19

Yield Point 2800
1480
LOAD IN POUNDS
Per Cent Elongation
Per Cent Reduction Area
Date

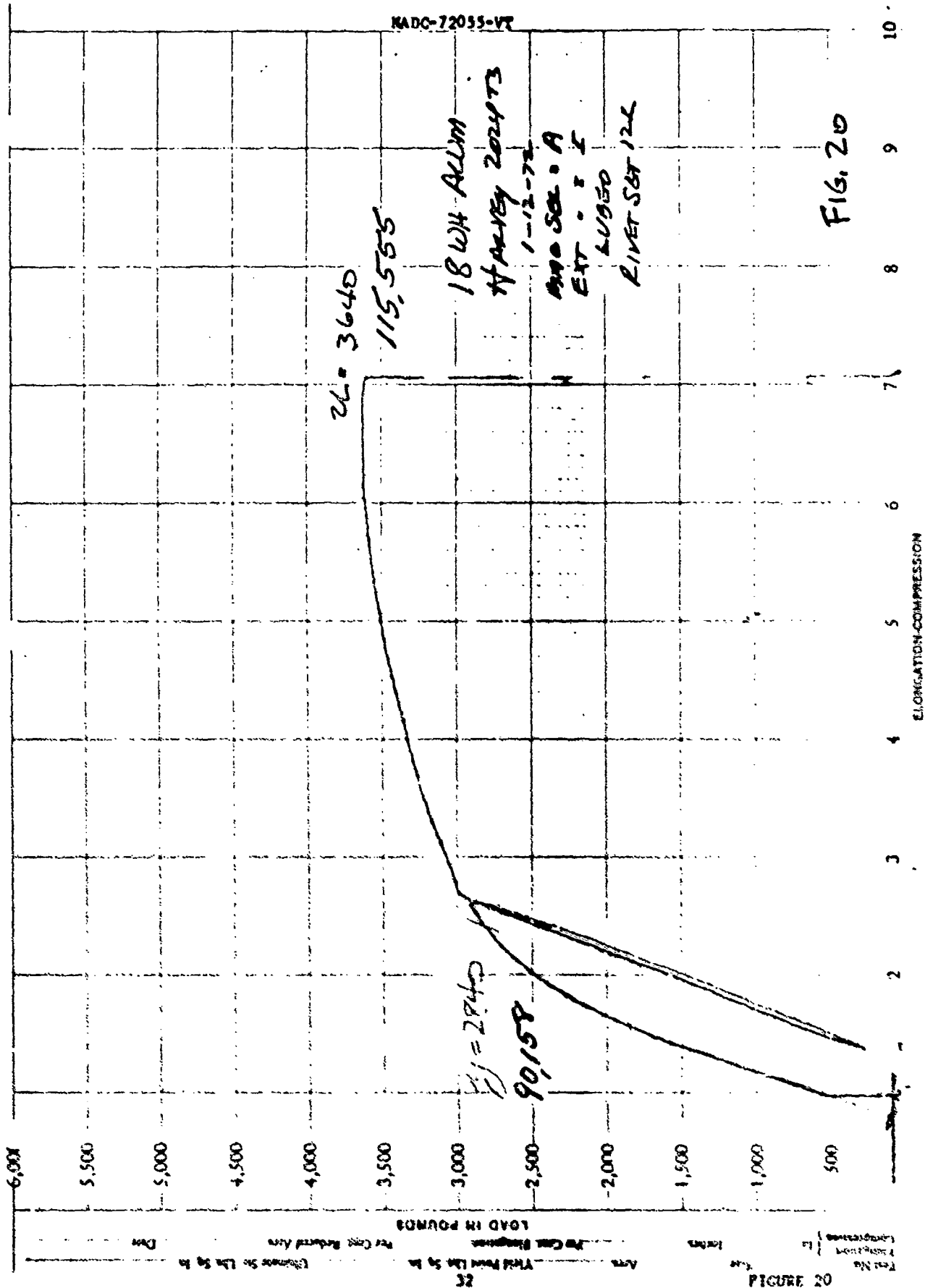


FIG. 20

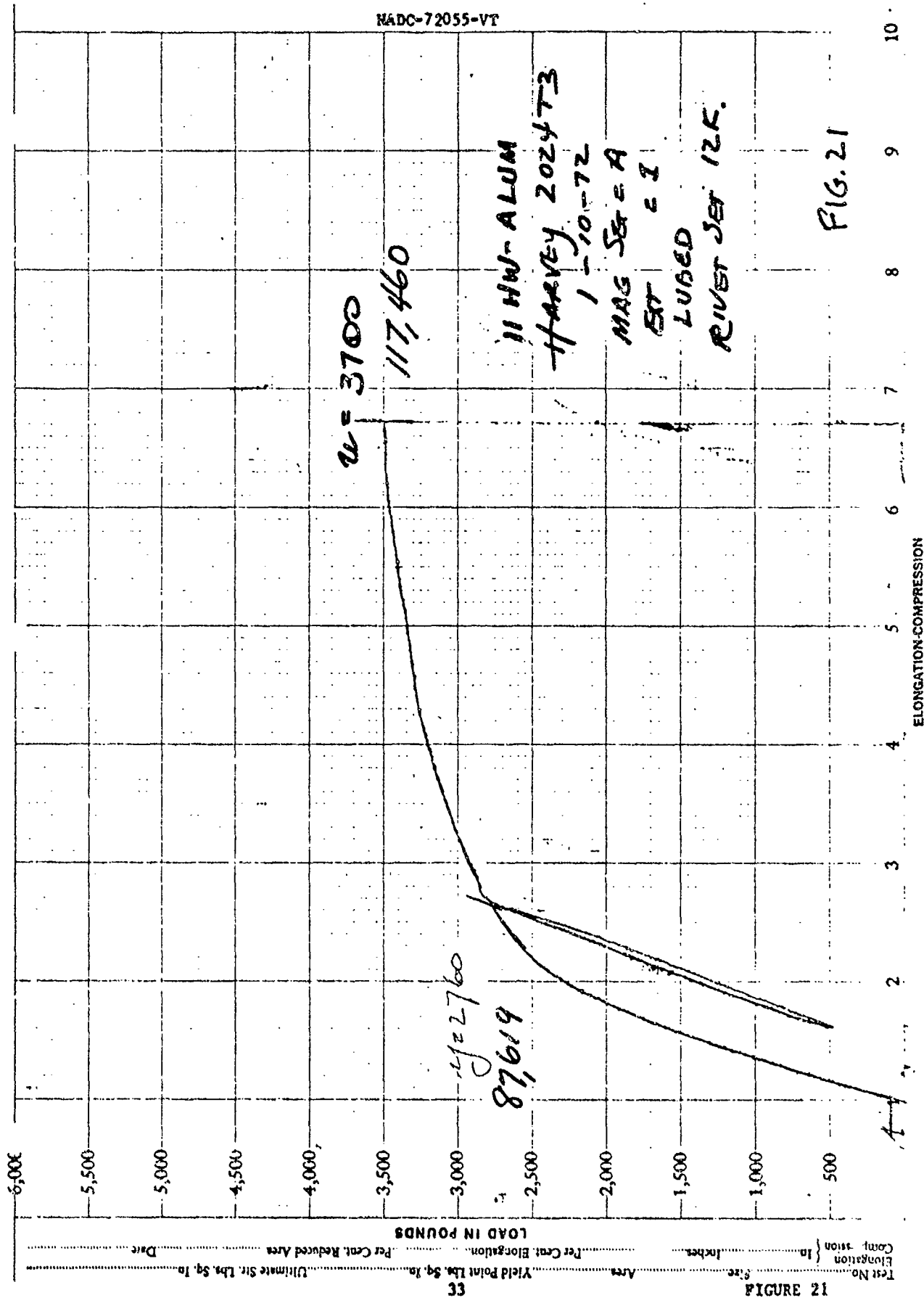


FIG. 21

FIGURE 21

CC

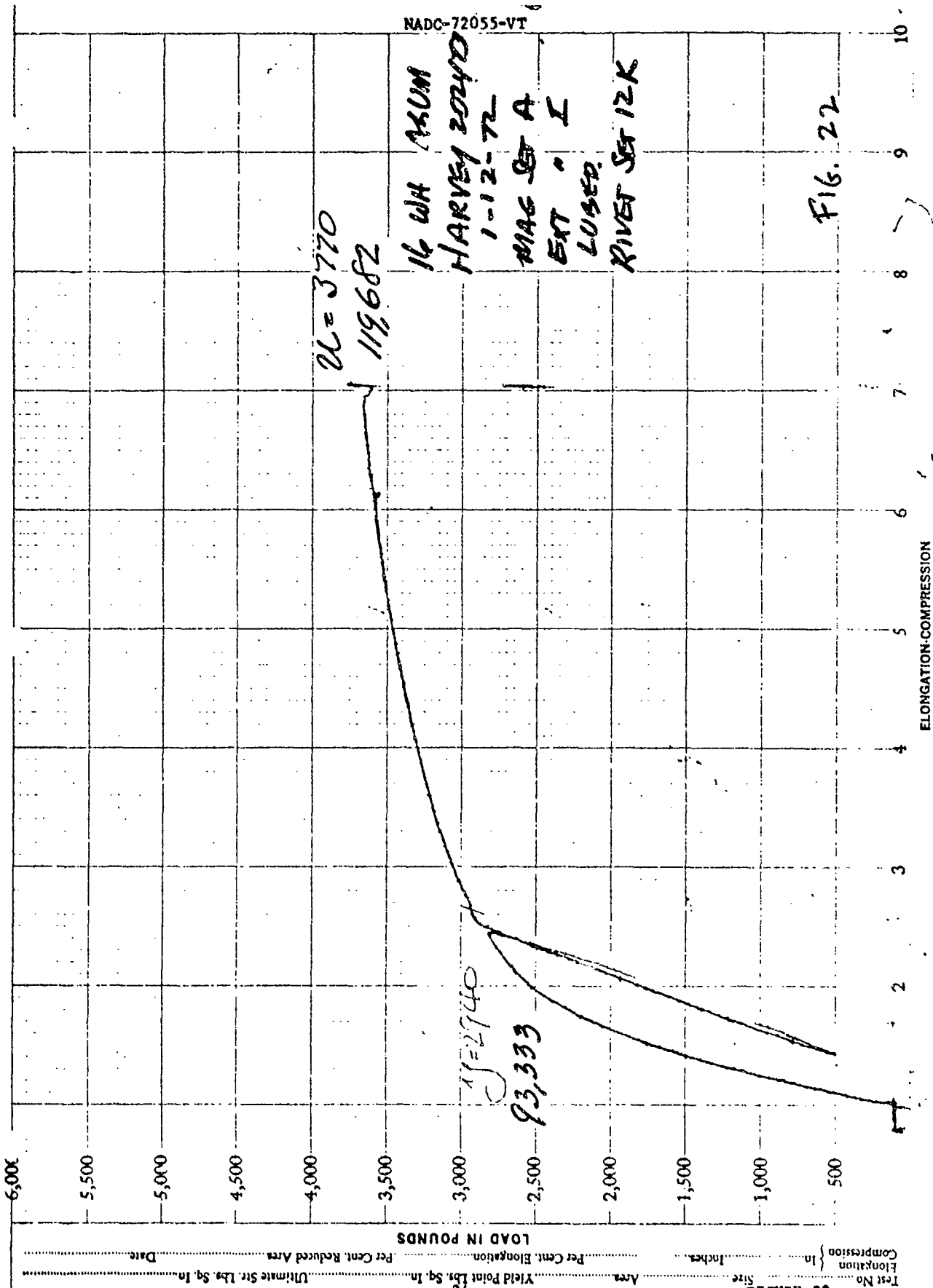
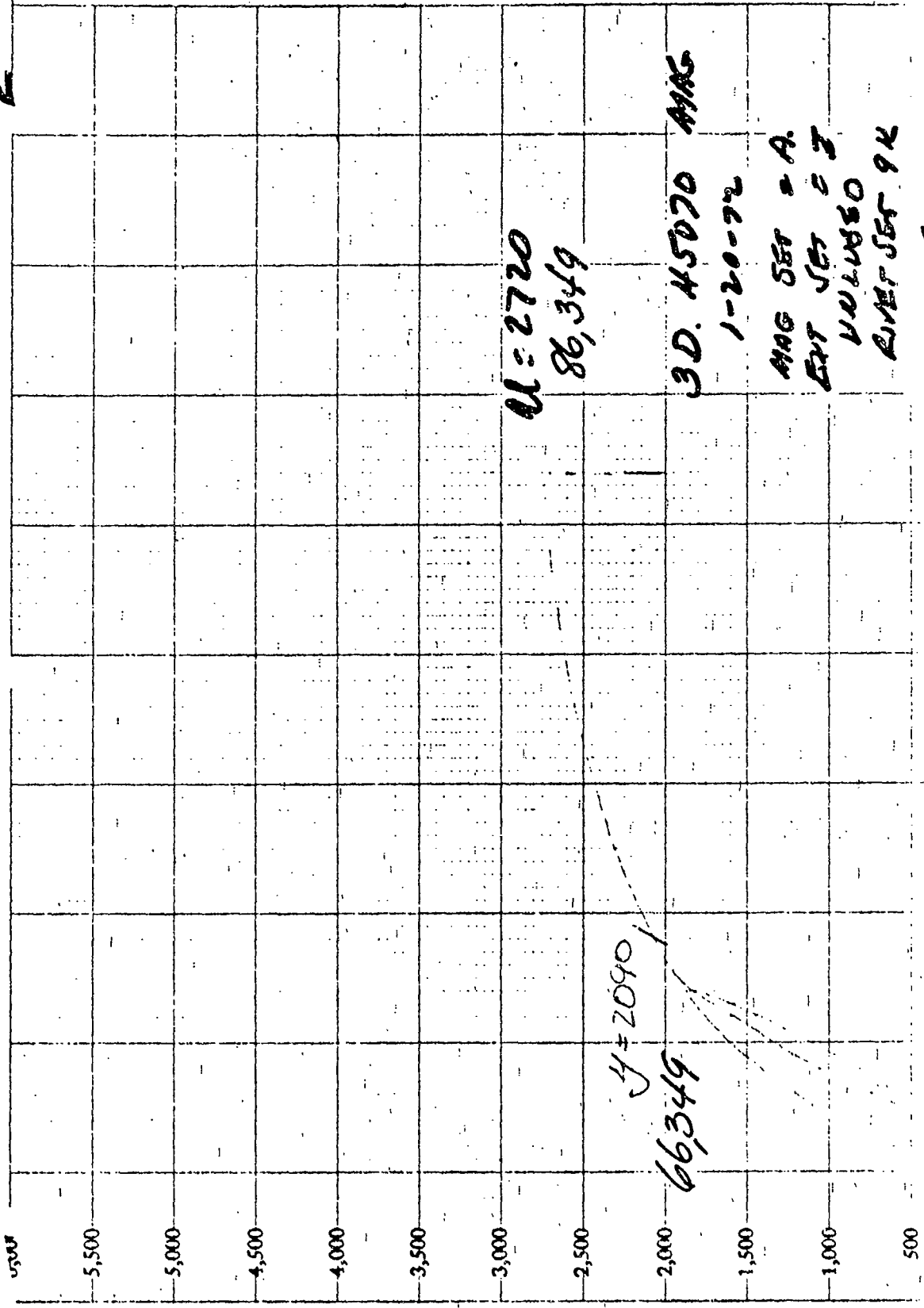


FIG. 22

2



55
 No. of Ration (Inches)
 Size (Inches)
 Area (Sq. In.)
 Yield Point Lbs. Sq. In.
 Ultimate Str. Lbs. Sq. In.
 Per Cent. Reduced Area
 Date:

FIGURE 23

FIG. 23

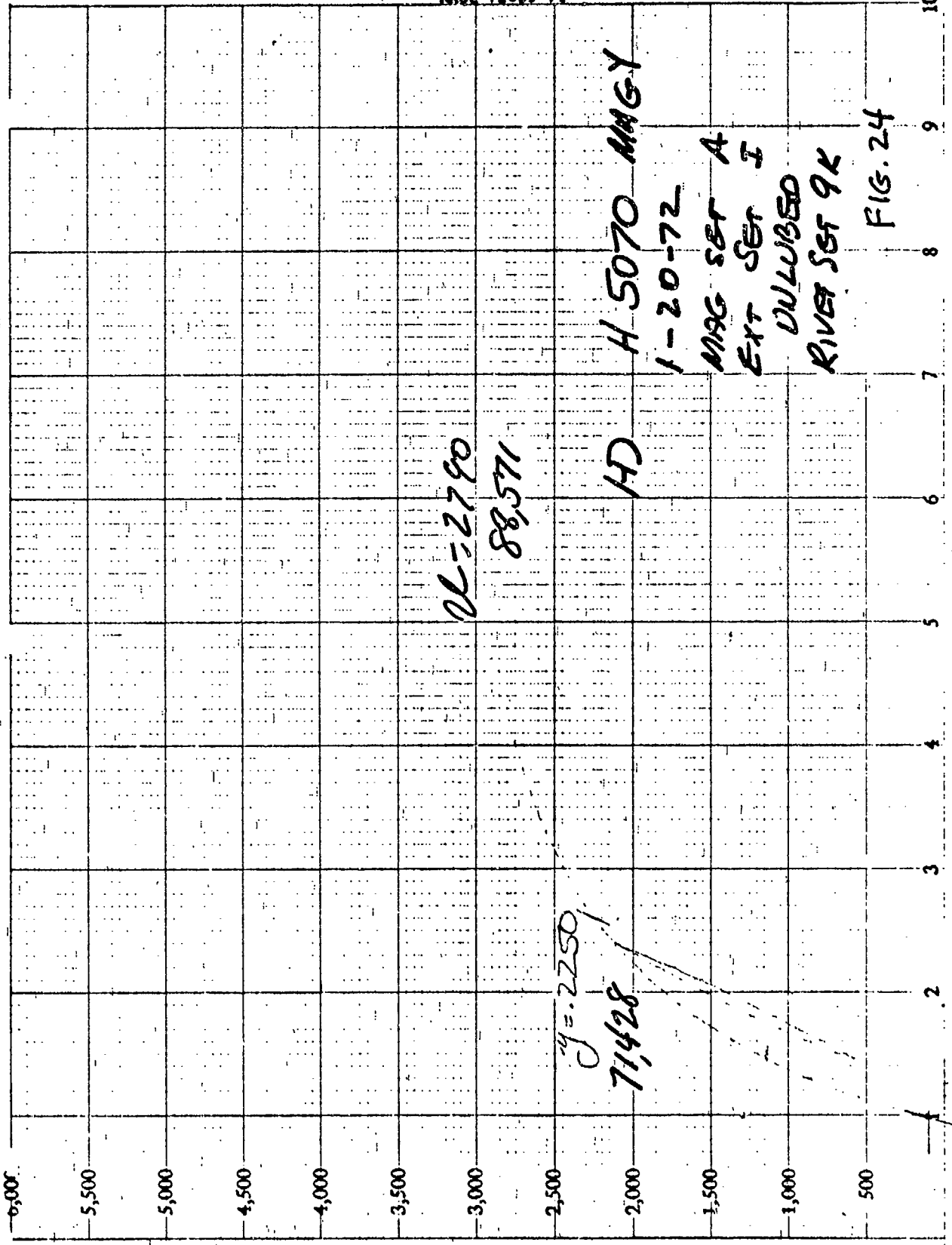
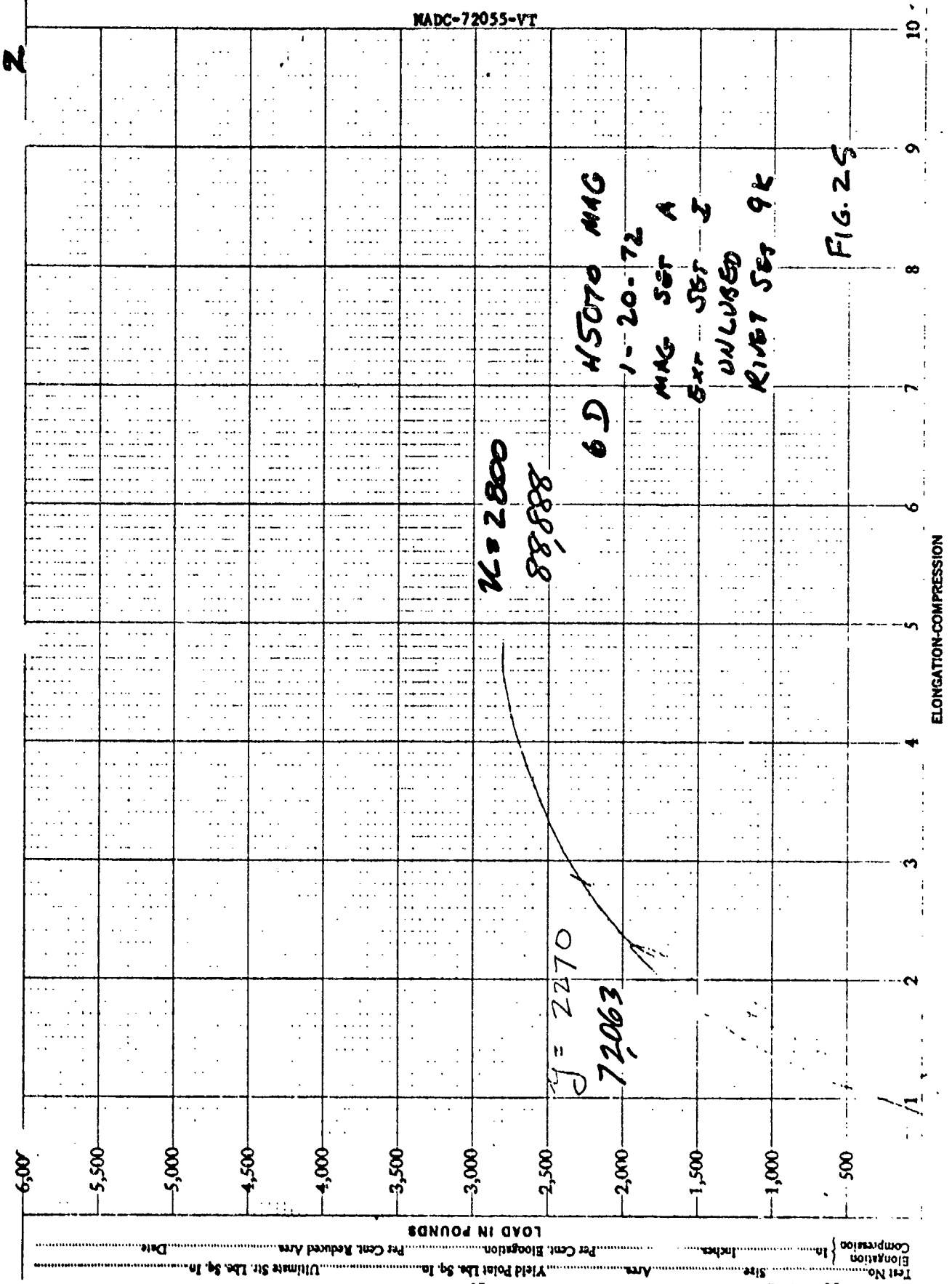


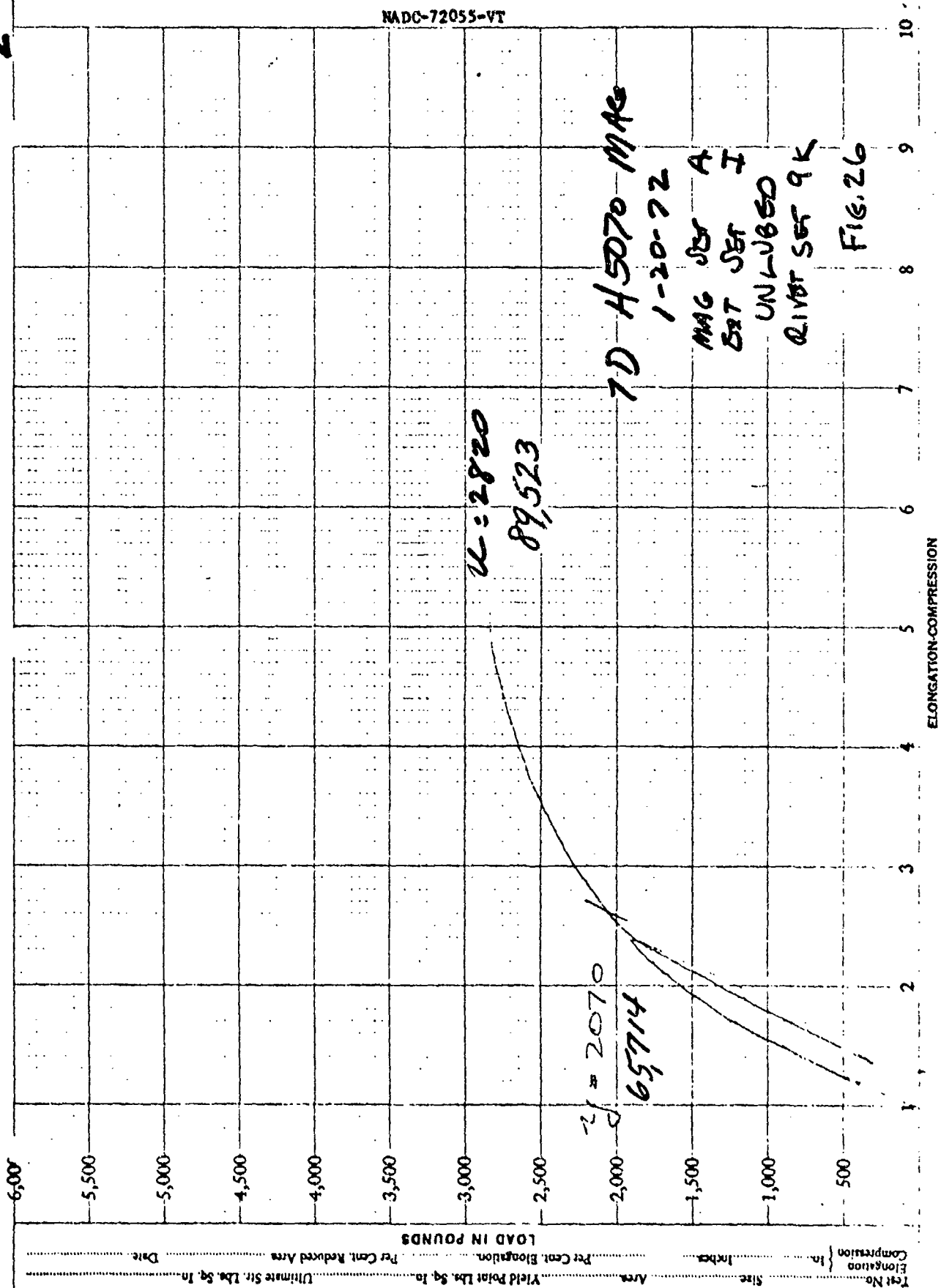
FIG. 24

ELONGATION-COMPRESSION



Test No. _____
 Elongation _____
 Compression _____
 In _____
 Size _____
 Area _____
 Yield Point Lbs. Sq. In. _____
 Ultimate Str. Lbs. Sq. In. _____
 Per Cent. Elongation _____
 Per Cent. Reduced Area _____
 Date _____

