WELLBORE TEMPERATURE MEASUREMENTS IN AIR AND WATER USING CONTINUOUS AND EQUILIBRIUM LOGGING METHODS

Brian K. Peterson

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INTRODUCTION

The purpose of this paper is to summarize observations made in analyzing high precision wellbore temperature log data that were obtained in two distinct downhole environments using two logging methods. The two environments were either "water," a term which is here loosely applied to groundwater, various liquid hydrocarbons, or mixtures of both; or "air," which might be more accurately denoted as methane with respect to the wells considered in this paper. The two logging methods used were the equilibrium method and the continuous method, both of which are described later.

A comparison between the results obtained with the equilibrium method and those obtained with the continous method is made in this paper. It is to be hoped that this comparison will (1) allow an evaluation to be made, with respect to accuracy and efficiency, of the two logging methods in a water column and in an air column, and (2) provide insight into appropriately interpreting data that is obtained in water and in air by either the continuous or the equilibrium logging method.

PROCEDURE

Equipment. The major components of the data acquisition system used in obtaining the temperature logs to be presented here were a thermistor, an 8000-foot length of fourconductor cable, an electronic digital ohmmeter, and an odometer which measured downhole cable length. The thermistor consisted of a device having a hydrodynamic profile and electrically conforming to a resistance of 100,000 ohms at 77° F. It was connected through the cable to the ohmmeter circuitry in a four-wire configuration. Thus, a constant current was supplied to the thermistor by the ohmmeter through two conductors while the resulting voltage drop across the thermistor was sensed via the remaining two conductors. This arrangement permitted measurement of the thermistor resistance while eliminating the effects of varying cable resistance. The current supplied to the thermistor was limited such that the I^2R loss occurring at the thermistor would be insignificant. The accuracy of the system was determined to be better than 0.05% for temperatures between 64.8° F. and 228.7° F.

Logging Methods. The equilibrium method of temperature logging consisted in lowering the probe into the well to a predetermined depth, then maintaining the probe at that depth for a period of time, usually fifteen to thirty minutes, while thermal equilibrium between the probe and its downhole environment was either attained or approached. During this stationary period the ohmmeter was actuated manually at regular intervals, usually thirty or sixty seconds. The probe resistance was automatically recorded via a thermal printer connected to the ohmmeter, thereby allowing the time response of the probe to be observed.

The preceding procedure was repeated at several successive depth intervals to obtain an "equilibrium log" of the well.

The continuous method of logging a well involved initially obtaining an equilibrium point near the upper part of the well as described above. Successive temperatures, however, were obtained by manually actuating the thermal printer as the probe passed certain predetermined depths as indicated by the cable odometer. The probe was generally lowered at the rate of sixty feet per minute and resistance was typically recorded at ten foot intervals. The resistance values recorded represented the average of the ten resistance measurements made in the most recent complete one-second averaging cycle of the ohmmeter.

Wells. Data from three wells are presented in this paper. The logging schedules of those wells are as follows:

Date: June 29, 1977 Well: Datil Probe: #4

Calibration Depths	Equilibrium Logging Interval
60 - 150 ft	30 ft
150 - 250	50
250 - 450	100
450 - 600	150
	Continuous Logging Interval
600 ft	10 ft
1000	10
1200	10
1400	10
1600	10
1800	10
2000	10

Date: June 30, 1977 Well: Datil Probe: #4

Calibration Depths	Continuous Logging Interval
70 ft	10 ft
1000	10
2000	10
2200	10
2400	10
2600	10
2800	10
3000	10
3200	10
3400	10
3600	10
4600	10
4900	10

Date: July 11, 1977 Well: Red Wash Probe: #6

Calibration Depths	Equilib. Log Interval	Contin. Log Interval
500 - 1900 ft	100 ft	25 ft

	Continuous Logging Interval
1900 ft	10 ft
2500	10
3000	10
3500	10
4000	10
4500	10
4800	10

Date: July 12, 1977 Well: Red Wash Probe: #6

Calibration Depths	Continuous Logging Interval
500 ft	25 ft
600	25
1300	25
1900	10
2000	10
2100	10
2200	10
2300	10
3000	10
3100	10

Date: July 14, 1977 Well: Cache Probe: #6

Calibration Depths	Continuous Logging Interval
400 ft	10 ft
900	10
1400	10
1600	10
1700	10
2000	10
3000	10
4000	10
5000	10
5500	10

DATA

The depth and resistance data that were recorded on the thermal printer paper tape in the field were entered onto data cards for computer processing. The output of the program for interpretation of the resistance data included a listing of temperatures, depths, and temperature gradients and provided plots of depth vs. temperature. Listings and depth-temperature plots for the Datil, Red Wash, and Cache wells are found on the following pages. It should be noted that the temperatures appearing in the listings at each calibration point represent the "~~touchdown~~ final" temperatures. The ~~TD~~ final temperature is the temperature recorded at the ~~time the probe reached a given depth and remained stationary during~~ end of the calibration interval.

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DATIL 6/29/77, TOOL #4, SYSTRON DONNER,RC=190

    DEPTH          *    GRAD     *        TEMPERATURE          *           RESISTANCE
 FEET    METERS    *  DEG C/KM   *   DEG C          DEG F      *        +          -          DELTA
   60.0    18.3     -303.097       16.882          62.387        145330.00
   90.0    27.4       60.453       14.110          57.398        165789.94
  120.0    36.6       67.349       14.663          58.393        161462.00
  150.0    45.7       98.386       15.279          59.502        156789.94
  200.0    61.0       56.650       16.778          62.200        146039.94
  250.0    76.2       51.799       17.641          63.755        140229.94
  350.0   106.7       56.611       19.220          66.596        130270.00
  450.0   137.2       66.556       20.946          69.702        120289.94
  600.0   182.9       68.314       23.989          75.180        104729.94
  610.0   185.9       99.903       24.197          75.554        103751.94
  620.0   189.0      108.944       24.501          76.103        102339.00
  630.0   192.0       65.491       24.833          76.700        100824.94
  640.0   195.1       51.839       25.033          77.060         99925.94
  650.0   198.1       35.043       25.191          77.344         99222.00
  660.0   201.2       30.798       25.298          77.536         98748.94
  670.0   204.2       20.841       25.392          77.705         98335.00
  680.0   207.3       21.862       25.455          77.820         98055.94
  690.0   210.3       23.098       25.522          77.939         97764.00
  700.0   213.4       33.066       25.592          78.066         97457.00
  710.0   216.4       43.879       25.693          78.248         97020.00
  720.0   219.5       80.829       25.827          78.488         96442.94
  730.0   222.5       90.186       26.073          78.932         95389.00
  740.0   225.6       80.168       26.348          79.427         94229.94
  750.0   228.6       73.706       26.592          79.866         93212.00
  760.0   231.6       70.166       26.817          80.271         92287.94
  770.0   234.7       49.761       27.031          80.656         91417.94
  780.0   237.7       39.744       27.183          80.929         90805.94
  790.0   240.8       57.961       27.304          81.147         90320.94
  800.0   243.8       70.301       27.480          81.465         89619.00
  810.0   246.9       49.526       27.695          81.851         88774.94
  820.0   249.9       41.716       27.846          82.122         88186.00
  830.0   253.0       50.332       27.973          82.351         87694.00
  840.0   256.0       41.809       28.126          82.627         87104.00
  850.0   259.1       40.103       28.254          82.857         86617.00
  860.0   262.1       39.532       28.376          83.077         86152.94
  870.0   265.2       36.682       28.496          83.294         85699.00
  880.0   268.2       36.764       28.608          83.495         85279.94
  890.0   271.3       39.881       28.720          83.697         84861.94
  900.0   274.3       43.022       28.842          83.915         84410.94
  910.0   277.4       49.439       28.973          84.151         83927.94
  920.0   280.4       55.746       29.124          84.423         83376.94
  930.0   283.5       52.518       29.294          84.728         82759.94
  940.0   286.5       36.003       29.454          85.017         82182.94
  950.0   289.6       22.509       29.563          85.214         81791.00
  960.0   292.6       23.208       29.632          85.338         81546.94
  970.0   295.7       33.898       29.703          85.465         81296.00
  980.0   298.7       27.493       29.806          85.651         80930.94
  990.0   301.8       37.079       29.890          85.802         80636.00
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1000.0   304.8    22.333    30.003     86.005   80240.00
1020.0   310.9    32.073    30.139     86.250   79766.94
1030.0   313.9    38.534    30.237     86.426   79429.00
1040.0   317.0    41.980    30.354     86.638   79024.94
1050.0   320.0    45.389    30.482     86.868   78587.00
1060.0   323.1   102.792    30.621     87.117   78117.00
1070.0   326.1   133.010    30.934     87.681   77065.00
1080.0   329.2    87.582    31.339     88.411   75727.00
1090.0   332.2   123.824    31.606     88.891   74860.00
1100.0   335.3    51.332    31.984     89.571   73654.00
1110.0   338.3    33.358    32.140     89.852   73160.00
1120.0   341.4    43.542    32.242     90.035   72841.00
1130.0   344.4    31.343    32.374     90.274   72427.94
1140.0   347.5    36.827    32.470     90.446   72132.00
1150.0   350.5    37.956    32.582     90.648   71785.94
1160.0   353.6    44.979    32.698     90.856   71430.94
1170.0   356.6    23.615    32.835     91.103   71013.00
1180.0   359.7    29.225    32.907     91.233   70794.94
1190.0   362.7    71.642    32.996     91.393   70526.00
1200.0   365.8    27.743    33.214     91.786   69871.00
1210.0   368.8    15.474    33.299     91.938   69619.00
1220.0   371.9    15.094    33.346     92.023   69479.00
1230.0   374.9    16.580    33.392     92.106   69343.00
1240.0   378.0    36.173    33.443     92.197   69194.00
1250.0   381.0    45.228    33.553     92.395   68869.94
1260.0   384.0    55.231    33.691     92.643   68466.94
1270.0   387.1    34.039    33.859     92.947   67977.94
1280.0   390.1    20.470    33.963     93.133   67679.00
1290.0   393.2    18.587    34.025     93.246   67500.00
1300.0   396.2    15.735    34.082     93.348   67337.94
1310.0   399.3    17.050    34.130     93.434   67201.00
1320.0   402.3    36.969    34.182     93.527   67052.94
1330.0   405.4    78.470    34.295     93.730   66733.00
1340.0   408.4   102.823    34.534     94.161   66059.94
1350.0   411.5   116.109    34.847     94.725   65190.00
1360.0   414.5    88.068    35.201     95.362   64223.00
1370.0   417.6    92.286    35.469     95.845   63500.00
1380.0   420.6    79.161    35.751     96.351   62753.00
1390.0   423.7    81.483    35.992     96.786   62119.99
1400.0   426.7    64.212    36.240     97.233   61476.00
1410.0   429.8    60.337    36.436     97.585   60974.00
1420.0   432.8    52.838    36.620     97.916   60506.00
1430.0   435.9    58.776    36.781     98.206   60100.00
1440.0   438.9    54.975    36.960     98.529   59651.99
1450.0   442.0    46.205    37.128     98.830   59235.99
1460.0   445.0    69.764    37.269     99.084   58889.00
1470.0   448.1    50.926    37.481     99.466   58369.99
1480.0   451.1    49.219    37.637     99.746   57994.00
1490.0   454.2    53.539    37.787    100.016   57632.99
1500.0   457.2    51.827    37.950    100.310   57244.00
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1510.0   460.2    49.925    38.108    100.594   56869.99
1520.0   463.3    49.618    38.260    100.868   56511.99
1530.0   466.3    50.861    38.411    101.140   56159.00
1540.0   469.4    47.767    38.566    101.419   55800.00
1550.0   472.4    36.116    38.712    101.681   55465.00
1560.0   475.5    39.077    38.822    101.879   55213.00
1570.0   478.5    54.485    38.941    102.094   54942.00
1580.0   481.6    28.199    39.107    102.393   54567.00
1590.0   484.6    38.867    39.193    102.547   54373.99
1600.0   487.7    55.216    39.311    102.761   54108.99
1610.0   490.7    50.966    39.480    103.063   53735.00
1620.0   493.8    48.728    39.635    103.343   53393.00
1630.0   496.8    48.732    39.784    103.610   53067.99
1640.0   499.9    50.931    39.932    103.878   52744.99
1650.0   502.9    58.265    40.087    104.157   52410.00
1660.0   506.0    45.518    40.265    104.477   52030.00
1670.0   509.0    49.359    40.404    104.727   51735.00
1680.0   512.1    52.527    40.554    104.997   51417.00
1690.0   515.1    44.804    40.714    105.286   51082.00
1700.0   518.2    49.349    40.851    105.531   50798.00
1710.0   521.2    56.607    41.001    105.802   50487.00
1720.0   524.3    51.287    41.174    106.113   50132.99
1730.0   527.3    48.343    41.330    106.394   49815.00
1740.0   530.4    51.926    41.477    106.659   49517.00
1750.0   533.4    50.055    41.636    106.944   49199.00
1760.0   536.4    53.729    41.788    107.219   48895.00
1770.0   539.5    48.043    41.952    107.514   48571.00
1780.0   542.5    48.373    42.098    107.777   48283.00
1790.0   545.6    53.729    42.246    108.043   47994.99
1800.0   548.6    52.368    42.410    108.337   47677.99
1810.0   551.7    46.511    42.569    108.625   47371.00
1820.0   554.7    44.452    42.711    108.880   47100.00
1830.0   557.8    42.171    42.847    109.124   46843.00
1840.0   560.8    41.505    42.975    109.355   46601.00
1850.0   563.9    46.314    43.102    109.583   46364.00
1860.0   566.9    38.066    43.243    109.837   46101.00
1870.0   570.0    45.103    43.359    110.046   45886.00
1880.0   573.0    39.592    43.496    110.293   45632.99
1890.0   576.1    35.828    43.617    110.510   45412.00
1900.0   579.1    38.519    43.726    110.707   45213.00
1910.0   582.2    26.552    43.844    110.918   45000.00
1920.0   585.2    28.334    43.924    111.064   44854.00
1930.0   588.3    27.340    44.011    111.219   44699.00
1940.0   591.3    30.747  ? 44.094    111.369   44550.00
1950.0   594.4    26.424    44.188    111.538   44382.99
1960.0   597.4     0.0      44.268    111.683   44240.00
1970.0   600.5    18.778    44.356    111.841   44085.00
1980.0   603.5    33.628    44.413    111.944   43983.99
1990.0   606.6    30.967    44.516    112.128   43804.00
2000.0   609.6    73.179    44.610    112.298   43639.00
 STOP      0
                                                                    00:01:19
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DATIL 6/30/77, TOOL #4, SYSTRON DONNER, RC=190
   DEPTH          *    GRAD     *      TEMPERATURE           *        RESISTANCE
 FEET    METERS   *  DEG C/KM   *    DEG C          DEG F    *      +          -          DELTA
   70.0    21.3      17.288        14.013         57.224       166559.94
   80.0    24.4      19.805        14.066         57.319       166139.94
   90.0    27.4      27.331        14.126         57.427       165660.00
  100.0    30.5      30.354        14.210         57.577       165000.00
  110.0    33.5      28.819        14.302         57.744       164270.00
  120.0    36.6      34.470        14.390         57.902       163580.00
  130.0    39.6      35.555        14.495         58.091       162759.94
  140.0    42.7      39.574        14.603         58.286       161919.94
  150.0    45.7      38.091        14.724         58.503       160990.00
  160.0    48.8      37.877        14.840         58.712       160100.00
  170.0    51.8      40.336        14.956         58.920       159220.00
  180.0    54.9      37.549        15.079         59.141       158289.94
  190.0    57.9     281.674        15.193         59.347       157429.94
  200.0    61.0     262.232        16.052         60.893       151139.94
  210.0    64.0      76.048        16.851         62.332       145539.94
  220.0    67.1      64.725        17.083         62.749       143960.00
  230.0    70.1      57.561        17.280         63.104       142630.00
  240.0    73.2      61.525        17.455         63.420       141460.00
  250.0    76.2      72.739        17.643         63.757       140220.00
  260.0    79.2      76.234        17.865         64.156       138770.00
  270.0    82.3      80.184        18.097         64.575       137270.00
  280.0    85.3      38.072        18.341         65.015       135710.00
  300.0    91.4      35.749        18.573         65.432       134250.00
  310.0    94.5      40.174        18.682         65.628       133570.00
  320.0    97.5      49.531        18.805         65.849       132809.94
  330.0   100.6      43.503        18.956         66.121       131880.00
  340.0   103.6      47.033        19.088         66.359       131070.00
  350.0   106.7      47.338        19.232         66.617       130199.94
  360.0   109.7      65.435        19.376         66.877       129330.00
  370.0   112.8      63.338        19.576         67.236       128139.94
  380.0   115.8      65.601        19.769         67.583       127000.00
  390.0   118.9      61.826        19.969         67.943       125830.00
  400.0   121.9      52.635        20.157         68.283       124740.00
  410.0   125.0      40.890        20.317         68.571       123820.00
  420.0   128.0      48.144        20.442         68.796       123110.00
  430.0   131.1      66.842        20.589         69.060       122279.94
  440.0   134.1      62.722        20.793         69.427       121139.94
  450.0   137.2      72.384        20.984         69.771       120080.00
  460.0   140.2      68.985        21.204         70.168       118869.94
  470.0   143.3      75.192        21.415         70.546       117729.94
  480.0   146.3      67.513        21.644         70.959       116500.00
  490.0   149.4      73.850        21.850         71.329       115410.00
  500.0   152.4      56.860        22.075         71.734       114229.94
  510.0   155.4      59.398        22.248         72.046       113330.00
  520.0   158.5      63.768        22.429         72.372       112399.94
  530.0   161.5      80.789        22.623         72.722       111410.00
  540.0   164.6      33.006        22.870         73.165       110169.94
  560.0   170.7     117.404        23.071         73.528       109169.00
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   570.0   173.7    73.074    23.429        74.172    107412.94
   580.0   176.8    58.947    23.651        74.573    106337.00
   590.0   179.8    58.582    23.831        74.896    105477.00
   600.0   182.9    61.005    24.010        75.217    104630.94
   610.0   185.9   101.620    24.196        75.552    103757.94
   620.0   189.0   124.408    24.505        76.110    102320.94
   630.0   192.0    75.638    24.885        76.792    100593.94
   640.0   195.1    40.099    25.115        77.207     99559.94
   650.0   198.1    37.496    25.237        77.427     99016.94
   660.0   201.2    24.530    25.352        77.633     98511.94
   670.0   204.2    18.983    25.426        77.767     98182.94
   680.0   207.3    14.167    25.484        77.872     97929.00
   690.0   210.3    18.738    25.527        77.949     97740.00
   700.0   213.4    45.256    25.585        78.052     97490.94
   710.0   216.4    48.830    25.722        78.300     96893.00
   720.0   219.5    88.919    25.871        78.568     96251.94
   730.0   222.5    79.503    26.142        79.056     95095.94
   740.0   225.6    82.917    26.385        79.492     94076.94
   750.0   228.6    81.235    26.637        79.947     93026.00
   760.0   231.6    67.618    26.885        80.393     92011.00
   770.0   234.7    48.435    27.091        80.764     91175.00
   780.0   237.7    37.406    27.239        81.030     90580.94
   790.0   240.8    53.521    27.353        81.235     90126.00
   800.0   243.8    57.341    27.516        81.529     89479.00
   810.0   246.9    52.820    27.691        81.843     88791.00
   820.0   249.9    47.621    27.852        82.133     88162.94
   840.0   256.0    40.802    28.142        82.655     87044.00
   850.0   259.1    37.710    28.266        82.879     86569.00
   860.0   262.1    39.803    28.381        83.086     86132.94
   870.0   265.2    38.785    28.503        83.305     85675.94
   880.0   268.2    39.973    28.621        83.517     85233.00
   890.0   271.3    50.400    28.743        83.737     84779.00
   900.0   274.3    32.779    28.896        84.013     84210.00
   910.0   277.4    48.859    28.996        84.193     83843.00
   920.0   280.4    62.345    29.145        84.461     83298.94
   930.0   283.5    50.085    29.335        84.803     82610.00
   940.0   286.5    31.458    29.488        85.078     82061.00
   950.0   289.6    21.317    29.584        85.251     81718.94
   960.0   292.6    23.413    29.649        85.367     81488.00
   970.0   295.7    33.733    29.720        85.496     81235.00
   980.0   298.7    31.257    29.823        85.681     80871.94
   990.0   301.8    32.159    29.918        85.853     80537.00
  1000.0   304.8    24.256    30.016        86.029     80194.00
  1010.0   307.8    22.522    30.090        86.162     79936.94
  1020.0   310.9    28.970    30.159        86.286     79699.00
  1030.0   313.9    44.477    30.247        86.445     79393.94
  1040.0   317.0    39.432    30.383        86.689     78927.94
  1050.0   320.0    47.402    30.503        86.905     78516.94
  1060.0   323.1   115.913    30.647        87.165     78026.94
  1070.0   326.1   140.223    31.000        87.801     76843.00
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1080.0   329.2   134.122   31.428    88.570   75438.00
1090.0   332.2    62.625   31.837    89.306   74121.00
1100.0   335.3    40.559   32.028    89.650   73514.94
1110.0   338.3    48.552   32.151    89.872   73125.00
1120.0   341.4    50.961   32.299    90.139   72662.00
1130.0   344.4    32.209   32.454    90.418   72179.94
1140.0   347.5    40.802   32.553    90.595   71876.94
1150.0   350.5    29.075   32.677    90.819   71494.94
1160.0   353.6    33.370   32.766    90.978   71223.94
1170.0   356.6    16.586   32.867    91.161   70914.94
1180.0   359.7    31.308   32.918    91.252   70761.94
1190.0   362.7    58.520   33.013    91.424   70473.94
1200.0   365.8    25.621   33.192    91.745   69938.94
1210.0   368.8    12.890   33.270    91.886   69705.94
1220.0   371.9    15.715   33.309    91.956   69589.00
1230.0   374.9    32.028   33.357    92.043   69447.00
1240.0   378.0    35.277   33.455    92.218   69158.94
1250.0   381.0    50.660   33.562    92.412   68843.00
1260.0   384.0    59.837   33.717    92.690   68391.94
1270.0   387.1    28.772   33.899    93.018   67863.00
1280.0   390.1    19.343   33.987    93.176   67610.94
1290.0   393.2    15.604   34.046    93.282   67442.00
1300.0   396.2    17.713   34.093    93.368   67305.94
1310.0   399.3    17.396   34.147    93.465   67151.94
1320.0   402.3    36.198   34.200    93.560   67001.00
1330.0   405.4    91.964   34.311    93.759   66688.00
1350.0   411.5   116.004   34.871    94.768   65123.99
1360.0   414.5    97.004   35.225    95.404   64159.00
1370.0   417.6    88.551   35.520    95.937   63364.00
1380.0   420.6    70.105   35.790    96.423   62649.00
1390.0   423.7    82.048   36.004    96.807   62089.00
1400.0   426.7    56.278   36.254    97.257   61440.99
1410.0   429.8    58.635   36.426    97.566   61001.00
1420.0   432.8    62.585   36.604    97.888   60546.00
1430.0   435.9    58.685   36.795    98.231   60065.00
1440.0   438.9    56.868   36.974    98.553   59618.00
1450.0   442.0    55.366   37.147    98.865   59188.00
1460.0   445.0    60.312   37.316    99.169   58772.99
1470.0   448.1    54.906   37.500    99.500   58325.00
1480.0   451.1    50.140   37.667    99.801   57920.00
1490.0   454.2    51.676   37.820   100.076   57552.99
1500.0   457.2    52.303   37.978   100.360   57177.99
1510.0   460.2    49.564   38.137   100.647   56800.99
1520.0   463.3    52.262   38.288   100.918   56446.00
1530.0   466.3    52.783   38.447   101.205   56075.00
1540.0   469.4    45.980   38.608   101.495   55703.00
1550.0   472.4    32.582   38.748   101.747   55381.00
1560.0   475.5    46.245   38.848   101.926   55154.00
1570.0   478.5    49.488   38.989   102.180   54834.00
1580.0   481.6    24.129   39.139   102.451   54494.00
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 1600.0   487.7     54.325    39.310     102.758    54112.00
 1610.0   490.7     50.951    39.476     103.056    53744.00
 1620.0   493.8     57.449    39.631     103.336    53401.99
 1630.0   496.8     50.895    39.806     103.651    53019.00
 1640.0   499.9     53.785    39.961     103.930    52682.00
 1650.0   502.9     53.719    40.125     104.225    52328.99
 1660.0   506.0     47.746    40.289     104.520    51979.00
 1670.0   509.0     52.113    40.434     104.782    51670.00
 1680.0   512.1     49.944    40.593     105.068    51335.00
 1690.0   515.1     54.200    40.745     105.342    51017.00
 1700.0   518.2     46.926    40.911     105.639    50673.99
 1710.0   521.2     54.515    41.054     105.897    50379.00
 1720.0   524.3     46.511    41.220     106.196    50039.00
 1730.0   527.3     52.663    41.362     106.451    49751.00
 1740.0   530.4     51.536    41.522     106.740    49427.00
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 1770.0   539.5     49.109    41.978     107.561    48519.00
 1780.0   542.5     52.007    42.128     107.831    48225.00
 1790.0   545.6     51.436    42.287     108.116    47916.00
 1800.0   548.6     44.393    42.443     108.398    47613.00
 1810.0   551.7     45.319    42.579     108.642    47353.00
 1820.0   554.7     47.606    42.717     108.890    47089.00
 1830.0   557.8     42.536    42.862     109.151    46813.99
 1840.0   560.8     46.986    42.992     109.385    46570.00
 1850.0   563.9     39.120    43.135     109.643    46302.00
 1860.0   566.9     41.660    43.254     109.857    46080.00
 1870.0   570.0     41.028    43.381     110.086    45845.00
 1880.0   573.0     40.514    43.506     110.311    45615.00
 1890.0   576.1     37.105    43.630     110.533    45389.00
 1900.0   579.1     35.646    43.743     110.737    45183.00
 1910.0   582.2     16.710    43.851     110.932    44985.99
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 1940.0   591.3     29.661    44.113     111.403    44517.00
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 2000.0   609.6     30.547    44.630     112.333    43604.99
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 2020.0   615.7     30.577    44.813     112.664    43285.99
 2030.0   618.7     38.942    44.906     112.832    43125.00
 2040.0   621.8     35.601    45.025     113.045    42921.00
 2050.0   624.8     37.675    45.134     113.241    42735.99
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 2080.0   634.0     15.213    45.408     113.735    42271.00
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2180.0   664.5    25.100   45.850   114.529   41535.99
2190.0   667.5    17.972   45.926   114.667   41410.00
2200.0   670.6    19.825   45.981   114.766   41320.00
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2220.0   676.7    10.232   46.061   114.910   41188.99
2230.0   679.7    10.664   46.092   114.966   41138.00
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2280.0   694.9    58.480   46.601   115.883   40315.99
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2380.0   725.4    65.734   48.523   119.342   37381.00
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2400.0   731.5    62.935   48.872   119.970   36873.99
2410.0   734.6    66.214   49.064   120.315   36599.00
2420.0   737.6    69.123   49.266   120.679   36312.00
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2450.0   746.8    61.208   49.870   121.766   35468.99
2460.0   749.8    56.893   50.056   122.101   35213.00
2470.0   752.9    67.782   50.230   122.414   34977.00
2480.0   755.9    58.811   50.436   122.785   34698.00
2490.0   759.0    69.073   50.616   123.108   34457.99
2500.0   762.0    63.386   50.826   123.487   34179.00
2510.0   765.0    58.370   51.019   123.835   33925.00
2520.0   768.1    57.539   51.197   124.155   33692.99
2530.0   771.1    66.936   51.373   124.471   33466.00
2540.0   774.2    63.391   51.577   124.838   33203.99
2550.0   777.2    51.967   51.770   125.186   32957.99
2560.0   780.3    61.719   51.928   125.471   32757.99
2570.0   783.3    55.131   52.116   125.809   32522.00
2580.0   786.4    67.697   52.284   126.112   32313.00
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  2640.0    804.7    -205.678      53.253       127.856      31138.00
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  2680.0    816.9      52.568      53.923       129.061      30354.99
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  2700.0    823.0      65.994      54.244       129.640      29987.00
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  2720.0    829.1      61.829      54.624       130.322      29559.00
  2730.0    832.1      57.804      54.812       130.662      29349.00
  2740.0    835.2      52.302      54.988       130.979      29154.00
  2750.0    838.2      57.454      55.148       131.266      28979.00
  2760.0    841.2      59.952      55.323       131.581      28787.99
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  2850.0    868.7      30.604      56.762       134.171      27272.99
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  3020.0    920.5      54.019      59.354       138.836      24768.00
  3030.0    923.5      54.801      59.518       139.133      24618.00
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3890.0  1185.7    16.691    72.634    162.742   15425.00
3900.0  1188.7    85.227    72.685    162.834   15398.00
3910.0  1191.8    47.646    72.945    163.301   15261.00
3920.0  1194.8    47.902    73.090    163.563   15185.00
3930.0  1197.9    48.809    73.236    163.825   15109.00
3940.0  1200.9    51.711    73.385    164.093   15032.00
3950.0  1204.0    44.258    73.543    164.377   14951.00
3960.0  1207.0    50.295    73.678    164.620   14882.00
3970.0  1210.1    51.972    73.831    164.896   14804.00
3980.0  1213.1    49.685    73.989    165.181   14724.00
3990.0  1216.2    49.950    74.141    165.453   14648.00
4000.0  1219.2    49.548    74.293    165.727   14572.00
4010.0  1222.3    51.241    74.444    165.999   14497.00
4020.0  1225.3    48.843    74.600    166.280   14420.00
4030.0  1228.3    49.765    74.749    166.548   14347.00
4040.0  1231.4    54.836    74.901    166.821   14273.00
4050.0  1234.4    41.598    75.068    167.122   14192.00
4060.0  1237.5    55.502    75.195    167.350   14131.00
4070.0  1240.5    42.701    75.364    167.655   14050.00
4080.0  1243.6    56.878    75.494    167.889   13988.00
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4090.0  1246.6   46.070   75.667   168.201   13906.00
4100.0  1249.7   45.583   75.808   168.454   13840.00
4110.0  1252.7   47.222   75.947   168.704   13775.00
4120.0  1255.8   49.675   76.091   168.963   13708.00
4130.0  1258.8   45.663   76.242   169.236   13638.00
4140.0  1261.9   40.133   76.381   169.486   13574.00
4150.0  1264.9   56.177   76.504   169.706   13518.00
4160.0  1268.0   50.124   76.675   170.015   13440.00
4170.0  1271.0   46.716   76.828   170.290   13371.00
4180.0  1274.1   44.739   76.970   170.546   13307.00
4190.0  1277.1   59.051   77.106   170.791   13246.00
4200.0  1280.2   35.663   77.286   171.115   13166.00
4210.0  1283.2   57.494   77.395   171.311   13118.00
4220.0  1286.3   51.051   77.570   171.626   13041.00
4230.0  1289.3   51.417   77.726   171.907   12973.00
4240.0  1292.4   48.692   77.883   172.189   12905.00
4250.0  1295.4   45.099   78.031   172.456   12841.00
4260.0  1298.5   47.607   78.168   172.703   12782.00
4270.0  1301.5   46.409   78.314   172.964   12720.00
4280.0  1304.5   45.875   78.455   173.219   12660.00
4290.0  1307.6   42.937   78.595   173.471   12601.00
4300.0  1310.6   47.861   78.726   173.706   12546.00
4310.0  1313.7   52.183   78.872   173.969   12485.00
4320.0  1316.7   42.920   79.031   174.255   12419.00
4330.0  1319.8   53.740   79.161   174.491   12365.00
4341.0  1323.1   44.628   79.342   174.815   12291.00
4350.0  1325.9   50.149   79.464   175.035   12241.00
4360.0  1328.9   50.405   79.617   175.311   12179.00
4370.0  1332.0   46.561   79.771   175.587   12117.00
4380.0  1335.0   55.907   79.913   175.843   12060.00
4390.0  1338.1   57.119   80.083   176.149   11992.00
4400.0  1341.1   51.606   80.257   176.463   11923.00
4410.0  1344.2   43.487   80.414   176.746   11861.00
4420.0  1347.2   55.652   80.547   176.984   11809.00
4430.0  1350.3   54.269   80.716   177.290   11743.00
4440.0  1353.3   55.421   80.882   177.587   11679.00
4450.0  1356.4   50.676   81.051   177.891   11614.00
4460.0  1359.4   57.919   81.205   178.170   11555.00
4470.0  1362.5   49.534   81.382   178.487   11488.00
4480.0  1365.5   55.952   81.533   178.759   11431.00
4490.0  1368.6   53.744   81.703   179.066   11367.00
4500.0  1371.6   50.481   81.867   179.361   11306.00
4510.0  1374.7   62.345   82.021   179.638   11249.00
4520.0  1377.7   55.677   82.211   179.980   11179.00
4530.0  1380.7   48.753   82.381   180.285   11117.00
4540.0  1383.8   54.649   82.529   180.553   11063.00
4600.0  1402.1   60.753   83.529   182.352   10707.60
4610.0  1405.1   45.039   83.714   182.685   10643.20
4620.0  1408.2   58.360   83.851   182.932   10595.70
4630.0  1411.2   43.903   84.029   183.252   10534.60
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 4640.0  1414.3     60.833      84.163       183.493      10488.90
 4650.0  1417.3     47.621      84.348       183.827      10425.90
 4660.0  1420.4     54.891      84.493       184.088      10376.90
 4670.0  1423.4     42.967      84.661       184.389      10320.80
 4680.0  1426.5     54.540      84.792       184.625      10277.10
 4690.0  1429.5     47.081      84.958       184.924      10221.90
 4700.0  1432.6     49.148      85.101       185.183      10174.60
 4710.0  1435.6     47.772      85.251       185.452      10125.50
 4720.0  1438.7     33.315      85.397       185.714      10078.00
 4730.0  1441.7     36.617      85.498       185.897      10045.00
 4740.0  1444.8     40.774      85.610       186.098      10008.90
 4750.0  1447.8    116.575      85.734       186.322       9968.90
 4760.0  1450.9     54.325      86.090       186.961       9855.40
 4770.0  1453.9     52.643      86.255       187.259       9803.10
 4780.0  1456.9     53.239      86.416       187.548       9752.70
 4790.0  1460.0     50.189      86.578       187.840       9702.00
 4800.0  1463.0     52.768      86.731       188.116       9654.50
 4810.0  1466.1     51.426      86.892       188.405       9604.90
 4820.0  1469.1     49.439      87.049       188.687       9556.80
 4830.0  1472.2     52.688      87.199       188.959       9510.80
 4840.0  1475.2     49.293      87.360       189.248       9462.10
 4850.0  1478.3     50.280      87.510       189.518       9416.80
 4860.0  1481.3     50.901      87.663       189.794       9370.80
 4870.0  1484.4     47.150      87.818       190.073       9324.50
 4880.0  1487.4     56.518      87.962       190.332       9281.90
 4890.0  1490.5     49.538      88.134       190.642       9231.10
 4900.0  1493.5     59.112      88.285       190.914       9186.80
  STOP       0
                                                                                 00:01:36
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RED WASH #137, 7/11/77, TOOL #6, SYSTRON DONNER, RC = 190

