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LAWRENCE RADIATION LABORATORY - UNIVERSITY OF CALIFORNIA

# ENGINEERING NOTE

| CODE | SERIAL | PAGE |
|---|---|---|
| BW/4350 | M5511 | 1 OF 80 |

| AUTHOR | DEPARTMENT | LOCATION | DATE |
|---|---|---|---|
| ROBERT YAMAMOTO | MECHANICAL ENGIN. | BERKELEY | APRIL 21, 1980 |

PROGRAM — PROJECT — JOB

HEAVY ION SPECTROMETER SYSTEM — HISS

MAGNET CRYOSTAT

TITLE

## SUPPORT CYLINDER

SUMMARY:

KEEPING HEAT LOAD TO A MINIMUM WHILE STILL MAINTAINING STRUCTURAL STRENGTH & INTEGRITY ARE THE MAIN CONSIDERATIONS USED IN THE DESIGN OF THE SUPPORT CYLINDER FOR THE HISS MAGNET CRYOSTAT. MATERIALS CONTEMPLATED FOR USE WERE 304 LN STAINLESS STEEL & TITANIUM 6AL-4V. BECAUSE OF THE NON-LINEARITY OF YIELD STRESS & THERMAL CONDUCTIVITY AS A FUNCTION OF TEMP., A HEWLETT PACKARD SYSTEM 45B DESKTOP COMPUTER WAS USED TO ANALYZE THIS PROBLEM.

THE TEMPERATURE GRADIENT ALONG THE SUPPORT CYLINDER'S LENGTH WAS COMPUTED USING INTEGRATION TECHNIQUES. BY KEEPING THE DESIGN STRESS OF THE CYLINDER CONSTANT THROUGHOUT THE TEMPERATURE GRADIENT, THE CROSS-SECTIONAL AREA (i.e. WALL THICKNESS) OF THE SUPPORT CYLINDER AS A FUNCTION OF CYLINDER LENGTH COULD BE DETERMINED FOR A GIVEN TEMPERATURE RANGE. HENCE, THE OPTIMUM DESIGN OF MINIMUM AREA (i.e. MINIMUM HEAT LOAD) VS. MATERIAL STRESS IS ACHEIVED.

THIS ENGINEERING NOTE COMPUTES & PRESENTS THE FOLLOWING DATA FOR BOTH MATERIALS FOR THE TWO TEMPERATURE RANGES NEEDED; 4.2°K TO 80°K & 82°K TO 290°K:

1. TOTAL CYLINDER HEAT LOAD AS A FUNCTION OF TEMPERATURE RANGE **
2. GRAPH OF MATERIAL YIELD STRESS VS. TEMPERATURE *1.
3. GRAPH OF THERMAL CONDUCTIVITY VS. TEMPERATURE *2.
4. GRAPH OF THERMAL CONDUCTIVITY / YIELD STRESS VS. TEMPERATURE **

* INPUT DATA

** CALCULATED DATA

5. GRAPH OF $\int_{T_1}^{T_2} \frac{\text{THERMAL COND.}}{\text{YIELD STRESS}}$ VS. TEMPERATURE **

6. GRAPH OF SUPPORT CYLINDER LENGTH VS. TEMP. **
7. GRAPH OF DESIGN STRESS IN SUPPORT CYLINDER VS. SUPPORT CYLINDER LENGTH. **
8. GRAPH OF CROSS-SECTIONAL AREA OF SUPPORT CYLINDER VS. SUPPORT CYLINDER LENGTH.**

** CALCULATED DATA

CALCULATIONS: 3.

THE FOLLOWING DERIVATION WAS USED TO CALCULATE THE ABOVE PARAMETERS:

BASIC CONDUCTION HEAT TRANSFER EQUATION:

$$Q = KA \frac{dT}{dx}$$

where $Q$ = HEAT LOAD (watts)
$K$ = THERMAL CONDUCTIVITY (watts / in - °K)
$A$ = CROSS-SECTIONAL AREA $(in)^2$
$\frac{dT}{dx}$ = TEMPERATURE GRADIENT IN DIRECTION OF HEAT FLOW (°K / in.)

BASIC STRESS EQUATION:

$$\sigma = \frac{F}{A}$$

where $\sigma$ = STRESS (lbs / in²)
$F$ = FORCE (lbs)
$A$ = CROSS-SECTIONAL AREA $(in)^2$

SINCE THERMAL CONDUCTIVITY & YIELD STRESS ARE A FUNCTION OF TEMPERATURE, THE ABOVE EQUATIONS ARE AS FOLLOWS:

$$Q = K(T)\, A \frac{dT}{dx} \qquad \sigma(T) = \frac{F}{A}, \quad A = \frac{F}{\sigma(T)}$$

SUBSTITUTING FOR CROSS SECTIONAL AREA:

$$Q = F \frac{K(T)}{\sigma(T)} \frac{dT}{dx}$$

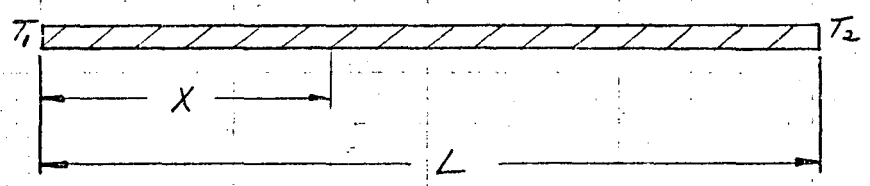
$$Q\,dx = F \frac{K(T)}{\sigma(T)}\, dT$$

INTEGRATING WITH RESPECT TO 'X' (LENGTH) & 'T' (TEMP.)

$$Q \int_0^X dx = F \int_{T_1}^{T_2} \frac{K(T)}{\sigma(T)}\, dT \qquad \text{OR}$$

$$QL = F \int_{T_1}^{T_2} \frac{K(T)}{\sigma(T)}\, dT$$

where $L$ = TOTAL LENGTH OF SUPPORT CYLINDER (in.)




TOTAL HEAT LOAD $Q = \frac{F}{L} \int_{T_1}^{T_2} \frac{K(T)}{\sigma(T) \cdot Z}\, dT$ OR

$$\boxed{Q = \frac{F}{L \cdot Z} \int_{T_1}^{T_2} \frac{K(T)}{\sigma(T)}\, dT \qquad \text{where } Z = \text{STRESS FACTOR}}$$

$Z = 0.666666$ FOR 304 LN STAINLESS STEEL

$Z = 0.333333$ FOR TITANIUM 6AL-4V

TEMPERATURE DISTRIBUTION ALONG THE SUPPORT CYLINDER LENGTH:

$$\int_0^x dx = \frac{F}{Q}\int_{T_1}^{T_2} \frac{K(T)}{\sigma(T)\cdot Z}\,dT$$

$$X(T) = \frac{F}{Q}\int_{T_1}^{T_2} \frac{K(T)}{\sigma(T)\cdot Z}\,dT$$

SUBSTITUTING IN FOR Q:

$$X(T) = \frac{F\int_{4.2°K}^{T_2} \frac{K(T)}{\sigma(T)\cdot Z}\,dT}{\frac{F}{L\cdot Z}\int_{4.2°K}^{80°K} \frac{K(T)}{\sigma(T)}\,dT}$$

OR

$$\boxed{X(T) = \frac{L\int_{4.2°K}^{T_2} \frac{K(T)}{\sigma(T)}\,dT}{\int_{4.2°K}^{80°K} \frac{K(T)}{\sigma(T)}\,dT}}$$

FINALLY, THE CROSS-SECTIONAL AREA OF THE SUPPORT CYLINDER IS:

$$\boxed{A(T) = \frac{F}{\sigma(T)\cdot Z}}$$

DATA:

TOTAL CYLINDER HEAT LOAD AS A FUNCTION OF TEMPERATURE RANGE: $T_1 = 4.2°K$ (see graph)

| $T_2$ (°K) | 304 LN STAINLESS STEEL | TITANIUM 6AL-4V |
|---|---|---|
| 77 | 29.33 WATTS | 13.73 WATTS |
| 78 | 30.12 | 14.06 |
| 79 | 30.92 | 14.40 |
| 80 | 31.73 | 14.75 |
| 81 | 32.54 | 15.09 |
| 82 | 33.37 | 15.44 |
| 83 | 34.20 | 15.79 |
| 84 | 35.04 | 16.15 |
| 85 | 35.89 | 16.51 |
| 86 | 36.76 | 16.88 |
| 87 | 37.62 | 17.25 |
| 88 | 38.50 | 17.62 |
| 89 | 39.39 | 17.99 |
| 90 | 40.29 WATTS | 18.37 WATTS |

RESULTS & CONCLUSIONS:

| MATERIAL | HEAT LOAD (watts) | TEMP. RANGE | STRESS FACTOR Z |
|---|---|---|---|
| 304 LN STAINLESS STEEL | 31.73 | 4.2°K → 80°K | 0.666666 |
| TITANIUM 6AL-4V | 14.75 | 4.2°K → 80°K | 0.333333 |
| 304 LN STAINLESS STEEL | 1369 | 82°K → 290°K | 0.666666 |
| TITANIUM 6AL-4V | 547 | 82°K → 290°K | 0.333333 |

304 LN STAINLESS STEEL WAS CHOSEN AS THE SUPPORT CYLINDER MATERIAL FOR THE FOLLOWING REASONS:

1. 304 LN STAINLESS STEEL HEAT LOAD JUDGED BARELY ACCEPTABLE.
2. 304 LN STAINLESS STEEL MATERIAL IS AVALIABLE FROM LIVERMORE LAB.
3. TITANIUM 6 AL-4V PLATE HAS A LEAD TIME WHICH IS UNACCEPTABLE TO THE SCHEDULE.
4. TITANIUM 6AL-4V HAS POTENTIAL WELDING PROBLEMS.
5. TITANIUM 6AL-4V HAS FRACTURE TOUGHNESS PROBLEMS AT CRYOGENIC TEMPERATURES.

THE SUPPORT CYLINDER IS APPROXIMATELY 92 IN. IN DIAMETER & 19 IN. IN LENGTH. WALL THICKNESS WILL BE TAPPERED FOLLOWING THE GRAPHS OF CROSS-SECTIONAL AREA OF SUPPORT CYLINDER VS. SUPPORT CYLINDER LENGTH. A LN COOLING TUBE WILL BE WELDED (OR BRAZED) ONTO THE SUPPORT CYLINDER AT A DISTANCE OF ABOUT 11 IN. FROM THE LIQUID HELIUM END OF THE CYLINDER TO REDUCE THE HEAT LOAD. (i.e. LIQUID HELIUM CONSUMPTION) HENCE, THE TEMPERATURE RANGES WILL BE FROM LHe (4.2°K) TO LN TEMP (80°K) & FROM LN TEMP (82°K; CONDUCTION LOSES) TO ROOM TEMP. (290°K)

# REFERENCES

1. YIELD STRESS VS. TEMPERATURE DATA FOR 304 LN STAINLESS STEEL SUPPLIED BY DICK REIMERS. (FROM LLL)

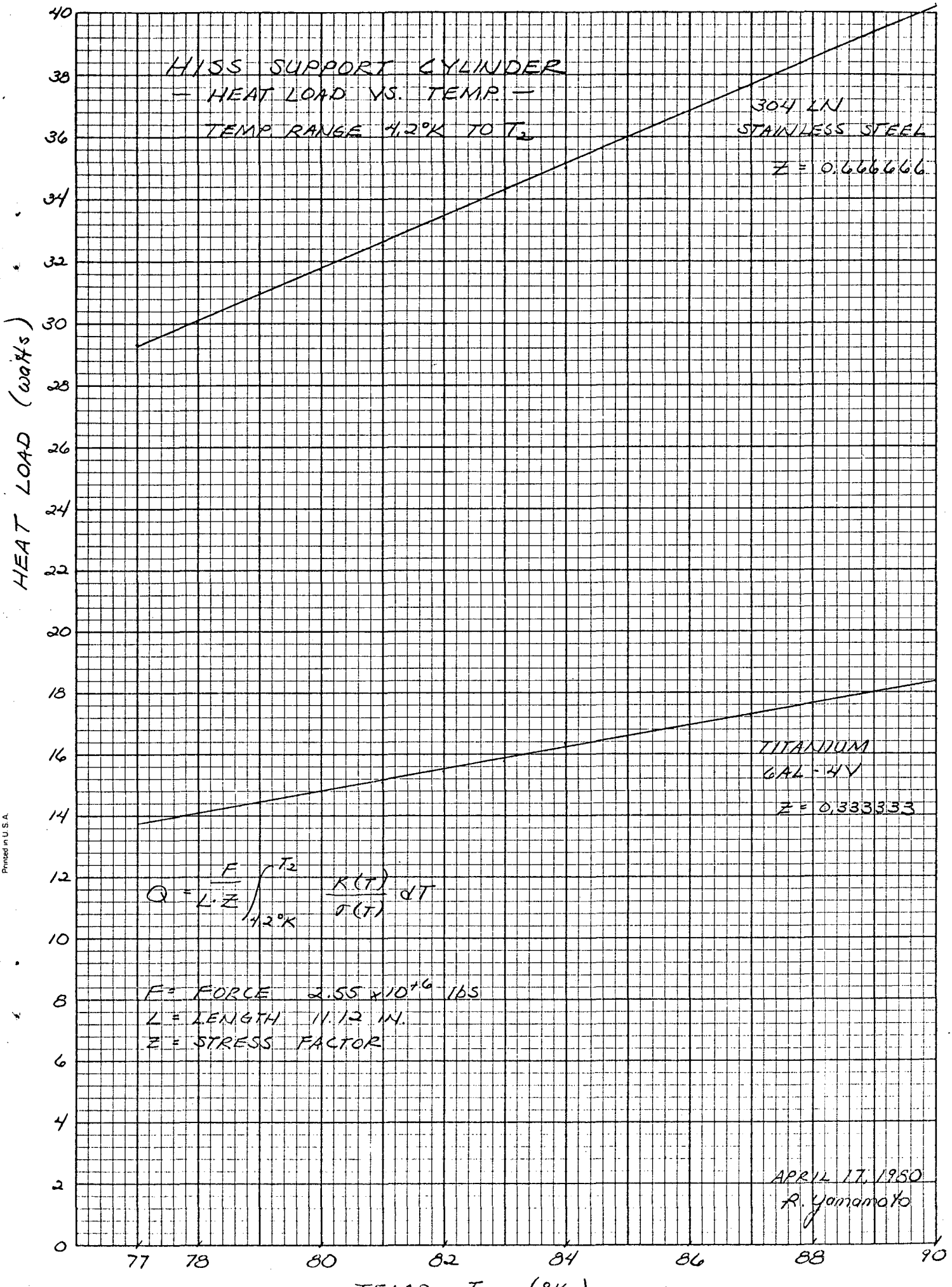
   YIELD STRESS VS. TEMPERATURE DATA FOR TITANIUM 6AL-4V SUPPLIED BY YOICHI KAJIYAMA.

2. THERMAL CONDUCTIVITY VS. TEMPERATURE DATA FOR 304 STAINLESS STEEL SUPPLIED BY ROBERT YAMAMOTO

   THERMAL CONDUCTIVITY VS. TEMPERATURE DATA FOR TITANIUM 6AL-4V SUPPLIED BY DICK WOLGAST.

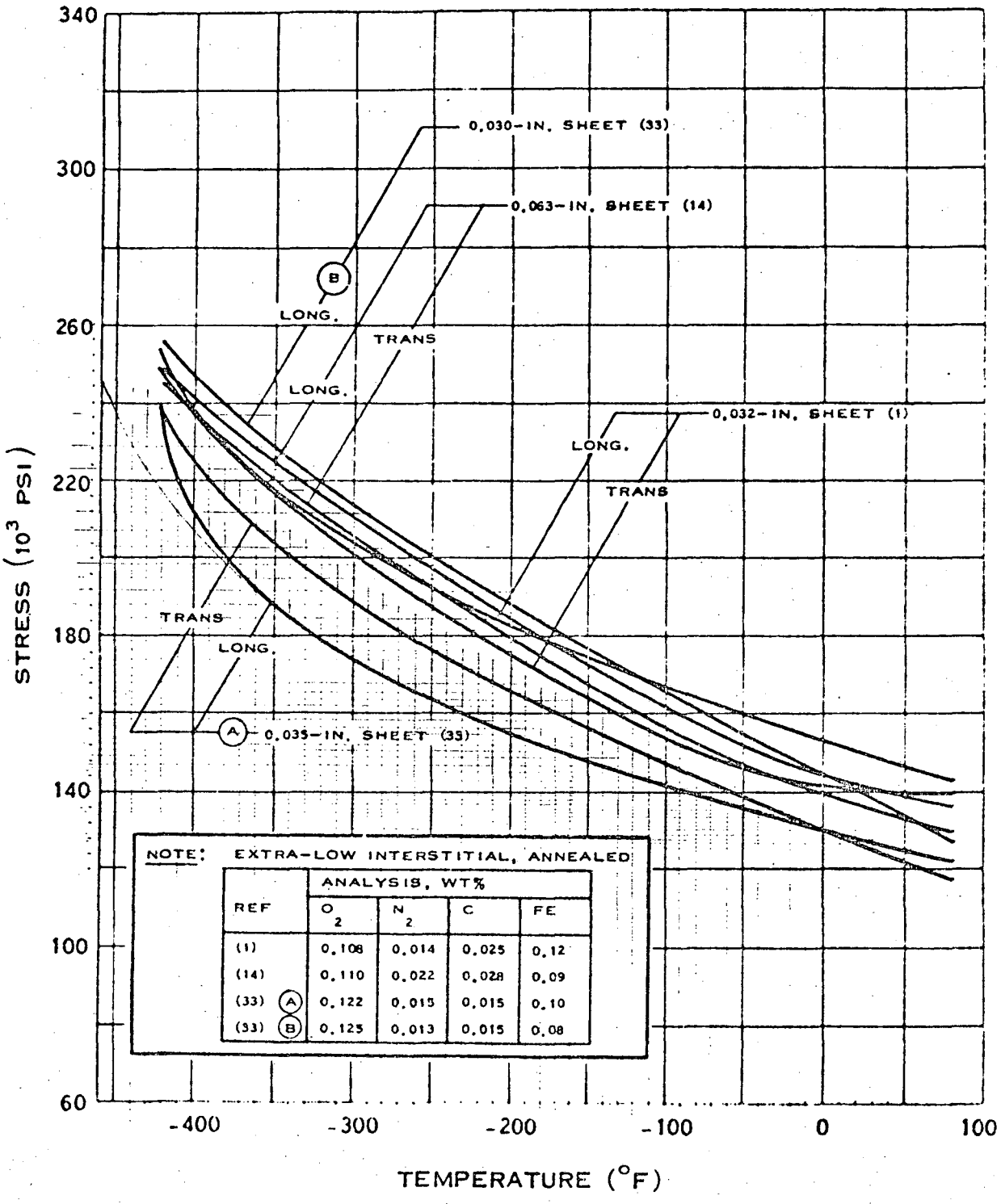
3. DERIVATION OF FORMULAS FROM COMMUNICATIONS WITH JACK TANABE.

4. SEE LBL DRAWING # 19F7886




GRAPH PAPER GRAPHIC CONTROLS CORPORATION Buffalo, New York Printed in U.S.A. SQUARE 5 X 5 TO THE HALF INCH AS-08111-60

C.7.a




| REF | ANALYSIS, WT% | | | |
|---|---|---|---|---|
| | $O_2$ | $N_2$ | C | FE |
| (1) | 0.108 | 0.014 | 0.025 | 0.12 |
| (14) | 0.110 | 0.022 | 0.028 | 0.09 |
| (33) A | 0.122 | 0.015 | 0.015 | 0.10 |
| (33) B | 0.125 | 0.013 | 0.015 | 0.08 |

YIELD STRENGTH OF 6Al-4V TITANIUM

13.301

# THERMAL CONDUCTIVITY INTEGRALS

## for FERROUS ALLOYS

Source of Data: Data Sheet 3.301: Thermal Conductivity of Ferrous Alloys.

Comments: In the table of values below, all the thermal conductivity curves for Ferrous Alloys, with the exception of Stainless, have been extrapolated. Of the extrapolated curves, all have been extrapolated to 4°K, and all except SAE 1020 and SAE 4130 have been extrapolated to 300°K. It is estimated that the extrapolated values deviate no more than 10% from the probable values.

$$Q = \frac{A}{L} \int_{T_o}^{T_L} \lambda \, dT; \qquad Q \frac{L}{A} = \int_{T_o}^{T_L} \lambda \, dT$$

Where:

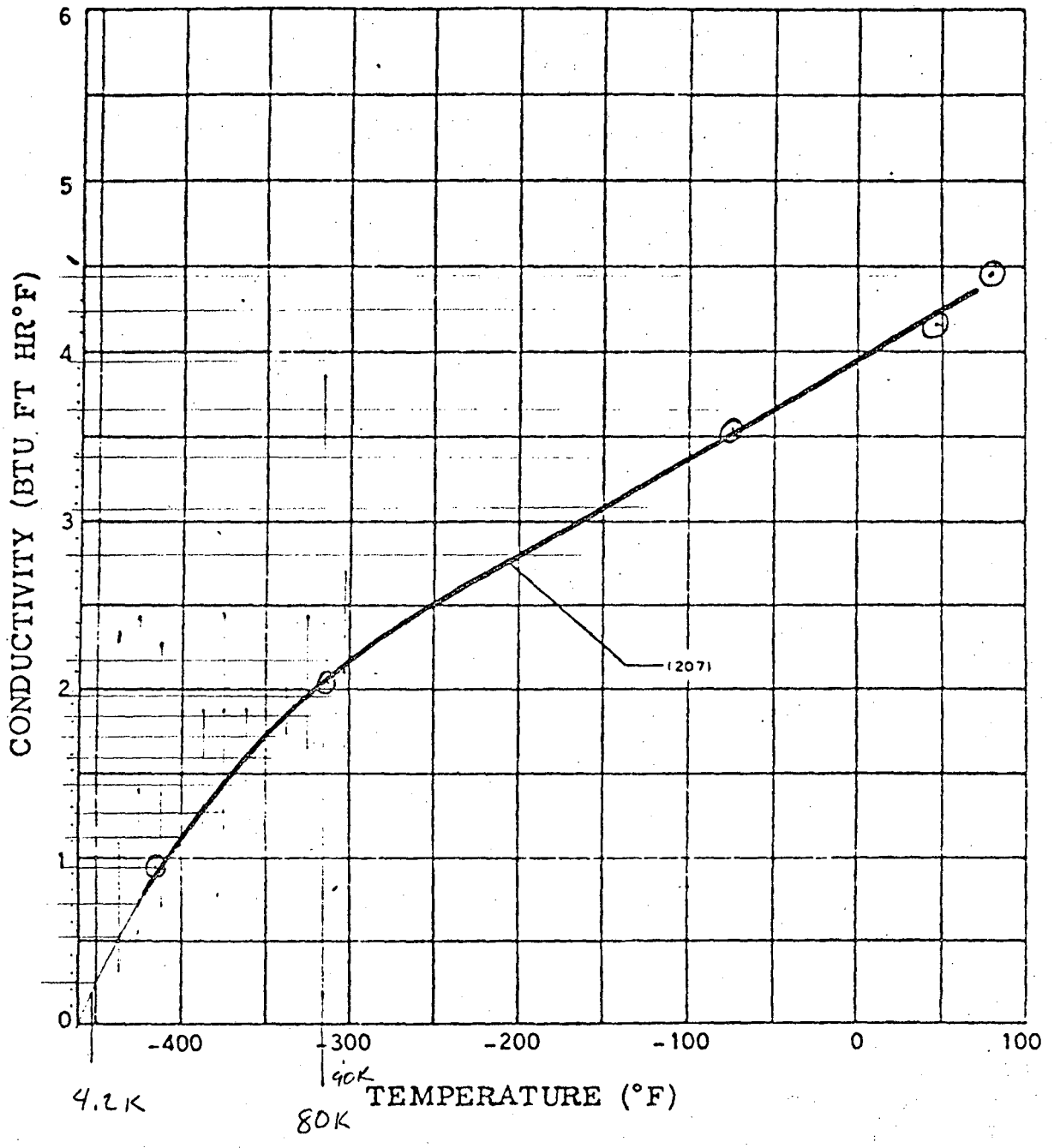
- Q = heat of flow in watts
- A = cross sectional area in $cm^2$
- L = length in cm
- λ = thermal conductivity in watts/cm-°K
- T = temperature in °K
- $T_o$ = initial temperature (4°K)

Thermal Conductivity Integrals are on the following page.

| Temp. °K | Thermal Conductivity watts/cm-°K | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | SAE 1020 | MILD 0.1% C | SAE 1095 | SAE 4130 | 410 | 4% Al | 13% Cr Quenched | Stain-less | 24% Ni |
| 4 | .030* | .025* | .011* | .0075* | .0045* | .0045* | .0032* | .0024 | .0018* |
| 6 | .058* | .050* | .019* | .013 * | .0070* | .0070* | .0055* | .0039 | .0033* |
| 8 | .085* | .073* | .027* | .018 * | .010 * | .010 * | .0080* | .0057 | .0050* |
| 10 | .115* | .100* | .035* | .023 * | .013 * | .013 * | .010 * | .0077 | .0067* |
| 15 | .180* | .157 | .060* | .040 * | .020 * | .020 | .0165 | .0132 | .0115 |
| 20 | .24 * | .22 | .080* | .060 * | .035 * | .033 | .024 | .0195 | .0165 |
| 25 | .28 | .27 | .108 | .078 | .050 | .045 | .032 | .026 | .021 |
| 30 | .32 | .31 | .130 | .100 | .070 | .054 | .040 | .033 | .025 |
| 35 | .37 | .34 | .157 | .120 | .090 | .060 | .048 | .040 | .029 |
| 40 | .40 | .37 | .180 | .137 | .108 | .066 | .056 | .047 | .032 |
| 50 | .48 | .42 | .22 | .170 | .135 | .080 | .070 | .058 | .039 |
| 60 | .53 | .48 | .26 | .195 | .157 | .092 | .082 | .068 | .045 |
| 70 | .57 | .51 | .29 | .22 | .177 | .108 | .095 | .076 | .051 |
| 76 | .59 | .53 | .30 | .23 | .183 | .115 | .100 | .080 | .054 |
| 80 | .60 | .54 | .31 | .24 | .19 | .120 | .105 | .083 | .057 |
| 90 | .61 | .57 | .33 | .27 | .20 | .135 | .113 | .090 | .062 |
| 100 | .63 | .59* | .34 | .27 | .21 | .150 | .120 | .095 | .068 |
| 120 | .65 | .60* | .37 | .30 | .23 | .160* | .140* | .103 | .077* |
| 140 | .65 | .60* | .38 | .32 | .24 | .180* | .150* | .110 | .085* |
| 160 | .65 | .60* | .40 | .33 | .25 | .190* | .160* | .120 | .090* |
| 180 | .65 | .60* | .41 | .34 | .255 | .20 * | .165* | .123 | .100* |
| 200 | .65 | .60* | .43 | .35 | .26 | .21 * | .17 * | .13 | .107* |
| 250 | .65 | .60* | .45 | .35 | .27 | .22 * | .18 * | .14 | .120* |
| 300 | .65 | .60* | .45* | .35 | .28* | .23 * | .19 * | .15 | .130* |

* Extrapolated Values

C.7.v




THERMAL CONDUCTIVITY OF 6Al-4V TITANIUM

POINTS FROM ACE 8

100

16-6H

INPUT PARAMETERS AND RESULTS:
APRIL 21, 07:12 and 55 sec.

