FCP Report No. 13

MATERIAL CHARACTERIZATION OF CAST 8630 STEEL; MONOTONIC AND CYCLIC STRESS-STRAIN BEHAVIOR AND STRAIN-LIFE RESPONSE

by

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ABSTRACT

Monotonic and cyclic stress-strain behavior and strain-life resistance of cast 8630 (Mn. modified) at 254 ± 5 BHN are reported. The material exhibits an engineering ultimate strength of 114 ksi, which is approximately 10% lower than a comparable wrought steel, and a comparatively low ductility of 17%. Cyclic softening of this cast alloy results in a cyclic yield strength (0.2% offset) of 80 ksi, whereas its monotonic yield strength is 103 ksi. Initial precycling of axially loaded fatigue specimens appears to decrease the fatigue life significantly. However, no general trend is exhibited when compared to non-precycled results. The fatigue performance of the cast steel is shown to be much poorer than would be obtained for a wrought steel with similar monotonic tension properties.

A Report of the
FRACTURE CONTROL PROGRAM

College of Engineering, University of Illinois
Urbana, Illinois 61801
October, 1974

FOREWORD

This is the second in a series of reports on the fatigue evaluation of steels of interest to sponsors of the Fracture Control Program (see FCP No. 12 for similar data on T-1 steel). Marion Power Shovel Company supplied cast 8630, modified with manganese, for evaluation in this report. The foremat of this report is similar to the previous one (FCP No. 12) in that reduced material characterization sheets and original laboratory records are included.

PROCEDURE

Specimens of the design, shown in Fig. 1, were removed from a 7 ft. dia., 6 in. thick gear casting, which had been normalized and tempered.[1] Samples were machined to a surface finish of approximately 10 rms. All testing was performed using a ±20 kip closed-loop test system. The ASTM E-9.08 tentative specification for low cycle fatigue testing served as a guide for these tests.

RESULTS

Stress-Strain Behavior

The data sheet for material characterization lists the results for the monotonic stress-strain tests. As would be expected with a cast material where internal micro-cavities are present, the ultimate strength (114 ksi) is lower than that of a comparable wrought material.[2] Similarly, the true fracture ductility of the cast material is much lower ($\epsilon_f = 0.17$) than that of a similar wrought product which should have a ductility of approximately one. A typical photomacrograph of a cast sample, shown in Fig. 2, reveals a pronounced dendritic structure which, along with internal porosities, would be conducive to low ductility. More complete homogenization of such a structure should improve this material property by reduction of composition gradients.

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[1] Normalized at 1600-1650° F for three hours; tempered at 1050-1100° F for six hours.

[2] From hardness measurements, the ultimate strength of the similar wrought product would be approximately 0.5 BHN $\cong$ 0.5 (254) $\cong$ 127 ksi.

As shown in Fig. 3, which is an enlargement of the stress-strain curves on the data sheets, the material cyclically softens and has a 0.2% yield strength of 80 ksi as its minimum bound represented by the incremental step-strain test results. Representation of the cyclic response of cast metals by such a stress-strain curve is perhaps fallacious, since we are not dealing with a homogeneous, wrought metal but with an "internally notched" member. This point is ramified in the other cyclic properties shown on the data sheet, which were obtained from several types of test data in an attempt to furnish "representative" results. The types of test employed and the interpretation of the result are appropriate for wrought metals but not for cast metals with controlling internal microcavities. Thus, the cyclic properties reported on the data sheets are to be used with caution. Further, attempts to employ these monotonic and cyclic results to predict the strain-life response of the cast metal, as commonly done with wrought metals, can lead to serious errors in predicted lives.

Strain-Life Resistance

Figure 4 illustrates the strain-life curves for median life test results, which are tabulated at the back of the report, in comparison to a strain-life curve which was predicted from monotonic and cyclic stress-strain results. Note that the predicted curve is non-conservative and several orders of magnitude in life errors can result, particularly at long lives.

A master plot of the strain-life fatigue results for non-precycled and precycled samples is shown near the back of this report. Median lives of only the non-precycled samples were used in a least square analysis for the elastic and plastic strain-life lines. From this analysis, the total strain-life curve and the equation appearing at the upper right of this figure were determined.

As common with cast metals, the transition fatigue life, $2N_t = 200$ reversals is short in comparison to that of the comparable wrought product ($2N_t \cong 10^4$ reversals).

Because of this, it would appear that increasing the strength (i.e. BHN) of the cast metal would proportionately improve its long-life fatigue resistance, since elastic strain predominates at lives greater than 10^5 reversals. This may not be the case since the internal microcavities would become more effective as "fatigue notches," at greater hardnesses, and a proportionate increase in fatigue strength would not be realized.

Also included on the strain-life plot are results of precycled specimens. In general, precycling appears to decrease life in comparison to non-precycled samples. This however is not a consistent trend since, in some cases, precycling resulted in increased lives.

CONCLUSIONS

Monotonic stress-strain results of cast 8630 (Mn. modified) are consistent with similar cast alloys of equivalent hardness in that the ultimate strength and ductility are lower than the wrought product. Cyclic stress-strain response of this cast alloy, determined by three methods, indicates cyclic softening. Methods which employ the cyclic and monotonic properties to predict the strain-life fatigue resistance of wrought products should <u>not</u> be employed to predict the fatigue resistance of the cast metal, since serious errors can result.

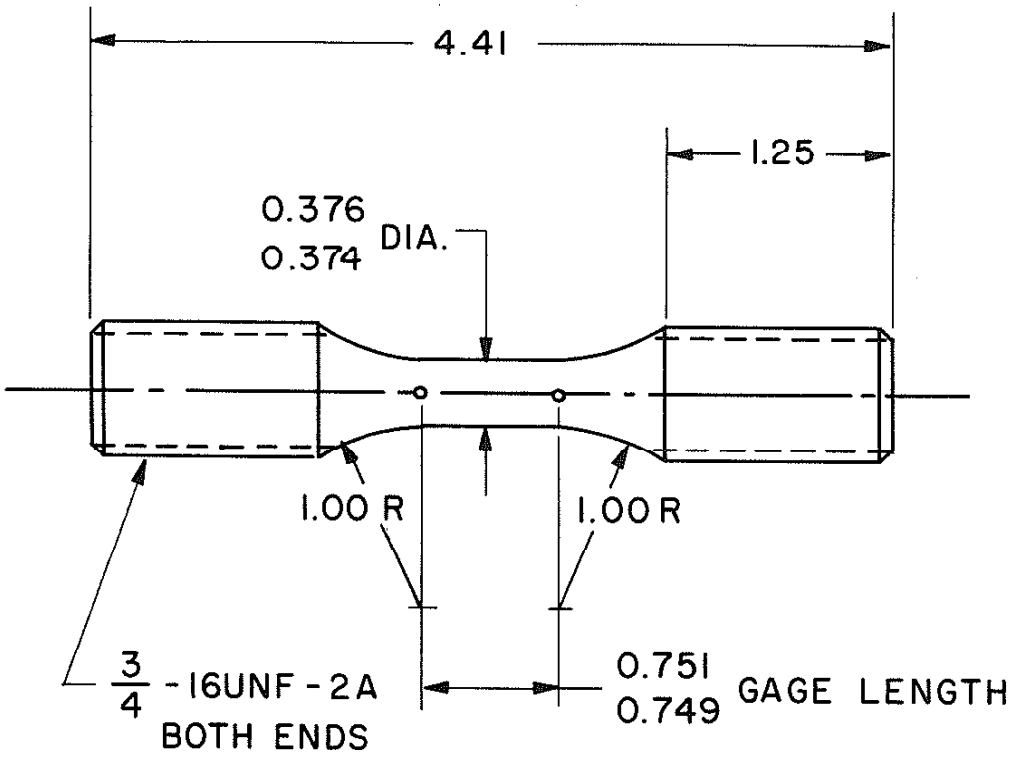
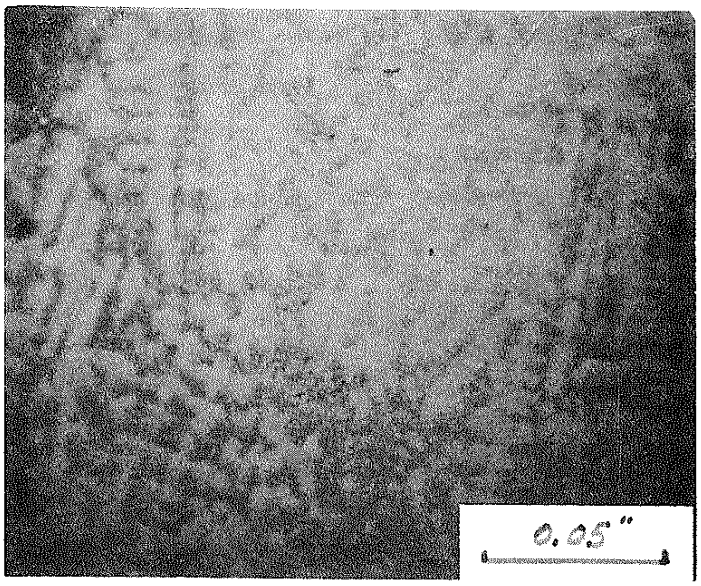
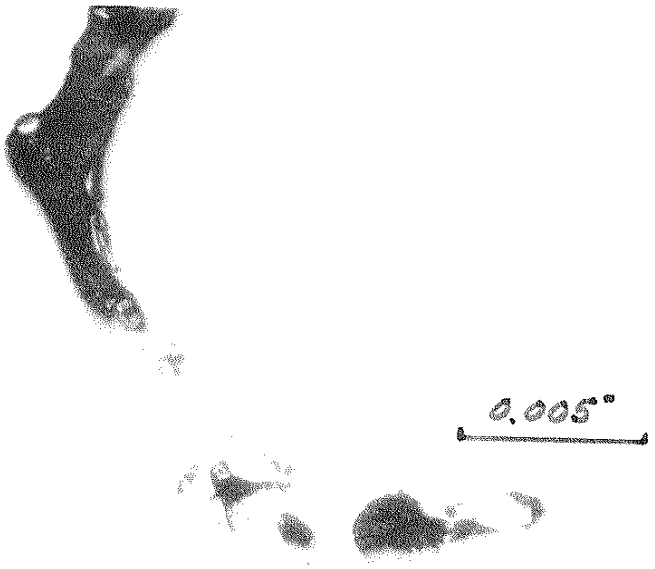


FIGURE 1 - SPECIMEN DESIGN



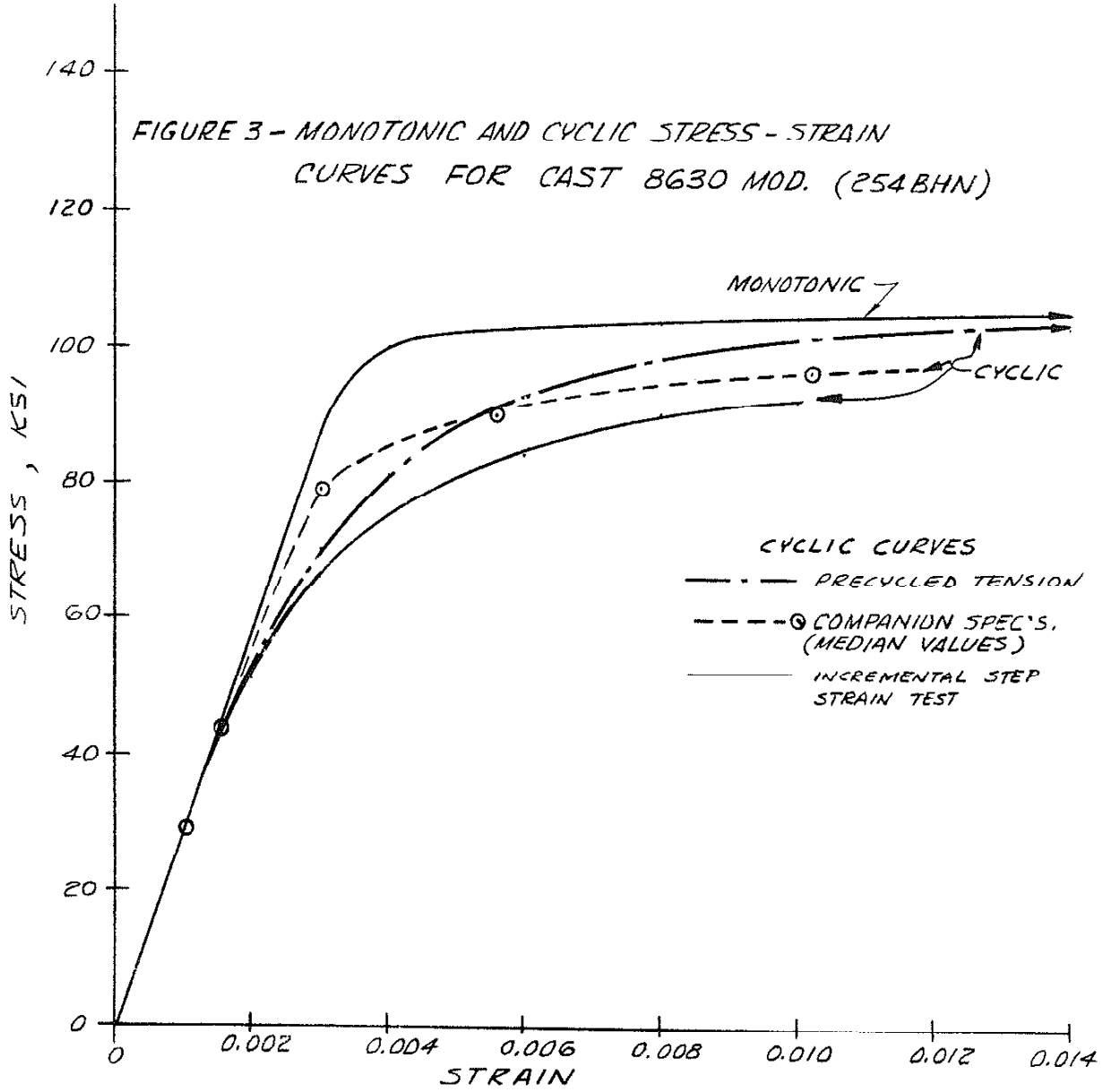
DENDRITIC STRUCTURE
(ETCH : 4% NITAL)



TYPICAL POROSITIES

FIGURE 2 - PHOTOGRAPHS OF DENDRITIC STRUCTURE AND POROSITIES.

FIGURE 3 – MONOTONIC AND CYCLIC STRESS - STRAIN CURVES FOR CAST 8630 MOD. (254 BHN)



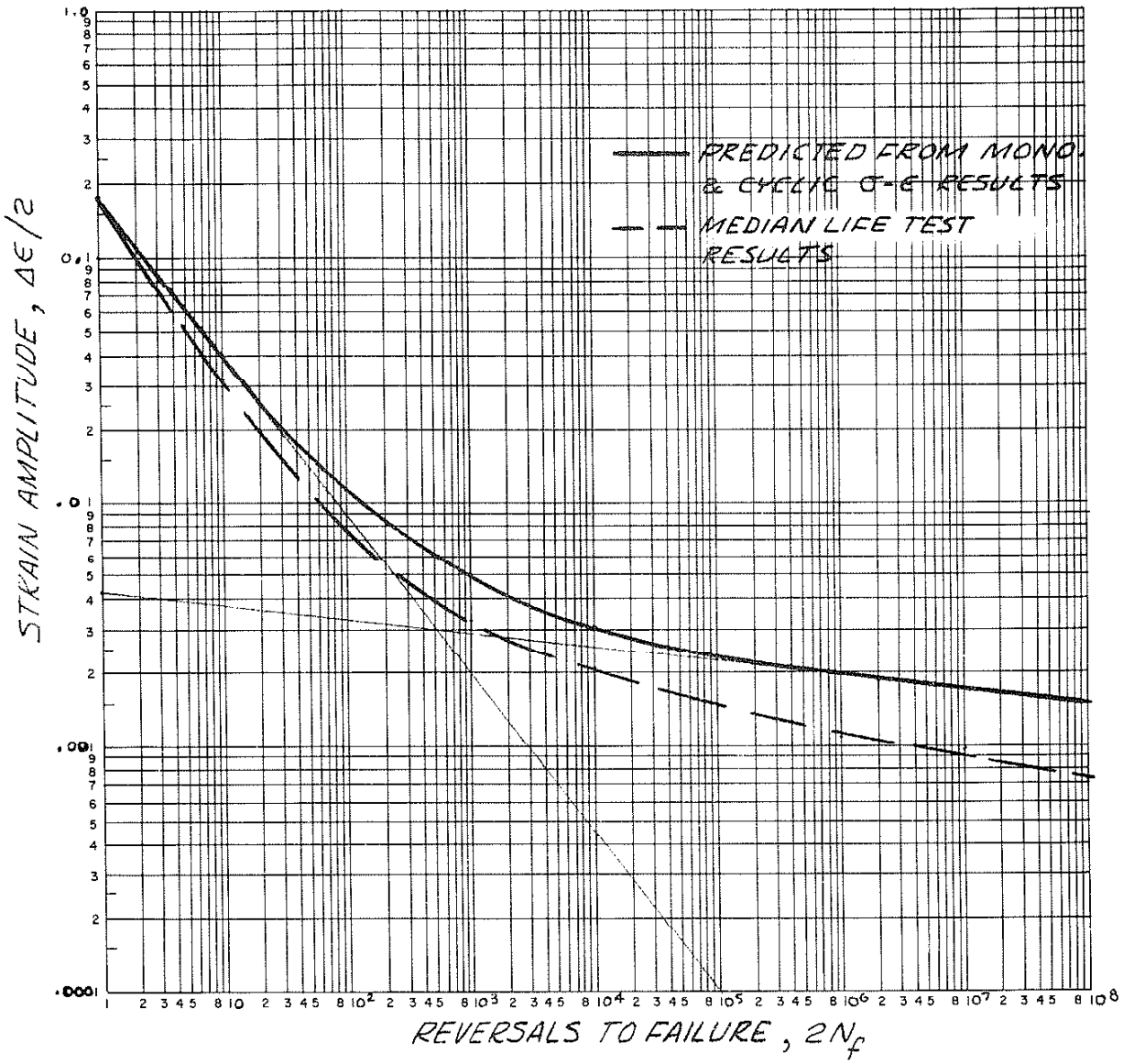


FIGURE 4 - PREDICTED AND MEDIAN VALUE STRAIN - LIFE RESULTS

MATERIAL CHARACTERIZATION SHEETS

DATA SHEET FOR MATERIAL CHARACTERIZATION

Material: MPS Cast 8630 (Mn. modified)

Condition: Normalized & Tempered

[1600-1650°F /½ hr/1" thick; 1050-1100°F/hr/1" thick]

Matrix Hardness: 254 ± 5 BHN

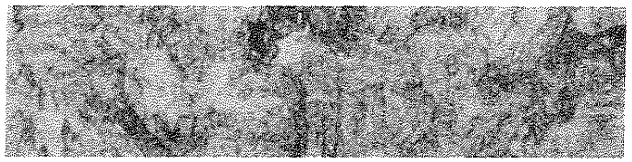
Converted from: R_c

Monotonic Properties:

Modulus of Elasticity, E	29.0×10^3 ksi
Yield Strength, 0.2% S_y	103 ksi
Ultimate Strength, S_u	114 ksi
Red. in Area, % RA	16
True Fracture Strength, σ_f	122 ksi
True Fracture Ductility, ϵ_f	0.17
Strain Hardening Exponent, n	0.08
Strength Coefficient, K	154 ksi
True Toughness, U_p	30×10^3 in-lb/in^3
Poisson's Ratio	---

Cyclic Properties: (Please see text of report)

Yield Strength, 0.2% S_y'	80 ksi*
Strain Hardening Exponent, n'	0.086#
Strength Coefficient, K'	154 ksi#
Fatigue Strength Coefficient, σ_f'	116 ksi#*
Fatigue Ductility Coefficient, ϵ_f'	0.17#*
Fatigue Strength Exponent, b	-0.107**
Fatigue Ductility Exponent, c	-0.795**
Transition Fatigue Life, $2N_t$	200 rev**



Microstructure: Tempered martensite, very fine grained.

Magnification: 0.002"

Composition:

w/o C	= 0.34	w/o Mo	= 0.28
w/o Si	= 0.49	w/o Cu	= ---
w/o P	= 0.027	w/o Ni	= 0.76
w/o S	= 0.028	w/o Va	= ---
w/o Mn	= 1.20	w/o Al	= ---
w/o Cr	= 0.85	w/o B	= ---

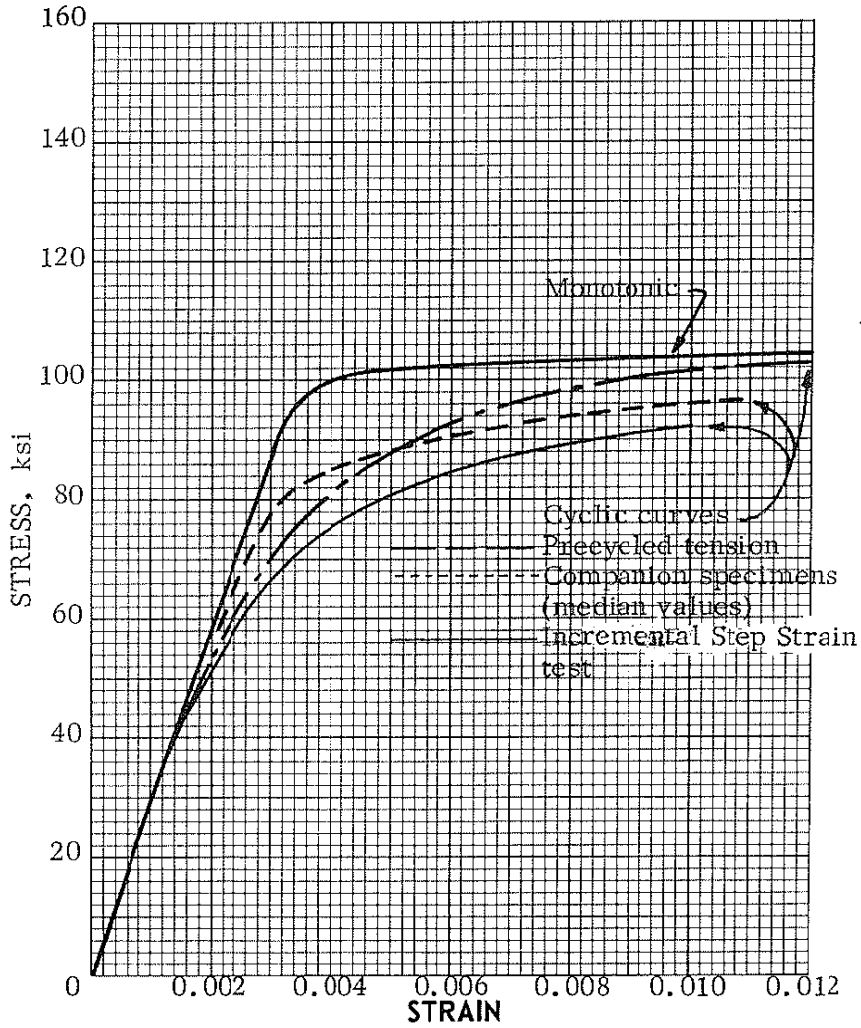
Grain Size: 8 ASTM

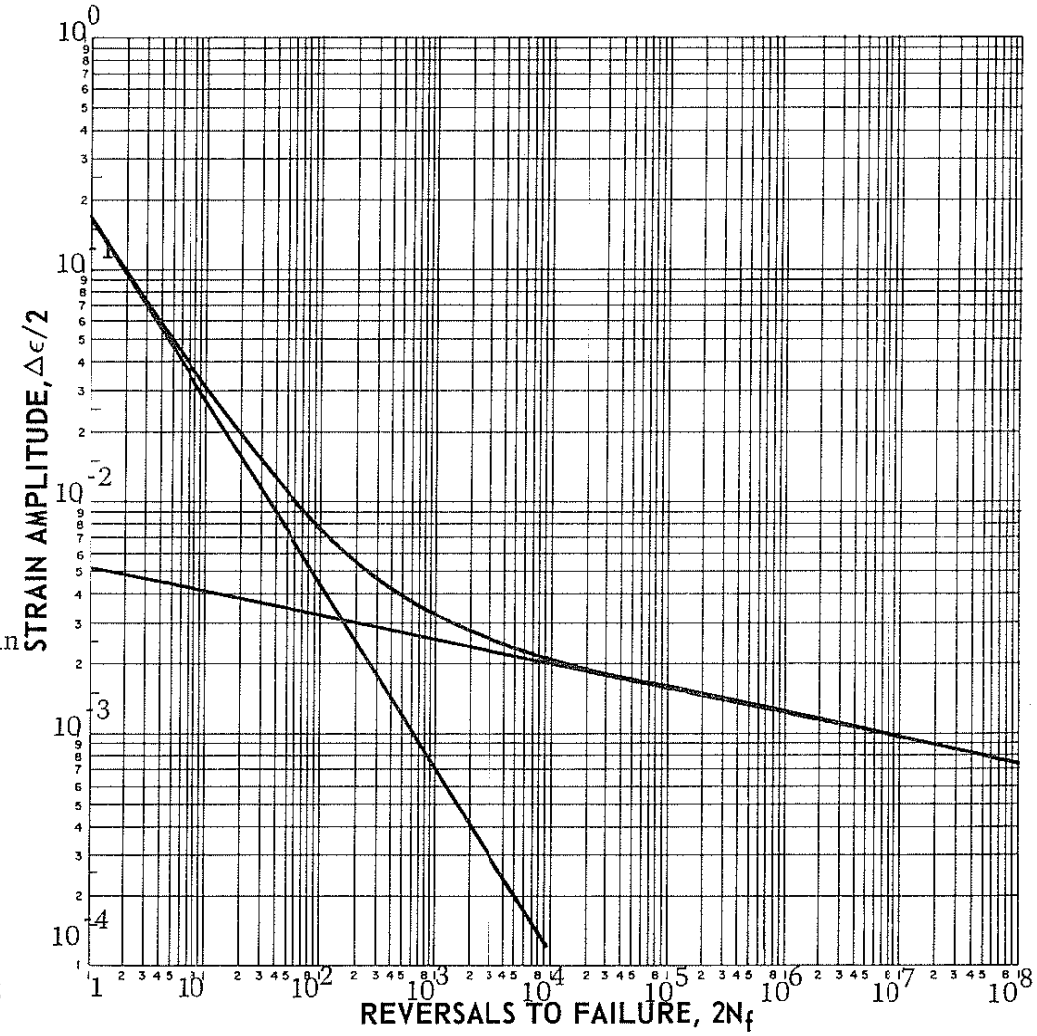
Eutectic Cell Size (Cast irons):

Comments: *from incremental step-strain test results
#determined by least square fit of log σ vs. log ϵ_p data from precycled tension test and companion specimen results
#*from incrementally precycled sample pulled in tension
**from least square analysis of companion specimen strain-life results.