   DEPTH          *     GRAD      *       TEMPERATURE          *            RESISTANCE
 FEET     METERS  *  DEG C/KM     *    DEG C          DEG F    *        +            -          DELTA
  500.0    152.4     -36.014          15.497          59.894        155169.94
  525.0    160.0      -0.877          15.222          59.400        157210.00
  550.0    167.6       3.860          15.216          59.388        157259.94
  575.0    175.3       8.441          15.245          59.441        157039.94
  600.0    182.9      14.302          15.309          59.557        156559.94
  625.0    190.5       6.737          15.418          59.753        155750.00
  650.0    198.1       9.065          15.470          59.846        155369.94
  675.0    205.7      15.582          15.539          59.970        154860.00
  700.0    213.4      28.363          15.658          60.184        153990.00
  725.0    221.0      10.369          15.874          60.573        152419.94
  750.0    228.6      11.871          15.953          60.715        151850.00
  775.0    236.2      15.623          16.043          60.878        151199.94
  800.0    243.8      38.307          16.162          61.092        150350.00
  825.0    251.5      12.009          16.454          61.617        148289.94
  850.0    259.1      13.194          16.546          61.782        147649.94
  875.0    266.7      15.203          16.646          61.963        146949.94
  900.0    274.3      38.204          16.762          62.172        146149.94
  925.0    281.9      17.647          17.053          62.696        144160.00
  950.0    289.6      15.445          17.188          62.938        143250.00
  975.0    297.2      16.332          17.305          63.150        142460.00
 1000.0    304.8      44.564          17.430          63.374        141630.00
 1025.0    312.4      14.121          17.769          63.985        139389.94
 1050.0    320.0      15.419          17.877          64.179        138690.00
 1075.0    327.7      17.548          17.994          64.390        137929.94
 1100.0    335.3      41.108          18.128          64.631        137070.00
 1126.0    343.2      15.467          18.454          65.217        135000.00
 1150.0    350.5      17.880          18.567          65.421        134289.94
 1175.0    358.1      16.086          18.703          65.666        133440.00
 1200.0    365.8      50.882          18.826          65.887        132679.94
 1225.0    373.4      16.084          19.214          66.585        130309.94
 1250.0    381.0      16.406          19.336          66.805        129570.00
 1275.0    388.6      15.006          19.461          67.030        128820.00
 1300.0    396.2      41.904          19.576          67.236        128139.94
 1325.0    403.9      21.206          19.895          67.811        126259.94      /
 1350.0    411.5       7.501          20.056          68.102        125320.00<-125630
 1375.0    419.1      17.575          20.114          68.204        124990.00
 1400.0    426.7      42.914          20.248          68.446        124220.00
 1425.0    434.3      14.973          20.575          69.034        122360.00
 1450.0    442.0      15.523          20.689          69.240        121720.00
 1475.0    449.6      16.555          20.807          69.452        121059.94
 1500.0    457.2      44.262          20.933          69.680        120360.00
 1525.0    464.8      14.778          21.270          70.287        118511.00
 1550.0    472.4      14.780          21.383          70.489        117901.00
 1575.0    480.1      15.867          21.496          70.692        117294.00
 1600.0    487.7      36.151          21.616          70.910        116645.94
 1625.0    495.3      18.675          21.892          71.406        115186.94
 1650.0    502.9      16.471          22.034          71.662        114440.94
 1675.0    510.5      20.369          22.160          71.888        113787.00
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1700.0   518.2    42.546    22.315        72.167    112985.00
1725.0   525.8    19.366    22.639        72.751    111330.00
1750.0   533.4    22.031    22.787        73.016    110585.00
1775.0   541.0    27.124    22.955        73.318    109746.00
1800.0   548.6    56.034    23.161        73.690    108722.00
1825.0   556.3    21.370    23.588        74.459    106641.00
1850.0   563.9    20.319    23.751        74.752    105858.94
1875.0   571.5    23.058    23.906        75.031    105121.00
1900.0   579.1    86.170    24.082        75.347    104292.00
1910.0   582.2    26.537    24.344        75.820    103065.00
1920.0   585.2    24.574    24.425        75.965    102690.00
1930.0   588.3    23.034    24.500        76.100    102345.00
1940.0   591.3    22.672    24.570        76.227    102022.94   — 102026 ✓
1950.0   594.4    26.209    24.639        76.351    101707.00
1960.0   597.4    22.892    24.719        76.495    101343.00
1970.0   600.5    22.897    24.789        76.620    101026.00
1980.0   603.5    20.416    24.859        76.746    100710.00
1990.0   606.6    20.409    24.921        76.858    100429.00
2000.0   609.6    23.889    24.983        76.970    100149.00
2010.0   612.6    22.589    25.056        77.101     99822.94
2020.0   615.7    24.950    25.125        77.225     99516.00
2030.0   618.7    22.948    25.201        77.362     99177.94
2040.0   621.8    19.019    25.271        77.488     98867.94
2050.0   624.8    20.169    25.329        77.592     98611.94
2060.0   627.9    19.870    25.390        77.703     98341.00
2070.0   630.9    20.735    25.451        77.812     98074.94
2080.0   634.0    21.651    25.514        77.925     97798.00
2090.0   637.0    20.241    25.580        78.044     97509.94
2100.0   640.1    17.726    25.642        78.155     97242.00
2110.0   643.1    18.292    25.696        78.253     97007.94
2120.0   646.2    20.867    25.752        78.353     96766.94
2130.0   649.2    21.531    25.815        78.467     96492.94
2140.0   652.3    21.195    25.881        78.586     96210.94
2150.0   655.3    24.201    25.945        78.702     95934.00
2160.0   658.4    22.262    26.019        78.835     95619.00
2170.0   661.4    21.613    26.087        78.957     95330.00
2180.0   664.5    18.888    26.153        79.075     95050.94
2190.0   667.5    20.505    26.211        79.179     94807.94
2200.0   670.6    22.123    26.273        79.291     94544.94
2210.0   673.6    21.165    26.340        79.413     94261.94
2220.0   676.7    20.369    26.405        79.529     93992.00
2230.0   679.7    18.368    26.467        79.641     93733.00
2240.0   682.8    19.844    26.523        79.742     93500.00
2250.0   685.8    24.576    26.584        79.850     93248.94
2260.0   688.8    26.101    26.658        79.985     92938.94
2270.0   691.9    24.670    26.738        80.128     92611.94
2280.0   694.9    22.824    26.813        80.264     92304.00
2290.0   698.0    23.789    26.883        80.389     92020.00
2300.0   701.0    23.869    26.955        80.519     91725.00
2310.0   704.1    20.366    27.028        80.650     91429.94
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2320.0   707.1    22.702    27.090     80.762    91179.00
2330.0   710.2    22.031    27.159     80.887    90899.94
2340.0   713.2    20.852    27.226     81.008    90630.00
2350.0   716.3    20.505    27.290     81.122    90376.00
2360.0   719.3    20.051    27.352     81.234    90126.94
2370.0   722.4    17.876    27.414     81.344    89884.00
2380.0   725.4    19.909    27.468     81.443    89667.94
2390.0   728.5     6.984    27.529     81.552    89427.94
2400.0   731.5    26.817    27.550     81.590    89343.94
2410.0   734.6    21.901    27.632     81.737    89022.00
2420.0   737.6    18.849    27.699     81.857    88759.94
2430.0   740.7    21.981    27.756     81.961    88535.00
2440.0   743.7    27.005    27.823     82.081    88274.00
2450.0   746.8    23.173    27.905     82.230    87955.00
2460.0   749.8    27.002    27.976     82.357    87682.00
2470.0   752.9    26.769    28.058     82.505    87365.00
2480.0   755.9    27.198    28.140     82.652    87052.00
2490.0   759.0    10.237    28.223     82.801    86735.00
2500.0   762.0    65.243    28.254     82.857    86615.94
2510.0   765.0    42.386    28.453     83.215    85863.00
2520.0   768.1    31.263    28.582     83.448    85378.00
2530.0   771.1    26.108    28.677     83.619    85022.00
2540.0   774.2    25.826    28.757     83.762    84725.94
2550.0   777.2    26.404    28.836     83.904    84434.00
2560.0   780.3    22.953    28.916     84.049    84136.94
2570.0   783.3    23.483    28.986     84.175    83880.00
2580.0   786.4    27.065    29.058     84.304    83617.94
2590.0   789.4    23.643    29.140     84.452    83317.00
2600.0   792.5    21.996    29.212     84.582    83054.94
2610.0   795.5    25.683    29.279     84.703    82811.94
2620.0   798.6    21.035    29.357     84.843    82529.00
2630.0   801.6    25.375    29.422     84.959    82298.00
2640.0   804.7    23.260    29.499     85.098    82020.94
2650.0   807.7    19.373    29.570     85.226    81768.00
2660.0   810.8    12.942    29.629     85.332    81557.94
2670.0   813.8    20.189    29.668     85.403    81417.94
2680.0   816.9    21.826    29.730     85.514    81199.94
2690.0   819.9    31.505    29.796     85.634    80964.94
2700.0   823.0    27.788    29.892     85.806    80626.94
2710.0   826.0    26.727    29.977     85.959    80330.00
2720.0   829.1    30.364    30.059     86.105    80046.00
2730.0   832.1    28.394    30.151     86.272    79725.00
2740.0   835.2    24.947    30.238     86.428    79425.94
2750.0   838.2    35.112    30.314     86.565    79164.00
2760.0   841.2    26.126    30.421     86.757    78796.94
2770.0   844.3    19.550    30.500     86.901    78524.94
2780.0   847.3    15.894    30.560     87.008    78322.00
2790.0   850.4    29.646    30.608     87.095    78158.00
2800.0   853.4    37.488    30.699     87.258    77852.94
2810.0   856.5    27.052    30.813     87.463    77468.94
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2820.0    859.5    205.482     30.895       87.612      77192.94
2830.0    862.6     51.201     31.522       88.739      75132.94
2840.0    865.6     51.997     31.678       89.020      74628.94
2850.0    868.7     48.006     31.836       89.305      74121.94
2860.0    871.7     35.287     31.983       89.569      73656.94
2870.0    874.8     32.013     32.090       89.762      73317.00
2880.0    877.8     27.590     32.188       89.938      73009.94
2890.0    880.9     21.596     32.272       90.089      72746.94
2900.0    883.9     32.369     32.338       90.208      72542.00
2910.0    887.0     29.743     32.436       90.386      72235.94
2920.0    890.0     20.975     32.527       90.549      71955.94
2930.0    893.1     23.630     32.591       90.664      71759.00
2940.0    896.1     26.467     32.663       90.793      71537.94
2950.0    899.2     24.564     32.744       90.939      71291.00
2960.0    902.2     27.615     32.819       91.073      71063.00
2970.0    905.3     30.747     32.903       91.225      70807.94
2980.0    908.3     25.951     32.996       91.394      70524.94
2990.0    911.4     35.360     33.076       91.536      70287.00
3000.0    914.4     37.855     33.183       91.730      69964.00
3010.0    917.4     23.453     33.299       91.938      69619.94
3020.0    920.5     23.355     33.370       92.066      69408.00
3030.0    923.5     27.888     33.441       92.194      69197.94
3040.0    926.6     27.876     33.526       92.348      68947.94
3050.0    929.6     25.726     33.611       92.500      68699.00
3060.0    932.7     30.006     33.690       92.642      68470.00
3070.0    935.7     23.425     33.781       92.806      68203.94
3080.0    938.8     23.864     33.853       92.935      67996.94
3090.0    941.8     27.423     33.925       93.066      67787.00
3100.0    944.9     23.380     34.009       93.216      67546.94
3110.0    947.9     24.605     34.080       93.344      67343.00
3120.0    951.0     23.065     34.155       93.479      67128.94
3130.0    954.0     24.069     34.225       93.606      66929.00
3140.0    957.1     30.056     34.299       93.738      66720.94
3150.0    960.1     31.751     34.390       93.903      66462.00
3160.0    963.2     24.424     34.487       94.077      66190.00
3170.0    966.2     19.884     34.562       94.211      65981.94
3180.0    969.3     24.436     34.622       94.320      65813.00
3190.0    972.3     19.774     34.697       94.454      65606.00
3200.0    975.4     18.868     34.757       94.563      65438.99
3210.0    978.4     17.564     34.815       94.666      65280.00
3230.0    984.5     27.030     34.922       94.859      64985.00
3240.0    987.6     23.458     35.004       95.007      64759.00
3250.0    990.6     26.432     35.076       95.136      64563.99
3260.0    993.6     30.404     35.156       95.281      64345.00
3270.0    996.7     42.106     35.249       95.448      64093.99
3280.0    999.7     22.237     35.377       95.679      63748.00
3290.0   1002.8     18.379     35.445       95.801      63565.99
3300.0   1005.8     25.831     35.501       95.902      63416.00
3310.0   1008.9     31.318     35.580       96.043      63205.99
3320.0   1011.9     26.834     35.675       96.215      62953.00
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3330.0  1015.0    28.925    35.757     96.362   62737.00
3340.0  1018.0    29.528    35.845     96.521   62505.00
3350.0  1021.1    21.476    35.935     96.683   62269.00
3360.0  1024.1    16.735    36.000     96.801   62098.00
3370.0  1027.2    29.823    36.051     96.893   61965.00
3380.0  1030.2    35.347    36.142     97.056   61729.00
3390.0  1033.3    37.810    36.250     97.250   61451.00
3400.0  1036.3    42.119    36.365     97.458   61155.00
3410.0  1039.4    33.801    36.494     97.689   60826.99
3420.0  1042.4    34.770    36.597     97.874   60565.00
3430.0  1045.5    33.946    36.703     98.065   60297.00
3440.0  1048.5    28.579    36.806     98.251   60037.00
3450.0  1051.6    29.998    36.893     98.408   59819.00
3460.0  1054.6    31.172    36.985     98.573   59591.00
3470.0  1057.7    22.397    37.080     98.744   59354.99
3480.0  1060.7    20.336    37.148     98.867   59186.00
3490.0  1063.8    34.236    37.210     98.978   59033.00
3500.0  1066.8    18.117    37.314     99.166   58776.99
3510.0  1069.9    13.457    37.370     99.265   58642.00
3520.0  1072.9    32.774    37.411     99.339   58542.00
3530.0  1075.9    43.921    37.511     99.519   58298.99
3540.0  1079.0    29.010    37.644     99.760   57975.00
3550.0  1082.0    29.565    37.733     99.919   57761.99
3560.0  1085.1    24.356    37.823    100.081   57546.00
3570.0  1088.1    27.198    37.897    100.215   57369.00
3580.0  1091.2    30.066    37.980    100.364   57172.00
3590.0  1094.2    25.713    38.072    100.529   56955.00
3600.0  1097.3    22.597    38.150    100.670   56770.00
3610.0  1100.3    30.364    38.219    100.794   56608.00
3620.0  1103.4    36.629    38.312    100.961   56391.00
3630.0  1106.4    34.842    38.423    101.162   56131.00
3640.0  1109.5    39.836    38.529    101.353   55884.99
3650.0  1112.5    29.290    38.651    101.571   55604.99
3660.0  1115.6    25.676    38.740    101.732   55399.99
3670.0  1118.6    26.474    38.818    101.873   55220.99
3680.0  1121.7    33.755    38.899    102.018   55037.00
3690.0  1124.7    36.959    39.002    102.203   54804.00
3700.0  1127.8    32.447    39.115    102.406   54550.00
3710.0  1130.8    26.407    39.213    102.584   54328.00
3720.0  1133.9    27.375    39.294    102.729   54147.99
3730.0  1136.9    24.224    39.377    102.879   53962.00
3740.0  1140.0    28.689    39.451    103.012   53798.00
3750.0  1143.0    35.210    39.539    103.170   53604.99
3760.0  1146.1    43.342    39.646    103.363   53369.00
3770.0  1149.1    52.037    39.778    103.601   53080.00
3780.0  1152.1    57.989    39.937    103.886   52735.00
3790.0  1155.2    46.626    40.113    104.204   52354.00
3800.0  1158.2    37.150    40.256    104.460   52050.00
3810.0  1161.3    35.010    40.369    104.664   51809.00
3820.0  1164.3    32.839    40.475    104.856   51582.99
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3830.0	1167.4	22.709	40.576	105.036	51371.99
3840.0	1170.4	22.622	40.645	105.161	51227.00
3850.0	1173.5	22.842	40.714	105.285	51082.99
3860.0	1176.5	29.237	40.783	105.410	50938.00
3870.0	1179.6	27.923	40.872	105.571	50753.00
3880.0	1182.6	29.761	40.958	105.724	50576.99
3890.0	1185.7	22.524	41.048	105.887	50390.00
3900.0	1188.7	23.924	41.117	106.011	50248.99
3910.0	1191.8	13.207	41.190	106.142	50100.00
3920.0	1194.8	19.844	41.230	106.214	50018.00
3930.0	1197.9	28.955	41.291	106.323	49895.00
3940.0	1200.9	32.326	41.379	106.482	49716.00
3950.0	1204.0	25.596	41.477	106.659	49517.00
3960.0	1207.0	25.506	41.555	106.800	49360.00
3970.0	1210.1	27.115	41.633	106.940	49203.99
3980.0	1213.1	28.064	41.716	107.088	49039.00
3990.0	1216.2	17.376	41.801	107.242	48869.00
4000.0	1219.2	16.591	41.854	107.338	48764.00
4010.0	1222.3	11.959	41.905	107.429	48664.00
4020.0	1225.3	29.653	41.941	107.494	48591.99
4030.0	1228.3	36.974	42.032	107.657	48414.00
4040.0	1231.4	17.621	42.144	107.860	48192.99
4050.0	1234.4	15.670	42.198	107.957	48088.00
4060.0	1237.5	21.986	42.246	108.043	47994.99
4070.0	1240.5	32.584	42.313	108.163	47865.00
4080.0	1243.6	36.477	42.412	108.342	47673.00
4090.0	1246.6	25.496	42.523	108.542	47459.00
4100.0	1249.7	19.390	42.601	108.682	47310.00
4110.0	1252.7	13.927	42.660	108.788	47197.00
4120.0	1255.8	18.948	42.703	108.865	47116.00
4130.0	1258.8	21.823	42.760	108.969	47006.00
4140.0	1261.9	29.751	42.827	109.089	46880.00
4150.0	1264.9	24.089	42.918	109.252	46709.00
4160.0	1268.0	29.598	42.991	109.384	46571.00
4170.0	1271.0	19.493	43.081	109.546	46401.99
4180.0	1274.1	16.725	43.141	109.653	46291.00
4190.0	1277.1	19.059	43.192	109.745	46196.00
4200.0	1280.2	14.853	43.250	109.850	46088.00
4210.0	1283.2	19.670	43.295	109.931	46004.00
4220.0	1286.3	17.801	43.355	110.039	45893.00
4230.0	1289.3	18.007	43.409	110.137	45793.00
4240.0	1292.4	19.305	43.464	110.235	45692.00
4250.0	1295.4	20.600	43.523	110.341	45584.00
4260.0	1298.5	22.457	43.586	110.454	45468.99
4270.0	1301.5	16.206	43.654	110.578	45343.99
4280.0	1304.5	22.742	43.704	110.666	45254.00
4290.0	1307.6	35.503	43.773	110.791	45128.00
4300.0	1310.6	17.873	43.881	110.986	44932.00
4310.0	1313.7	13.887	43.936	111.084	44834.00
4320.0	1316.7	14.459	43.978	111.160	44757.99