THIS OUTPUT IS FOR 304 LN STAINLESS STEEL

THE TEMPERATURE RANGE IS BETWEEN 4.2 deg K AND 80 deg K

THE FORCE EXERTED ON THE SUPPORT IS 2550000 LBS

THE LENGTH OF THE SUPPORT IS 11.12 INCHES

THE YIELD STRESS FACTOR IS .666666

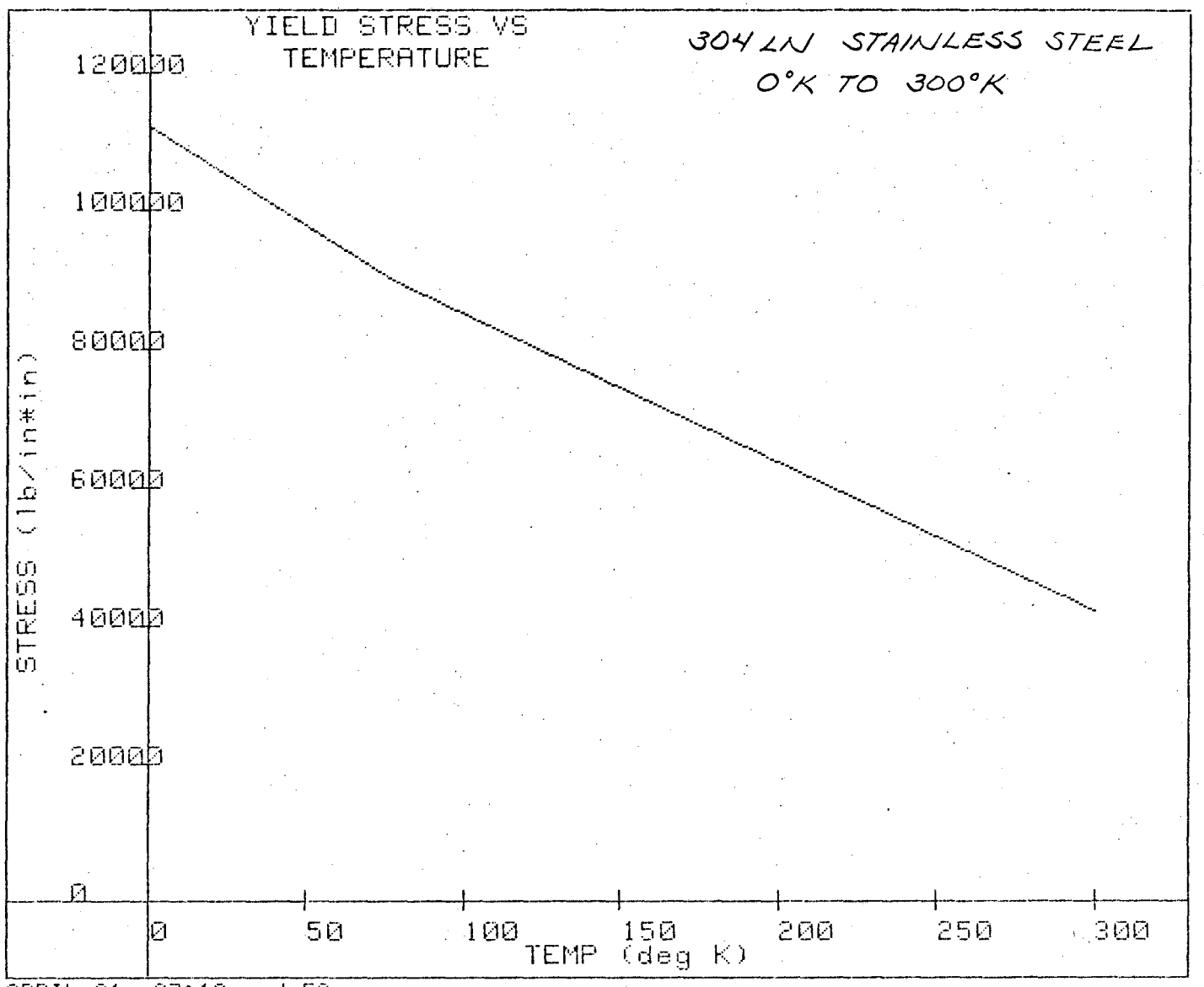
THE NUMBER OF YIELD STRESS INPUT POINTS IS 3

THE NUMBER OF THERMAL CONDUCTIVITY INPUT POINTS IS 18

THE TEMPERATURE INCREMENT IS .765656565657

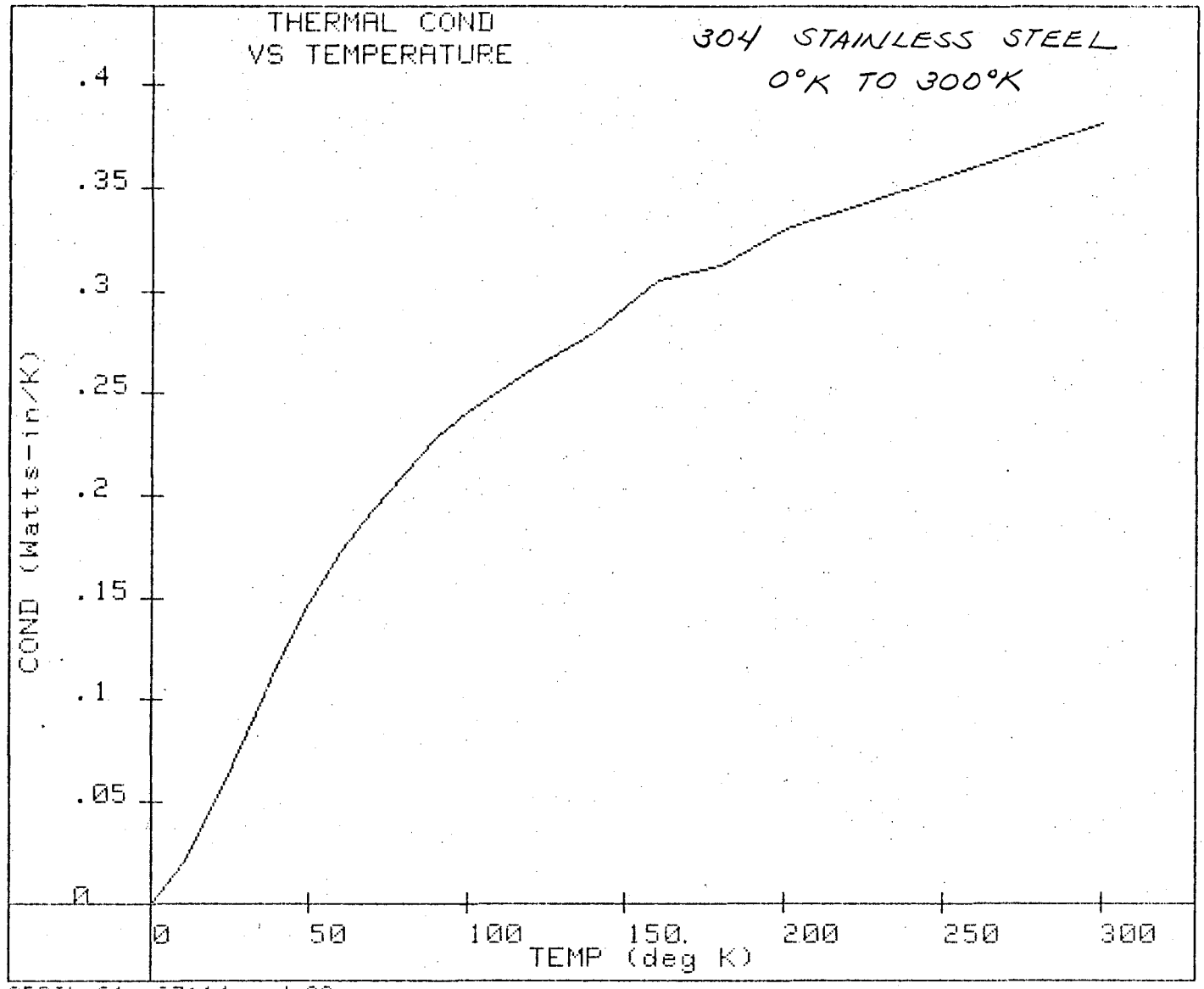
THE FINAL INTEGRAL FROM 4.2 TO 80 deg K IS 9.22347949517E-05

THE HEAT LOAD ON THE SUPPORT IS 31.726478731 watts



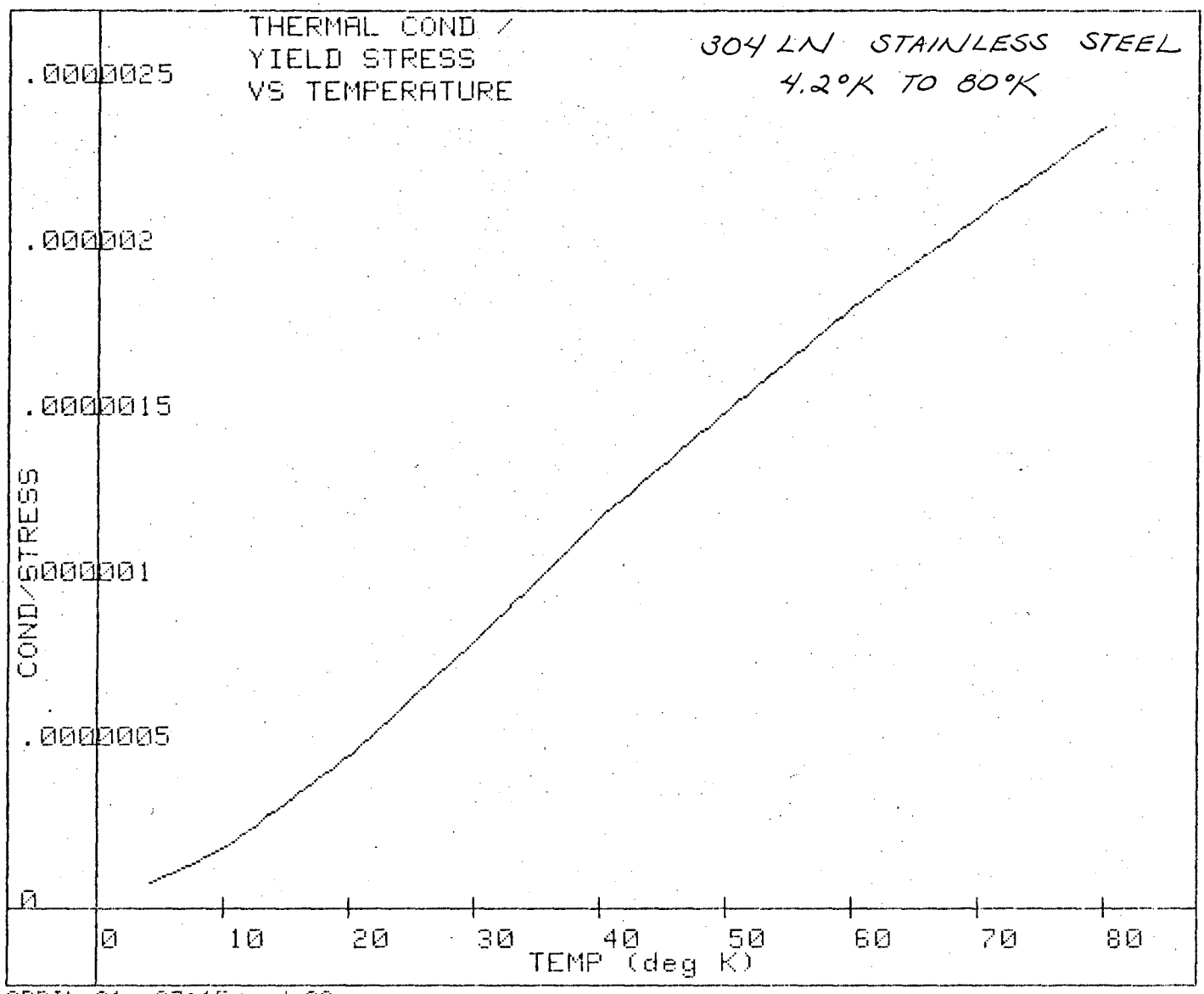

APRIL 21, 07:13 and 50 sec.
INPUT DATA:

| TEMPERATURE deg K | YIELD STRESS lb/in*in |
|---|---|
| 0.00 | 112000.000 |
| 77.00 | 90000.000 |
| 300.00 | 42000.000 |




APRIL 21, 07:14 and 30 sec.
INPUT DATA:

| TEMPERATURE deg K | THERMAL COND watts-in/deg K |
|---|---|
| 0.00 | 0.00000000 |
| 10.00 | .01960000 |
| 20.00 | .04950000 |
| 30.00 | .08380000 |
| 40.00 | .11940000 |
| 50.00 | .14730000 |
| 60.00 | .17270000 |
| 70.00 | .19300000 |
| 80.00 | .21080000 |
| 90.00 | .22860000 |
| 100.00 | .24130000 |
| 120.00 | .26160000 |
| 140.00 | .27940000 |
| 160.00 | .30480000 |
| 180.00 | .31240000 |
| 200.00 | .33020000 |
| 250.00 | .35560000 |
| 300.00 | .38100000 |




APRIL 21, 07:15 and 28 sec.
CALCULATED DATA:

| TEMPERATURE deg K | THERMAL COND / YIELD STRESS watts-in/lb deg K |
|---|---|
| 4.2000000000 | .0000000743 |
| 4.9656565657 | .0000000880 |
| 5.7313131313 | .0000001018 |
| 6.4969696970 | .0000001156 |
| 7.2626262626 | .0000001295 |
| 8.0282828283 | .0000001434 |
| 8.7939393939 | .0000001574 |
| 9.5595959596 | .0000001715 |
| 10.3252525253 | .0000001887 |
| 11.0909090909 | .0000002101 |
| 11.8565656566 | .0000002316 |
| 12.6222222222 | .0000002532 |
| 13.3878787879 | .0000002748 |
| 14.1535353535 | .0000002966 |
| 14.9191919192 | .0000003184 |
| 15.6848484849 | .0000003404 |
| 16.4505050505 | .0000003624 |
| 17.2161616162 | .0000003845 |
| 17.9818181818 | .0000004067 |
| 18.7474747475 | .0000004290 |
| 19.5131313131 | .0000004514 |

| | |
|---|---|
| 20.2787878788 | .0000004751 |
| 21.0444444445 | .0000005008 |
| 21.8101010101 | .0000005267 |
| 22.5757575758 | .0000005527 |
| 23.3414141414 | .0000005788 |
| 24.1070707071 | .0000006049 |
| 24.8727272727 | .0000006312 |
| 25.6383838384 | .0000006577 |
| 26.4040404041 | .0000006842 |
| 27.1696969697 | .0000007108 |
| 27.9353535354 | .0000007375 |
| 28.7010101010 | .0000007644 |
| 29.4666666667 | .0000007914 |
| 30.2323232323 | .0000008187 |
| 30.9979797980 | .0000008469 |
| 31.7636363637 | .0000008752 |
| 32.5292929293 | .0000009036 |
| 33.2949494950 | .0000009321 |
| 34.0606060606 | .0000009608 |
| 34.8262626263 | .0000009895 |
| 35.5919191919 | .0000010184 |
| 36.3575757576 | .0000010474 |
| 37.1232323233 | .0000010766 |
| 37.8888888889 | .0000011059 |
| 38.6545454546 | .0000011353 |
| 39.4202020202 | .0000011648 |
| 40.1858585859 | .0000011930 |
| 40.9515151515 | .0000012169 |
| 41.7171717172 | .0000012409 |
| 42.4828282829 | .0000012650 |
| 43.2484848485 | .0000012892 |
| 44.0141414142 | .0000013136 |
| 44.7797979798 | .0000013380 |
| 45.5454545455 | .0000013625 |
| 46.3111111111 | .0000013872 |
| 47.0767676768 | .0000014119 |
| 47.8424242424 | .0000014368 |
| 48.6080808081 | .0000014618 |
| 49.3737373738 | .0000014869 |
| 50.1393939394 | .0000015117 |
| 50.9050505051 | .0000015350 |
| 51.6707070707 | .0000015585 |
| 52.4363636364 | .0000015821 |
| 53.2020202020 | .0000016057 |
| 53.9676767677 | .0000016295 |
| 54.7333333334 | .0000016534 |
| 55.4989898990 | .0000016774 |
| 56.2646464647 | .0000017015 |
| 57.0303030303 | .0000017257 |
| 57.7959595960 | .0000017500 |
| 58.5616161616 | .0000017744 |
| 59.3272727273 | .0000017990 |
| 60.0929292930 | .0000018231 |
| 60.8585858586 | .0000018438 |
| 61.6242424243 | .0000018645 |
| 62.3898989899 | .0000018853 |
| 63.1555555556 | .0000019063 |
| 63.9212121212 | .0000019273 |
| 64.6868686869 | .0000019484 |
| 65.4525252526 | .0000019697 |
| 66.2181818182 | .0000019910 |
| 66.9838383839 | .0000020124 |
| 67.7494949495 | .0000020340 |
| 68.5151515152 | .0000020556 |
| 69.2808080808 | .0000020773 |

| | |
|---|---|
| 70.0464646465 | .0000020990 |
| 70.8121212122 | .0000021189 |
| 71.5777777778 | .0000021388 |
| 72.3434343435 | .0000021589 |
| 73.1090909091 | .0000021790 |
| 73.8747474748 | .0000021993 |
| 74.6404040404 | .0000022196 |
| 75.4060606061 | .0000022400 |
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| 76.9373737374 | .0000022812 |
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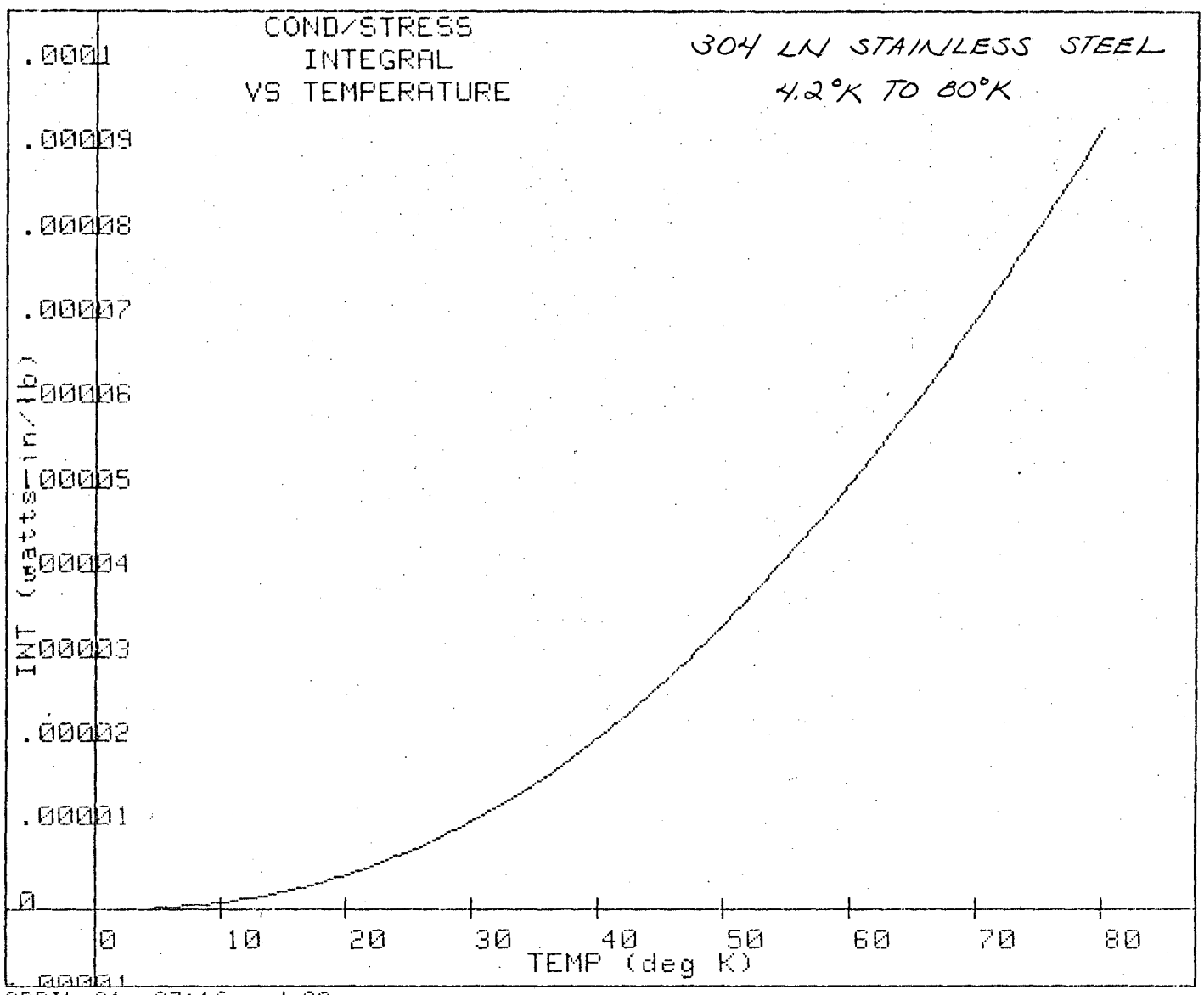
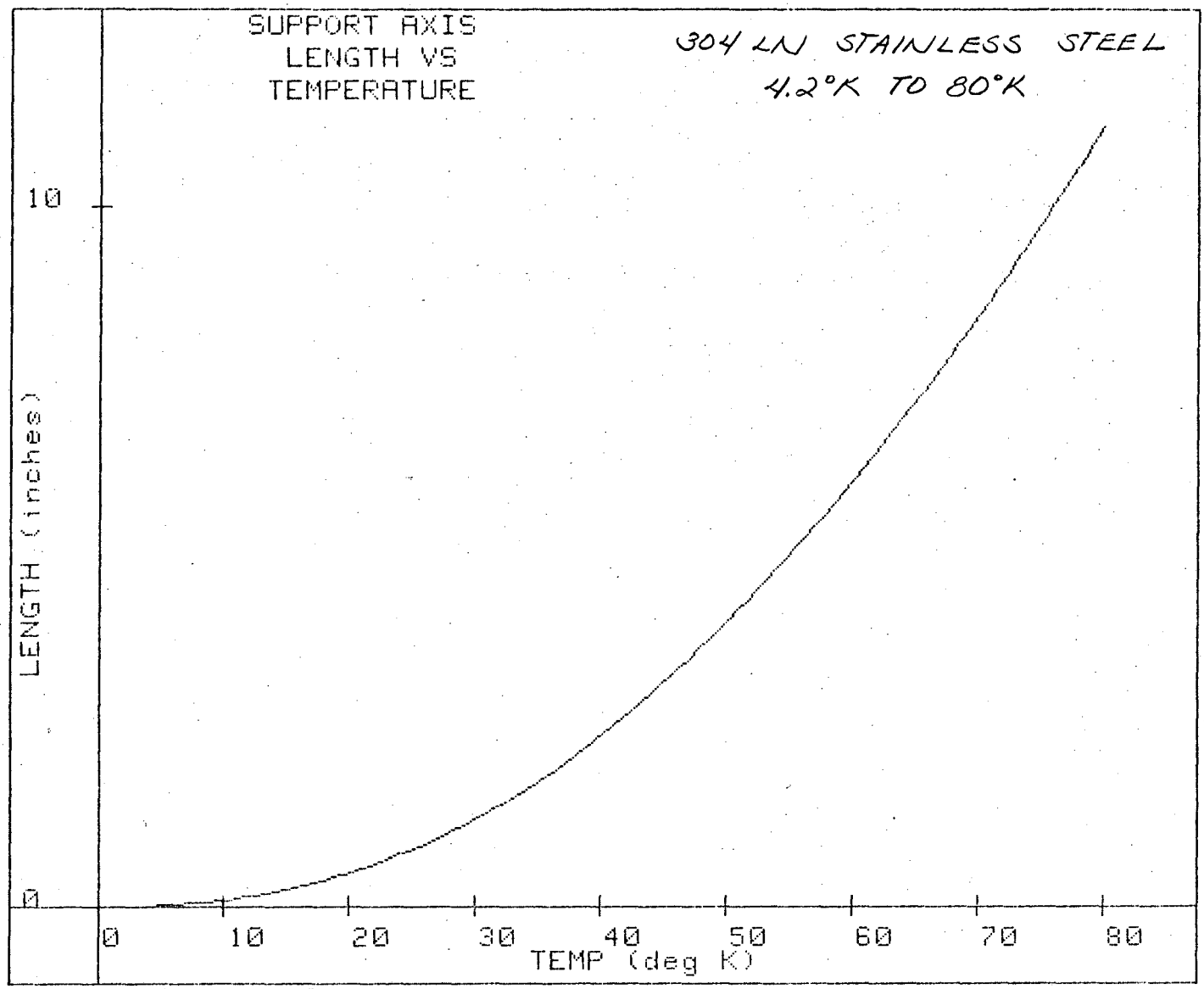