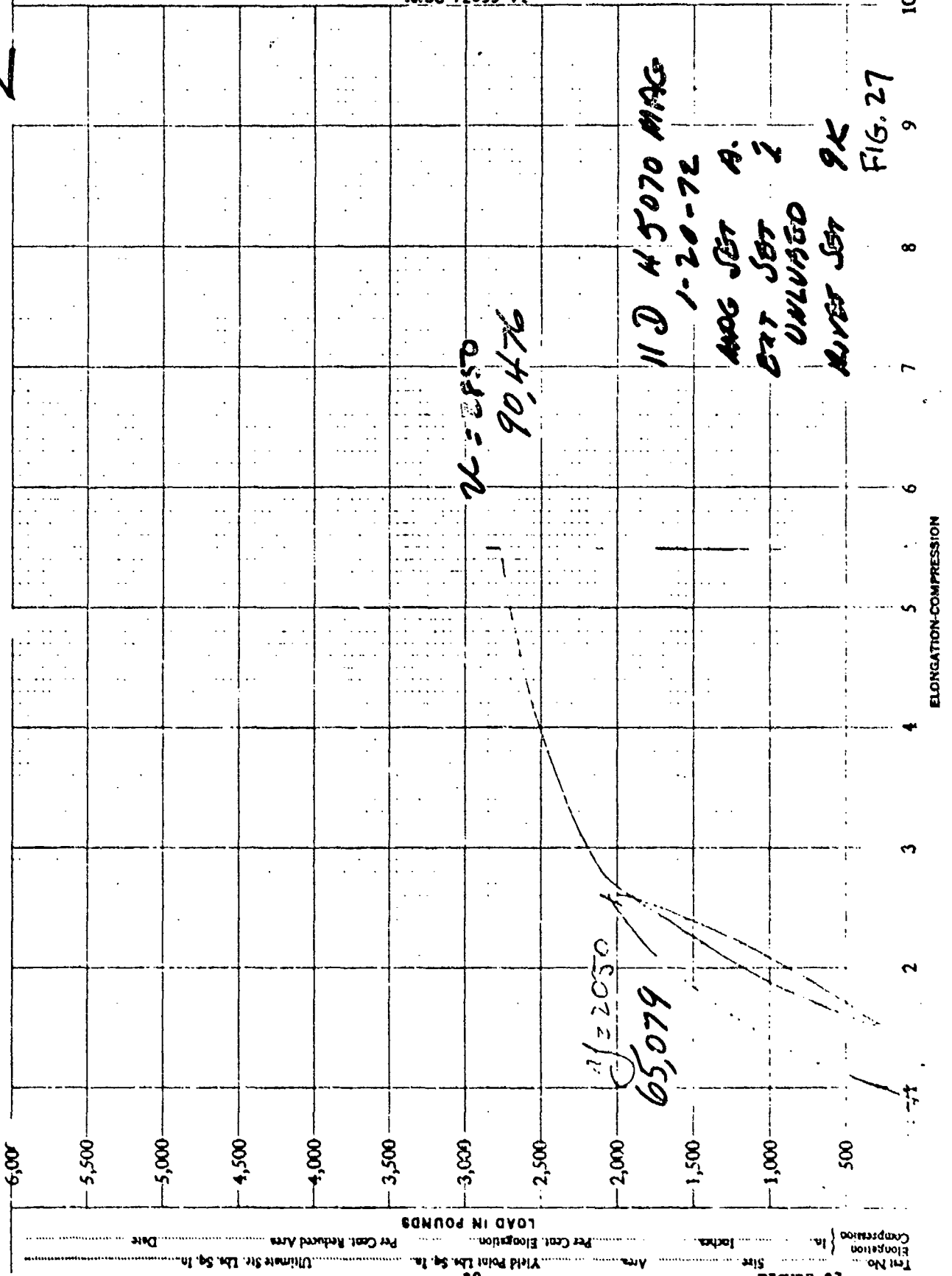
2



Test No. _____
 Elongation _____
 Compression _____
 In. _____
 Area _____
 Yield Point Lbs. Sq. In. _____
 Per Cent. Elongation _____
 Per Cent. Reduced Area _____
 Ultimate Str. Lbs. Sq. In. _____
 Date _____

FIGURE 26

Z



K=2850
90,476

σ = 2050
65,079

11 D H 5070 MAG
1-20-72
MAG SET A.
ERT SET I
UNLUAGD
MUT SET 9K

FIG. 27

ELONGATION-COMPRESSION

FIGURE 27

2

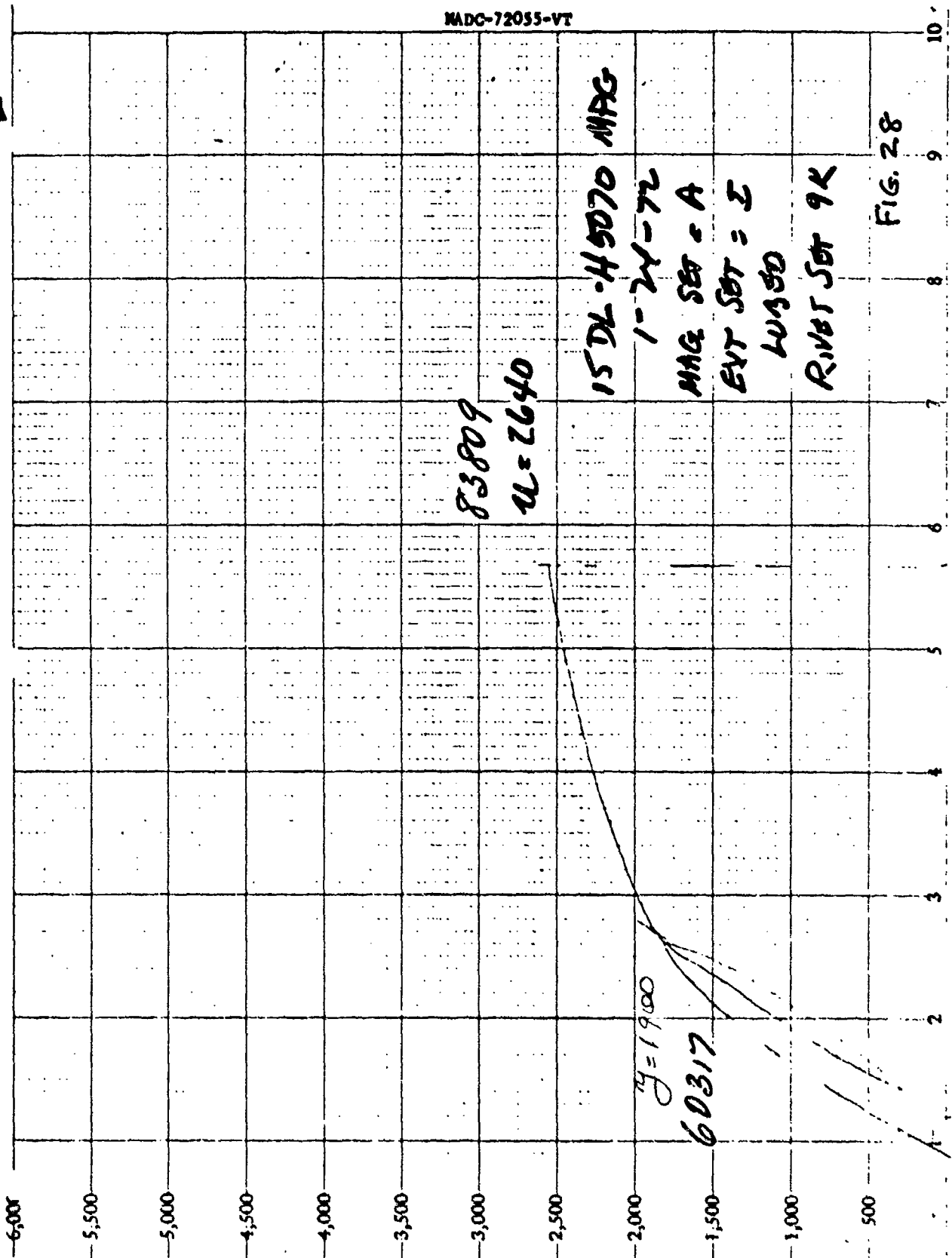
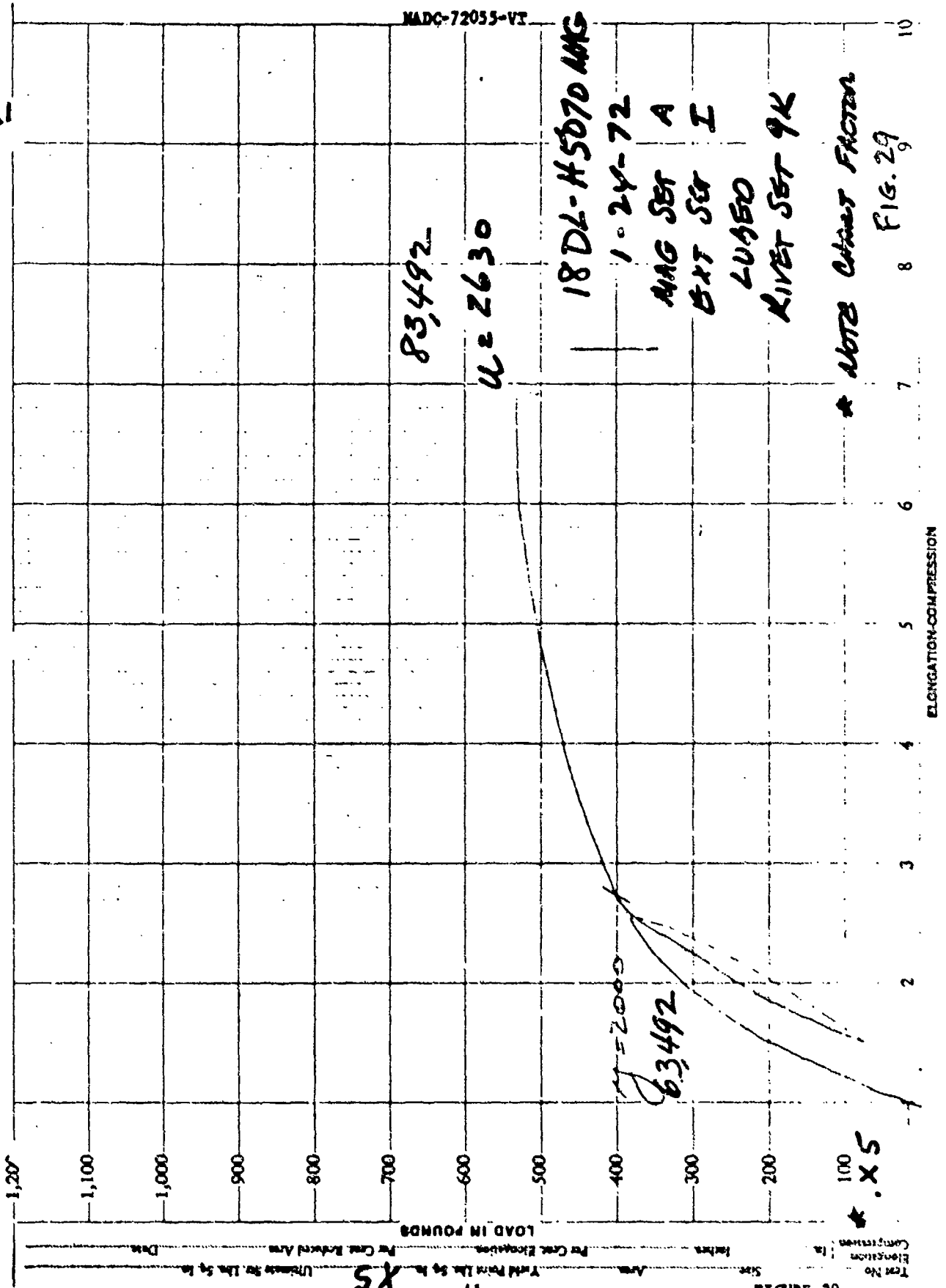


FIG. 28

Test No. _____
 Elongation _____ in _____
 Compression _____ in _____
 Size _____
 Area _____
 Yield Point Lbs. Sq. In. _____
 Ultimate Str. Lbs. Sq. In. _____
 Per Cent. Elongation _____
 Per Cent. Reduced Area _____
 Date _____



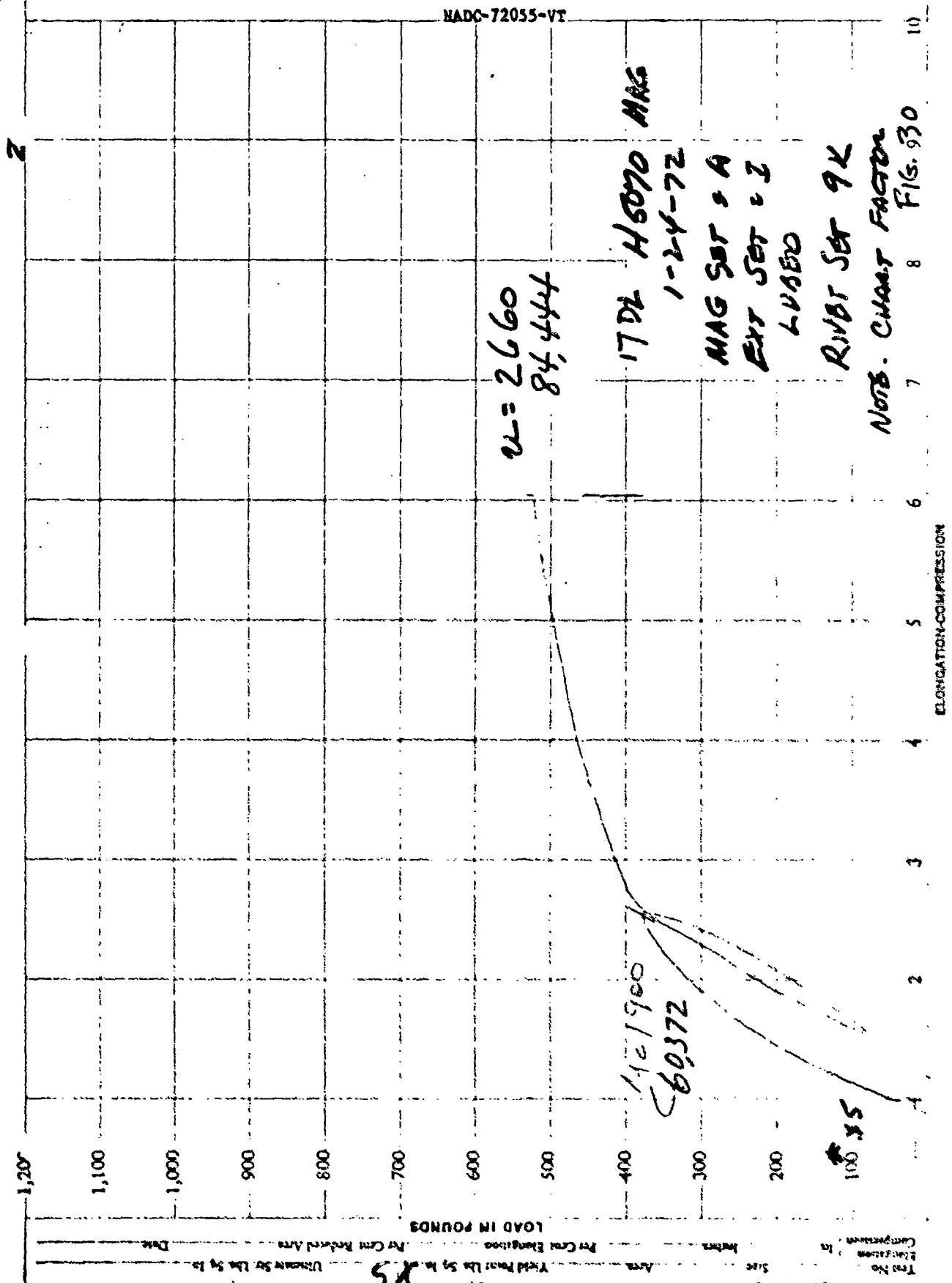
19

FIGURE 29

Yield Point Lbs. Sq. In. $\frac{L}{A}$
 Ultimate Str. Lbs. Sq. In. $\frac{L}{A}$
 Per Cent Elongation $\frac{L - L_0}{L_0}$
 Per Cent Reduction Area $\frac{A_0 - A_f}{A_0}$
 Date

Test No. _____
 Elongation in _____
 Compression _____

ELONGATION-COMPRESSION



1,200

1,100

1,000

900

800

700

600

500

400

300

200

100

0

1

2

3

4

5

6

7

8

9

10

LOAD IN POUNDS

ELONGATION-COMPRESSION

Z

$\nu = 2660$
84.444

17 DL H5070 MAG
1-24-72
MAG SET = A
EXT SET = J
LVABO

RIVBT SET 9K

NOTE - CHART FACTOR FIG. 930

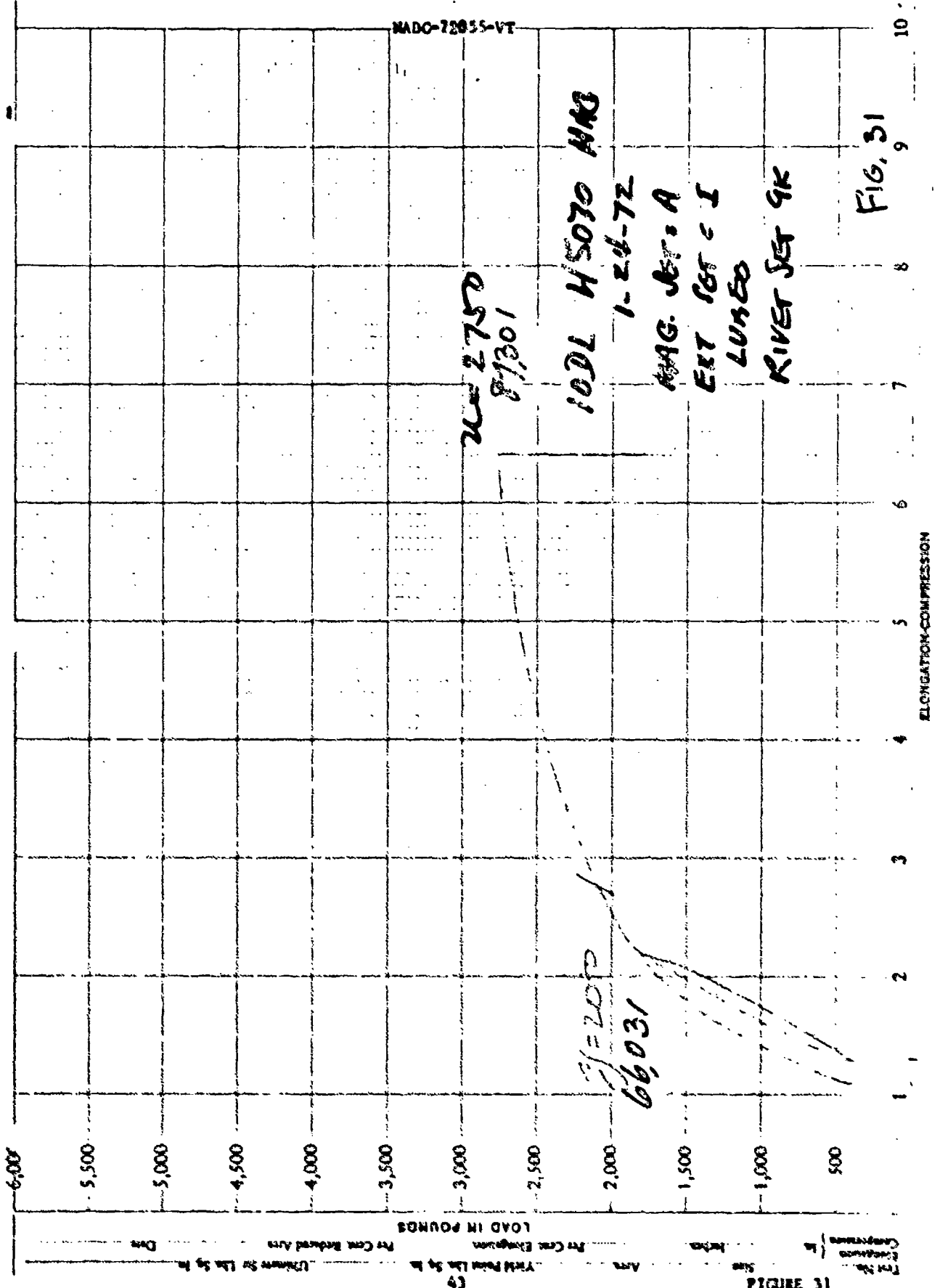
1421900
60372

100 x 5

FIGURE 30

KS

Test No. _____
 Location _____
 Date _____
 Area _____
 Yield Point Lbs Sq In _____
 Ultimate St Lbs Sq In _____
 Per Cent Elongation _____
 Per Cent Reduced Area _____
 Dia _____



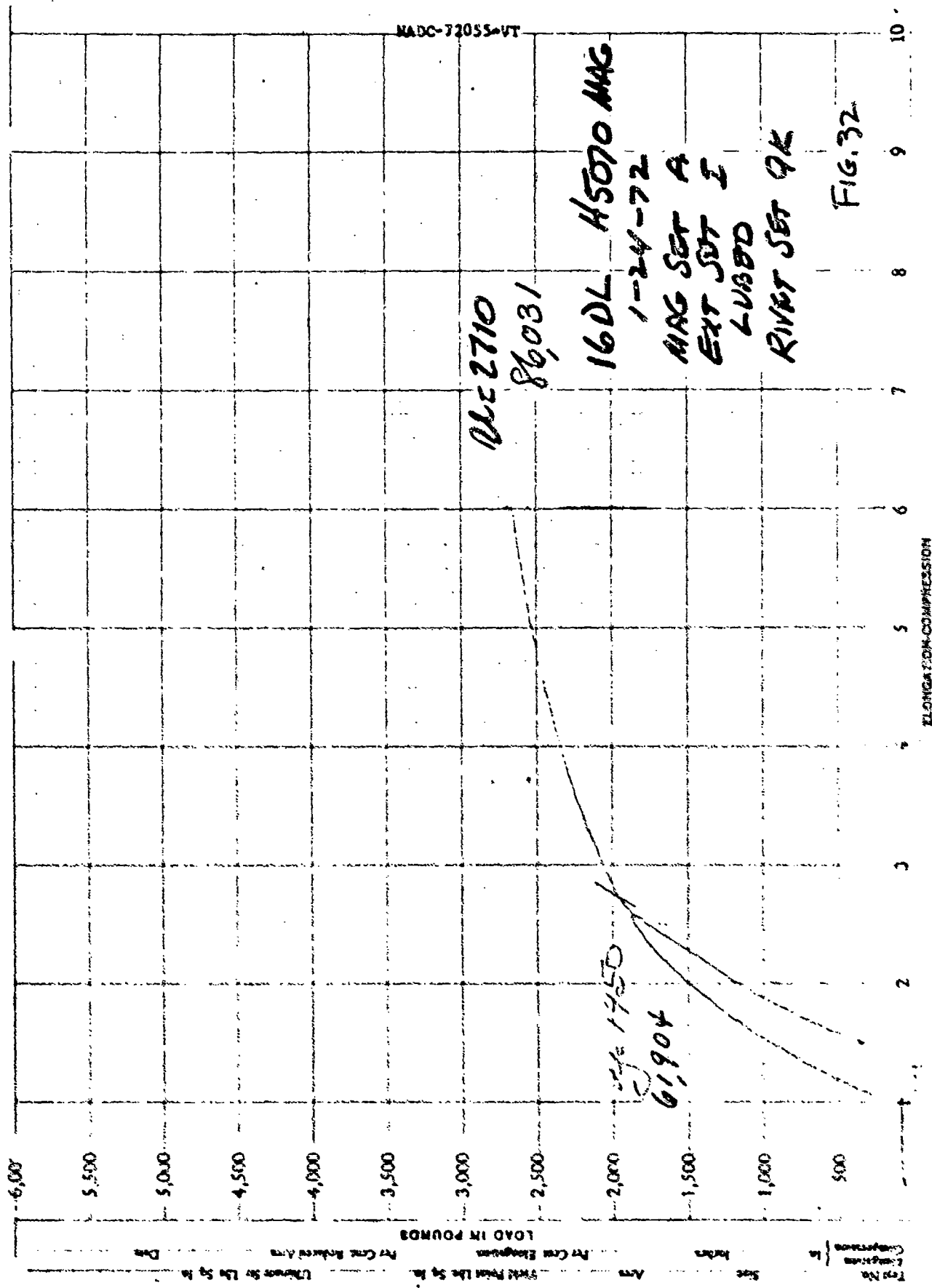
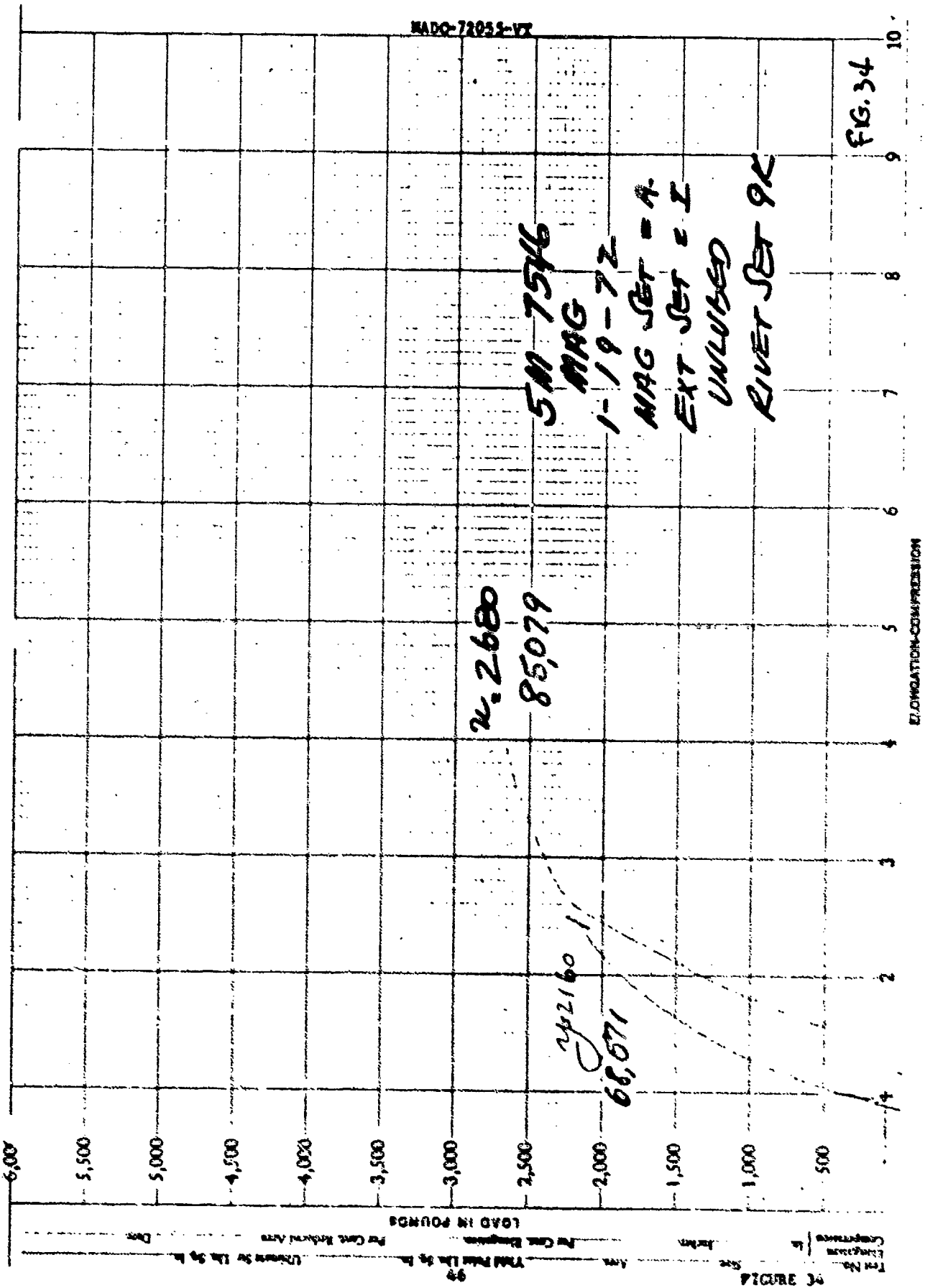
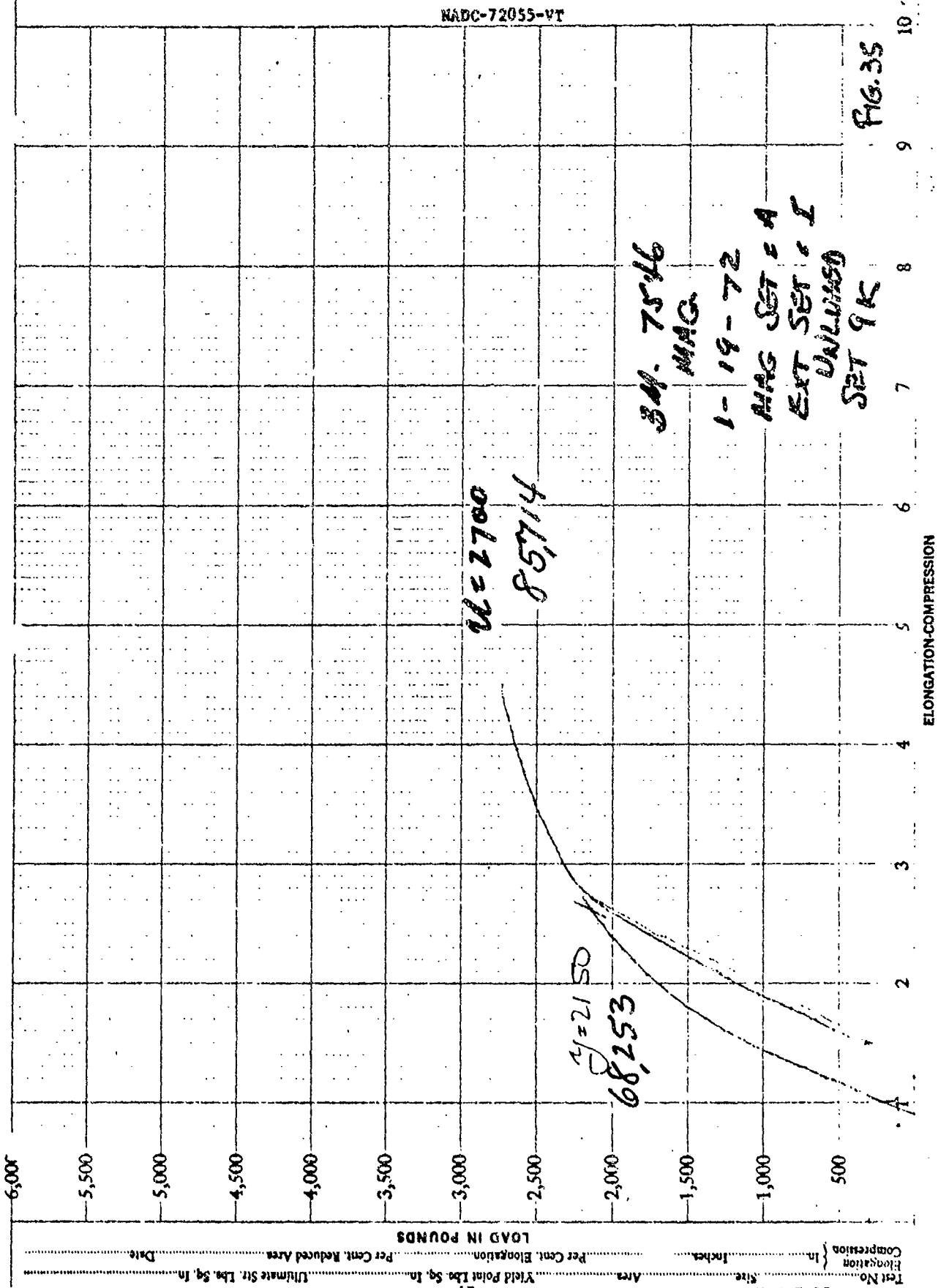