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4330.0  1319.8    18.532    44.022     111.240    44679.00
4340.0  1322.8    17.461    44.078     111.341    44578.00
4350.0  1325.9    18.974    44.132     111.437    44483.00
4360.0  1328.9    27.173    44.190     111.541    44380.00
4370.0  1332.0    20.194    44.272     111.690    44233.00
4380.0  1335.0    19.690    44.334     111.801    44123.99
4390.0  1338.1    18.442    44.394     111.909    44018.00
4400.0  1341.1    18.328    44.450     112.010    43919.00
4410.0  1344.2    19.313    44.506     112.111    43821.00
4420.0  1347.2    18.978    44.565     112.217    43718.00
4430.0  1350.3    21.282    44.623     112.321    43617.00
4440.0  1353.3    30.046    44.688     112.438    43504.00
4450.0  1356.4    44.423    44.779     112.602    43345.00
4460.0  1359.4    30.519    44.915     112.846    43110.99
4470.0  1362.5    17.671    45.008     113.014    42951.00
4480.0  1365.5    15.964    45.061     113.111    42858.99
4490.0  1368.6    31.075    45.110     113.198    42776.00
4500.0  1371.6    39.928    45.205     113.369    42615.00
4510.0  1374.7    23.350    45.327     113.588    42409.00
4520.0  1377.7    28.489    45.398     113.716    42289.00
4530.0  1380.7    23.693    45.485     113.872    42143.00
4540.0  1383.8    26.985    45.557     114.002    42022.00
4550.0  1386.8    71.110    45.639     114.150    41884.99
4560.0  1389.9    28.094    45.856     114.540    41526.00
4570.0  1392.9    47.451    45.941     114.694    41384.99
4580.0  1396.0    29.611    46.086     114.955    41147.99
4590.0  1399.0    28.927    46.176     115.117    41001.00
4600.0  1402.1    26.387    46.264     115.276    40858.00
4610.0  1405.1    25.245    46.345     115.421    40728.00
4620.0  1408.2    21.648    46.422     115.559    40604.00
4630.0  1411.2    28.064    46.488     115.678    40498.00
4640.0  1414.3    19.919    46.573     115.832    40360.99
4650.0  1417.3    25.187    46.634     115.941    40264.00
4660.0  1420.4    63.406    46.711     116.079    40142.00
4670.0  1423.4    92.336    46.904     116.427    39837.00
4680.0  1426.5    51.115    47.186     116.934    39397.00
4690.0  1429.5    24.294    47.341     117.214    39156.00
4700.0  1432.6    32.091    47.415     117.348    39042.00
4710.0  1435.6    27.903    47.513     117.524    38892.00
4720.0  1438.7    29.085    47.598     117.677    38761.99
4730.0  1441.7    42.229    47.687     117.836    38627.00
4740.0  1444.8    42.356    47.816     118.068    38432.00
4750.0  1447.8    35.763    47.945     118.300    38238.00
4760.0  1450.9    35.916    48.054     118.497    38075.00
4770.0  1453.9     6.623    48.163     118.694    37912.00
4780.0  1456.9     0.0    ? 48.183     118.730    37882.00
4790.0  1460.0    32.086    48.316     118.968    37686.00
4800.0  1463.0    33.091    48.413     119.144    37542.00
 STOP     0
                                                                        00:01:34
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RED WASH #137, 7/12/77, TOOL #6, SYSTRON DONNER, RC=190

    DEPTH          *    GRAD      *       TEMPERATURE           *        RESISTANCE
FEET     METERS    *  DEG C/KM    *   DEG C          DEG F      *       +          -        DELTA
 500.0    152.4      23.897         14.779          58.602         160570.00
 525.0    160.0       1.724         14.961          58.930         159179.94
 550.0    167.6       7.975         14.974          58.953         159080.00
 575.0    175.3       6.786         15.035          59.063         158619.94
 600.0    182.9      30.314         15.087          59.156         158229.94
 625.0    190.5       7.055         15.318          59.572         156500.00
 650.0    198.1       3.712         15.371          59.668         156100.00
 675.0    205.7      20.595         15.400          59.719         155889.94   — 155490
 700.0    213.4      12.909         15.557          60.002         154729.94
 725.0    221.0      12.244         15.655          60.179         154009.94
 750.0    228.6      11.941         15.748          60.347         153330.00
 775.0    236.2      17.457         15.839          60.511         152669.94
 800.0    243.8      22.356         15.972          60.750         151710.00
 825.0    251.5      15.545         16.143          61.057         150490.00
 850.0    259.1      18.615         16.261          61.270         149649.94
 875.0    266.7      14.232         16.403          61.525         148649.94
 900.0    274.3      15.247         16.511          61.720         147889.94
 925.0    281.9      21.094         16.627          61.929         147080.00
 950.0    289.6      24.933         16.788          62.219         145970.00
 975.0    297.2      24.766         16.978          62.561         144669.94
1000.0    304.8      21.699         17.167          62.900         143389.94
1025.0    312.4      18.925         17.332          63.198         142279.94
1050.0    320.0      21.642         17.476          63.458         141320.00
1075.0    327.7      19.408         17.641          63.755         140229.94
1100.0    335.3      21.847         17.789          64.021         139259.94
1125.0    342.9      22.832         17.956          64.320         138179.94
1150.0    350.5      23.022         18.130          64.634         137059.94
1175.0    358.1      27.464         18.305          64.949         135940.00
1200.0    365.8      26.054         18.514          65.326         134619.94
1225.0    373.4      22.682         18.713          65.683         133380.00
1250.0    381.0      22.718         18.886          65.994         132309.94
1275.0    388.6      17.053         19.059          66.306         131250.00
1300.0    396.2      87.717         19.189          66.540         130460.00
1325.0    403.9      11.228         19.857          67.743         126479.94
1350.0    411.5      10.607         19.943          67.897         125979.94
1375.0    419.1      15.225         20.024          68.043         125509.94
1400.0    426.7      19.428         20.140          68.251         124839.94
1425.0    434.3      20.950         20.288          68.518         123990.00
1450.0    442.0       8.795         20.447          68.805         123080.00
1475.0    449.6      15.846         20.514          68.926         122699.94
1500.0    457.2      17.601         20.635          69.143         122020.00
1525.0    464.8      17.475         20.769          69.385         121270.00
1550.0    472.4      18.295         20.902          69.624         120529.94
1575.0    480.1      19.648         21.042          69.875         119759.94
1600.0    487.7      17.388         21.191          70.145         118940.00
1625.0    495.3      22.129         21.324          70.383         118220.00
1650.0    502.9      19.841         21.493          70.687         117309.94
1675.0    510.5      21.038         21.644          70.959         116500.00
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1700.0    518.2     22.704     21.804      71.247   115649.94
1725.0    525.8     30.472     21.977      71.559   114740.00
1750.0    533.4     30.888     22.209      71.977   113529.94
1775.0    541.0     28.898     22.445      72.400   112320.00
1800.0    548.6     27.397     22.665      72.797   111199.94
1825.0    556.3     23.098     22.874      73.173   110149.94
1850.0    563.9     24.569     23.050      73.489   109274.00
1875.0    571.5     29.316     23.237      73.826   108350.00
1900.0    579.1    261.084     23.460      74.228   107259.94
1910.0    582.2     22.762     24.256      75.661   103475.94
1920.0    585.2     20.640     24.325      75.786   103152.94
1930.0    588.3     14.519     24.388      75.899   102860.94
1940.0    591.3     17.381     24.433      75.979   102656.00
1950.0    594.4     25.813     24.486      76.074   102412.00
1960.0    597.4     16.775     24.564      76.216   102050.94
1970.0    600.5     20.269     24.615      76.308   101817.00
1980.0    603.5     19.320     24.677      76.419   101535.00
1990.0    606.6     22.772     24.736      76.525   101266.94
2000.0    609.6    115.373     24.805      76.650   100951.94
2010.0    612.6     23.065     25.157      77.283    99373.00
2020.0    615.7     18.677     25.227      77.409    99061.00
2030.0    618.7     16.420     25.284      77.512    98809.00
2040.0    621.8     17.122     25.334      77.602    98587.94
2050.0    624.8     15.073     25.387      77.696    98358.00
2060.0    627.9     13.017     25.432      77.778    98156.00
2070.0    630.9     15.809     25.472      77.850    97981.94
2080.0    634.0     13.817     25.520      77.937    97770.94
2090.0    637.0     16.226     25.562      78.012    97587.00
2100.0    640.1     98.794     25.612      78.101    97371.94
2110.0    643.1     18.467     25.913      78.643    96072.94
2120.0    646.2     10.689     25.969      78.745    95832.00
2130.0    649.2     17.231     26.002      78.803    95692.94
2140.0    652.3     12.720     26.054      78.898    95468.94
2150.0    655.3     12.391     26.093      78.968    95304.00
2160.0    658.4     17.236     26.131      79.036    95143.94
2170.0    661.4     17.512     26.184      79.130    94921.94
2180.0    664.5     18.652     26.237      79.226    94697.00
2190.0    667.5     21.361     26.294      79.329    94457.94
2200.0    670.6     87.577     26.359      79.446    94184.94
2210.0    673.6     11.594     26.626      79.926    93074.00
2220.0    676.7     13.716     26.661      79.990    92927.94
2230.0    679.7      5.582     26.703      80.065    92755.94
2240.0    682.8     23.138     26.720      80.096    92686.00
2250.0    685.8     17.422     26.790      80.223    92397.00
2260.0    688.8     18.097     26.844      80.318    92179.94
2270.0    691.9     15.243     26.899      80.418    91955.00
2280.0    694.9     13.577     26.945      80.501    91766.00
2290.0    698.0     21.135     26.987      80.576    91598.00
2300.0    701.0    112.690     27.051      80.692    91337.00
2310.0    704.1     12.982     27.394      81.310    89960.00
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2320.0	707.1	10.683	27.434	81.381	89802.94
2330.0	710.2	13.431	27.467	81.440	89673.94
2340.0	713.2	12.952	27.508	81.514	89511.94
2350.0	716.3	14.067	27.547	81.585	89356.00
2360.0	719.3	13.167	27.590	81.662	89186.94
2370.0	722.4	11.449	27.630	81.734	89029.00
2380.0	725.4	11.864	27.665	81.797	88891.94
2390.0	728.5	13.082	27.701	81.862	88750.00
2400.0	731.5	14.182	27.741	81.934	88593.94
2410.0	734.6	24.840	27.784	82.012	88425.00
2420.0	737.6	19.150	27.860	82.148	88130.94
2430.0	740.7	16.550	27.918	82.253	87904.94
2440.0	743.7	17.963	27.969	82.344	87710.00
2450.0	746.8	16.885	28.023	82.442	87498.94
2460.0	749.8	17.876	28.075	82.535	87300.94
2470.0	752.9	24.526	28.129	82.633	87091.94
2480.0	755.9	21.331	28.204	82.768	86805.94
2490.0	759.0	18.542	28.269	82.885	86557.94
2500.0	762.0	19.345	28.326	82.986	86343.00
2510.0	765.0	20.009	28.385	83.092	86119.94
2520.0	768.1	19.368	28.446	83.202	85889.94
2530.0	771.1	15.825	28.505	83.308	85667.94
2540.0	774.2	28.059	28.553	83.395	85486.94
2550.0	777.2	21.908	28.638	83.549	85167.00
2560.0	780.3	24.449	28.705	83.669	84917.94
2570.0	783.3	19.654	28.780	83.804	84641.00
2580.0	786.4	19.275	28.840	83.911	84419.00
2590.0	789.4	19.639	28.898	84.017	84201.94
2600.0	792.5	21.296	28.958	84.125	83981.94
2610.0	795.5	23.430	29.023	84.242	83744.00
2620.0	798.6	23.328	29.095	84.370	83483.00
2630.0	801.6	23.568	29.166	84.498	83223.94
2640.0	804.7	19.655	29.238	84.628	82962.94
2650.0	807.7	21.621	29.297	84.735	82746.00
2660.0	810.8	19.490	29.363	84.854	82507.94
2670.0	813.8	20.234	29.423	84.961	82294.00
2680.0	816.9	27.393	29.484	85.072	82072.94
2690.0	819.9	26.013	29.568	85.222	81774.94
2700.0	823.0	22.672	29.647	85.365	81492.94
2710.0	826.0	24.139	29.716	85.489	81248.00
2720.0	829.1	21.613	29.790	85.622	80988.00
2730.0	832.1	16.330	29.856	85.740	80755.94
2740.0	835.2	37.027	29.906	85.830	80580.94
2750.0	838.2	-31.227	30.018	86.033	80186.00
2760.0	841.2	29.626	29.923	85.862	80518.94
2770.0	844.3	7.169	30.013	86.024	80203.00
2780.0	847.3	16.510	30.035	86.064	80126.94
2790.0	850.4	27.928	30.086	86.154	79951.94
2800.0	853.4	36.407	30.171	86.307	79656.94
2810.0	856.5	16.510	30.282	86.507	79274.00

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2820.0   859.5   291.470   30.332   86.598   79100.94
2830.0   862.6   128.069   31.221   88.197   76115.94
2840.0   865.6    57.539   31.611   88.900   74845.00
2850.0   868.7    42.319   31.786   89.215   74281.94
2860.0   871.7    33.330   31.915   89.447   73871.00
2870.0   874.8    27.323   32.017   89.630   73548.94
2880.0   877.8    40.171   32.100   89.780   73285.94
2890.0   880.9    24.615   32.223   90.001   72901.00
2900.0   883.9    24.169   32.298   90.136   72667.00
2910.0   887.0    33.688   32.371   90.268   72438.00
2920.0   890.0    27.863   32.474   90.453   72119.94
2930.0   893.1    22.514   32.559   90.606   71858.00
2940.0   896.1    24.404   32.627   90.729   71647.00
2950.0   899.2    25.235   32.702   90.863   71419.00
2960.0   902.2    26.799   32.779   91.002   71184.00
2970.0   905.3    31.678   32.860   91.149   70936.00
2980.0   908.3    28.519   32.957   91.323   70643.94
2990.0   911.4    27.105   33.044   91.479   70382.00
3000.0   914.4    47.892   33.127   91.628   70134.00
3010.0   917.4    12.004   33.273   91.891   69697.94
3020.0   920.5    33.488   33.309   91.956   69589.00
3030.0   923.5    29.200   33.411   92.140   69287.00
3040.0   926.6    23.475   33.500   92.300   69024.94
3050.0   929.6    29.275   33.572   92.429   68815.00
3060.0   932.7    27.143   33.661   92.590   68554.00
3070.0   935.7    25.653   33.744   92.739   68313.00
3080.0   938.8    22.217 ? 33.822   92.879   68085.94
3090.0   941.8     0.0     33.890   93.001   67889.94
3100.0   944.9    35.973   33.990   93.182   67600.94
 STOP      0                                           00:01:25
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3102.