APRIL 21, 07:16 and 38 sec.
CALCULATED DATA:

| TEMPERATURE deg K | INTEGRAL watts-in/lb |
|---|---|
| 4.2000000000 | 0.0000000000 |
| 4.9656565657 | .0000000621 |
| 5.7313131313 | .0000001348 |
| 6.4969696970 | .0000002180 |
| 7.2626262626 | .0000003119 |
| 8.0282828283 | .0000004163 |
| 8.7939393939 | .0000005315 |
| 9.5595959596 | .0000006574 |
| 10.3252525253 | .0000007953 |
| 11.0909090909 | .0000009479 |
| 11.8565656566 | .0000011170 |
| 12.6222222222 | .0000013026 |
| 13.3878787879 | .0000015047 |
| 14.1535353535 | .0000017235 |
| 14.9191919192 | .0000019589 |
| 15.6848484849 | .0000022111 |
| 16.4505050505 | .0000024802 |
| 17.2161616162 | .0000027661 |
| 17.9818181818 | .0000030691 |
| 18.7474747475 | .0000033890 |

| | |
|---|---|
| 19.5131313131 | .0000037261 |
| 20.2787878788 | .0000040808 |
| 21.0444444445 | .0000044544 |
| 21.8101010101 | .0000048478 |
| 22.5757575758 | .0000052610 |
| 23.3414141414 | .0000056941 |
| 24.1070707071 | .0000061473 |
| 24.8727272727 | .0000066205 |
| 25.6383838384 | .0000071140 |
| 26.4040404041 | .0000076277 |
| 27.1696969697 | .0000081617 |
| 27.9353535354 | .0000087162 |
| 28.7010101010 | .0000092911 |
| 29.4666666667 | .0000098867 |
| 30.2323232323 | .0000105031 |
| 30.9979797980 | .0000111408 |
| 31.7636363637 | .0000118001 |
| 32.5292929293 | .0000124810 |
| 33.2949494950 | .0000131838 |
| 34.0606060606 | .0000139084 |
| 34.8262626263 | .0000146551 |
| 35.5919191919 | .0000154238 |
| 36.3575757576 | .0000162146 |
| 37.1232323233 | .0000170278 |
| 37.8888888889 | .0000178633 |
| 38.6545454546 | .0000187212 |
| 39.4202020202 | .0000196018 |
| 40.1858585859 | .0000205044 |
| 40.9515151515 | .0000214270 |
| 41.7171717172 | .0000223679 |
| 42.4828282829 | .0000233272 |
| 43.2484848485 | .0000243051 |
| 44.0141414142 | .0000253015 |
| 44.7797979798 | .0000263166 |
| 45.5454545455 | .0000273504 |
| 46.3111111111 | .0000284030 |
| 47.0767676768 | .0000294746 |
| 47.8424242424 | .0000305652 |
| 48.6080808081 | .0000316748 |
| 49.3737373738 | .0000328036 |
| 50.1393939394 | .0000339516 |
| 50.9050505051 | .0000351179 |
| 51.6707070707 | .0000363022 |
| 52.4363636364 | .0000375045 |
| 53.2020202020 | .0000387249 |
| 53.9676767677 | .0000399634 |
| 54.7333333334 | .0000412202 |
| 55.4989898990 | .0000424953 |
| 56.2646464647 | .0000437888 |
| 57.0303030303 | .0000451008 |
| 57.7959595960 | .0000464314 |
| 58.5616161616 | .0000477807 |
| 59.3272727273 | .0000491487 |
| 60.0929292930 | .0000505353 |
| 60.8585858586 | .0000519391 |
| 61.6242424243 | .0000533588 |
| 62.3898989899 | .0000547943 |
| 63.1555555556 | .0000562459 |
| 63.9212121212 | .0000577135 |
| 64.6868686869 | .0000591972 |
| 65.4525252526 | .0000606972 |
| 66.2181818182 | .0000622134 |
| 66.9838383839 | .0000637461 |
| 67.7494949495 | .0000652951 |
| 68.5151515152 | .0000668607 |

| | |
|---|---|
| 69.2808080808 | .0000684429 |
| 70.0464646465 | .0000700417 |
| 70.8121212122 | .0000716565 |
| 71.5777777778 | .0000732864 |
| 72.3434343435 | .0000749317 |
| 73.1090909091 | .0000765924 |
| 73.8747474748 | .0000782685 |
| 74.6404040404 | .0000799602 |
| 75.4060606061 | .0000816674 |
| 76.1717171718 | .0000833904 |
| 76.9373737374 | .0000851291 |
| 77.7030303031 | .0000868832 |
| 78.4686868687 | .0000886521 |
| 79.2343434344 | .0000904360 |
| 80.0000000000 | .0000922348 |

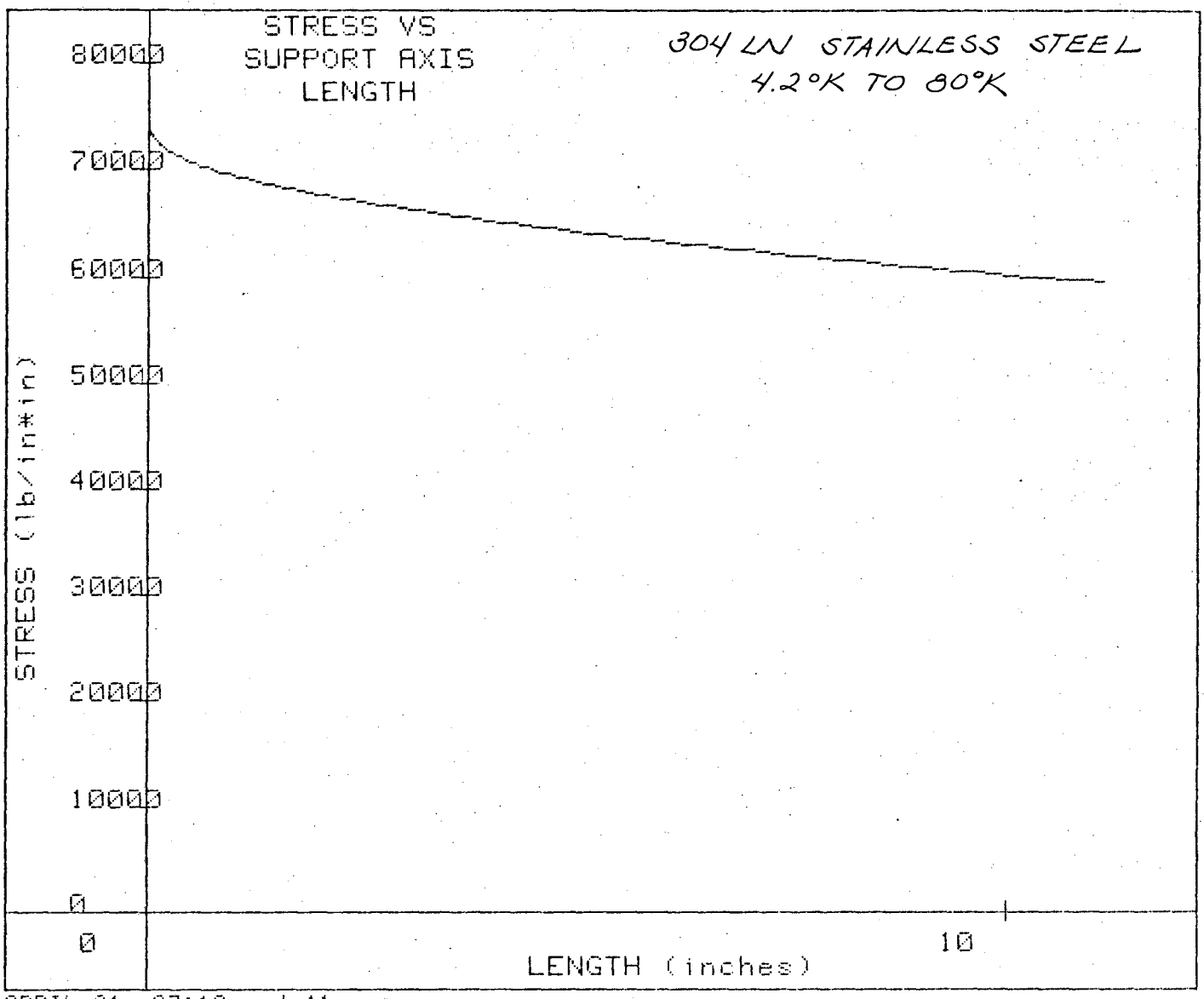



APRIL 21, 07:17 and 35 sec.
CALCULATED DATA:

| TEMPERATURE deg K | SUPPORT AXIS LENGTH inches |
|---|---|
| 4.2000000000 | 0.000000 |
| 4.9656565657 | .007491 |
| 5.7313131313 | .016251 |
| 6.4969696970 | .026285 |
| 7.2626262626 | .037598 |
| 8.0282828283 | .050195 |
| 8.7939393939 | .064081 |
| 9.5595959596 | .079261 |
| 10.3252525253 | .095883 |
| 11.0909090909 | .114285 |
| 11.8565656566 | .134669 |
| 12.6222222222 | .157041 |
| 13.3878787879 | .181410 |
| 14.1535353535 | .207784 |
| 14.9191919192 | .236170 |
| 15.6848484849 | .266578 |
| 16.4505050505 | .299016 |
| 17.2161616162 | .333491 |
| 17.9818181818 | .370012 |
| 18.7474747475 | .408587 |

| | |
|---|---|
| 19.5131313131 | .449226 |
| 20.2787878788 | .491989 |
| 21.0444444445 | .537031 |
| 21.8101010101 | .584457 |
| 22.5757575758 | .634275 |
| 23.3414141414 | .686496 |
| 24.1070707071 | .741129 |
| 24.8727272727 | .798185 |
| 25.6383838384 | .857673 |
| 26.4040404041 | .919605 |
| 27.1696969697 | .983989 |
| 27.9353535354 | 1.050837 |
| 28.7010101010 | 1.120158 |
| 29.4666666667 | 1.191964 |
| 30.2323232323 | 1.266278 |
| 30.9979797980 | 1.343155 |
| 31.7636363637 | 1.422637 |
| 32.5292929293 | 1.504736 |
| 33.2949494950 | 1.589462 |
| 34.0606060606 | 1.676827 |
| 34.8262626263 | 1.766842 |
| 35.5919191919 | 1.859519 |
| 36.3575757576 | 1.954868 |
| 37.1232323233 | 2.052901 |
| 37.8888888889 | 2.153631 |
| 38.6545454546 | 2.257068 |
| 39.4202020202 | 2.363224 |
| 40.1858585859 | 2.472046 |
| 40.9515151515 | 2.583274 |
| 41.7171717172 | 2.696713 |
| 42.4828282829 | 2.812373 |
| 43.2484848485 | 2.930263 |
| 44.0141414142 | 3.050393 |
| 44.7797979798 | 3.172773 |
| 45.5454545455 | 3.297414 |
| 46.3111111111 | 3.424324 |
| 47.0767676768 | 3.553515 |
| 47.8424242424 | 3.684995 |
| 48.6080808081 | 3.818777 |
| 49.3737373738 | 3.954868 |
| 50.1393939394 | 4.093265 |
| 50.9050505051 | 4.233886 |
| 51.6707070707 | 4.376666 |
| 52.4363636364 | 4.521617 |
| 53.2020202020 | 4.668748 |
| 53.9676767677 | 4.818068 |
| 54.7333333334 | 4.969587 |
| 55.4989898990 | 5.123316 |
| 56.2646464647 | 5.279265 |
| 57.0303030303 | 5.437443 |
| 57.7959595960 | 5.597861 |
| 58.5616161616 | 5.760529 |
| 59.3272727273 | 5.925457 |
| 60.0929292930 | 6.092634 |
| 60.8585858586 | 6.261878 |
| 61.6242424243 | 6.433032 |
| 62.3898989899 | 6.606105 |
| 63.1555555556 | 6.781106 |
| 63.9212121212 | 6.958044 |
| 64.6868686869 | 7.136927 |
| 65.4525252526 | 7.317765 |
| 66.2181818182 | 7.500568 |
| 66.9838383839 | 7.685344 |
| 67.7494949495 | 7.872102 |
| 68.5151515152 | 8.060853 |

| | |
|---|---|
| 69.2808080808 | 8.251605 |
| 70.0464646465 | 8.444362 |
| 70.8121212122 | 8.639037 |
| 71.5777777778 | 8.835550 |
| 72.3434343435 | 9.033909 |
| 73.1090909091 | 9.234122 |
| 73.8747474748 | 9.436199 |
| 74.6404040404 | 9.640149 |
| 75.4060606061 | 9.845981 |
| 76.1717171718 | 10.053704 |
| 76.9373737374 | 10.263326 |
| 77.7030303031 | 10.474800 |
| 78.4686868687 | 10.688068 |
| 79.2343434344 | 10.903132 |
| 80.0000000000 | 11.120000 |

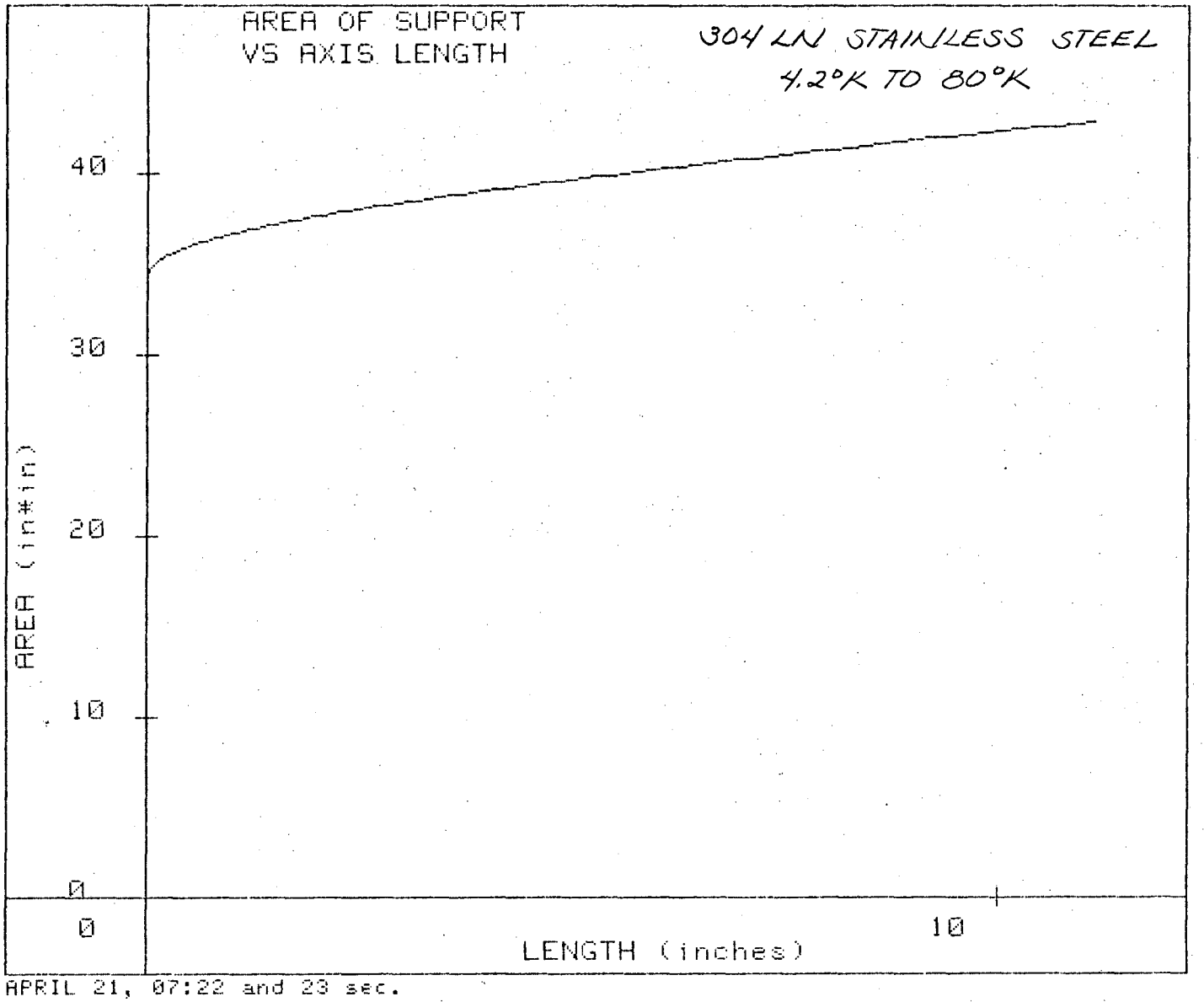



APRIL 21, 07:18 and 41 sec.
CALCULATED DATA:

| SUPPORT AXIS LENGTH inches | STRESS lb/in*in |
|---|---|
| 0.000000 | 73866.5928 |
| .007491 | 73720.7536 |
| .016251 | 73574.9144 |
| .026285 | 73429.0752 |
| .037598 | 73283.2360 |
| .050195 | 73137.3968 |
| .064081 | 72991.5576 |
| .079261 | 72845.7184 |
| .095883 | 72699.8792 |
| .114285 | 72554.0400 |
| .134669 | 72408.2008 |
| .157041 | 72262.3616 |
| .181410 | 72116.5224 |
| .207784 | 71970.6832 |
| .236170 | 71824.8440 |
| .266578 | 71679.0048 |
| .299016 | 71533.1656 |
| .333491 | 71387.3264 |
| .370012 | 71241.4872 |
| .408587 | 71095.6480 |

| | |
|---|---|
| .449226 | 70949.8088 |
| .491989 | 70803.9696 |
| .537031 | 70658.1304 |
| .584457 | 70512.2912 |
| .634275 | 70366.4520 |
| .686496 | 70220.6128 |
| .741129 | 70074.7736 |
| .798185 | 69928.9344 |
| .857673 | 69783.0952 |
| .919605 | 69637.2560 |
| .983989 | 69491.4168 |
| 1.050837 | 69345.5776 |
| 1.120158 | 69199.7384 |
| 1.191964 | 69053.8992 |
| 1.266278 | 68908.0600 |
| 1.343155 | 68762.2208 |
| 1.422637 | 68616.3816 |
| 1.504736 | 68470.5424 |
| 1.589462 | 68324.7032 |
| 1.676827 | 68178.8640 |
| 1.766842 | 68033.0248 |
| 1.859519 | 67887.1856 |
| 1.954868 | 67741.3464 |
| 2.052901 | 67595.5072 |
| 2.153631 | 67449.6680 |
| 2.257068 | 67303.8288 |
| 2.363224 | 67157.9896 |
| 2.472046 | 67012.1504 |
| 2.583274 | 66866.3112 |
| 2.696713 | 66720.4720 |
| 2.812373 | 66574.6328 |
| 2.930263 | 66428.7936 |
| 3.050393 | 66282.9544 |
| 3.172773 | 66137.1152 |
| 3.297414 | 65991.2760 |
| 3.424324 | 65845.4368 |
| 3.553515 | 65699.5976 |
| 3.684995 | 65553.7584 |
| 3.818777 | 65407.9192 |
| 3.954868 | 65262.0800 |
| 4.093265 | 65116.2408 |
| 4.233886 | 64970.4016 |
| 4.376666 | 64824.5624 |
| 4.521617 | 64678.7232 |
| 4.668748 | 64532.8840 |
| 4.818068 | 64387.0448 |
| 4.969587 | 64241.2056 |
| 5.123316 | 64095.3664 |
| 5.279265 | 63949.5272 |
| 5.437443 | 63803.6880 |
| 5.597861 | 63657.8488 |
| 5.760529 | 63512.0096 |
| 5.925457 | 63366.1704 |
| 6.092634 | 63220.3312 |
| 6.261878 | 63074.4920 |
| 6.433032 | 62928.6528 |
| 6.606105 | 62782.8136 |
| 6.781106 | 62636.9744 |
| 6.958044 | 62491.1352 |
| 7.136927 | 62345.2960 |
| 7.317765 | 62199.4568 |
| 7.500568 | 62053.6176 |
| 7.685344 | 61907.7784 |
| 7.872102 | 61761.9392 |
| 8.060853 | 61616.1000 |

| | |
|---|---|
| 8.251605 | 61470.2608 |
| 8.444362 | 61324.4216 |
| 8.639037 | 61178.5824 |
| 8.835550 | 61032.7432 |
| 9.033909 | 60886.9040 |
| 9.234122 | 60741.0648 |
| 9.436199 | 60595.2256 |
| 9.640149 | 60449.3864 |
| 9.845981 | 60303.5472 |
| 10.053704 | 60157.7080 |
| 10.263326 | 60011.8688 |
| 10.474800 | 59899.0568 |
| 10.689068 | 59789.1869 |
| 10.903132 | 59679.3170 |
| 11.120000 | 59569.4472 |




APRIL 21, 07:22 and 23 sec.
CALCULATED DATA:

| SUPPORT AXIS LENGTH inches | AREA OF SUPPORT in*in |
|---|---|
| 0.00000 | 34.521695 |
| .00749 | 34.589988 |
| .01625 | 34.658552 |
| .02629 | 34.727388 |
| .03760 | 34.796498 |
| .05020 | 34.865884 |
| .06408 | 34.935547 |
| .07926 | 35.005489 |
| .09588 | 35.075712 |
| .11429 | 35.146217 |
| .13467 | 35.217005 |
| .15704 | 35.288080 |
| .18141 | 35.359442 |
| .20778 | 35.431093 |
| .23617 | 35.503036 |
| .26658 | 35.575271 |
| .29902 | 35.647800 |
| .33349 | 35.720626 |
| .37001 | 35.793750 |
| .40859 | 35.867174 |

| | |
|---|---|
| .44923 | 35.940900 |
| .49199 | 36.014930 |
| .53703 | 36.089265 |
| .58446 | 36.163908 |
| .63428 | 36.238860 |
| .68650 | 36.314123 |
| .74113 | 36.389700 |
| .79818 | 36.465592 |
| .85767 | 36.541801 |
| .91960 | 36.618330 |
| .98399 | 36.695179 |
| 1.05084 | 36.772352 |
| 1.12016 | 36.849850 |
| 1.19196 | 36.927676 |
| 1.26628 | 37.005831 |
| 1.34315 | 37.084317 |
| 1.42264 | 37.163137 |
| 1.50474 | 37.242293 |
| 1.58946 | 37.321787 |
| 1.67683 | 37.401621 |
| 1.76684 | 37.481797 |
| 1.85952 | 37.562317 |
| 1.95487 | 37.643184 |
| 2.05290 | 37.724401 |
| 2.15363 | 37.805968 |
| 2.25707 | 37.887889 |
| 2.36322 | 37.970166 |
| 2.47205 | 38.052801 |
| 2.58327 | 38.135796 |
| 2.69671 | 38.219154 |
| 2.81237 | 38.302877 |
| 2.93026 | 38.386968 |
| 3.05039 | 38.471429 |
| 3.17277 | 38.556263 |
| 3.29741 | 38.641471 |
| 3.42432 | 38.727057 |
| 3.55351 | 38.813023 |
| 3.68500 | 38.899371 |
| 3.81878 | 38.986105 |
| 3.95487 | 39.073226 |
| 4.09326 | 39.160737 |
| 4.23389 | 39.248641 |
| 4.37667 | 39.336941 |
| 4.52162 | 39.425639 |
| 4.66875 | 39.514738 |
| 4.81807 | 39.604240 |
| 4.96959 | 39.694149 |
| 5.12332 | 39.784467 |
| 5.27926 | 39.875197 |
| 5.43744 | 39.966342 |
| 5.59786 | 40.057904 |
| 5.76053 | 40.149887 |
| 5.92546 | 40.242293 |
| 6.09263 | 40.335126 |
| 6.26188 | 40.428387 |
| 6.43303 | 40.522082 |
| 6.60611 | 40.616211 |
| 6.78111 | 40.710779 |
| 6.95804 | 40.805788 |
| 7.13693 | 40.901241 |
| 7.31777 | 40.997143 |
| 7.50057 | 41.093495 |
| 7.68534 | 41.190301 |
| 7.87210 | 41.287564 |
| 8.06085 | 41.385287 |

| | |
|---|---|
| 8.25160 | 41.483475 |
| 8.44436 | 41.582129 |
| 8.63904 | 41.681253 |
| 8.83555 | 41.780852 |
| 9.03391 | 41.880927 |
| 9.23412 | 41.981483 |
| 9.43620 | 42.082523 |
| 9.64015 | 42.184051 |
| 9.84598 | 42.286070 |
| 10.05370 | 42.388583 |
| 10.26333 | 42.491595 |
| 10.47480 | 42.571622 |
| 10.68807 | 42.649852 |
| 10.90313 | 42.728371 |
| 11.12000 | 42.807179 |

INPUT PARAMETERS AND RESULTS:
APRIL 21, 07:24 and 41 sec.