FIG. 32

FIGURE 32





Test No. _____
 Elongation _____ in.
 Compression _____ in.
 Area _____ Sq. In.
 Yield Point Lbs. Sq. In. _____
 Ultimate Str. Lbs. Sq. In. _____
 Per Cent. Elongation _____
 Per Cent. Reduced Area _____
 Date _____

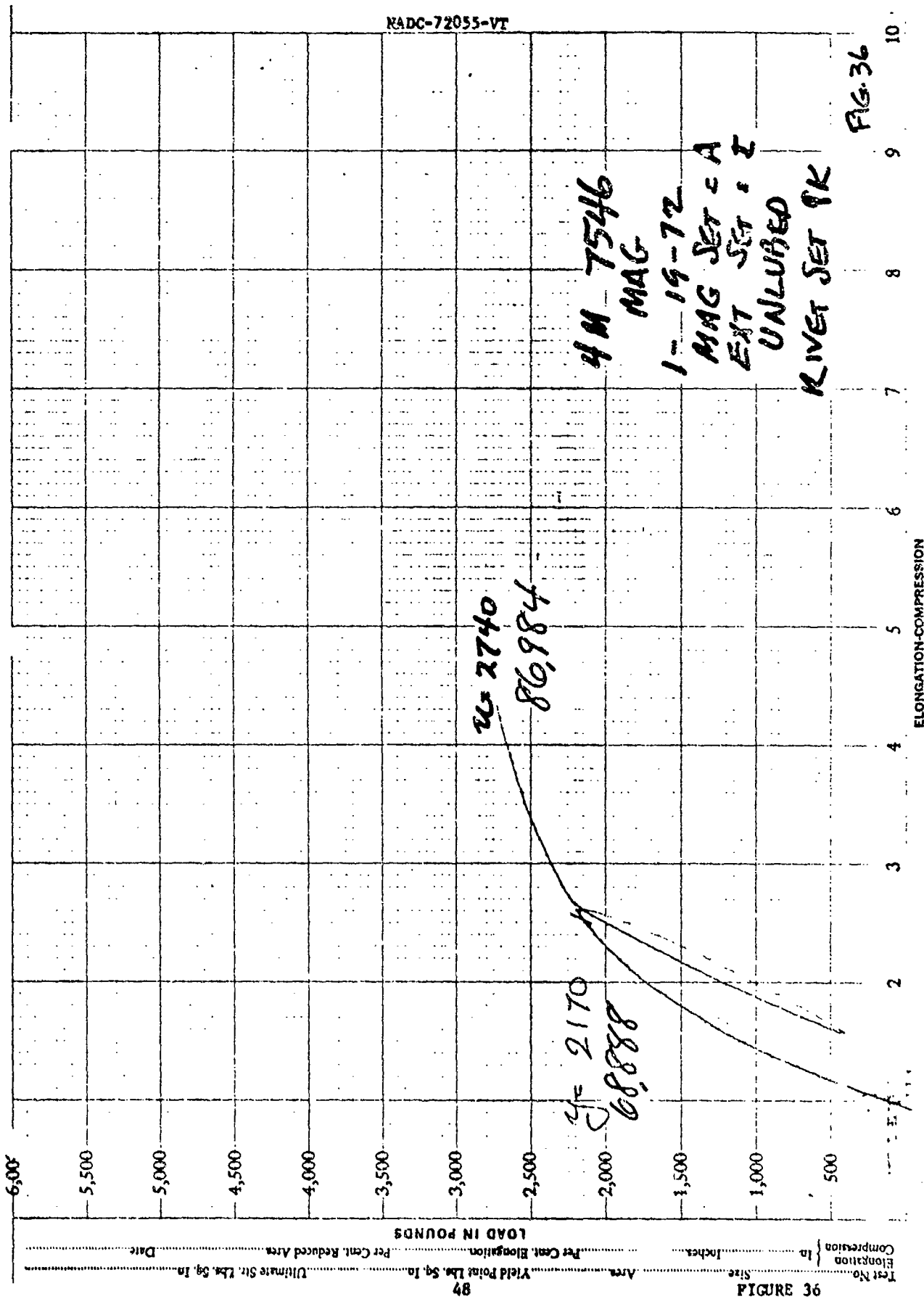
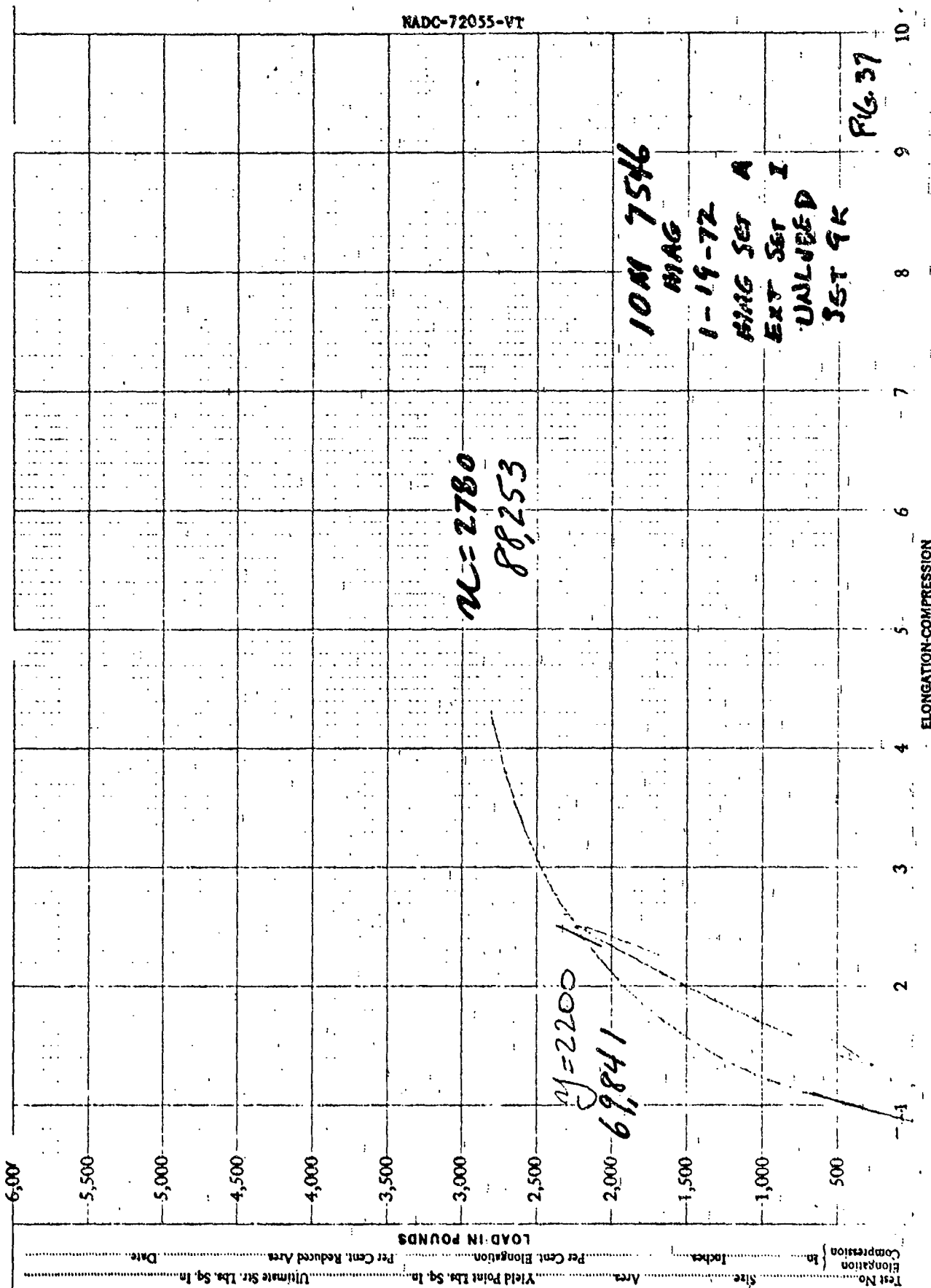


FIG. 36

FIGURE 36



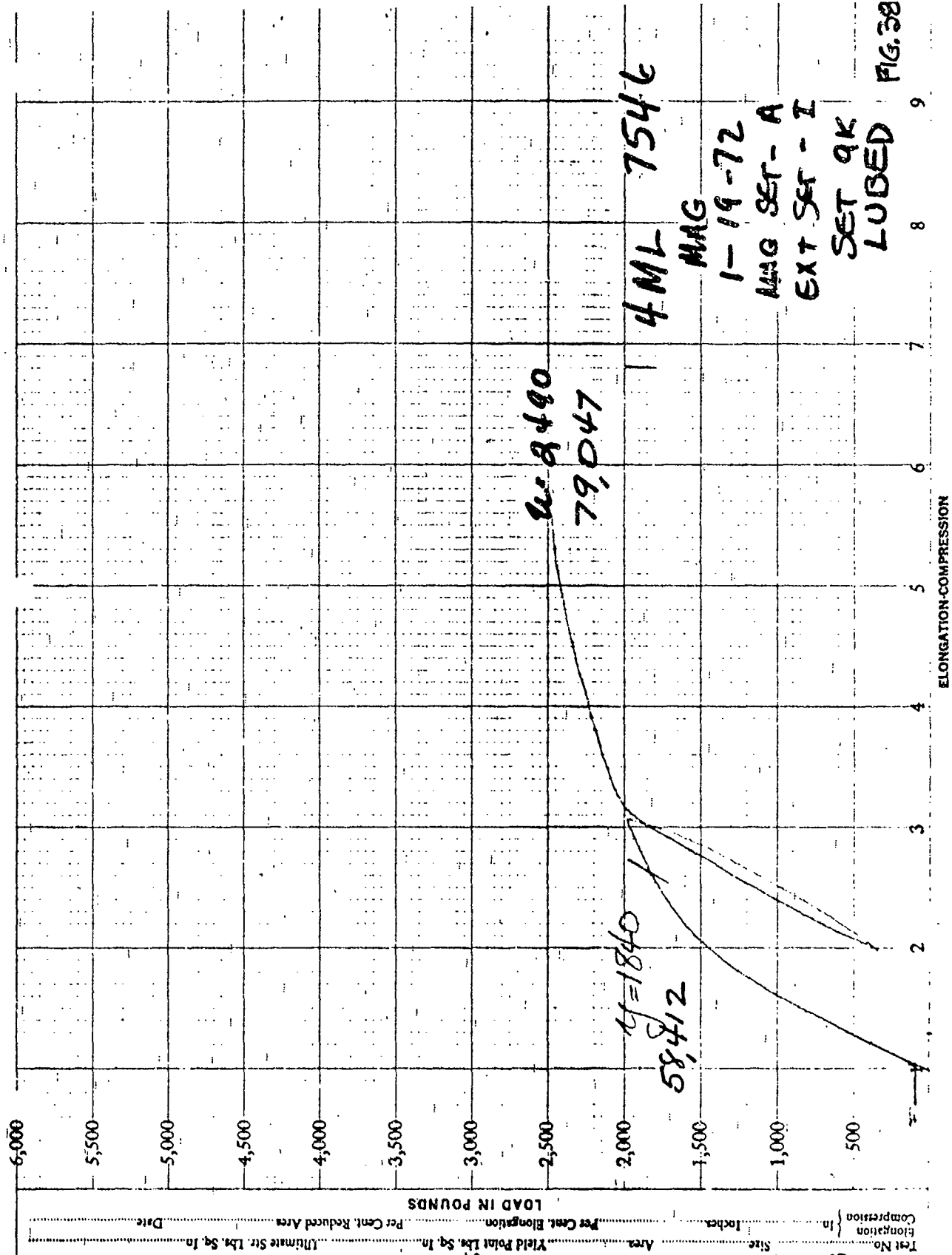


FIGURE 38

95

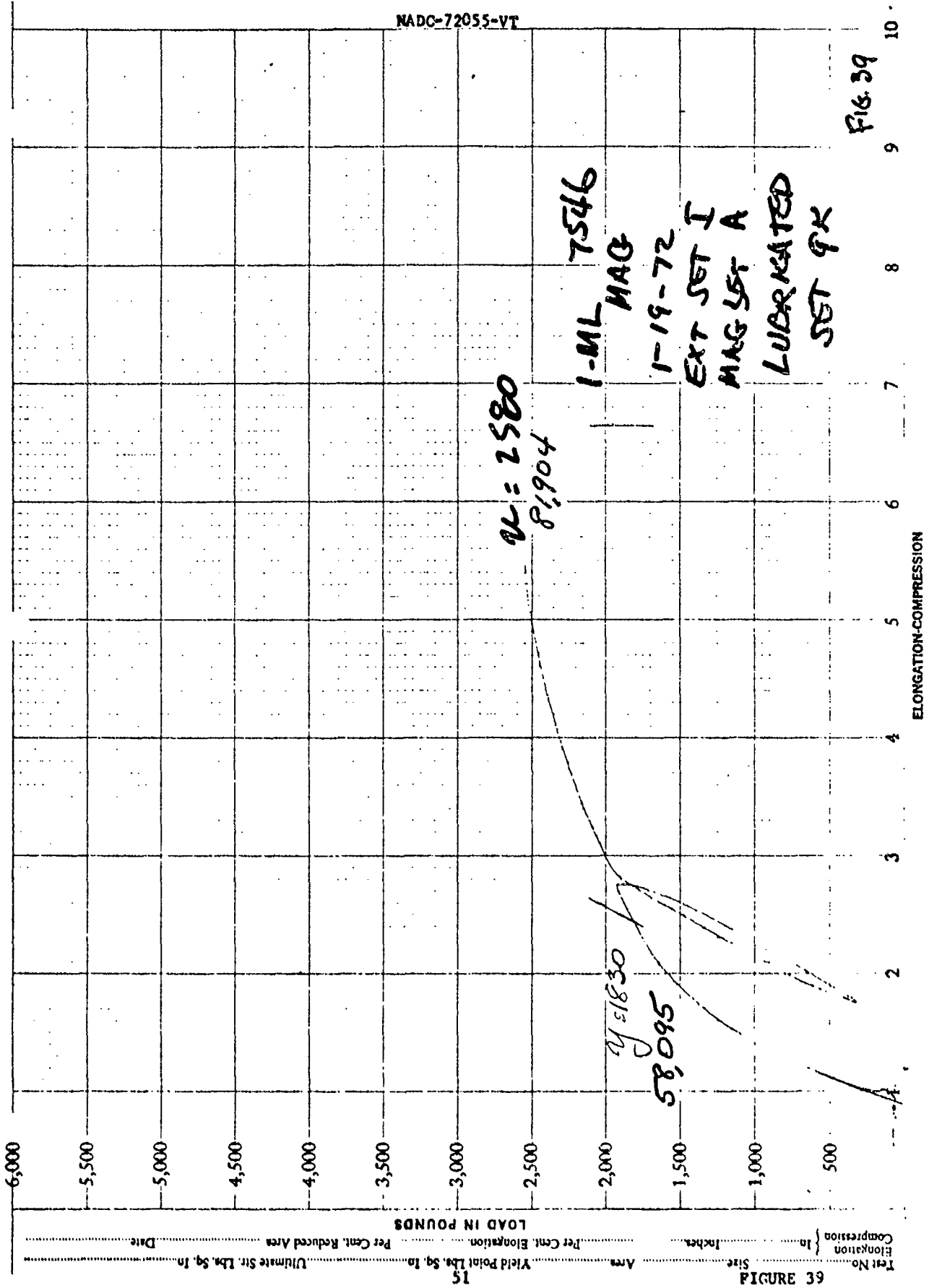


FIG 39

ELONGATION-COMPRESSION

Test No. _____
 Size _____
 Area _____
 Yield Point Lbs. Sq. In. _____
 Ultimate Str. Lbs. Sq. In. _____
 Per Cent. Elongation _____
 Per Cent. Reduced Area _____
 Date _____

FIGURE 39

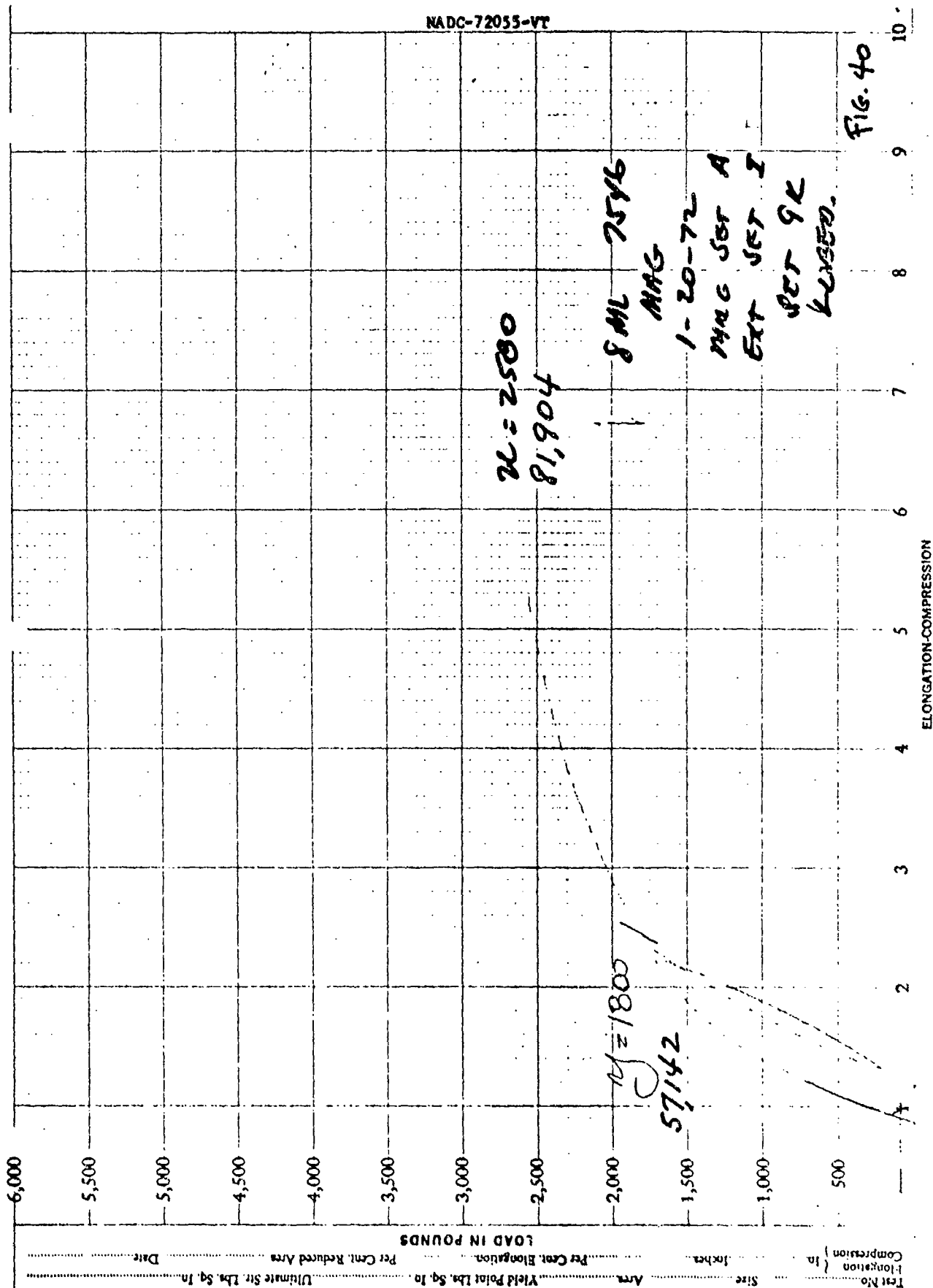


FIG. 40

Test No. _____ Size _____ inches _____
 Yield Point Lbs. Sq. In. _____ Ultimate Str. Lbs. Sq. In. _____
 Per Cent. Elongation _____ Per Cent. Reduced Area _____
 Date _____

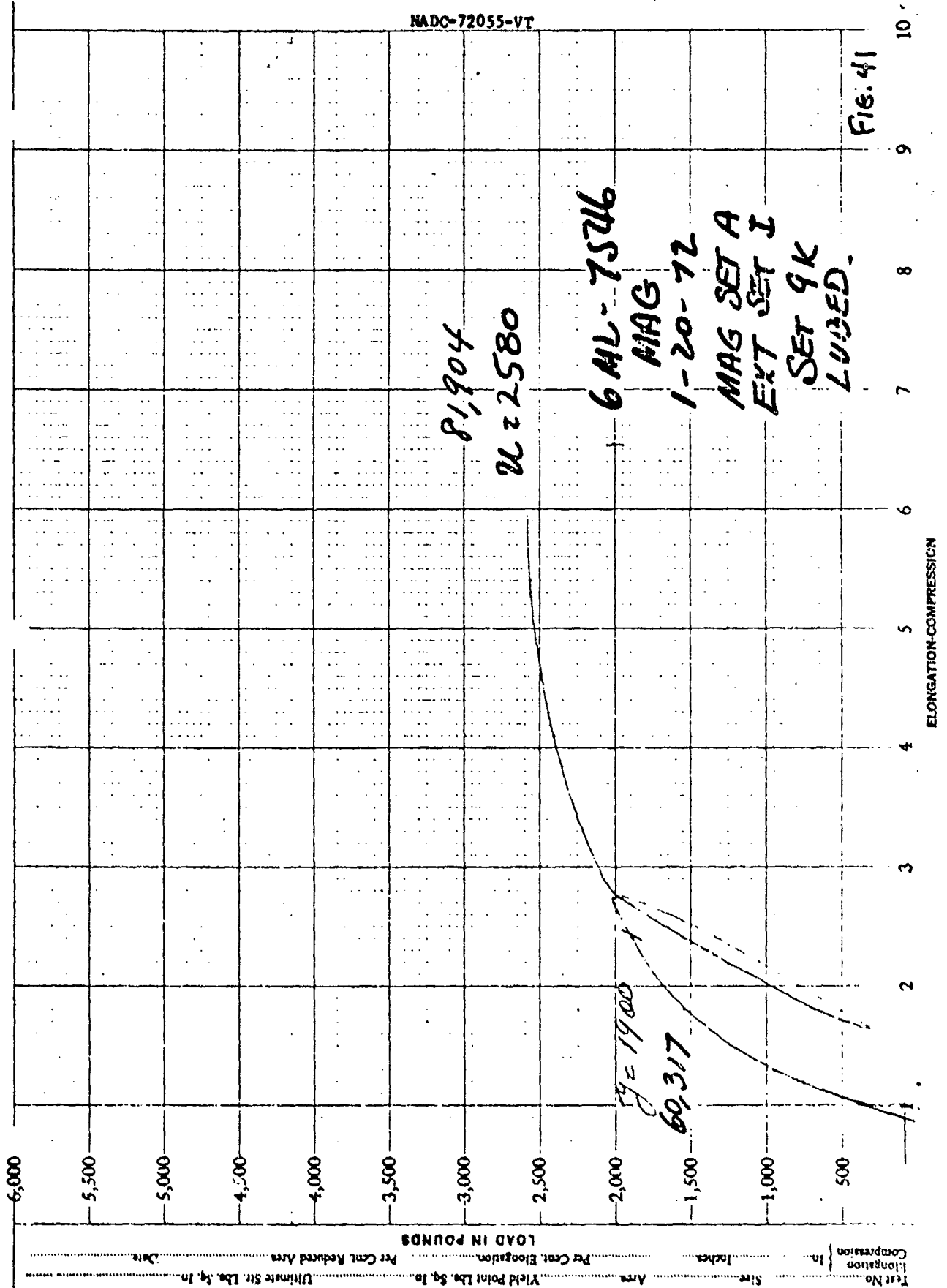


FIG. 41

FIGURE 41

ES

Test No. _____
 Elongation _____ In. _____
 Compression _____ In. _____
 Area _____ Sq. In. _____
 Yield Point Lbs. Sq. In. _____
 Ultimate Str. Lbs. Sq. In. _____
 Per Cent. Reduced Area _____
 Per Cent. Elongation _____
 Date _____