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CACHE #19, TOOL #6, SYSTRON DONNER, RC = 190

     DEPTH          *     GRAD     *        TEMPERATURE              *              RESISTANCE
  FEET     METERS   *   DEG C/KM   *     DEG C             DEG F     *          +                -          DELTA
   400.0    121.9        82.416          17.310            63.158          142429.94
   410.0    125.0        -2.488          17.561            63.610          140759.94
   420.0    128.0        -3.469          17.553            63.596          140809.94
   430.0    131.1         1.487          17.543            63.577          140880.00
   440.0    134.1         4.470          17.547            63.585          140850.00
   450.0    137.2         5.957          17.561            63.610          140759.94
   460.0    140.2         3.479          17.579            63.643          140639.94
   470.0    143.3         5.472          17.590            63.662          140570.00
   480.0    146.3         5.972          17.606            63.692          140460.00
   490.0    149.4         5.477          17.625            63.724          140339.94
   500.0    152.4         6.984          17.641            63.755          140229.94
   510.0    155.4         6.483          17.663            63.793          140089.94
   520.0    158.5         7.990          17.682            63.828          139960.00
   530.0    161.5         8.505          17.707            63.872          139800.00
   540.0    164.6         9.016          17.733            63.919          139630.00
   550.0    167.6        10.047          17.760            63.968          139449.94
   560.0    170.7         9.577          17.791            64.023          139250.00
   570.0    173.7         9.086          17.820            64.076          139059.94
   580.0    176.8        11.624          17.848            64.126          138880.00
   590.0    179.8        10.127          17.883            64.190          138649.94
   600.0    182.9        10.137          17.914            64.245          138449.94
   610.0    185.9        10.668          17.945            64.301          138250.00
   620.0    189.0         9.146          17.977            64.359          138039.94
   630.0    192.0        13.752          18.005            64.410          137860.00
   640.0    195.1        13.266          18.047            64.485          137589.94
   650.0    198.1        15.854          18.088            64.558          137330.00
   660.0    201.2        19.995          18.136            64.645          137020.00
   670.0    204.2        17.476          18.197            64.754          136630.00
   680.0    207.3        15.454          18.250            64.850          136289.94
   690.0    210.3        16.030          18.297            64.935          135990.00
   700.0    213.4        18.172          18.346            65.023          135679.94
   710.0    216.4        16.671          18.402            65.123          135330.00
   720.0    219.5        16.706          18.452            65.214          135009.94
   730.0    222.5        19.359          18.503            65.306          134690.00
   740.0    225.6        15.744          18.562            65.412          134320.00
   750.0    228.6        15.254          18.610            65.498          134020.00
   760.0    231.6        17.391          18.657            65.582          133729.94
   770.0    234.7        13.732          18.710            65.678          133399.94
   780.0    237.7        14.293          18.752            65.753          133139.94
   790.0    240.8        14.848          18.795            65.831          132869.94
   800.0    243.8        14.348          18.840            65.913          132589.94
   810.0    246.9        13.096          18.884            65.992          132320.00
   830.0    253.0         7.499          18.964            66.135          131830.00
   840.0    256.0         9.127          18.987            66.176          131690.00
   850.0    259.1         5.371          19.015            66.226          131520.00
   860.0    262.1         9.141          19.031            66.256          131419.94
   870.0    265.2        12.932          19.059            66.306          131250.00
   880.0    268.2        12.405          19.098            66.377          131009.94
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 890.0   271.3      10.804       19.136          66.445       130779.94
 900.0   274.3     137.225       19.169          66.504       130580.00
 910.0   277.4      14.953       19.587          67.257       128070.00
 920.0   280.4      11.109       19.633          67.339       127800.00
 930.0   283.5      11.674       19.667          67.400       127600.00
 940.0   286.5      10.578       19.702          67.464       127389.94
 950.0   289.6      11.710       19.735          67.522       127199.94
 960.0   292.6      11.178       19.770          67.587       126990.00
 970.0   295.7      -0.566       19.804          67.648       126789.94
 980.0   298.7       0.566       19.803          67.645       126800.00
 990.0   301.8       2.228       19.804          67.648       126789.94
1000.0   304.8       2.238       19.811          67.660       126750.00
1010.0   307.8       2.798       19.818          67.672       126710.00
1020.0   310.9       3.359       19.827          67.688       126660.00
1030.0   313.9       6.158       19.837          67.706       126600.00
1040.0   317.0      10.653       19.856          67.740       126490.00
1050.0   320.0       9.551       19.888          67.798       126300.00
1060.0   323.1       8.436       19.917          67.851       126130.00
1070.0   326.1       9.571       19.943          67.897       125979.94
1080.0   329.2      10.153       19.972          67.950       125809.94
1090.0   332.2       7.925       20.003          68.005       125630.00
1100.0   335.3      16.450       20.027          68.049       125490.00
1110.0   338.3      12.511       20.077          68.139       125199.94
1120.0   341.4      11.384       20.115          68.208       124979.94
1130.0   344.4      13.417       20.150          68.270       124779.94
1150.0   350.5      13.161       20.232          68.417       124309.94
1160.0   353.6      13.772       20.272          68.490       124080.00
1170.0   356.6      13.217       20.314          68.565       123839.94
1180.0   359.7      13.241       20.354          68.638       123610.00
1190.0   362.7      13.272       20.395          68.710       123380.00
1200.0   365.8      14.442       20.435          68.783       123149.94
1210.0   368.8      13.326       20.479          68.862       122899.94
1220.0   371.9      12.766       20.520          68.935       122669.94
1230.0   374.9      16.920       20.559          69.005       122449.94
1240.0   378.0      16.375       20.610          69.098       122160.00
1250.0   381.0      15.825       20.660          69.188       121880.00
1260.0   384.0      15.278       20.708          69.275       121610.00
1270.0   387.1      14.719       20.755          69.359       121350.00
1280.0   390.1      14.152       20.800          69.440       121100.00
1290.0   393.2      15.368       20.843          69.517       120860.00
1300.0   396.2      15.415       20.890          69.602       120600.00
1310.0   399.3      13.646       20.937          69.686       120339.94
1320.0   402.3      15.426       20.978          69.761       120110.00
1350.0   411.5      14.703       21.119          70.015       119333.94
1360.0   414.5      16.191       21.164          70.096       119089.00
1370.0   417.6      11.093       21.214          70.184       118820.00
1380.0   420.6      16.321       21.247          70.245       118636.00
1390.0   423.7     -31.988       21.297          70.335       118365.94
1400.0   426.7     202.498       21.200          70.159       118895.94
1410.0   429.8      15.500       21.817          71.270       115582.94
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1420.0   432.8    15.398   21.864    71.355   115333.94
1430.0   435.9    12.190   21.911    71.440   115087.00
1440.0   438.9    13.773   21.948    71.507   114891.94
1450.0   442.0    12.039   21.990    71.582   114671.94
1460.0   445.0    13.698   22.027    71.648   114479.94
1470.0   448.1    11.259   22.069    71.723   114261.94
1480.0   451.1    12.670   22.103    71.785   114082.94
1490.0   454.2    11.625   22.141    71.855   113882.00
1500.0   457.2    14.102   22.177    71.918   113697.94
1510.0   460.2    11.694   22.220    71.996   113475.00
1520.0   463.3    12.741   22.256    72.060   113291.00
1530.0   466.3    12.500   22.294    72.130   113091.00
1540.0   469.4    12.215   22.332    72.198   112895.00
1550.0   472.4    17.858   22.370    72.265   112703.94
1560.0   475.5    14.252   22.424    72.363   112425.00
1570.0   478.5    12.927   22.468    72.442   112203.00
1580.0   481.6    14.042   22.507    72.513   112001.94
1590.0   484.6     7.809   22.550    72.590   111783.94
1600.0   487.7    48.317   22.574    72.632   111662.94
1610.0   490.7    20.905   22.721    72.898   110917.00
1620.0   493.8   -50.020   22.785    73.012   110595.94
1630.0   496.8   212.852   22.632    72.738   111365.94
1640.0   499.9   104.956   23.281    73.906   108134.00
1650.0   502.9    29.135   23.601    74.481   106580.94
1660.0   506.0    22.258   23.690    74.641   106154.00
1670.0   509.0   -10.558   23.757    74.763   105828.94
1680.0   512.1    50.730   23.725    74.705   105983.00
1690.0   515.1    17.096   23.880    74.984   105244.94
1700.0   518.2    24.795   23.932    75.078   104998.00
1710.0   521.2    21.608   24.008    75.214   104641.00
1720.0   524.3    16.275   24.073    75.332   104330.94
1730.0   527.3    17.791   24.123    75.421   104098.00
1740.0   530.4    19.089   24.177    75.519   103843.94
1750.0   533.4    16.685   24.235    75.624   103572.00
1760.0   536.4    17.427   24.286    75.715   103335.00
1770.0   539.5    15.839   24.339    75.811   103087.94
1780.0   542.5    18.637   24.388    75.898   102863.94
1790.0   545.6    19.260   24.444    76.000   102600.94
1800.0   548.6    19.518   24.503    76.106   102330.94
1810.0   551.7    19.513   24.563    76.213   102057.94
1820.0   554.7    17.968   24.622    76.320   101785.94
1830.0   557.8    16.790   24.677    76.418   101535.94
1840.0   560.8    18.412   24.728    76.511   101302.94
1850.0   563.9    19.054   24.784    76.612   101048.00
1860.0   566.9    15.964   24.842    76.716   100785.00
1870.0   570.0    18.048   24.891    76.804   100565.00
1880.0   573.0    17.441   24.946    76.903   100317.00
1890.0   576.1    19.223   24.999    76.998   100078.00
1900.0   579.1    18.303   25.058    77.104    99815.94
1910.0   582.2    19.919   25.113    77.204    99567.00
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1920.0   585.2    19.443   25.174     77.314    99296.94
1930.0   588.3    17.277   25.233     77.420    99033.94
1940.0   591.3    19.699   25.286     77.515    98800.94
1950.0   594.4    19.225   25.346     77.623    98535.94
1960.0   597.4    18.667   25.405     77.729    98277.94
1970.0   600.5    21.346   25.462     77.831    98027.94
1980.0   603.5    20.782   25.527     77.948    97742.94
1990.0   606.6     4.746   25.590     78.062    97466.94
2000.0   609.6    40.599   25.605     78.088    97404.00
2010.0   612.6    20.992   25.728     78.311    96867.94
2020.0   615.7    19.358   25.792     78.426    96591.94
2030.0   618.7    21.180   25.851     78.532    96337.94
2040.0   621.8    21.097   25.916     78.648    96061.00
2050.0   624.8    20.219   25.980     78.764    95785.94
2060.0   627.9    21.442   26.042     78.875    95522.94
2070.0   630.9    21.486   26.107     78.993    95244.94
2080.0   634.0    20.159   26.173     79.111    94968.00
2090.0   637.0    21.302   26.234     79.221    94708.94
2100.0   640.1    20.740   26.299     79.338    94436.00
2110.0   643.1    21.426   26.362     79.452    94171.00
2120.0   646.2    21.808   26.427     79.570    93897.94
2130.0   649.2    20.359   26.494     79.689    93621.00
2140.0   652.3    20.269   26.556     79.801    93363.00
2150.0   655.3    21.698   26.618     79.912    93106.94
2160.0   658.4    20.450   26.684     80.031    92833.94
2170.0   661.4    20.757   26.746     80.143    92578.00
2180.0   664.5    21.291   26.810     80.257    92319.00
2190.0   667.5    21.606   26.874     80.374    92054.00
2200.0   670.6    21.653   26.940     80.493    91785.94
2210.0   673.6    20.104   27.006     80.611    91518.00
2220.0   676.7    23.168   27.068     80.722    91270.00
2230.0   679.7    21.362   27.138     80.849    90985.00
2240.0   682.8    19.338   27.203     80.966    90723.00
2250.0   685.8    20.056   27.262     81.072    90486.94
2260.0   688.8    19.288   27.323     81.182    90242.94
2270.0   691.9    18.262   27.382     81.288    90009.00
2280.0   694.9    22.624   27.438     81.388    89787.94
2290.0   698.0    26.191   27.507     81.512    89514.94
2300.0   701.0    27.103   27.587     81.656    89199.94
2310.0   704.1    26.304   27.669     81.805    88875.00
2320.0   707.1    27.888   27.749     81.949    88561.00
2330.0   710.2    29.455   27.834     82.102    88229.94
2340.0   713.2    26.013   27.924     82.264    87882.00
2350.0   716.3    26.191   28.003     82.406    87576.00
2360.0   719.3    27.135   28.083     82.550    87268.94
2370.0   722.4    29.721   28.166     82.699    86951.94
2380.0   725.4    31.252   28.257     82.862    86606.00
2390.0   728.5    34.089   28.352     83.033    86244.00
2400.0   731.5    31.358   28.456     83.220    85852.00
2410.0   734.6    29.641   28.551     83.392    85492.94
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2420.0	737.6	32.411	28.642	83.555	85154.94	
2430.0	740.7	28.734	28.740	83.733	84787.00	
2440.0	743.7	26.919	28.828	83.890	84462.00	
2450.0	746.8	31.453	28.910	84.038	84158.94	
2460.0	749.8	30.597	29.006	84.211	83807.00	
2470.0	752.9	30.729	29.099	84.379	83466.00	
2480.0	755.9	29.951	29.193	84.547	83125.00	
2490.0	759.0	33.981	29.284	84.712	82794.00	
2500.0	762.0	30.609	29.388	84.898	82419.94	
2510.0	765.0	27.383	29.481	85.066	82085.00	
2520.0	768.1	43.317	29.564	85.216	81787.00	
2530.0	771.1	33.228	29.697	85.454	81317.94	
2540.0	774.2	32.624	29.798	85.636	80960.00	
2550.0	777.2	32.782	29.897	85.815	80610.00	
2560.0	780.3	30.927	29.997	85.995	80259.94	
2570.0	783.3	31.913	30.091	86.165	79932.00	
2580.0	786.4	56.402	30.189	86.340	79595.00	
2590.0	789.4	2.398	30.361	86.649	79003.00	— 79 300
2600.0	792.5	30.381	30.368	86.662	78977.94	
2610.0	795.5	32.051	30.461	86.829	78660.94	
2620.0	798.6	32.884	30.558	87.005	78328.00	
2630.0	801.6	30.482	30.658	87.185	77988.94	
2640.0	804.7	28.652	30.751	87.352	77675.94	
2650.0	807.7	27.378	30.839	87.510	77382.94	
2660.0	810.8	28.572	30.922	87.660	77104.00	
2670.0	813.8	31.638	31.009	87.817	76813.94	
2680.0	816.9	37.375	31.106	87.990	76494.00	
2690.0	819.9	31.846	31.220	88.195	76119.00	
2700.0	823.0	35.593	31.317	88.370	75800.94	
2710.0	826.0	34.657	31.425	88.565	75447.00	
2720.0	829.1	36.241	31.531	88.755	75104.00	
2730.0	832.1	34.136	31.641	88.954	74746.94	
2740.0	835.2	35.335	31.745	89.142	74412.94	
2750.0	838.2	30.857	31.853	89.335	74069.00	
2760.0	841.2	31.703	31.947	89.505	73770.00	
2770.0	844.3	29.338	32.044	89.679	73464.00	
2780.0	847.3	25.586	32.133	89.840	73182.00	
2790.0	850.4	26.582	32.211	89.980	72936.94	
2800.0	853.4	28.717	32.292	90.126	72684.00	
2810.0	856.5	28.604	32.380	90.283	72412.00	
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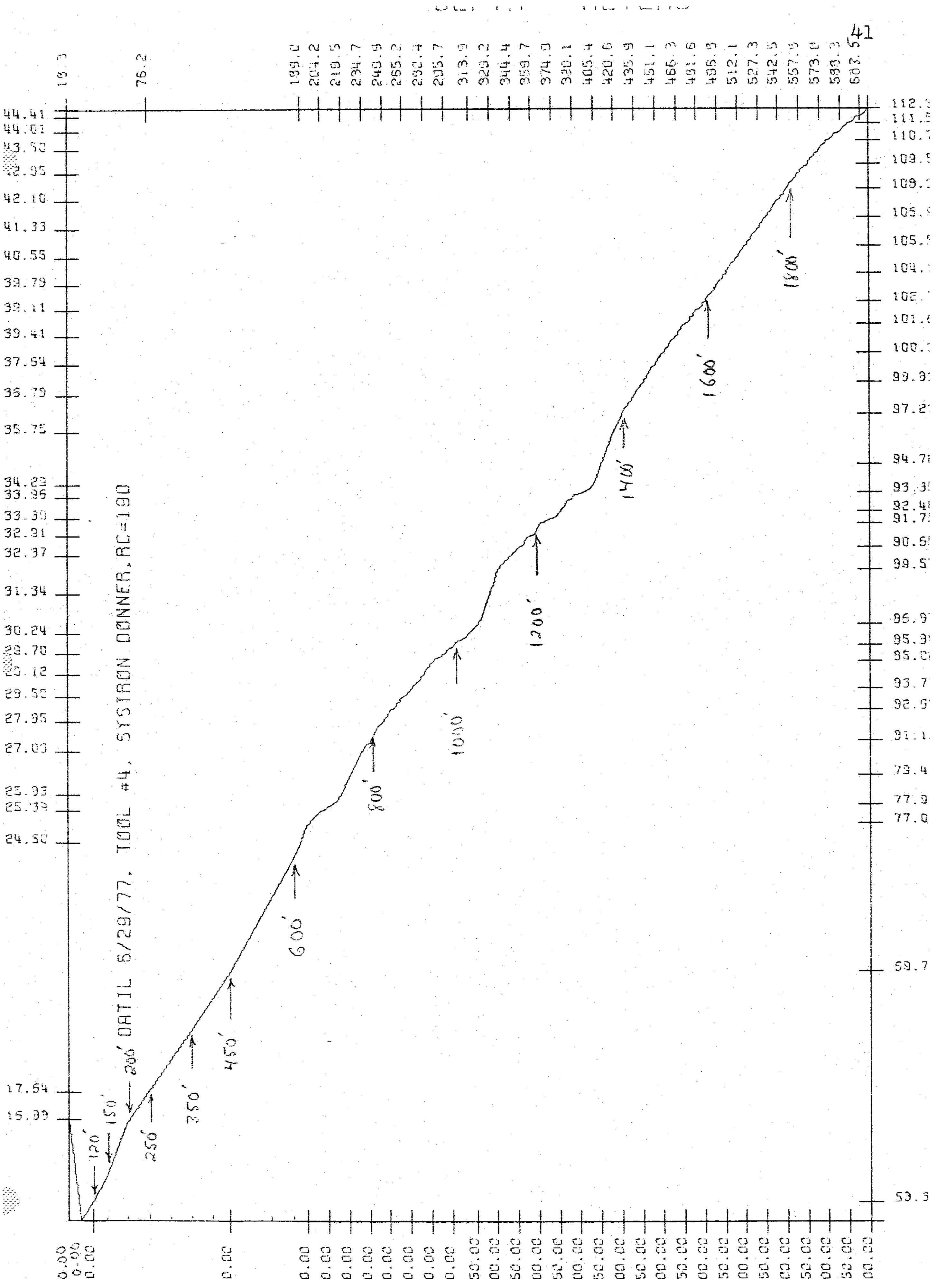