Material: MPS Cast 8630 (Mn. modified) **Hardness:** 254 ± 5 BHN

Condition: Normalized & Tempered





FRACTURE CONTROL PROGRAM
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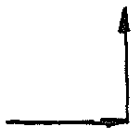
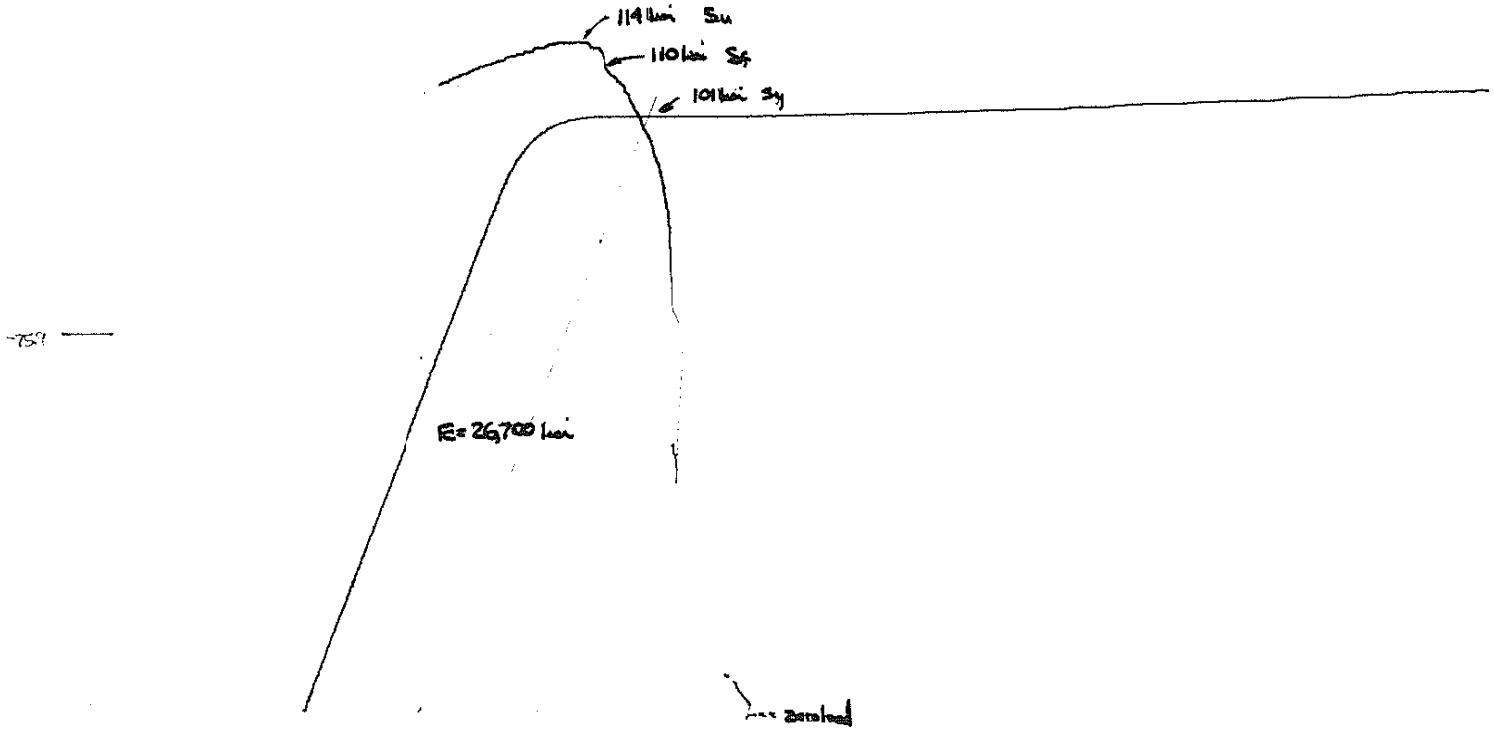
MONOTONIC STRESS-STRAIN RESULTS

MP-8630-*05


20ksi
0.002
0.020


114ksi Su
110ksi Sf
101ksi Sy
E= 26,700 ksi
Strain

```
**********************************************************************
********************** MP 8630 #05      **********************
**********************************************************************
```

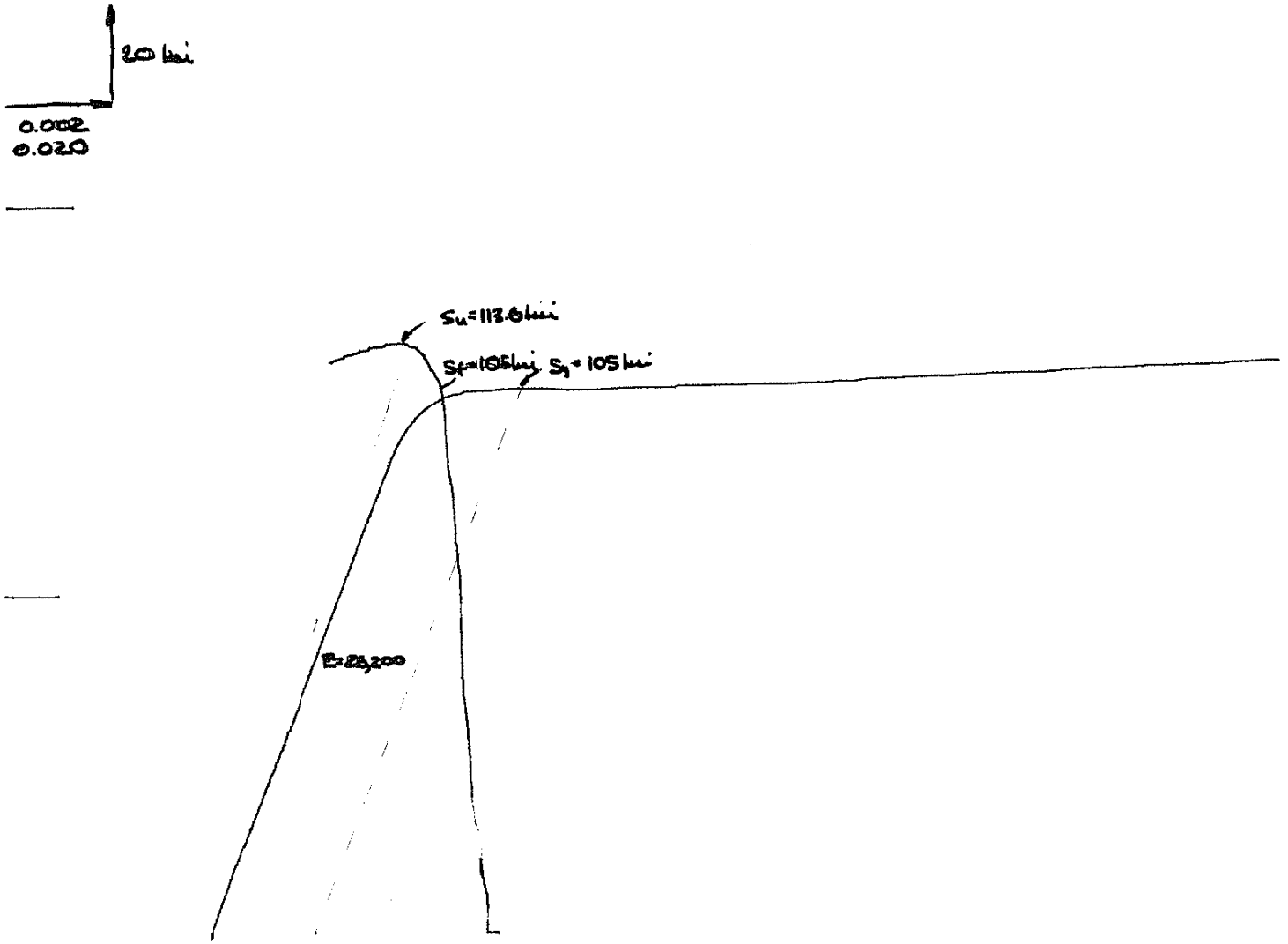
REF	TRUE STRESS	TRUE STRAIN	PL. TRUE STRAIN
1	20.0150	0.000749	0.000000
2	40.0596	0.001489	-0.000010
3	60.1338	0.002227	-0.000023
4	80.2399	0.002995	-0.000007
5	90.3050	0.003384	0.000005
6	95.3495	0.003673	0.000105
7	100.4339	0.004330	0.000572
8	101.6024	0.004957	0.001156
9	101.8046	0.006945	0.003136
10	102.3095	0.008929	0.005101
11	103.0177	0.010909	0.007055
12	103.8294	0.012887	0.009002
13	104.7449	0.014859	0.010940
14	105.8665	0.016827	0.012866
15	107.2975	0.018792	0.014777
16	109.2531	0.022709	0.018622
17	110.8047	0.025638	0.021492
18	112.9876	0.029529	0.025301
19	114.1431	0.032438	0.028167
20	115.8214	0.035338	0.031004
21	117.2997	0.038230	0.033841
22	118.2635	0.041112	0.036688
23	119.0220	0.043988	0.039534

```
********************** LEAST SQUARE FITS **************************

LEAST SQUARE FIT 1
******************

IS NORMAL FIT TO BE MADE?
?Y
INPUT REF #'S FOR FIT
?11,23
EXCLUSIONS
?N

*************************
* N( 1)=+8.9612840E-02 *
* K( 1)=+1.5772760E+02 *
*************************

PLOT?
?N
```

```
STRESS-STRAIN VALUE
?N
REPEAT LEAST SQUARE FIT?
?N


INPUT INIT & FINAL AREA
?.1093,.0899
INPUT DIV & SCALE OF STRESS -LAST POINT
?105,1
YIELD PTS. FROM LST SQ FITS
?N



**********************************************************************
* ELASTIC MODULUS                          =     2.67E+04   KSI     *
* ULTIMATE STRENGTH                        =   113.90       KSI     *
* TRUE FRACTURE DUCTILITY                  =     0.20       IN/IN   *
* TRUE FRACTURE STRENGTH (UNCORRECTED)     =   127.66       KSI     *
* TRUE FRACTURE STRENGTH (CORRECTED)       =   124.24       KSI     *
* PER CENT REDUCTION IN AREA               =    17.75       %       *
**********************************************************************

   1.98 SEC       0.09 SERVICE UNITS
```

MP-8630*12B

DFD 7/27/74

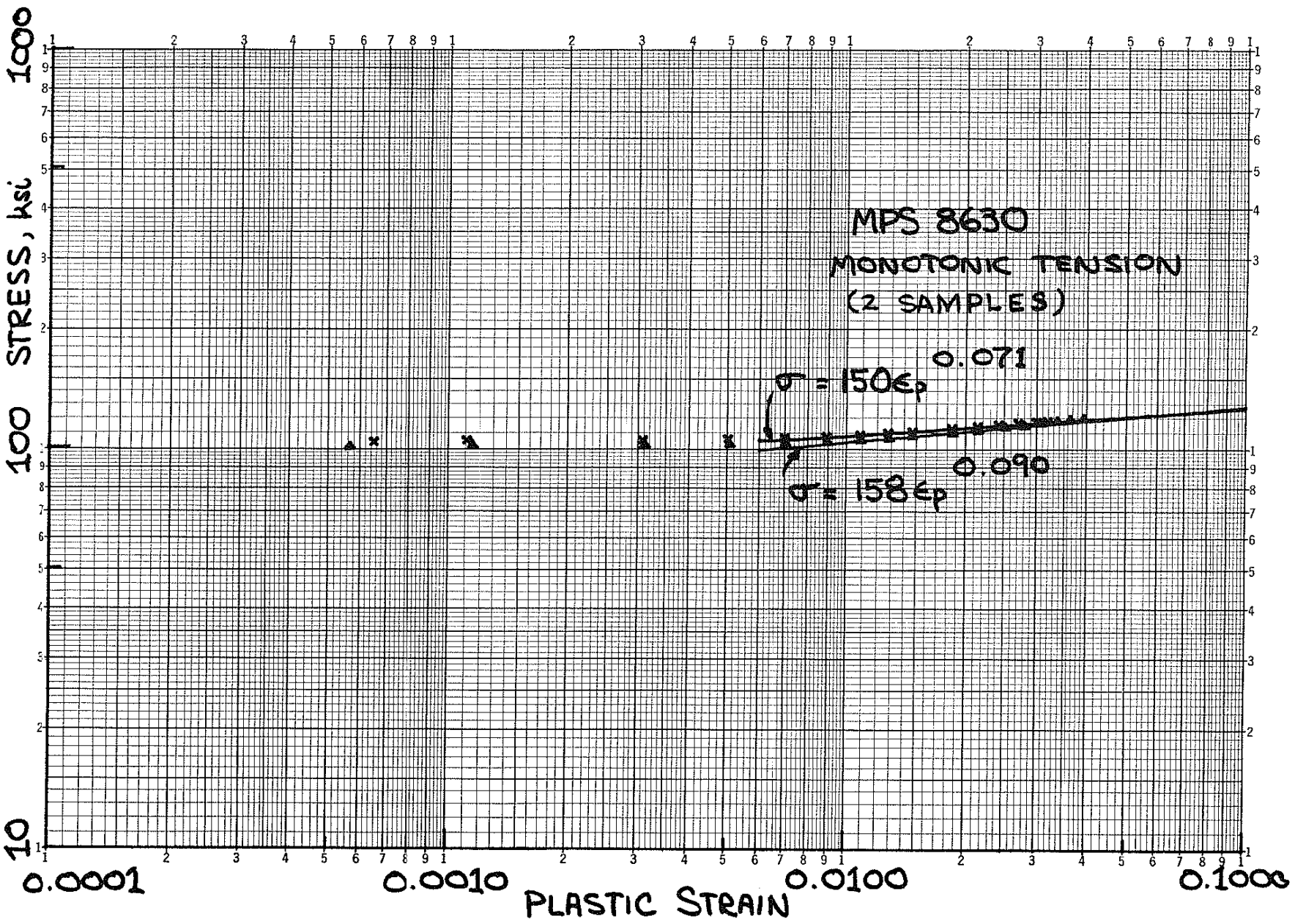


```
**********************************************************************
********************** MP 8630 #12B      **********************
**********************************************************************
```

REF	TRUE STRESS	TRUE STRAIN	PL. TRUE STRAIN
1	20.0144	0.000719	-0.000026
2	40.0596	0.001489	-0.000002
3	60.1344	0.002237	-0.000001
4	80.2399	0.002995	0.000010
5	95.3429	0.003603	0.000056
6	100.4000	0.003992	0.000256
7	103.6643	0.004489	0.000633
8	104.7209	0.004987	0.001091
9	105.0301	0.006976	0.003068
10	105.9450	0.008960	0.005018
11	106.3572	0.010940	0.006983
12	107.4792	0.012916	0.008917
13	108.6049	0.014888	0.010847
14	109.7342	0.016856	0.012774
15	110.5614	0.018821	0.014707
16	112.6323	0.022739	0.018549
17	114.0911	0.025667	0.021422
18	115.3508	0.028587	0.024295
19	116.4095	0.031498	0.027167
20	117.3690	0.034401	0.030035
21	117.8032	0.036332	0.031949

```
********************** LEAST SQUARE FITS **************************

LEAST SQUARE FIT 1
******************

IS NORMAL FIT TO BE MADE?
?Y
INPUT REF #'S FOR FIT
?11,21
EXCLUSIONS
?N

************************
* N( 1)=+7.0496500E-02 *
* K( 1)=+1.4978260E+02 *
************************

PLOT?
?N
STRESS-STRAIN VALUE
?N
REPEAT LEAST SQUARE FIT?
?N
```

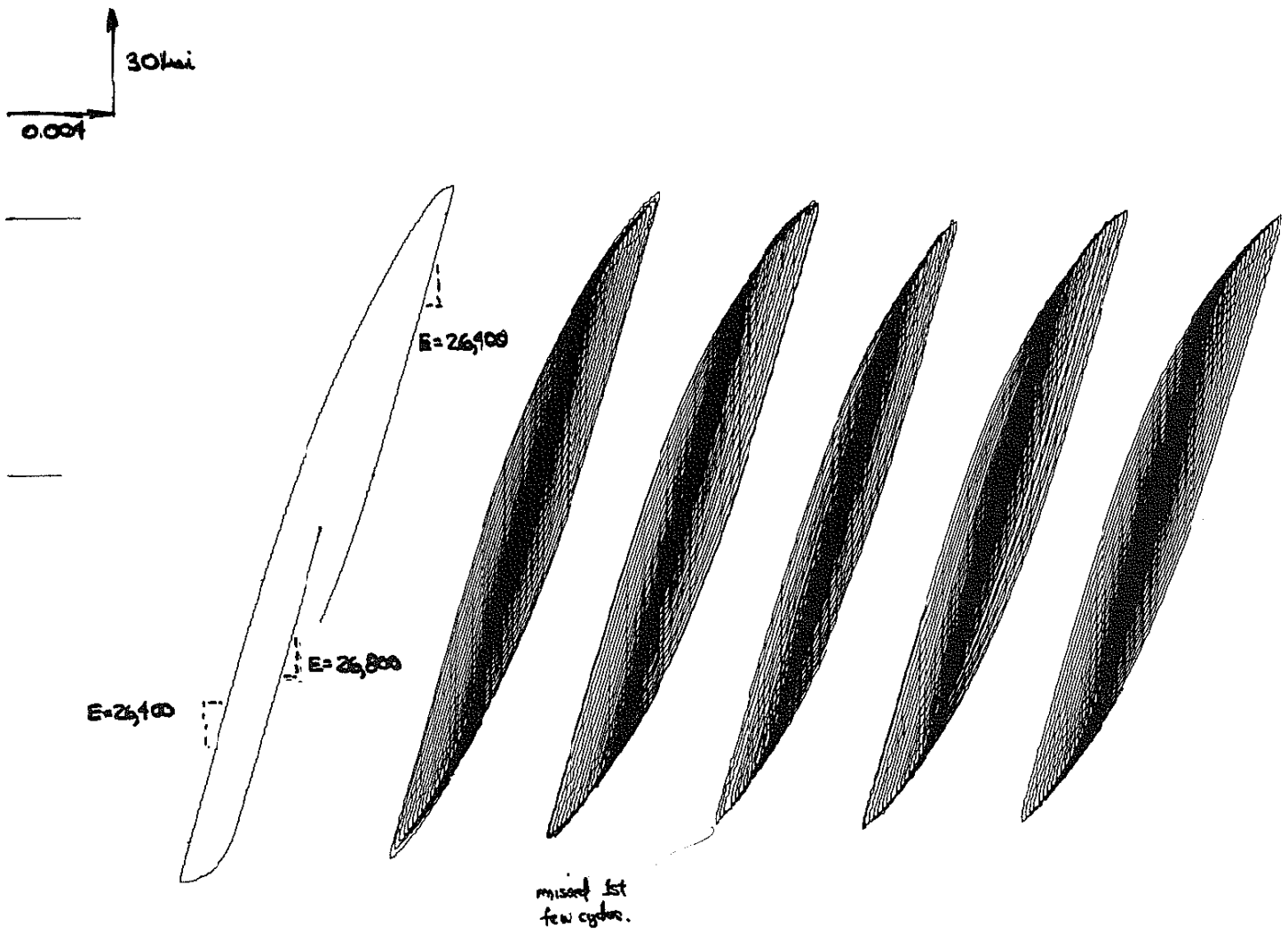
```
INPUT INIT & FINAL AREA
?.1110,.0952
INPUT DIV & SCALE OF STRESS -LAST POINT
?105,1
YIELD PTS. FROM LST SQ FITS
?N


**********************************************************************
* ELASTIC MODULUS                              =     2.69E+04  KSI   *
* ULTIMATE STRENGTH                            =    113.60     KSI   *
* TRUE FRACTURE DUCTILITY                      =      0.15     IN/IN*
* TRUE FRACTURE STRENGTH (UNCORRECTED)         =    122.43     KSI   *
* TRUE FRACTURE STRENGTH (CORRECTED)           =    120.24     KSI   *
* PER CENT REDUCTION IN AREA                   =     14.23     %     *
**********************************************************************

   2.12 SEC       0.09 SERVICE UNITS
```


MPS 8630
MONOTONIC TENSION
(2 SAMPLES)
σ = 150ε_p^0.071
σ = 158ε_p^0.090
STRESS, ksi
1000
100
10
0.0001
0.0010
0.0100
0.1000
PLASTIC STRAIN

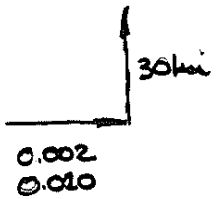
CYCLIC STRESS-STRAIN RESULTS

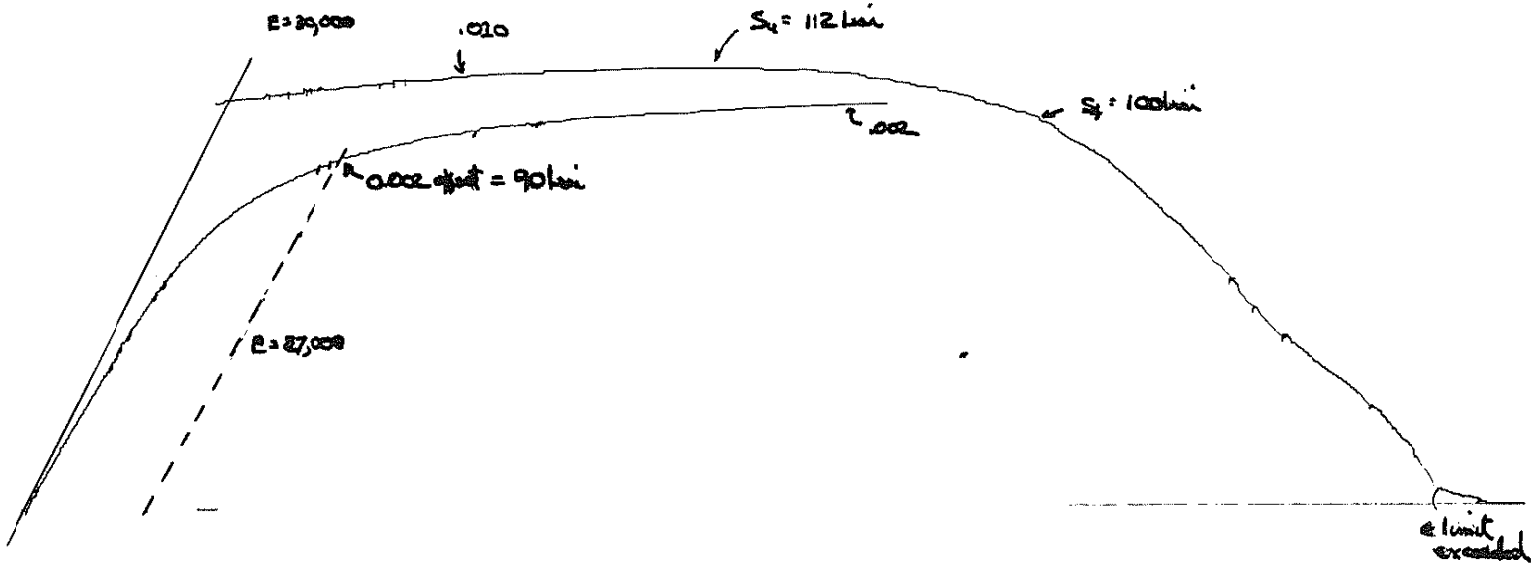
MP 8630 #02

DFD 8/01/74



MP-8630 #02 PRECYCLED TENSION





```
**************************************************************************
********************** MP #02 PRECYCLED **************************
**************************************************************************
```

REF	TRUE STRESS	TRUE STRAIN	PL. TRUE STRAIN
1	15.0081	0.000540	-0.000016
2	30.0336	0.001119	0.000007
3	45.0778	0.001728	0.000059
4	60.1440	0.002397	0.000169
5	68.4492	0.002915	0.000380
6	75.1060	0.003414	0.000632
7	80.4139	0.003912	0.000934
8	84.3712	0.004410	0.001285
9	87.4279	0.004907	0.001669
10	90.3369	0.005405	0.002059
11	92.3434	0.005902	0.002482
12	95.6070	0.006896	0.003355
13	98.2721	0.007888	0.004248
14	99.8830	0.008880	0.005181
15	101.1939	0.009870	0.006122
16	103.0640	0.011849	0.008032
17	104.6365	0.013824	0.009948
18	105.7087	0.016778	0.012862
19	107.0915	0.019724	0.015757
20	109.6151	0.024614	0.020554
21	111.5403	0.029481	0.025350
22	113.3237	0.034324	0.030127
23	115.4311	0.039144	0.034868
24	116.7698	0.043940	0.039615
25	117.8009	0.048713	0.044350
26	118.6784	0.053464	0.049069

```
********************** LEAST SQUARE FITS ************************

LEAST SQUARE FIT 1
******************

IS NORMAL FIT TO BE MADE?
?Y
INPUT REF #'S FOR FIT
?8,26
EXCLUSIONS
?N

************************
* N( 1)=+8.6323800E-02 *
* K( 1)=+1.5444480E+02 *
************************

PLOT?
?N
```

```
STRESS-STRAIN VALUE
?N
REPEAT LEAST SQUARE FIT?
?N


INPUT INIT & FINAL AREA
?.1109,.0936
INPUT DIV & SCALE OF STRESS -LAST POINT
?100,1


YIELD PTS. FROM LST SQ FITS
?N



**********************************************************************
* ELASTIC MODULUS                          =     2.70E+04  KSI     *
* ULTIMATE STRENGTH                        =   112.50      KSI     *
* TRUE FRACTURE DUCTILITY                  =     0.17      IN/IN   *
* TRUE FRACTURE STRENGTH (UNCORRECTED)     =   118.48      KSI     *
* TRUE FRACTURE STRENGTH (CORRECTED)       =   115.96      KSI     *
* PER CENT REDUCTION IN AREA               =    15.60      %       *
**********************************************************************

   2.38 SEC       0.10 SERVICE UNITS
```

MP-8630 #08

DFD 7/31/74

30 ksi

0.004

1 dec.

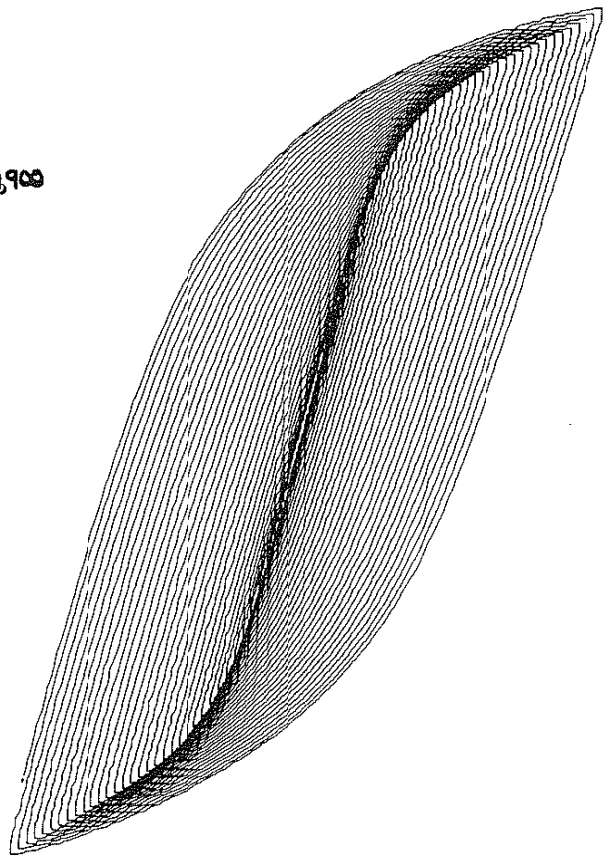
0

-74.8 ksi

E = 24,900

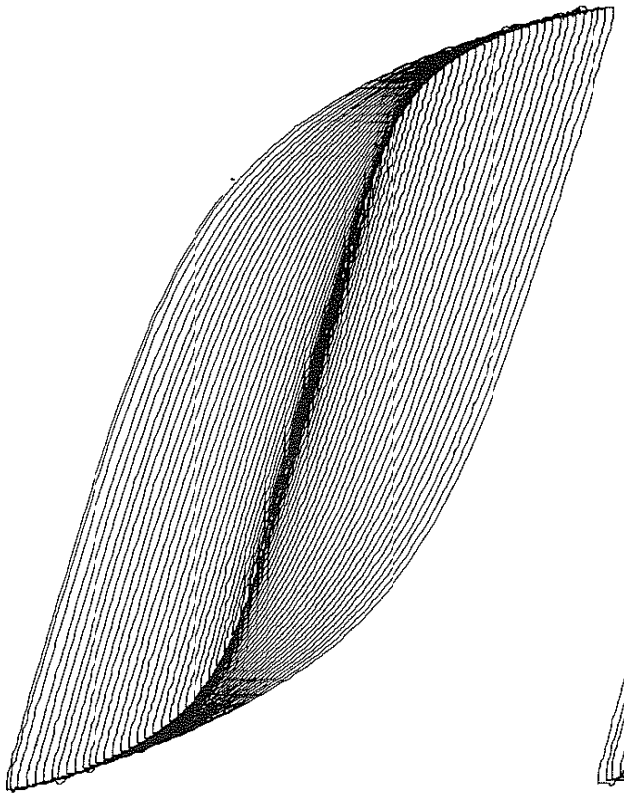
E = 28,900

E = 26,500



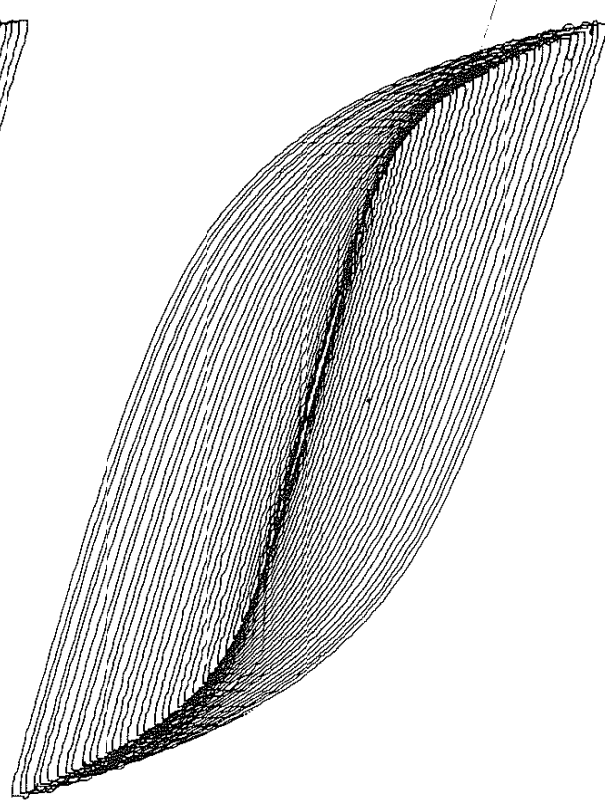
MP-8630 #09

1 inc.