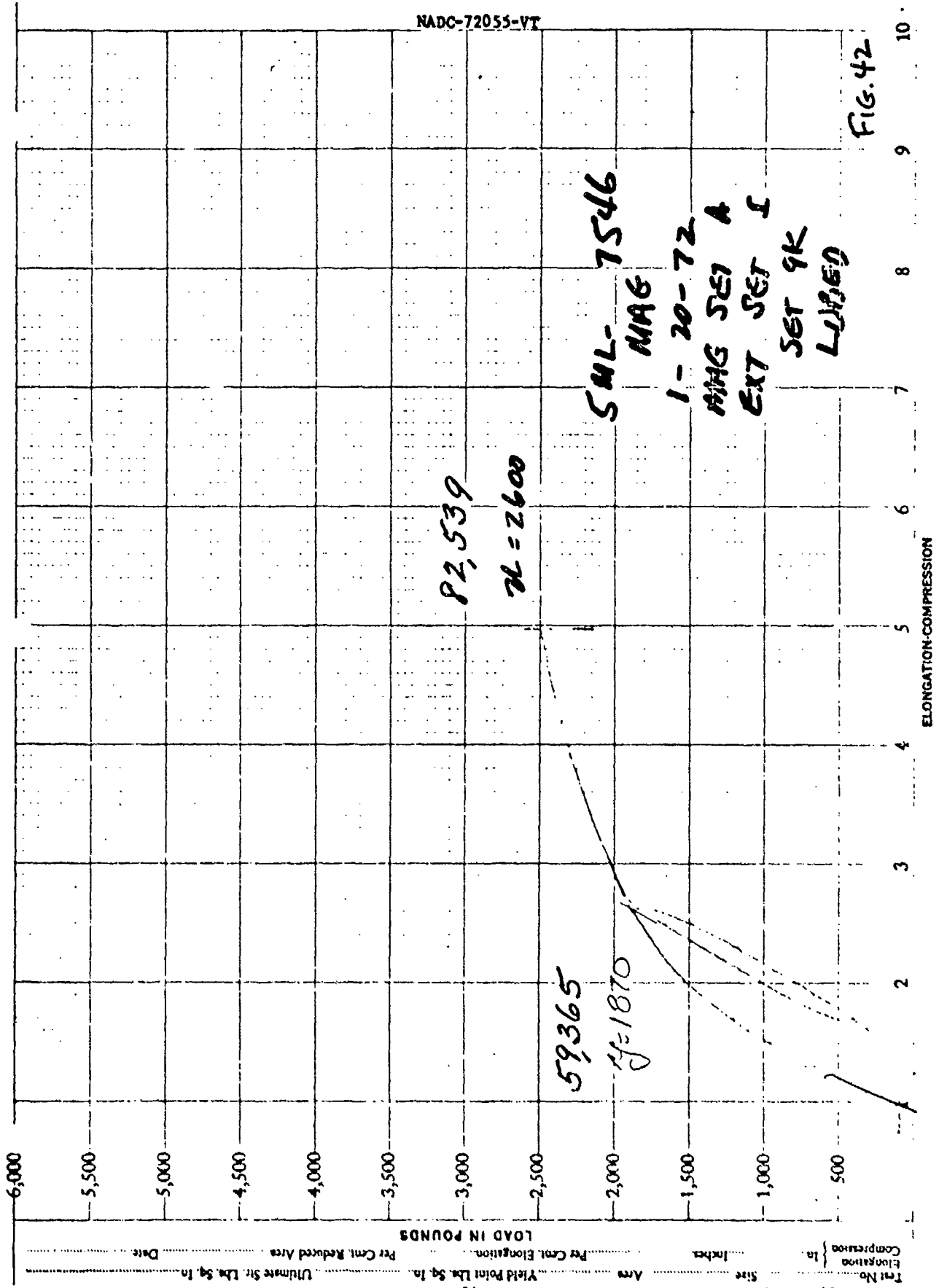


FIG. 42

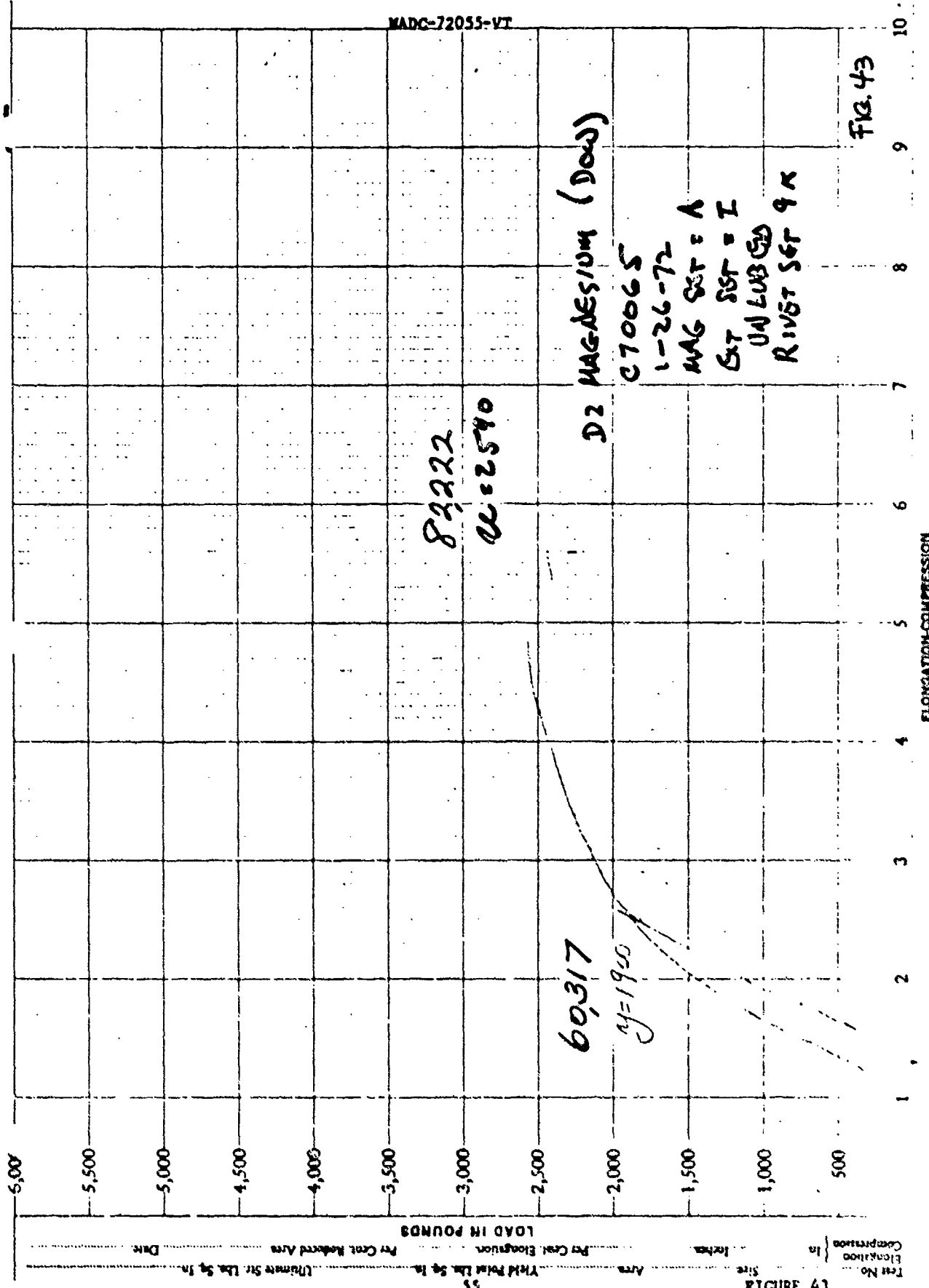


FIG. 43

ELONGATION-COMPRESSION

Test No. _____
 Elongation _____ in _____
 Compression _____
 Area _____
 Yield Point Lbs. Sq. In. _____
 Ultimate Str. Lbs. Sq. In. _____
 Per Cent. Elongation _____
 Per Cent. Reduced Area _____
 Date _____

55

FIGURE 43

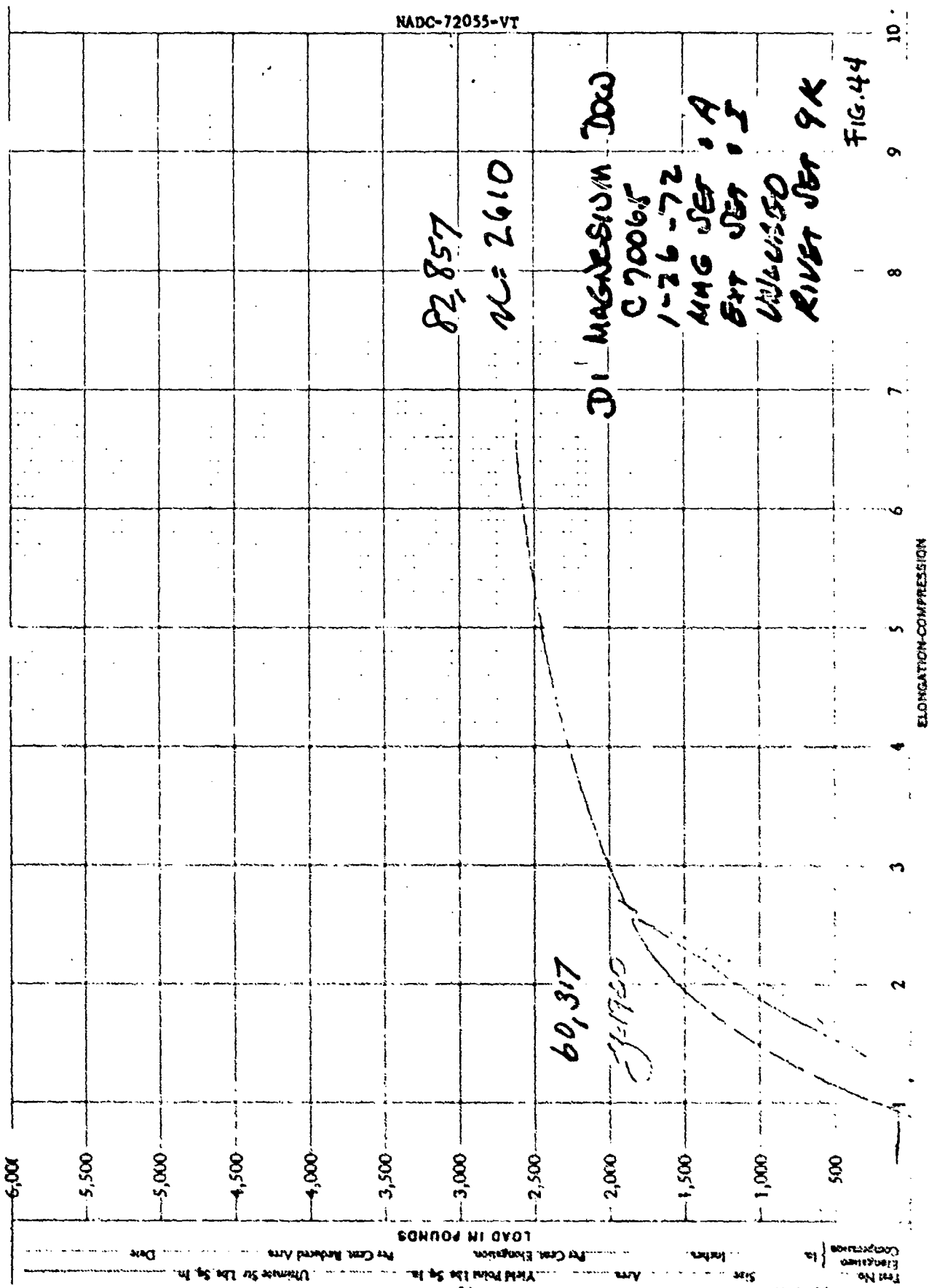


FIG. 44

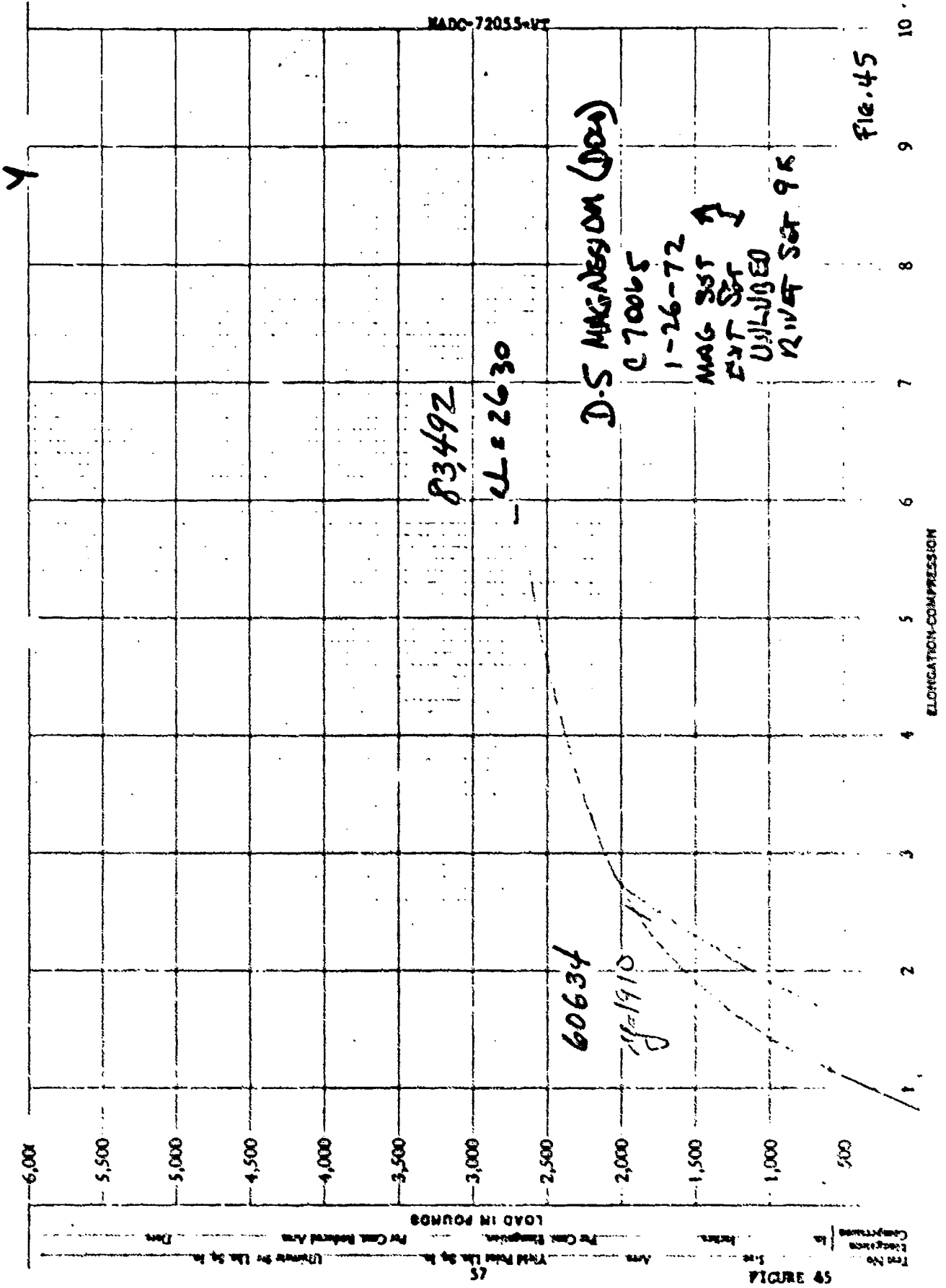
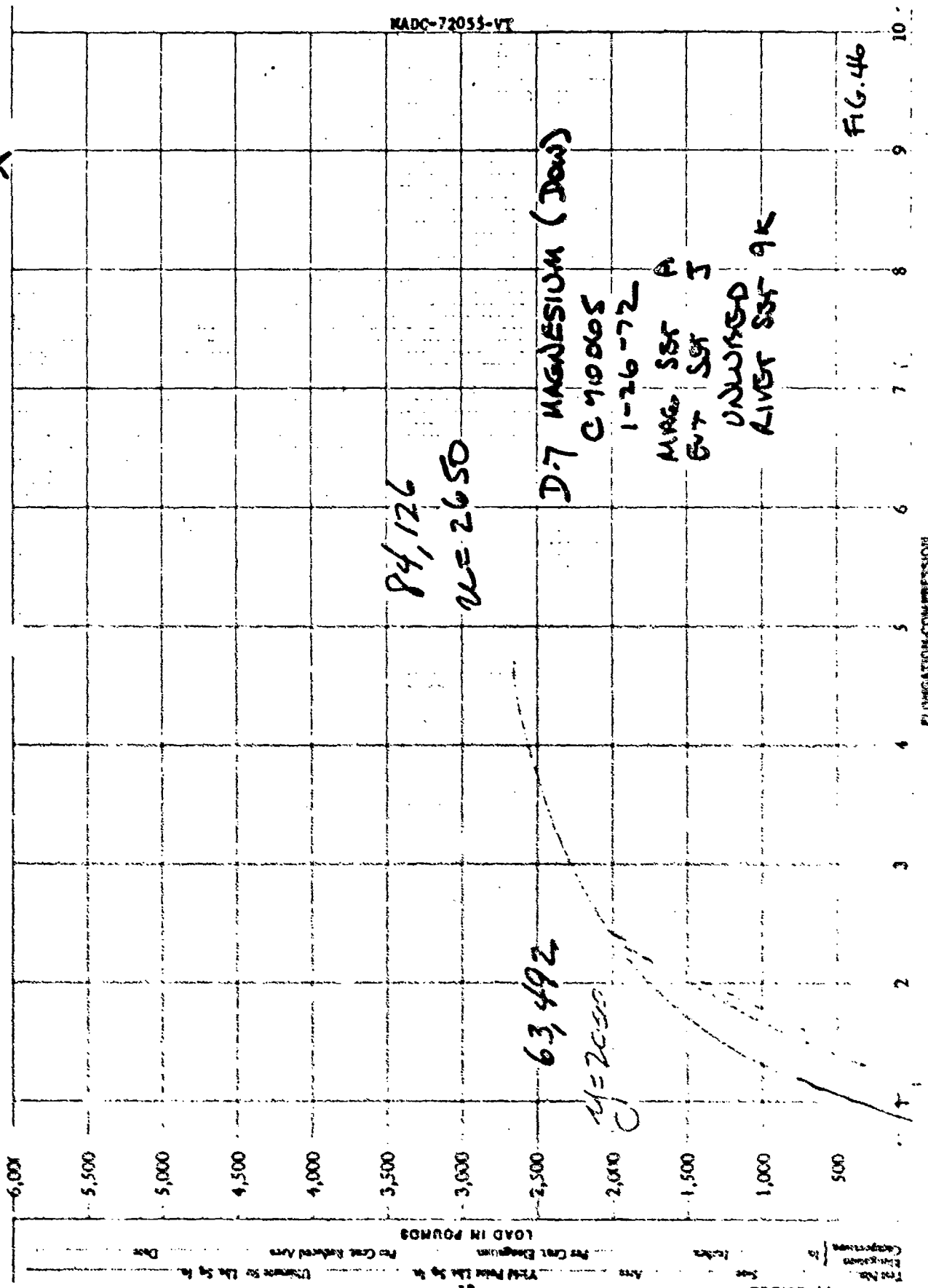


Fig. 45

FIGURE 45

X



Tensile Test
 Temperature in
 Force in
 Test
 Per Cent Elongation
 Per Cent Reduced Area
 Date

FIGURE 46

ELONGATION-COMPRESSION



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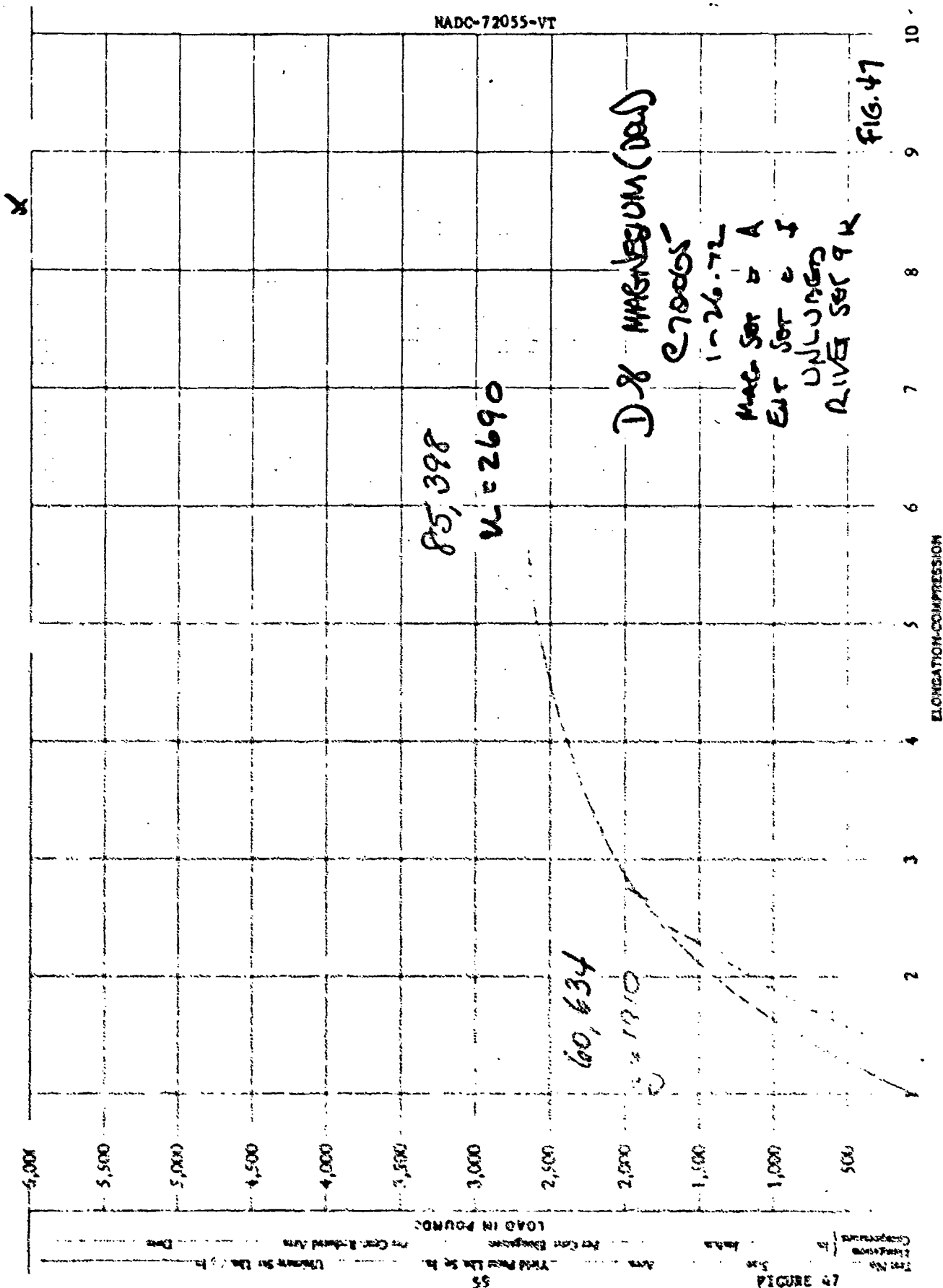


FIGURE 47

55

X

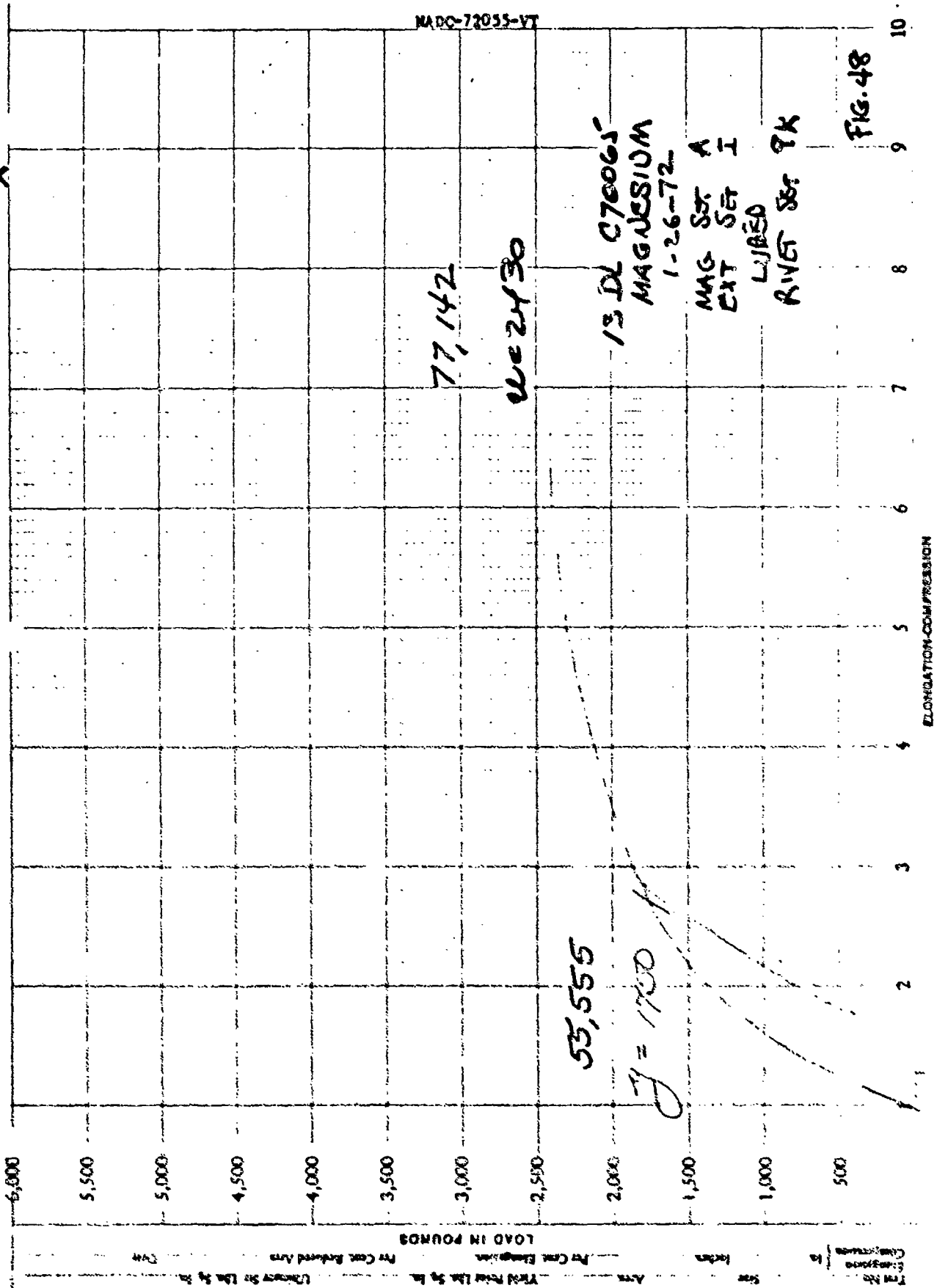
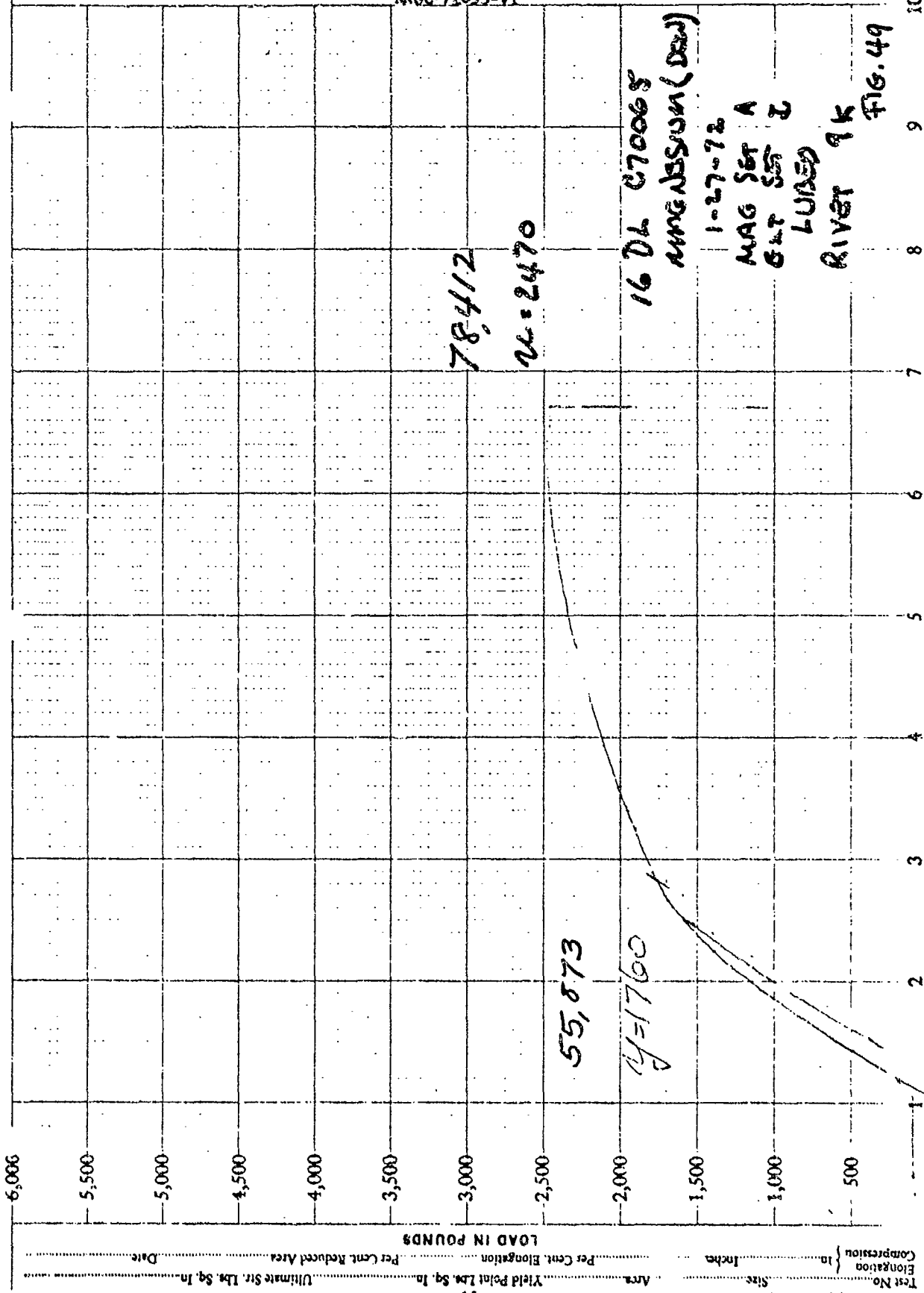
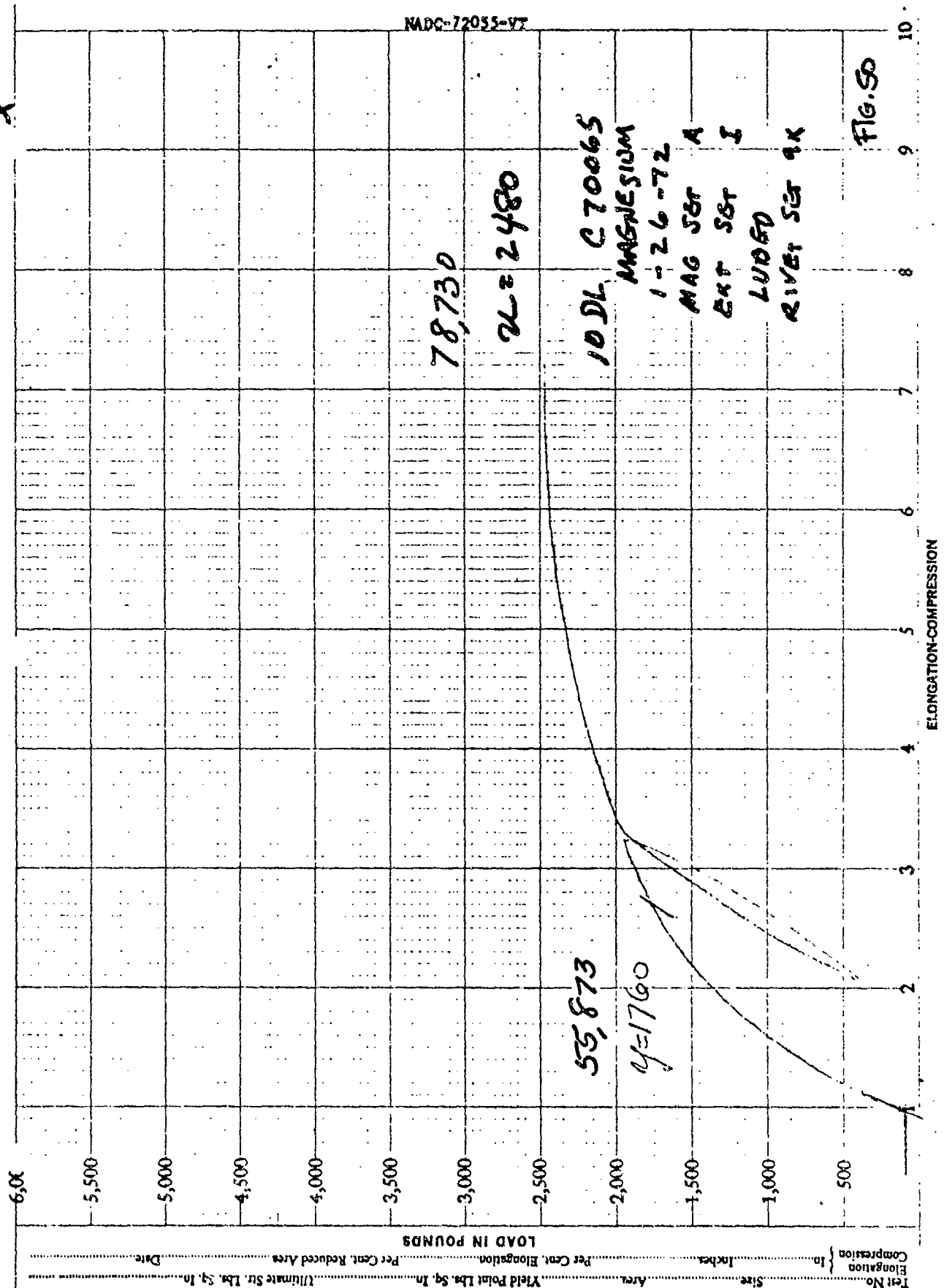