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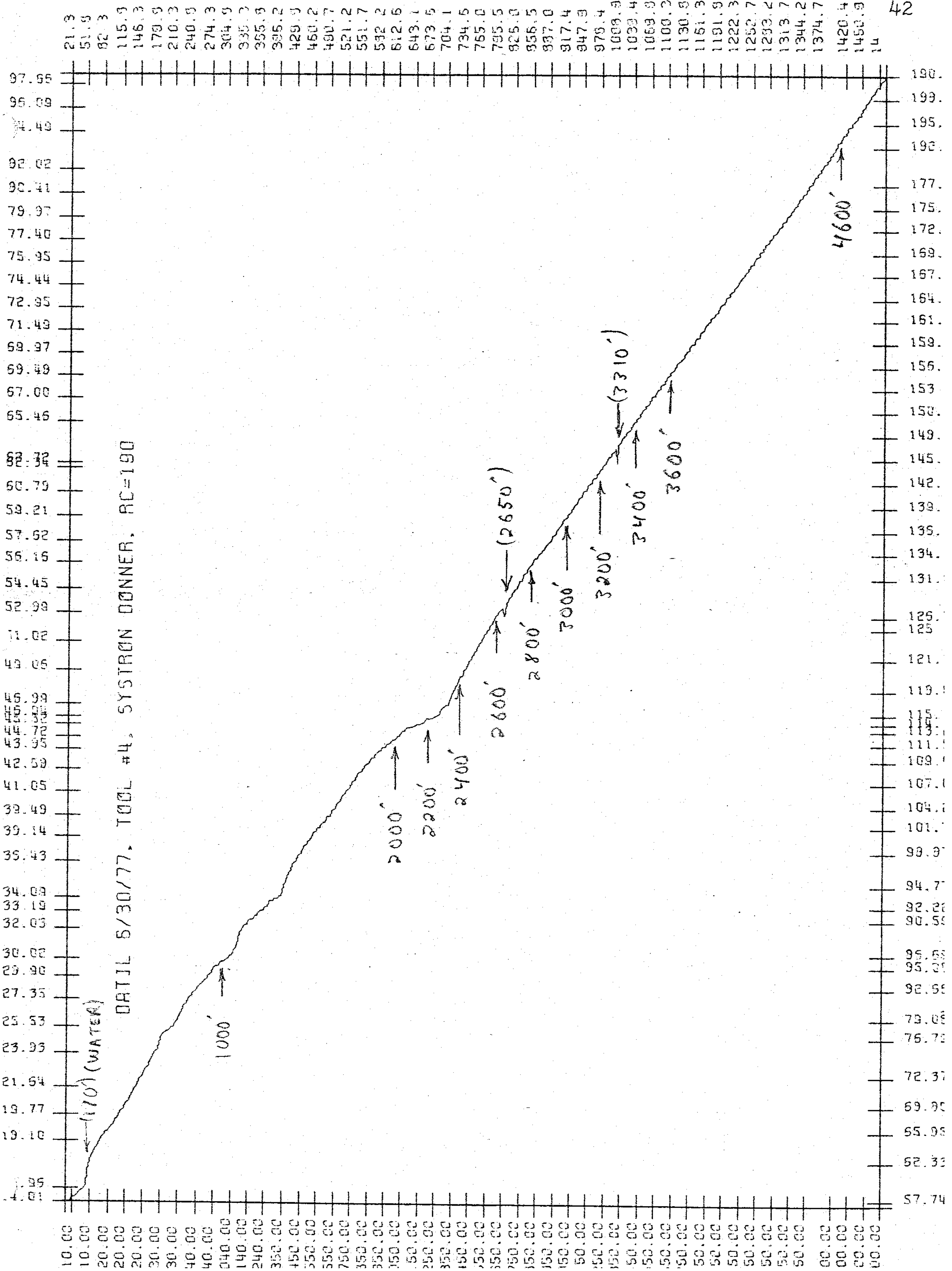
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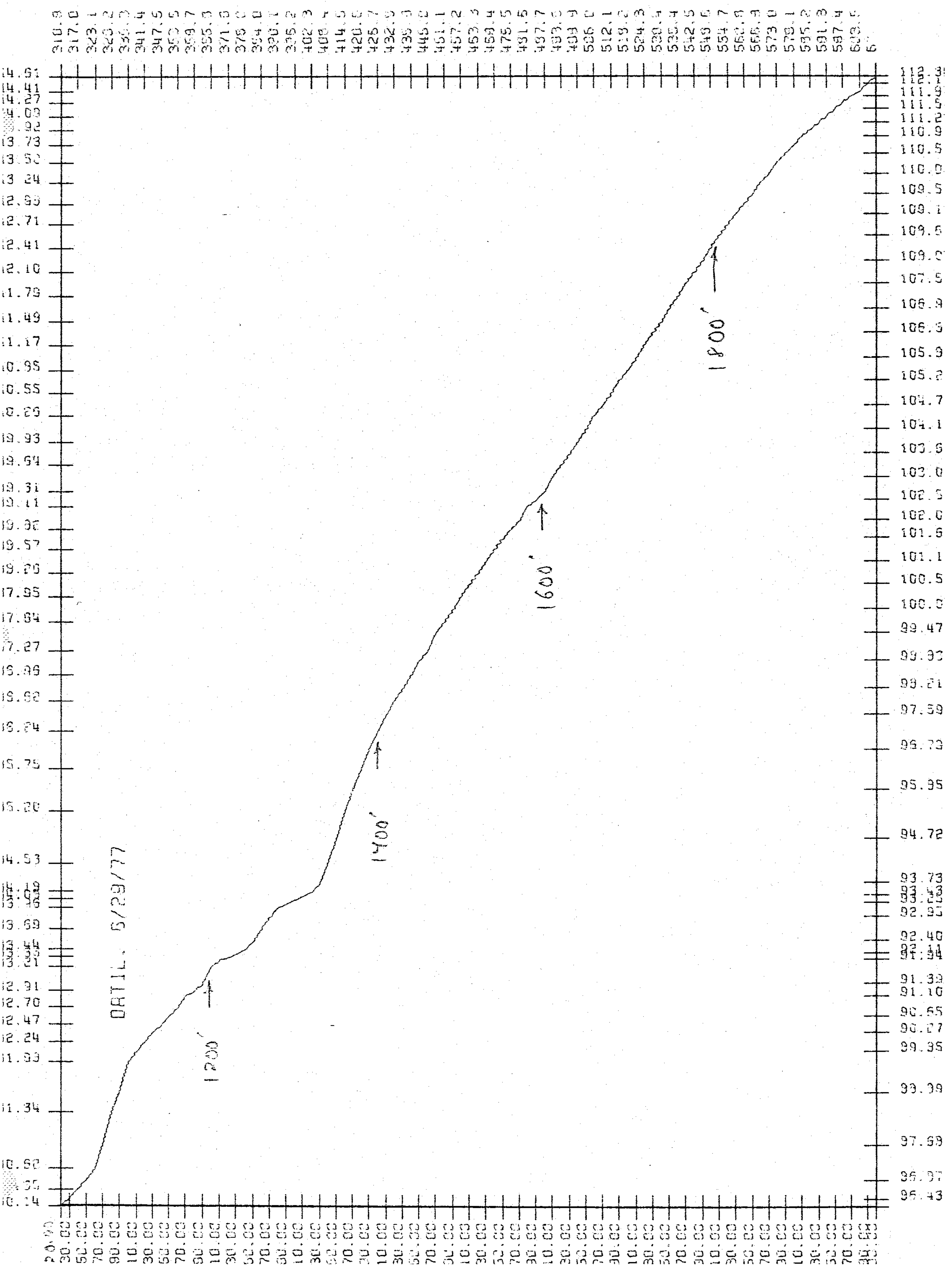
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457.2
463.3
469.4
475.5
481.6
487.7
493.8
499.9
506.0
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518.2
524.3
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542.5
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573.0
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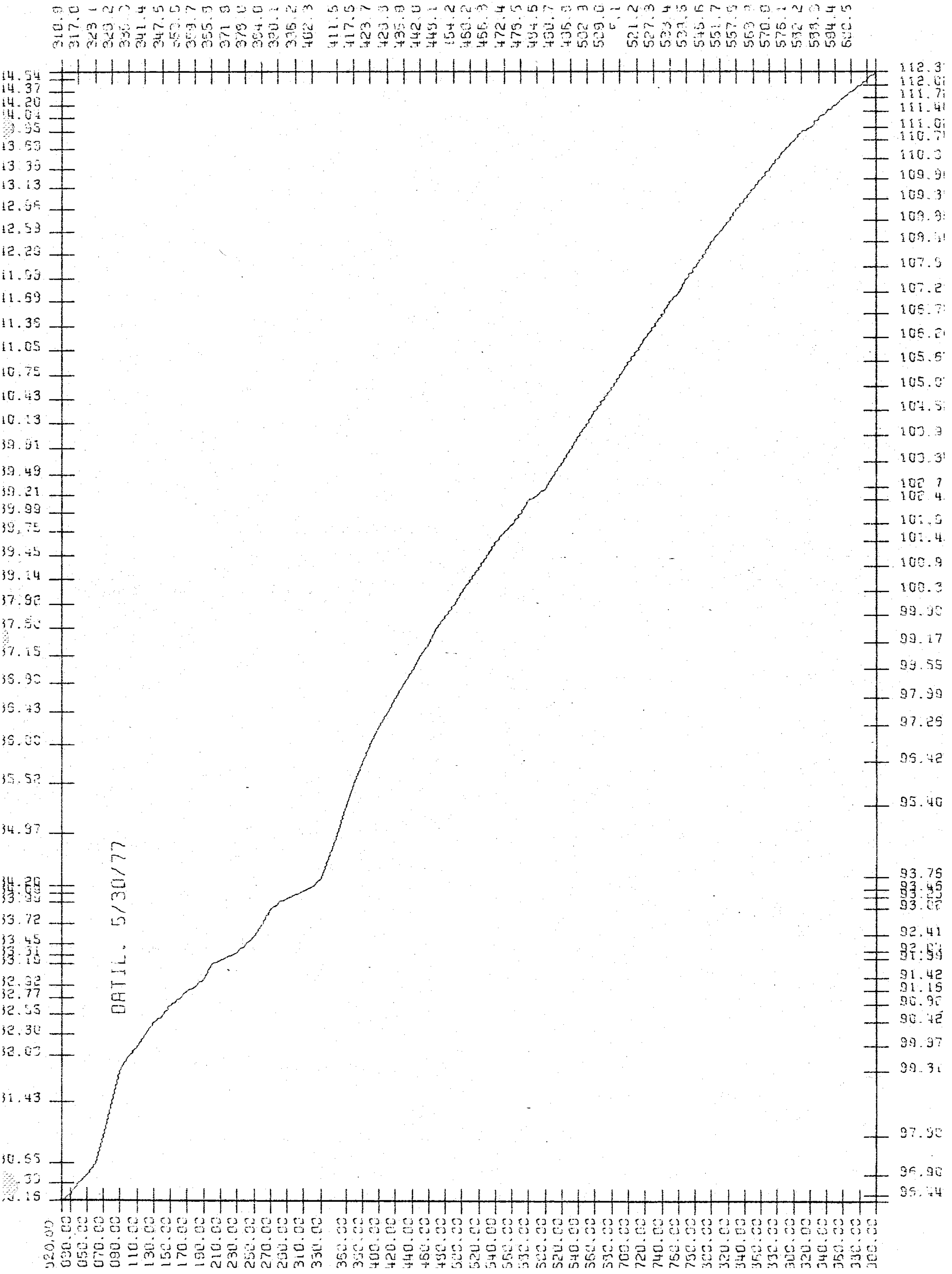
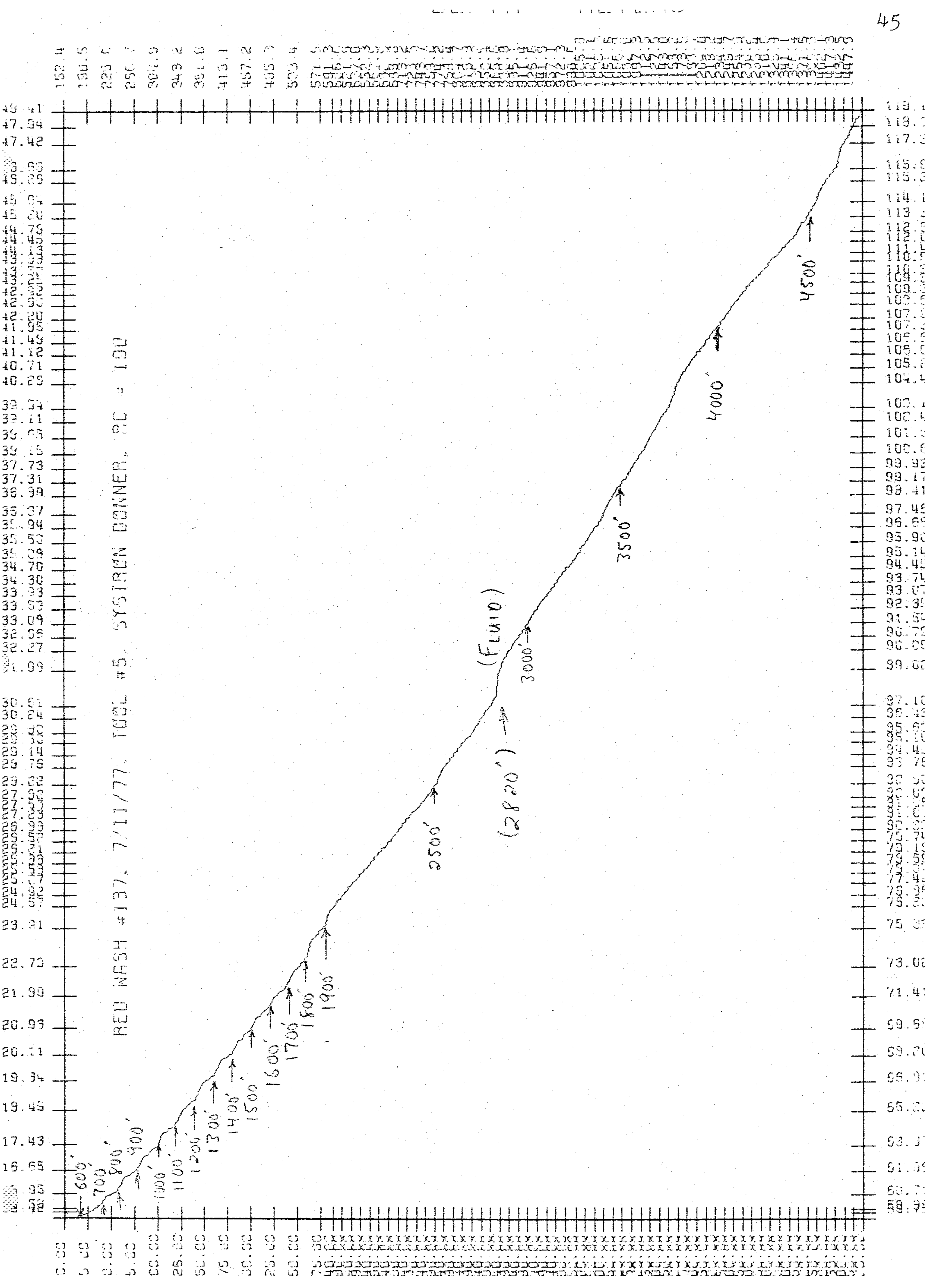

DATIL. 5/30/77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800'
900'
1000'
1100'
1200'
1300'
1400'
1500
1600'
1700'
1800'
1900'
2500'
(2820')
(FLUID)
3000'
3500'
4000'
4500'
47.94
47.42
45.20
44.79
42.20
41.95
41.49
41.12
40.71
40.29
37.73
37.31
36.99
34.70
34.30
33.93
33.53
33.09
32.27
30.24
23.91
22.70
21.90
20.93
20.11
19.34
17.43
16.65
75
73.0
71.4
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97.4
95.9
95.1
94.4
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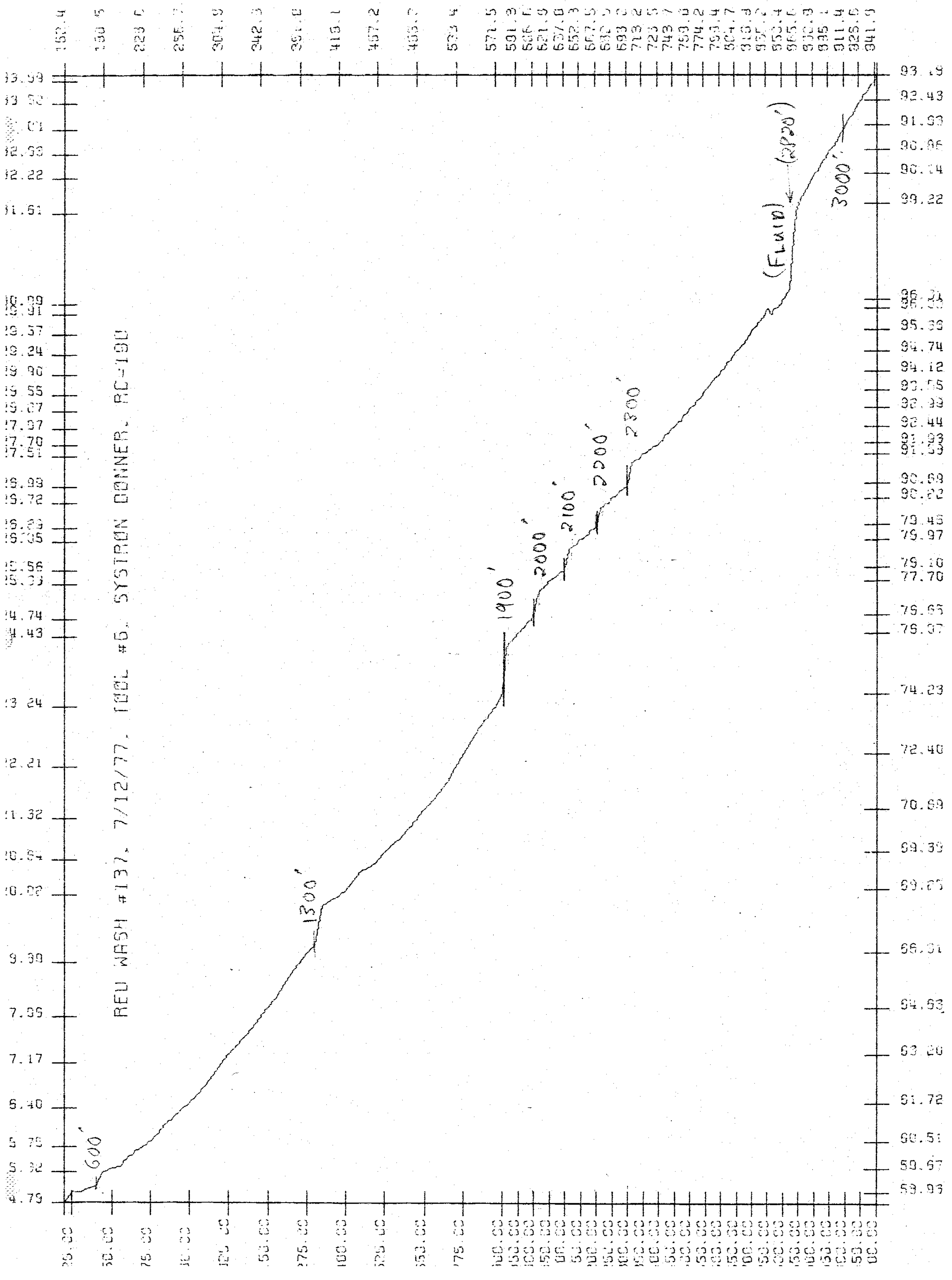
419.1
457.2
533.4