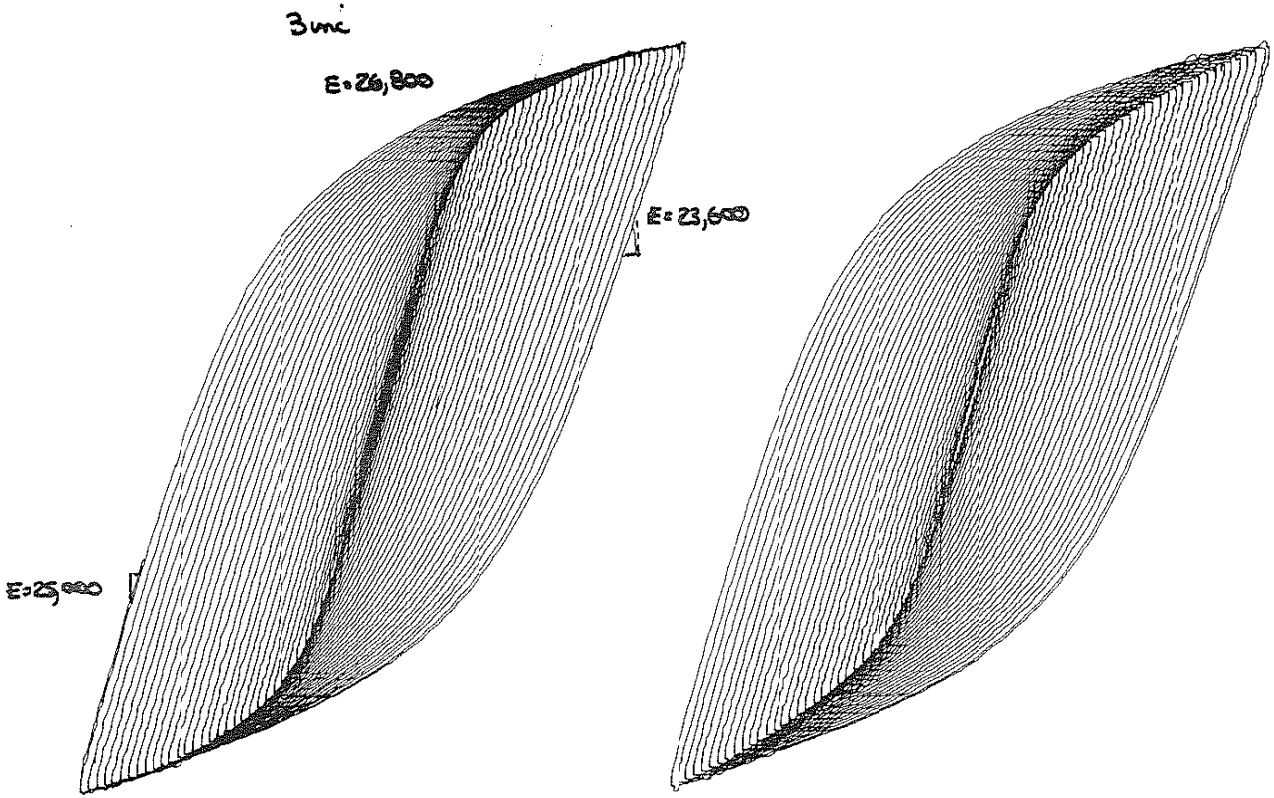
2 dec

0.002 offset = 82 psi

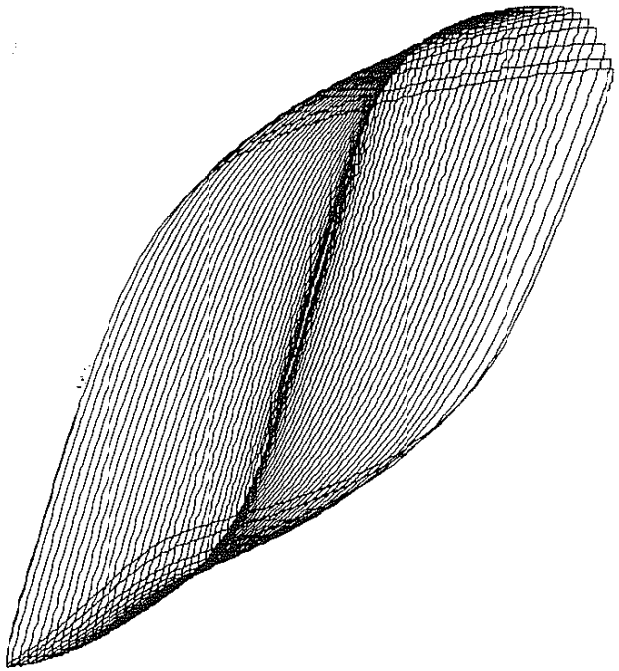


0.002 d/ft = 80 bar

3 dec. (gradering)



3 in.



```
**********************************************************************
 ********************** MP 8630 I.S. #08 **********************
**********************************************************************
```

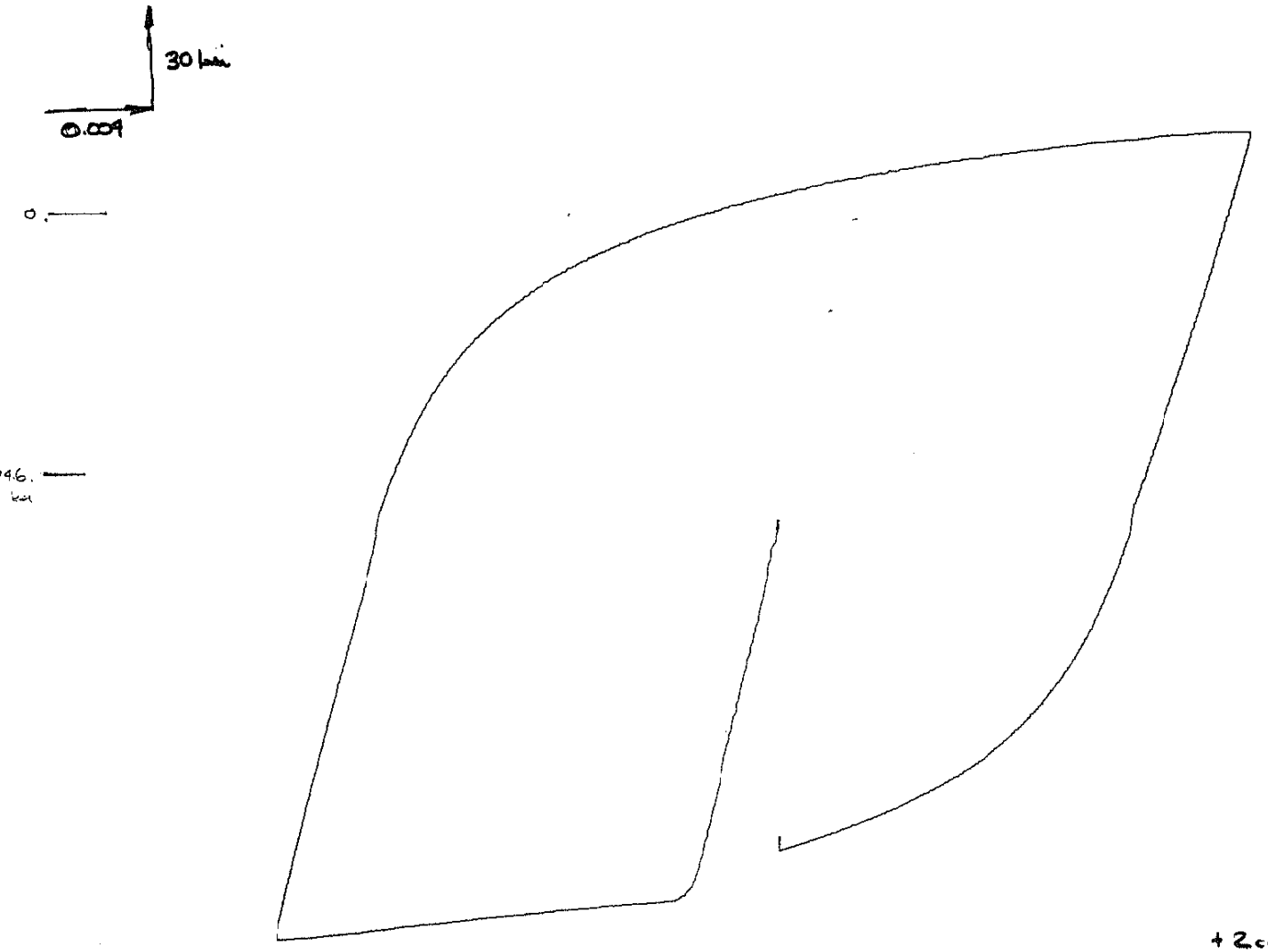
REF	AV EP	AV SG	AV PEP	AV PEP(EQ)
1	0.002090	52.0504	0.000160	0.000148
2	0.002340	57.1495	0.000240	0.000207
3	0.002600	60.7519	0.000340	0.000333
4	0.002880	64.7239	0.000460	0.000465
5	0.003130	68.0236	0.000610	0.000592
6	0.003410	70.1965	0.000780	0.000791
7	0.003700	72.3712	0.000940	0.000999
8	0.003960	74.4711	0.001130	0.001181
9	0.004240	76.2719	0.001330	0.001394
10	0.004470	77.8434	0.001520	0.001565
11	0.004750	79.3423	0.001710	0.001790
12	0.005290	81.8182	0.002140	0.002237
13	0.005810	83.9871	0.002560	0.002676
14	0.006371	86.1591	0.003000	0.003156
15	0.006900	88.1098	0.003450	0.003613
16	0.007441	89.6032	0.003930	0.004097
17	0.007980	90.9515	0.004400	0.004587
18	0.008540	92.2234	0.004850	0.005099
19	0.009041	93.4184	0.005340	0.005555
20	0.009571	94.2414	0.005830	0.006054
21	0.010131	95.0644	0.006301	0.006584

```
********************** LEAST SQUARE FITS **********************

LEAST SQUARE FIT 1
******************

IS NORMAL FIT TO BE MADE?
?Y
INPUT REF #'S FOR FIT
?8,21
EXCLUSIONS
?N

************************
* N(1)=+1.4395340E-01 *
* K(1)=+1.9708840E+02 *
************************

DO YOU WANT A PLOT MADE OF THIS?
?N
STRESS-STRAIN VALUE
?N
REPEAT LEAST SQUARE FIT?
?Y
```

```
LEAST SQUARE FIT 2
******************

IS NORMAL FIT TO BE MADE?
?N
INPUT 1 OR 2
***LOGLOG OR LINEAR
?1
***ENG. OR TRUE
?2
***TOTAL OR PLASTIC STRAIN
?2
***PLASTIC STRAIN FROM EQN. OR LOOPS
?2
INPUT REF #'S FOR FIT
?8,21
EXCLUSIONS
?N


************************
* N(2)=+1.4394460E-01 *
* K(2)=+1.9831730E+02 *
************************

DO YOU WANT A PLOT MADE OF THIS?
?N
STRESS-STRAIN VALUE
?N
REPEAT LEAST SQUARE FIT?
?N

   2.33 SEC        0.10 SERVICE UNITS
```

MP-8630 #09

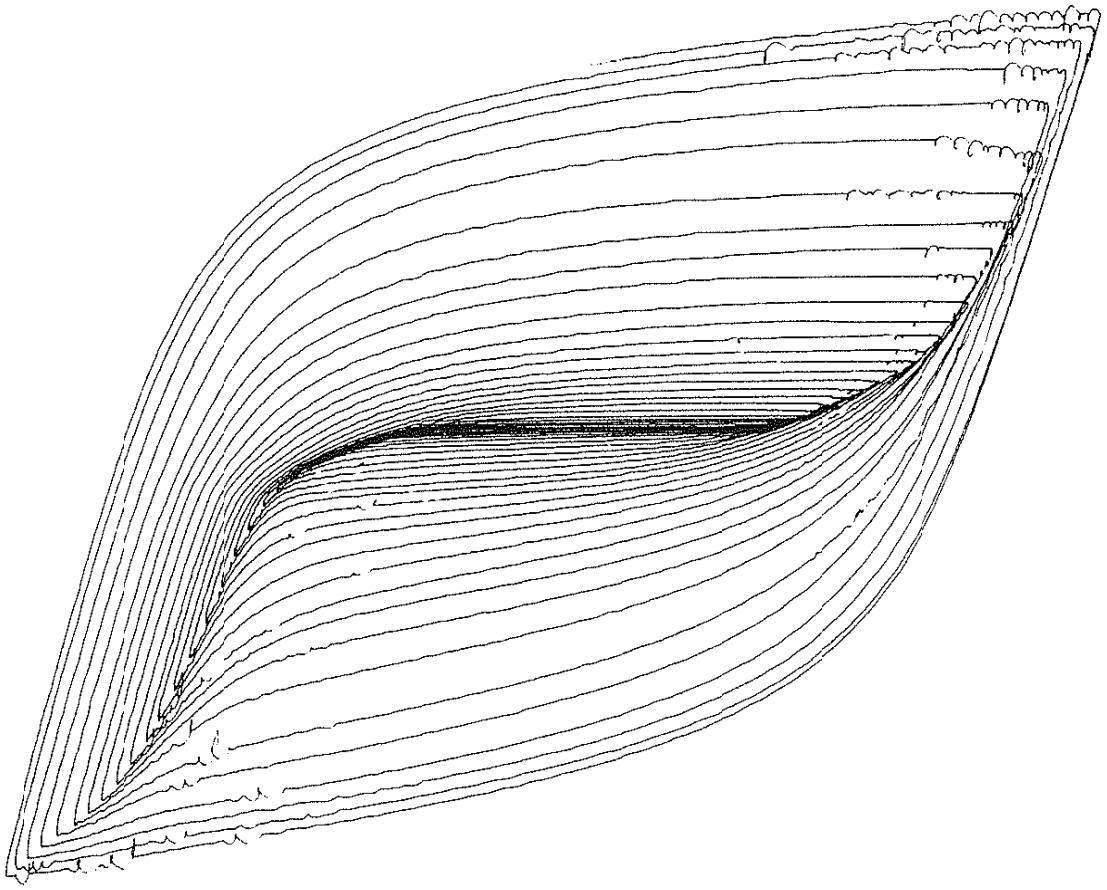
DFD 7/28/74



+ 2 cycles at same ε amplitude

MP-863-#09

2 OF 2

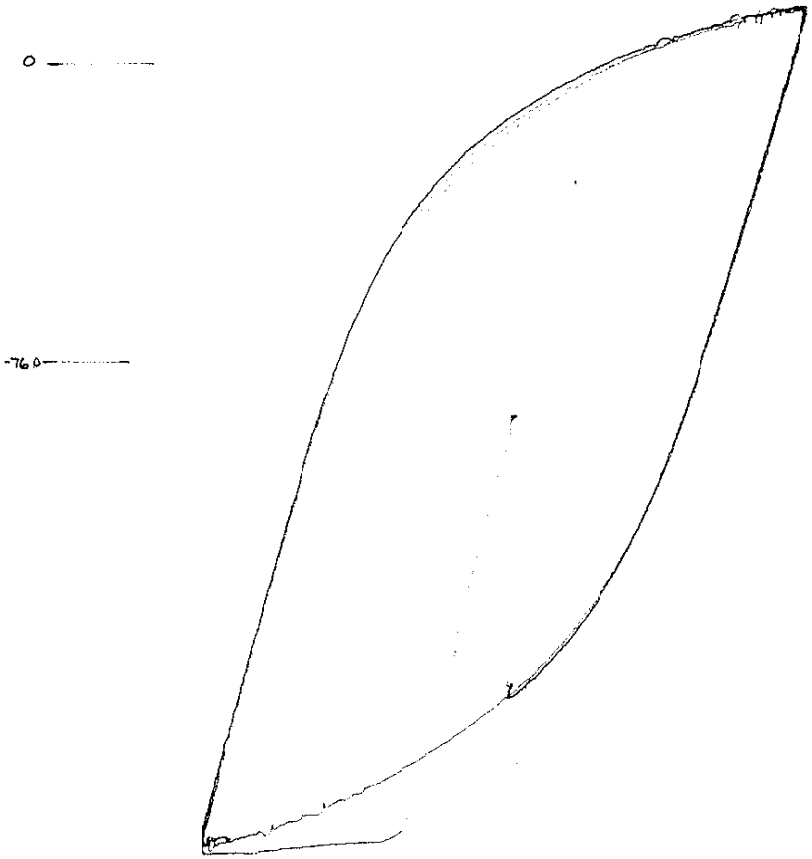


MP-8650 #23

30 ksi

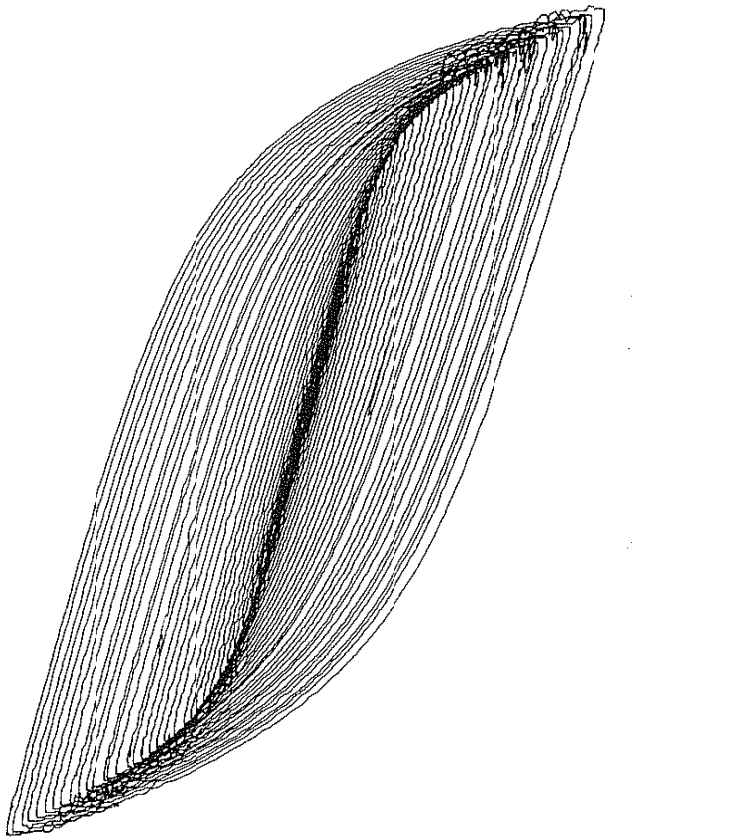
0.004

DFD 7/31/74



1 dec

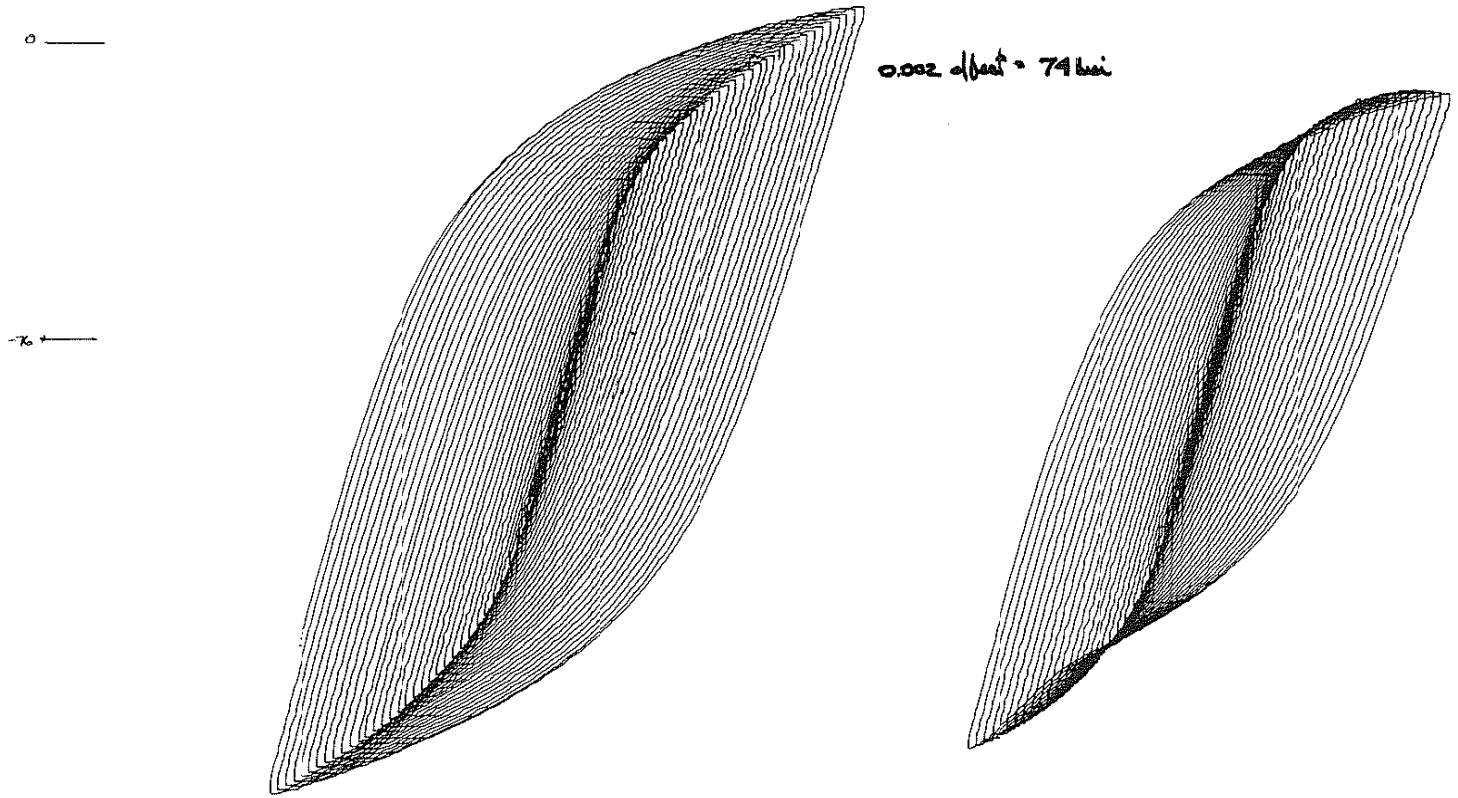
0.002 div = 87 ksi

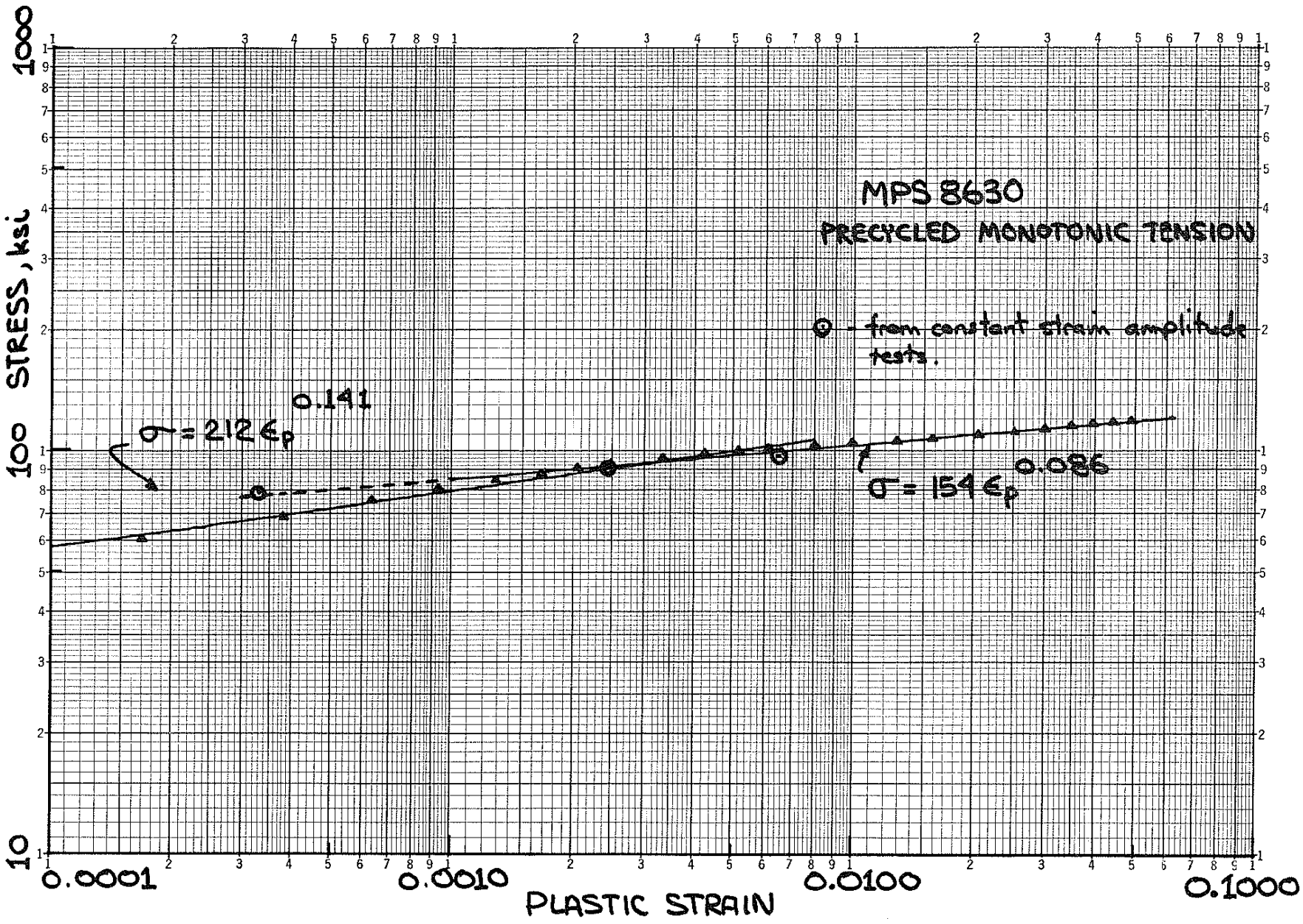


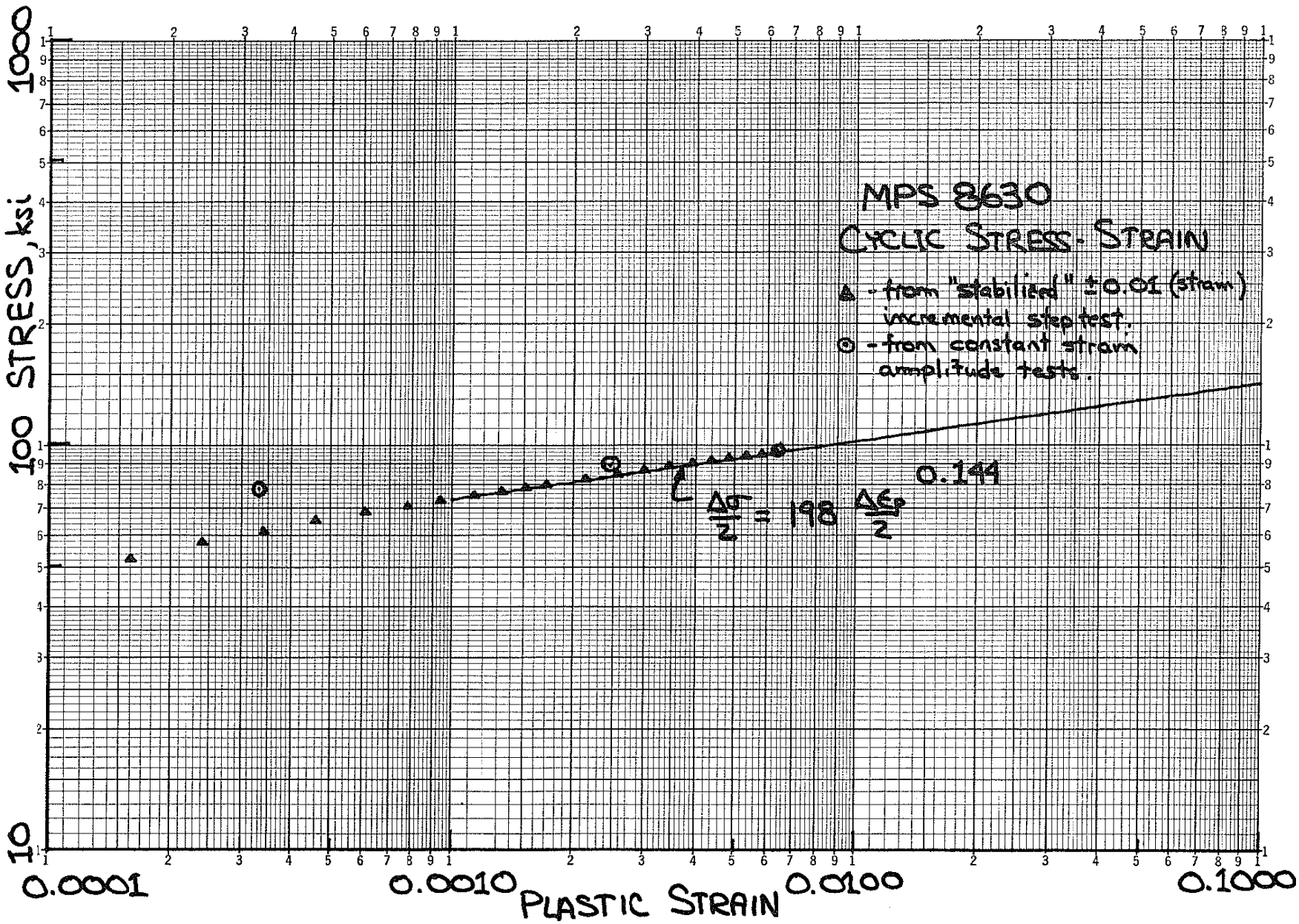
MP-830 #25

2 dia

2 inc. (cracking)