FIGURE 48



X



Test No. _____
 Elongation _____
 Compression _____
 Size _____
 Area _____
 Yield Point Lbs. Sq. In. _____
 Per Cent. Elongation _____
 Ultimate Str. Lbs. Sq. In. _____
 Per Cent. Reduced Area _____
 Date _____

FIGURE 50

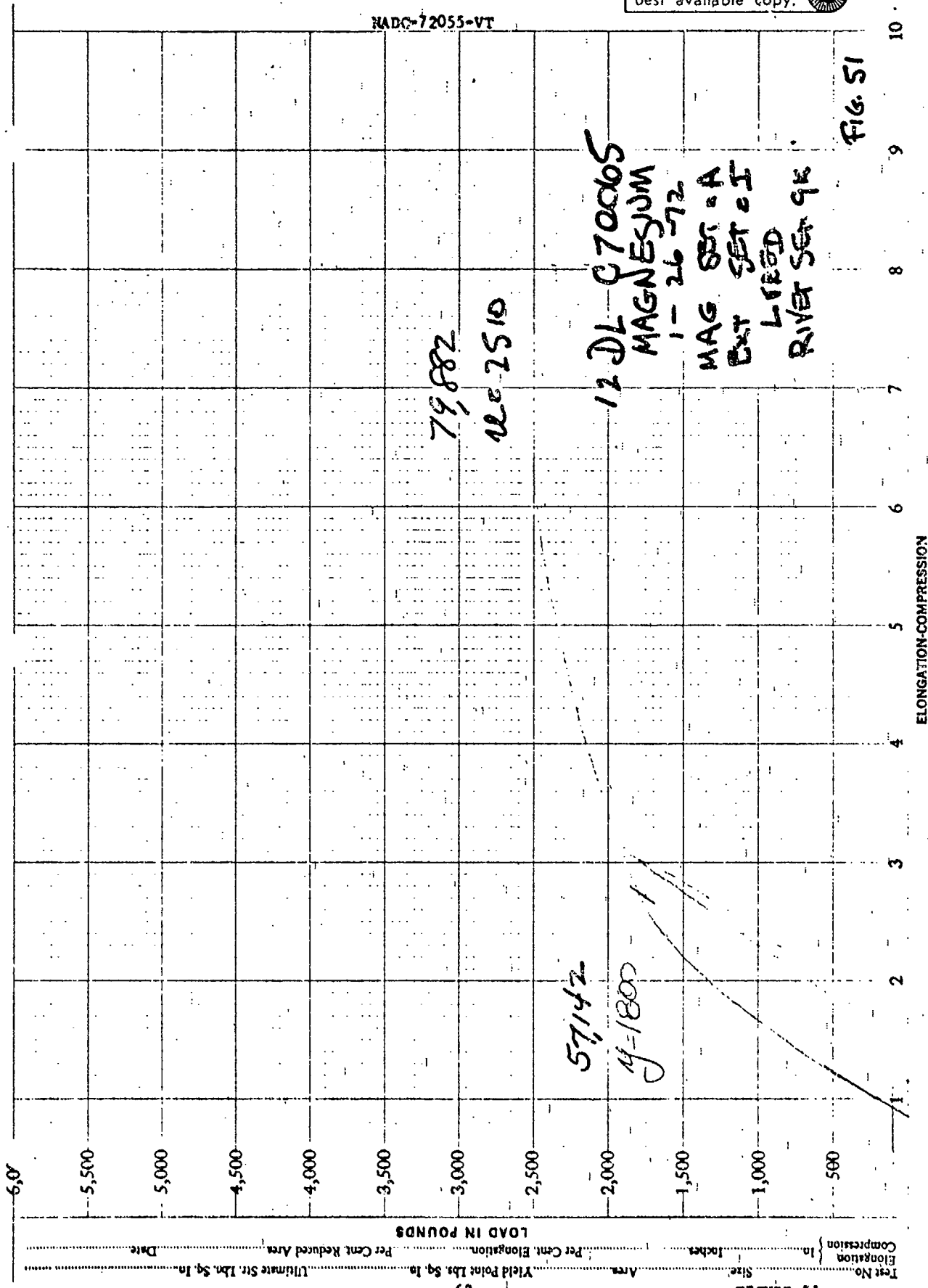
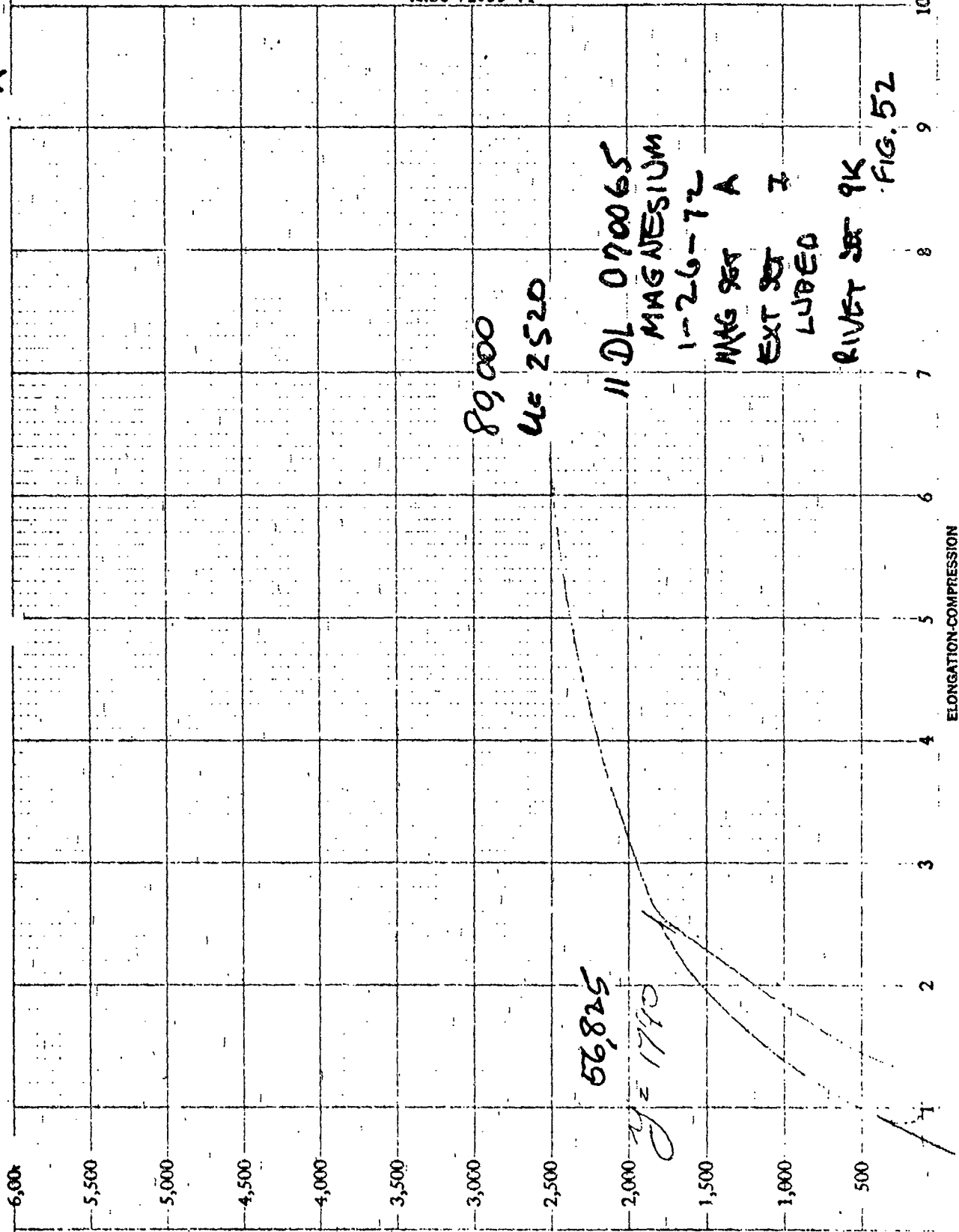


FIG. 51

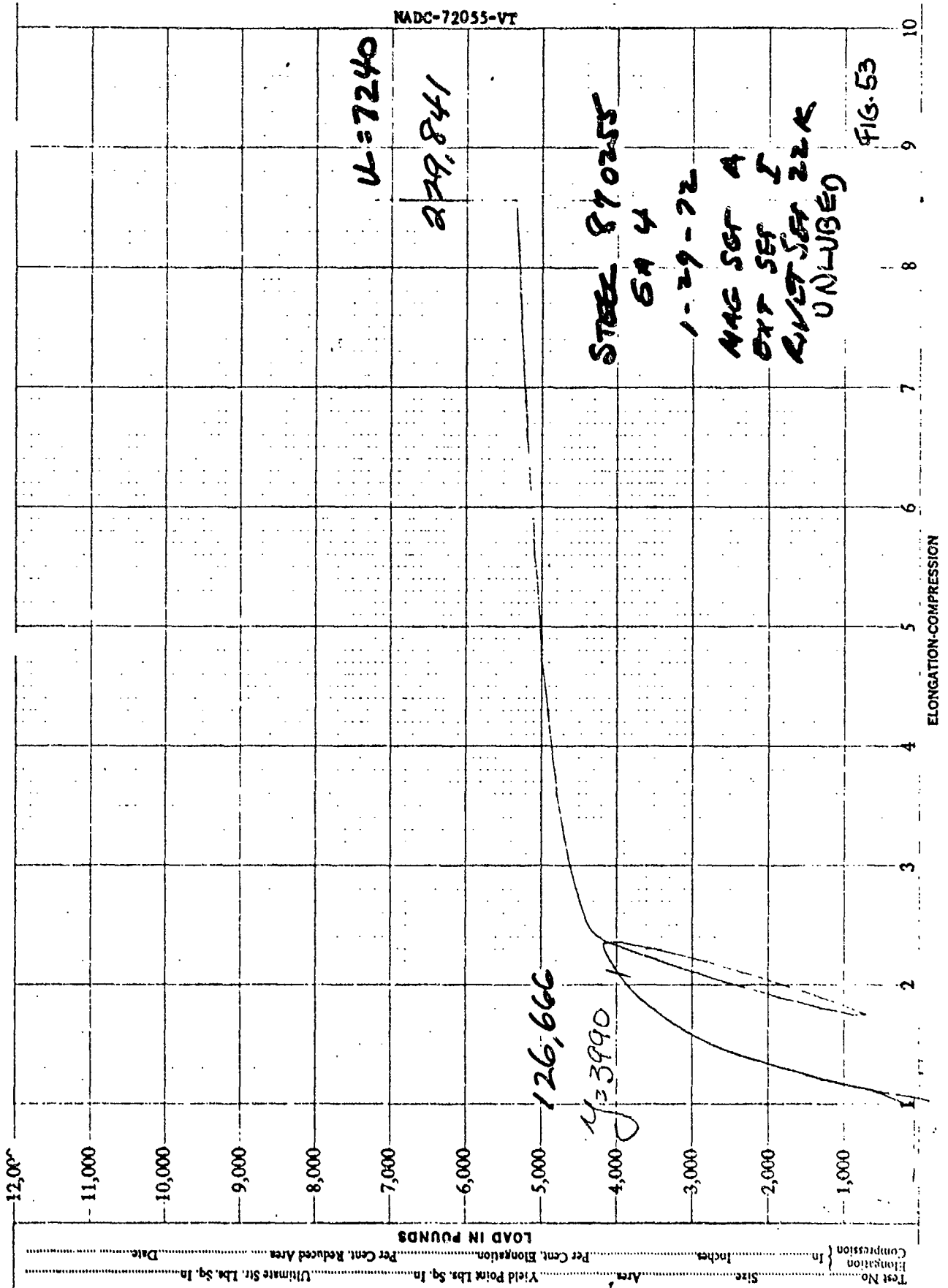
Test No. _____
 Elongation _____ in _____
 Compression _____ in _____
 Size _____ inches _____
 Area _____
 Yield Point Lbs. Sq. In. _____
 Per Cent. Elongation _____
 Per Cent. Reduced Area _____
 Ultimate Str. Lbs. Sq. In. _____
 Date _____

X



Test Pto. { Elongation
 Compression } In. { Per Cent. Elongation }
 Area { Yield Point Tls. Sq. In. } Ultimate Str. Tls. Sq. In. }
 Size, Inches { Per Cent. Reduced Area }
 Load in Pounds { Date.

FIGURE 52



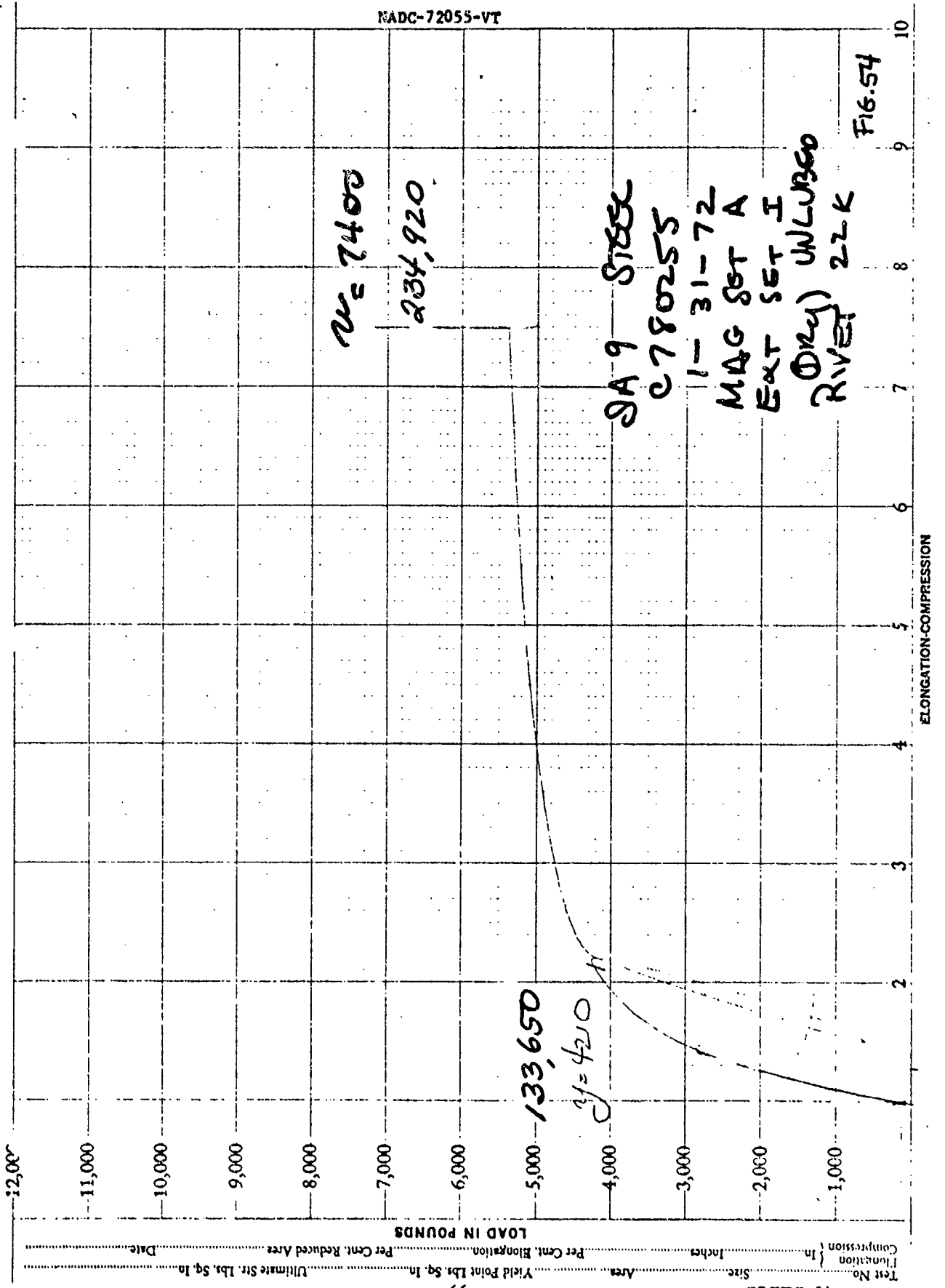
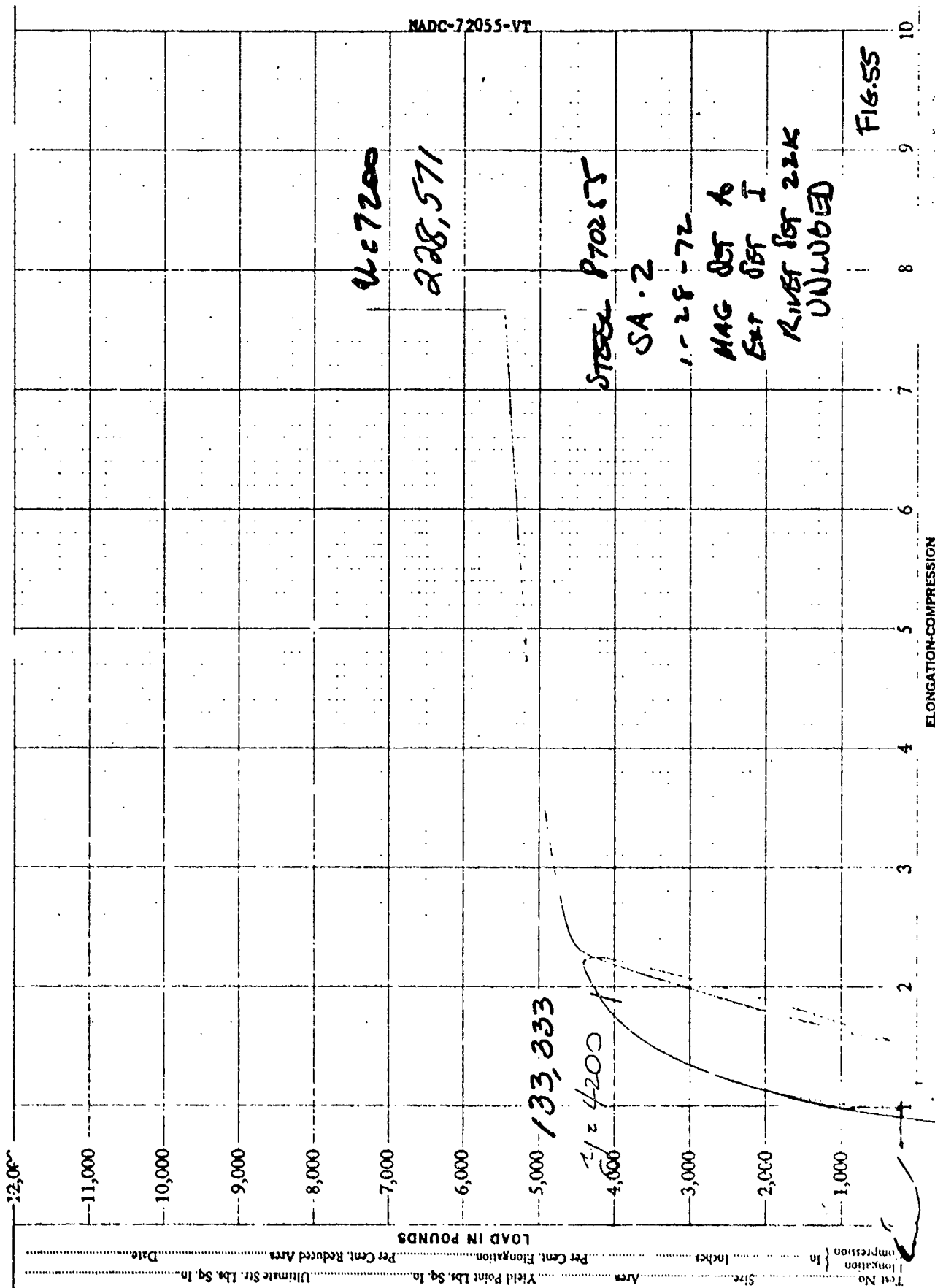


FIGURE 54



Test No. _____
 Elongation {
 in _____
 Size _____
 Area _____
 Yield Point Lbs. Sq. In. _____
 Ultimate Str. Lbs. Sq. In. _____
 Per Cent. Elongation _____
 Per Cent. Reduced Area _____
 Date _____

FIGURE 55

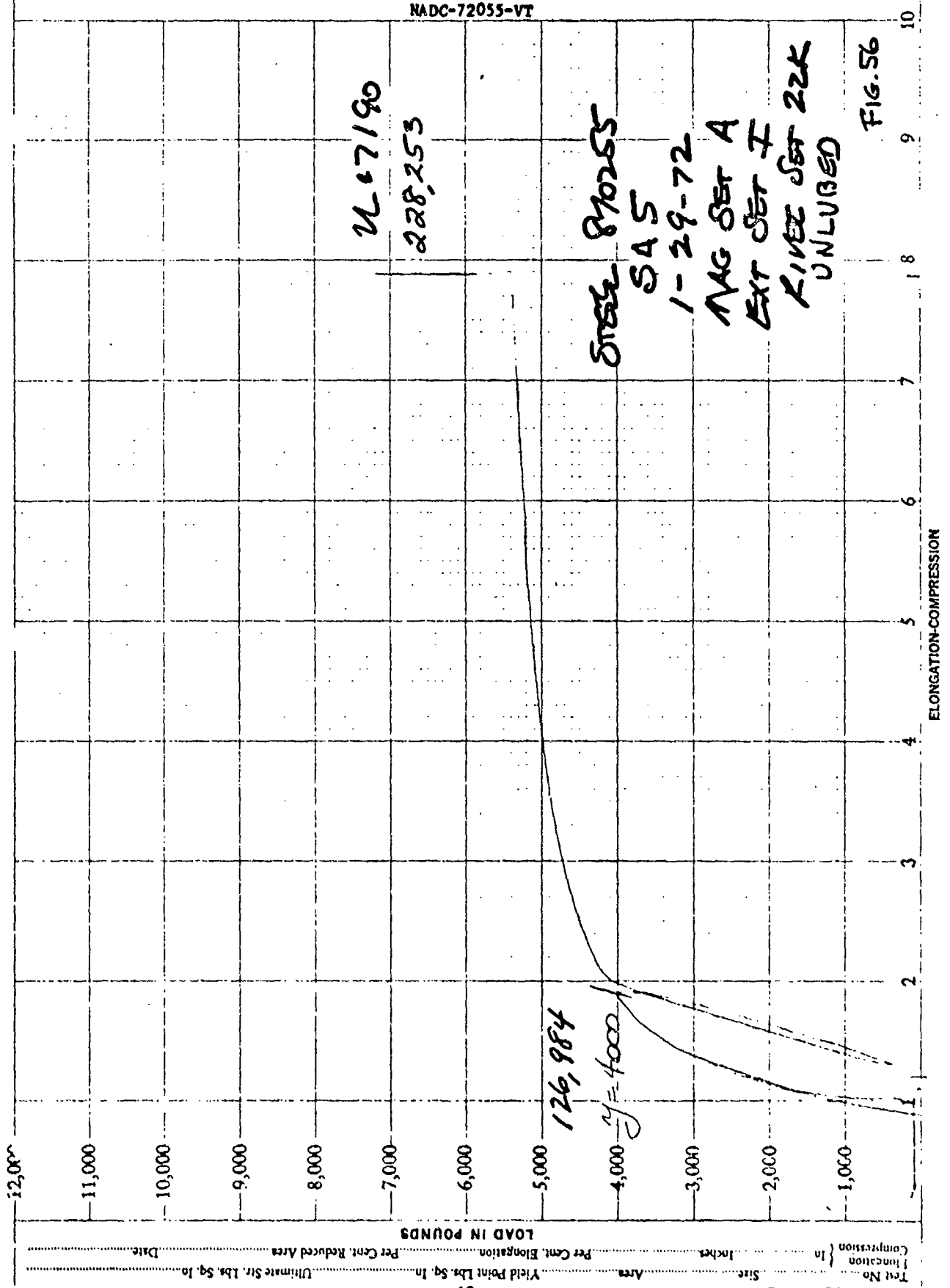


FIG. 56

Test No. _____
 Elongation { In _____
 Compression { In _____
 Size _____ In _____
 Area _____
 Yield Point Lbs. Sq. In. _____
 Per Cent. Elongation _____
 Ultimate Str. Lbs. Sq. In. _____
 Per Cent. Reduced Area _____
 Date _____