RED WASH #137, 7/12/77, TOOL #5, SYSTRON DONNER, RC-190
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1900'
2000'
2100'
2200'
2300'
(FLUID)
(2820')
3000'
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6.40
7.17
9.30
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93.19
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74.23
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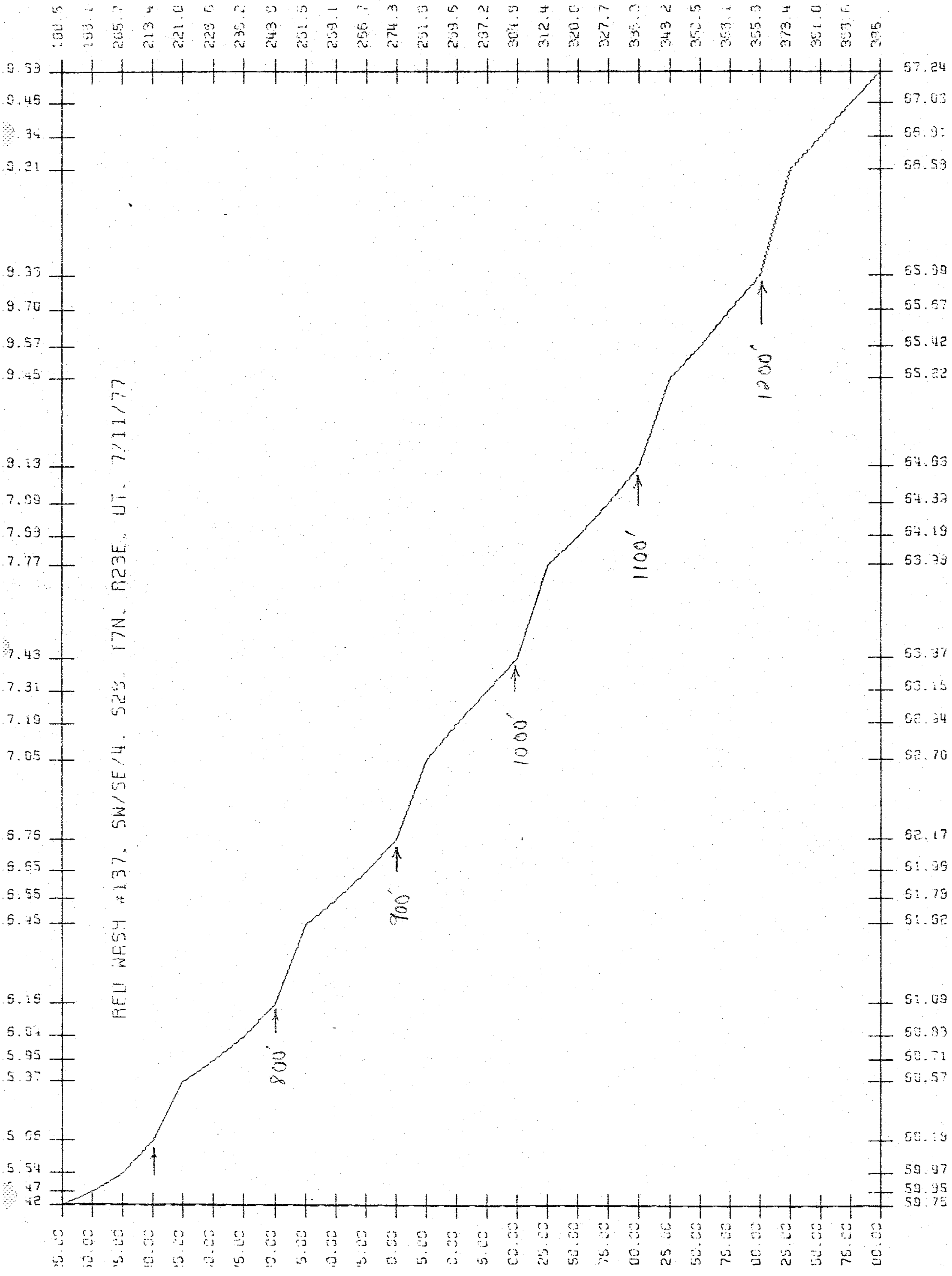
RED WASH #137, SW/SE/4, S28, T7N, R23E, UT. 7/11/77
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1100'
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205.7
213.4
221.0
228.6
236.2
243.8
251.5
259.1
266.7
274.3
281.9
289.5
297.2
304.9
312.4
320.0
327.7
335.3
343.2
350.5
358.4
365.3
373.4
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388.6
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.9.57
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.9.13
.7.99
.7.90
.7.77
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.7.05
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.6.55
.6.45
.6.16
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.5.95
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.5.54
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59.95
59.75
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5.00
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5.00
0.00
5.00
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5.00
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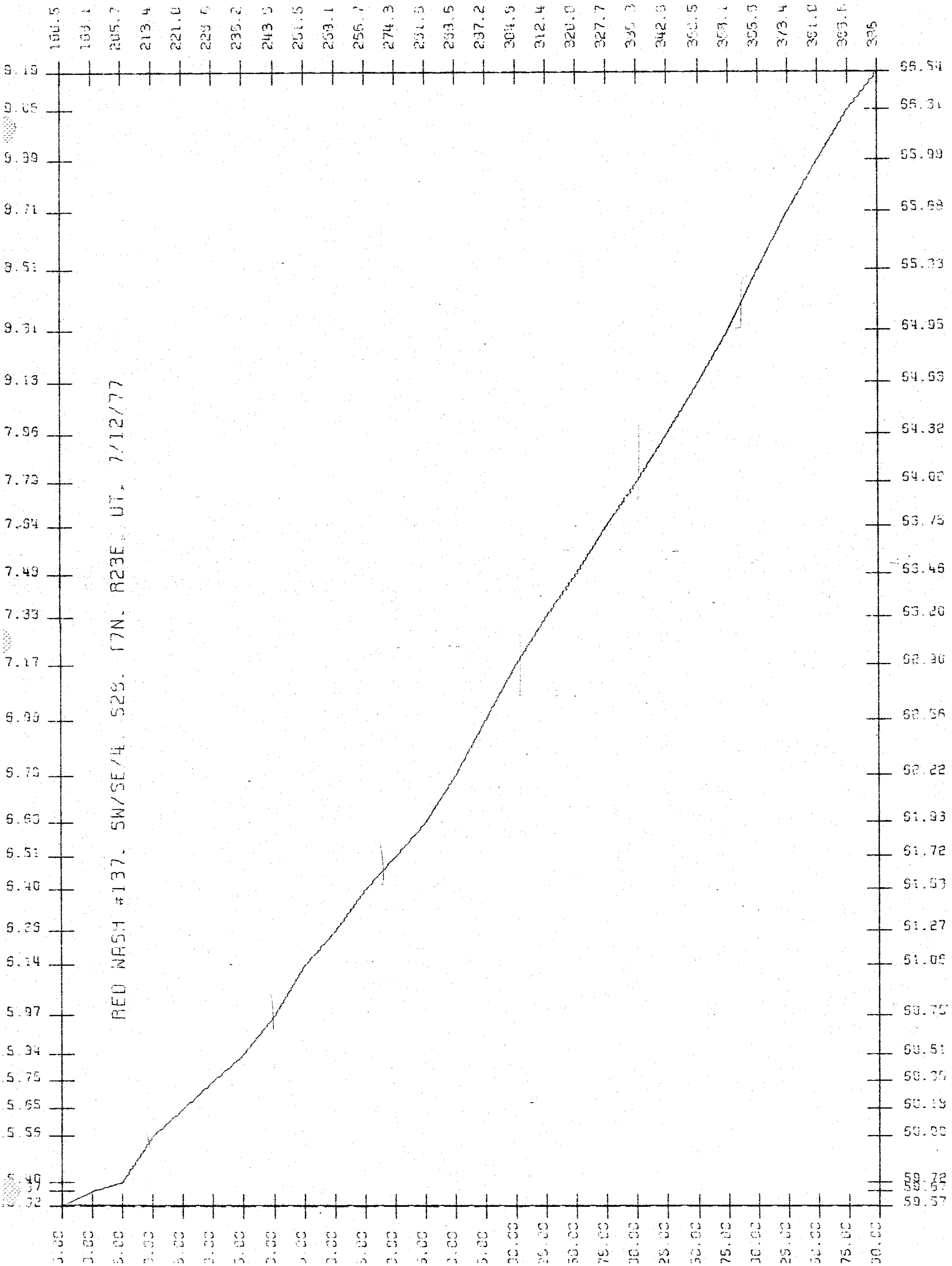
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266.7
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0.05
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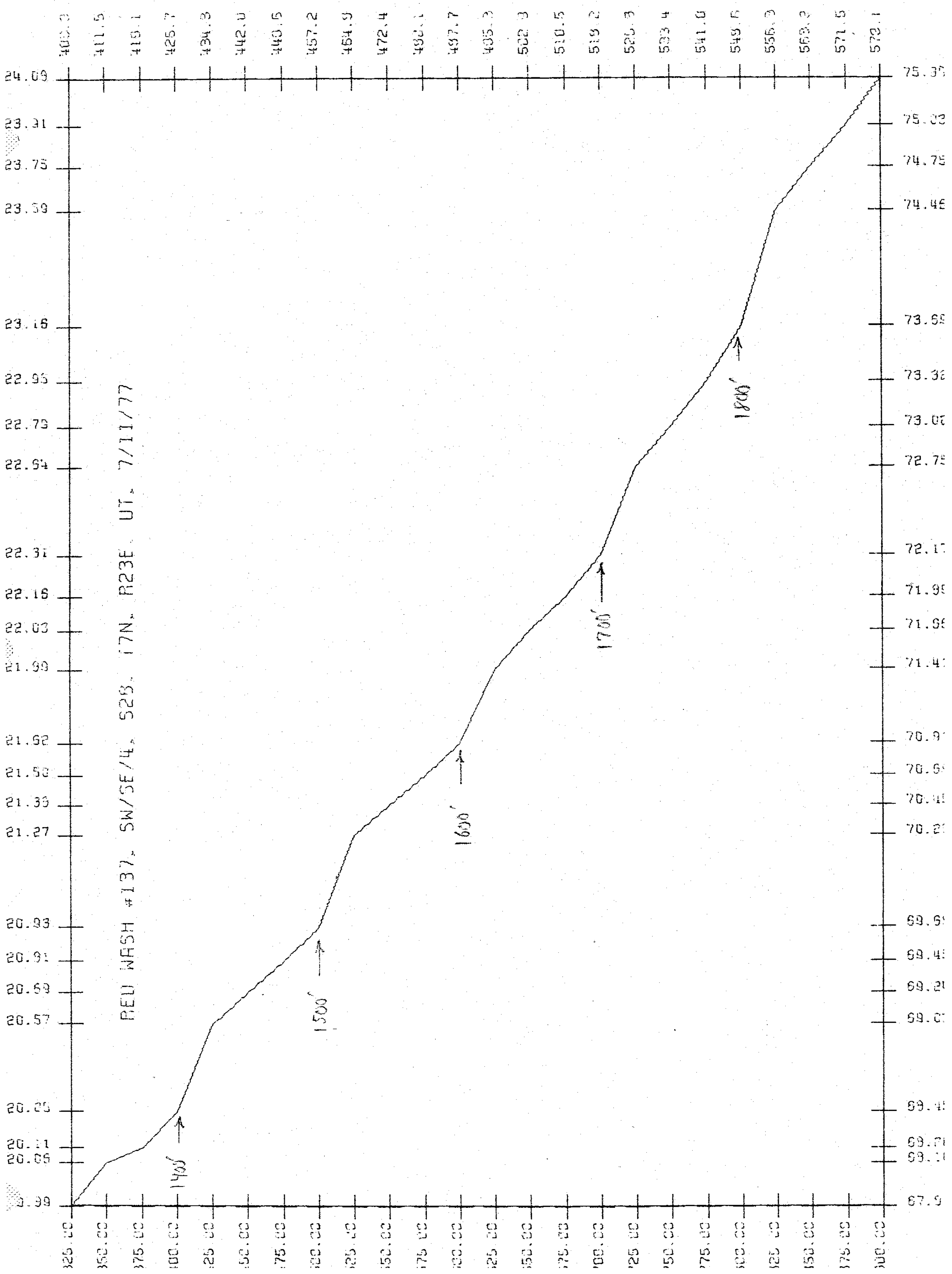
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1500'
1600'
1700'
1800'
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411.5
419.1
425.7
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442.0
449.5
457.2
464.9
472.4
480.1
487.7
495.3
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510.5
518.2
525.8
533.4
541.0
548.6
556.3
563.9
571.5
579.1
24.09
23.91
23.75
23.59
23.16
22.95
22.79
22.64
22.31
22.16
22.03
21.89
21.62
21.50
21.39
21.27
20.93
20.81
20.69
20.57
20.25
20.11
20.06
19.99
75.35
75.03
74.79
74.46
73.69
73.38
72.75
67.9
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350.00
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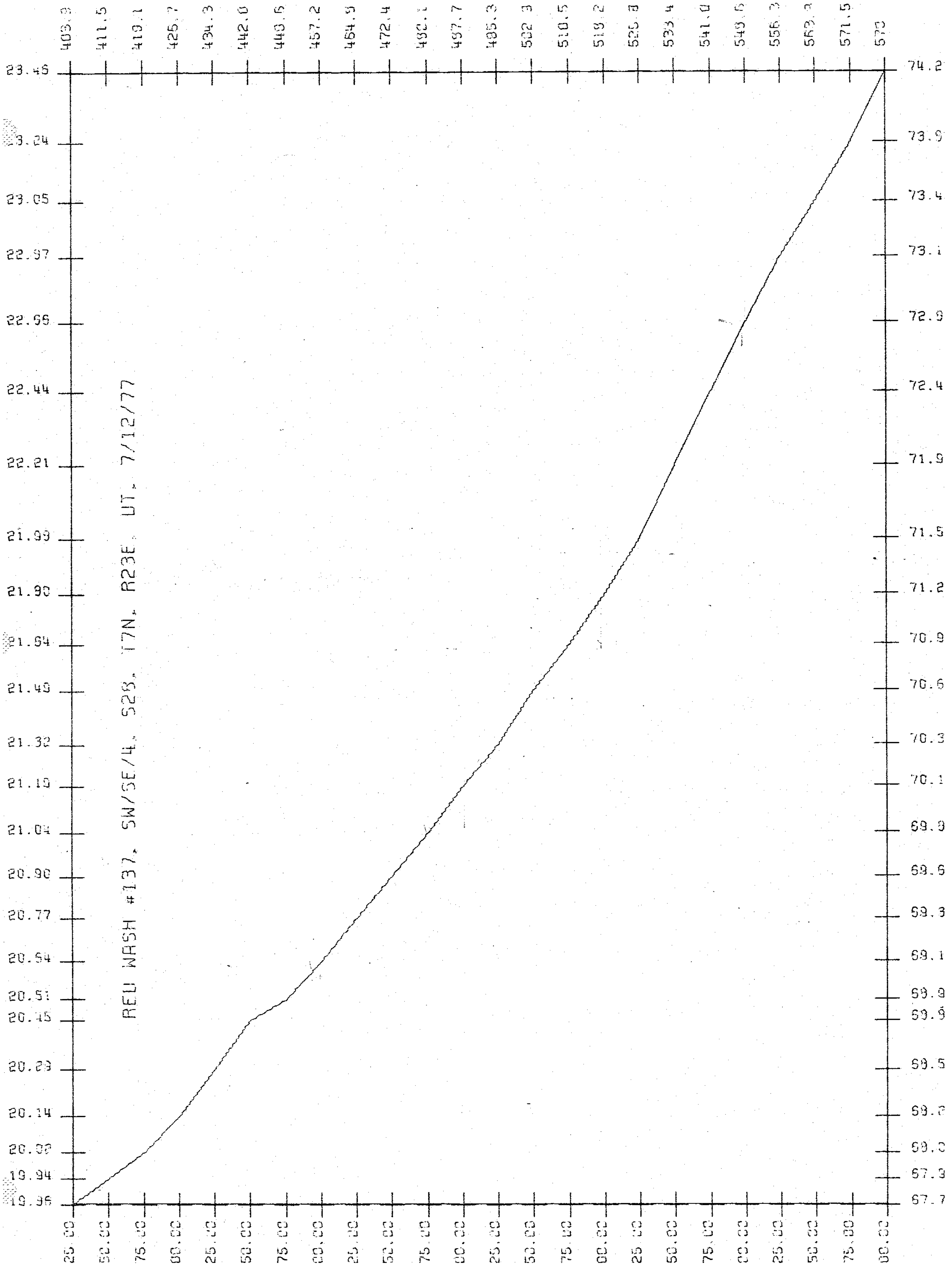
850.00
875.00
900.00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464.9
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525.8
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571.5
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23.46
23.24
23.05
22.97
22.66
22.44
22.21
21.99
21.90
21.64
21.49
21.32
21.10
21.04
20.90
20.77
20.54
20.51
20.45
20.28
20.14
20.02
19.94
19.86
74.2
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73.4
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68.2
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67.9
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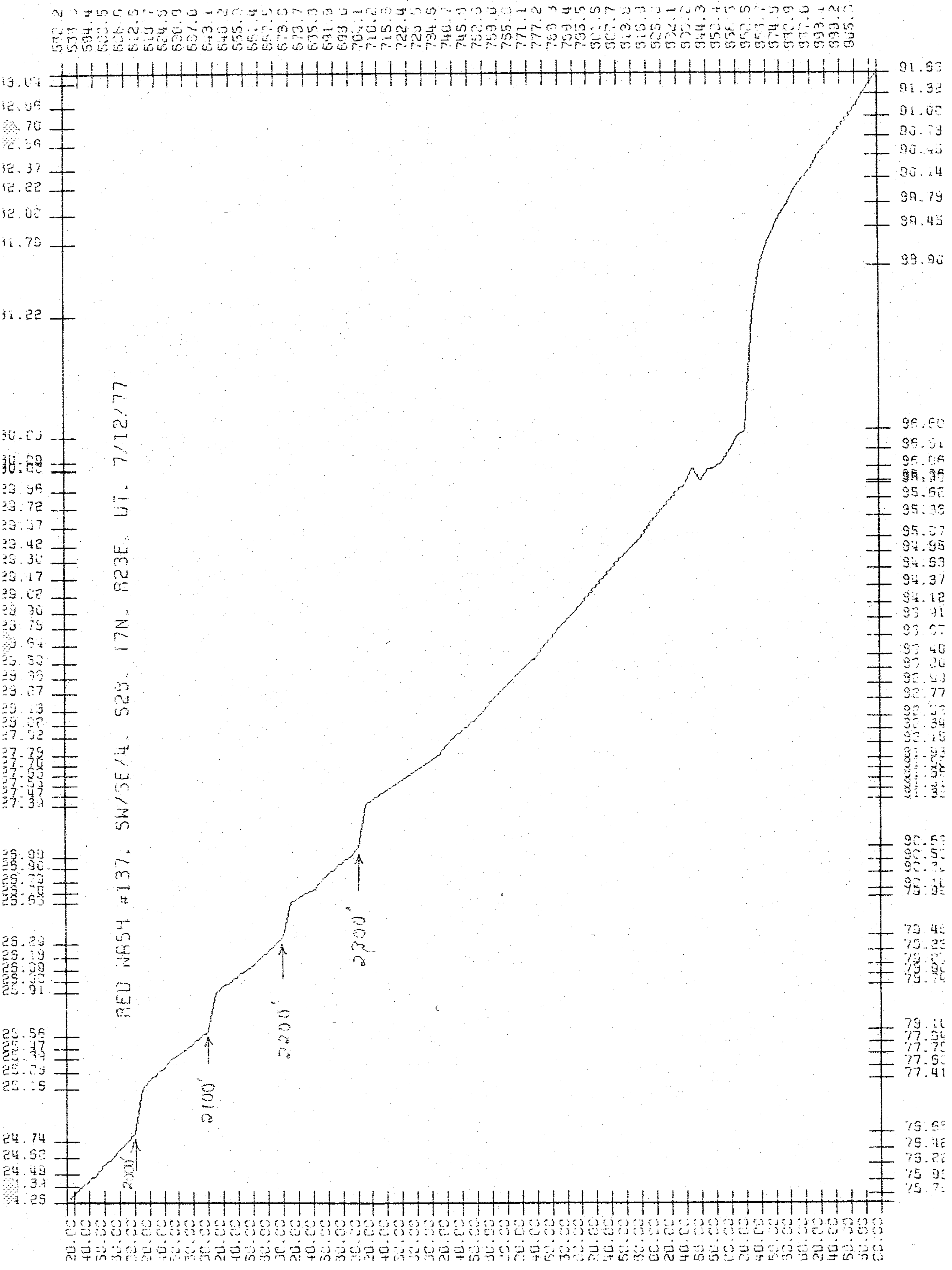
RED WASH #137, SW/SE/4, S28, T7N, R23E, UT. 7/12/77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2100'
2200'
2300'
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25.16
25.56
25.91
26.28
27.33
27.79
29.72
29.96
30.23
31.22
31.79
32.00
32.22
32.37
32.96
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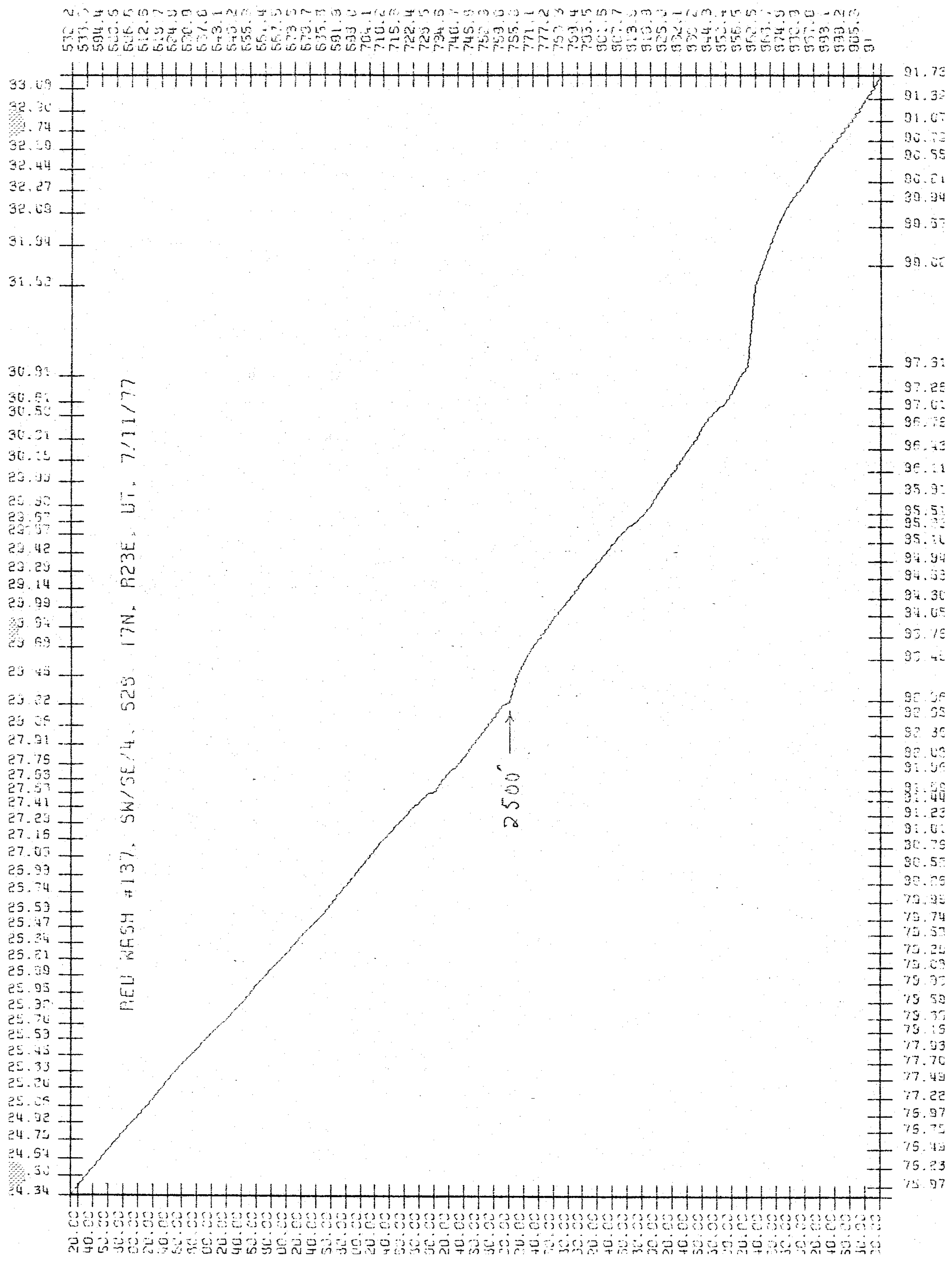
99.90