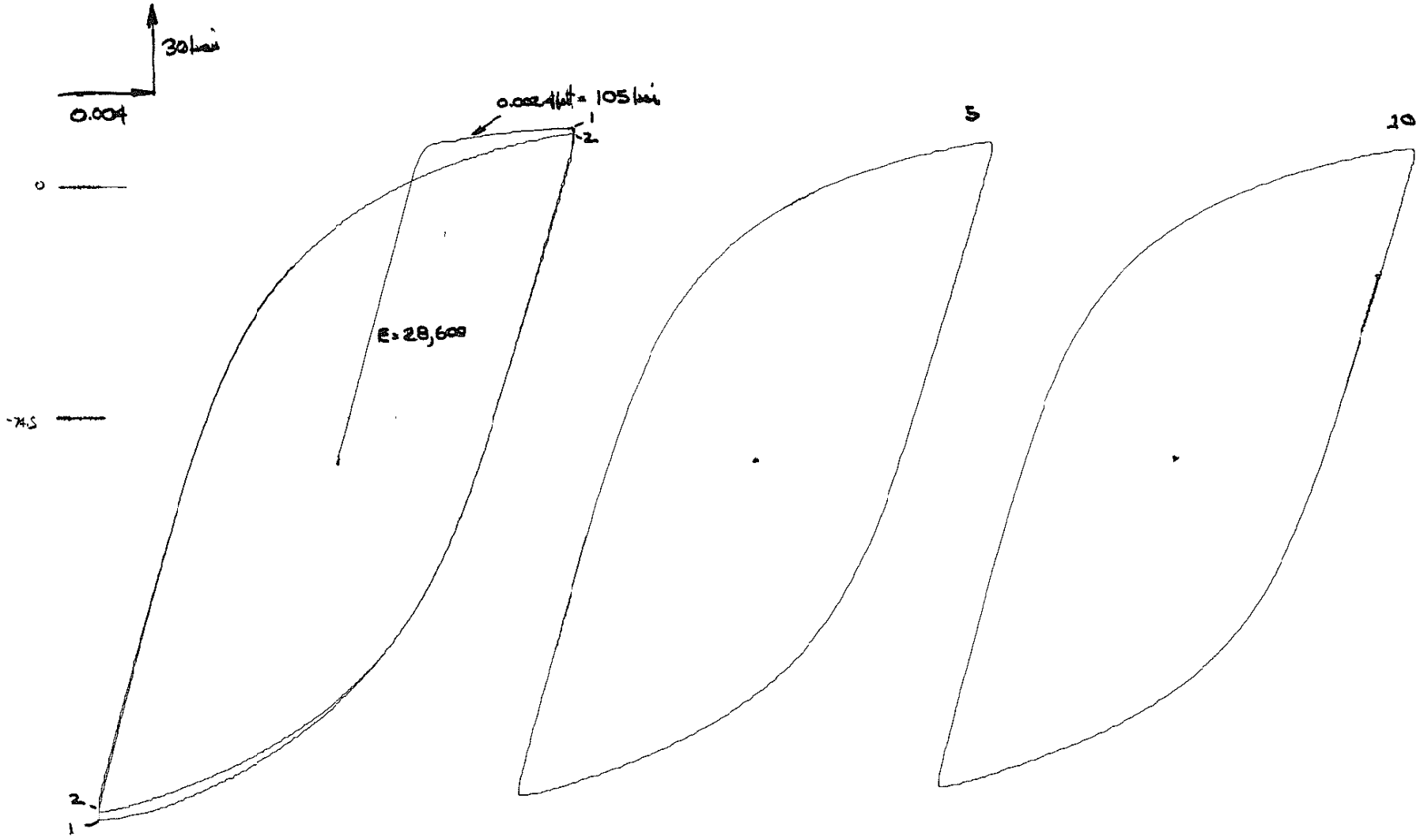

MPS 8630
PRECYCLED MONOTONIC TENSION
⊙ - from constant strain amplitude tests.
σ = 212 ε_p^0.141
σ = 154 ε_p^0.086
STRESS, ksi
PLASTIC STRAIN
1000
100
10
0.0001
0.0010
0.0100
0.1000


MPS 8630
CYCLIC STRESS-STRAIN
▲ - from "stabilized" ±0.01 (strain) incremental step test.
⊙ - from constant strain amplitude tests.
$\frac{\Delta\sigma}{2} = 198 \left(\frac{\Delta\varepsilon_p}{2}\right)^{0.144}$
100 STRESS, ksi
1000
10
0.0001
0.0010
0.0100
0.1000
PLASTIC STRAIN

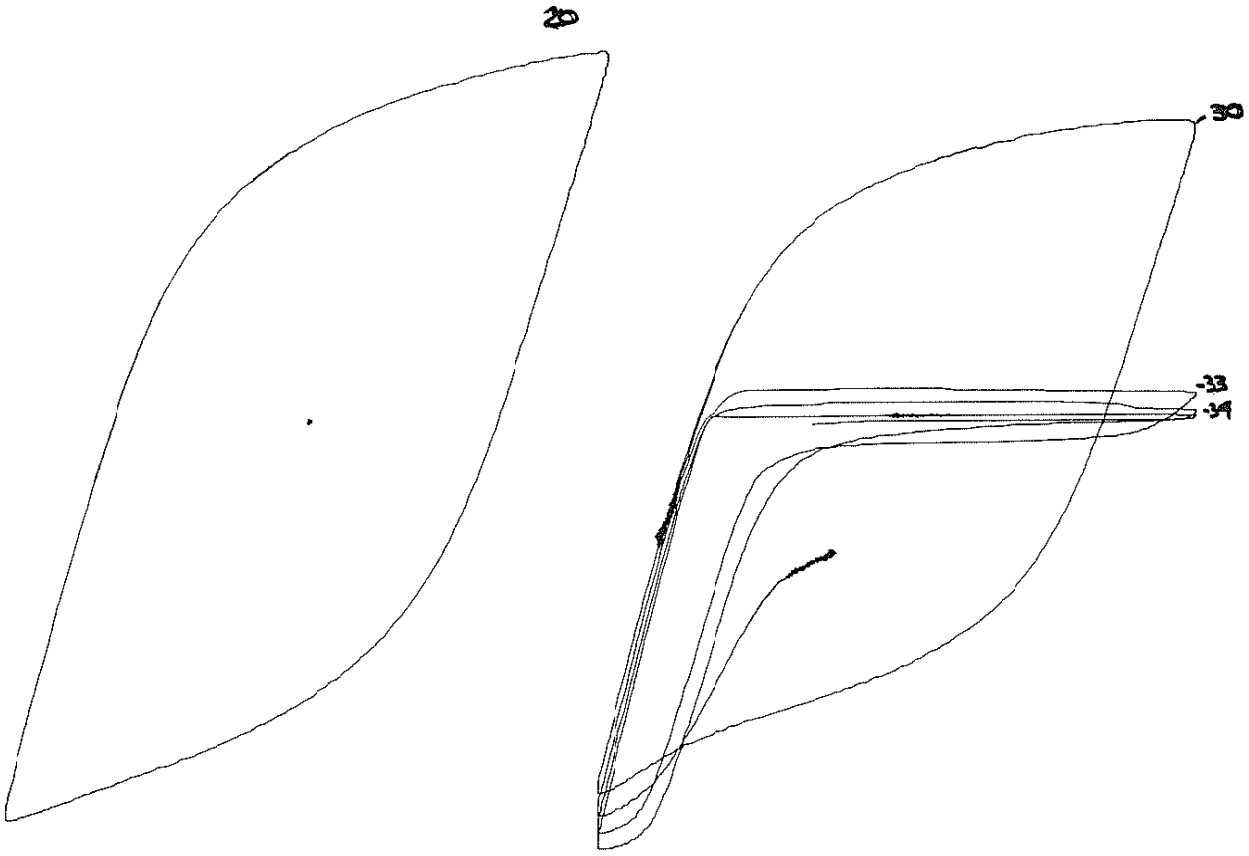
STRESS-STRAIN HYSTERESIS LOOPS FROM CONTROLLED STRAIN FATIGUE TESTS

MP 8630 # 19 No Pre.

DFD 8/06/74



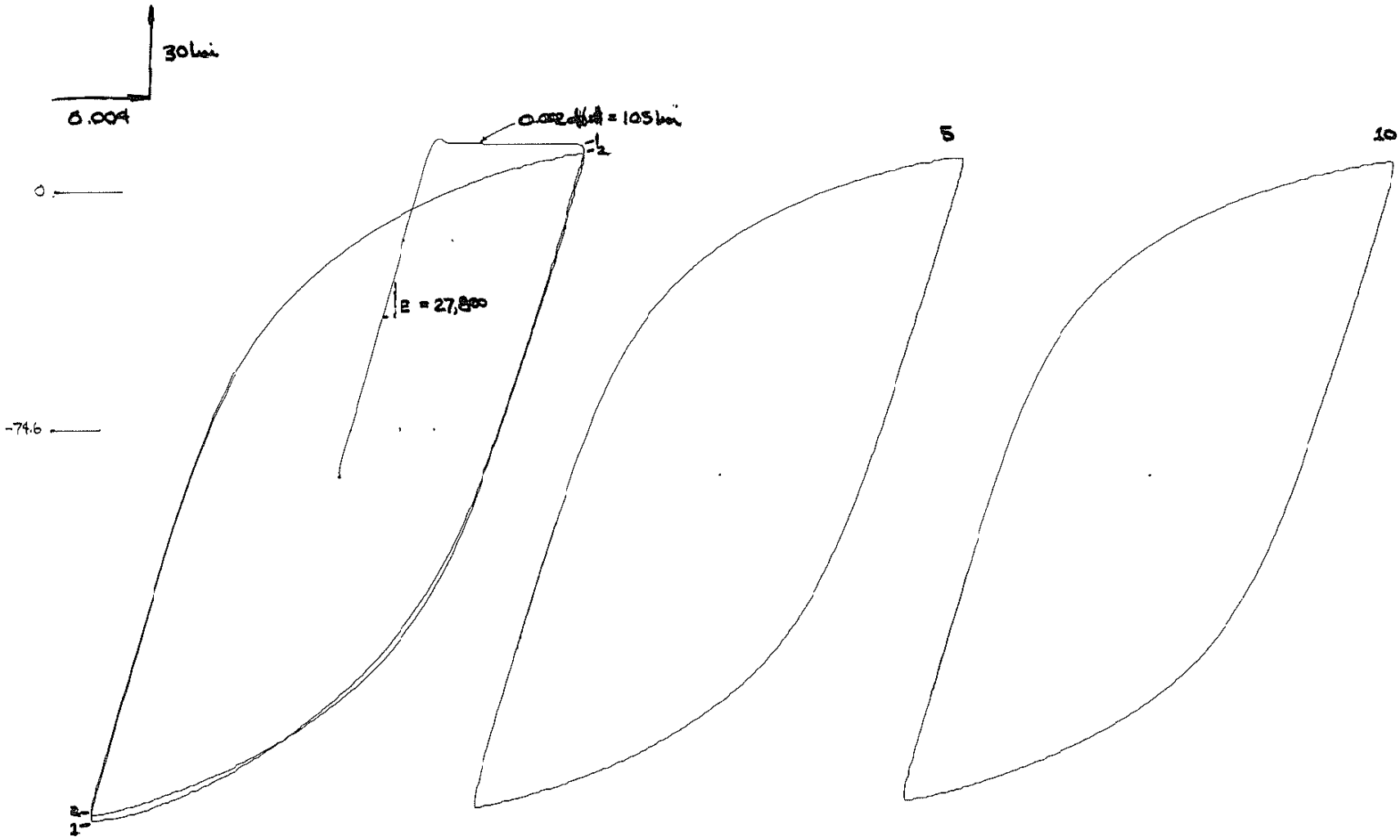
MP 8630 # 19



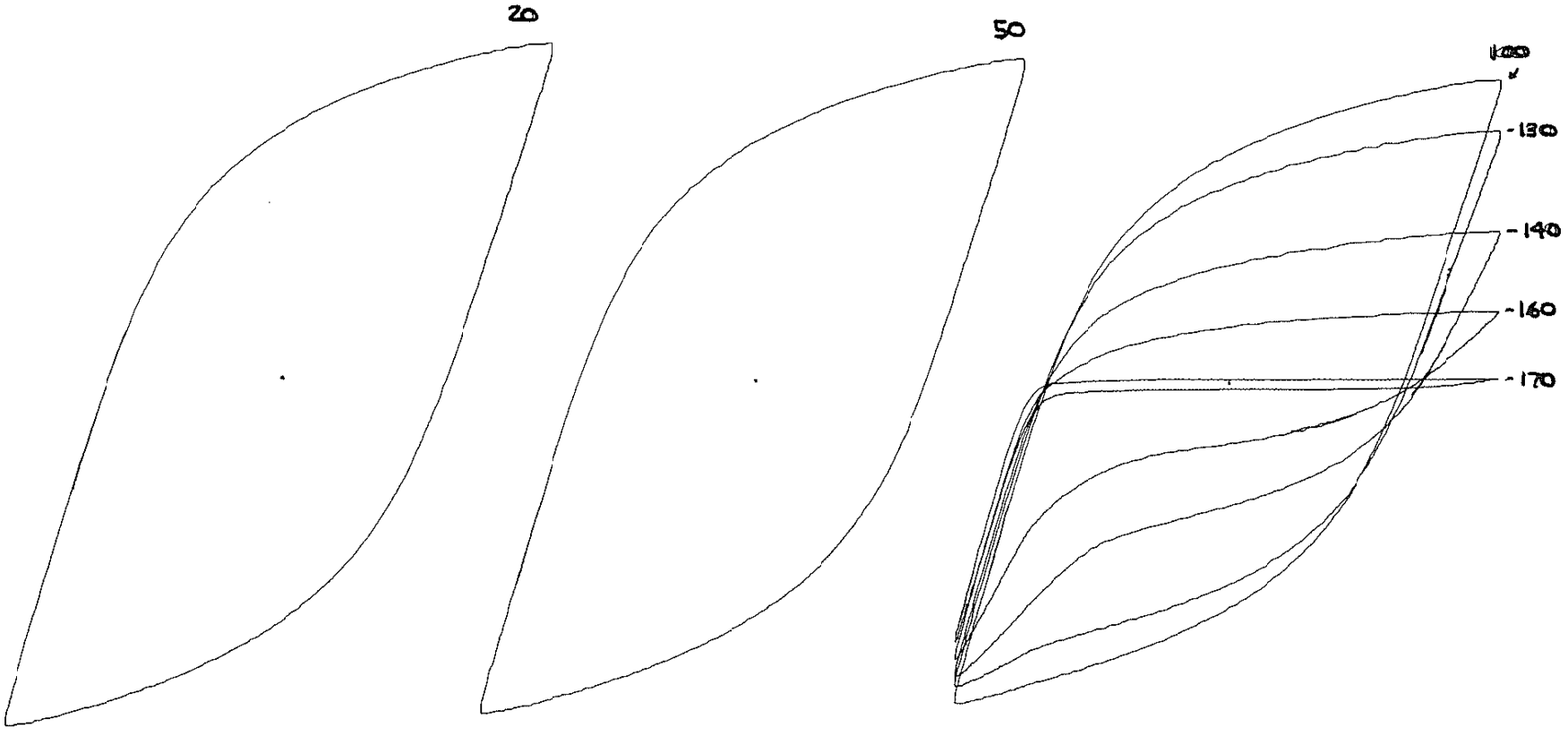
$N_1 = 30$

```
**********************************************************************
******************** MP 8630 #19          ************************
******************** NO PRE.              ************************
**********************************************************************
OUTPUT IN ENG. VALUES
?N
OUTPUT IN TRUE VALUES
?Y


PEAKS
?N
RANGES(R) OR AMPLITUDES(A) OR BOTH(B) OR NONE(N)
?A


TRUE STRESS & STRAIN AMPLITUDES & MEANS
  N      REV          E         S          EP          E0        S0
  1        2     .010200    111.1     .006221    -.000052    -1.7
  2        4     .010200    108.9     .006221    -.000052    -1.4
  3       10     .010140    104.8     .006231    -.000052    -1.0
  4       20     .010170    102.1     .006351    -.000042    -1.7
  5       40     .010201     97.3     .006551    -.000192    -2.5


PLOT?
?N
```

MP 8630* 32A No. Pcs. DFD 8/02/74 1 OF 2



MP 8630 #32A

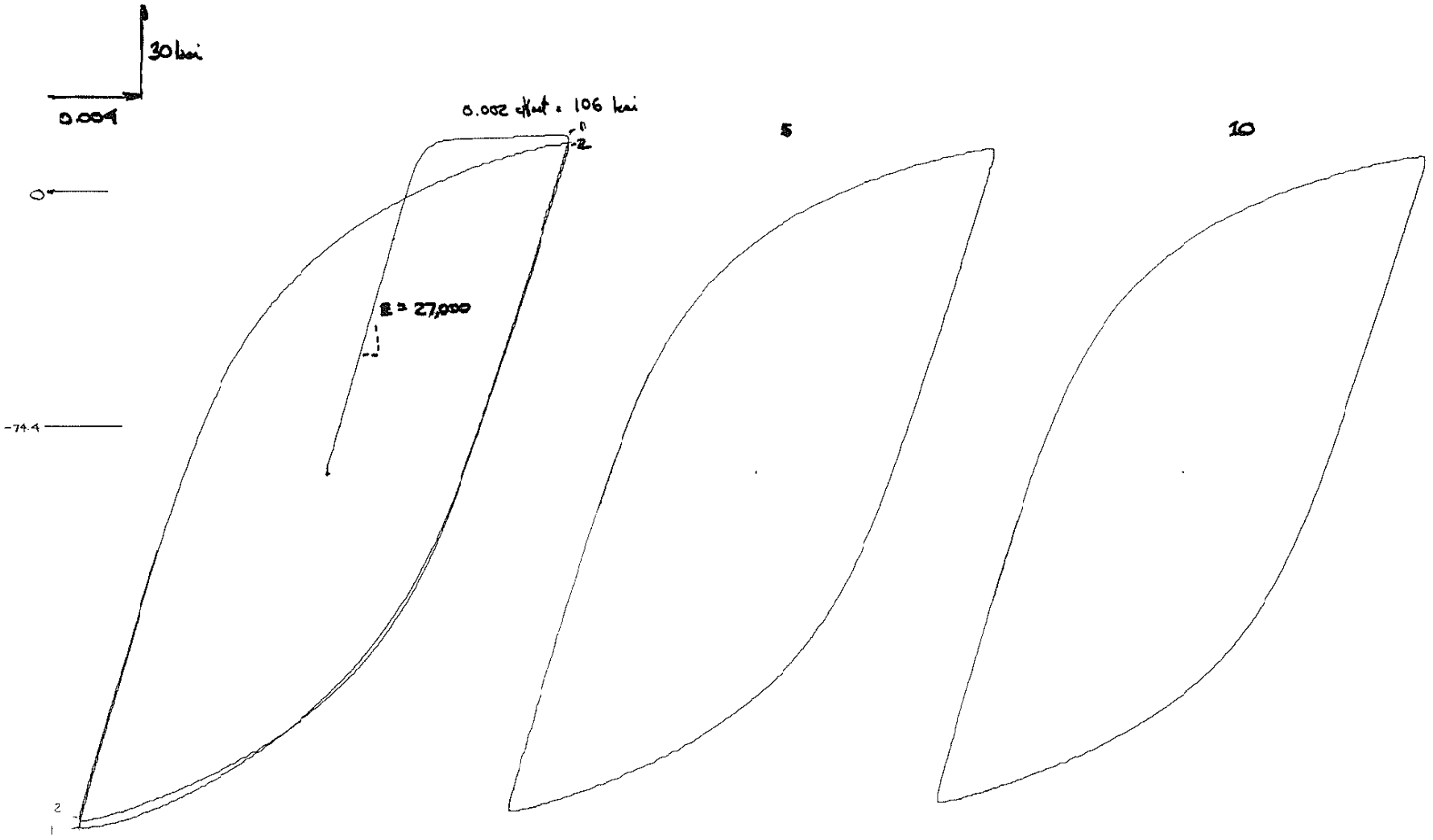


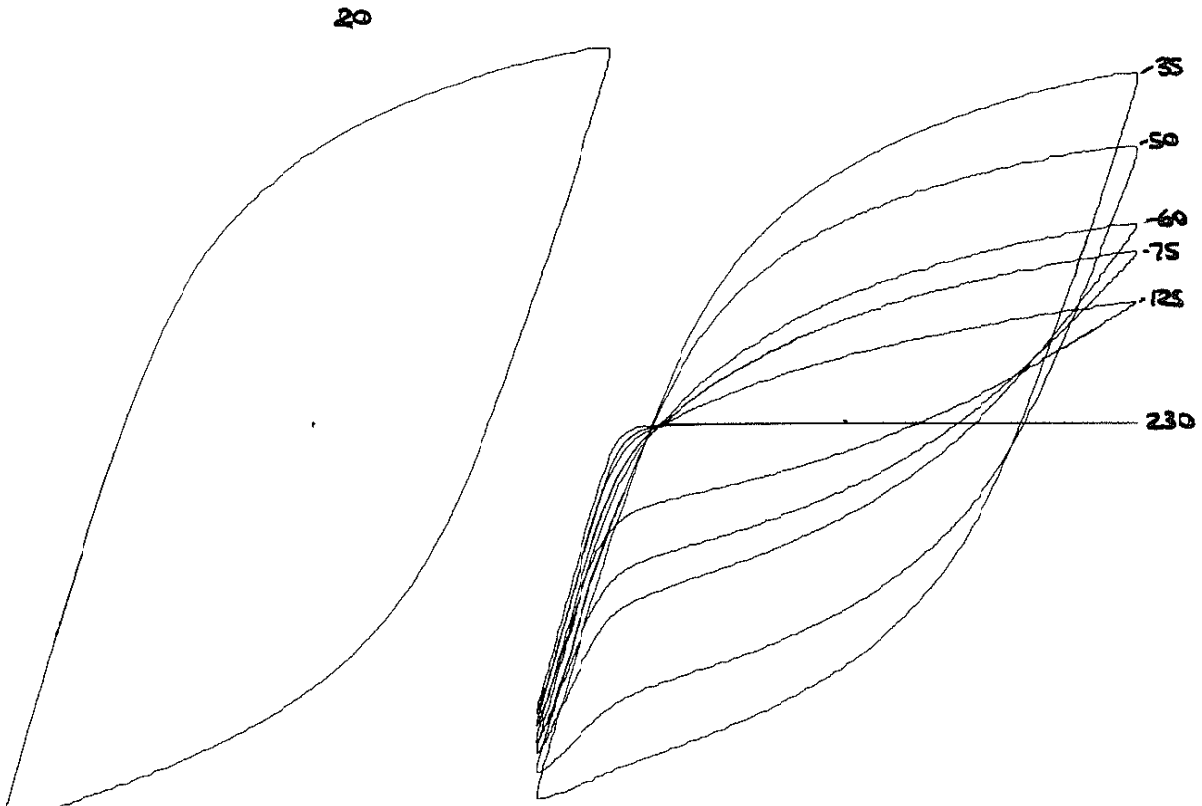
N_f = 130

* 20% drop in tensile peak

```
**********************************************************************
****************** MP 8630 #32A        **********************
****************** NO PRE.             **********************
**********************************************************************
OUTPUT IN ENG. VALUES
?N
OUTPUT IN TRUE VALUES
?Y


PEAKS
?N
RANGES(R) OR AMPLITUDES(A) OR BOTH(B) OR NONE(N)
?A


TRUE STRESS & STRAIN AMPLITUDES & MEANS
  N      REV          E         S          EP          E0        S0
  1        2     .010210     106.5     .006120    -.000062     -0.4
  2        4     .010210     104.1     .006140    -.000062     -1.0
  3       10     .010151     102.0     .006161    -.000122     -0.8
  4       20     .010141     100.0     .006271    -.000112     -0.8
  5       40     .010181      97.6     .006391    -.000112     -0.6
  6      100     .010151      93.3     .006550    -.000102     -0.4
  7      200     .010161      89.0     .006711    -.000132     -1.4


PLOT?
?N
```

MP8630#03 No Pre. DFD 8/02/74 1 OF 2





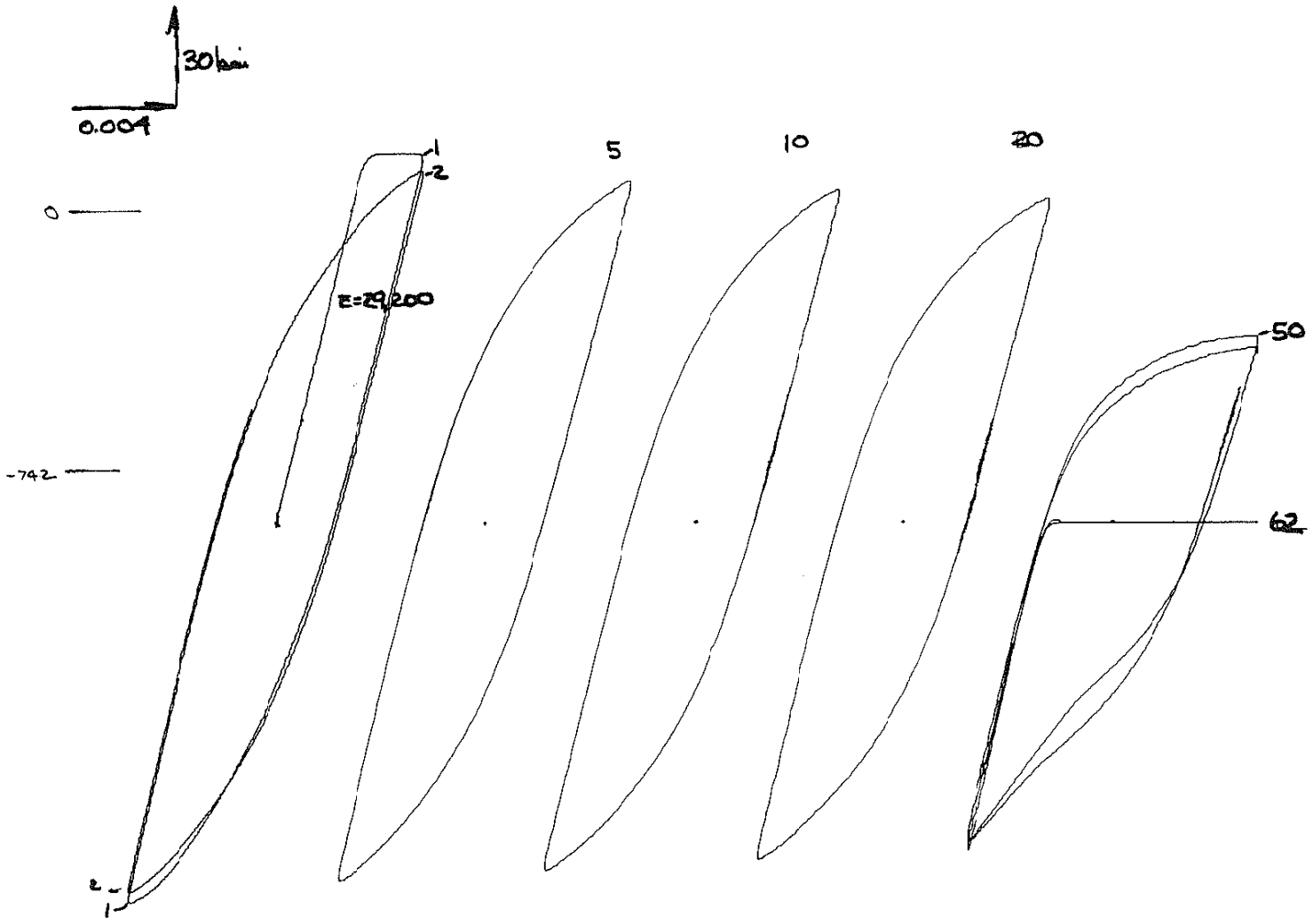
$N_4 = 45$

```
**********************************************************************
******************** MP 8630 #03          **************************
******************** NO PRE.              **************************
**********************************************************************
OUTPUT IN ENG. VALUES
?N
OUTPUT IN TRUE VALUES
?Y


PEAKS
?N
RANGES(R) OR AMPLITUDES(A) OR BOTH(B) OR NONE(N)
?A


TRUE STRESS & STRAIN AMPLITUDES & MEANS
  N      REV          E         S          EP          EØ        SØ
  1        2     .010200    109.4     .005900    -.000072     -0.9
  2        4     .010200    107.2     .005930    -.000072     -1.1
  3       10     .010162    104.5     .005971    -.000252     -0.7
  4       20     .010172    101.8     .006071    -.000222     -0.8
  5       40     .010202     98.0     .006201    -.000232     -1.3


PLOT?
?N
```

MP 8630 #07 No Pre.