FIGURE 56

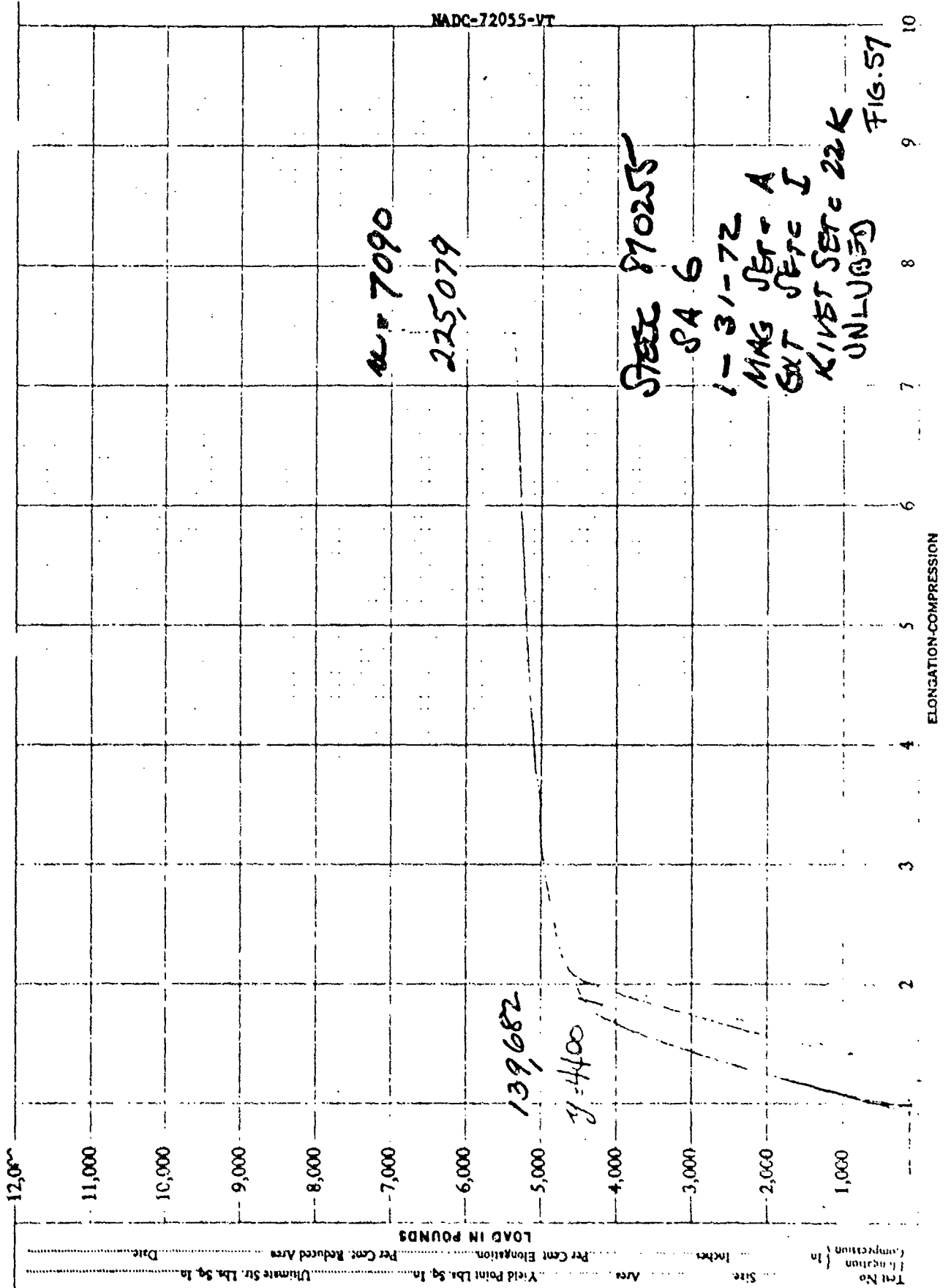
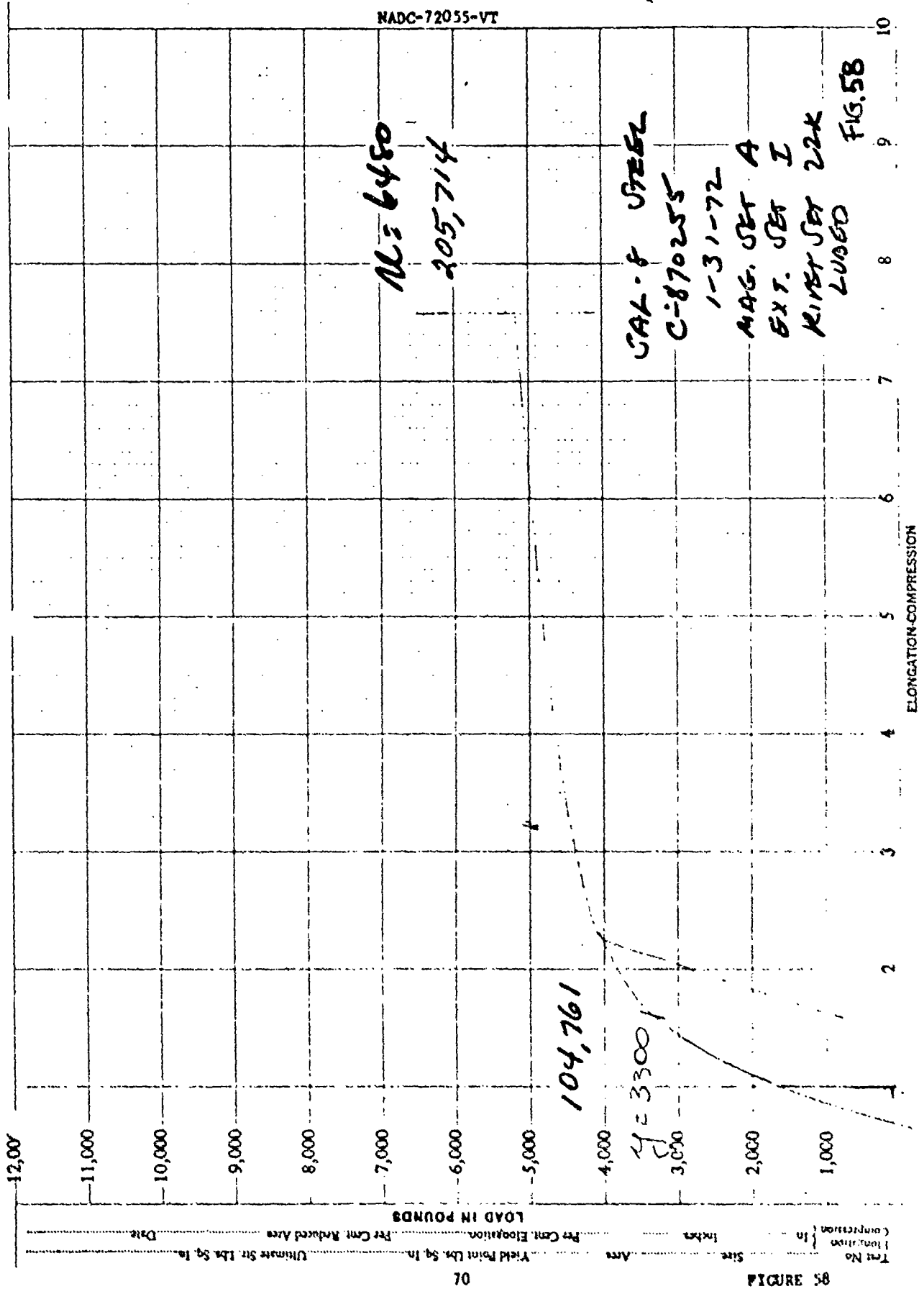


FIG. 57

Trial No. _____
 Elongation (in) _____
 Size _____
 Area _____
 Yield Point Lbs. Sq. In. _____
 Per Cent Elongation _____
 Per Cent Reduced Area _____
 Ultimate Str. Lbs. Sq. In. _____
 Date _____

FIGURE 57



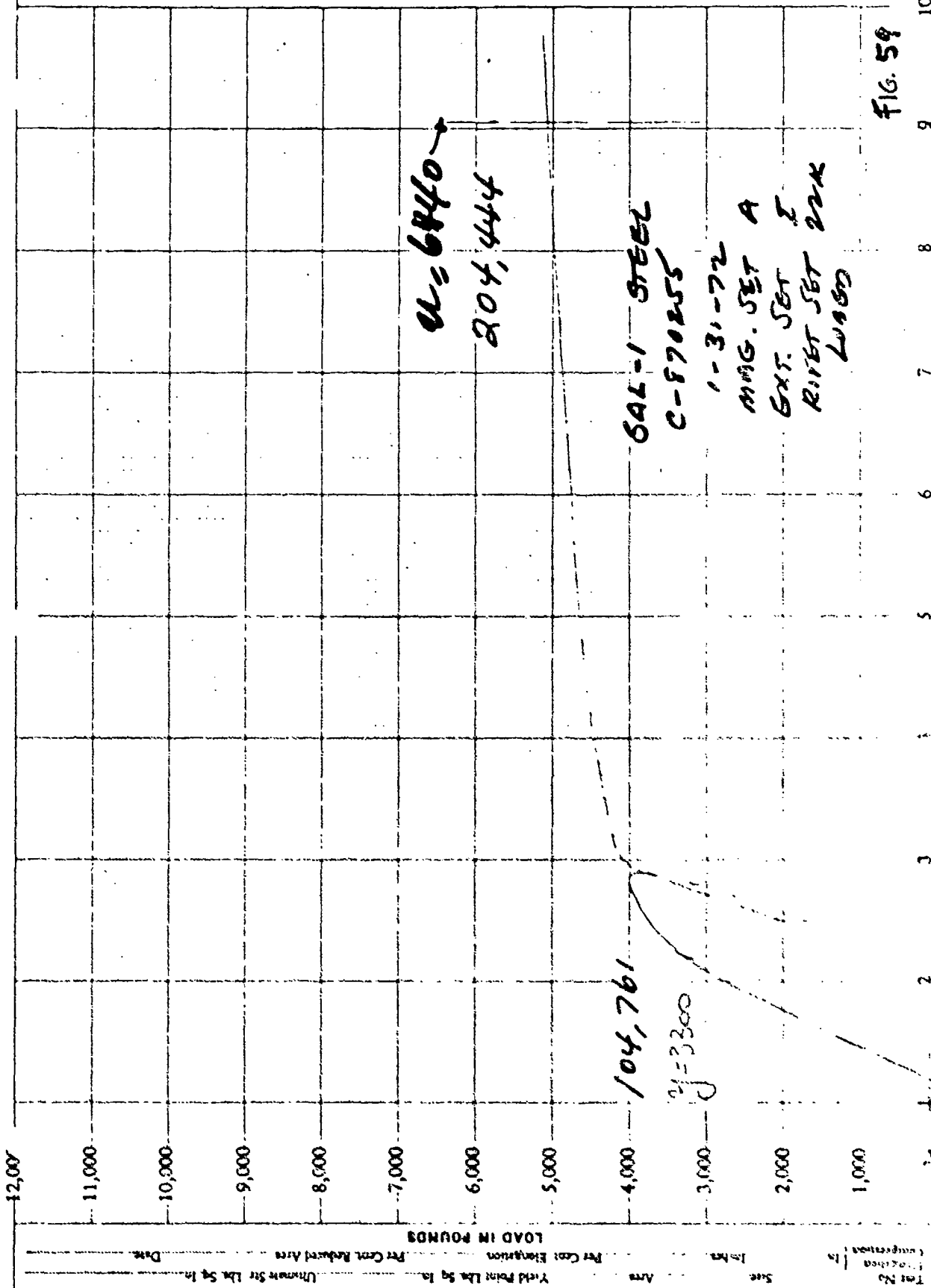


FIG. 59

FIGURE 59

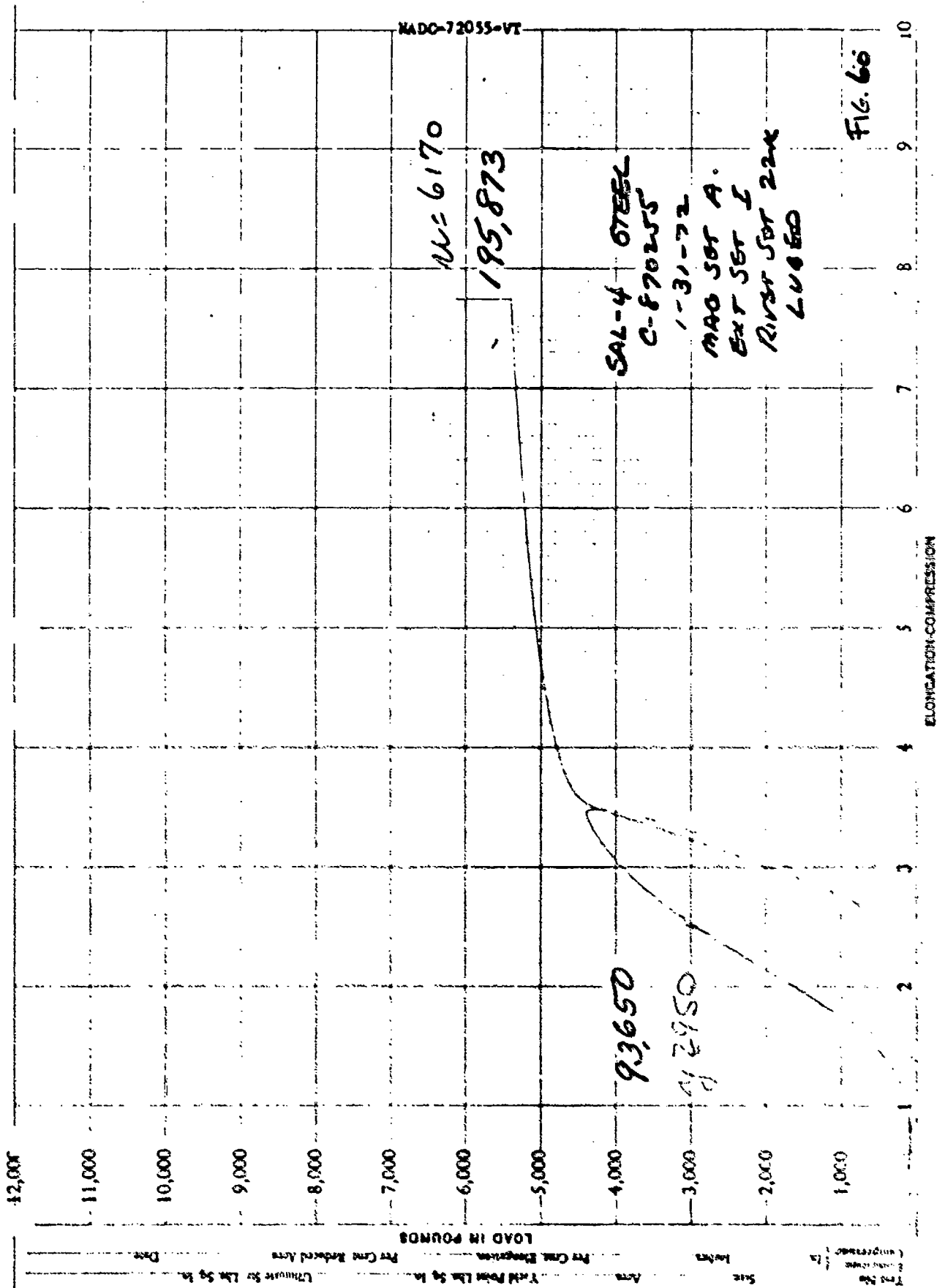


FIG. 60

ELONGATION-COMPRESSION

LOAD IN POUNDS

Test No. _____
 Sample No. _____
 Size _____
 Area _____
 Yield Point Lbs Sq In _____
 Ultimate Str Lbs Sq In _____
 Date _____
 Per Cent Elongation _____
 Per Cent Reduced Area _____

FIGURE 60

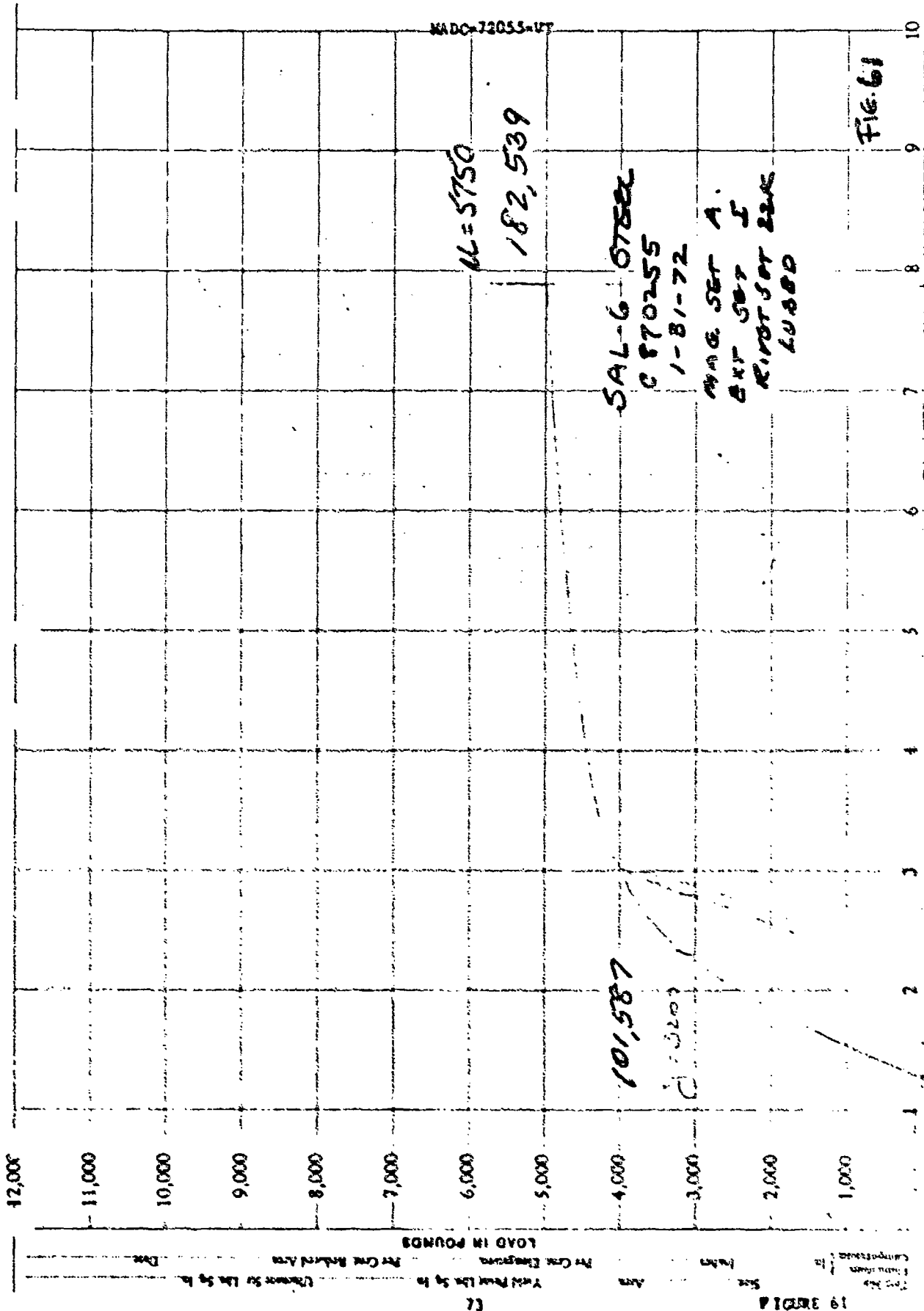


Fig. 61

ELONGATION-COMPRESSION

19 3RD 14
 Part No. _____
 Part Name _____
 Quantity _____
 Drawing No. _____
 Date _____
 See _____
 Part No. _____
 Part Name _____
 Quantity _____
 Drawing No. _____
 Date _____
 Yield Point Lbs. Sq. In. _____
 Tensile Strength Lbs. Sq. In. _____
 Elongation % _____
 Per Cent Elongation _____
 Per Cent Reduction Area _____
 Dia. _____

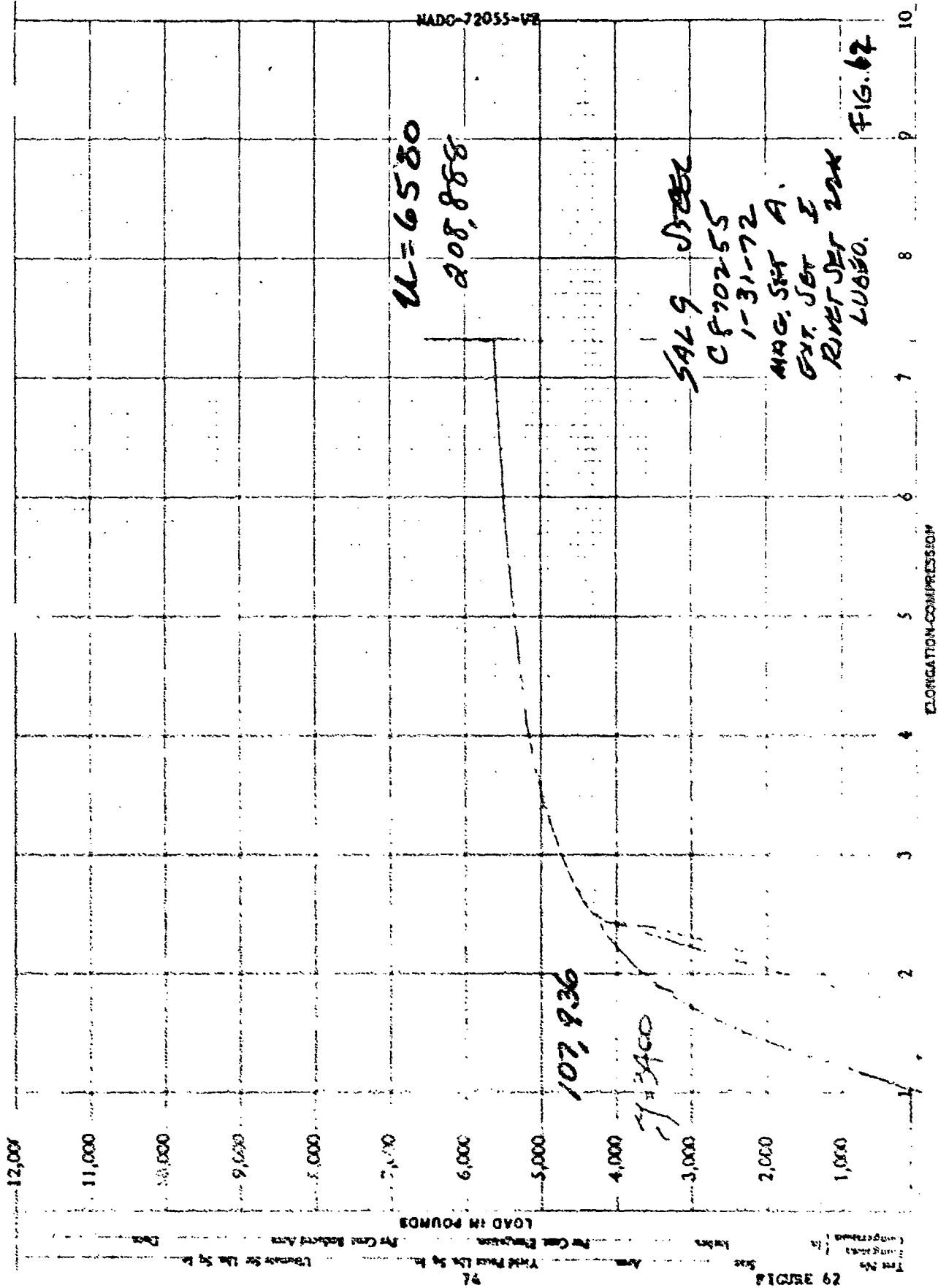


FIG. 62

72 3RD 62
 Test No. _____
 Sample No. _____
 Specimen No. _____
 Test Date _____
 Test Location _____
 Test Engineer _____
 Test Operator _____
 Test Room _____
 Test Equipment _____
 Test Method _____
 Test Results _____
 Test Comments _____

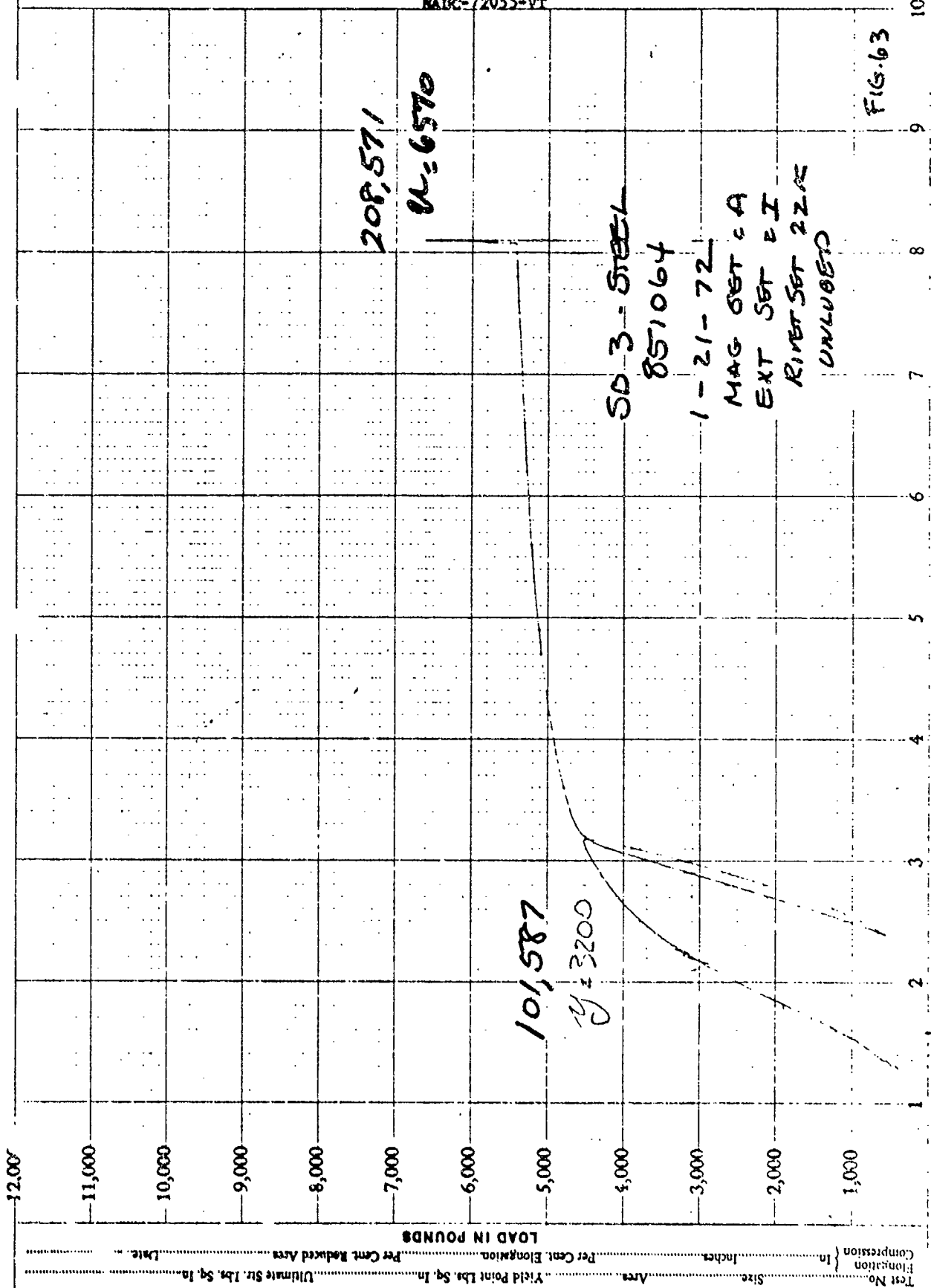


FIG. 63

Test No. _____
 Elongation _____ In. _____
 Compression _____ In. _____
 Size _____ Inches _____
 Area _____
 Yield Point Lbs. Sq. In. _____
 Ultimate Str. Lbs. Sq. In. _____
 Per Cent. Elongation _____
 Per Cent. Reduced Area _____
 Late _____