RED WASH #137, SW/SE/4, S28 T7N, R23E, UT. 7/11/77
2500'
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24.34
91.73
75.97

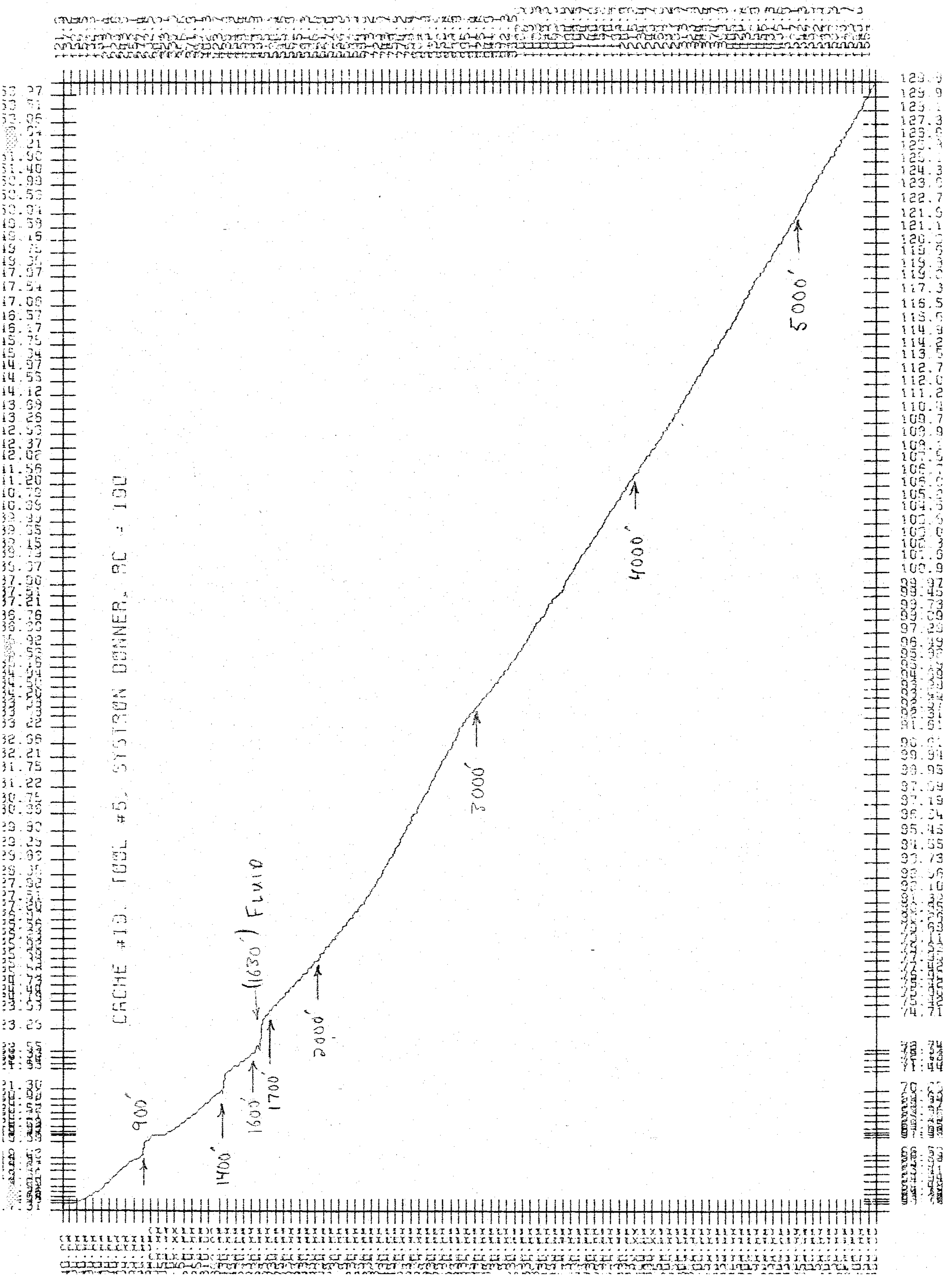

CACHE #10. TOOL #5, SYSTRON DONNER, RC = 100
900'
1400'
1600'
1700'
(1630') FLUID
2000'
3000'
4000'
5000'
129.9
127.3
124.3
122.7
121.9
117.3
116.5
114.9
114.2
113.5
112.7
112.0
111.2
109.7
100.9
99.97
95.45
93.73
74.71
33.29
32.95
32.21
31.75
31.22

Table 1. Comparison of TD temperature to average temperature and final temperature in water.

	Cal Depth (ft)	TD Temp (°F)	Ave Temp (°F)	Final Temp (°F)	Time (min)	TD vs Ave (%)	TD vs Final (%)
Datil 6/29/77	250	63.77	63.86	63.89	6	-0.14	-0.19
	350	66.60	66.56	66.58	5	+0.06	+0.03
	450	69.68	69.61	69.64	5.5	+0.10	+0.06
	600	75.18	75.06	75.17	5	+0.16	+0.01
	800	81.46	81.55	81.61	4.5	-0.11	-0.18
	1000	86.03	85.96	85.97	6.5	+0.08	+0.07
	1200	91.81	91.79	91.78	9	+0.02	+0.03
	1400	97.07	97.29	97.36	11	-0.23	-0.30
	1600	102.77	102.77	102.76	5	0.00	+0.01
	1800	108.33	108.28	108.33	5	+0.05	0.00
	2000	112.29	112.23	112.34	4.5	+0.05	-0.04
Datil 6/30/77	2000	112.32	112.17	112.24	5	+0.13	+0.07
	2200	114.77	114.71	114.75	5	+0.05	+0.02
	2400	119.93	119.77	119.84	5	+0.13	+0.08
	2600	126.87	126.69	126.73	5	+0.14	+0.11
	2800	132.83	132.74	132.79	6	+0.07	+0.03
	3000	138.31	138.24	138.28	5	+0.05	+0.02
	3200	143.88	143.76	143.81	5	+0.08	+0.05
	3400	149.49	149.33	149.39	5	+0.11	+0.07
	3600	155.00	154.90	155.00	5	+0.06	0.00
	4600	182.38	182.29	182.35	5.5	+0.05	+0.02
Red Wash 7/11/77	3000	91.75	91.75	91.66	10	0.00	+0.10
	3500	99.16	99.05	99.11	7.5	+0.11	+0.05
	4000	107.33	107.22	107.13	5	+0.10	+0.19
	4500	113.37	113.34	113.40	5	+0.03	-0.03
	4800	119.12	118.96	118.96	5	+0.13	+0.13
Cache 7/14/77	1700	75.08	74.82	74.91	9	+0.35	+0.23
	2000	78.09	78.03	78.12	12	+0.08	-0.04
	3000	93.06	92.87	92.97	10	+0.20	+0.10
	4000	106.91	106.85	106.91	11	+0.06	0.00
	5000	121.86	121.76	121.89	10.5	+0.08	-0.02
	5500	129.85	129.91	129.99	16	-0.05	-0.11
				Average Values:		+0.06	+0.02

Table 2. Estimating temperature at calibration points by linear regression of continuous data. Datil 6/29/77 and Datil 6/30/77 data in water.

Cal Depth (ft)	TD Temp (°F)	Contin Temp (°F)	Est Temp (°F)	Contin vs TD Temp (%)	Est vs TD Temp (%)	Est vs Contin Temp (%)
250	63.755	63.757	63.814	+0.003	+0.093	+0.089
350	66.596	66.617	66.648	+0.032	+0.078	+0.047
450	69.702	69.771	69.800	+0.099	+0.141	+0.042
600	75.180	75.217	75.283	+0.049	+0.137	+0.088
800	81.465	81.529	81.560	+0.079	+0.117	+0.038
1200	91.786	91.745	91.630	-0.045	-0.170	-0.125
1400	97.233	97.257	97.171	+0.025	-0.064	-0.088
1600	102.761	102.758	102.857	-0.003	+0.093	+0.096
1800	108.337	108.398	108.370	+0.056	+0.030	-0.026
		Average	Values:	+0.033	+0.051	+0.018

Table 3. Time response of #4 probe at 1200 foot calibration point in water. Datil well. 6/29/77.

Time (min)	Temp (°F)
0	91.81
1	91.77
2	91.82
3	91.82
4	91.76
5	91.78
6	91.80
7	91.75
8	91.76
9	91.78

Table 4. Time response of #6 probe at 3000 foot calibration point in water. Red Wash well. 7/11/77.

Time (min)	Temp (°F)
0	91.75
1	91.64
2	91.57
3	91.70
4	91.72
5	91.72
6	91.62
7	91.70
8	91.69
9	91.68
10	91.66

Table 5. Time response of #6 probe at 3000 foot calibration point in water. Cache well. 7/14/77.

Time (min)	Temp (°F)
0.0	93.06
0.5	92.90
1.0	92.93
1.5	92.88
2.0	92.77
2.5	92.65
3.0	92.75
3.5	92.71
4.0	92.77
4.5	92.85
5.0	92.82
5.5	92.90
6.0	92.88
6.5	92.88
7.0	92.89
7.5	92.86
8.0	92.94
8.5	92.93
9.0	92.98
9.5	93.01
10.0	92.97

Table 6. Comparison of TD temperature to average temperature and final temperature in air.

	Cal Depth (ft)	TD Temp (°F)	Ave Temp (°F)	Final Temp (°F)	Time (min)	TD vs Ave (%)	TD vs Final (%)
Red Wash 7/11/77 7/12/77	500	58.59	58.99	59.04	15	-0.68	-0.76
	600	59.53	59.70	59.72	15	-0.28	-0.32
	700	60.15	60.30	60.43	15	-0.25	-0.46
	800	61.07	61.21	61.39	15	-0.23	-0.52
	900	62.17	62.27	62.43	15	-0.16	-0.42
	1000	63.38	63.54	63.71	15	-0.25	-0.52
	1100	64.65	64.77	64.94	15	-0.19	-0.45
	1200	65.89	66.08	66.26	15	-0.29	-0.56
	1300	67.23	67.38	67.53	15	-0.22	-0.44
	1400	68.43	68.58	68.75	15	-0.22	-0.47
	1500	69.66	69.82	69.99	15	-0.23	-0.47
	1600	70.88	70.96	71.12	15	-0.11	-0.34
	1700	72.18	72.24	72.39	15	-0.08	-0.29
	1800	73.71	73.83	74.07	15	-0.16	-0.49
	1900	75.35	75.34	75.54	14	-0.01	-0.25
	2000	76.63	76.84	77.10	15	-0.27	-0.61
	2100	78.10	78.27	78.50	15	-0.22	-0.51
	2200	79.43	79.49	79.75	15	-0.08	-0.40
	2300	80.67	80.81	81.10	15	-0.17	-0.53
Cache 7/14/77	400	63.16	63.64	63.68	15	-0.76	-0.82
	900	66.51	66.57	66.93	15	-0.09	-0.63
	1400	70.13	70.37	70.80	15	-0.34	-0.96
			Red Wash Average Values:			-0.22	-0.46

Figure 14. Time response of #4 probe at 1200 foot calibration point in water. Datil well. 6/29/77.

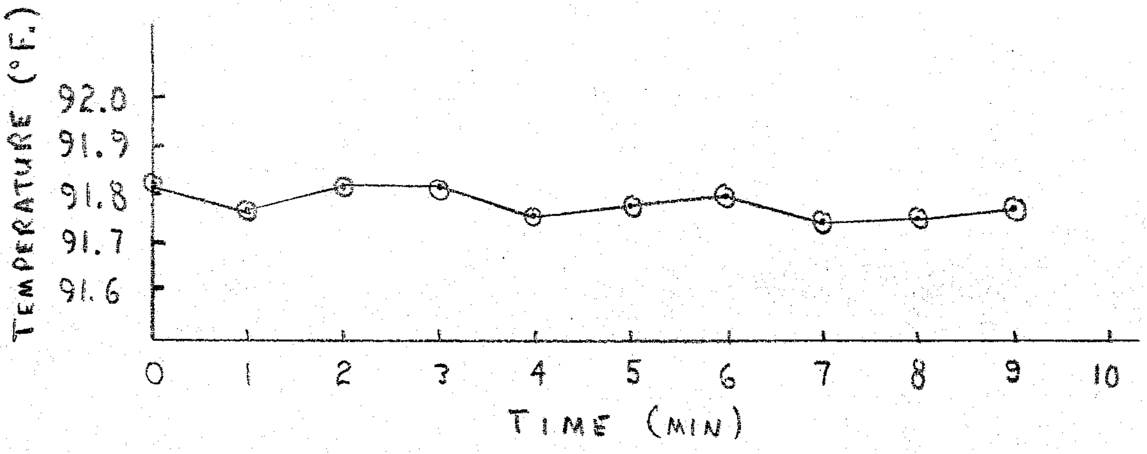


Figure 15. Time response of #6 probe at 3000 foot calibration point in water. Red Wash well. 7/11/77.

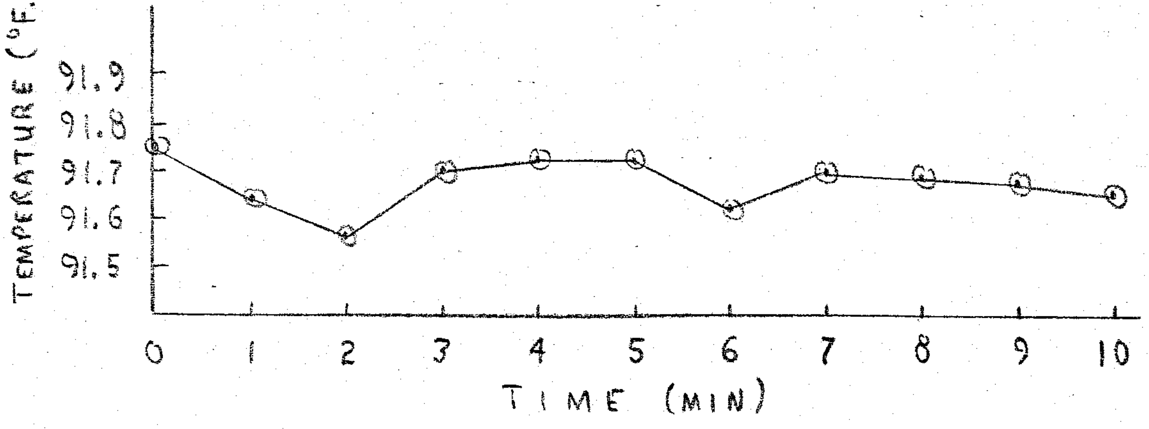


Figure 16. Time response of #6 probe at 3000 foot calibration point in water. Cache well. 7/14/77.

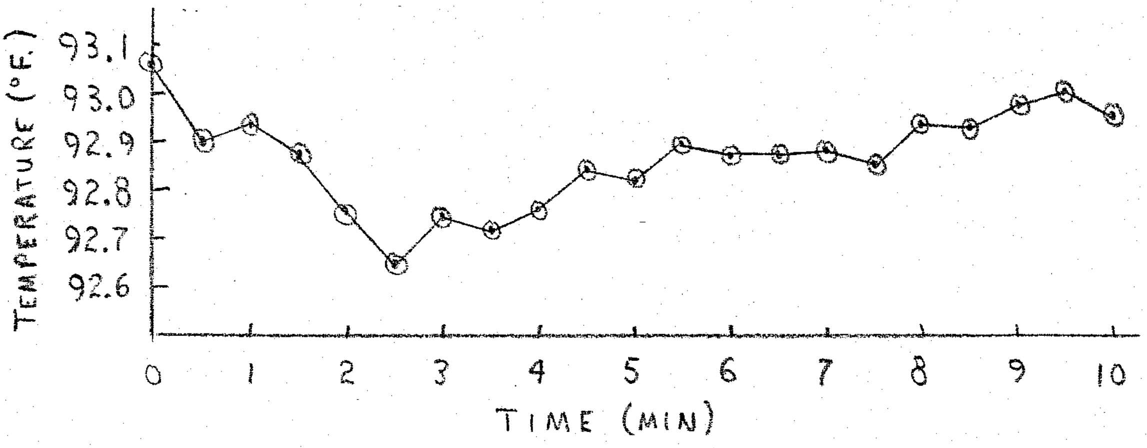


Table 7. Estimating temperature at calibration points by linear regression of continuous data. Red Wash 7/11/77 and Red Wash 7/12/77 data in air.

Cal Depth (ft)	TD Temp (°F)	Final Temp (°F)	Contin Temp (°F)	Est Temp (°F)
700	60.184	60.43	60.002	-
800	61.092	61.39	60.750	-
900	62.172	62.43	61.720	-
1000	63.374	63.71	62.900	-
1100	64.631	64.94	64.021	-
1200	65.887	66.30	65.326	-
1400	68.446	68.75	68.251	-
1500	69.680	69.99	69.143	-
1600	70.910	71.12	70.145	-
1700	72.167	72.39	71.247	-
1800	73.690	74.07	72.797	-
2000	76.650	77.10	76.970	76.983
2100	78.101	78.50	78.155	78.144
2200	79.446	79.75	79.291	79.300
2300	80.692	81.10	80.519	80.517

Table 7 (continued):

Cal Depth (ft)	Contin vs TD (%)	Contin vs Final (%)	Est vs TD (%)	Est vs Final (%)	Est vs Contin (%)
700	-0.302	-0.71	-	-	-
800	-0.560	-1.04	-	-	-
900	-0.727	-1.14	-	-	-
1000	-0.748	-1.27	-	-	-
1100	-0.944	-1.42	-	-	-
1200	-0.851	-1.47	-	-	-
1400	-0.285	-0.73	-	-	-
1500	-0.771	-1.21	-	-	-
1600	-1.079	-1.37	-	-	-
1700	-1.275	-1.58	-	-	-
1800	-1.212	-1.72	-	-	-
2000	+0.417	-0.17	+0.434	-0.15	+0.017
2100	+0.069	-0.44	+0.055	-0.45	-0.014
2200	-0.195	-0.58	-0.184	-0.56	+0.011
2300	-0.214	-0.72	-0.217	-0.72	-0.002
Ave:	-0.533	-0.95	+0.022	-0.47	+0.003

Table 8. Time response of #4 probe at 120 foot calibration point in air. Datil well. 6/29/77.

Time (min)	Temperature (°F)
0	58.35
1	58.45
2	58.50
3	58.56
4	58.64
5	58.69
6	58.71
7	58.72
8	58.73
9	58.76
10	58.76
11	58.79
12	58.84
13	58.88
14	58.91
15	58.95

Table 9. Time response of #6 probe at 1100 foot calibration point in air. Red Wash well. 7/11/77.

Time (min)	Temperature (°F)
0	64.65
3	64.60
6	64.73
9	64.81
12	64.88
15	64.94

Table 10. Time response of #6 probe at 900 foot calibration point in air. Cache well. 7/14/77.

Time (min)	Temperature (°F)
0	66.51
1	66.40
2	66.34
3	66.37
4	66.41
5	66.48
6	66.51
7	66.56
8	66.60
9	66.66
11	66.76
12	66.80
13	66.84
14	66.88

Figure 17. Time response of #4 probe at 120 foot calibration point in air. Datil well. 6/29/77.

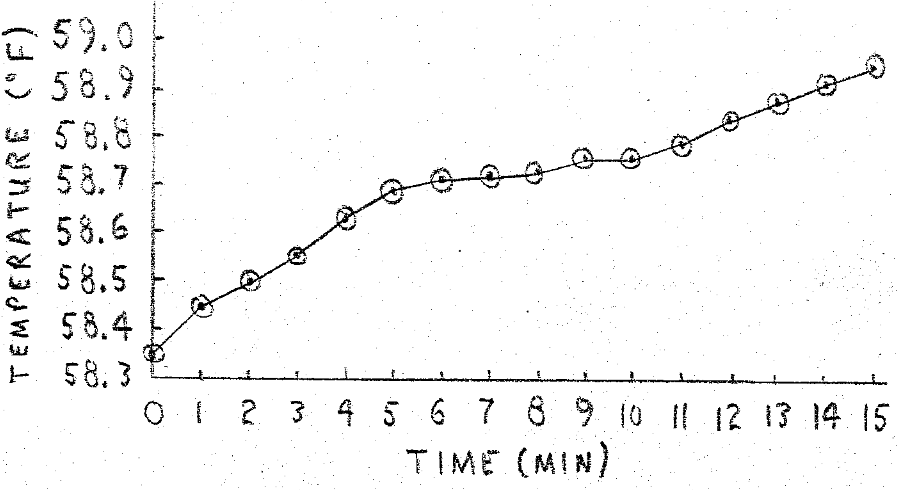


Figure 18. Time response of #6 probe at 1100 foot calibration point in air. Red Wash well. 7/11/77.

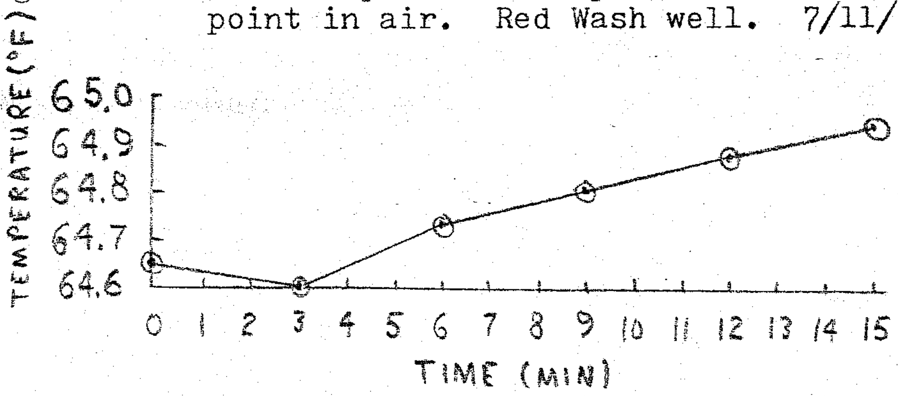


Figure 19. Time response of #6 probe at 900 foot calibration point in air. Cache well. 7/14/77.