DFD 8/16/79

1 of 1

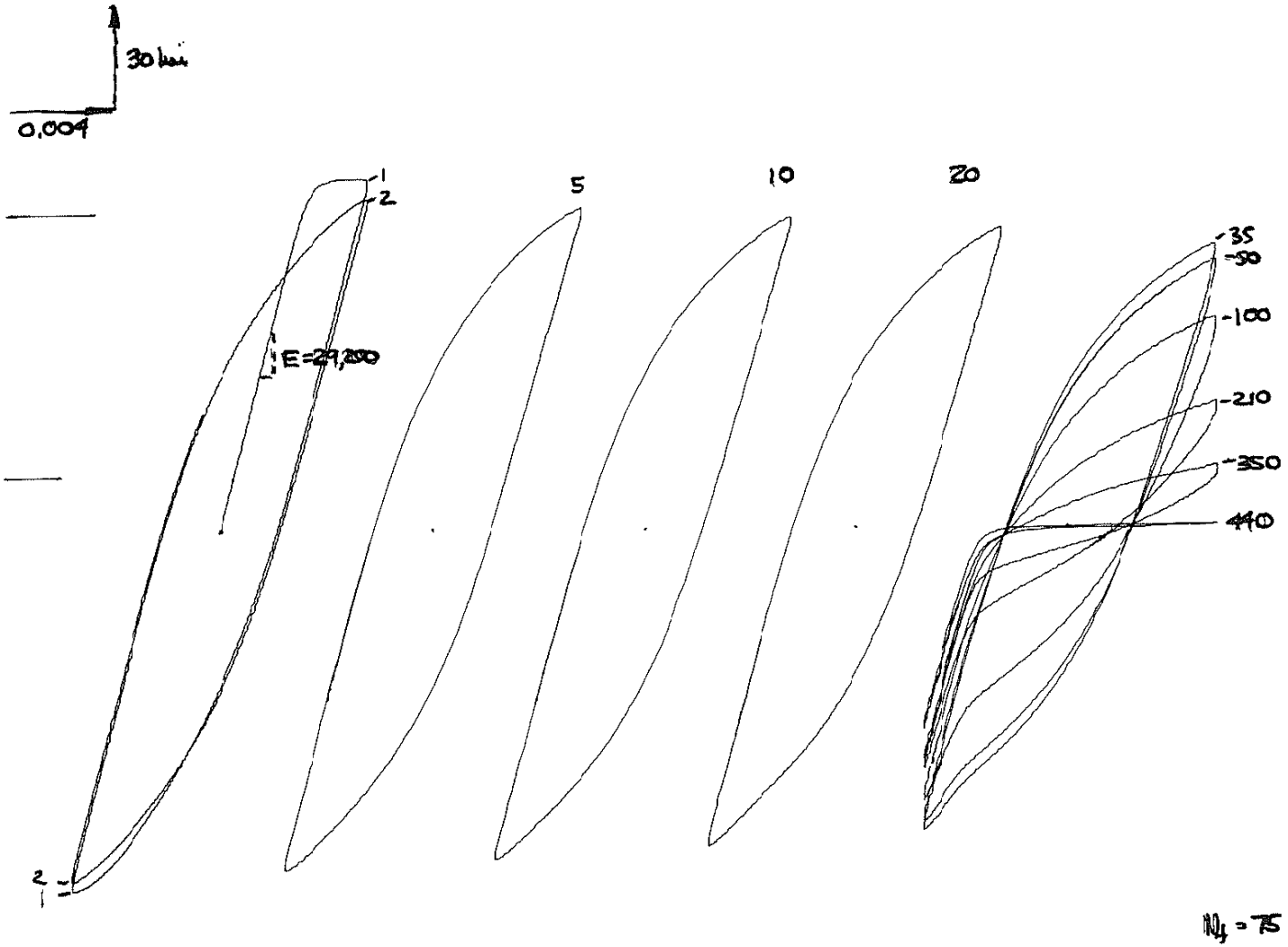


N_f = 95

```
**********************************************************************
******************** MP 8630 #07          **************************
******************** NO PRE.              **************************
**********************************************************************
OUTPUT IN ENG. VALUES
?N
OUTPUT IN TRUE VALUES
?Y


PEAKS
?N
RANGES(R) OR AMPLITUDES(A) OR BOTH(B) OR NONE(N)
?A


TRUE STRESS & STRAIN AMPLITUDES & MEANS
  N      REV          E         S          EP          E0        S0
  1        2     .005590     107.2     .002200    -.000066    -0.2
  2        4     .005590     103.3     .002280    -.000066    -1.1
  3       10     .005590     100.1     .002310    -.000066    -1.2
  4       20     .005561      97.5     .002360    -.000116    -1.3
  5       40     .005570      94.5     .002450    -.000026    -1.1


PLOT?
?N
```

MP8630 #28 No Pre

DSD 8/16/74

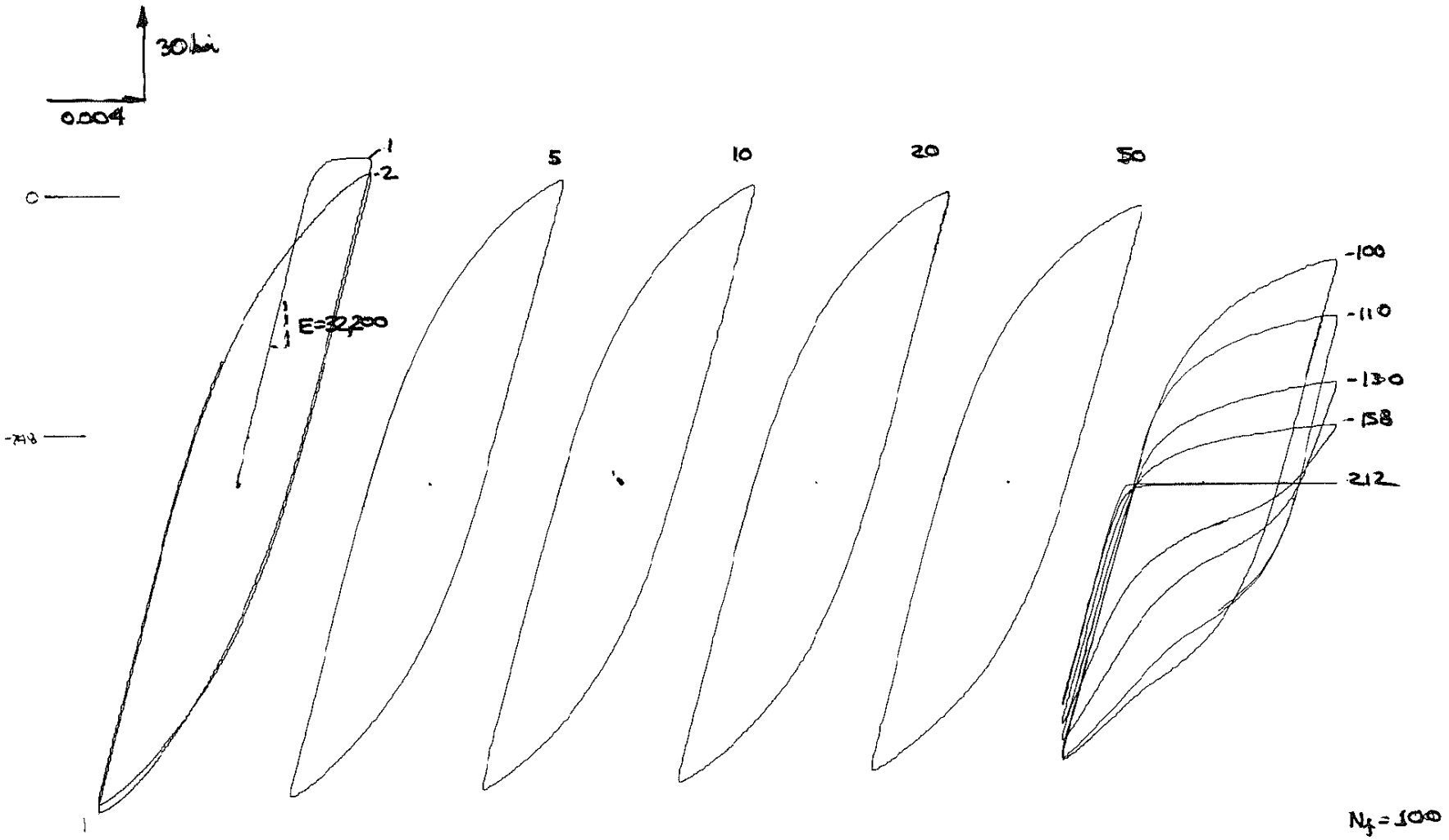


$N_f = 75$

```
**********************************************************************
********** MP 8630 #28          **************************
********** NO PRE.              **************************
**********************************************************************
OUTPUT IN ENG. VALUES
?N
OUTPUT IN TRUE VALUES
?Y


PEAKS
?N
RANGES(R) OR AMPLITUDES(A) OR BOTH(B) OR NONE(N)
?A


TRUE STRESS & STRAIN AMPLITUDES & MEANS
  N      REV          E         S          EP          E0         S0
  1        2     .005580     100.4     .002150    -.000016      0.0
  2        4     .005580      96.2     .002210    -.000016     -1.6
  3       10     .005590      93.3     .002200    -.000006     -1.7
  4       20     .005580      90.5     .002230    -.000036     -1.8
  5       40     .005530      87.1     .002300    -.000085     -2.1

PLOT?
?N
```

MP8630 #33 No Pre.

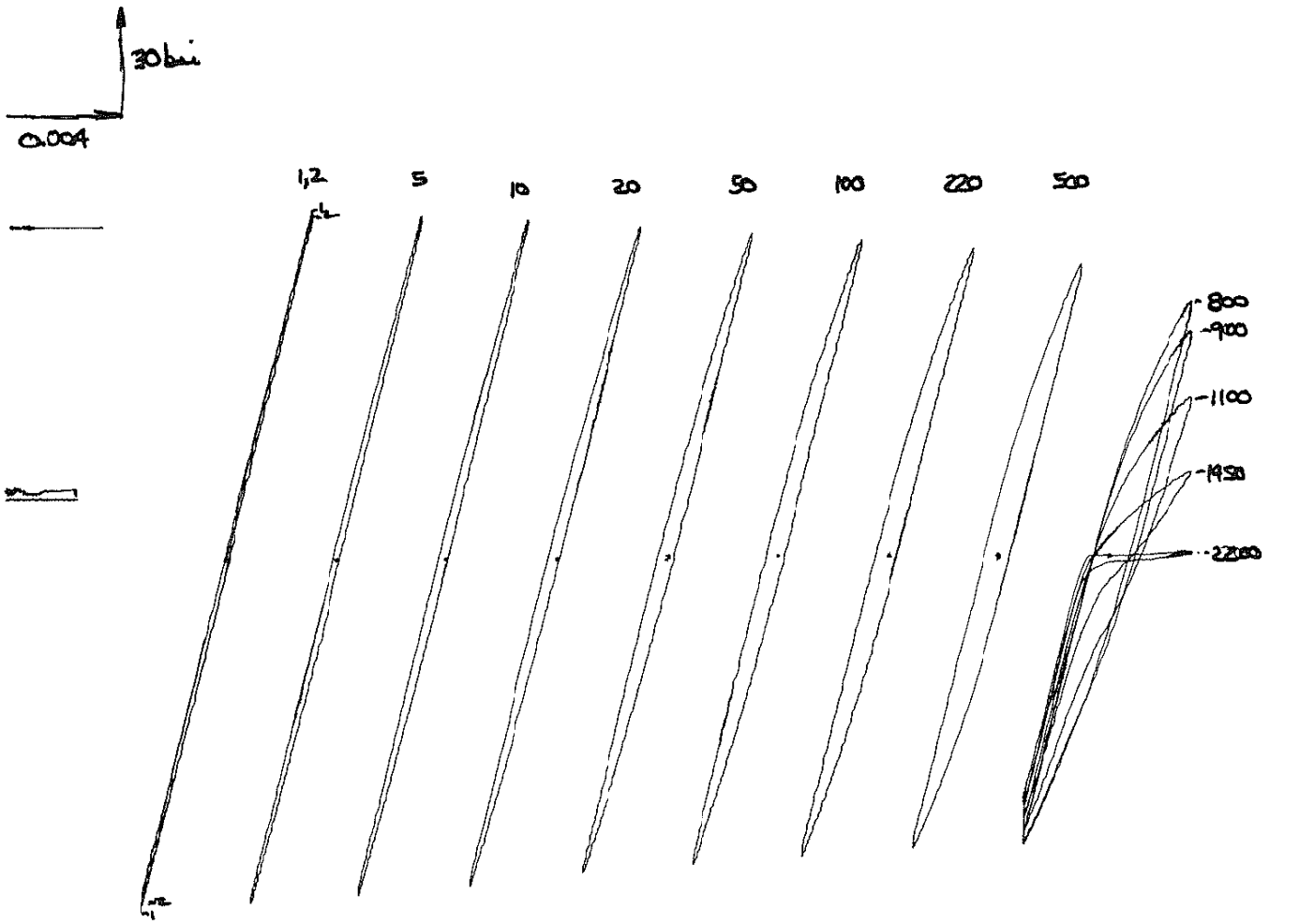
DFD 8/16/74



```
**********************************************************************
******************** MP 8630 #33          ************************
******************** NO PRE.              ************************
**********************************************************************
OUTPUT IN ENG. VALUES
?N
OUTPUT IN TRUE VALUES
?Y


PEAKS
?N
RANGES(R) OR AMPLITUDES(A) OR BOTH(B) OR NONE(N)
?A


TRUE STRESS & STRAIN AMPLITUDES & MEANS
  N      REV          E         S          EP          E0         S0
  1        2     .005570     101.6     .002260    -.000086      0.8
  2        4     .005570      98.1     .002310    -.000086     -0.4
  3       10     .005591      95.5     .002350    -.000186     -0.4
  4       20     .005581      93.7     .002400    -.000216     -0.4
  5       40     .005540      91.5     .002480    -.000095     -0.7
  6      100     .005540      87.4     .002580    -.000115     -0.9


PLOT?
?N
```

MP 8630 #BB No Pre

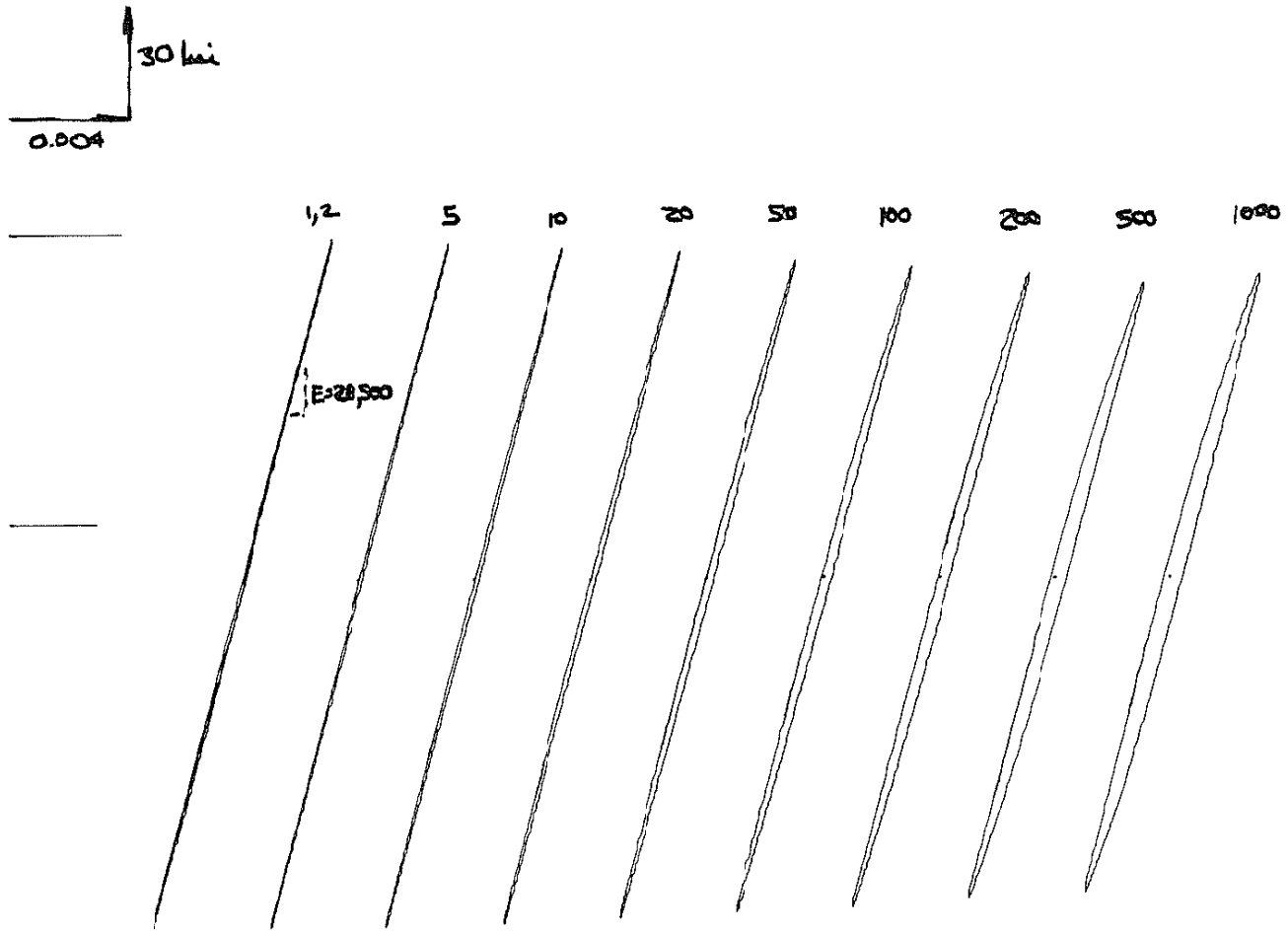
DFD 8/06/79



$N_f = 850$

```
**********************************************************************
********** MP 8630 #13B          **************************
********** NO PRE.               **************************
**********************************************************************
OUTPUT IN ENG. VALUES
?N
OUTPUT IN TRUE VALUES
?Y


PEAKS
?N
RANGES(R) OR AMPLITUDES(A) OR BOTH(B) OR NONE(N)
?A


TRUE STRESS & STRAIN AMPLITUDES & MEANS
  N      REV          E         S          EP          E0         S0
  1        2     .003010      95.2     .000070    -.000035      -0.8
  2        4     .003010      94.0     .000070    -.000035      -0.2
  3       10     .003020      93.2     .000120    -.000045       0.1
  4       20     .003020      91.6     .000170    -.000165       0.4
  5       40     .003010      89.7     .000210    -.000135       0.6
  6      100     .003010      86.8     .000300    -.000055       1.7
  7      200     .003000      84.8     .000320    -.000065       2.1
  8      440     .003010      82.6     .000390    -.000055       1.8
  9     1000     .003000      79.3     .000480    -.000085       0.6


PLOT?
?N
```

MP8630 #26 No Pha. DPD 8/21/74 1 OF 1



N = 1050
out of g-l.

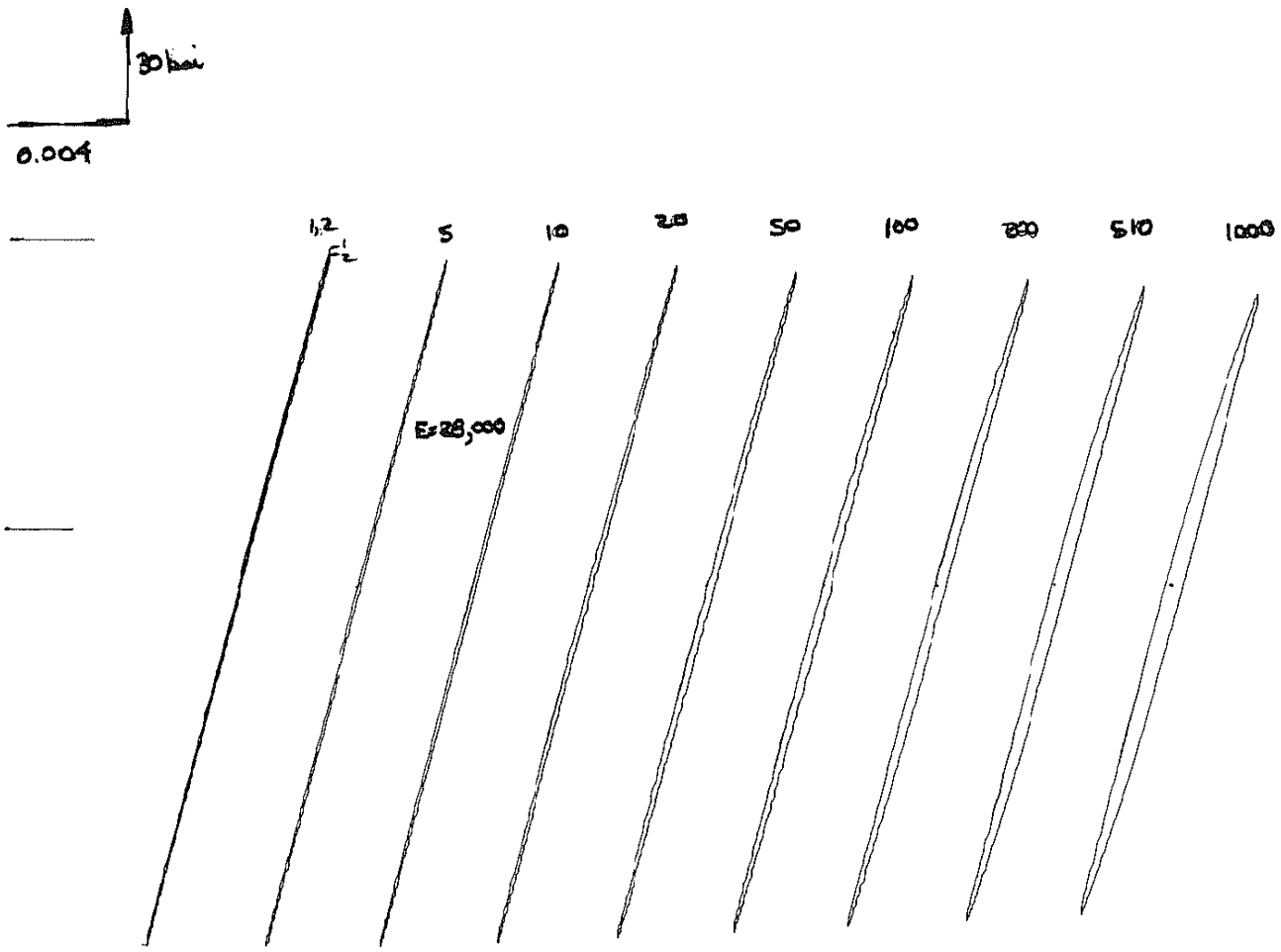
```
**********************************************************************
********** MP 8630 #26          **********
********** NO PRE.              **********
**********************************************************************
OUTPUT IN ENG. VALUES
?N
OUTPUT IN TRUE VALUES
?Y


PEAKS
?N
RANGES(R) OR AMPLITUDES(A) OR BOTH(B) OR NONE(N)
?A


TRUE STRESS & STRAIN AMPLITUDES & MEANS
```

N	REV	E	S	EP	E0	S0
1	2	.002990	89.1	.000030	.000005	-0.2
2	4	.002990	89.1	.000030	.000005	-0.2
3	10	.003000	88.5	.000060	.000035	-0.9
4	20	.003010	87.8	.000070	.000005	-1.5
5	40	.003010	86.8	.000090	.000025	-1.4
6	100	.002990	84.8	.000130	.000005	-2.1
7	200	.003000	83.2	.000160	-.000005	-2.2
8	400	.003000	81.5	.000200	.000035	-2.4
9	1000	.003010	79.3	.000270	.000025	-2.8
10	2000	.003010	79.7	.000310	.000065	-1.3

```
PLOT?
?N
```

MP8630 #23 No Pile

DED 8/02/79

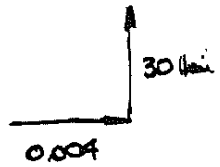


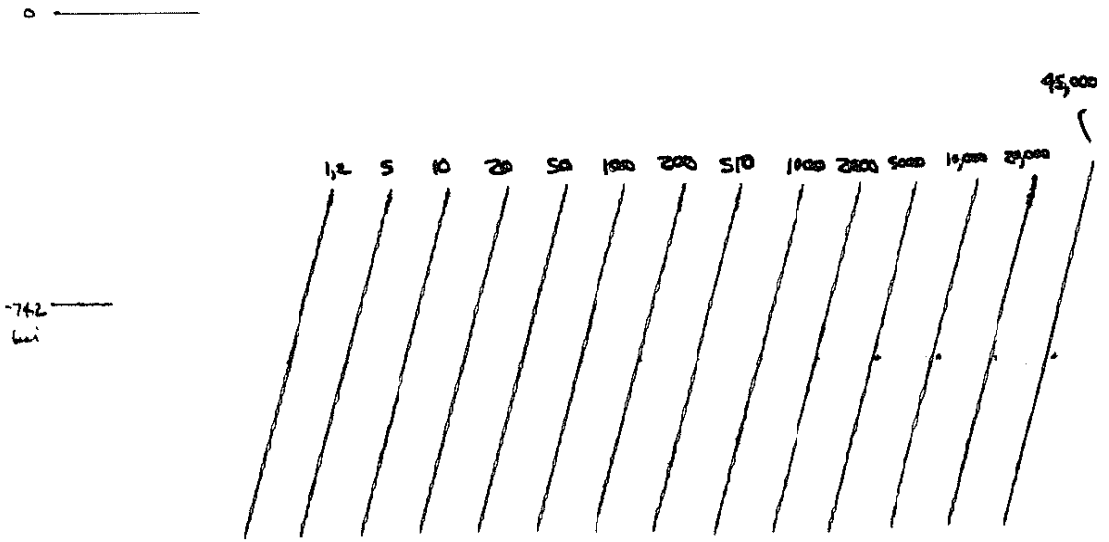
N = 1890 (out of 3.1)

```
**********************************************************************
********** MP 8630 #23          **********
********** NO PRE.              **********
**********************************************************************
OUTPUT IN ENG. VALUES
?N
OUTPUT IN TRUE VALUES
?Y


PEAKS
?N
RANGES(R) OR AMPLITUDES(A) OR BOTH(B) OR NONE(N)
?INVALID INPUT DATA ... RETYPE IT
?A


TRUE STRESS & STRAIN AMPLITUDES & MEANS
  N      REV          E         S          EP          EØ        SØ
  1        2     .003000     89.4     .000040    -.000025     -1.8
  2        4     .003000     89.1     .000040    -.000025     -2.1
  3       10     .003010     88.0     .000070     .000005     -3.4
  4       20     .003020     87.9     .000060    -.000065     -3.8
  5       40     .003010     87.0     .000090    -.000055     -4.1
  6      100     .002990     85.5     .000130     .000005     -4.2
  7      200     .002990     84.4     .000130     .000005     -4.2
  8      400     .003010     83.2     .000180    -.000055     -3.9
  9     1020     .002990     81.4     .000250    -.000015     -4.2
 10     2000     .003010     79.6     .000310    -.000055     -4.5


PLOT?
?N
```

MP 8630# 10 No Pre.