THIS OUTPUT IS FOR 304 LN STAINLESS STEEL

THE TEMPERATURE RANGE IS BETWEEN 82 deg K AND 290 deg K

THE FORCE EXERTED ON THE SUPPORT IS 2550000 LBS

THE LENGTH OF THE SUPPORT IS 2.908 INCHES

THE YIELD STRESS FACTOR IS .666666

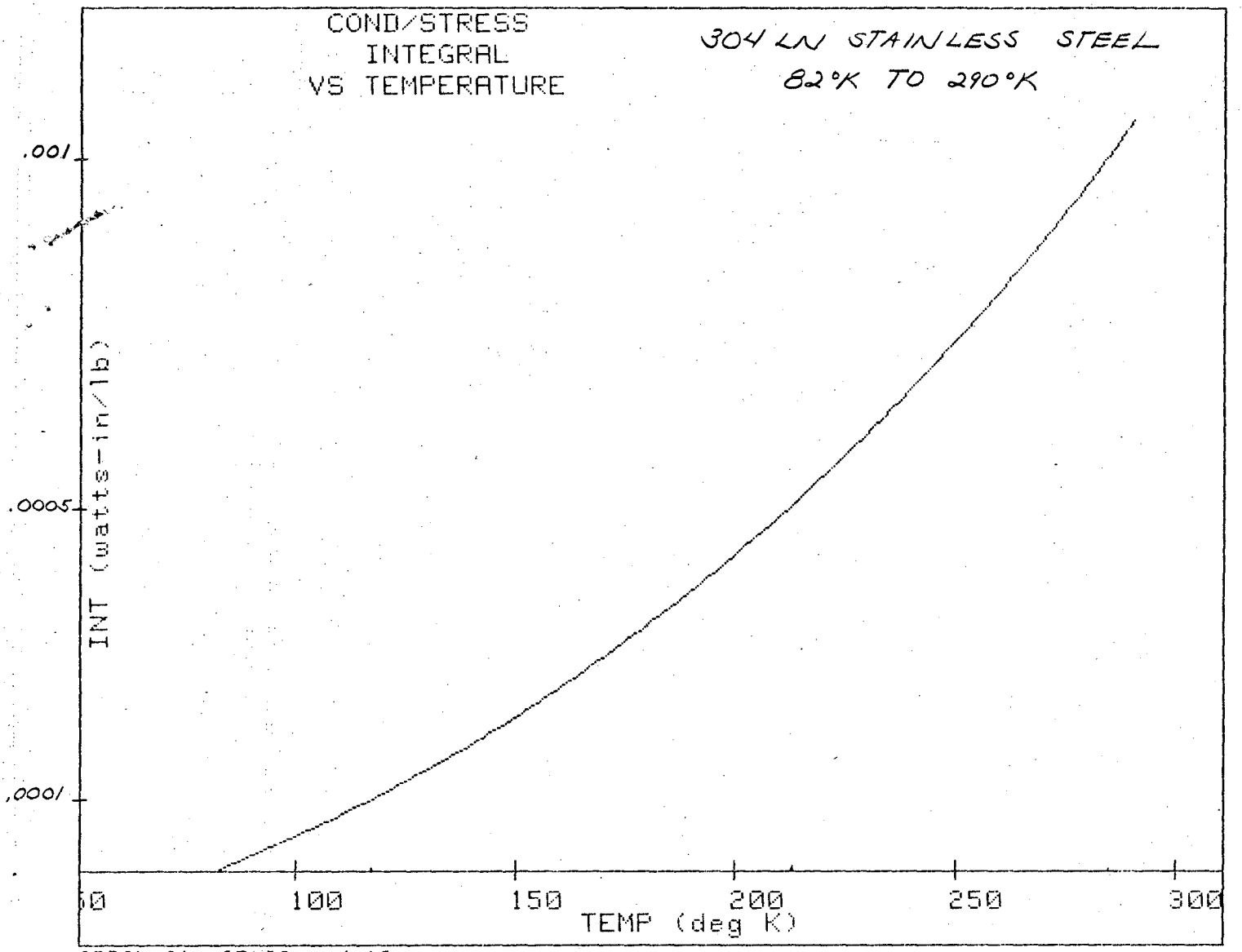
THE NUMBER OF YIELD STRESS INPUT POINTS IS 3

THE NUMBER OF THERMAL CONDUCTIVITY INPUT POINTS IS 18

THE TEMPERATURE INCREMENT IS 2.10101010101

THE FINAL INTEGRAL FROM 82 TO 290 deg K IS 1.04086149458E-03

THE HEAT LOAD ON THE SUPPORT IS 1369.08500621 watts

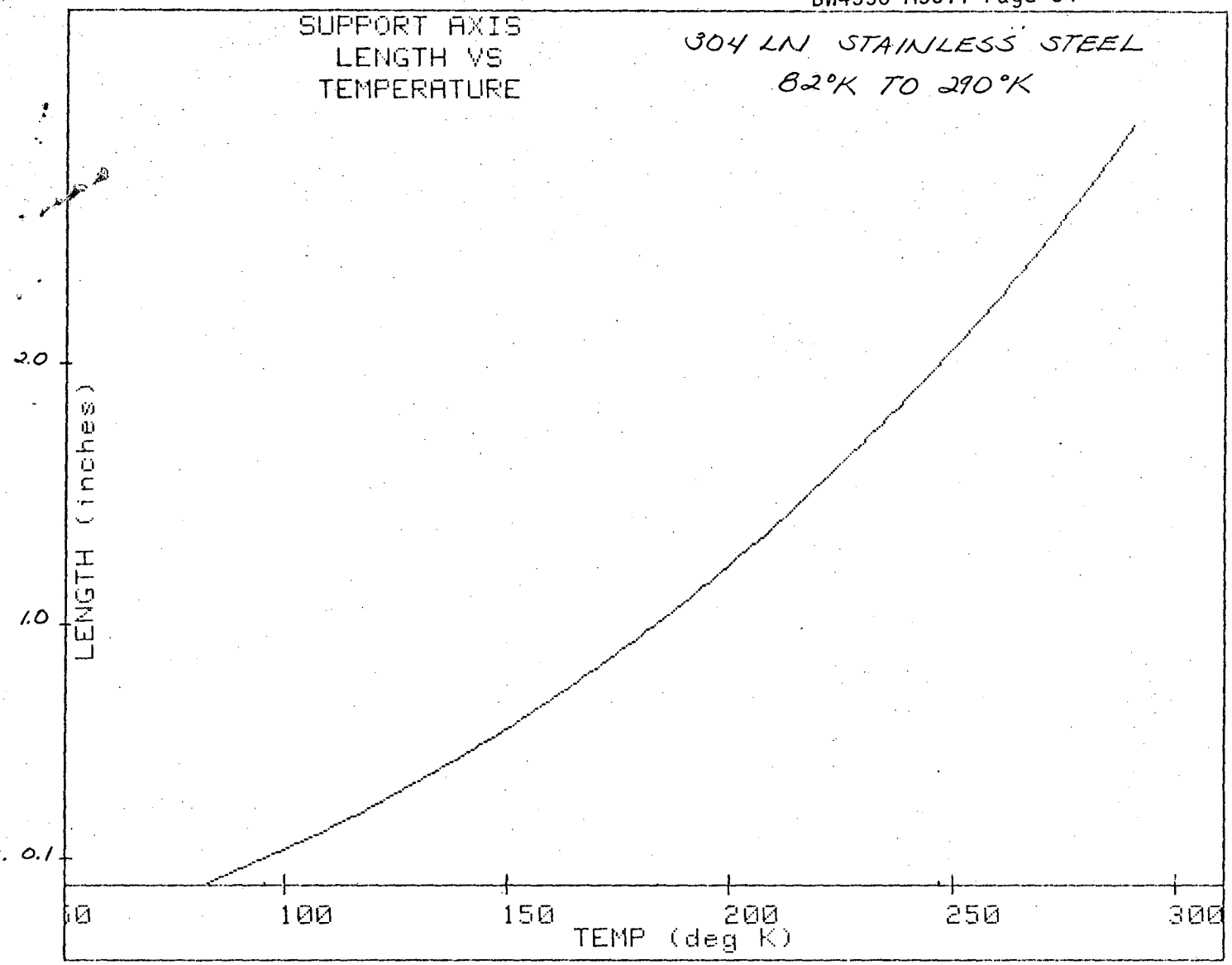



APRIL 21, 07:28 and 10 sec.
CALCULATED DATA:

| TEMPERATURE deg K | INTEGRAL watts-in/lb |
|---|---|
| 82.0000000000 | 0.0000000000 |
| 84.1010101010 | .0000051221 |
| 86.2020202020 | .0000103594 |
| 88.3030303030 | .0000157132 |
| 90.4040404040 | .0000211822 |
| 92.5050505051 | .0000267547 |
| 94.6060606061 | .0000324212 |
| 96.7070707071 | .0000381826 |
| 98.8080808081 | .0000440401 |
| 100.9090909090 | .0000499917 |
| 103.0101010100 | .0000560319 |
| 105.1111111110 | .0000621577 |
| 107.2121212120 | .0000683701 |
| 109.3131313130 | .0000746701 |
| 111.4141414140 | .0000810586 |
| 113.5151515150 | .0000875365 |
| 115.6161616160 | .0000941049 |
| 117.7171717170 | .0001007648 |
| 119.8181818180 | .0001075172 |
| 121.9191919190 | .0001143599 |

| | |
|---|---|
| 124.0202020200 | .0001212906 |
| 126.1212121210 | .0001283100 |
| 128.2222222220 | .0001354191 |
| 130.3232323230 | .0001426189 |
| 132.4242424240 | .0001499105 |
| 134.5252525250 | .0001572949 |
| 136.6262626260 | .0001647732 |
| 138.7272727270 | .0001723466 |
| 140.8282828280 | .0001800204 |
| 142.9292929290 | .0001878069 |
| 145.0303030300 | .0001957142 |
| 147.1313131310 | .0002037437 |
| 149.2323232320 | .0002118969 |
| 151.3333333330 | .0002201753 |
| 153.4343434340 | .0002285804 |
| 155.5353535350 | .0002371139 |
| 157.6363636360 | .0002457772 |
| 159.7373737370 | .0002545721 |
| 161.8383838380 | .0002634762 |
| 163.9393939390 | .0002724634 |
| 166.0404040400 | .0002815315 |
| 168.1414141410 | .0002906814 |
| 170.2424242420 | .0002999142 |
| 172.3434343430 | .0003092310 |
| 174.4444444440 | .0003186328 |
| 176.5454545460 | .0003281208 |
| 178.6464646470 | .0003376961 |
| 180.7474747480 | .0003473659 |
| 182.8484848480 | .0003571480 |
| 184.9494949490 | .0003670548 |
| 187.0505050510 | .0003770880 |
| 189.1515151520 | .0003872493 |
| 191.2525252530 | .0003975405 |
| 193.3535353540 | .0004079633 |
| 195.4545454550 | .0004185197 |
| 197.5555555560 | .0004292114 |
| 199.6565656570 | .0004400405 |
| 201.7575757580 | .0004509977 |
| 203.8585858590 | .0004620715 |
| 205.9595959600 | .0004732613 |
| 208.0606060610 | .0004845689 |
| 210.1616161620 | .0004959960 |
| 212.2626262630 | .0005075443 |
| 214.3636363640 | .0005192157 |
| 216.4646464650 | .0005310120 |
| 218.5656565660 | .0005429352 |
| 220.6666666670 | .0005549871 |
| 222.7676767680 | .0005671697 |
| 224.8686868690 | .0005794850 |
| 226.9696969700 | .0005919352 |
| 229.0707070710 | .0006045223 |
| 231.1717171720 | .0006172485 |
| 233.2727272730 | .0006301160 |
| 235.3737373740 | .0006431272 |
| 237.4747474750 | .0006562843 |
| 239.5757575760 | .0006695897 |
| 241.6767676770 | .0006830460 |
| 243.7777777780 | .0006966555 |
| 245.8787878790 | .0007104209 |
| 247.9797979800 | .0007243447 |
| 250.0808080810 | .0007384298 |
| 252.1818181820 | .0007526789 |
| 254.2828282830 | .0007670949 |
| 256.3838383840 | .0007816805 |
| 258.4848484850 | .0007964390 |

| | |
|---|---|
| 260.5858585860 | .0008113733 |
| 262.6868686870 | .0008264866 |
| 264.7878787880 | .0008417822 |
| 266.8888888890 | .0008572633 |
| 268.9898989900 | .0008729335 |
| 271.0909090910 | .0008887963 |
| 273.1919191920 | .0009048553 |
| 275.2929292930 | .0009211142 |
| 277.3939393940 | .0009375768 |
| 279.4949494950 | .0009542472 |
| 281.5959595960 | .0009711293 |
| 283.6969696970 | .0009882275 |
| 285.7979797980 | .0010055459 |
| 287.8989898990 | .0010230890 |
| 290.0000000000 | .0010408615 |

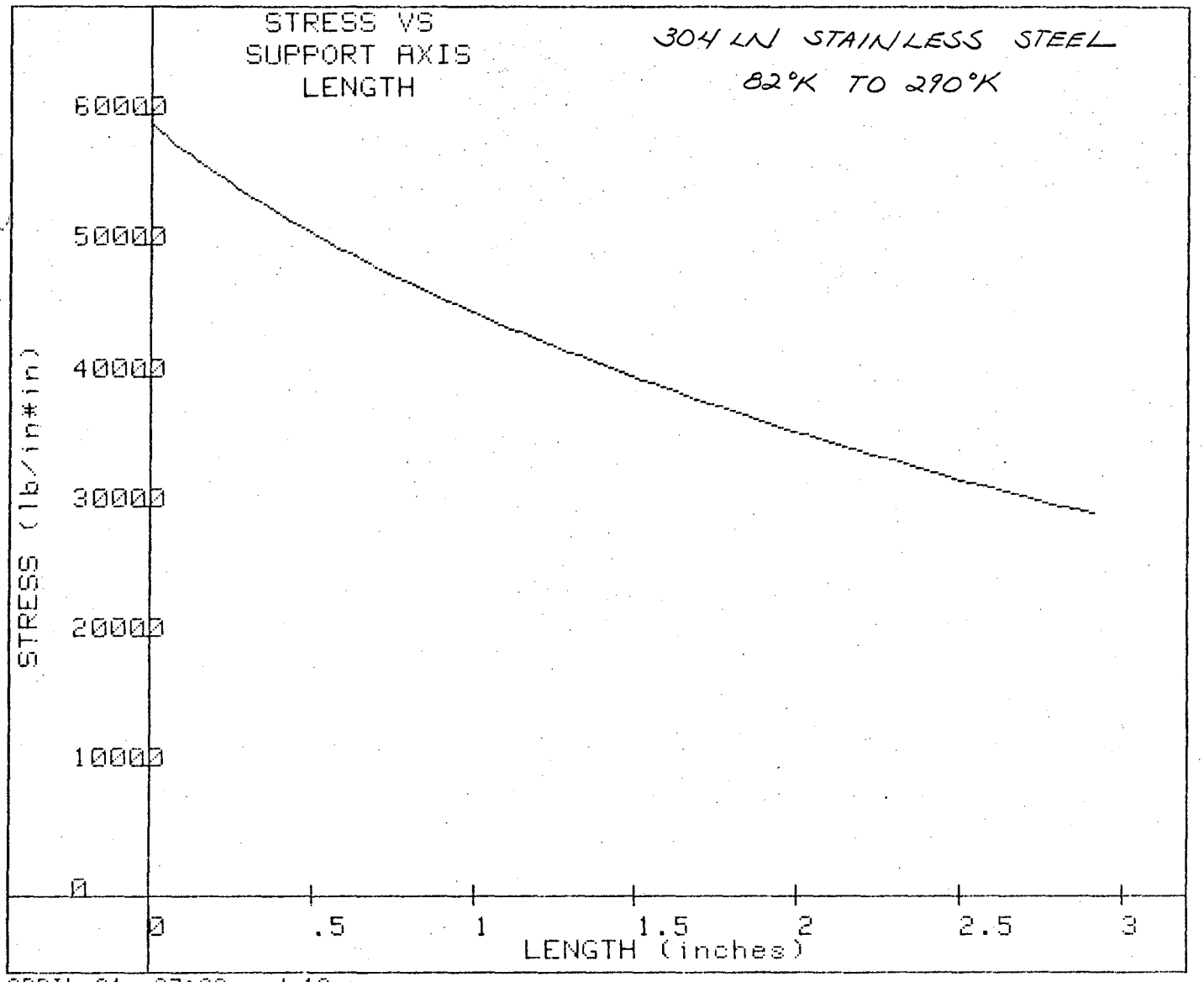



APRIL 21, 07:29 and 07 sec.
CALCULATED DATA:

| TEMPERATURE deg K | SUPPORT AXIS LENGTH inches |
|---|---|
| 82.0000000000 | 0.000000 |
| 84.1010101010 | .014310 |
| 86.2020202020 | .028942 |
| 88.3030303030 | .043900 |
| 90.4040404040 | .059180 |
| 92.5050505051 | .074748 |
| 94.6060606061 | .090579 |
| 96.7070707071 | .106676 |
| 98.8080808081 | .123041 |
| 100.9090909090 | .139669 |
| 103.0101010100 | .156544 |
| 105.1111111110 | .173659 |
| 107.2121212120 | .191015 |
| 109.3131313130 | .208616 |
| 111.4141414140 | .226465 |
| 113.5151515150 | .244563 |
| 115.6161616160 | .262914 |
| 117.7171717170 | .281521 |
| 119.8181818180 | .300386 |
| 121.9191919190 | .319503 |

| | |
|---|---|
| 124.0202020200 | .338867 |
| 126.1212121210 | .358478 |
| 128.2222222220 | .378339 |
| 130.3232323230 | .398454 |
| 132.4242424240 | .418826 |
| 134.5252525250 | .439457 |
| 136.6262626260 | .460350 |
| 138.7272727270 | .481509 |
| 140.8282828280 | .502948 |
| 142.9292929290 | .524702 |
| 145.0303030300 | .546794 |
| 147.1313131310 | .569227 |
| 149.2323232320 | .592006 |
| 151.3333333330 | .615134 |
| 153.4343434340 | .638617 |
| 155.5353535350 | .662458 |
| 157.6363636360 | .686662 |
| 159.7373737370 | .711234 |
| 161.8383838380 | .736110 |
| 163.9393939390 | .761219 |
| 166.0404040400 | .786554 |
| 168.1414141410 | .812117 |
| 170.2424242420 | .837912 |
| 172.3434343430 | .863942 |
| 174.4444444440 | .890209 |
| 176.5454545460 | .916717 |
| 178.6464646470 | .943469 |
| 180.7474747480 | .970485 |
| 182.8484848480 | .997814 |
| 184.9494949490 | 1.025492 |
| 187.0505050510 | 1.053523 |
| 189.1515151520 | 1.081912 |
| 191.2525252530 | 1.110664 |
| 193.3535353540 | 1.139784 |
| 195.4545454550 | 1.169277 |
| 197.5555555560 | 1.199148 |
| 199.6565656570 | 1.229403 |
| 201.7575757580 | 1.260015 |
| 203.8585858590 | 1.290954 |
| 205.9595959600 | 1.322216 |
| 208.0606060610 | 1.353808 |
| 210.1616161620 | 1.385733 |
| 212.2626262630 | 1.417997 |
| 214.3636363640 | 1.450605 |
| 216.4646464650 | 1.483562 |
| 218.5656565660 | 1.516874 |
| 220.6666666670 | 1.550545 |
| 222.7676767680 | 1.584581 |
| 224.8686868690 | 1.618988 |
| 226.9696969700 | 1.653772 |
| 229.0707070710 | 1.688938 |
| 231.1717171720 | 1.724493 |
| 233.2727272730 | 1.760443 |
| 235.3737373740 | 1.796794 |
| 237.4747474750 | 1.833553 |
| 239.5757575760 | 1.870726 |
| 241.6767676770 | 1.908321 |
| 243.7777777780 | 1.946344 |
| 245.8787878790 | 1.984802 |
| 247.9797979800 | 2.023703 |
| 250.0808080810 | 2.063054 |
| 252.1818181820 | 2.102864 |
| 254.2828282830 | 2.143140 |
| 256.3838383840 | 2.183890 |
| 258.4848484850 | 2.225123 |

| | |
|---|---|
| 260.5858585860 | 2.266847 |
| 262.6868686870 | 2.309071 |
| 264.7878787880 | 2.351804 |
| 266.8888888890 | 2.395056 |
| 268.9898989900 | 2.438836 |
| 271.0909090910 | 2.483154 |
| 273.1919191920 | 2.528020 |
| 275.2929292930 | 2.573445 |
| 277.3939393940 | 2.619439 |
| 279.4949494950 | 2.666014 |
| 281.5959595960 | 2.713180 |
| 283.6969696970 | 2.760949 |
| 285.7979797980 | 2.809334 |
| 287.8989898990 | 2.858347 |
| 290.0000000000 | 2.908000 |

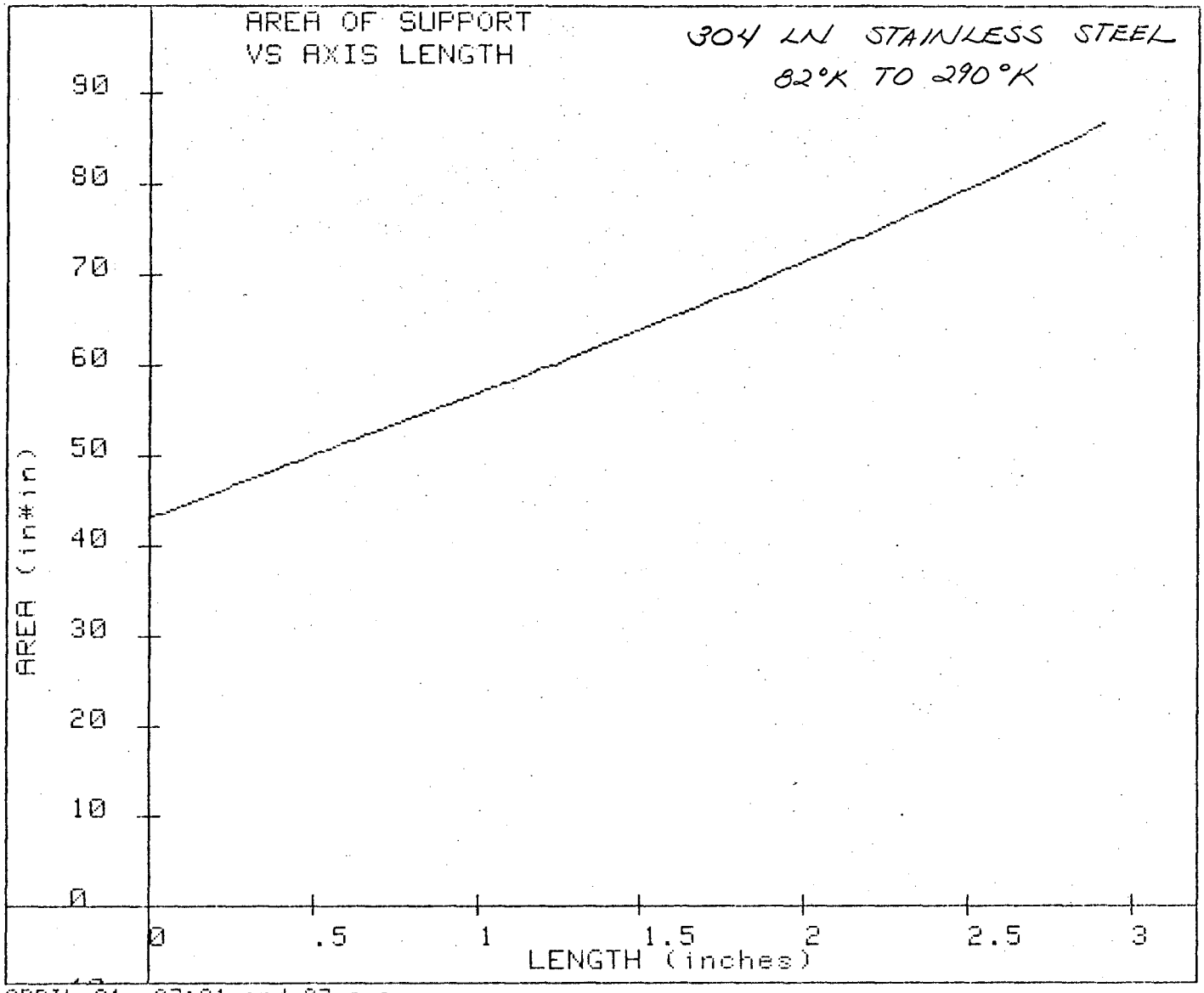



APRIL 21, 07:30 and 12 sec.
CALCULATED DATA:

| SUPPORT AXIS LENGTH inches | STRESS lb/in*in |
|---|---|
| 0.000000 | 59282.4519 |
| .014310 | 58980.9620 |
| .028942 | 58679.4721 |
| .043900 | 58377.9821 |
| .059180 | 58076.4922 |
| .074748 | 57775.0022 |
| .090579 | 57473.5123 |
| .106676 | 57172.0224 |
| .123041 | 56870.5324 |
| .139669 | 56569.0425 |
| .156544 | 56267.5526 |
| .173659 | 55966.0626 |
| .191015 | 55664.5727 |
| .208616 | 55363.0827 |
| .226465 | 55061.5928 |
| .244563 | 54760.1029 |
| .262914 | 54458.6129 |
| .281521 | 54157.1230 |
| .300386 | 53855.6331 |
| .319503 | 53554.1431 |

| | |
|---|---|
| .338867 | 53252.6532 |
| .358478 | 52951.1632 |
| .378339 | 52649.6733 |
| .398454 | 52348.1834 |
| .418826 | 52046.6934 |
| .439457 | 51745.2035 |
| .460350 | 51443.7136 |
| .481509 | 51142.2236 |
| .502948 | 50840.7337 |
| .524702 | 50539.2437 |
| .546794 | 50237.7538 |
| .569227 | 49936.2639 |
| .592006 | 49634.7739 |
| .615134 | 49333.2840 |
| .638617 | 49031.7941 |
| .662458 | 48730.3041 |
| .686662 | 48428.8142 |
| .711234 | 48127.3243 |
| .736110 | 47825.8343 |
| .761219 | 47524.3444 |
| .786554 | 47222.8544 |
| .812117 | 46921.3645 |
| .837912 | 46619.8746 |
| .863942 | 46318.3846 |
| .890209 | 46016.8947 |
| .916717 | 45715.4048 |
| .943469 | 45413.9148 |
| .970485 | 45112.4249 |
| .997814 | 44810.9349 |
| 1.025492 | 44509.4450 |
| 1.053523 | 44207.9551 |
| 1.081912 | 43906.4651 |
| 1.110664 | 43604.9752 |
| 1.139784 | 43303.4853 |
| 1.169277 | 43001.9953 |
| 1.199148 | 42700.5054 |
| 1.229403 | 42399.0154 |
| 1.260015 | 42097.5255 |
| 1.290954 | 41796.0356 |
| 1.322216 | 41494.5456 |
| 1.353808 | 41193.0557 |
| 1.385733 | 40891.5658 |
| 1.417997 | 40590.0758 |
| 1.450605 | 40288.5859 |
| 1.483562 | 39987.0959 |
| 1.516874 | 39685.6060 |
| 1.550545 | 39384.1161 |
| 1.584581 | 39082.6261 |
| 1.618988 | 38781.1362 |
| 1.653772 | 38479.6463 |
| 1.688938 | 38178.1563 |
| 1.724493 | 37876.6664 |
| 1.760443 | 37575.1764 |
| 1.796794 | 37273.6865 |
| 1.833553 | 36972.1966 |
| 1.870726 | 36670.7066 |
| 1.908321 | 36369.2167 |
| 1.946344 | 36067.7268 |
| 1.984802 | 35766.2368 |
| 2.023703 | 35464.7469 |
| 2.063054 | 35163.2570 |
| 2.102864 | 34861.7670 |
| 2.143140 | 34560.2771 |
| 2.183890 | 34258.7871 |
| 2.225123 | 33957.2972 |

| | |
|---|---|
| 2.266847 | 33655.8073 |
| 2.309071 | 33354.3173 |
| 2.351804 | 33052.8274 |
| 2.395056 | 32751.3375 |
| 2.438836 | 32449.8475 |
| 2.483154 | 32148.3576 |
| 2.528020 | 31846.8676 |
| 2.573445 | 31545.3777 |
| 2.619439 | 31243.8878 |
| 2.666014 | 30942.3978 |
| 2.713180 | 30640.9079 |
| 2.760949 | 30339.4180 |
| 2.809334 | 30037.9280 |
| 2.858347 | 29736.4381 |
| 2.908000 | 29434.9481 |