FIGURE 63

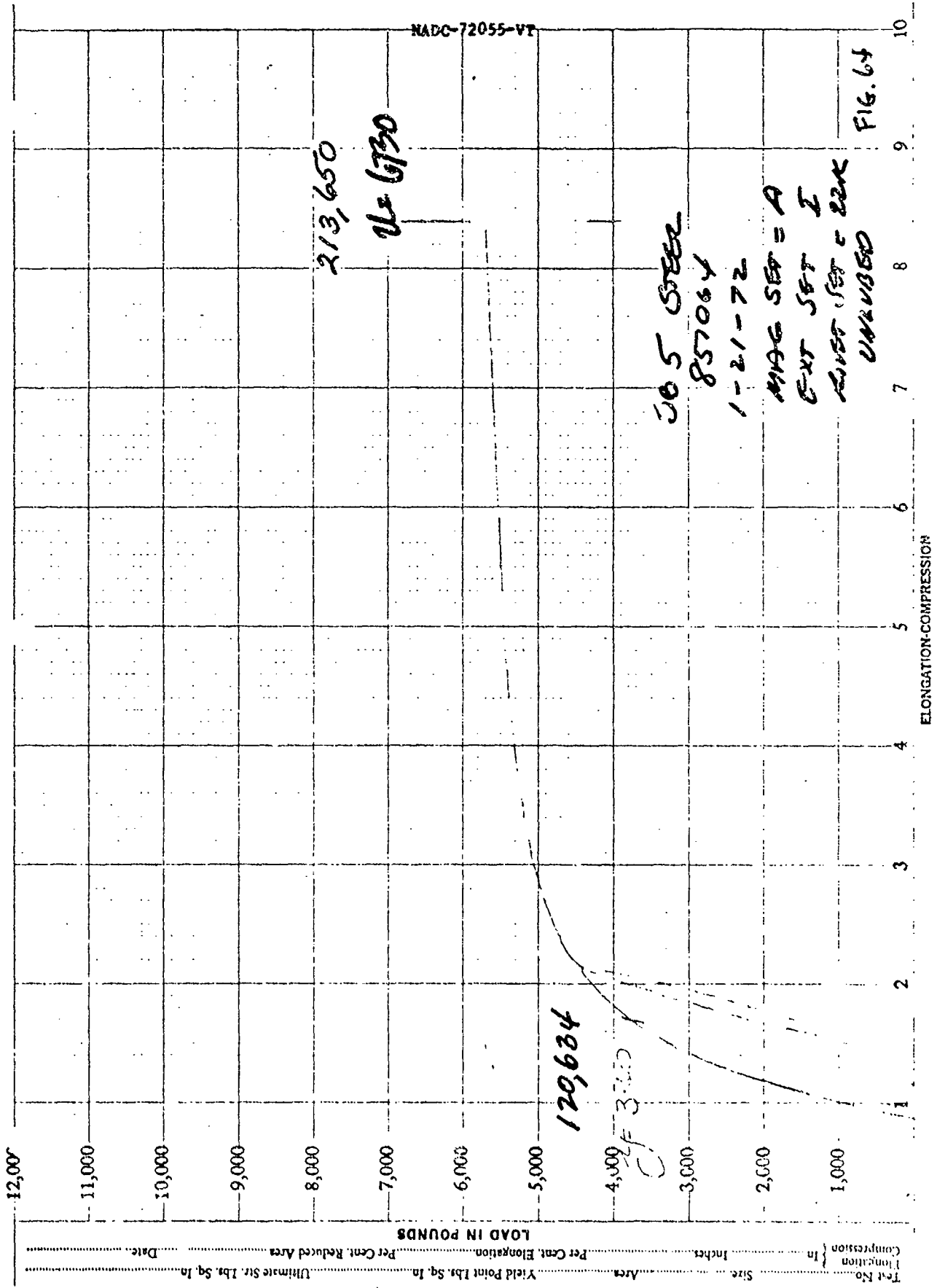
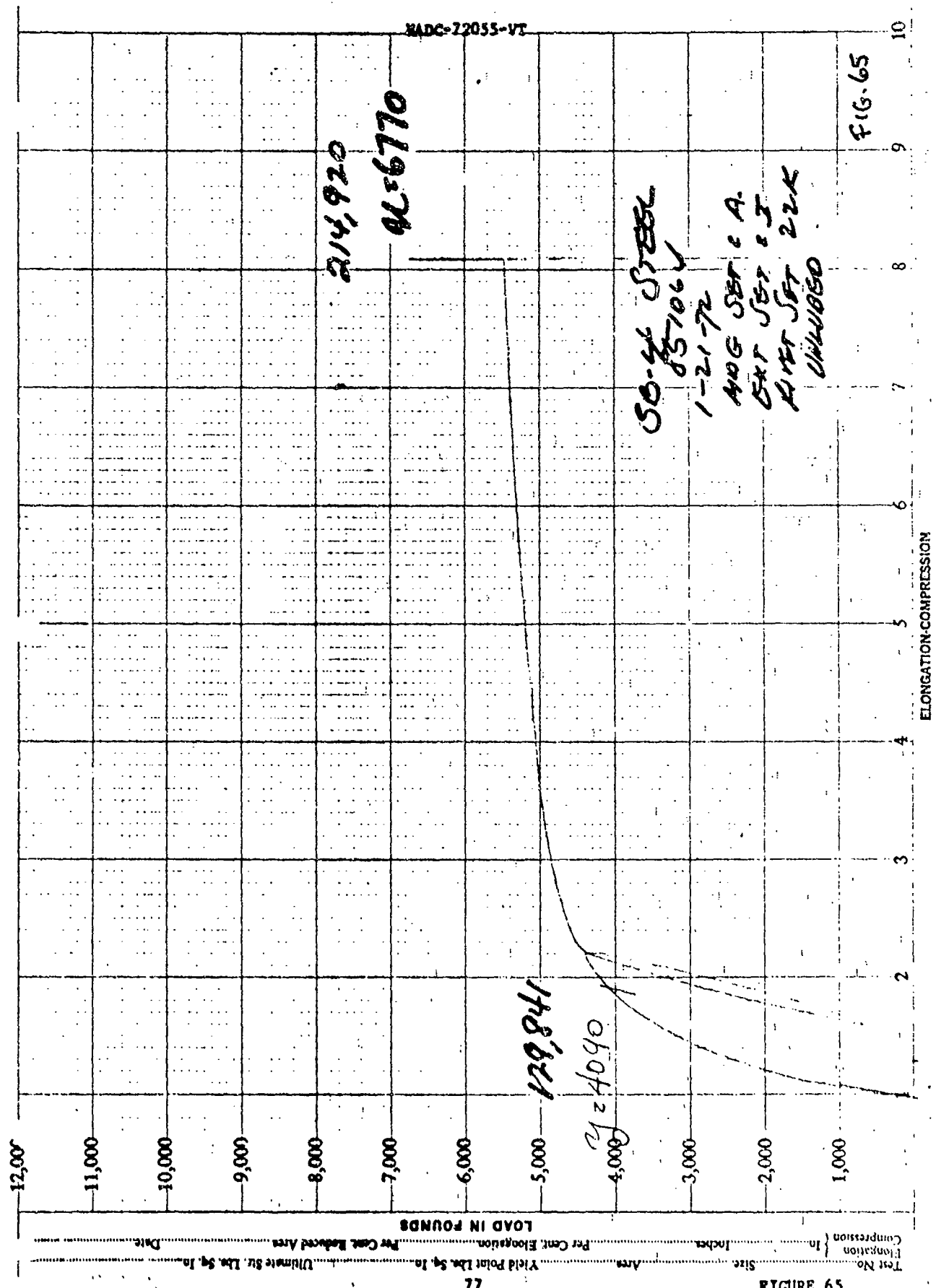


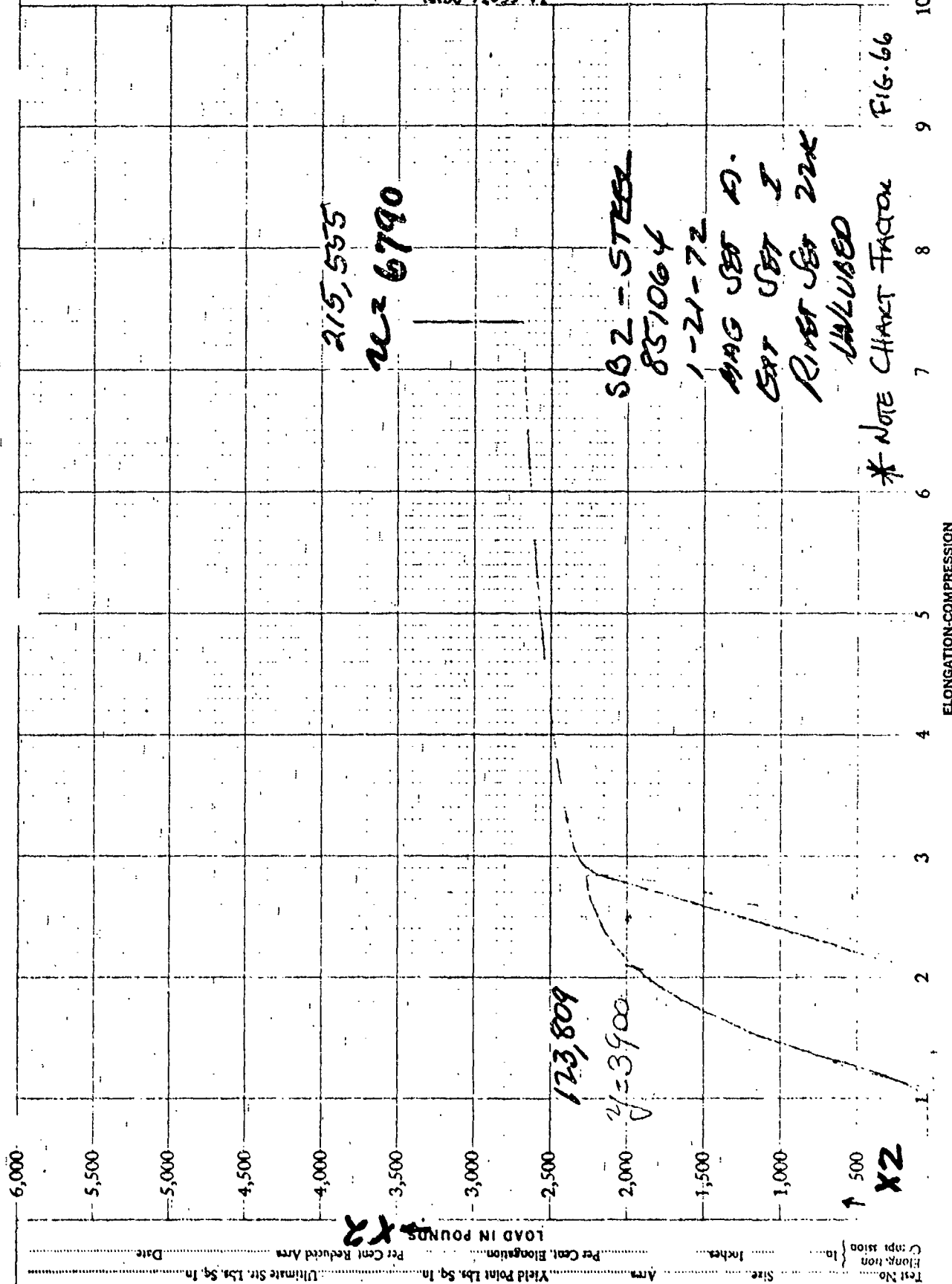
FIG. 64

FIGURE 64

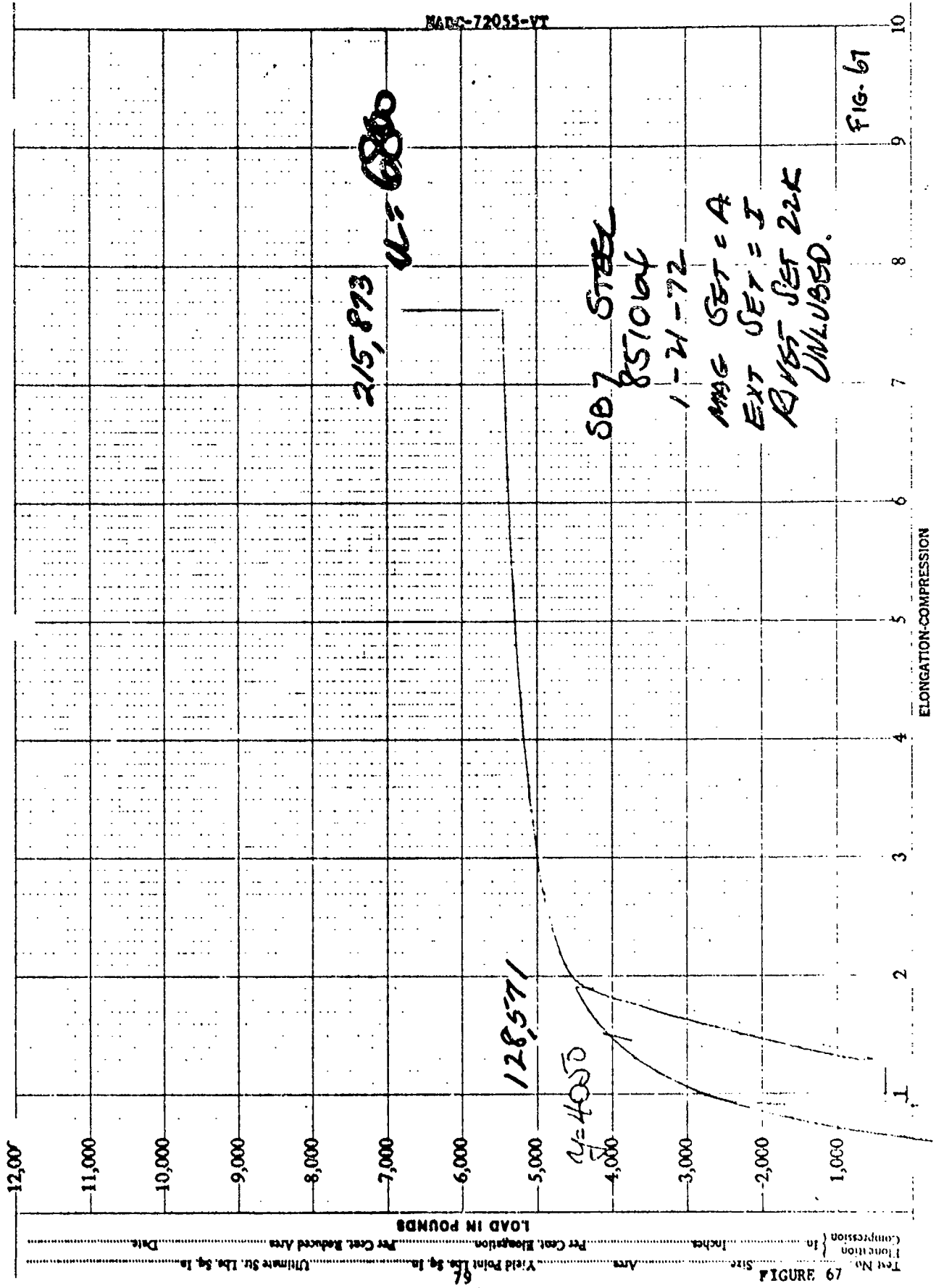


NADC-22055-VT

FIG. 65



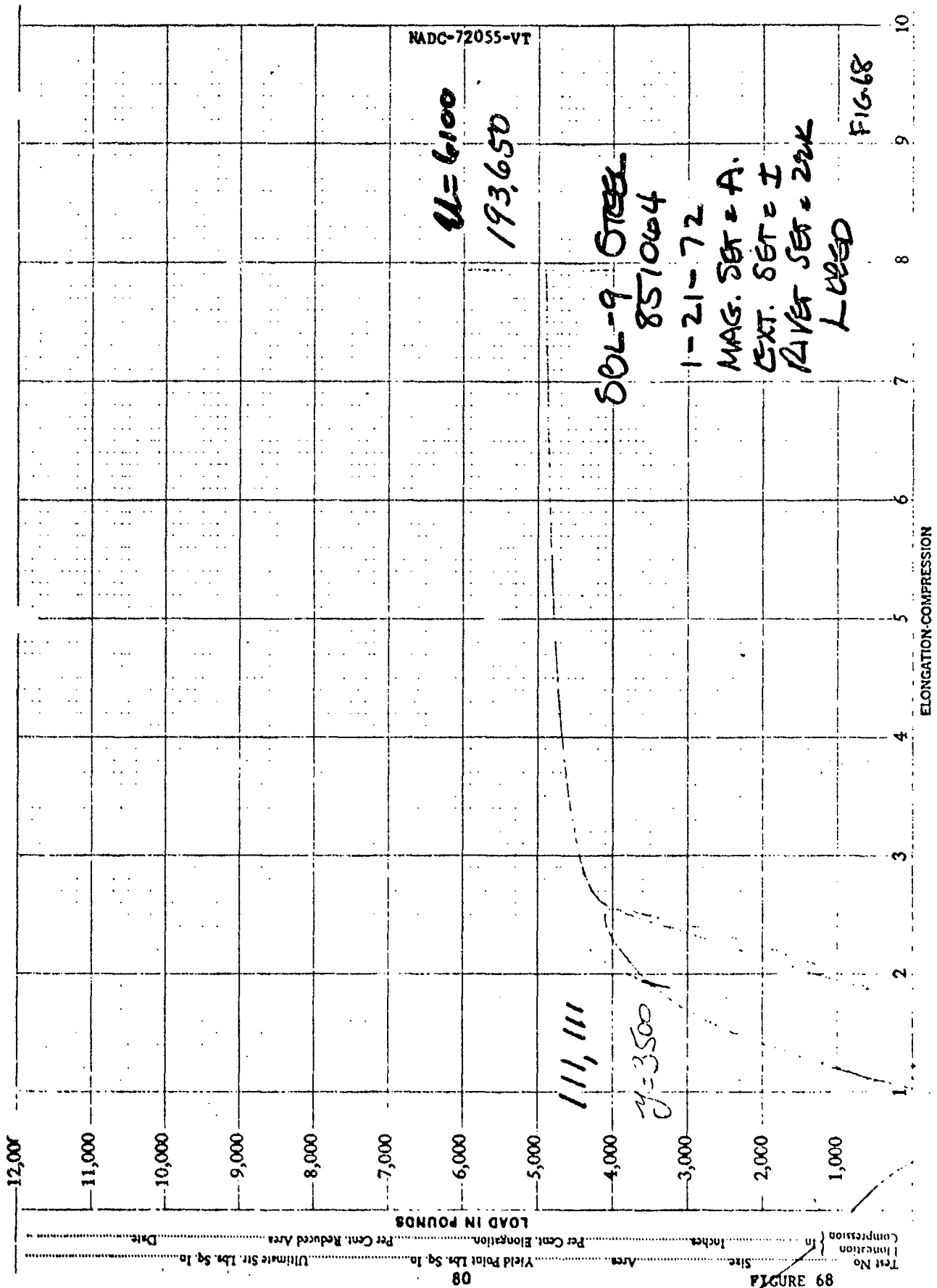
Test No. _____
 Flange _____
 In. _____
 Size _____
 Area _____
 Yield Point Lbs. Sq. In. _____
 Ultimate Str. Lbs. Sq. In. _____
 Per Cent. Elongation _____
 Per Cent. Reduced Area _____
 Date _____



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FIG-67

Test No. 79
 Size: _____
 Area: _____
 Yield Point: _____
 Ultimate Str.: _____
 Per Cent. Elongation: _____
 Per Cent. Reduced Area: _____
 Date: _____



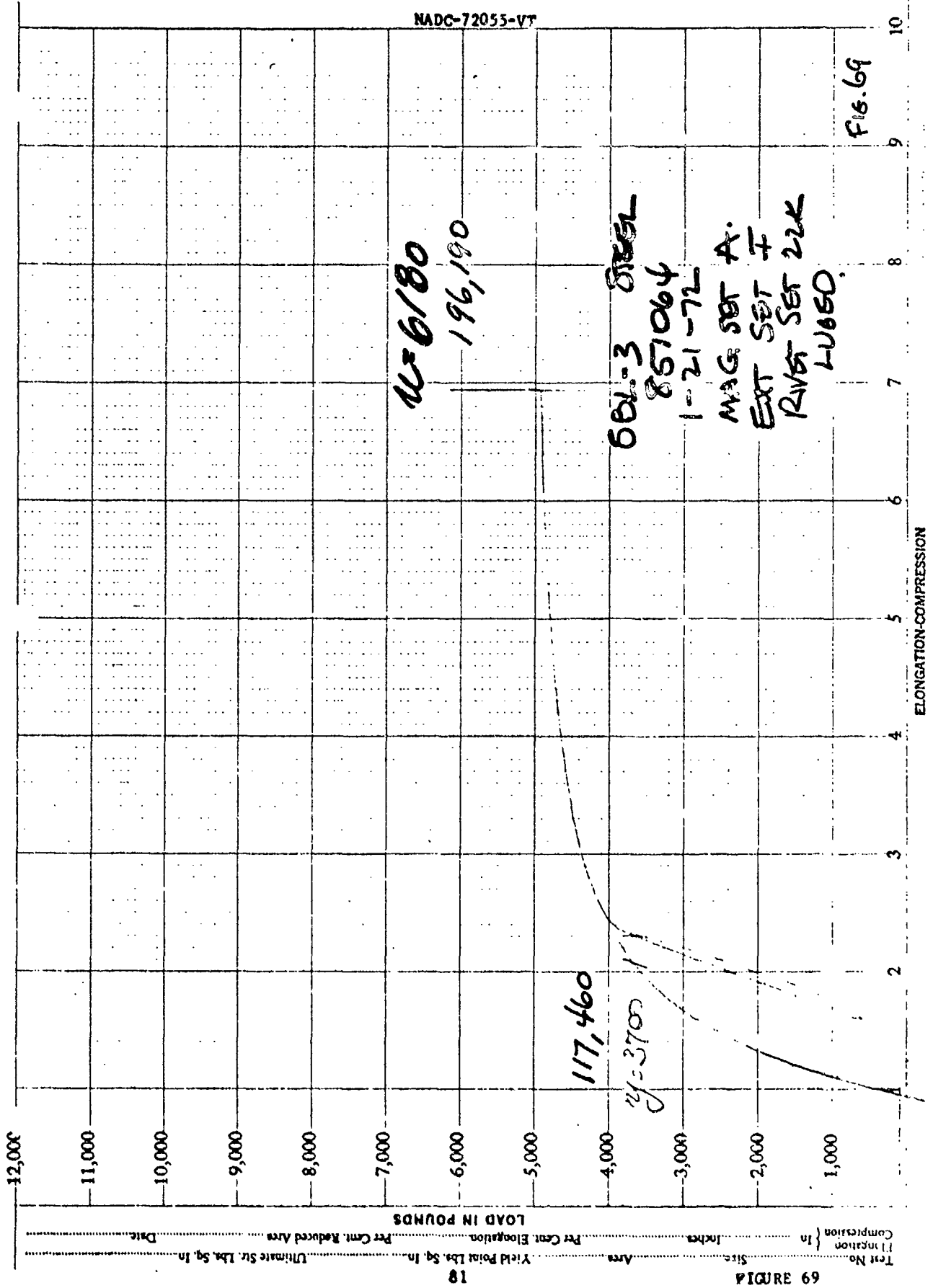


FIGURE 69

18

Test No. _____
 Yield Point Lbs. Sq. In. _____
 Area _____
 Per Cent Elongation _____
 Per Cent Reduced Area _____
 Ultimate Str. Lbs. Sq. In. _____
 Date _____

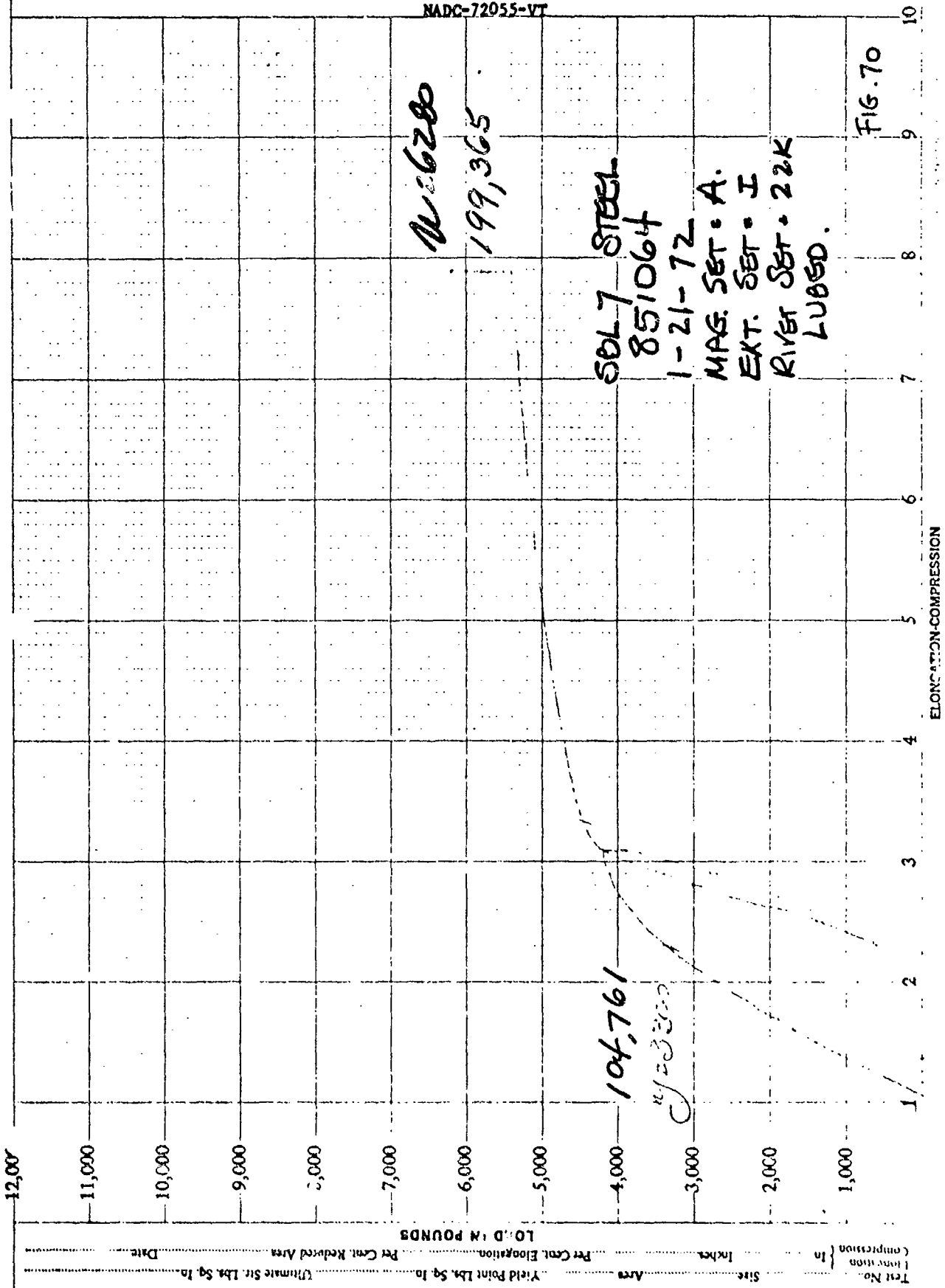
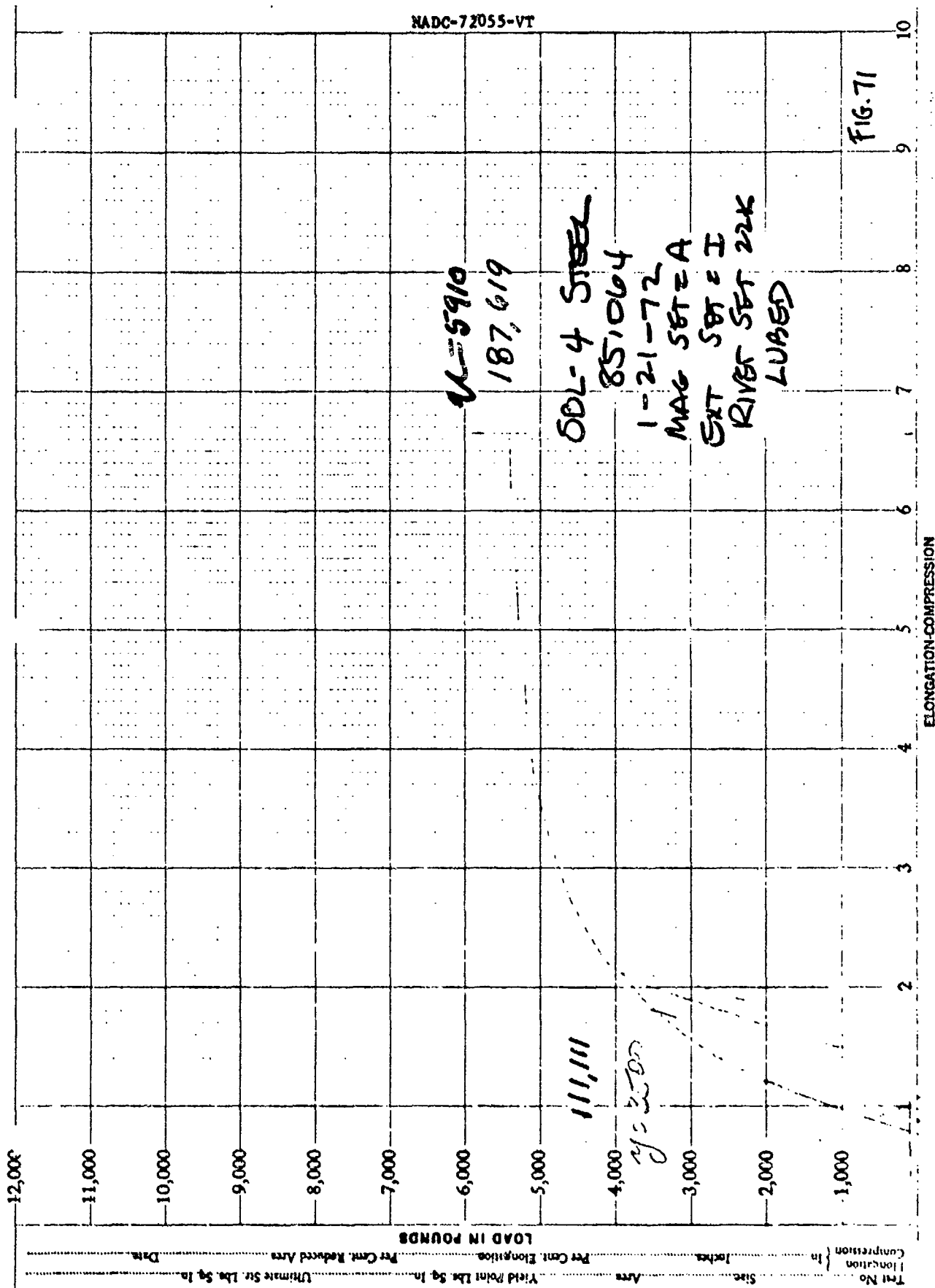
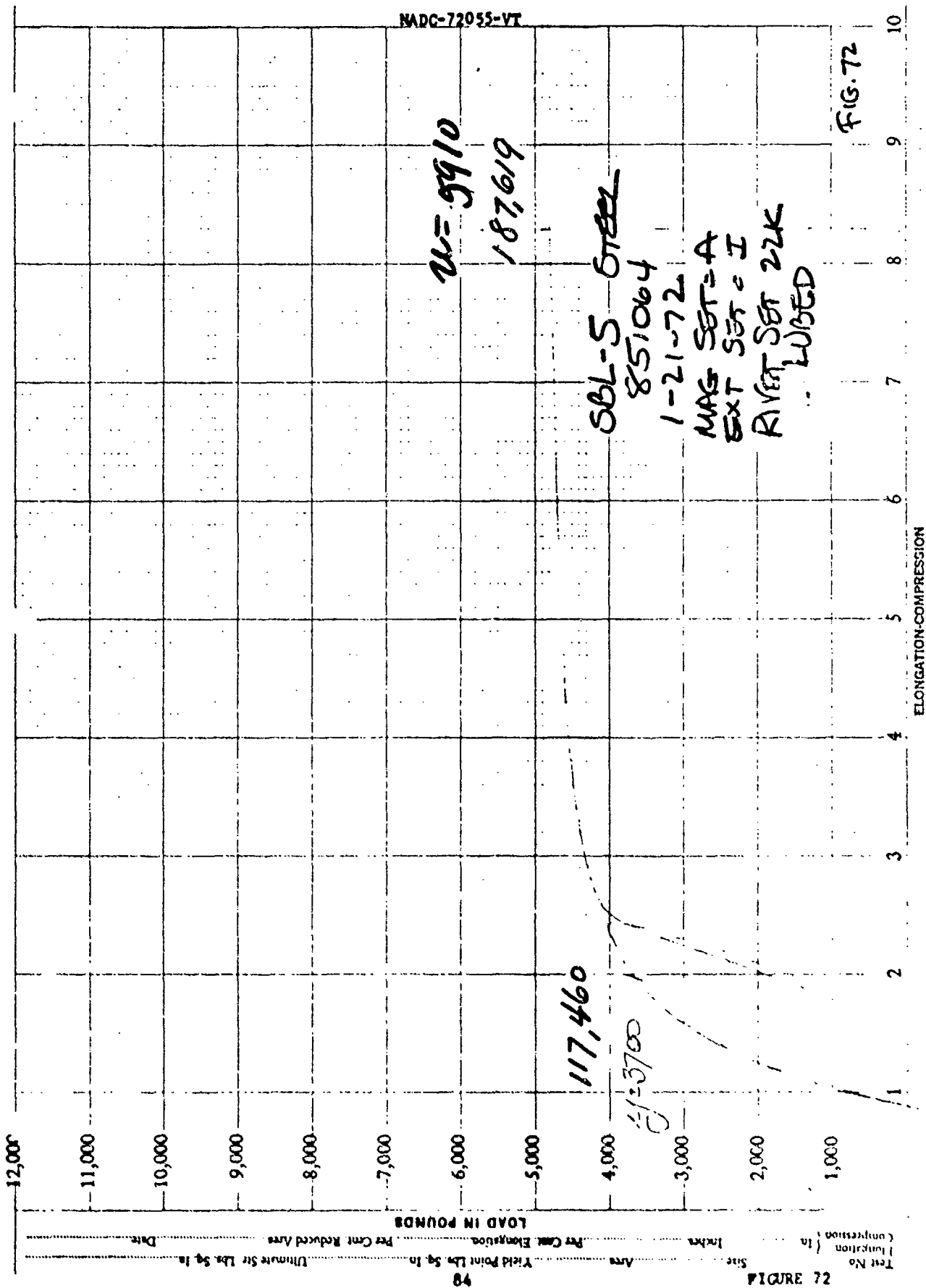