DFD 8/06/74



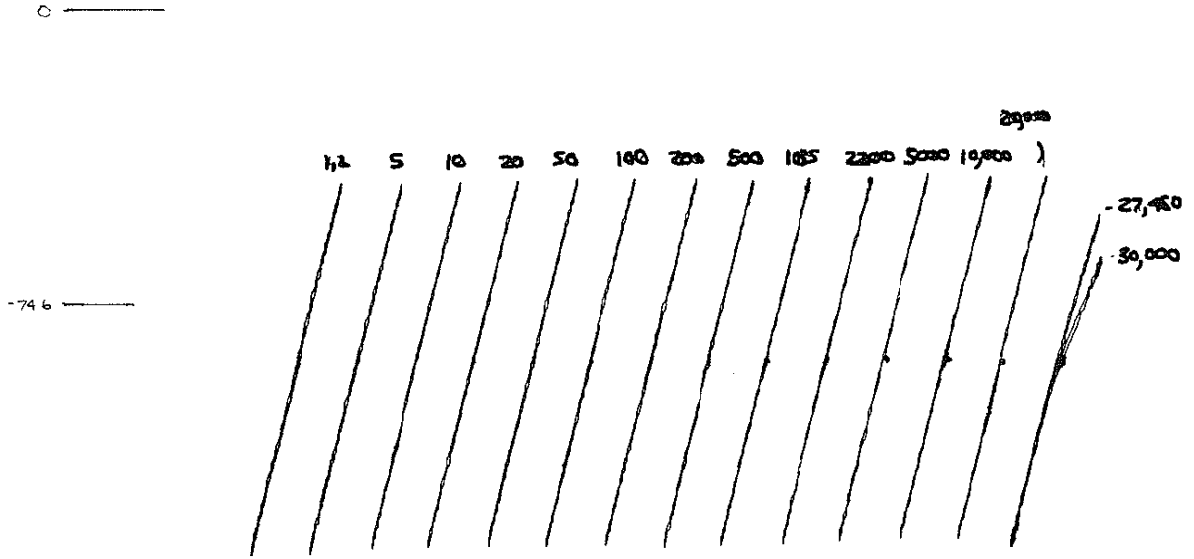


$N_4 = 47{,}600$ (out of gl.)

```
**********************************************************************
****************** MP 8630 #10          **********************
****************** NO PRE.              **********************
**********************************************************************
OUTPUT IN ENG. VALUES
?N
OUTPUT IN TRUE VALUES
?Y


PEAKS
?N
RANGES(R) OR AMPLITUDES(A) OR BOTH(B) OR NONE(N)
?A


TRUE STRESS & STRAIN AMPLITUDES & MEANS
  N      REV          E         S          EP          E0        S0
  1        2     .001490     44.7    0.000000     .000008      0.1
  2        4     .001490     44.7    0.000000     .000008      0.1
  3       10     .001500     44.5     .000015    -.000082      0.2
  4       20     .001490     44.2     .000015    -.000072      0.4
  5       40     .001480     44.2     .000008    -.000042      0.7
  6      100     .001480     44.2     .000005    -.000062      1.0
  7      200     .001490     44.2     .000015    -.000072      1.0
  8      400     .001480     44.2     .000005    -.000081      1.0
  9     1020     .001490     44.2     .000015    -.000111      0.8
 10     2000     .001480     44.7    -.000010    -.000022      0.2
 11     4000     .001490     44.4     .000010    -.000091      0.7
 12    10000     .001490     44.4     .000010    -.000131      0.7
 13    20000     .001480     44.3     .000003    -.000101      1.3
 14    40000     .001490     44.3     .000012    -.000111      2.1


PLOT?
?N
```

MP 8630ff 30A No Pre

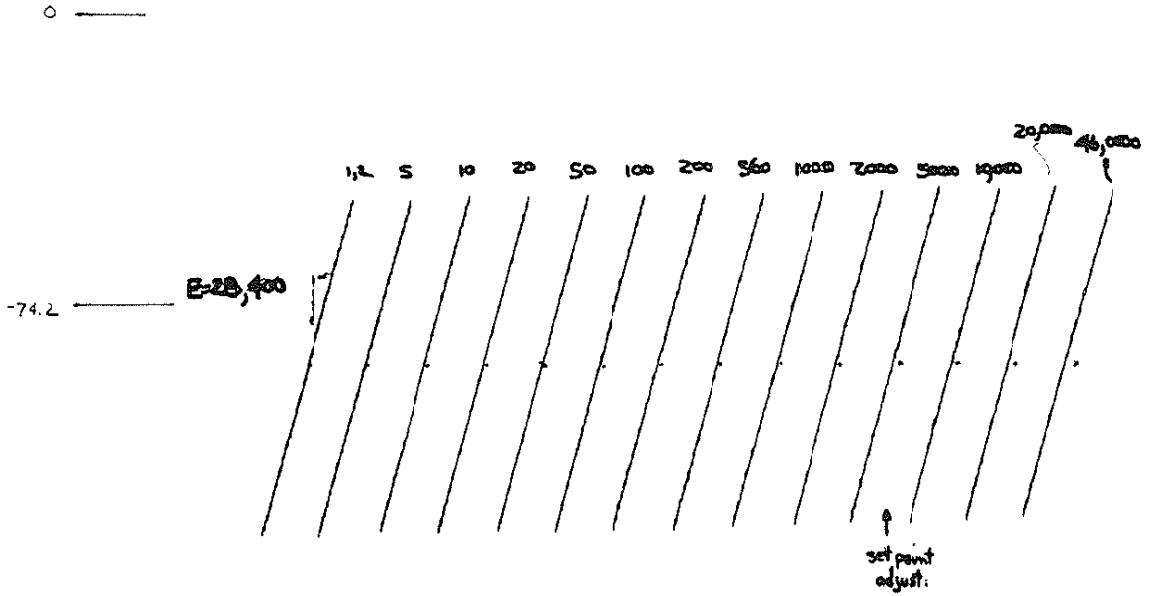
DFD 8/06/74



N_f = 27,500

```
**********************************************************************
********** MP 8630 #30A          **************************
********** NO PRE.               **************************
**********************************************************************
OUTPUT IN ENG. VALUES
?N
OUTPUT IN TRUE VALUES
?Y


PEAKS
?N
#WAIT
RANGES(R) OR AMPLITUDES(A) OR BOTH(B) OR NONE(N)
?A


TRUE STRESS & STRAIN AMPLITUDES & MEANS
  N      REV          E         S         EP          E0         S0
  1        2     .001500     47.0     .000030    -.000062     -1.5
  2        4     .001500     47.0     .000030    -.000062     -1.5
  3       10     .001490     46.9     .000023    -.000052     -1.6
  4       20     .001470     46.5     .000017     .000029     -0.5
  5       40     .001500     46.5     .000047    -.000062     -0.2
  6      100     .001440     46.6    -.000018    -.000021      0.1
  7      200     .001490     46.6     .000035    -.000072     -0.0
  8      400     .001460     46.6     .000004    -.000001      0.1
  9     1000     .001480     46.6     .000025    -.000062     -0.3
 10     2070     .001490     46.6     .000032    -.000111      0.2
 11     4400     .001480     46.4     .000029    -.000081      0.1
 12    10000     .001500     46.5     .000047    -.000082      1.3
 13    20000     .001490     46.4     .000039    -.000072      0.4
 14    40000     .001490     45.9     .000056    -.000111      1.0


PLOT?
?N
```

MP 8630 #20 No. Pre DFD 8/02/74 1 of 1



$N_4 = 66,900$

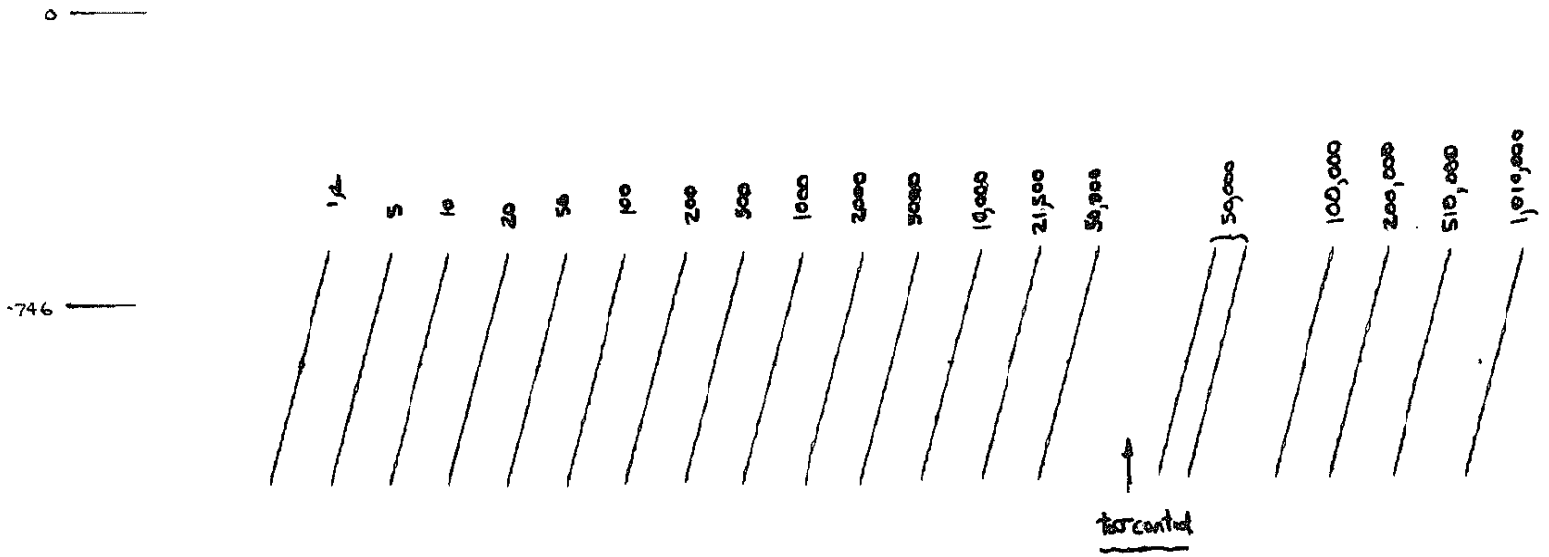
out of 9 l.

```
**********************************************************************
********** MP 8630 #20          **************************
********** NO PRE.              **************************
**********************************************************************
OUTPUT IN ENG. VALUES
?N
OUTPUT IN TRUE VALUES
?Y


PEAKS
?N
RANGES(R) OR AMPLITUDES(A) OR BOTH(B) OR NONE(N)
?A


TRUE STRESS & STRAIN AMPLITUDES & MEANS
  N      REV          E        S          EP          E0        S0
  1        2     .001500     42.6     .000010    -.000082     -0.4
  2        4     .001500     42.6     .000010    -.000082     -0.4
  3       10     .001490     42.7    -.000005    -.000131     -0.5
  4       20     .001490     42.7    -.000002    -.000091      0.7
  5       40     .001490     42.7    -.000005    -.000091      0.5
  6      100     .001490     42.7    -.000002    -.000091      0.7
  7      200     .001490     42.7    -.000002    -.000111      0.7
  8      400     .001490     42.6     .000000    -.000111      0.8
  9     1120     .001490     42.7    -.000002    -.000111      0.9
 10     2000     .001490     42.4     .000006    -.000111      1.6
 11     4000     .001480     42.5    -.000007    -.000081      1.9
 12    10000     .001500     42.7     .000008    -.000121      2.5
 13    20000     .001490     42.6     .000000    -.000111      2.3
 14    40000     .001470     42.3    -.000009    -.000211      2.9
 15    92000     .001490     41.6     .000035    -.000251      3.0


PLOT?
?N
```

MP-8630 #1A No Plot

DFD 8/04/74

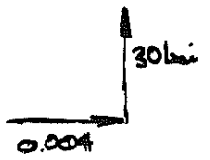
1 of 1

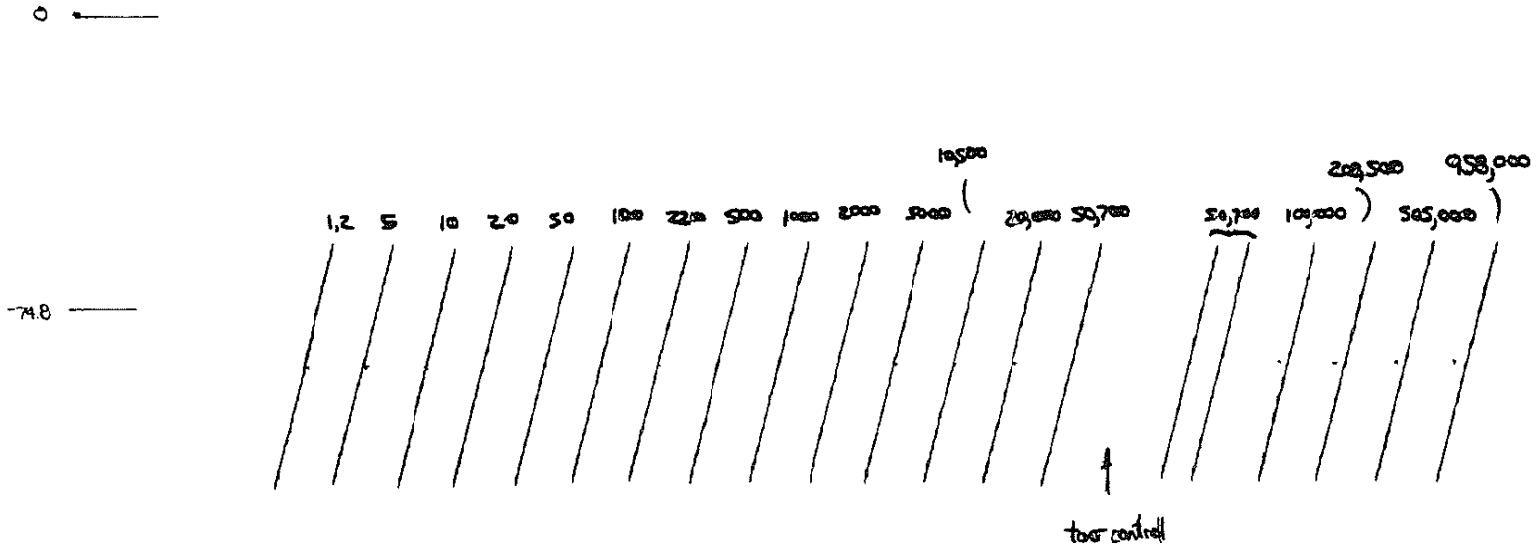


$N_t = 1,850,000$

```
**********************************************************************
****************** MP 8630 #01A        **********************
****************** NO PRE.             **********************
**********************************************************************
OUTPUT IN ENG. VALUES
?N
OUTPUT IN TRUE VALUES
?Y


PEAKS
?N
RANGES(R) OR AMPLITUDES(A) OR BOTH(B) OR NONE(N)
?A


TRUE STRESS & STRAIN AMPLITUDES & MEANS
  N      REV          E         S          EP          EØ        SØ
  1        2      .000980     29.6    -.000024    -.000141     -0.5
  2        4      .000980     29.6    -.000024    -.000141     -0.5
  3       10      .000980     29.4    -.000016    -.000021     -0.9
  4       20      .000980     29.4    -.000017    -.000081     -1.0
  5       40      .000980     29.4    -.000016    -.000021     -1.0
  6      100      .000980     29.7    -.000027    -.000041     -1.3
  7      200      .000970     29.6    -.000034    -.000031     -1.4
  8      400      .000980     29.4    -.000016    -.000021     -1.0
  9     1000      .000980     29.3    -.000014    -.000021     -0.8
 10     2000      .000970     29.3    -.000024    -.000051     -0.9
 11     4000      .000980     29.7    -.000027    -.000001     -1.3
 12    10000      .000980     29.5    -.000022    -.000081     -1.2
 13    20000      .000990     29.2    -.000001     .000009     -0.7
 14    43000      .000990     29.9    -.000022     .000029     -0.1
 15   100000      .000990     29.8    -.000021    -.000011     -0.1
 16   200000      .000980     29.3    -.000014     .000019     -0.3
 17   400000      .000960     29.5    -.000039    -.000101     -0.2
 18  1020000      .000980     29.1    -.000007    -.000001     -0.6
 19  2020000      .000960     29.1    -.000027     .000439     -0.6


PLOT?
?N
```

MP 8630 #21 NoPha. DFD 8/05/74 1 of 1





$N_f = 2,350,000$

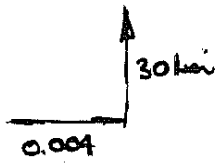
```
**********************************************************************
********** MP 8630 #21          **********
********** NO PRE.              **********
**********************************************************************
OUTPUT IN ENG. VALUES
?N
OUTPUT IN TRUE VALUES
?Y


PEAKS
?N
RANGES(R) OR AMPLITUDES(A) OR BOTH(B) OR NONE(N)
?A


TRUE STRESS & STRAIN AMPLITUDES & MEANS
```

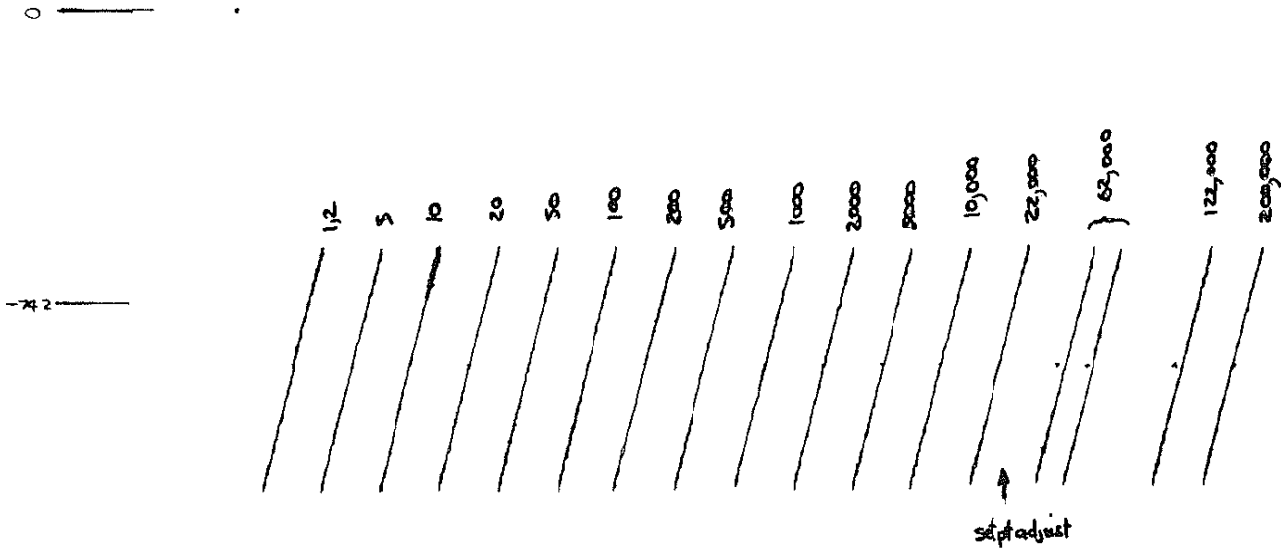
N	REV	E	S	EP	E0	S0
1	2	.000980	31.1	.000007	-.000141	0.3
2	4	.000980	31.1	.000007	-.000141	0.3
3	10	.000980	30.7	.000021	-.000141	0.7
4	20	.000980	30.5	.000026	.000019	-0.5
5	40	.000980	30.4	.000030	-.000021	-0.0
6	100	.000980	30.3	.000033	.000039	0.0
7	200	.000980	30.5	.000026	-.000001	0.9
8	440	.000980	30.6	.000024	-.000021	1.2
9	1000	.000980	30.7	.000021	-.000021	0.7
10	2000	.000980	30.7	.000021	-.000001	0.9
11	4000	.000980	30.7	.000021	.000019	0.7
12	10000	.000980	30.7	.000019	-.000041	0.8
13	21000	.000990	30.7	.000031	-.000011	0.9
14	40000	.000980	30.7	.000021	-.000041	0.7
15	101400	.000970	30.8	.000007	-.000051	-0.2
16	200000	.000950	30.2	.000008	.000309	0.2
17	405000	.000980	30.4	.000031	.000319	0.4
18	1010000	.000990	30.5	.000036	.000329	0.4
19	1900000	.000980	30.4	.000031	.000399	0.1

```
PLOT?
?N
```

MP 8630# 11 NaPhe

DFD 8/07/74





N_f = 431,000
(out of g. l.)

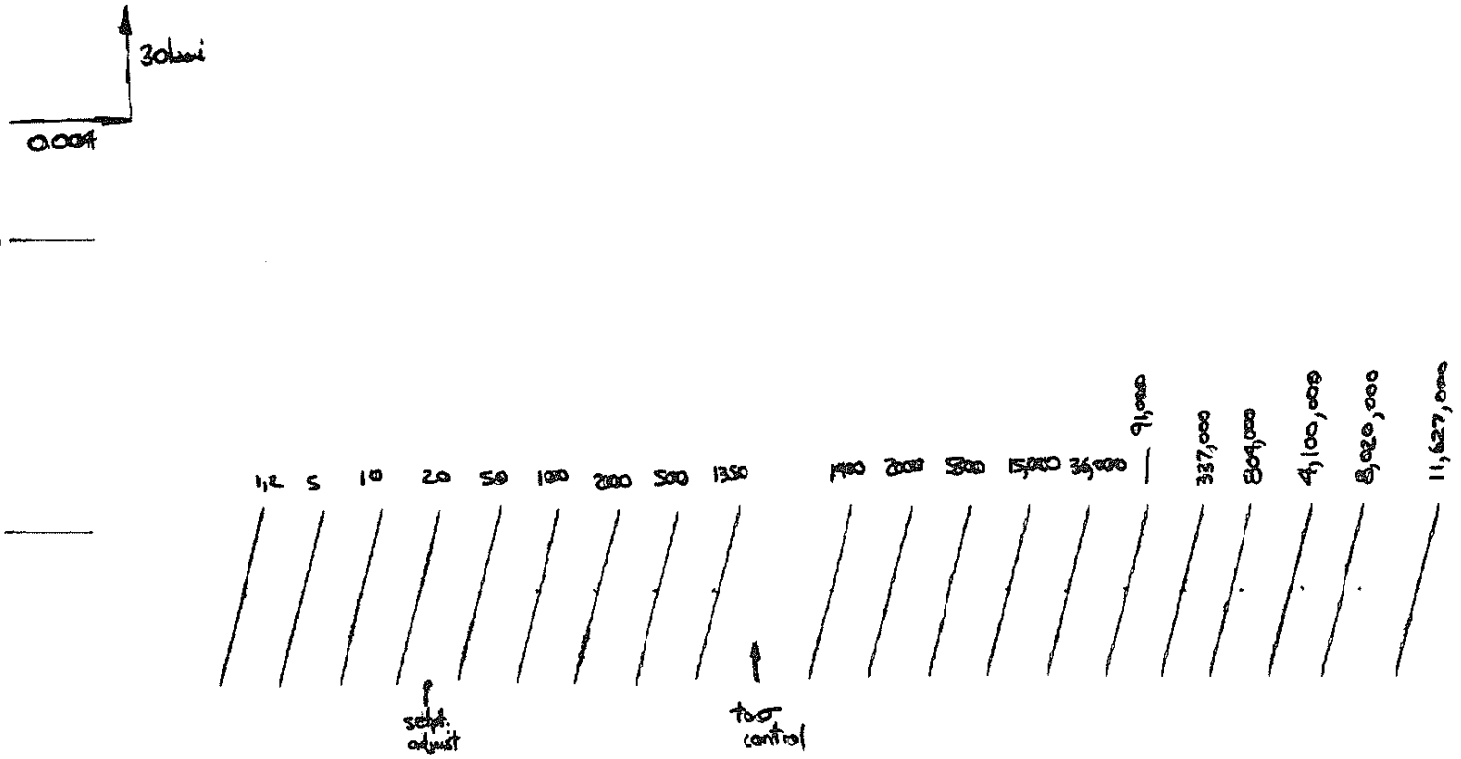
```
**********************************************************************
******************** MP 8630 #11          ************************
******************** NO PRE.              ************************
**********************************************************************
OUTPUT IN ENG. VALUES
?N
OUTPUT IN TRUE VALUES
?Y


PEAKS
?N
RANGES(R) OR AMPLITUDES(A) OR BOTH(B) OR NONE(N)
?A


TRUE STRESS & STRAIN AMPLITUDES & MEANS
```

N	REV	E	S	EP	E0	S0
1	2	.000990	31.0	.000020	.000009	-1.2
2	4	.000990	31.0	.000020	.000009	-1.2
3	10	.000980	31.2	.000005	-.000001	-1.5
4	20	.000990	31.0	.000020	-.000011	-1.2
5	40	.000980	31.0	.000012	-.000001	-0.9
6	100	.000980	31.0	.000010	-.000001	-1.2
7	200	.000980	31.0	.000010	.000019	-1.0
8	400	.000990	30.9	.000024	-.000011	-1.0
9	1000	.000990	31.0	.000022	-.000011	-0.8
10	2000	.000980	30.5	.000026	.000019	-0.5
11	4000	.000950	30.8	-.000013	.000049	-0.9
12	10000	.000980	30.7	.000021	.000019	-0.9
13	20000	.000980	30.7	.000021	-.000001	-0.8
14	44000	.000980	30.2	.000035	-.000001	0.1
15	124000	.000970	30.0	.000032	.000249	0.0
16	244000	.000980	30.2	.000036	.000219	-0.2
17	400000	.000990	30.1	.000048	-.000011	-0.3

```
PLOT?
?N
```

MP 8630 #13A NoPre

DFD 8/09/74



N_4 = 14,939,000
(out of g.l.)

```
**********************************************************************
******************** MP 8630 #13A          ************************
******************** NO PRE.               ************************
**********************************************************************
OUTPUT IN ENG. VALUES
?N
OUTPUT IN TRUE VALUES
?Y


PEAKS
?N
RANGES(R) OR AMPLITUDES(A) OR BOTH(B) OR NONE(N)
?A


TRUE STRESS & STRAIN AMPLITUDES & MEANS
```