APRIL 21, 07:31 and 07 sec.
CALCULATED DATA:

| SUPPORT AXIS LENGTH inches | AREA OF SUPPORT in*in |
|---|---|
| 0.00000 | 43.014415 |
| .01431 | 43.234290 |
| .02894 | 43.456424 |
| .04390 | 43.680852 |
| .05918 | 43.907611 |
| .07475 | 44.136736 |
| .09058 | 44.368265 |
| .10668 | 44.602235 |
| .12304 | 44.838687 |
| .13967 | 45.077659 |
| .15654 | 45.319192 |
| .17366 | 45.563327 |
| .19102 | 45.810106 |
| .20862 | 46.059574 |
| .22646 | 46.311773 |
| .24456 | 46.566750 |
| .26291 | 46.824549 |
| .28152 | 47.085219 |
| .30039 | 47.348807 |
| .31950 | 47.615364 |

| | |
|---|---|
| .33887 | 47.884938 |
| .35848 | 48.157582 |
| .37834 | 48.433349 |
| .39845 | 48.712292 |
| .41883 | 48.994467 |
| .43946 | 49.279930 |
| .46035 | 49.568739 |
| .48151 | 49.860953 |
| .50295 | 50.156633 |
| .52470 | 50.455840 |
| .54679 | 50.758639 |
| .56923 | 51.065094 |
| .59201 | 51.375272 |
| .61513 | 51.689241 |
| .63862 | 52.007071 |
| .66246 | 52.328834 |
| .68666 | 52.654603 |
| .71123 | 52.984454 |
| .73611 | 53.318463 |
| .76122 | 53.656711 |
| .78655 | 53.999277 |
| .81212 | 54.346246 |
| .83791 | 54.697702 |
| .86394 | 55.053733 |
| .89021 | 55.414430 |
| .91672 | 55.779885 |
| .94347 | 56.150191 |
| .97048 | 56.525447 |
| .99781 | 56.905753 |
| 1.02549 | 57.291211 |
| 1.05352 | 57.681926 |
| 1.08191 | 58.078007 |
| 1.11066 | 58.479565 |
| 1.13978 | 58.886715 |
| 1.16928 | 59.299574 |
| 1.19915 | 59.718263 |
| 1.22940 | 60.142906 |
| 1.26002 | 60.573632 |
| 1.29095 | 61.010571 |
| 1.32222 | 61.453860 |
| 1.35381 | 61.903638 |
| 1.38573 | 62.360048 |
| 1.41800 | 62.823238 |
| 1.45061 | 63.293361 |
| 1.48356 | 63.770572 |
| 1.51687 | 64.255035 |
| 1.55054 | 64.746915 |
| 1.58458 | 65.246383 |
| 1.61899 | 65.753618 |
| 1.65377 | 66.268800 |
| 1.68894 | 66.792120 |
| 1.72449 | 67.323771 |
| 1.76044 | 67.863953 |
| 1.79679 | 68.412873 |
| 1.83355 | 68.970747 |
| 1.87073 | 69.537793 |
| 1.90832 | 70.114240 |
| 1.94634 | 70.700325 |
| 1.98480 | 71.296290 |
| 2.02370 | 71.902388 |
| 2.06305 | 72.518880 |
| 2.10286 | 73.146034 |
| 2.14314 | 73.784131 |
| 2.18389 | 74.433458 |
| 2.22512 | 75.094316 |

| | |
|---|---|
| 2.26685 | 75.767013 |
| 2.30907 | 76.451872 |
| 2.35180 | 77.149224 |
| 2.39506 | 77.859416 |
| 2.43884 | 78.582804 |
| 2.48315 | 79.319760 |
| 2.52802 | 80.070669 |
| 2.57345 | 80.835932 |
| 2.61944 | 81.615963 |
| 2.66601 | 82.411196 |
| 2.71318 | 83.222077 |
| 2.76095 | 84.049074 |
| 2.80933 | 84.892673 |
| 2.85835 | 85.753377 |
| 2.90800 | 86.631714 |

INPUT PARAMETERS AND RESULTS:
APRIL 21, 07:35 and 15 sec.

THIS OUTPUT IS FOR TITANIUM 6AL-4V

THE TEMPERATURE RANGE IS BETWEEN 4.2 deg K AND 80 deg K

THE FORCE EXERTED ON THE SUPPORT IS 2550000 LBS

THE LENGTH OF THE SUPPORT IS 11.12 INCHES

THE YIELD STRESS FACTOR IS .333333

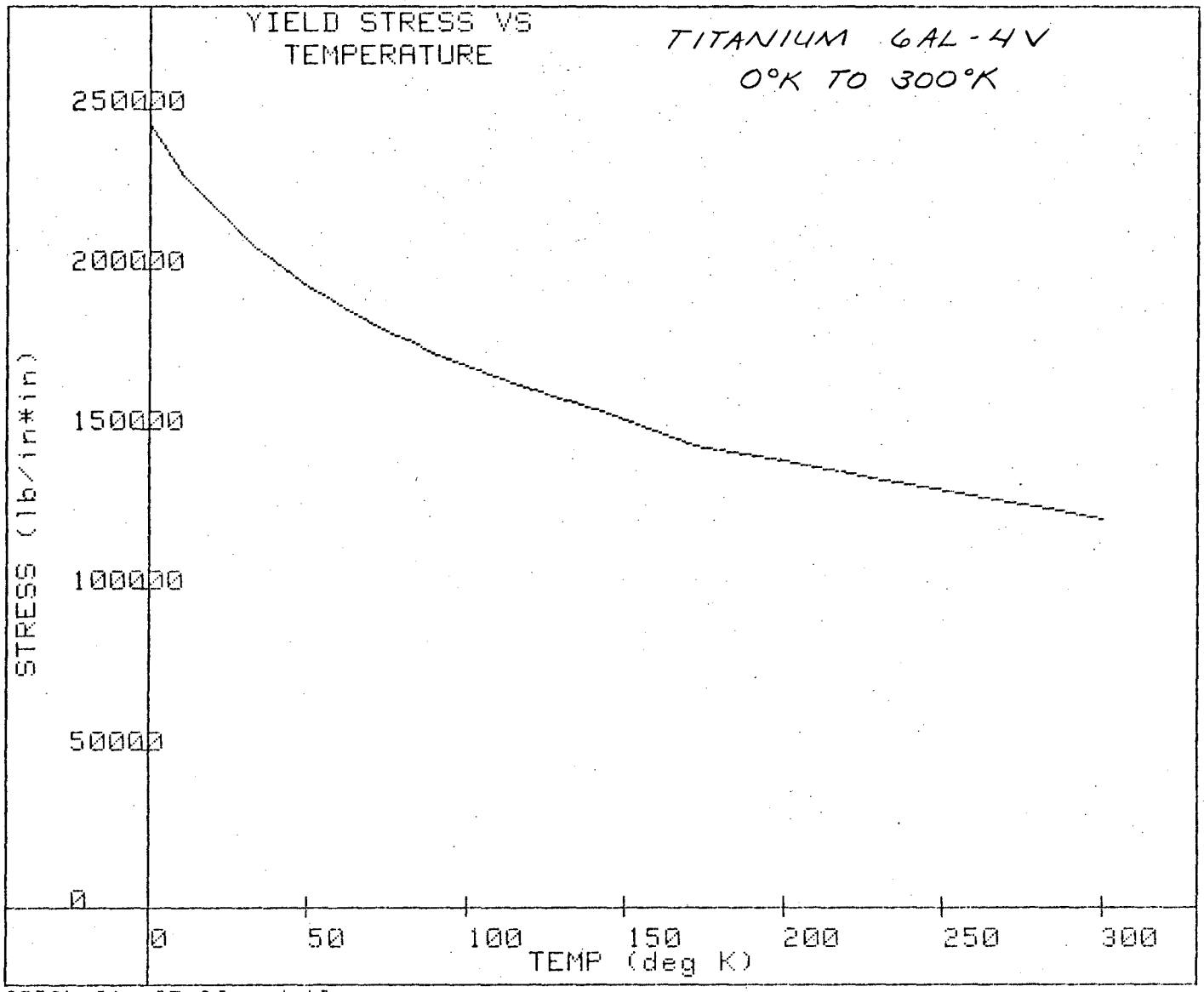
THE NUMBER OF YIELD STRESS INPUT POINTS IS 25

THE NUMBER OF THERMAL CONDUCTIVITY INPUT POINTS IS 21

THE TEMPERATURE INCREMENT IS .765656565657

THE FINAL INTEGRAL FROM 4.2 TO 80 deg K IS 2.14332426733E-05

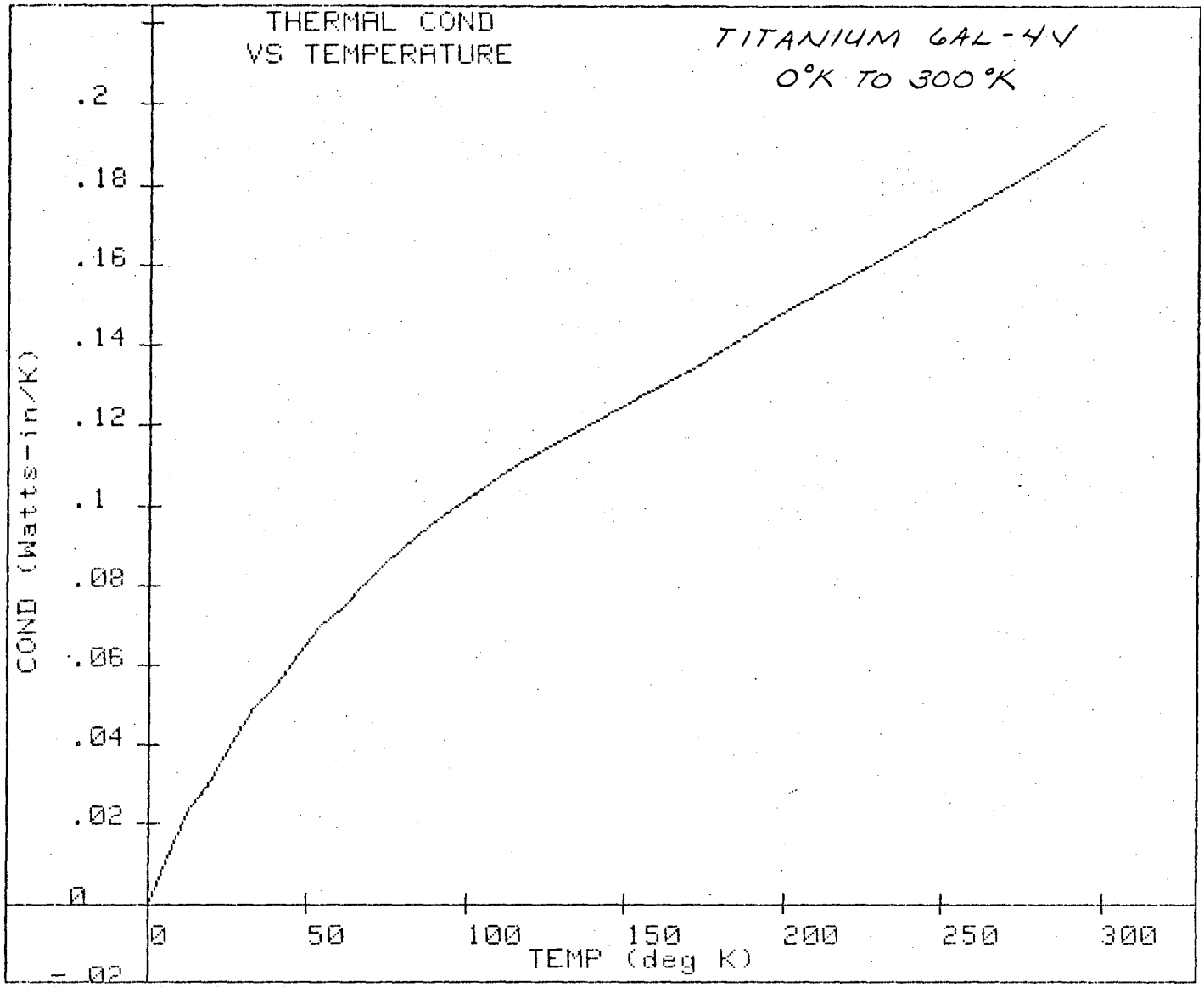
THE HEAT LOAD ON THE SUPPORT IS 14.7450063323 watts




APRIL 21, 07:36 and 12 sec.
INPUT DATA:

| TEMPERATURE deg K | YIELD STRESS lb/in*in |
|---|---|
| 0.00 | 245000.000 |
| 5.38 | 237000.000 |
| 10.94 | 229000.000 |
| 16.49 | 223000.000 |
| 22.05 | 218000.000 |
| 27.60 | 212000.000 |
| 33.16 | 207000.000 |
| 38.72 | 203000.000 |
| 44.27 | 199000.000 |
| 49.83 | 195000.000 |
| 55.38 | 192000.000 |
| 60.94 | 188000.000 |
| 66.49 | 185000.000 |
| 72.05 | 182000.000 |
| 77.60 | 179000.000 |
| 83.16 | 177000.000 |
| 88.72 | 174000.000 |
| 116.49 | 164000.000 |
| 144.27 | 155000.000 |
| 172.05 | 145000.000 |

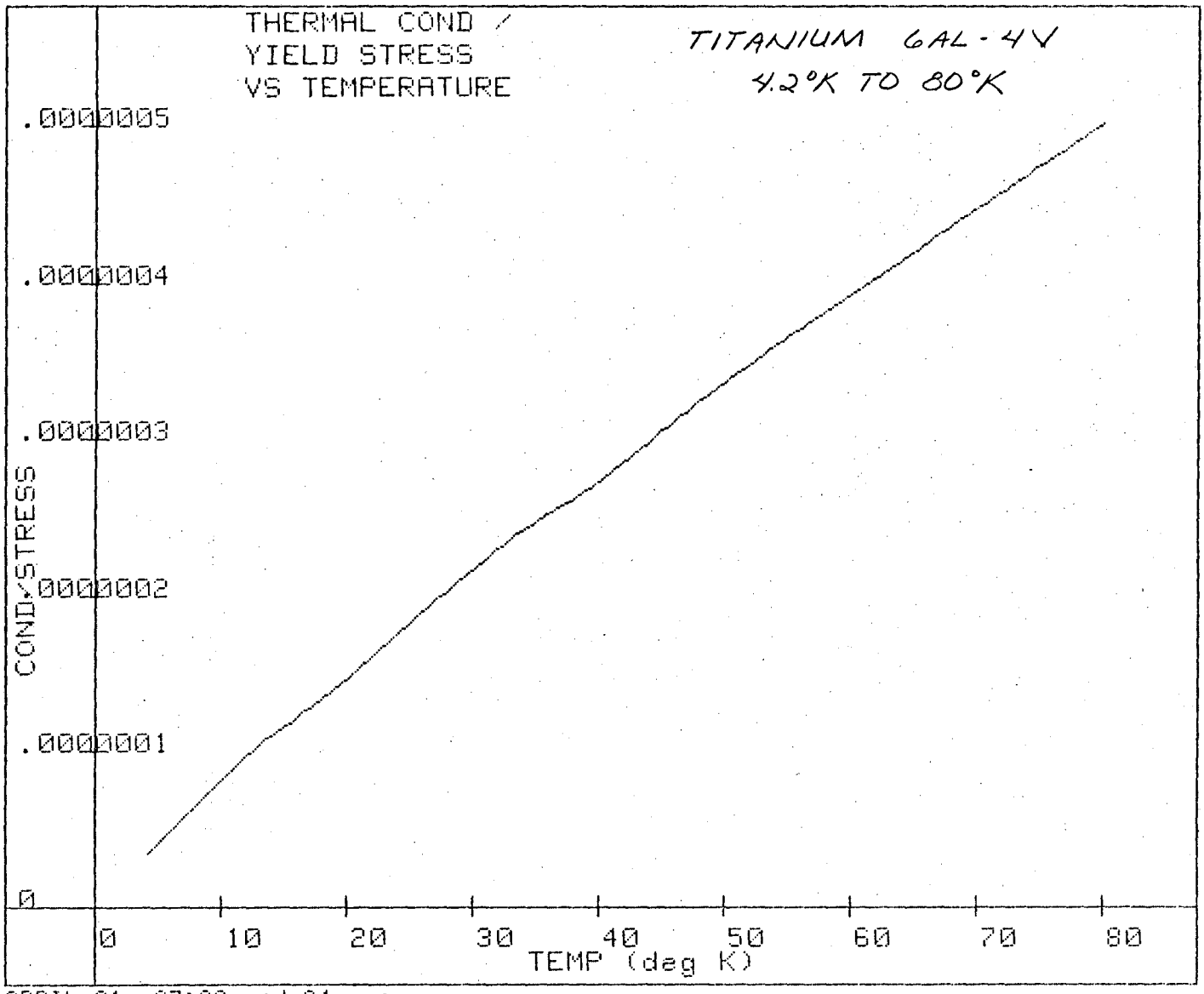
| | |
|---|---|
| 199.83 | 140000.000 |
| 227.60 | 135000.000 |
| 255.38 | 130000.000 |
| 283.16 | 125000.000 |
| 300.00 | 122000.000 |




APRIL 21, 07:37 and 01 sec.
INPUT DATA:

| TEMPERATURE deg K | THERMAL COND watts-in/deg K |
|---|---|
| 0.00 | 0.00000000 |
| 5.38 | .01050000 |
| 12.33 | .02290000 |
| 19.27 | .03120000 |
| 26.22 | .04090000 |
| 33.16 | .04920000 |
| 40.10 | .05540000 |
| 47.05 | .06280000 |
| 53.99 | .06940000 |
| 60.94 | .07470000 |
| 67.88 | .08040000 |
| 74.83 | .08570000 |
| 88.72 | .09540000 |
| 116.49 | .11030000 |
| 144.27 | .12310000 |
| 172.05 | .13490000 |
| 199.83 | .14850000 |
| 227.60 | .16040000 |
| 255.38 | .17270000 |
| 283.16 | .18630000 |

300.00 .19510000

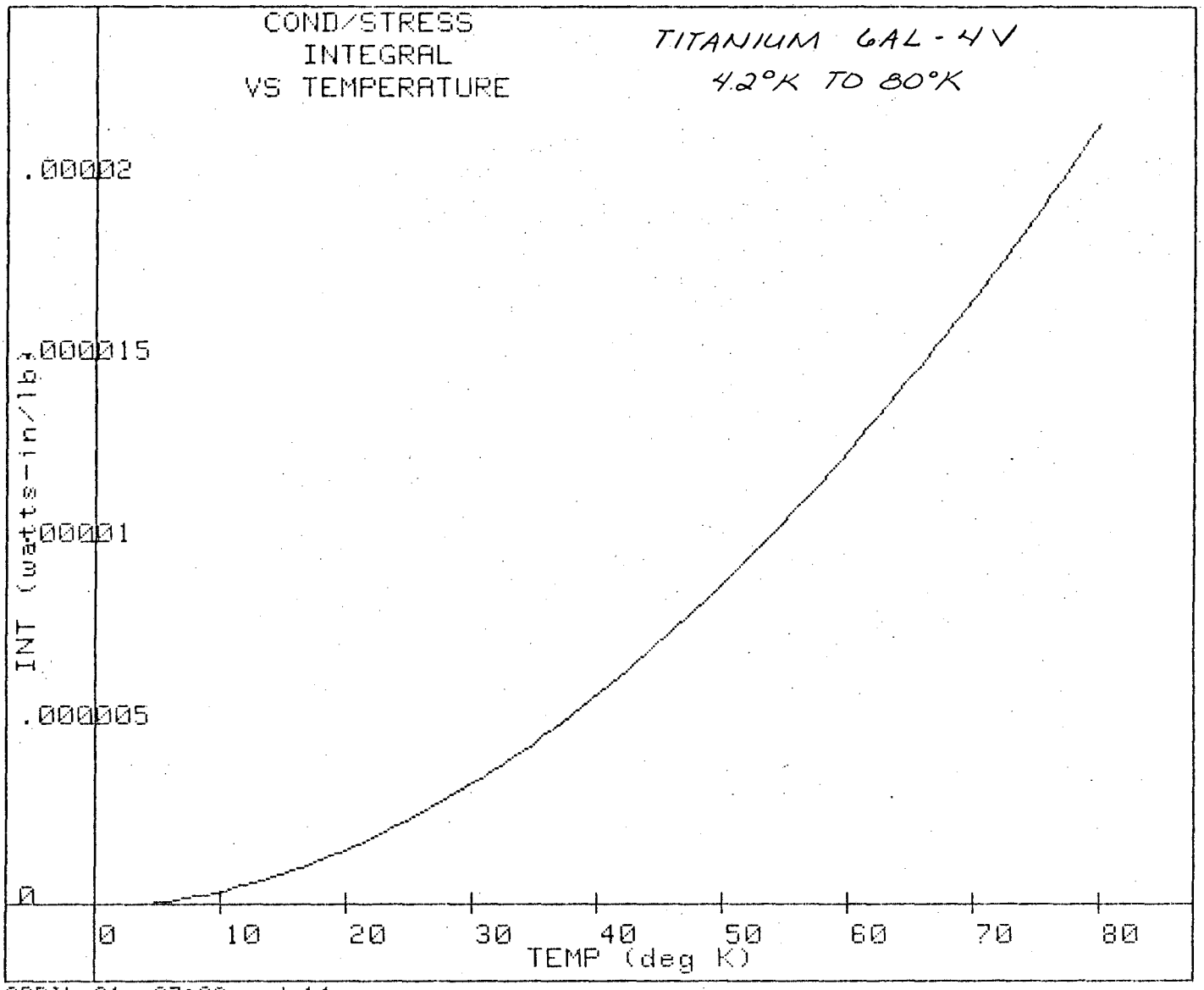



APRIL 21, 07:38 and 04 sec.
CALCULATED DATA:

| TEMPERATURE deg K | THERMAL COND / YIELD STRESS watts-in/lb deg K |
|---|---|
| 4.2000000000 | .0000000343 |
| 4.9656565657 | .0000000408 |
| 5.7313131313 | .0000000470 |
| 6.4969696970 | .0000000531 |
| 7.2626262626 | .0000000592 |
| 8.0282828283 | .0000000653 |
| 8.7939393939 | .0000000715 |
| 9.5595959596 | .0000000777 |
| 10.3252525253 | .0000000841 |
| 11.0909090909 | .0000000904 |
| 11.8565656566 | .0000000967 |
| 12.6222222222 | .0000001023 |
| 13.3878787879 | .0000001068 |
| 14.1535353535 | .0000001112 |
| 14.9191919192 | .0000001157 |
| 15.6848484849 | .0000001202 |
| 16.4505050505 | .0000001248 |
| 17.2161616162 | .0000001293 |
| 17.9818181818 | .0000001338 |
| 18.7474747475 | .0000001384 |

| | |
|---|---|
| 19.5131313131 | .0000001432 |
| 20.2787878788 | .0000001485 |
| 21.0444444445 | .0000001538 |
| 21.8101010101 | .0000001592 |
| 22.5757575758 | .0000001647 |
| 23.3414141414 | .0000001703 |
| 24.1070707071 | .0000001759 |
| 24.8727272727 | .0000001815 |
| 25.6383838384 | .0000001872 |
| 26.4040404041 | .0000001928 |
| 27.1696969697 | .0000001978 |
| 27.9353535354 | .0000002029 |
| 28.7010101010 | .0000002079 |
| 29.4666666667 | .0000002129 |
| 30.2323232323 | .0000002180 |
| 30.9979797980 | .0000002231 |
| 31.7636363637 | .0000002282 |
| 32.5292929293 | .0000002334 |
| 33.2949494950 | .0000002384 |
| 34.0606060606 | .0000002423 |
| 34.8262626263 | .0000002463 |
| 35.5919191919 | .0000002503 |
| 36.3575757576 | .0000002543 |
| 37.1232323233 | .0000002583 |
| 37.8888888889 | .0000002624 |
| 38.6545454546 | .0000002665 |
| 39.4202020202 | .0000002706 |
| 40.1858585859 | .0000002748 |
| 40.9515151515 | .0000002796 |
| 41.7171717172 | .0000002844 |
| 42.4828282829 | .0000002893 |
| 43.2484848485 | .0000002941 |
| 44.0141414142 | .0000002991 |
| 44.7797979798 | .0000003040 |
| 45.5454545455 | .0000003090 |
| 46.3111111111 | .0000003139 |
| 47.0767676768 | .0000003189 |
| 47.8424242424 | .0000003235 |
| 48.6080808081 | .0000003282 |
| 49.3737373738 | .0000003328 |
| 50.1393939394 | .0000003374 |
| 50.9050505051 | .0000003419 |
| 51.6707070707 | .0000003464 |
| 52.4363636364 | .0000003509 |
| 53.2020202020 | .0000003554 |
| 53.9676767677 | .0000003599 |
| 54.7333333334 | .0000003637 |
| 55.4989898990 | .0000003676 |
| 56.2646464647 | .0000003717 |
| 57.0303030303 | .0000003759 |
| 57.7959595960 | .0000003800 |
| 58.5616161616 | .0000003842 |
| 59.3272727273 | .0000003884 |
| 60.0929292930 | .0000003926 |
| 60.8585858586 | .0000003969 |
| 61.6242424243 | .0000004011 |
| 62.3898989899 | .0000004054 |
| 63.1555555556 | .0000004096 |
| 63.9212121212 | .0000004139 |
| 64.6868686869 | .0000004182 |
| 65.4525252526 | .0000004225 |
| 66.2181818182 | .0000004269 |
| 66.9838383839 | .0000004312 |
| 67.7494949495 | .0000004356 |
| 68.5151515152 | .0000004398 |

| | |
|---|---|
| 69.2808080808 | .0000004440 |
| 70.0464646465 | .0000004482 |
| 70.8121212122 | .0000004524 |
| 71.5777777778 | .0000004566 |
| 72.3434343435 | .0000004609 |
| 73.1090909091 | .0000004651 |
| 73.8747474748 | .0000004694 |
| 74.6404040404 | .0000004737 |
| 75.4060606061 | .0000004779 |
| 76.1717171718 | .0000004819 |
| 76.9373737374 | .0000004860 |
| 77.7030303031 | .0000004901 |
| 78.4686868687 | .0000004938 |
| 79.2343434344 | .0000004976 |
| 80.0000000000 | .0000005014 |