FIG. 70

FIGURE 70

Test No. _____
 Site _____
 Area _____
 Yield Point Lbs. Sq. In. _____
 Ultimate Str. Lbs. Sq. In. _____
 Date _____
 Per Cent. Elongation _____
 Per Cent. Reduced Area _____
 Load in Pounds _____
 Elongation-Compression _____





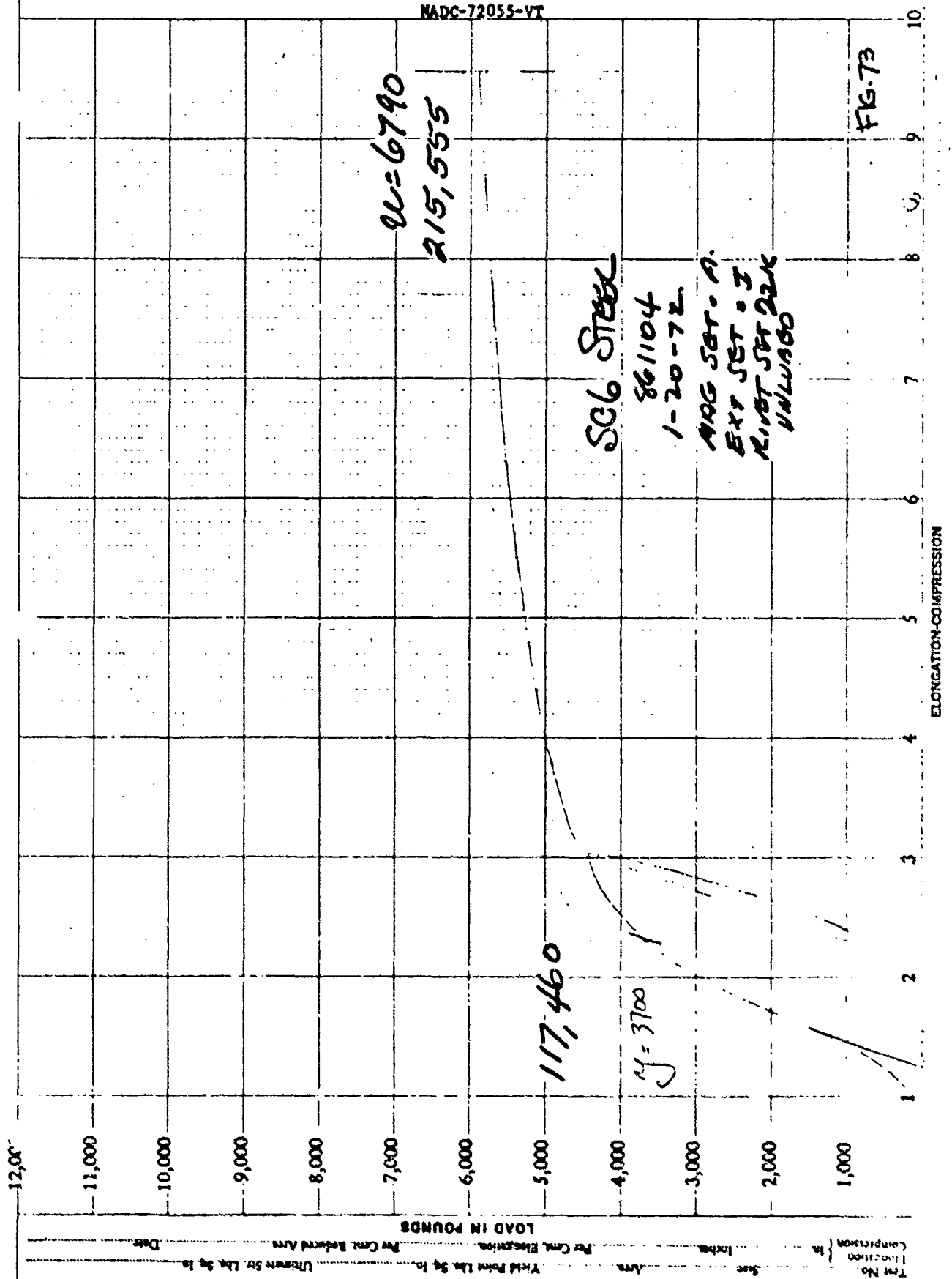


FIG. 73

12,000

11,000

10,000

9,000

8,000

7,000

6,000

5,000

4,000

3,000

2,000

1,000

LOAD IN POUNDS

ELONGATION-COMPRESSION

10

9

8

7

6

5

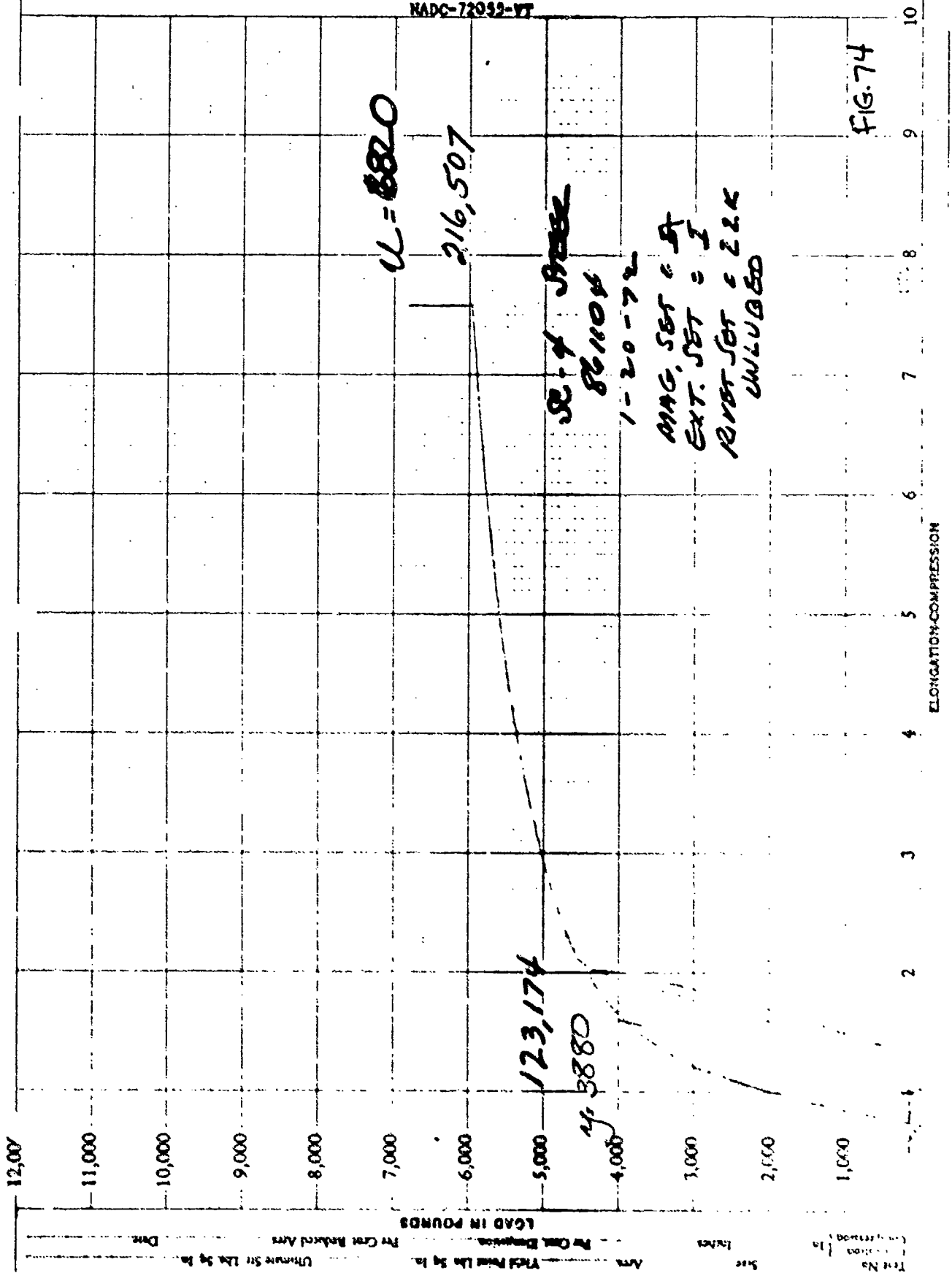
4

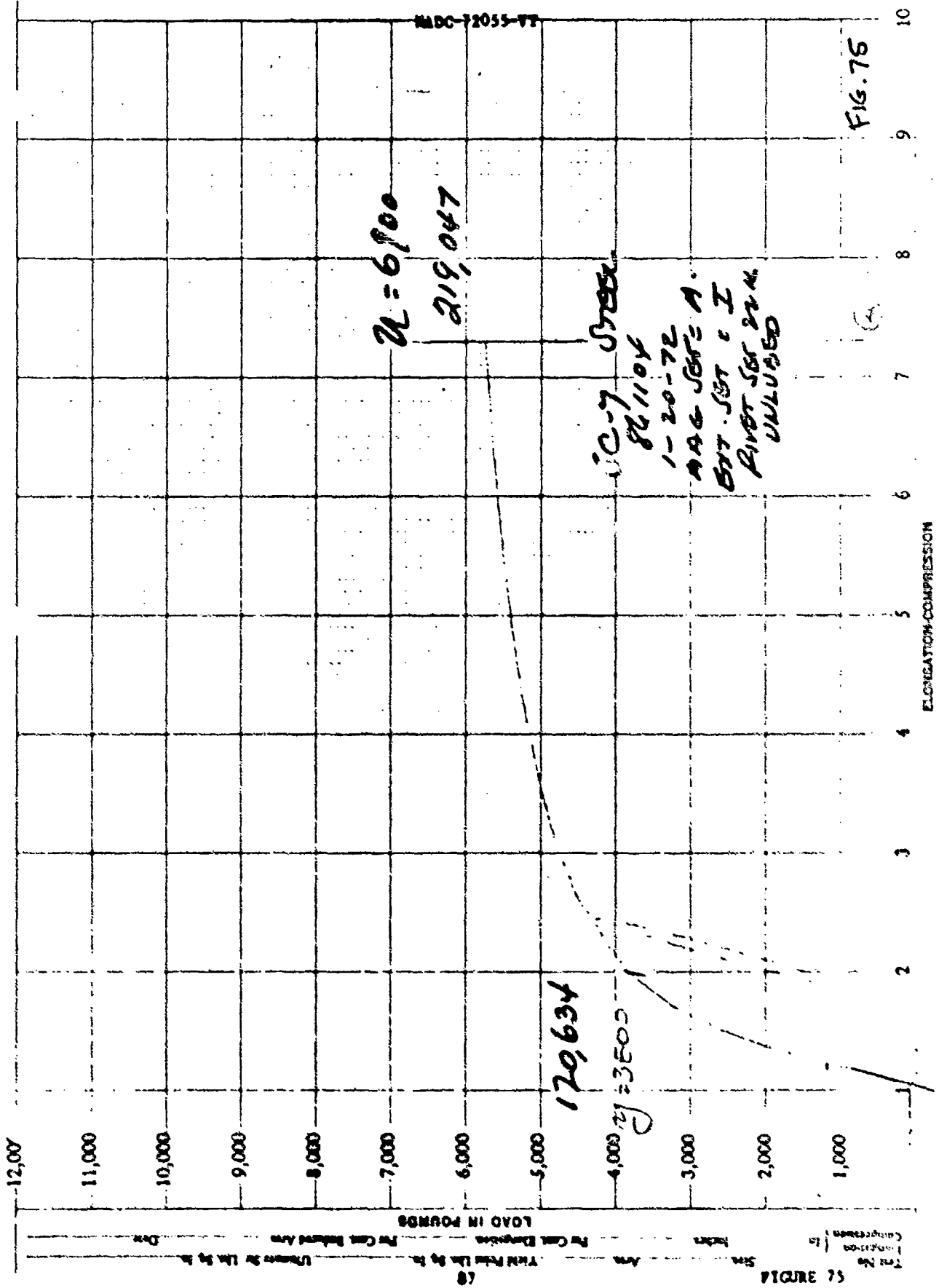
3

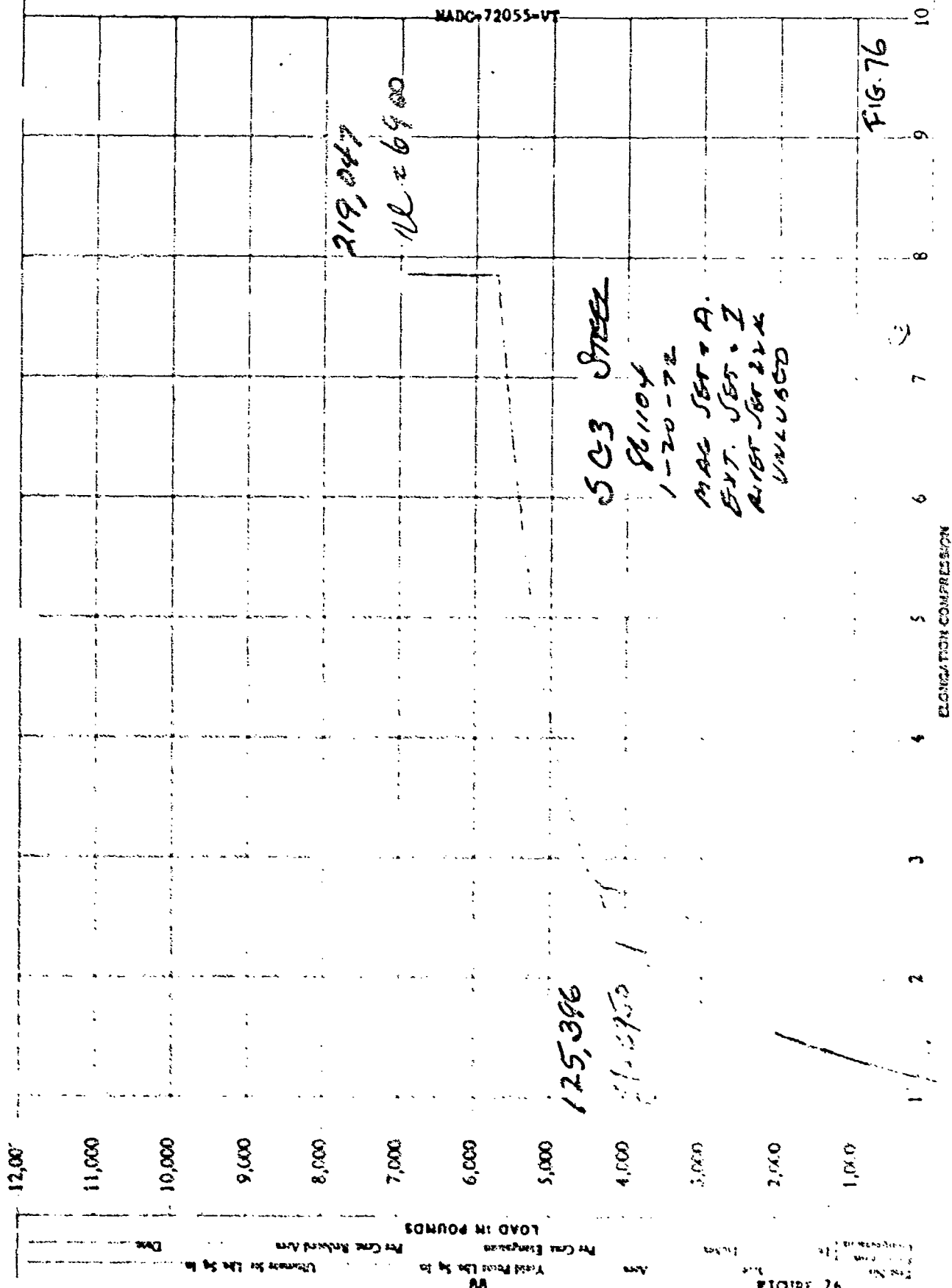
2

1

Test No. _____ Date _____
 Location _____
 Spec. _____
 Area _____
 Yield Point Lbs. Sq. In. _____
 Ultimate Str. Lbs. Sq. In. _____
 Per Cent Elongation _____
 Per Cent Reduction Area _____







12,000

11,000

10,000

9,000

8,000

7,000

6,000

5,000

4,000

3,000

2,000

1,000

226,849

K. 7130

SC-5 STEEL

861104

1-20-72

MAG SET = A

EXT SET = I

RIVER SET = LK

UNLWAGD

128,571

100,000

Vertical text on the right side of the page, including '100,000', '128,571', and other numbers, likely representing data points or values.

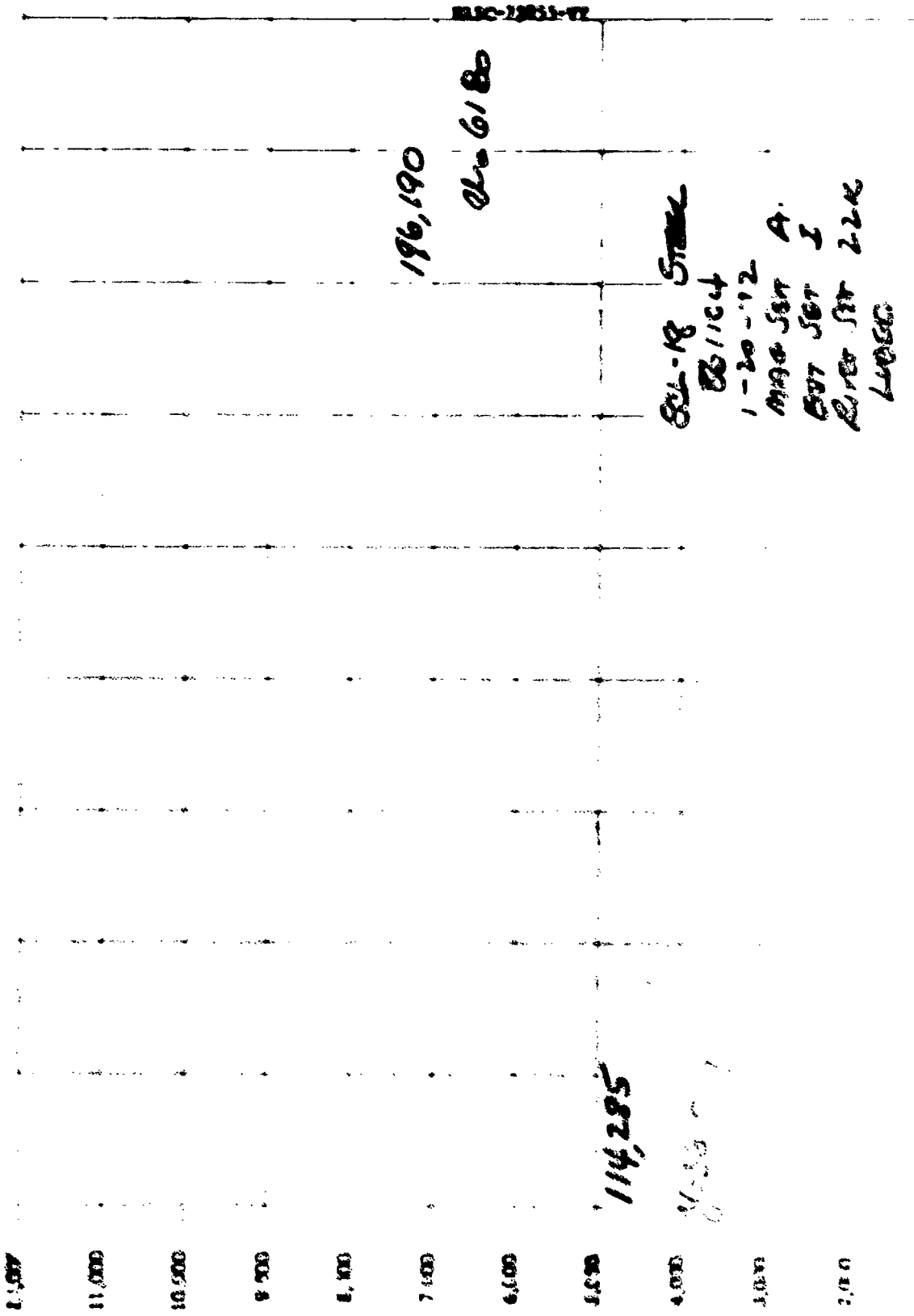


FIG 78

EXPLANATION OF SYMBOLS

12,000

11,000

10,000

9,000

8,000

7,000

6,000

5,000

4,000

3,000

2,000

1,000

104,761

11,100

66-6080
193,015

6CL-12 STEEL

861104

1-20-72

MAX. SET A

ENT. SET I

RIVER SET = 24K

LUBED.

FIG. 79

CONCRETE COMMISSION

FIG. 80

10
9
8
7
6
5
4
3
2
1

191, 111

4L=6020

SCA-15 STREZ

861104

1-20-72

MARG SCALE - A

ERT JPT S I

RIVER SET - 22K

LURSEC

107, 916

12,000

11,000

10,000

9,000

8,000

7,000

6,000

5,000

4,000

3,000

2,000

1,000

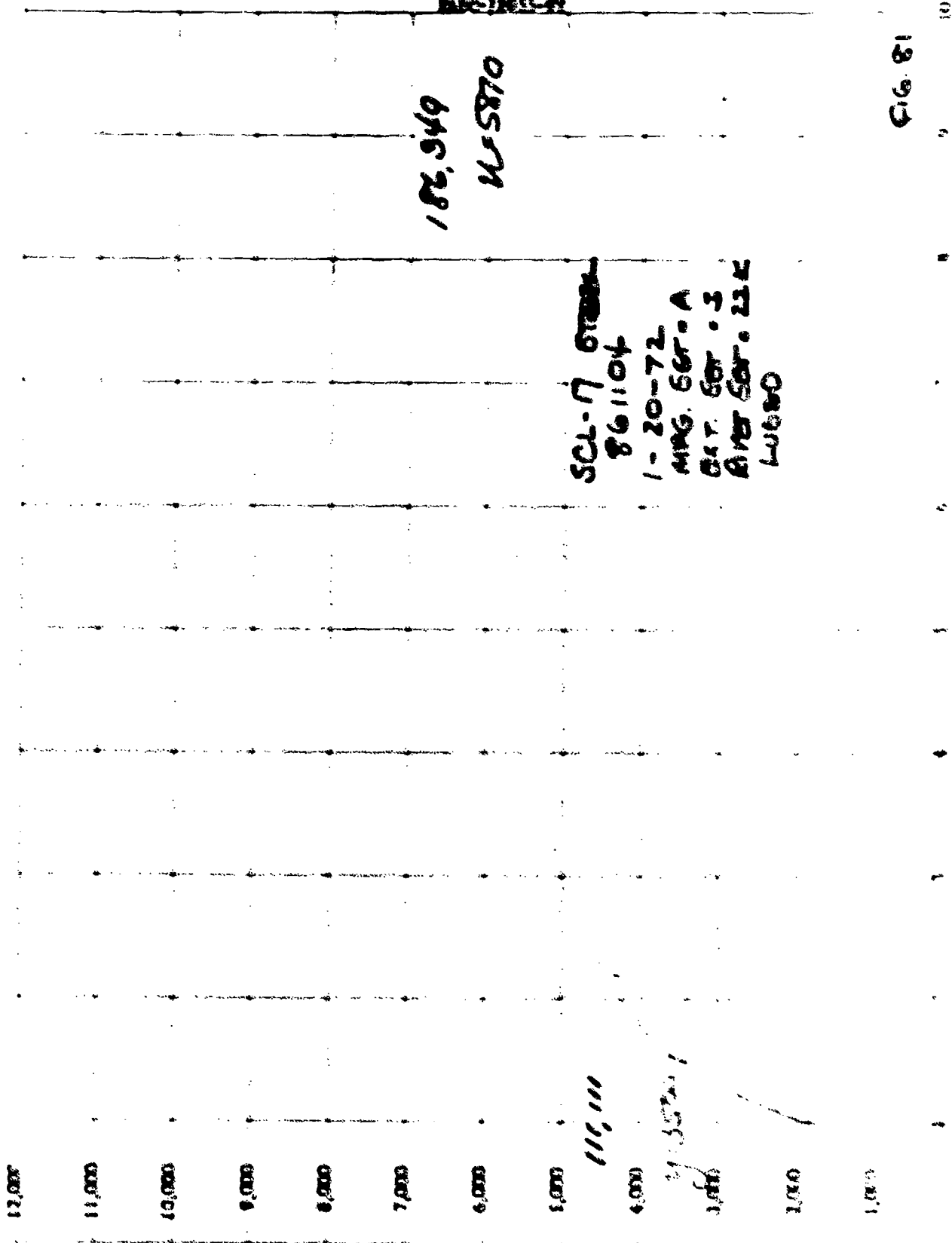


Fig. 81

10

9

8

7

6

5

4

3

2

1

12,000

11,000

10,000

9,000

8,000

7,000

6,000

5,000

4,000

3,000

2,000

1,000

12,000
11,000
10,000
9,000
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000