N	REV	E	S	EP	E0	S0
1	2	.000730	22.6	.000002	-.000050	-1.1
2	4	.000730	22.6	.000002	-.000050	-1.1
3	10	.000730	22.4	.000007	-.000030	-1.6
4	20	.000720	22.5	-.000006	.000039	-1.3
5	40	.000720	22.3	-.000001	-.000040	-1.5
6	100	.000720	22.1	.000007	.000079	-0.4
7	200	.000720	22.0	.000011	.000059	-1.1
8	400	.000720	22.1	.000006	.000059	-1.4
9	1000	.000720	22.1	.000006	.000079	-2.0
10	2700	.000710	22.0	.000001	.000109	-0.5
11	4000	.000730	21.7	.000028	-.000011	-0.6
12	10600	.000730	21.8	.000026	.000009	-0.5
13	30000	.000700	21.9	-.000006	-.000020	-0.1
14	72000	.000710	21.7	.000011	.000069	-0.5
15	182000	.000700	21.8	-.000004	.000059	-0.5
16	674000	.000710	21.8	.000006	-.000090	-0.5
17	1608000	.000730	21.9	.000023	-.000011	-0.4
18	8200000	.000720	21.8	.000016	-.000001	-0.5
19	******* 16,040,000	.000730	21.9	.000023	-.000011	-0.4
20	******* 23,254,000	.000710	21.9	.000004	-.000090	-0.4

```
PLOT?
?N
```

MP 8630* 32B Precycled

DPD 8/06/74

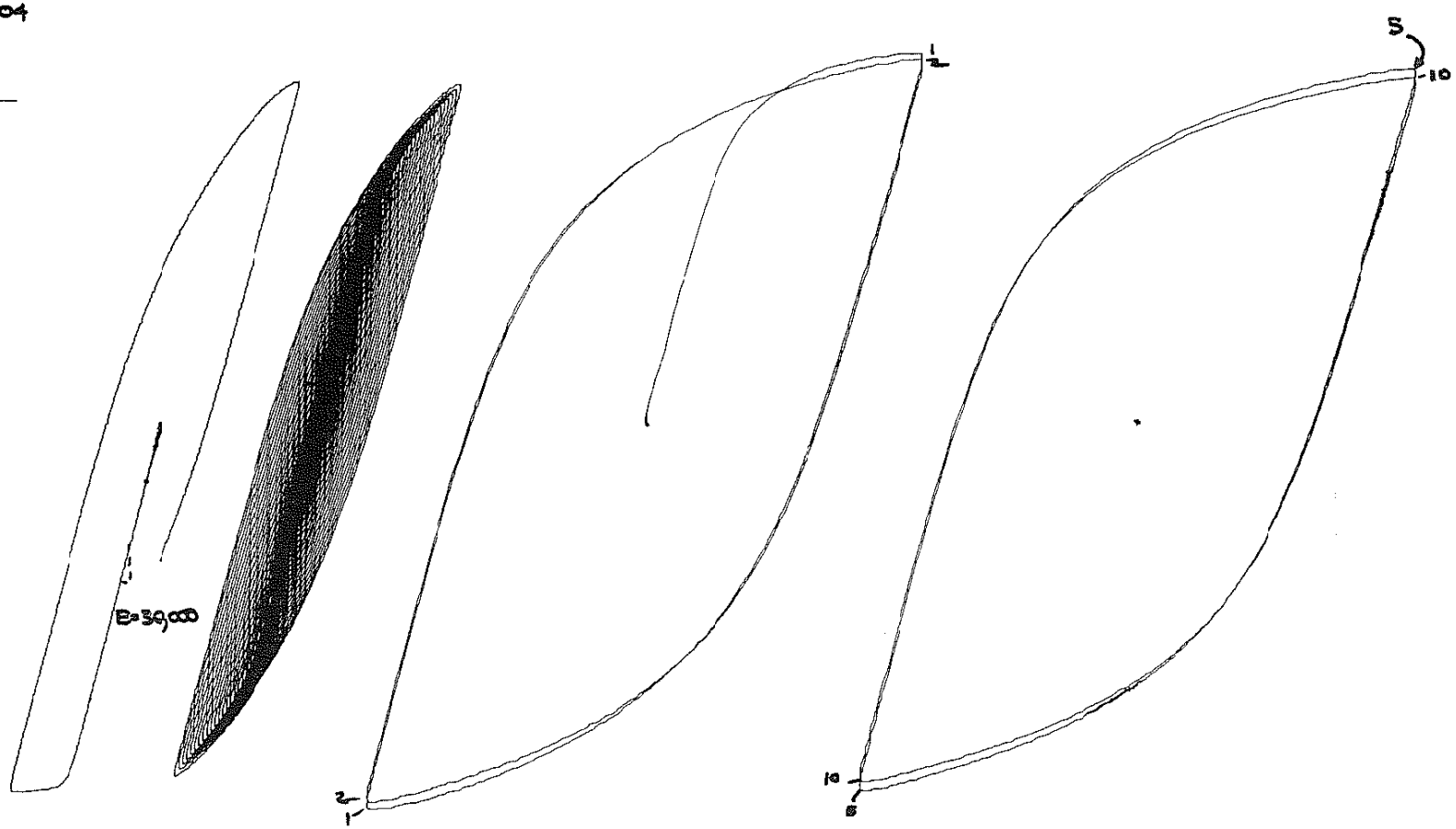
30ksi

.004

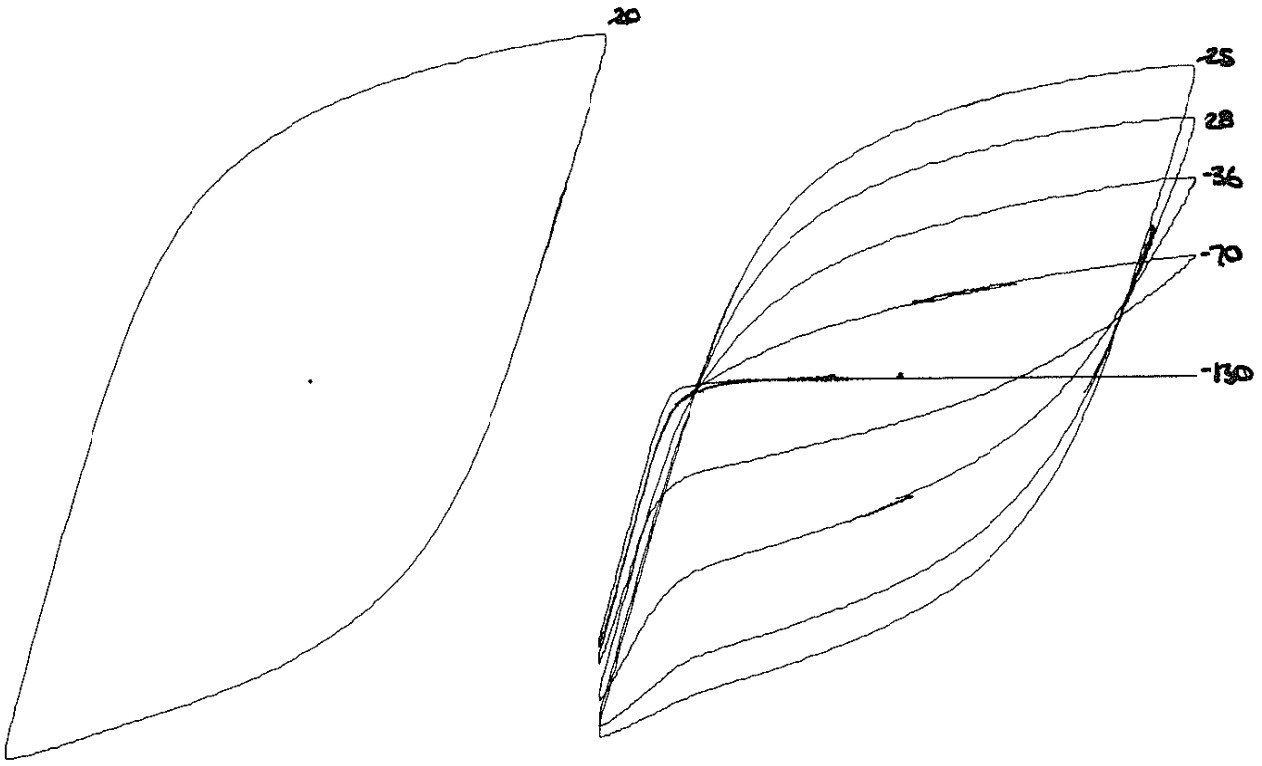
0

-76

E=30,000



MP 8630 #32A Pre.

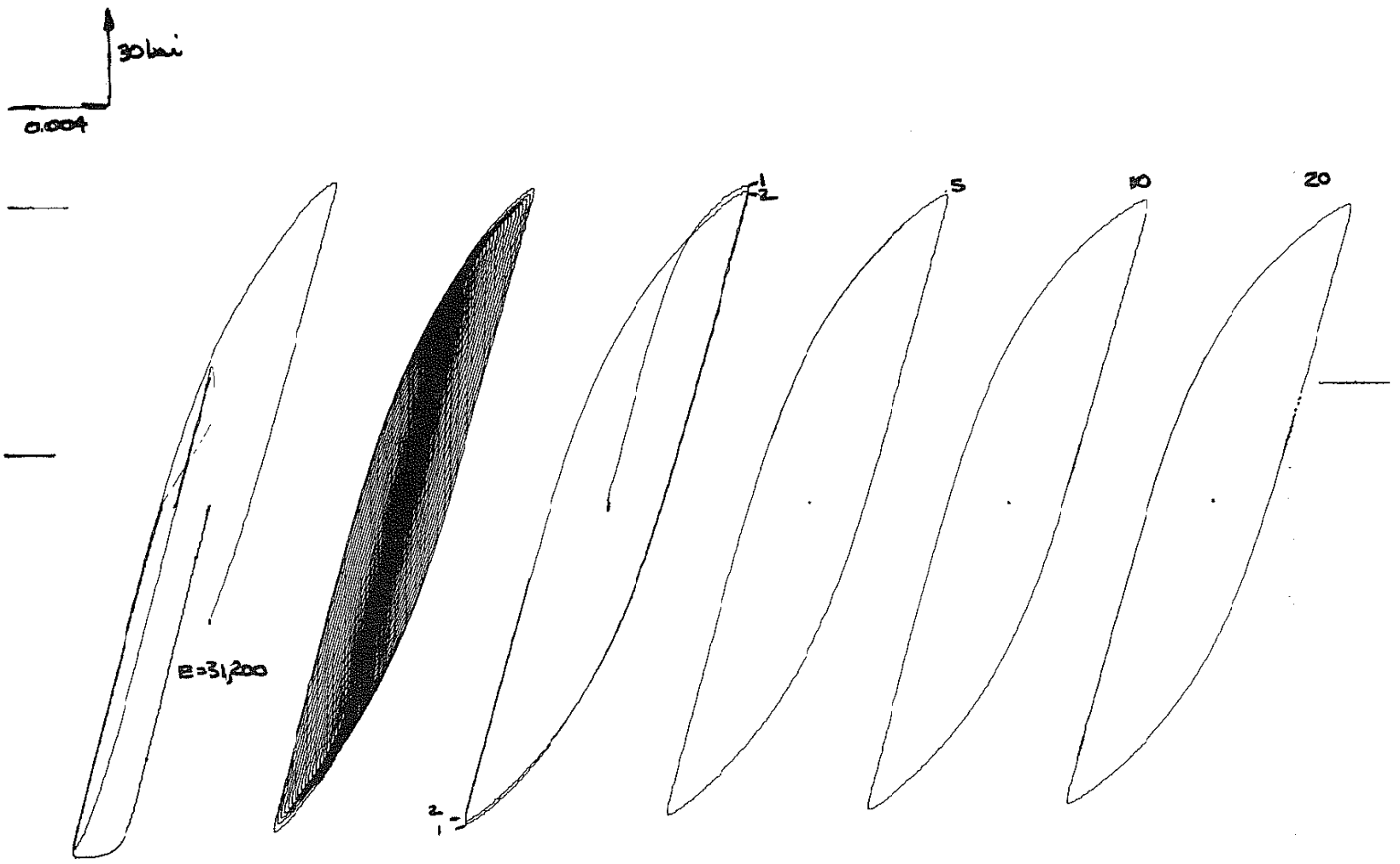


$N_f = 25$

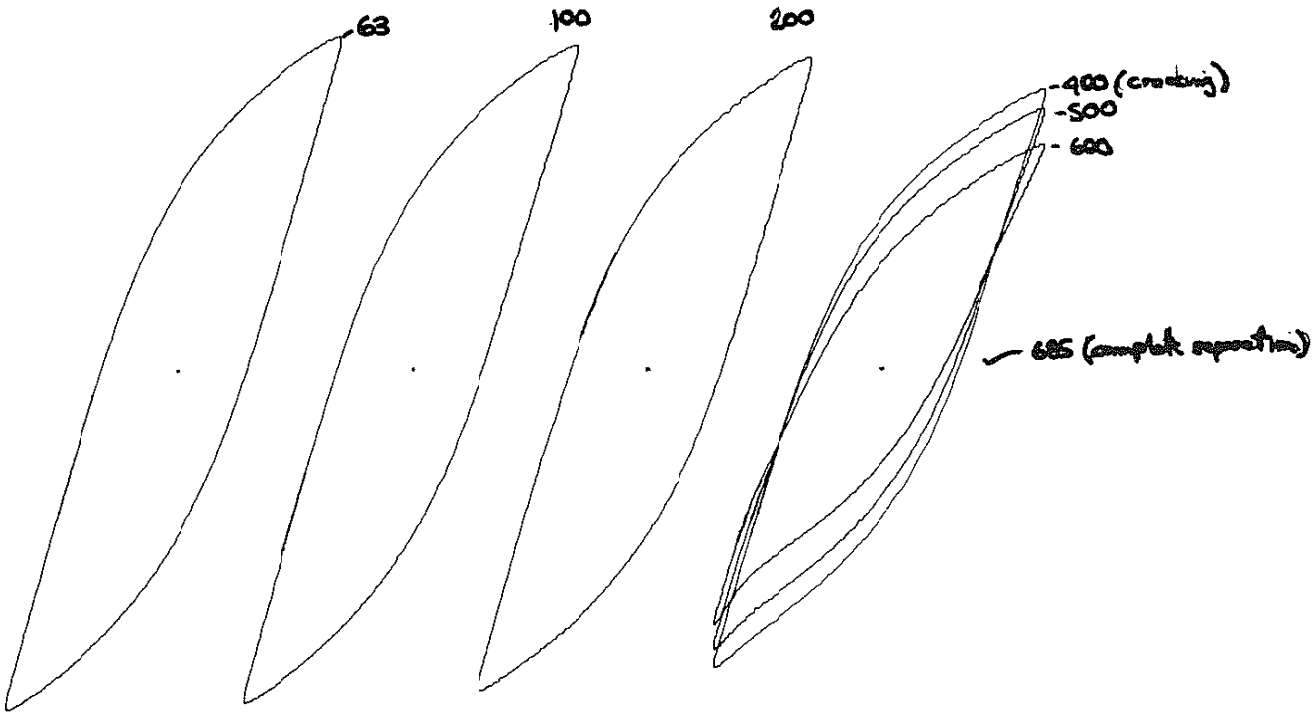
```
**********************************************************************
******************** MP 8630 #32B          **************************
******************** PRECYCLED             **************************
**********************************************************************
OUTPUT IN ENG. VALUES
?N
OUTPUT IN TRUE VALUES
?Y


PEAKS
?N
RANGES(R) OR AMPLITUDES(A) OR BOTH(B) OR NONE(N)
?A


TRUE STRESS & STRAIN AMPLITUDES & MEANS
  N      REV          E          S          EP          E0          S0
  1        2     .010131      103.6     .006351    -.000182        -0.7
  2        4     .010131      101.9     .006411    -.000182        -0.7
  3       10     .010141       99.0     .006510    -.000132        -0.9
  4       20     .010141       96.6     .006571    -.000132        -1.1
  5       40     .010192       91.6     .006731    -.000222        -2.2


PLOT?
?N
```

MP 8630#-30B Recycled

DRP 8/16/74



MP 8630 #308

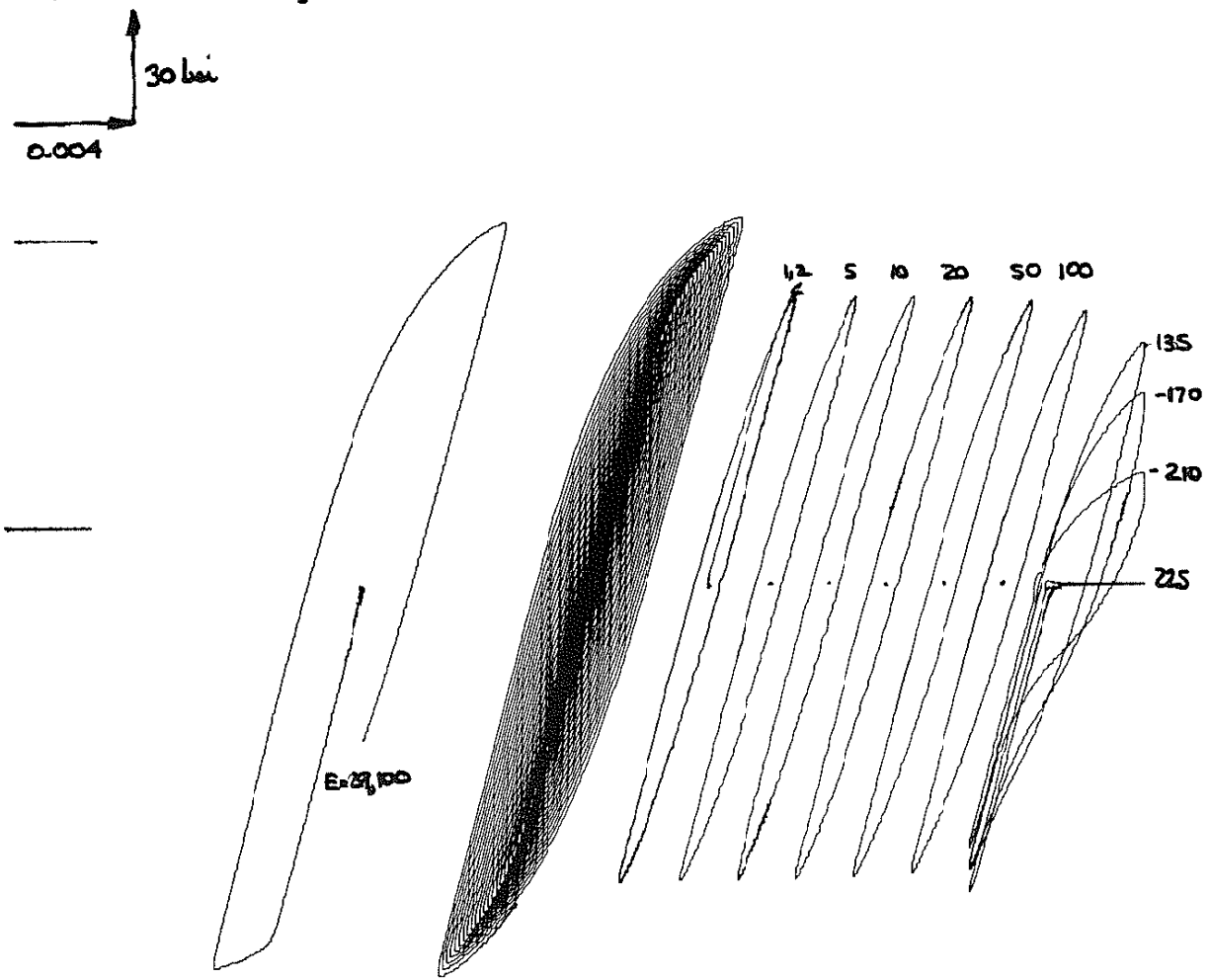


N_f = 525

```
**********************************************************************
******************** MP 8630 #30B          ************************
******************** PRECYCLED             ************************
**********************************************************************
OUTPUT IN ENG. VALUES
?N
OUTPUT IN TRUE VALUES
?Y


PEAKS
?N
RANGES(R) OR AMPLITUDES(A) OR BOTH(B) OR NONE(N)
?A


TRUE STRESS & STRAIN AMPLITUDES & MEANS
  N      REV          E          S          EP          EØ          SØ
  1        2     .005590     94.8     .002210    -.000046      Ø.5
  2        4     .005590     93.7     .002230    -.000046     -Ø.2
  3       1Ø     .005540     92.2     .002280    -.000095     -Ø.Ø
  4       2Ø     .005571     9Ø.6     .002300    -.000166     -Ø.2
  5       4Ø     .005561     89.1     .002330    -.000116     -Ø.4
  6      126     .005591     85.9     .002450    -.000166     -Ø.2
  7      2ØØ     .005601     83.5     .002480    -.000116     -Ø.6
  8      4ØØ     .005571     8Ø.5     .002560    -.000126     -Ø.7


PLOT?
?N
```

MP 8630 * 120 Precydad

DFD 8/06/74

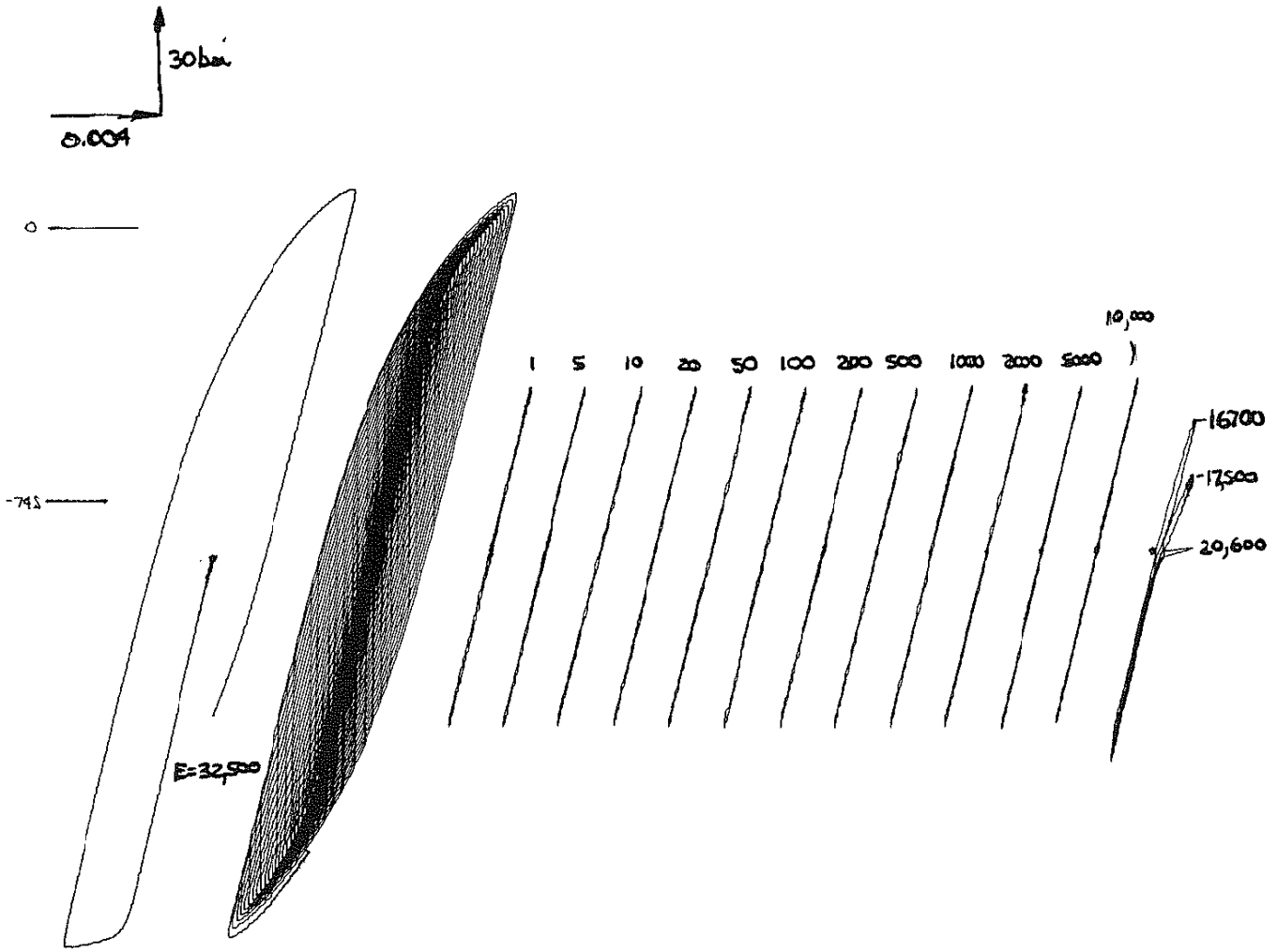


$N_f = 140$

```
**********************************************************************
********** MP 8630 #12A          **************************
********** PRECYCLED             **************************
**********************************************************************
OUTPUT IN ENG. VALUES
?N
OUTPUT IN TRUE VALUES
?Y


PEAKS
?N
RANGES(R) OR AMPLITUDES(A) OR BOTH(B) OR NONE(N)
?A


TRUE STRESS & STRAIN AMPLITUDES & MEANS
  N      REV          E         S          EP          E0         S0
  1        2     .003010     75.8     .000420    -.000155     -0.3
  2        4     .003010     75.6     .000420    -.000155     -0.5
  3       10     .003010     75.4     .000420    -.000035     -0.4
  4       20     .003020     75.1     .000450    -.000065     -0.4
  5       40     .003010     74.7     .000450    -.000055     -0.7
  6      100     .003020     74.1     .000460    -.000045     -0.7
  7      200     .003010     72.5     .000540    -.000135     -1.8


PLOT?
?N
```

MP8630* 14 Precycled

DFD 8/06/79



N_f = 16,500

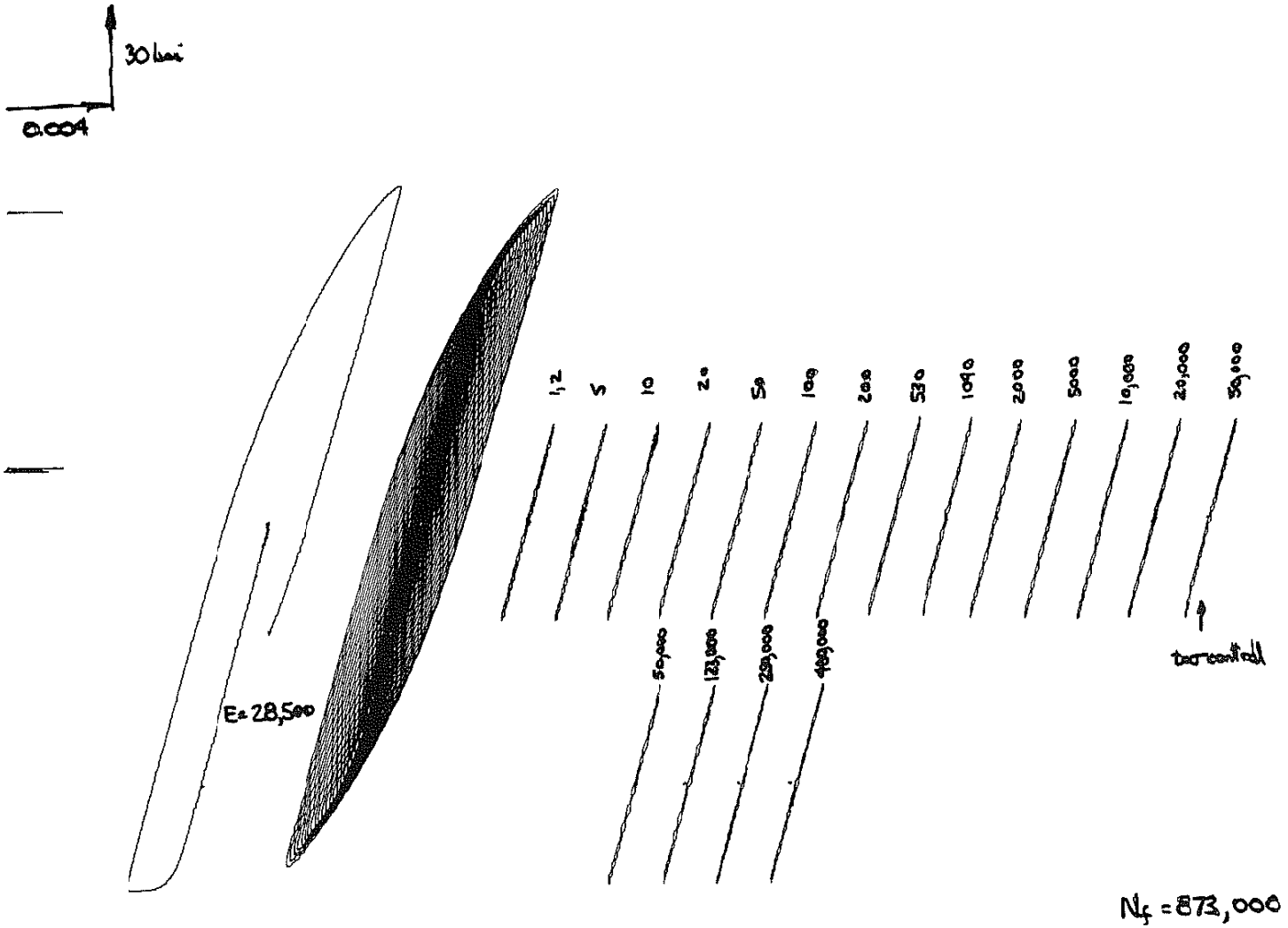
```
**********************************************************************
********** MP 8630 #14          **************************
********** PRECYCLED            **************************
**********************************************************************
OUTPUT IN ENG. VALUES
?N
OUTPUT IN TRUE VALUES
?Y


PEAKS
?N
RANGES(R) OR AMPLITUDES(A) OR BOTH(B) OR NONE(N)
?A


TRUE STRESS & STRAIN AMPLITUDES & MEANS
```