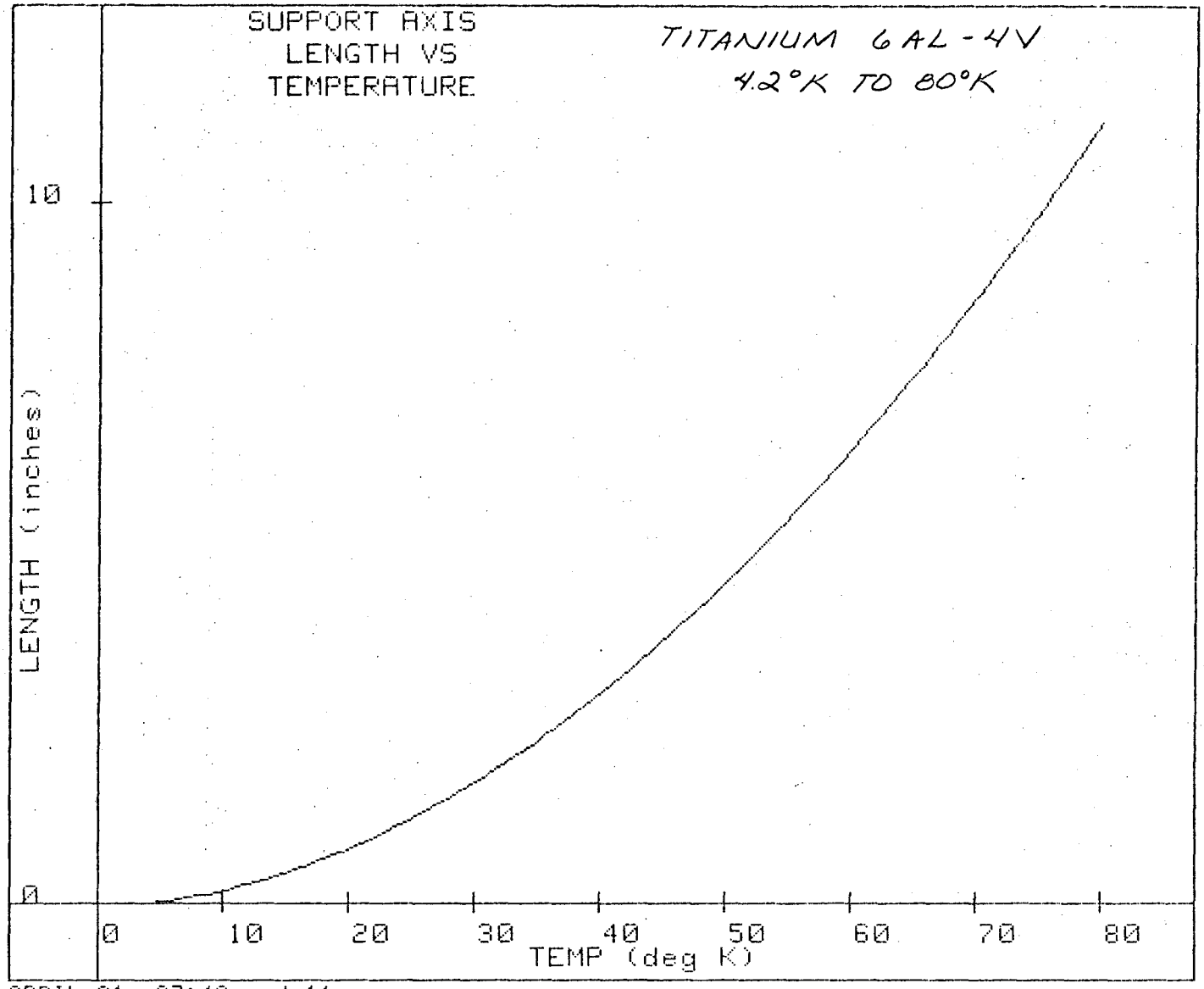



APRIL 21, 07:39 and 14 sec.
CALCULATED DATA:

| TEMPERATURE deg K | INTEGRAL watts-in/lb |
|---|---|
| 4.2000000000 | 0.0000000000 |
| 4.9656565657 | .0000000288 |
| 5.7313131313 | .0000000624 |
| 6.4969696970 | .0000001007 |
| 7.2626262626 | .0000001437 |
| 8.0282828283 | .0000001913 |
| 8.7939393939 | .0000002437 |
| 9.5595959596 | .0000003008 |
| 10.3252525253 | .0000003627 |
| 11.0909090909 | .0000004295 |
| 11.8565656566 | .0000005012 |
| 12.6222222222 | .0000005774 |
| 13.3878787879 | .0000006574 |
| 14.1535353535 | .0000007409 |
| 14.9191919192 | .0000008277 |
| 15.6848484849 | .0000009181 |
| 16.4505050505 | .0000010118 |
| 17.2161616162 | .0000011091 |
| 17.9818181818 | .0000012098 |
| 18.7474747475 | .0000013140 |

| | |
|---|---|
| 19.5131313131 | .0000014218 |
| 20.2787878788 | .0000015335 |
| 21.0444444445 | .0000016492 |
| 21.8101010101 | .0000017690 |
| 22.5757575758 | .0000018931 |
| 23.3414141414 | .0000020213 |
| 24.1070707071 | .0000021538 |
| 24.8727272727 | .0000022906 |
| 25.6383838384 | .0000024318 |
| 26.4040404041 | .0000025773 |
| 27.1696969697 | .0000027268 |
| 27.9353535354 | .0000028803 |
| 28.7010101010 | .0000030375 |
| 29.4666666667 | .0000031986 |
| 30.2323232323 | .0000033636 |
| 30.9979797980 | .0000035324 |
| 31.7636363637 | .0000037052 |
| 32.5292929293 | .0000038819 |
| 33.2949494950 | .0000040626 |
| 34.0606060606 | .0000042466 |
| 34.8262626263 | .0000044336 |
| 35.5919191919 | .0000046237 |
| 36.3575757576 | .0000048169 |
| 37.1232323233 | .0000050132 |
| 37.8888888889 | .0000052125 |
| 38.6545454546 | .0000054150 |
| 39.4202020202 | .0000056206 |
| 40.1858585859 | .0000058294 |
| 40.9515151515 | .0000060416 |
| 41.7171717172 | .0000062575 |
| 42.4828282829 | .0000064772 |
| 43.2484848485 | .0000067005 |
| 44.0141414142 | .0000069276 |
| 44.7797979798 | .0000071585 |
| 45.5454545455 | .0000073931 |
| 46.3111111111 | .0000076316 |
| 47.0767676768 | .0000078739 |
| 47.8424242424 | .0000081198 |
| 48.6080808081 | .0000083693 |
| 49.3737373738 | .0000086224 |
| 50.1393939394 | .0000088790 |
| 50.9050505051 | .0000091390 |
| 51.6707070707 | .0000094025 |
| 52.4363636364 | .0000096694 |
| 53.2020202020 | .0000099398 |
| 53.9676767677 | .0000102136 |
| 54.7333333334 | .0000104906 |
| 55.4989898990 | .0000107706 |
| 56.2646464647 | .0000110537 |
| 57.0303030303 | .0000113399 |
| 57.7959595960 | .0000116292 |
| 58.5616161616 | .0000119218 |
| 59.3272727273 | .0000122176 |
| 60.0929292930 | .0000125166 |
| 60.8585858586 | .0000128188 |
| 61.6242424243 | .0000131243 |
| 62.3898989899 | .0000134331 |
| 63.1555555556 | .0000137451 |
| 63.9212121212 | .0000140603 |
| 64.6868686869 | .0000143789 |
| 65.4525252526 | .0000147008 |
| 66.2181818182 | .0000150259 |
| 66.9838383839 | .0000153545 |
| 67.7494949495 | .0000156863 |
| 68.5151515152 | .0000160214 |

| | |
|---|---|
| 69.2808080808 | .0000163598 |
| 70.0464646465 | .0000167013 |
| 70.8121212122 | .0000170461 |
| 71.5777777778 | .0000173941 |
| 72.3434343435 | .0000177453 |
| 73.1090909091 | .0000180998 |
| 73.8747474748 | .0000184576 |
| 74.6404040404 | .0000188186 |
| 75.4060606061 | .0000191829 |
| 76.1717171718 | .0000195504 |
| 76.9373737374 | .0000199209 |
| 77.7030303031 | .0000202946 |
| 78.4686868687 | .0000206713 |
| 79.2343434344 | .0000210508 |
| 80.0000000000 | .0000214332 |

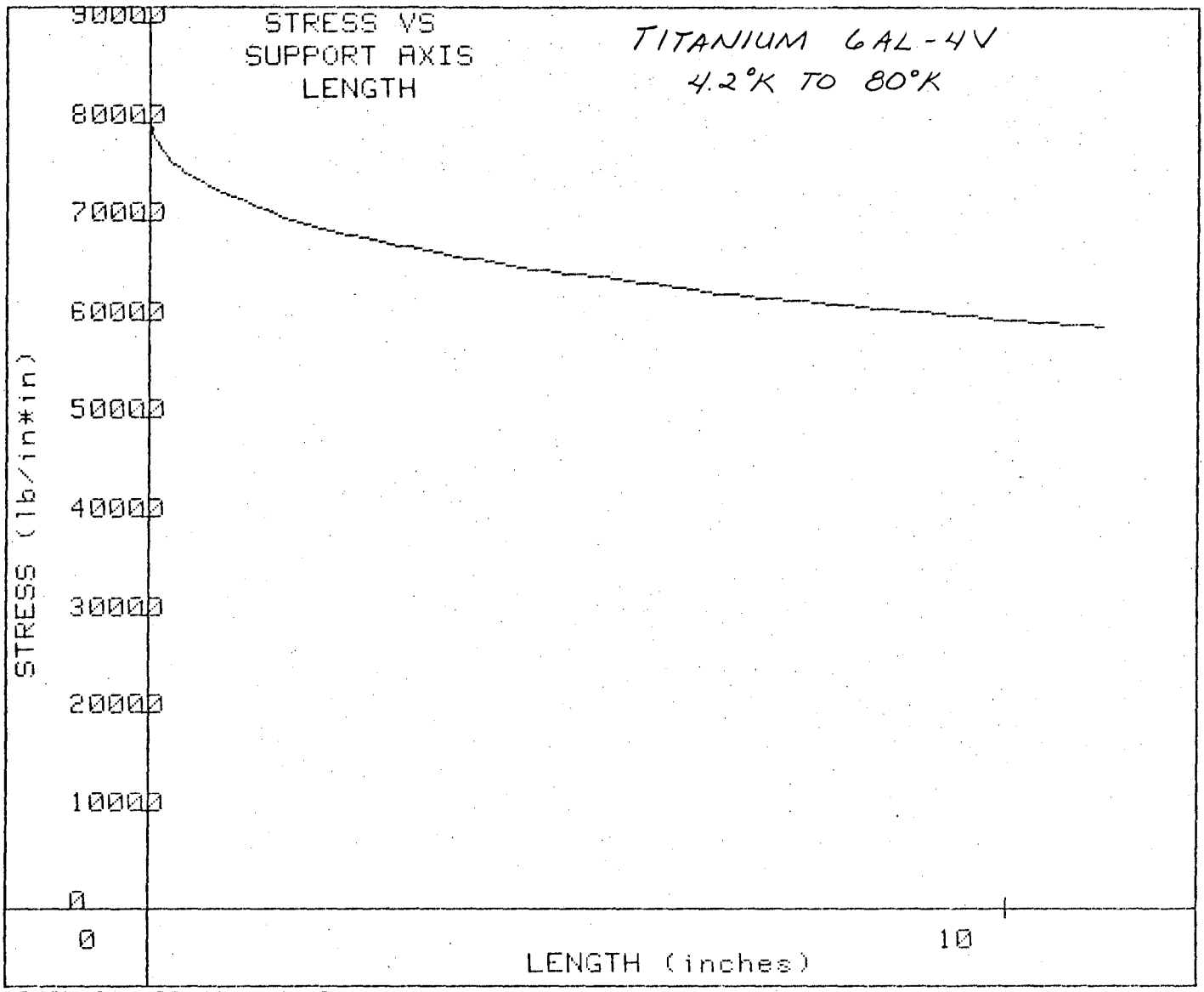



APRIL 21, 07:40 and 11 sec.
CALCULATED DATA:

| TEMPERATURE deg K | SUPPORT AXIS LENGTH inches |
|---|---|
| 4.2000000000 | 0.000000 |
| 4.9656565657 | .014920 |
| 5.7313131313 | .032366 |
| 6.4969696970 | .052252 |
| 7.2626262626 | .074542 |
| 8.0282828283 | .099258 |
| 8.7939393939 | .126425 |
| 9.5595959596 | .156064 |
| 10.3252525253 | .188200 |
| 11.0909090909 | .222852 |
| 11.8565656566 | .260022 |
| 12.6222222222 | .299561 |
| 13.3878787879 | .341092 |
| 14.1535353535 | .384384 |
| 14.9191919192 | .429452 |
| 15.6848484849 | .476308 |
| 16.4505050505 | .524966 |
| 17.2161616162 | .575423 |
| 17.9818181818 | .627676 |
| 18.7474747475 | .681735 |

| | |
|---|---|
| 19.5131313131 | .737655 |
| 20.2787878788 | .795586 |
| 21.0444444445 | .855636 |
| 21.8101010101 | .917816 |
| 22.5757575758 | .982156 |
| 23.3414141414 | 1.048692 |
| 24.1070707071 | 1.117445 |
| 24.8727272727 | 1.188434 |
| 25.6383838384 | 1.261675 |
| 26.4040404041 | 1.337152 |
| 27.1696969697 | 1.414740 |
| 27.9353535354 | 1.494334 |
| 28.7010101010 | 1.575923 |
| 29.4666666667 | 1.659506 |
| 30.2323232323 | 1.745094 |
| 30.9979797980 | 1.832703 |
| 31.7636363637 | 1.922344 |
| 32.5292929293 | 2.014032 |
| 33.2949494950 | 2.107735 |
| 34.0606060606 | 2.203212 |
| 34.8262626263 | 2.300262 |
| 35.5919191919 | 2.398895 |
| 36.3575757576 | 2.499118 |
| 37.1232323233 | 2.600940 |
| 37.8888888889 | 2.704370 |
| 38.6545454546 | 2.809417 |
| 39.4202020202 | 2.916090 |
| 40.1858585859 | 3.024411 |
| 40.9515151515 | 3.134521 |
| 41.7171717172 | 3.246543 |
| 42.4828282829 | 3.360487 |
| 43.2484848485 | 3.476365 |
| 44.0141414142 | 3.594187 |
| 44.7797979798 | 3.713964 |
| 45.5454545455 | 3.835707 |
| 46.3111111111 | 3.959425 |
| 47.0767676768 | 4.085128 |
| 47.8424242424 | 4.212738 |
| 48.6080808081 | 4.342181 |
| 49.3737373738 | 4.473467 |
| 50.1393939394 | 4.606587 |
| 50.9050505051 | 4.741505 |
| 51.6707070707 | 4.878200 |
| 52.4363636364 | 5.016679 |
| 53.2020202020 | 5.156950 |
| 53.9676767677 | 5.299020 |
| 54.7333333334 | 5.442754 |
| 55.4989898990 | 5.588017 |
| 56.2646464647 | 5.734864 |
| 57.0303030303 | 5.883348 |
| 57.7959595960 | 6.033479 |
| 58.5616161616 | 6.185266 |
| 59.3272727273 | 6.338719 |
| 60.0929292930 | 6.493847 |
| 60.8585858586 | 6.650660 |
| 61.6242424243 | 6.809159 |
| 62.3898989899 | 6.969342 |
| 63.1555555556 | 7.131216 |
| 63.9212121212 | 7.294787 |
| 64.6868686869 | 7.460063 |
| 65.4525252526 | 7.627052 |
| 66.2181818182 | 7.795762 |
| 66.9838383839 | 7.966200 |
| 67.7494949495 | 8.138374 |
| 68.5151515152 | 8.312250 |

| | |
|---|---|
| 69.2808080808 | 8.487788 |
| 70.0464646465 | 8.664987 |
| 70.8121212122 | 8.843855 |
| 71.5777777778 | 9.024399 |
| 72.3434343435 | 9.206627 |
| 73.1090909091 | 9.390547 |
| 73.8747474748 | 9.576167 |
| 74.6404040404 | 9.763495 |
| 75.4060606061 | 9.952497 |
| 76.1717171718 | 10.143127 |
| 76.9373737374 | 10.335380 |
| 77.7030303031 | 10.529252 |
| 78.4686868687 | 10.724676 |
| 79.2343434344 | 10.921590 |
| 80.0000000000 | 11.120000 |

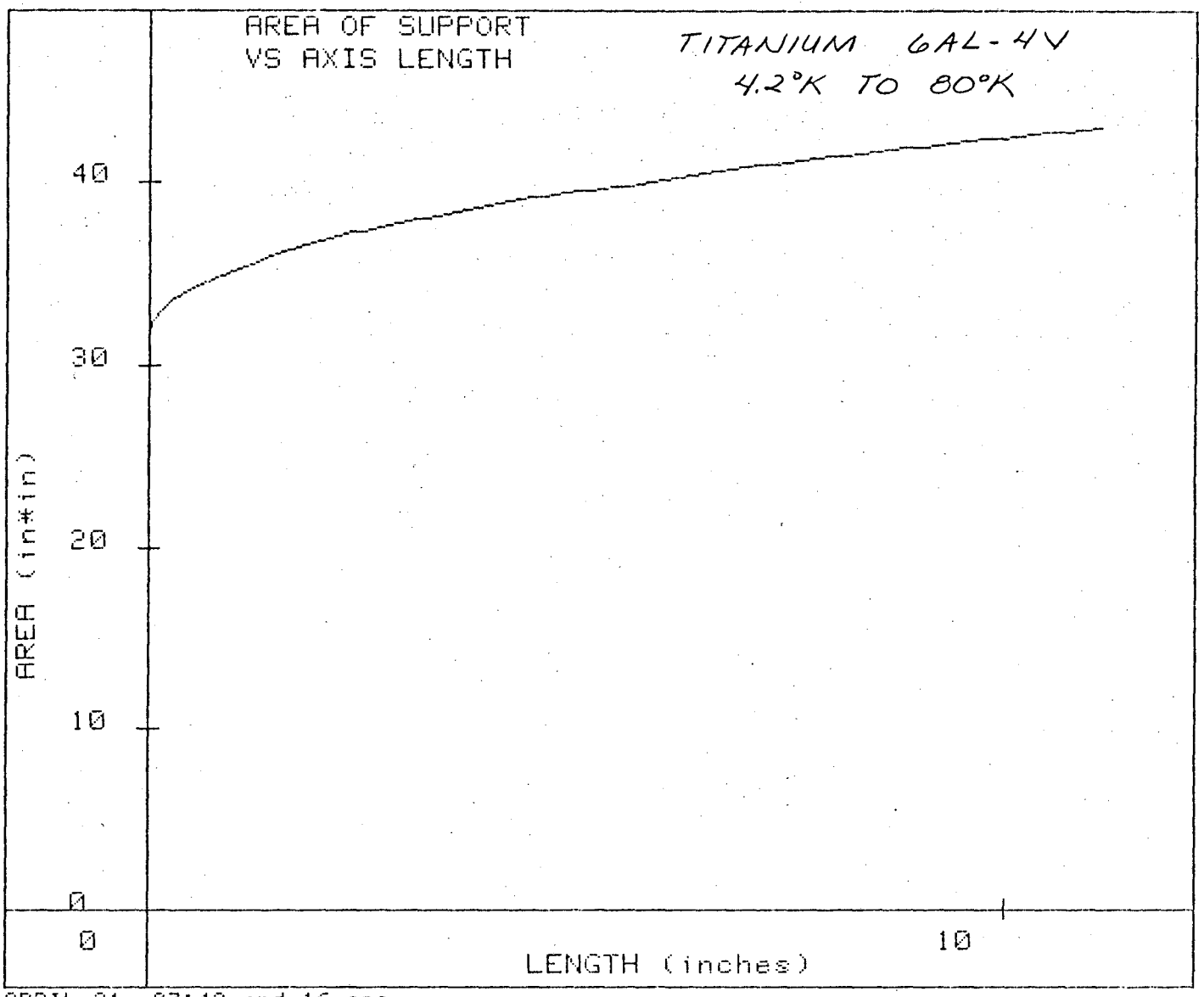



APRIL 21, 07:41 and 18 sec.
CALCULATED DATA:

| SUPPORT AXIS LENGTH inches | STRESS lb/in*in |
|---|---|
| 0.000000 | 79584.8027 |
| .014920 | 79205.2955 |
| .032366 | 78831.4257 |
| .052252 | 78464.2047 |
| .074542 | 78096.9836 |
| .099258 | 77729.7626 |
| .126425 | 77362.5416 |
| .156064 | 76995.3206 |
| .188200 | 76628.0996 |
| .222852 | 76278.8754 |
| .260022 | 76002.9634 |
| .299561 | 75727.0514 |
| .341092 | 75451.1394 |
| .384384 | 75175.2274 |
| .429452 | 74899.3154 |
| .476308 | 74623.4034 |
| .524966 | 74347.4914 |
| .575423 | 74115.5849 |
| .627676 | 73886.0717 |
| .681735 | 73656.5586 |

| | |
|---|---|
| .737655 | 73427.0455 |
| .795586 | 73197.5324 |
| .855636 | 72968.0192 |
| .917816 | 72738.5061 |
| .982156 | 72477.1320 |
| 1.048692 | 72201.2200 |
| 1.117445 | 71925.3080 |
| 1.188434 | 71649.3960 |
| 1.261675 | 71373.4840 |
| 1.337152 | 71097.5720 |
| 1.414740 | 70821.6600 |
| 1.494334 | 70566.0705 |
| 1.575923 | 70336.5573 |
| 1.659506 | 70107.0442 |
| 1.745094 | 69877.5311 |
| 1.832703 | 69648.0179 |
| 1.922344 | 69418.5048 |
| 2.014032 | 69188.9917 |
| 2.107735 | 68967.5690 |
| 2.203212 | 68783.9585 |
| 2.300262 | 68600.3480 |
| 2.398895 | 68416.7375 |
| 2.499118 | 68233.1270 |
| 2.600940 | 68049.5165 |
| 2.704370 | 67865.9060 |
| 2.809417 | 67682.2955 |
| 2.916090 | 67498.3825 |
| 3.024411 | 67314.4411 |
| 3.134521 | 67130.4998 |
| 3.246543 | 66946.5585 |
| 3.360487 | 66762.6171 |
| 3.476365 | 66578.6758 |
| 3.594187 | 66394.7345 |
| 3.713964 | 66211.0134 |
| 3.835707 | 66027.4029 |
| 3.959425 | 65843.7924 |
| 4.085128 | 65660.1819 |
| 4.212738 | 65476.5714 |
| 4.342181 | 65292.9609 |
| 4.473467 | 65109.3504 |
| 4.606587 | 64944.1884 |
| 4.741505 | 64806.2324 |
| 4.878200 | 64668.2764 |
| 5.016679 | 64530.3204 |
| 5.156950 | 64392.3644 |
| 5.299020 | 64254.4084 |
| 5.442754 | 64116.4524 |
| 5.588017 | 63971.4013 |
| 5.734864 | 63787.7908 |
| 5.883348 | 63604.1803 |
| 6.033479 | 63420.5698 |
| 6.185266 | 63236.9593 |
| 6.338719 | 63053.3488 |
| 6.493847 | 62869.7383 |
| 6.650660 | 62686.1278 |
| 6.809159 | 62543.3172 |
| 6.969342 | 62405.3612 |
| 7.131216 | 62267.4052 |
| 7.294787 | 62129.4492 |
| 7.460063 | 61991.4932 |
| 7.627052 | 61853.5372 |
| 7.795762 | 61715.5812 |
| 7.966200 | 61577.7852 |
| 8.138374 | 61440.0774 |
| 8.312250 | 61302.3695 |

| | |
|---|---|
| 8.487788 | 61164.6616 |
| 8.664987 | 61026.9537 |
| 8.843855 | 60889.2458 |
| 9.024399 | 60751.5380 |
| 9.206627 | 60613.7350 |
| 9.390547 | 60475.7790 |
| 9.576167 | 60337.8230 |
| 9.763495 | 60199.8670 |
| 9.952497 | 60061.9110 |
| 10.143127 | 59923.9550 |
| 10.335380 | 59785.9990 |
| 10.529252 | 59654.2533 |
| 10.724676 | 59562.4480 |
| 10.921590 | 59470.6428 |
| 11.120000 | 59378.8375 |




APRIL 21, 07:42 and 16 sec.
CALCULATED DATA:

| SUPPORT AXIS LENGTH inches | AREA OF SUPPORT in*in |
|---|---|
| 0.00000 | 32.041293 |
| .01492 | 32.194817 |
| .03237 | 32.347506 |
| .05225 | 32.498896 |
| .07454 | 32.651709 |
| .09926 | 32.805967 |
| .12642 | 32.961689 |
| .15606 | 33.118896 |
| .18820 | 33.277610 |
| .22285 | 33.429963 |
| .26002 | 33.551323 |
| .29956 | 33.673568 |
| .34109 | 33.796706 |
| .38438 | 33.920749 |
| .42945 | 34.045705 |
| .47631 | 34.171585 |
| .52497 | 34.298400 |
| .57542 | 34.405719 |
| .62768 | 34.512594 |
| .68173 | 34.620135 |

| | |
|---|---|
| .73766 | 34.728348 |
| .79559 | 34.837240 |
| .85564 | 34.946817 |
| .91782 | 35.057085 |
| .98216 | 35.183511 |
| 1.04869 | 35.317963 |
| 1.11745 | 35.453446 |
| 1.18843 | 35.589972 |
| 1.26168 | 35.727554 |
| 1.33715 | 35.866204 |
| 1.41474 | 36.005934 |
| 1.49433 | 36.136347 |
| 1.57592 | 36.254262 |
| 1.65951 | 36.372950 |
| 1.74509 | 36.492417 |
| 1.83270 | 36.612671 |
| 1.92234 | 36.733721 |
| 2.01403 | 36.855574 |
| 2.10774 | 36.973900 |
| 2.20321 | 37.072597 |
| 2.30026 | 37.171823 |
| 2.39889 | 37.271581 |
| 2.49912 | 37.371877 |
| 2.60094 | 37.472713 |
| 2.70437 | 37.574095 |
| 2.80942 | 37.676027 |
| 2.91609 | 37.778683 |
| 3.02441 | 37.881916 |
| 3.13452 | 37.985715 |
| 3.24654 | 38.090083 |
| 3.36049 | 38.195028 |
| 3.47637 | 38.300551 |
| 3.59419 | 38.406660 |
| 3.71396 | 38.513230 |
| 3.83571 | 38.620329 |
| 3.95943 | 38.728024 |
| 4.08513 | 38.836323 |
| 4.21274 | 38.945228 |
| 4.34218 | 39.054746 |
| 4.47347 | 39.164882 |
| 4.60659 | 39.264483 |
| 4.74151 | 39.348067 |
| 4.87820 | 39.432008 |
| 5.01668 | 39.516308 |
| 5.15695 | 39.600969 |
| 5.29902 | 39.685993 |
| 5.44275 | 39.771383 |
| 5.58802 | 39.861562 |
| 5.73486 | 39.976302 |
| 5.88335 | 40.091704 |
| 6.03348 | 40.207775 |
| 6.18527 | 40.324520 |
| 6.33872 | 40.441944 |
| 6.49385 | 40.560054 |
| 6.65066 | 40.678857 |
| 6.80916 | 40.771742 |
| 6.96934 | 40.861874 |
| 7.13122 | 40.952405 |
| 7.29479 | 41.043338 |
| 7.46006 | 41.134676 |
| 7.62705 | 41.226422 |
| 7.79576 | 41.318577 |
| 7.96620 | 41.411038 |
| 8.13837 | 41.503854 |
| 8.31225 | 41.597087 |

| | |
|---|---|
| 8.48779 | 41.690740 |
| 8.66499 | 41.784815 |
| 8.84386 | 41.879317 |
| 9.02440 | 41.974246 |
| 9.20663 | 42.069673 |
| 9.39055 | 42.165641 |
| 9.57617 | 42.262048 |
| 9.76349 | 42.358898 |
| 9.95250 | 42.456192 |
| 10.14313 | 42.553934 |
| 10.33538 | 42.652127 |
| 10.52925 | 42.746323 |
| 10.72468 | 42.812209 |
| 10.92159 | 42.878299 |
| 11.12000 | 42.944593 |

INPUT PARAMETERS AND RESULTS:
APRIL 21, 07:44 and 05 sec.

THIS OUTPUT IS FOR TITANIUM 6AL-4V

THE TEMPERATURE RANGE IS BETWEEN 82 deg K AND 290 deg K

THE FORCE EXERTED ON THE SUPPORT IS 2550000 LBS

THE LENGTH OF THE SUPPORT IS 2.908 INCHES

THE YIELD STRESS FACTOR IS .333333

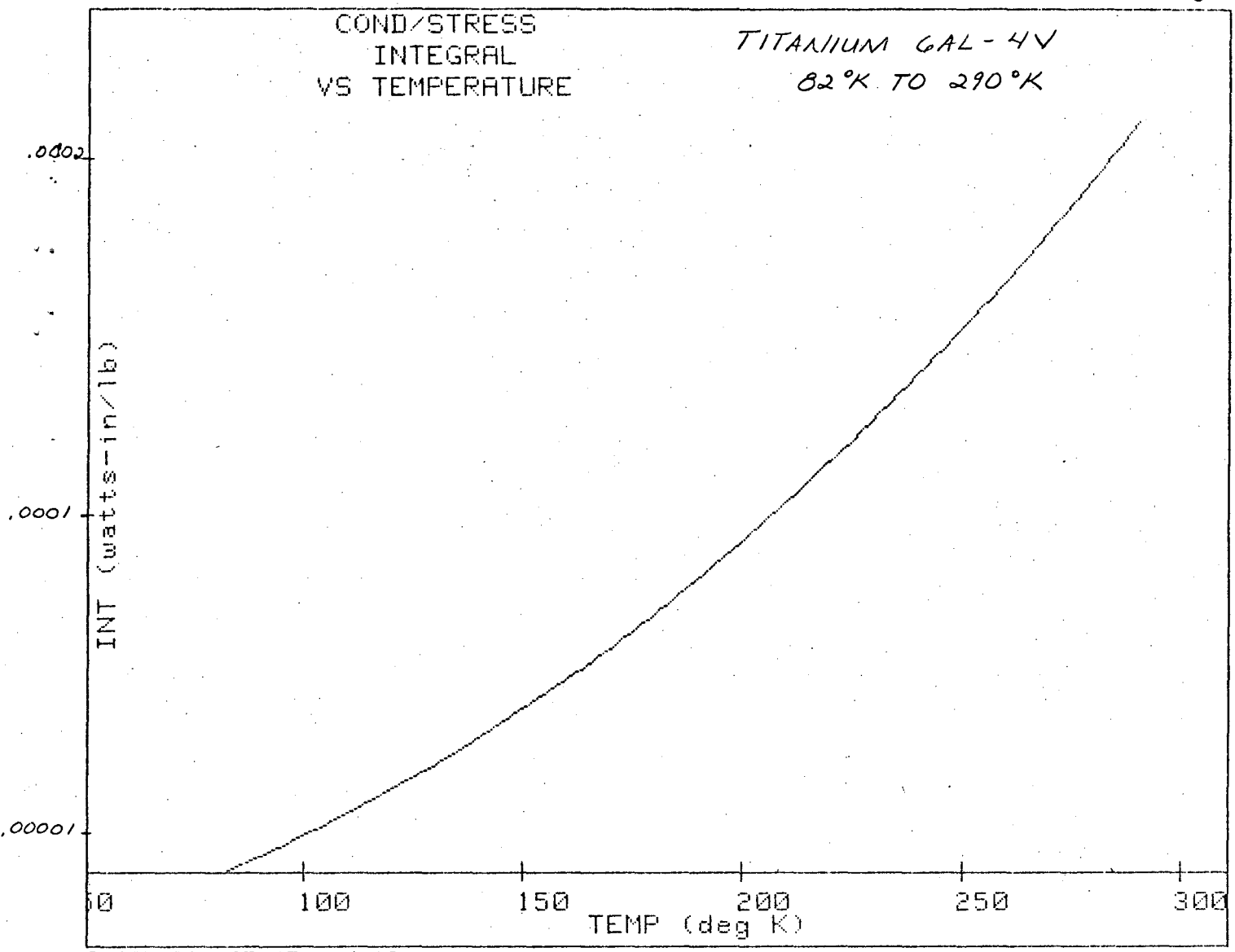
THE NUMBER OF YIELD STRESS INPUT POINTS IS 25

THE NUMBER OF THERMAL CONDUCTIVITY INPUT POINTS IS 21

THE TEMPERATURE INCREMENT IS 2.10101010101

THE FINAL INTEGRAL FROM 82 TO 290 deg K IS 2.07966022482E-04

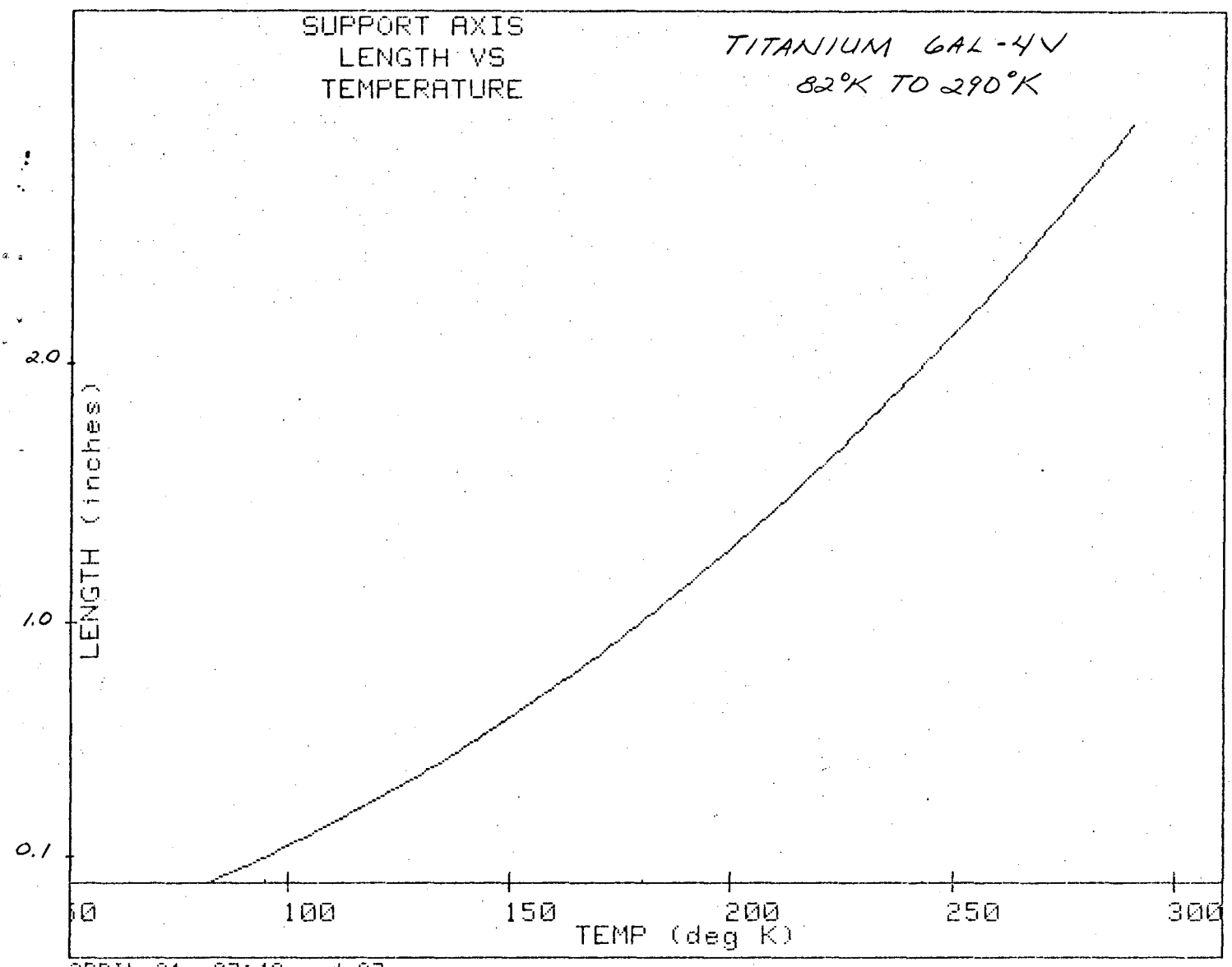
THE HEAT LOAD ON THE SUPPORT IS 547.09135589 watts




APRIL 21, 07:47 and 10 sec.
CALCULATED DATA:

| TEMPERATURE deg K | INTEGRAL watts-in/lb |
|---|---|
| 82.0000000000 | 0.0000000000 |
| 84.1010101010 | .0000010857 |
| 86.2020202020 | .0000021953 |
| 88.3030303030 | .0000033298 |
| 90.4040404040 | .0000044867 |
| 92.5050505051 | .0000056630 |
| 94.6060606061 | .0000068583 |
| 96.7070707071 | .0000080726 |
| 98.8080808081 | .0000093062 |
| 100.9090909090 | .0000105592 |
| 103.0101010100 | .0000118318 |
| 105.1111111110 | .0000131241 |
| 107.2121212120 | .0000144365 |
| 109.3131313130 | .0000157689 |
| 111.4141414140 | .0000171217 |
| 113.5151515150 | .0000184950 |
| 115.6161616160 | .0000198889 |
| 117.7171717170 | .0000213030 |
| 119.8181818180 | .0000227359 |
| 121.9191919190 | .0000241874 |

| | |
|---|---|
| 124.0202020200 | .0000256576 |
| 126.1212121210 | .0000271465 |
| 128.2222222220 | .0000286545 |
| 130.3232323230 | .0000301816 |
| 132.4242424240 | .0000317280 |
| 134.5252525250 | .0000332939 |
| 136.6262626260 | .0000348794 |
| 138.7272727270 | .0000364847 |
| 140.8282828280 | .0000381100 |
| 142.9292929290 | .0000397555 |
| 145.0303030300 | .0000414213 |
| 147.1313131310 | .0000431074 |
| 149.2323232320 | .0000448141 |
| 151.3333333330 | .0000465414 |
| 153.4343434340 | .0000482897 |
| 155.5353535350 | .0000500592 |
| 157.6363636360 | .0000518499 |
| 159.7373737370 | .0000536623 |
| 161.8383838380 | .0000554963 |
| 163.9393939390 | .0000573524 |
| 166.0404040400 | .0000592308 |
| 168.1414141410 | .0000611315 |
| 170.2424242420 | .0000630550 |
| 172.3434343430 | .0000650011 |
| 174.4444444440 | .0000669686 |
| 176.5454545460 | .0000689563 |
| 178.6464646470 | .0000709641 |
| 180.7474747480 | .0000729923 |
| 182.8484848480 | .0000750409 |
| 184.9494949490 | .0000771100 |
| 187.0505050510 | .0000791999 |
| 189.1515151520 | .0000813104 |
| 191.2525252530 | .0000834419 |
| 193.3535353540 | .0000855944 |
| 195.4545454550 | .0000877679 |
| 197.5555555560 | .0000899627 |
| 199.6565656570 | .0000921788 |
| 201.7575757580 | .0000944155 |
| 203.8585858590 | .0000966719 |
| 205.9595959600 | .0000989480 |
| 208.0606060610 | .0001012439 |
| 210.1616161620 | .0001035599 |
| 212.2626262630 | .0001058958 |
| 214.3636363640 | .0001082520 |
| 216.4646464650 | .0001106284 |
| 218.5656565660 | .0001130252 |
| 220.6666666670 | .0001154426 |
| 222.7676767680 | .0001178805 |
| 224.8686868690 | .0001203393 |
| 226.9696969700 | .0001228188 |
| 229.0707070710 | .0001253195 |
| 231.1717171720 | .0001278417 |
| 233.2727272730 | .0001303855 |
| 235.3737373740 | .0001329512 |
| 237.4747474750 | .0001355388 |
| 239.5757575760 | .0001381484 |
| 241.6767676770 | .0001407802 |
| 243.7777777780 | .0001434343 |
| 245.8787878790 | .0001461108 |
| 247.9797979800 | .0001488099 |
| 250.0808080810 | .0001515316 |
| 252.1818181820 | .0001542762 |
| 254.2828282830 | .0001570437 |
| 256.3838383840 | .0001598347 |
| 258.4848484850 | .0001626501 |



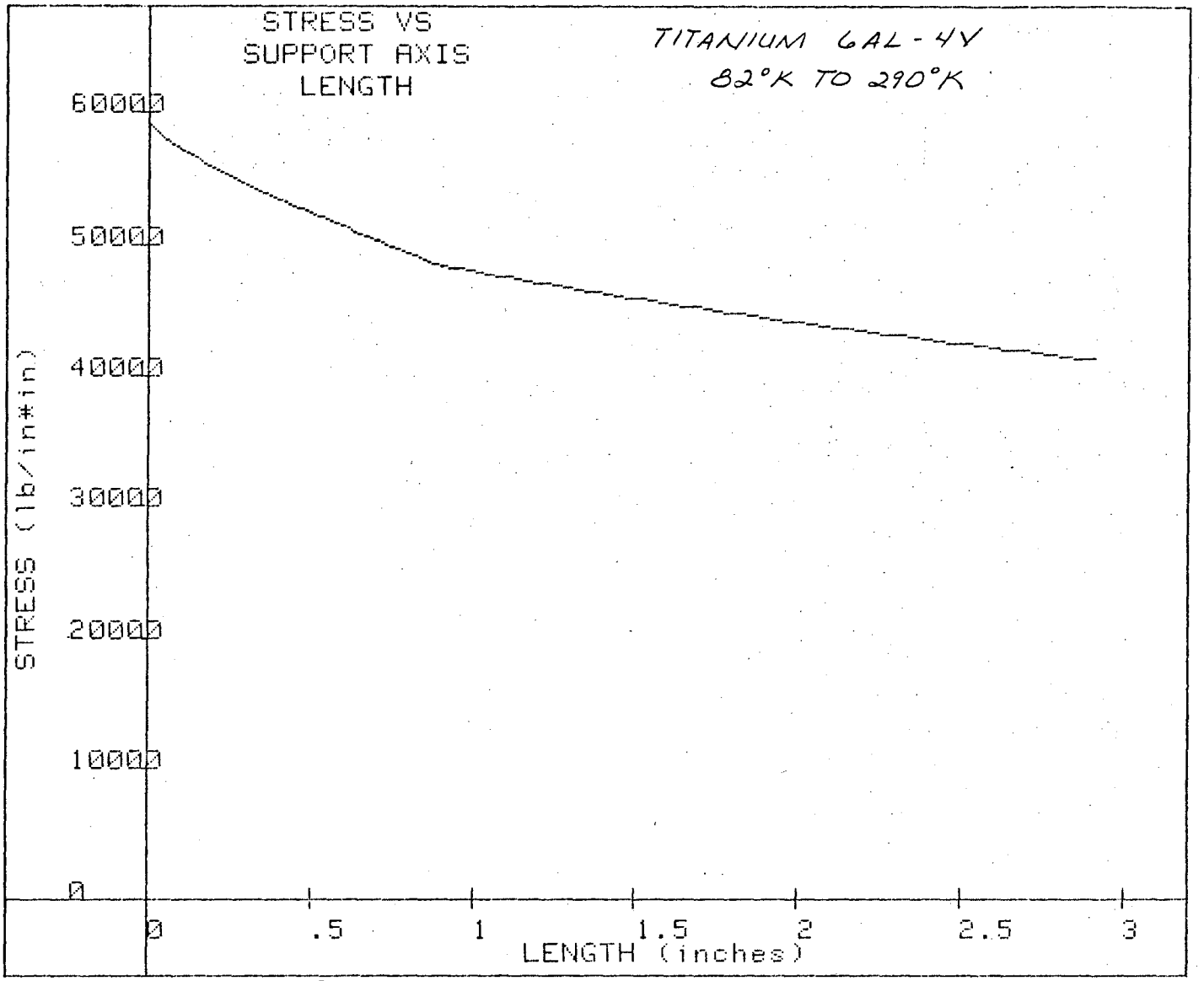

APRIL 21, 07:48 and 07 sec.
CALCULATED DATA:

| TEMPERATURE deg K | SUPPORT AXIS LENGTH inches |
|---|---|
| 82.0000000000 | 0.000000 |
| 84.1010101010 | .015182 |
| 86.2020202020 | .030697 |
| 88.3030303030 | .046560 |
| 90.4040404040 | .062738 |
| 92.5050505051 | .079186 |
| 94.6060606061 | .095899 |
| 96.7070707071 | .112879 |
| 98.8080808081 | .130129 |
| 100.9090909090 | .147649 |
| 103.0101010100 | .165444 |
| 105.1111111110 | .183515 |
| 107.2121212120 | .201866 |
| 109.3131313130 | .220498 |
| 111.4141414140 | .239413 |
| 113.5151515150 | .258616 |
| 115.6161616160 | .278108 |
| 117.7171717170 | .297881 |
| 119.8181818180 | .317918 |
| 121.9191919190 | .338214 |

| | |
|---|---|
| 260.5858585860 | .0001654905 |
| 262.6868686870 | .0001683559 |
| 264.7878787880 | .0001712466 |
| 266.8888888890 | .0001741627 |
| 268.9898989900 | .0001771044 |
| 271.0909090910 | .0001800717 |
| 273.1919191920 | .0001830649 |
| 275.2929292930 | .0001860842 |
| 277.3939393940 | .0001891295 |
| 279.4949494950 | .0001922013 |
| 281.5959595960 | .0001952994 |
| 283.6969696970 | .0001984244 |
| 285.7979797980 | .0002015768 |
| 287.8989898990 | .0002047573 |
| 290.0000000000 | .0002079660 |

| | |
|---|---|
| 124.0202020200 | .358771 |
| 126.1212121210 | .379591 |
| 128.2222222220 | .400677 |
| 130.3232323230 | .422031 |
| 132.4242424240 | .443654 |
| 134.5252525250 | .465550 |
| 136.6262626260 | .487720 |
| 138.7272727270 | .510168 |
| 140.8282828280 | .532894 |
| 142.9292929290 | .555903 |
| 145.0303030300 | .579196 |
| 147.1313131310 | .602773 |
| 149.2323232320 | .626638 |
| 151.3333333330 | .650792 |
| 153.4343434340 | .675238 |
| 155.5353535350 | .699980 |
| 157.6363636360 | .725020 |
| 159.7373737370 | .750362 |
| 161.8383838380 | .776008 |
| 163.9393939390 | .801962 |
| 166.0404040400 | .828227 |
| 168.1414141410 | .854806 |
| 170.2424242420 | .881701 |
| 172.3434343430 | .908914 |
| 174.4444444440 | .936426 |
| 176.5454545460 | .964219 |
| 178.6464646470 | .992295 |
| 180.7474747480 | 1.020655 |
| 182.8484848480 | 1.049301 |
| 184.9494949490 | 1.078234 |
| 187.0505050510 | 1.107456 |
| 189.1515151520 | 1.136968 |
| 191.2525252530 | 1.166773 |
| 193.3535353540 | 1.196871 |
| 195.4545454550 | 1.227264 |
| 197.5555555560 | 1.257953 |
| 199.6565656570 | 1.288941 |
| 201.7575757580 | 1.320217 |
| 203.8585858590 | 1.351768 |
| 205.9595959600 | 1.383595 |
| 208.0606060610 | 1.415699 |
| 210.1616161620 | 1.448083 |
| 212.2626262630 | 1.480747 |
| 214.3636363640 | 1.513693 |
| 216.4646464650 | 1.546923 |
| 218.5656565660 | 1.580438 |
| 220.6666666670 | 1.614240 |
| 222.7676767680 | 1.648330 |
| 224.8686868690 | 1.682710 |
| 226.9696969700 | 1.717382 |
| 229.0707070710 | 1.752349 |
| 231.1717171720 | 1.787617 |
| 233.2727272730 | 1.823188 |
| 235.3737373740 | 1.859064 |
| 237.4747474750 | 1.895246 |
| 239.5757575760 | 1.931736 |
| 241.6767676770 | 1.968537 |
| 243.7777777780 | 2.005649 |
| 245.8787878790 | 2.043075 |
| 247.9797979800 | 2.080816 |
| 250.0808080810 | 2.118875 |
| 252.1818181820 | 2.157252 |
| 254.2828282830 | 2.195951 |
| 256.3838383840 | 2.234978 |
| 258.4848484850 | 2.274345 |

| | |
|---|---|
| 260.5858585860 | 2.314062 |
| 262.6868686870 | 2.354130 |
| 264.7878787880 | 2.394551 |
| 266.8888888890 | 2.435327 |
| 268.9898989900 | 2.476460 |
| 271.0909090910 | 2.517953 |
| 273.1919191920 | 2.559807 |
| 275.2929292930 | 2.602025 |
| 277.3939393940 | 2.644609 |
| 279.4949494950 | 2.687560 |
| 281.5959595960 | 2.730882 |
| 283.6969696970 | 2.774579 |
| 285.7979797980 | 2.818660 |
| 287.8989898990 | 2.863133 |
| 290.0000000000 | 2.908000 |