N	REV	E	S	EP	E0	S0
1	2	.001490	45.9	.000078	.000029	-0.5
2	4	.001490	45.9	.000078	.000029	-0.5
3	10	.001480	45.9	.000068	-.000022	-0.5
4	20	.001460	46.0	.000045	-.000001	-0.5
5	40	.001460	45.8	.000050	-.000022	-0.6
6	100	.001480	46.0	.000065	-.000022	-0.8
7	200	.001490	46.0	.000073	-.000072	-1.1
8	400	.001470	45.9	.000058	.000029	-1.1
9	1000	.001460	46.0	.000043	-.000022	-1.4
10	2000	.001470	46.3	.000044	-.000012	-1.1
11	4000	.001480	46.2	.000058	-.000002	-1.0
12	10000	.001450	46.3	.000024	-.000011	-1.4
13	20000	.001490	46.7	.000055	.000029	0.4

```
PLOT?
?NN#W#
N
```

MP 8630 # 1B PRECYCLED

DFD 8/08/74



$N_f = 873,000$

```
**********************************************************************
****************** MP 8630 #01B        ***********************
****************** PRECYCLED           ***********************
**********************************************************************
OUTPUT IN ENG. VALUES
?N
OUTPUT IN TRUE VALUES
?Y


PEAKS
?N
RANGES(R) OR AMPLITUDES(A) OR BOTH(B) OR NONE(N)
?A


TRUE STRESS & STRAIN AMPLITUDES & MEANS
```

N	REV	E	S	EP	EØ	SØ
1	2	.000970	28.3	-.000005	-.000071	-0.0
2	4	.000970	28.3	-.000005	-.000071	-0.0
3	10	.000990	28.2	.000018	-.000031	0.0
4	20	.000980	28.3	.000002	-.000021	0.0
5	40	.000980	28.3	.000005	-.000041	0.1
6	100	.000980	28.3	.000002	-.000061	0.0
7	200	.000980	28.4	-.000000	-.000021	0.1
8	400	.000990	28.4	.000010	-.000051	0.1
9	1060	.000960	28.4	-.000020	-.000061	1.3
10	2080	.000970	28.4	-.000010	-.000011	1.0
11	4000	.000980	28.3	.000002	-.000161	0.2
12	10000	.000980	28.3	.000002	-.000041	0.0
13	20000	.000990	28.4	.000010	-.000011	-0.0
14	40000	.000970	28.3	-.000008	-.000031	0.0
15	100000	.000970	28.4	-.000010	.000049	-0.0
16	246000	.000950	28.5	-.000033	.000129	-0.3
17	500000	.000990	28.6	.000005	.000169	-0.2
18	960000	.000990	28.5	.000007	.000229	-0.1

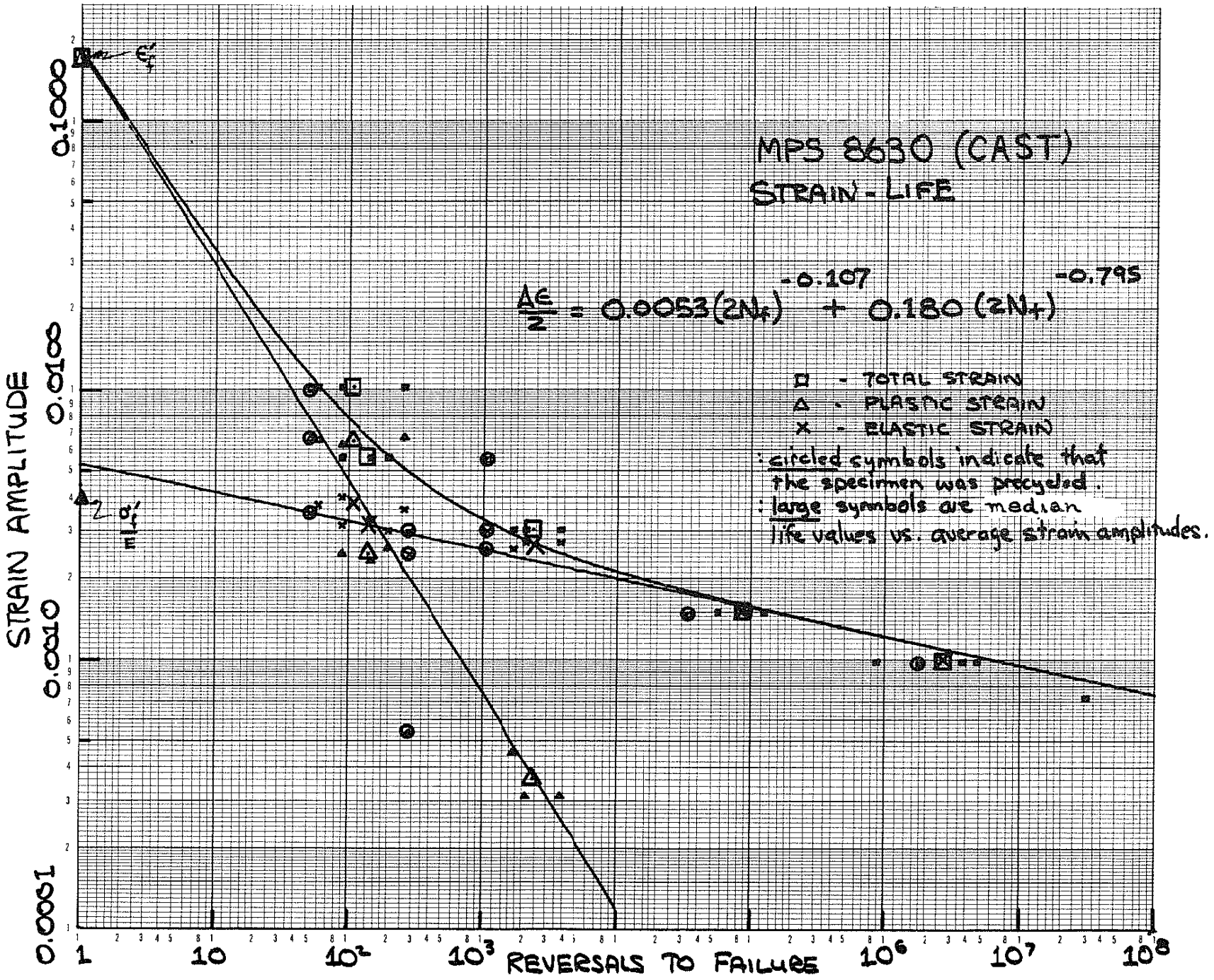
```
PLOT?
?N
```

STRAIN-LIFE RESULTS

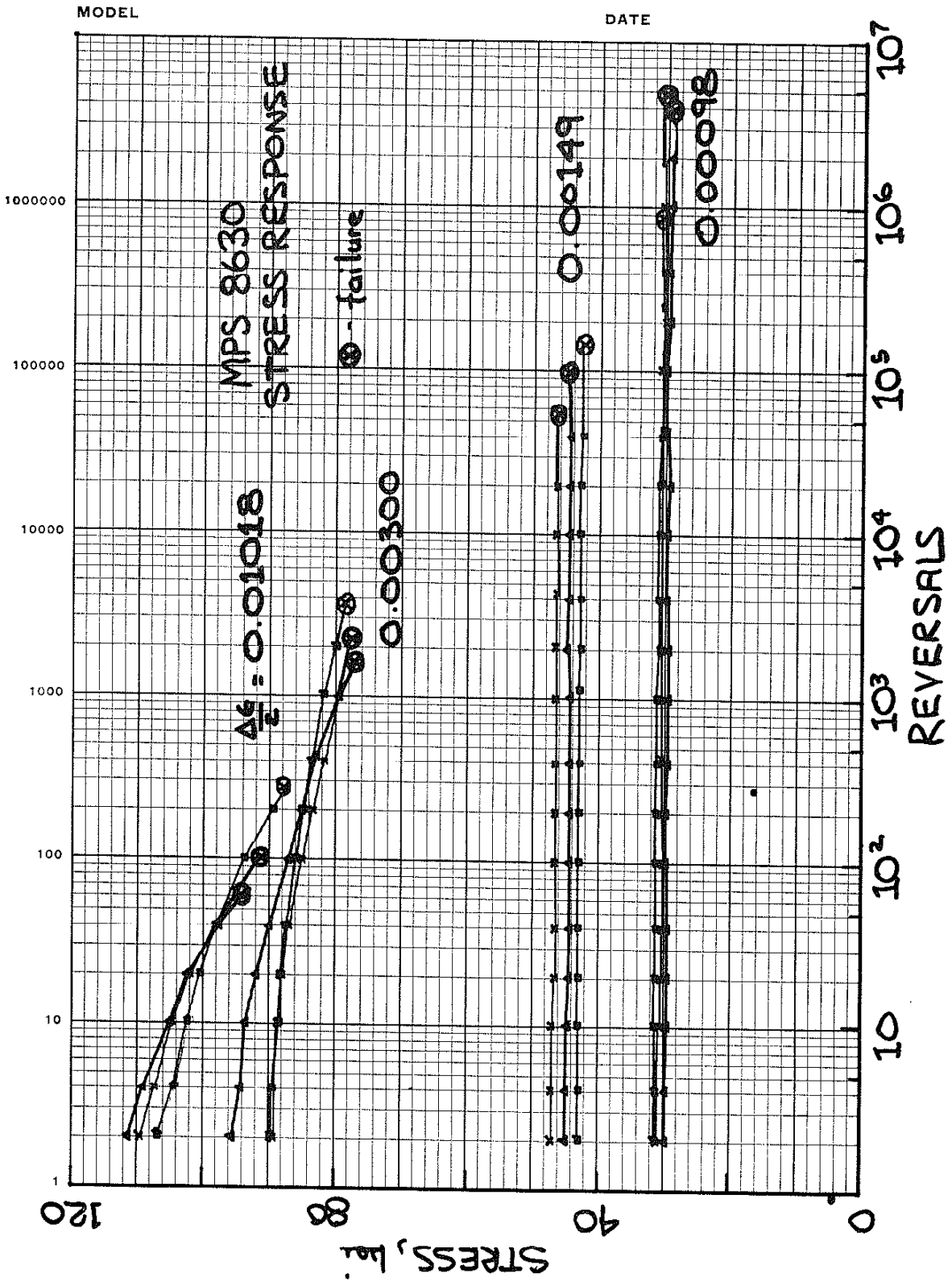
STRAIN-LIFE RESULTS FOR CAST 8630 STEEL

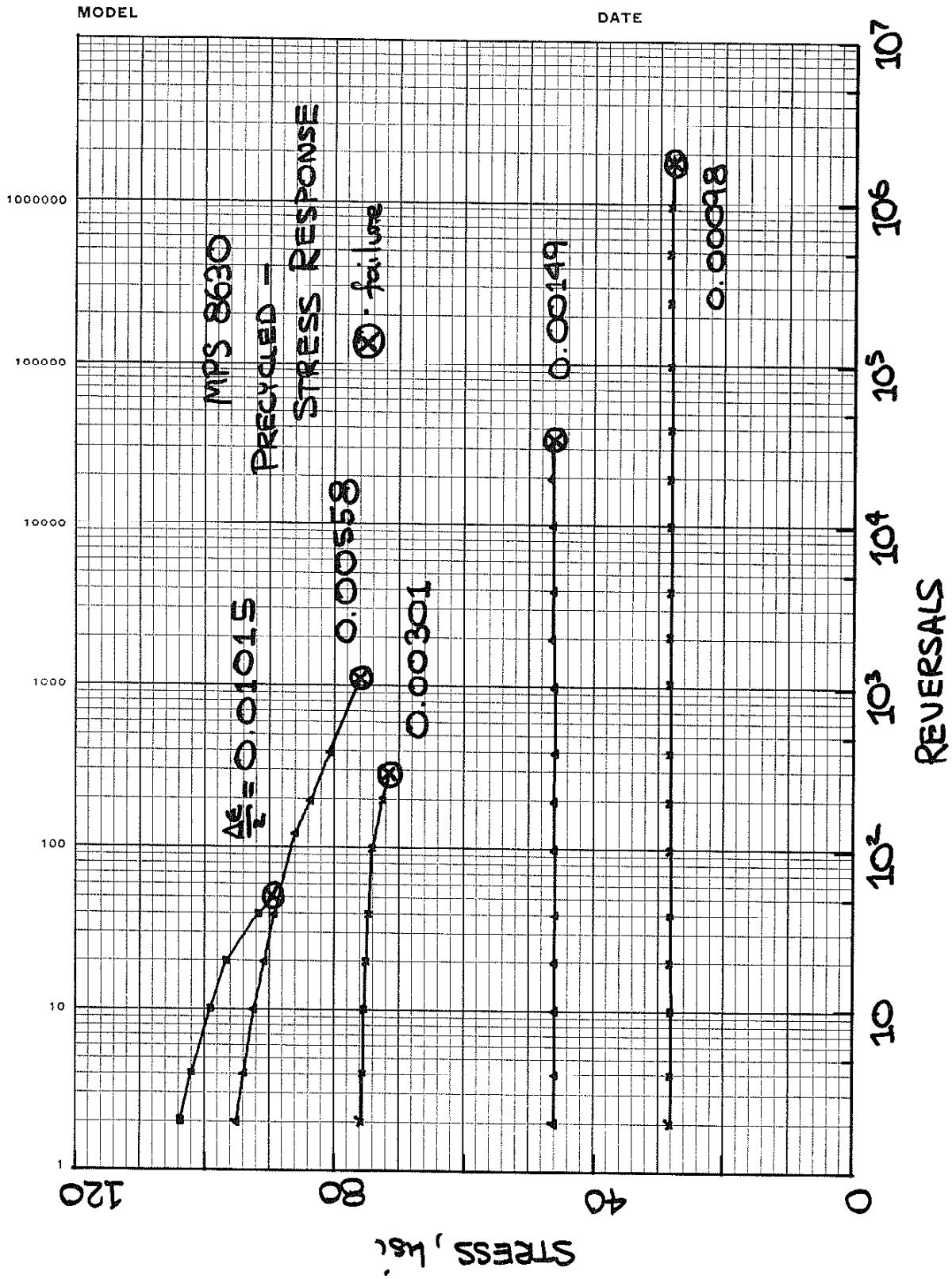
Spec. No.	Strain Amplitude $\Delta\epsilon/2$	Reversals to Failure $2N_f$	Elastic Strain Amplitude $\Delta\epsilon_e/2$	Plastic Strain Amplitude $\Delta\epsilon_p/2$	Saturation* Stress Amplitude $\Delta\sigma/2$, ksi
05	0.20	1	0.00465	0.20	124.2
12B	0.15	1	0.00446	0.15	120.2
02	0.17	1	0.00429	0.17	116.0
Median values	0.173	1	0.00447	0.173	120.1
19	0.01018	60	0.00373	0.00645	99.7
32A	0.01018	260	0.00358	0.00660	90.8
03	0.01018	90	0.00398	0.00620	98.0
Median values	0.01018	110	0.00376	0.00642	96.2
07	0.00558	90	0.00313	0.00245	94.5
28	0.00558	150	0.00328	0.00230	87.1
33	0.00557	200	0.00299	0.00258	87.4
Median values	0.00558	145	0.00314	0.00244	89.7
13B	0.00301	1,700	0.00256	0.00045	79.3
26	0.00301	2,100	0.00270	0.00031	79.7
23	0.00301	3,780	0.00270	0.00031	79.6
Median values	0.00301	2,400	0.00265	0.00036	79.5
10	0.00149	95,200	0.00149	---	44.3
30A	0.00149	55,000	0.00149	---	46.0
20	0.00149	123,800	0.00149	---	42.2
Median values	0.00149	92,000	0.00149	---	44.2
01A	0.00098	3.7×10^6	0.00098	---	29.1
21	0.00098	4.7×10^6	0.00098	---	30.4
11	0.00098	862,000	0.00098	---	30.1
Median values	0.00098	2.8×10^6	0.00098	---	29.9
13A	0.00072	29.86×10^6	0.00072	---	21.9
		Received an Initial Precycle			
32B	0.01015	52	0.00353	0.00662	94.0
30B	0.00558	1,050	0.00302	0.00256	---
12A	0.00301	280	0.00247	0.00054	72.5
14	0.00149	33,000	0.00149	---	46.5
01B	0.00098	1,746,000	0.00098	---	28.5

*Measured at 50% of life to failure


MPS 8630 (CAST)
STRAIN - LIFE
$\frac{\Delta\epsilon}{2} = 0.0053(2N_f)^{-0.107} + 0.180(2N_f)^{-0.795}$
□ - TOTAL STRAIN
△ - PLASTIC STRAIN
× - ELASTIC STRAIN
: circled symbols indicate that the specimen was precycled.
: large symbols are median life values vs. average strain amplitudes.
ϵ_f'
$2\frac{\sigma_f'}{E}$
STRAIN AMPLITUDE
0.1000
0.0100
0.0010
0.0001
1
10
10^2
10^3
REVERSALS TO FAILURE
10^6
10^7
10^8

STRESS-TIME RESPONSE TO CONTROLLED STRAIN FATIGUE TESTS

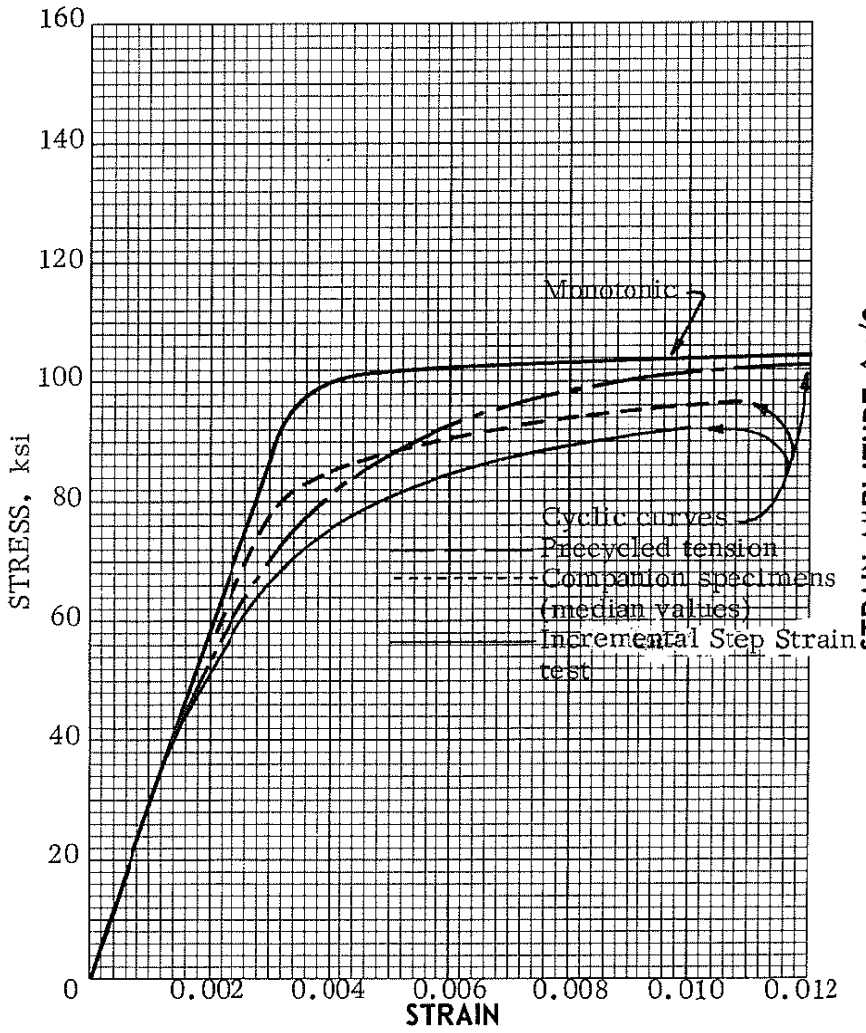

MODEL
DATE
MPS 8630
STRESS RESPONSE
⊗ - failure
$\Delta\varepsilon/2$ = 0.01018
0.00300
0.0149
0.00098
1000000
100000
10000
1000
100
10
1
10^7
10^6
10^5
10^4
10^3
10^2
10
REVERSALS
120
80
40
0
STRESS, ksi

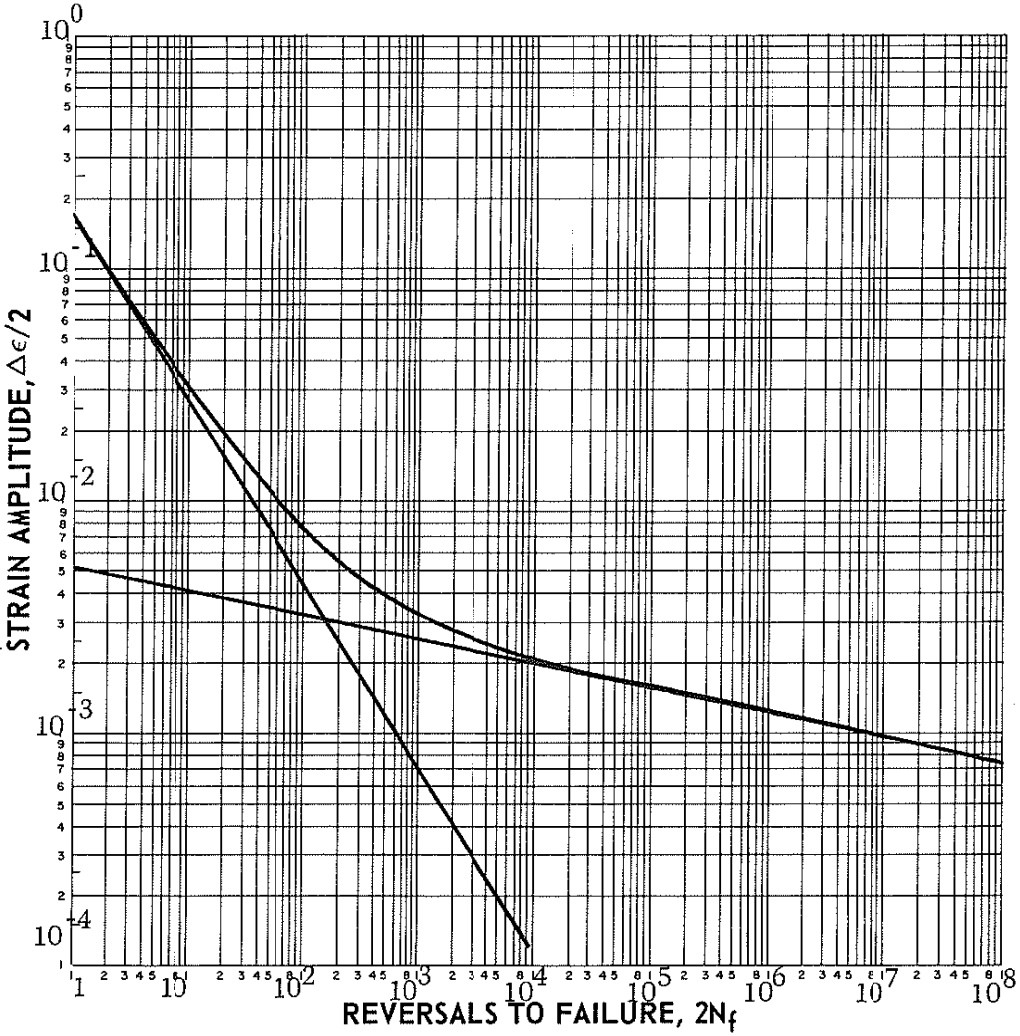

MODEL
DATE
MPS 8630
PRECYCLED - STRESS RESPONSE
⊗ - failure
$\frac{\Delta\varepsilon}{2}$ = 0.01015
0.00558
0.00301
0.00149
0.00098
1000000
100000
10000
1000
100
10
1
10^7
10^6
10^5
10^4
10^3
10^2
10
REVERSALS
120
80
40
0
STRESS, ksi

ADDITIONAL MATERIAL CHARACTERIZATION SHEETS

Material: MPS Cast 8630 (Mn. modified) **Hardness:** 254 ± 5 BHN

Condition: Normalized & Tempered





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DATA SHEET FOR MATERIAL CHARACTERIZATION

Material: MPS Cast 8630 (Mn. modified)

Condition: Normalized & Tempered

[1600-1650°F /½ hr/1" thick; 1050-1100°F/hr/1" thick]

Monotonic Properties:

Modulus of Elasticity, E	29.0×10^3 ksi
Yield Strength, 0.2% S_y	103 ksi
Ultimate Strength, S_u	114 ksi
Red. in Area, % RA	16
True Fracture Strength, σ_f	122 ksi
True Fracture Ductility, ϵ_f	0.17
Strain Hardening Exponent, n	0.08
Strength Coefficient, K	154 ksi
True Toughness, U_p	30×10^3 in-lb/in^3
Poisson's Ratio	---

Composition:

w/o C	= 0.34	w/o Mo	= 0.28
w/o Si	= 0.49	w/o Cu	= ---
w/o P	= 0.027	w/o Ni	= 0.76
w/o S	= 0.028	w/o Va	= ---
w/o Mn	= 1.20	w/o Al	= ---
w/o Cr	= 0.85	w/o B	= ---

Grain Size: 8 ASTM

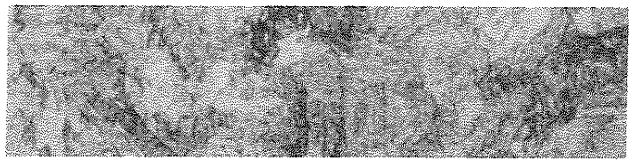
Eutectic Cell Size (Cast Irons):

Matrix Hardness: 254 ± 5 BHN

Converted from: R_c

Cyclic Properties: (Please see text of report)

Yield Strength, 0.2% S_y'	80 ksi*
Strain Hardening Exponent, n'	0.086#
Strength Coefficient, K'	154 ksi#
Fatigue Strength Coefficient, σ_f'	116 ksi#*
Fatigue Ductility Coefficient, ϵ_f'	0.17#*
Fatigue Strength Exponent, b	-0.107**
Fatigue Ductility Exponent, c	-0.795**
Transition Fatigue Life, $2N_t$	200 rev**



Microstructure: Tempered martensite, very fine grained.

Magnification: 0.002"

Comments: *from incremental step-strain test results
#determined by least square fit of log σ vs. log ϵ_p data from precycled tension test and companion specimen results
#*from incrementally precycled sample pulled in tension
**from least square analysis of companion specimen strain-life results.

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