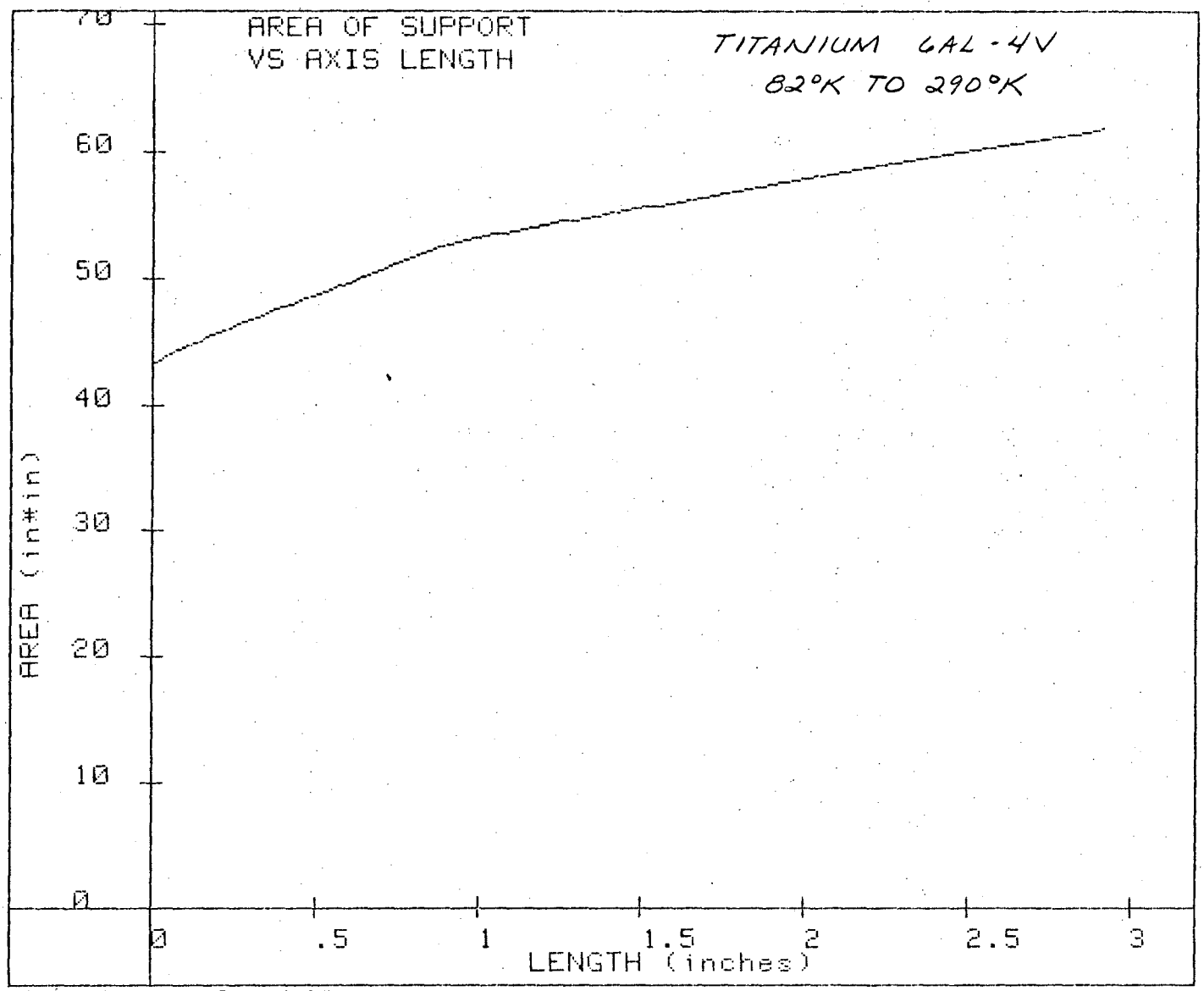



APRIL 21, 07:49 and 12 sec.
CALCULATED DATA:

| SUPPORT AXIS LENGTH inches | STRESS lb/in*in |
|---|---|
| 0.000000 | 59139.0296 |
| .015182 | 58830.6947 |
| .030697 | 58452.8156 |
| .046560 | 58074.9365 |
| .062738 | 57797.8008 |
| .079186 | 57545.6092 |
| .095899 | 57293.4176 |
| .112879 | 57041.2260 |
| .130129 | 56789.0345 |
| .147649 | 56536.8429 |
| .165444 | 56284.6513 |
| .183515 | 56032.4597 |
| .201866 | 55780.2682 |
| .220498 | 55528.0766 |
| .239413 | 55275.8850 |
| .258616 | 55023.6934 |
| .278108 | 54771.5019 |
| .297881 | 54534.0882 |
| .317918 | 54307.1975 |
| .338214 | 54080.3068 |

| | |
|---|---|
| .358771 | 53853.4161 |
| .379591 | 53626.5253 |
| .400677 | 53399.6346 |
| .422031 | 53172.7439 |
| .443654 | 52945.8532 |
| .465550 | 52718.9625 |
| .487720 | 52492.0718 |
| .510168 | 52265.1811 |
| .532894 | 52038.2903 |
| .555903 | 51811.3996 |
| .579196 | 51575.3860 |
| .602773 | 51323.2852 |
| .626638 | 51071.1844 |
| .650792 | 50819.0837 |
| .675238 | 50566.9829 |
| .699980 | 50314.8821 |
| .725020 | 50062.7813 |
| .750362 | 49810.6805 |
| .776008 | 49558.5797 |
| .801962 | 49306.4789 |
| .828227 | 49054.3781 |
| .854806 | 48802.2773 |
| .881701 | 48550.1765 |
| .908914 | 48315.6804 |
| .936426 | 48189.6300 |
| .964219 | 48063.5796 |
| .992295 | 47937.5292 |
| 1.020655 | 47811.4788 |
| 1.049301 | 47685.4284 |
| 1.078234 | 47559.3780 |
| 1.107456 | 47433.3276 |
| 1.136968 | 47307.2772 |
| 1.166773 | 47181.2268 |
| 1.196871 | 47055.1764 |
| 1.227264 | 46929.1260 |
| 1.257953 | 46803.0756 |
| 1.288941 | 46677.0252 |
| 1.320217 | 46550.9332 |
| 1.351768 | 46424.8374 |
| 1.383595 | 46298.7416 |
| 1.415699 | 46172.6458 |
| 1.448083 | 46046.5500 |
| 1.480747 | 45920.4542 |
| 1.513693 | 45794.3585 |
| 1.546923 | 45668.2627 |
| 1.580438 | 45542.1669 |
| 1.614240 | 45416.0711 |
| 1.648330 | 45289.9753 |
| 1.682710 | 45163.8795 |
| 1.717382 | 45037.7837 |
| 1.752349 | 44911.7197 |
| 1.787617 | 44785.6693 |
| 1.823188 | 44659.6189 |
| 1.859064 | 44533.5685 |
| 1.895246 | 44407.5181 |
| 1.931736 | 44281.4677 |
| 1.968537 | 44155.4173 |
| 2.005649 | 44029.3670 |
| 2.043075 | 43903.3166 |
| 2.080816 | 43777.2662 |
| 2.118875 | 43651.2158 |
| 2.157252 | 43525.1654 |
| 2.195951 | 43399.1150 |
| 2.234978 | 43273.0646 |
| 2.274345 | 43147.0142 |

| | |
|---|---|
| 2.314062 | 43020.9638 |
| 2.354130 | 42894.9134 |
| 2.394551 | 42768.8630 |
| 2.435327 | 42642.8126 |
| 2.476460 | 42516.7622 |
| 2.517953 | 42390.7118 |
| 2.559807 | 42264.6614 |
| 2.602025 | 42138.6110 |
| 2.644609 | 42012.5606 |
| 2.687560 | 41886.5102 |
| 2.730882 | 41760.4598 |
| 2.774579 | 41634.7385 |
| 2.818660 | 41509.9755 |
| 2.863133 | 41385.2126 |
| 2.908000 | 41260.4496 |




APRIL 21, 07:50 and 08 sec.
CALCULATED DATA:

| SUPPORT AXIS LENGTH inches | AREA OF SUPPORT in*in |
|---|---|
| 0.00000 | 43.118733 |
| .01518 | 43.344720 |
| .03070 | 43.624930 |
| .04656 | 43.908787 |
| .06274 | 44.119326 |
| .07919 | 44.312677 |
| .09590 | 44.507731 |
| .11288 | 44.704509 |
| .13013 | 44.903035 |
| .14765 | 45.103332 |
| .16544 | 45.305424 |
| .18352 | 45.509335 |
| .20187 | 45.715090 |
| .22050 | 45.922714 |
| .23941 | 46.132233 |
| .25862 | 46.343672 |
| .27811 | 46.557058 |
| .29788 | 46.759744 |
| .31792 | 46.955102 |
| .33821 | 47.152099 |

| | |
|---|---|
| .35877 | 47.350757 |
| .37959 | 47.551095 |
| .40068 | 47.753136 |
| .42203 | 47.956901 |
| .44365 | 48.162412 |
| .46555 | 48.369692 |
| .48772 | 48.578765 |
| .51017 | 48.789652 |
| .53289 | 49.002378 |
| .55590 | 49.216968 |
| .57920 | 49.442189 |
| .60277 | 49.685050 |
| .62664 | 49.930309 |
| .65079 | 50.178000 |
| .67524 | 50.428162 |
| .69998 | 50.680830 |
| .72502 | 50.936043 |
| .75036 | 51.193840 |
| .77601 | 51.454259 |
| .80196 | 51.717341 |
| .82823 | 51.983128 |
| .85481 | 52.251660 |
| .88170 | 52.522981 |
| .90891 | 52.777897 |
| .93643 | 52.915949 |
| .96422 | 53.054725 |
| .99229 | 53.194231 |
| 1.02065 | 53.334472 |
| 1.04930 | 53.475455 |
| 1.07823 | 53.617186 |
| 1.10746 | 53.759669 |
| 1.13697 | 53.902912 |
| 1.16677 | 54.046920 |
| 1.19687 | 54.191700 |
| 1.22726 | 54.337257 |
| 1.25795 | 54.483599 |
| 1.28894 | 54.630731 |
| 1.32022 | 54.778709 |
| 1.35177 | 54.927494 |
| 1.38359 | 55.077091 |
| 1.41570 | 55.227504 |
| 1.44808 | 55.378742 |
| 1.48075 | 55.530810 |
| 1.51369 | 55.683715 |
| 1.54692 | 55.837465 |
| 1.58044 | 55.992066 |
| 1.61424 | 56.147525 |
| 1.64833 | 56.303851 |
| 1.68271 | 56.461049 |
| 1.71738 | 56.619127 |
| 1.75235 | 56.778053 |
| 1.78762 | 56.937856 |
| 1.82319 | 57.098562 |
| 1.85906 | 57.260177 |
| 1.89525 | 57.422709 |
| 1.93174 | 57.586167 |
| 1.96854 | 57.750558 |
| 2.00565 | 57.915891 |
| 2.04307 | 58.082172 |
| 2.08082 | 58.249412 |
| 2.11887 | 58.417617 |
| 2.15725 | 58.586796 |
| 2.19595 | 58.756959 |
| 2.23498 | 58.928112 |
| 2.27435 | 59.100266 |

| | |
|---|---|
| 2.31406 | 59.273428 |
| 2.35413 | 59.447608 |
| 2.39455 | 59.622815 |
| 2.43533 | 59.799057 |
| 2.47646 | 59.976345 |
| 2.51795 | 60.154687 |
| 2.55981 | 60.334093 |
| 2.60202 | 60.514572 |
| 2.64461 | 60.696134 |
| 2.68756 | 60.878789 |
| 2.73088 | 61.062546 |
| 2.77458 | 61.246932 |
| 2.81866 | 61.431017 |
| 2.86313 | 61.616211 |
| 2.90800 | 61.802526 |

```
10    INPUT "DOES THE COMPUTER HAVE A REAL TIME CLOCK?",Rtime$
20    INPUT "INPUT THE MAXIMUM TEMPERATURE IN deg K",Tmax
30    INPUT "INPUT THE MINIMUM TEMPERATURE IN deg K",Tmin
40    INPUT "INPUT THE YIELD STRESS FACTOR 'K'",K
50    DIM X1(20),Y1(20),Z1(20),Z2(20),Xx(101),Yy(101),Yy1(101),Yy2(101),Int(100)
,Thermo(20),Dx(100),Ax(100),Yx(100)
60    DIM X(101),Y(101)
61    PRINT "DO YOU WANT A HARDCOPY OF THE INPUT PARAMETERS AND RESULTS?"
62    INPUT Answer$
63    IF (Answer$="YES") OR (Answer$="Y") THEN GOTO 66
64    An=0
65    GOTO 70
66    An=1
70    F=2.55E6
80    L=11.12
90    A=0
100   READ N1
110   FOR I=1 TO N1
120   READ Z1(I)
130   NEXT I
140   FOR I=1 TO N1
150   READ Y1(I)
160   NEXT I
170   READ N2
180   FOR I=1 TO N2
190   READ Z2(I)
200   NEXT I
210   FOR I=1 TO N2
220   READ Thermo(I)
230   NEXT I
240   Xn=(Tmax-Tmin)/99
250   FOR I=1 TO 100
260   Xx(I)=Tmin+(I-1)*Xn
270   FOR J=1 TO N1-1
280   IF (Z1(J)<Xx(I)) AND (Xx(I)<=Z1(J+1)) THEN GOTO 300
290   GOTO 310
300   Yy1(I)=Y1(J)+(Y1(J+1)-Y1(J))/(Z1(J+1)-Z1(J))*(Xx(I)-Z1(J))
310   NEXT J
320   NEXT I
330   FOR I=1 TO 100
340   FOR J=1 TO N2-1
350   IF (Z2(J)<Xx(I)) AND (Xx(I)<=Z2(J+1)) THEN GOTO 370
360   GOTO 380
370   Yy2(I)=Thermo(J)+(Thermo(J+1)-Thermo(J))/(Z2(J+1)-Z2(J))*(Xx(I)-Z2(J))
380   NEXT J
390   NEXT I
400   FOR I=1 TO 100
410   Yy(I)=Yy2(I)/Yy1(I)
420   Yx(I)=Yy1(I)*K
430   NEXT I
440   Int(1)=0
450   FOR I=2 TO 100
460   Int(I)=Int(I-1)+(Yy(I)+Yy(I-1))*Xn/2
470   NEXT I
480   FOR I=1 TO 100
490   Dx(I)=L*Int(I)/Int(100)
500   Ax(I)=F/Yx(I)
510   NEXT I
511   IF An=1 THEN PRINTER IS 0
512   IF An=0 THEN PRINTER IS 16
520   GOTO 750
530   PRINT "INPUT DATA:"
540   PRINT ""
550   PRINT "TEMPERATURE       YIELD STRESS"
560   PRINT "   deg K            lb/in*in"
```

```
570   PRINT ""
580   FOR I=1 TO N1
590   PRINT USING 600;Z1(I),Y1(I)
600   IMAGE XXDDD.DDXXXXXXXX,DDDDDDDD.DDD
610   NEXT I
630   GOTO 3190
640   PRINT "INPUT DATA:"
650   PRINT ""
660   PRINT "TEMPERATURE       THERMAL COND"
670   PRINT "   deg K         watts-in/deg K"
680   PRINT ""
690   FOR I=1 TO N2
700   PRINT USING 710;Z2(I),Thermo(I)
710   IMAGE XXDDD.DDXXXXXXXX,DDD.DDDDDDDD
720   NEXT I
740   GOTO 3190
750   PRINT "INPUT PARAMETERS AND RESULTS:"
760   IF (Rtime$="YES") OR (Rtime$="Y") THEN GOSUB Rtime
770   PRINT ""
771   PRINT "THIS OUTPUT IS FOR 304 LN STAINLESS STEEL"
772   PRINT ""
780   PRINT "THE TEMPERATURE RANGE IS BETWEEN";Tmin;"deg K AND";Tmax;"deg K"
790   PRINT ""
800   PRINT "THE FORCE EXERTED ON THE SUPPORT IS";F;"LBS"
810   PRINT ""
820   PRINT "THE LENGTH OF THE SUPPORT IS";L;"INCHES"
830   PRINT ""
840   PRINT "THE YIELD STRESS FACTOR IS";K
850   PRINT ""
860   PRINT "THE NUMBER OF YIELD STRESS INPUT POINTS IS";N1
870   PRINT ""
880   PRINT "THE NUMBER OF THERMAL CONDUCTIVITY INPUT POINTS IS";N2
890   PRINT ""
900   PRINT "THE TEMPERATURE INCREMENT IS";Xn
910   GOTO 1460
920   PRINT "CALCULATED DATA:"
930   PRINT ""
940   PRINT "  TEMPERATURE      THERMAL COND / YIELD STRESS"
950   PRINT "     deg K                watts-in/lb deg K"
960   PRINT ""
970   FOR I=1 TO 100
980   PRINT USING 990;Xx(I),Yy(I)
990   IMAGE DDD.DDDDDDDDDDXXXXXXXXXX,DD.DDDDDDDDDDXXXXXXXXXXXXXX
1000  NEXT I
1020  GOTO 3190
1030  PRINT "CALCULATED DATA:"
1040  PRINT ""
1050  PRINT "  TEMPERATURE            INTEGRAL"
1060  PRINT "     deg K             watts-in/lb"
1070  PRINT ""
1080  FOR I=1 TO 100
1090  PRINT USING 1100;Xx(I),Int(I)
1100  IMAGE DDD.DDDDDDDDDDXXXXX,DDD.DDDDDDDDDD
1110  NEXT I
1130  GOTO 3190
1140  PRINT "CALCULATED DATA:"
1150  PRINT ""
1160  PRINT "  TEMPERATURE      SUPPORT AXIS LENGTH"
1170  PRINT "     deg K                  inches"
1180  PRINT ""
1190  FOR I=1 TO 100
1200  PRINT USING 1210;Xx(I),Dx(I)
1210  IMAGE DDD.DDDDDDDDDDXXXXXXXX,DDDD.DDDDDD
1220  NEXT I
1240  GOTO 3190
1250  PRINT "CALCULATED DATA:"
```

```
1260  PRINT ""
1270  PRINT "SUPPORT AXIS LENGTH          STRESS"
1280  PRINT "      inches                 lb/in*in"
1290  PRINT ""
1300  FOR I=1 TO 100
1310  PRINT USING 1320;Dx(I),Yx(I)
1320  IMAGE XXXDDD.DDDDDDXXXXXXXXXXXX,DDDDDD.DDDD
1330  NEXT I
1350  GOTO 3190
1360  PRINT "CALCULATED DATA:"
1370  PRINT ""
1380  PRINT "SUPPORT AXIS LENGTH         AREA OF SUPPORT"
1390  PRINT "      inches                     in*in"
1400  PRINT ""
1410  FOR I=1 TO 100
1420  PRINT USING 1430;Dx(I),Ax(I)
1430  IMAGE XXXDDD.DDDDDXXXXXXXXXXXXXXXX,DDDD.DDDDDD
1440  NEXT I
1450  GOTO 3190
1460  PRINT ""
1470  PRINT "THE FINAL INTEGRAL FROM";Tmin;"TO";Tmax;"deg K IS";Int(100)
1480  PRINT ""
1490  Q=F*Int(100)/(L*K)
1500  PRINT "THE HEAT LOAD ON THE SUPPORT IS";Q;"watts"
1501  PRINTER IS 16
1510  WAIT 3000
1520  Nplot=1 ! DEFAULT VALUE FOR THE NUMBER OF PLOTS.
1530  N=N1
1540  MAT X=Z1
1550  MAT Y=Y1
1560  Titlea$="YIELD STRESS VS"
1570  Titleb$="  TEMPERATURE"
1580  Xlabel$="TEMP (deg K)"
1590  Ylabel$="STRESS (lb/in*in)"
1591  A=1
1600  GOSUB Graphics
1610  N=N2
1620  MAT X=Z2
1630  MAT Y=Thermo
1640  Titlea$=" THERMAL COND"
1650  Titleb$="VS TEMPERATURE"
1660  Xlabel$="TEMP (deg K)"
1670  Ylabel$="COND (Watts-in/K)"
1671  A=2
1680  GOSUB Graphics
1690  N=100
1700  MAT X=Xx
1710  MAT Y=Yy
1720  Titlea$="THERMAL COND /"
1730  Titleb$="YIELD STRESS"
1740  Titlec$="VS TEMPERATURE"
1750  Ylabel$="COND/STRESS"
1760  Xlabel$="TEMP (deg K)"
1761  A=3
1770  GOSUB Graphics
1780  N=100
1790  MAT X=Xx
1800  MAT Y=Int
1810  Titlea$=" COND/STRESS"
1820  Titleb$="   INTEGRAL"
1830  Titlec$="VS TEMPERATURE"
1840  Xlabel$="TEMP (deg K)"
1850  Ylabel$="INT (watts-in/lb)"
1851  A=4
1860  GOSUB Graphics
```

```
1870  N=100
1880  MAT X=Xx
1890  MAT Y=Dx
1900  Titlea$="SUPPORT AXIS"
1910  Titleb$="  LENGTH VS"
1920  Titlec$=" TEMPERATURE"
1930  Xlabel$="TEMP (deg K)"
1940  Ylabel$="LENGTH (inches)"
1941  A=5
1950  GOSUB Graphics
1960  N=100
1970  MAT X=Dx
1980  MAT Y=Yx
1990  Titlea$=" STRESS VS"
2000  Titleb$="SUPPORT AXIS"
2010  Titlec$="   LENGTH"
2020  Xlabel$="LENGTH (inches)"
2030  Ylabel$="STRESS (lb/in*in)"
2031  A=6
2040  GOSUB Graphics
2050  N=100
2060  MAT X=Dx
2070  MAT Y=Ax
2080  Titlea$="AREA OF SUPPORT"
2090  Titleb$="VS AXIS LENGTH"
2100  Titlec$=""
2110  Xlabel$="LENGTH (inches)"
2120  Ylabel$="AREA (in*in)"
2121  A=7
2130  GOSUB Graphics
2140  STOP
2150  END
2160 Graphics:  Code$="Graphics"
2170  Ymax=Y(1)
2180  Ymin=Y(1)
2190  Imax=1
2200  Imin=1
2210  FOR I=1 TO N
2220  IF Y(I)>Ymax THEN Imax=I
2230  IF Y(I)>Ymax THEN Ymax=Y(I)
2240  IF Y(I)<Ymin THEN Imin=I
2250  IF Y(I)<Ymin THEN Ymin=Y(I)
2260  NEXT I
2270  IF Nplot=1 THEN GOTO 2340
2280  FOR I=1 TO N
2290  IF Y1(I)>Ymax THEN Imax=I
2300  IF Y1(I)>Ymax THEN Ymax=Y1(I)
2310  IF Y1(I)<Ymin THEN Imin=I
2320  IF Y1(I)<Ymin THEN Ymin=Y1(I)
2330  NEXT I
2340  Xmin=X(1)
2350  Xmax=X(N)
2360  IF Ymin>0 THEN Ymin=0
2370  Ysize=Ymax-Ymin
2380  Xsize=ABS(Xmax-Xmin)
2390  FOR I=-20 TO 20
2400  Xscale=Xsize*10^I
2410  Yscale=Ysize*10^I
2420  IF (Xscale>1) AND (Xscale<=10) THEN Ixscale=I
2430  IF (Yscale>1) AND (Yscale<=10) THEN Iyscale=I
2440  NEXT I
2450  Xscale=Xsize*10^Ixscale
2460  Yscale=Ysize*10^Iyscale
2470  IF (Xscale>=1) AND (Xscale<2) THEN Xscale=.2*10^(-Ixscale)
2480  IF (Yscale>=1) AND (Yscale<2) THEN Yscale=.2*10^(-Iyscale)
```

```
2490  IF (Xscale>=2) AND (Xscale<5) THEN Xscale=.5*10^(-Ixscale)
2500  IF (Yscale>=2) AND (Yscale<5) THEN Yscale=.5*10^(-Iyscale)
2510  IF (Xscale>=5) AND (Xscale<10) THEN Xscale=1*10^(-Ixscale)
2520  IF (Yscale>=5) AND (Yscale<10) THEN Yscale=1*10^(-Iyscale)
2530  GRAPHICS
2540  GCLEAR
2550  LOCATE 0,123,0,100
2560  FRAME
2570  SCALE Xmin-.15*Xsize,Xmax+.1*Xsize,Ymin-.1*Ysize,Ymax+.15*Ysize
2580  AXES Xscale,Yscale,0,0
2590  MOVE X(1),Y(1)
2600  FOR I=1 TO N
2610  DRAW X(I),Y(I)
2620  NEXT I
2630  IF Nplot=1 THEN GOTO 2700
2640  LINE TYPE 8
2650  MOVE X(1),Y1(I)
2660  FOR I=1 TO N
2670  DRAW X(I),Y1(I)
2680  NEXT I
2690  LINE TYPE 1
2700  FOR I=0 TO 12
2710  MOVE (I-.1)*Xscale,-.05*Ysize
2720  LABEL I*Xscale
2730  NEXT I
2740  FOR I=-10 TO 10
2750  MOVE -.1*Xsize,I*Yscale
2760  LABEL I*Yscale
2770  NEXT I
2780  MOVE Xmin+.1*Xsize,Ymax+.12*Ysize
2790  LABEL Titlea$
2800  LABEL Titleb$
2810  LABEL Titlec$
2820  MOVE Xmin+.4*Xsize,-.08*Ysize
2830  LABEL Xlabel$
2840  MOVE Xmin-.12*Xsize,Ymin+.3*Ysize
2850  LDIR PI/2
2860  LABEL Ylabel$
2870  LDIR 0
2880  IF Nplot=1 THEN GOTO 2990
2890  MOVE Xmin+.4*Xsize,Ymin+.1*Ysize
2900  LABEL C1$
2910  MOVE Xmin+.65*Xsize,Ymin+.1*Ysize
2920  DRAW Xmax,Ymin+.1*Ysize
2930  MOVE Xmin+.4*Xsize,Ymin+.05*Ysize
2940  LABEL C2$
2950  LINE TYPE 8
2960  MOVE Xmin+.65*Xsize,Ymin+.05*Ysize
2970  DRAW Xmax,Ymin+.05*Ysize
2980  LINE TYPE 1
2990  WAIT 5000
3000  PRINT PAGE
3010  PRINT "DO YOU WANT A HARD COPY OF THIS GRAPH?"
3020  INPUT Answer$
3030  IF (Answer$="YES") OR (Answer$="Y") THEN GOSUB Dump
3040  GCLEAR
3050  Answer$="NO"
3060  EXIT GRAPHICS
3070  RETURN
3080 Dump: PRINTER IS 0
3090  PRINT PAGE
3100  DUMP GRAPHICS
3110  IF (Rtime$="YES") OR (Rtime$="Y") THEN GOSUB Rtime
3120  IF A=1 THEN GOTO 530
3130  IF A=2 THEN GOTO 640
```

```
3140  IF A=3 THEN GOTO 920
3150  IF A=4 THEN GOTO 1030
3160  IF A=5 THEN GOTO 1140
3170  IF A=6 THEN GOTO 1250
3180  IF A=7 THEN GOTO 1360
3190  PRINTER IS 16
3200  RETURN
3210 Rtime:  ! SUBROUTINE TO PRINT THE CURRENT REAL TIME.
3220  OUTPUT 9;"R" !REQUESTS THE REAL TIME FROM THE CLOCK.
3230  ENTER 9;T$ !ASSIGNS THE OUTPUT OF THE CLOCK TO T$.
3240  IF T$[1;2]="01" THEN Month$="JANUARY"
3250  IF T$[1;2]="02" THEN Month$="FEBRUARY"
3260  IF T$[1;2]="03" THEN Month$="MARCH"
3270  IF T$[1;2]="04" THEN Month$="APRIL"
3280  IF T$[1;2]="05" THEN Month$="MAY"
3290  IF T$[1;2]="06" THEN Month$="JUNE"
3300  IF T$[1;2]="07" THEN Month$="JULY"
3310  IF T$[1;2]="08" THEN Month$="AUGUST"
3320  IF T$[1;2]="09" THEN Month$="SEPTEMBER"
3330  IF T$[1;2]="10" THEN Month$="OCTOBER"
3340  IF T$[1;2]="11" THEN Month$="NOVEMBER"
3350  IF T$[1;2]="12" THEN Month$="DECEMBER"
3360  PRINT Month$;" ";T$[4;2];",";" ";T$[7;5];" and ";T$[13];" sec."
3370  RETURN
3380  DATA 3
3390  DATA 0,77,300
3400  DATA 112E3,90E3,42E3
3410  DATA 18
3420  DATA 0,10,20,30,40,50,60,70,80,90,100,120,140,160,180,200,250,300
3430  DATA 0,.0196,.0495,.0838,.1194,.1473,.1727,.193,.2108,.2286,.2413,.2616,.2
794,.3048,.3124,.3302,.3556,.381
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