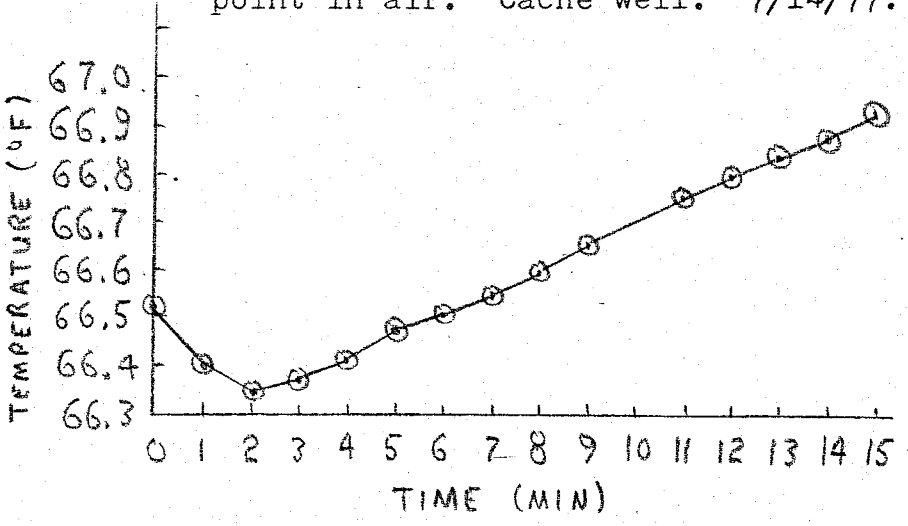


Figure 20. Equilibrium final temperature minus continuous temperature vs depth. Red Wash well. 7/11/77 and 7/12/77.

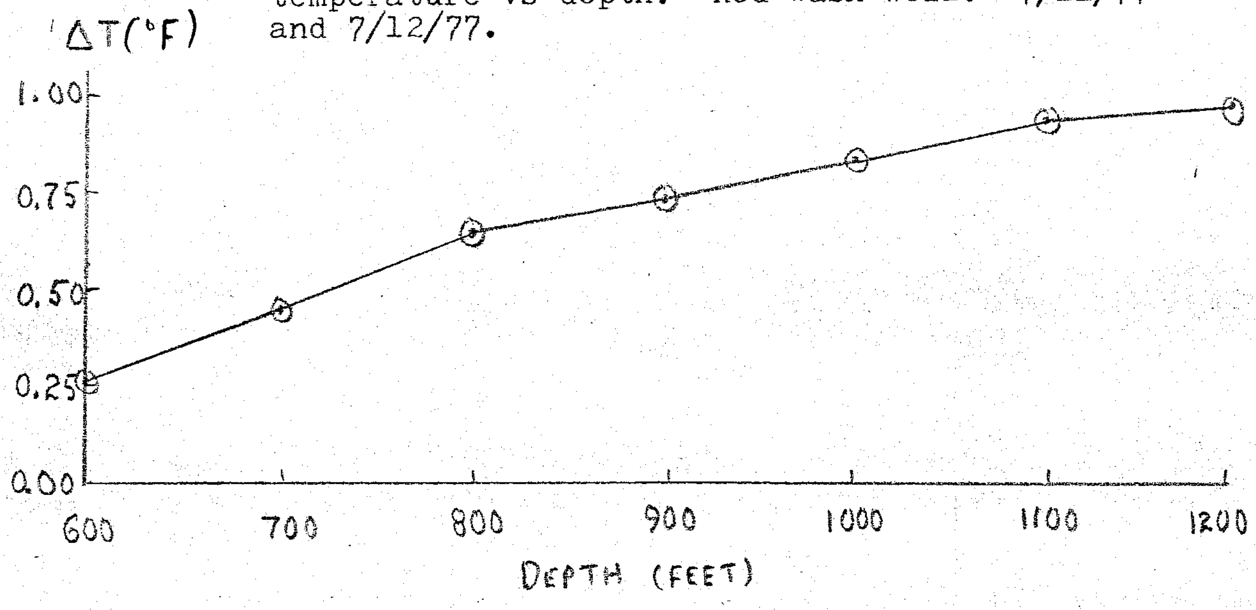
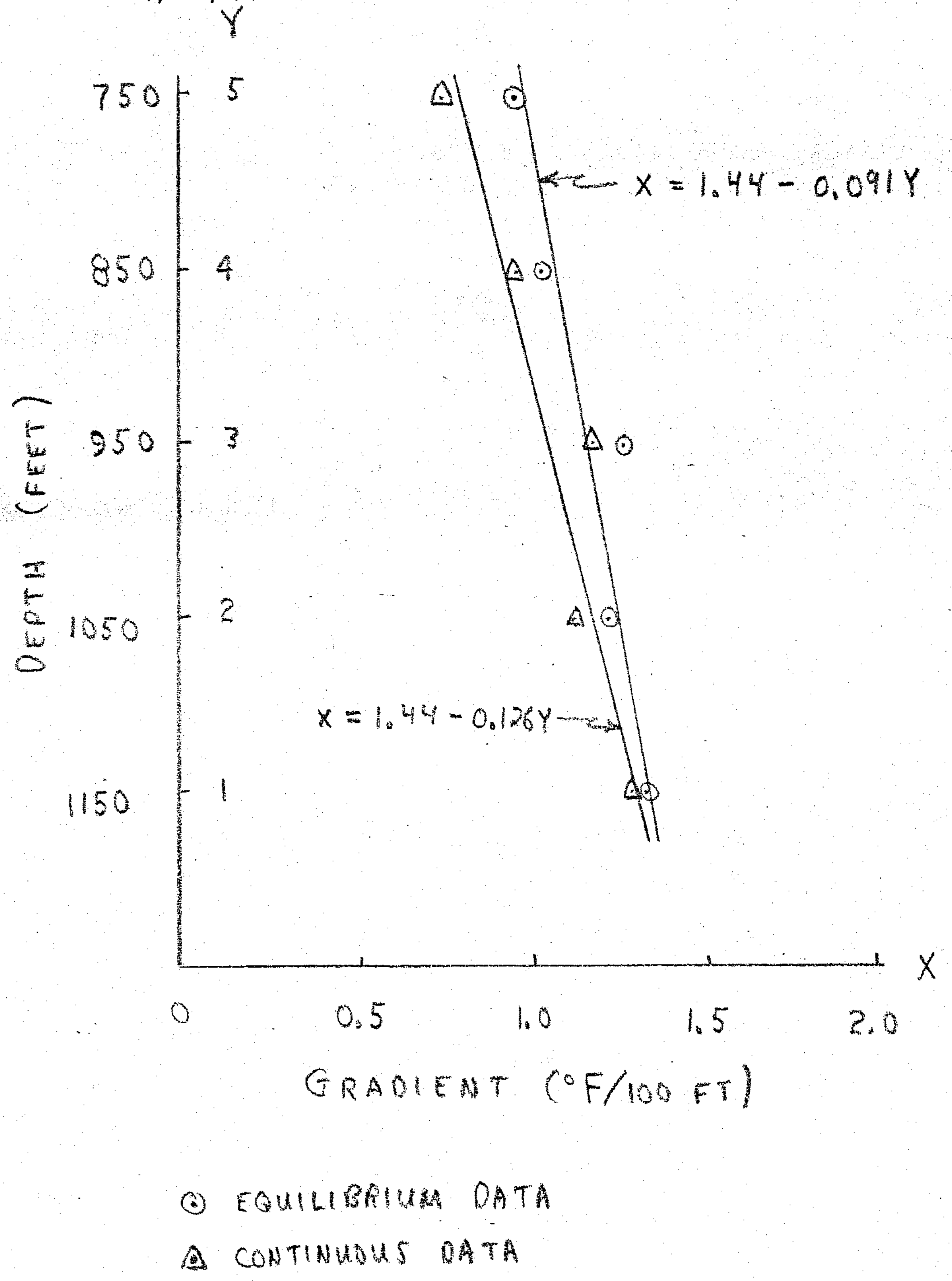


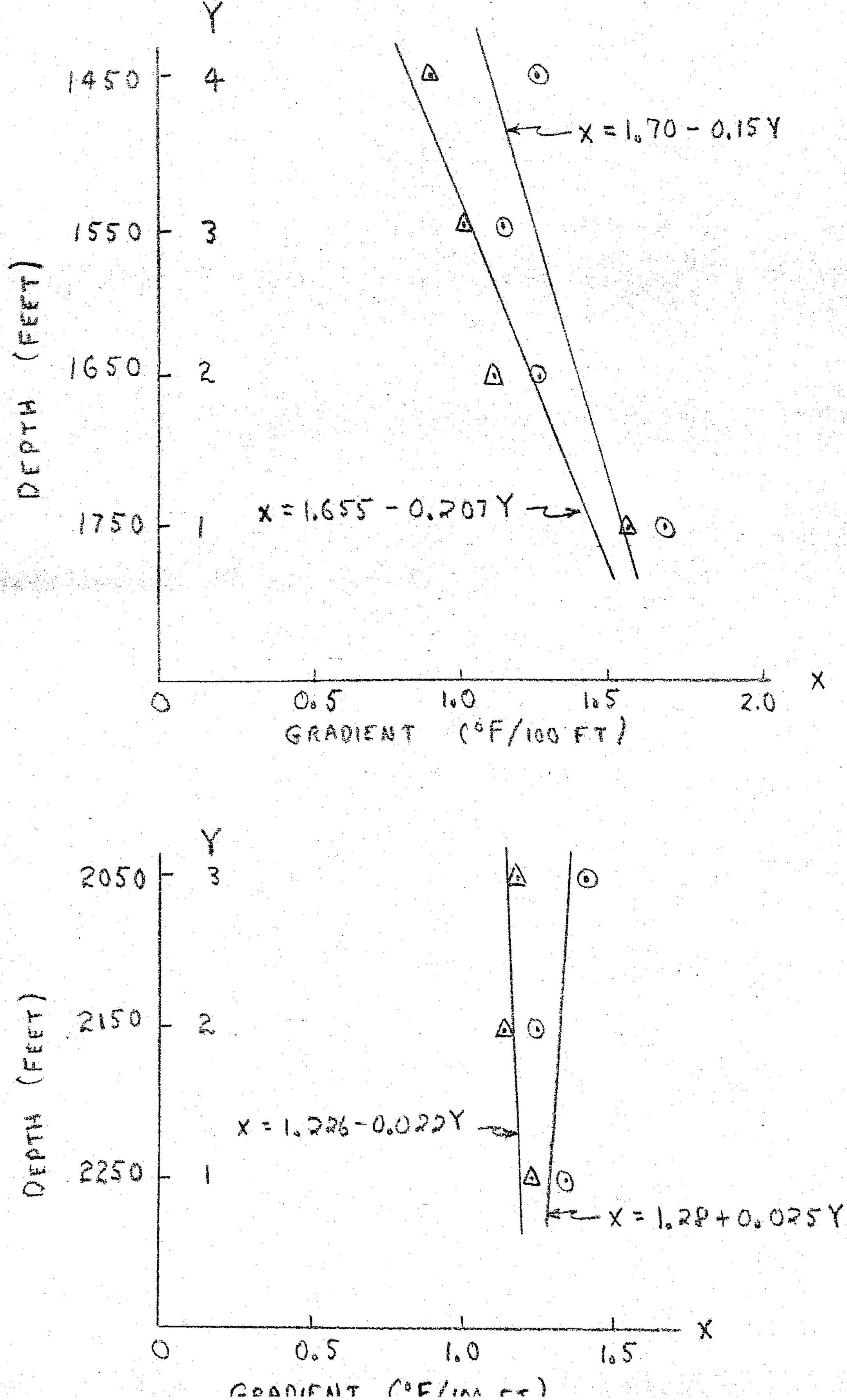
Table 11. Comparison of equilibrium gradient and continuous gradient in air. Red Wash well. 7/11/77 and 7/12/77.

Depth (ft)	Continuous Temp Grad (°F/100 ft)	Equilib Final Temp Grad (°F/100 ft)
700	0.7480	0.960
800	0.9700	1.040
900	1.180	1.280
1000	1.121	1.230
1100	1.305	1.320
1200		
Ave:	1.065	1.166
1400	0.892	1.24
1500	1.002	1.13
1600	1.102	1.27
1700	1.550	1.68
1800		
Ave:	1.136	1.33
2000	1.185	1.40
2100	1.136	1.25
2200	1.228	1.35
2300		
Ave:	1.183	1.33

Figure 21. Comparison of equilibrium gradient and continuous gradient in air. Red Wash well. 7/11/77 and 7/12/77.



Figures 22 & 23. Comparison of equilibrium gradient and continuous gradient in air. Red Wash.



RESULTS AND CONCLUSIONS

Water Level Determination

Continuous Mode. The water level is indicated for the Datil, Red Wash, and Cache wells on Figures 2, 5, and 13, respectively. The water level is apparent on a depth vs. temperature plot as a region of very gentle negative slope. This region represents a relatively large increase in probe temperature over a relatively small depth interval, which is interpreted by the computer program as a large temperature gradient. Thus, the water level may also be determined from the tabulations of temperature gradient. The water levels in the Datil, Red Wash, and Cache wells appear to be at 190 feet, 2820 feet, and 1630 feet, respectively. The temperature gradients for the Datil, Red Wash, and Cache wells at those depths are 281 °C/km, 291°C/km, and 213°C/km, respectively. The water level at the Red Wash well was verified by "shooting" the well.

It might be concluded from these data that the water level will be associated with an apparent temperature gradient of about 200°C/km to 300°C/km. This sudden gradient increase represents, of course, an artifact of the probe response rather than the actual temperature gradient in the well. If the probe temperature is considered to lag the well temperature when moving downhole at sixty ft/min in air but to quickly attain thermal equilibrium with the well in water, then a sudden transition in downhole environment from air to water would explain the observed gradient at the transition level.

Equilibrium Mode. The water level was observed at depths traversed in a continuous logging mode. A large temperature gradient also appears, however, at the calibration points that occur in air in the equilibrium mode, as seen in Figures 5 and 13. Similar gradient anomalies are not observed at the calibration points that occur in water, as may be noted in Figures 2, 5, and 13. These observations may indicate, on the one hand, that the probe is in thermal equilibrium with the well when traveling downhole at sixty ft/min in water. The probe absorbs very little additional heat from the well during the stationary calibration interval, thereby resuming its downhole travel after calibration without introducing a temperature increment that is due to its response time. On the other hand, the probe does not appear to be in thermal equilibrium with the well when traveling downhole at sixty ft/min in air. During the stationary calibration interval, the probe apparently continues to absorb heat from the well, thereby introducing a temperature increment in the first continuous reading following calibration. The large temperature gradient observed in air at a calibration point in the equilibrium mode, then, is due to the time constant of the probe rather than an actual gradient increase and does not indicate water level.

Water Data

TD Temperature vs. Final Temperature. Table 1 represents data compiled in an effort to evaluate the equilibrium method of logging in water. By comparing the equilibrium data below the water level in the three wells, the following results were obtained: (1) The TD temperature was found to be 0.06% greater than the average temperature of the calibration period. (2) The TD temperature was found to be 0.02% greater than the final temperature of the calibration period. It may be concluded from these data that, in water, (a) the probe tends to cool slightly during the calibration period, and (b) the TD temperature may be used as a close approximation to the equilibrium temperature.

TD Temperature vs. Continuous Temperature. Table 2 represents a comparison between the equilibrium and the continuous methods of temperature logging. An "estimated temperature" was calculated at a given calibration depth in water for the Datil well by applying linear regression to the two adjacent depths both above and below the calibration depth. Averaging the results of the comparisons, it was found that (1) the temperature at the calibration depth in the continuous mode was 0.033% higher than the TD temperature at that depth, also (2) the estimated temperature at the calibration depth was 0.051% higher than the TD temperature at that depth, and finally (3) the estimated temperature at the calibration depth was 0.018% higher than the temperature observed at that depth in the continuous mode. These results seem to support the following conclusions: (a) A continuous temperature log in water may be expected to yield results that are about 0.03% higher than the TD temperatures of an equilibrium log, which, in turn, are 0.02% higher than the equilibrium temperatures. (b) The TD temperatures of an equilibrium log may be predicted approximately from a continuous log.

Plot Comparison: Continuous vs. Equilibrium Logs. Figure 3 represents an equilibrium log of the Datil well from 1020 feet to 2000 feet with an interval of 200 feet. It may be noted that readings were also taken within this interval every ten feet in a continuous logging mode. Figure 4 represents a continuous log of the same section of the well taken about twenty-four hours later. By superimposing the two plots, it may be seen that the curves very nearly coincide. Thus, a graphical verification of the conclusion suggested by Table 2 has been obtained. That is, a continuous temperature log in water very closely approximates an equilibrium temperature log that is based on TD temperatures in water.

Probe Response. The above conclusion may be considered in terms of probe response by examining Tables 3, 4, and 5 and associated Figures 14, 15, and 16, respectively. These three sets of data show the time response of the probe at a stationary calibration point below the water level at around 92°F. in the three wells. Each plot displays a TD temperature that is slightly higher than the final temperature. This initial and final temperature difference was seen in the data of Table 1. Each plot displays a non-monotonic curve which is initially downward-going. That is, the curve represents an oscillation in temperature over a time interval. The above-mentioned two features were observed in nearly all plots of probe response in water for the three wells. It may be concluded that an initially downward-going oscillating response and a final temperature that approaches but does not attain the TD temperature in a ten-minute time interval are very likely to be associated with a downhole water environment. Further, this characteristic response of the probe in water would seem to strongly indicate that the probe is very nearly in thermal equilibrium with the downhole environment at touchdown. This would imply that the probe is in thermal equilibrium as it is traveling downhole, assuming the rate of travel to be no greater than the sixty ft/min rate as used in acquiring the data presented in this paper.

The data that has been considered up to this point has been taken from below the water level and subjected to examination in terms of (a) TD temperature vs. final temperature, (b) TD temperature vs. continuous temperature, and (c) probe response. These same considerations will next be applied to the data that were obtained above the water level, that is, in the air column.

Air Data

TD Temperature vs. Final Temperature. Table 6 represents a means of evaluating the equilibrium temperature logging method in air. It was found that the average TD temperatures for the Red Wash well were 0.46% lower than the final temperature and 0.22% lower than the average temperatures. It was also determined that the average TD temperatures for the Cache well, for which there were only three useable calibration points in air, were 0.80% lower than the final temperatures and 0.40% lower than the average temperatures. These data might be explained by the concept of a probe which continues to absorb heat from the well during the calibration interval. It may therefore be concluded that the probe was not in thermal equilibrium with the well in an air column at touchdown. The average temperature appears to be about midway between the TD temperature and the final temperature for both wells. This may indicate that the probe was experiencing a linear increase in temperature during the fifteen-minute calibration interval. It may also be concluded that the probe had not attained thermal equilibrium at the end of the fifteen-minute calibration interval.

<u>TD Temperature vs. Continuous Temperature</u>. Table 7 represents a comparison between the equilibrium and continuous methods of temperature logging in air. An "estimated temperature" was calculated only for those calibration depths that corresponded to depths at which the continuous logging interval was ten feet. Since data above 2000 feet was taken at twenty-five foot intervals, which would seem to reduce the meaning of predicted temperatures based on linear regression to such widely spaced points, predicted (or estimated) temperatures occur in the table only below 1800 feet. It was found that the continuous temperature was about 0.5% lower than the TD temperature and about 1.0% lower than the final temperature. It would not seem to be appropriate to draw conclusions based on these particular

observations, however, because the equilibrium temperatures obtained at the calibration depths of the two successive logging days do not coincide. For example, at 600 feet on the first day at Red Wash, a final temperature of 59.72°F was recorded while at the same depth on the second day, a final temperature of 59.45°F was attained. In contrast to this situation, the data recorded below the water level at Red Wash show a temperature of 91.70°F after seven minutes at 3000 feet on the first day and a temperature of 91.69°F after seven minutes at 3000 feet on the second day. Therefore, a comparison between the continuous data of the second day and equilibrium data of the first day in terms of absolute temperatures was found to be possible only in water.

<u>Plot Comparison: Continuous vs. Equilibrium Logs</u>. The same problem in comparing the continuous data with the equilibrium data in air may be observed graphically by considering the Red Wash data plots through three sections of the air column. Figure 7 is an equilibrium log from 625 feet to 1300 feet. Figure 8 is a continuous log through the same section. Comparison of these two plots by superposition is not meaningful because the horizontal scales represent different total temperature intervals while the vertical scales represent equal depth intervals. That is, the initial reading on the first day was 59.75°F. The final reading was 67.24°F, resulting in a total temperature interval of 7.49°F. The initial reading on the second day was 59.57°F. The final reading was 66.54°F, resulting in a total temperature interval for the second day of 6.97°F.

The vertical scales on both plots, however, represent total depth intervals of 675 feet. It is therefore not meaningful to superimpose the two plots in an attempt to compare the continuous data with the equilibrium data. Figures 9 and 10 are equilibrium and continuous logs, respectively, from 1325 feet to 1900 feet. Comparison between the two plots of the continuous and equilibrium data is not appropriate for the reasons mentioned above. Figures 11 and 12 are equilibrium and continuous logs, respectively, from 1910 feet to 3000 feet. Again, plot comparisons are not meaningful in this case for reasons indicated above. It may be concluded that it is not possible to evaluate the continuous method of temperature logging relative to the equilibrium method in air based on the TD temperature data vs. continuous temperature data as presented in Table 7 and in Figures 7 through 12.

Probe Response. It may be possible to relate the time response of the probe in air to the above-mentioned difficulty of obtaining compatible data on separate logging days. Tables 8, 9, and 10 and associated Figures 17, 18, and 19 represent the time response of the probe in air in the three wells. These three particular response curves were selected as being characteristic of the response curves of each of the three wells. Figure 17 shows a monotonic increase in temperature from the TD temperature at a generally decreasing rate. The difference between final and TD temperature over a fifteen-minute interval was 0.60°F. Figure 18 shows an initial three-minute cooling trend followed by a monotonic increase in temperature at a generally decreasing rate.

The initial cooling trend in air was generally observed only at calibration depths below 700 feet in the Red Wash well. The difference between final and TD temperature over a fifteen-minute interval was 0.29°F. Figure 19 shows an initial two-minute cooling trend followed by a nearly linear increase in temperature. The initial cooling trend in air was observed only at calibration depths below 400 feet in the Cache well. The difference between final and TD temperature over a fifteen-minute interval was 0.42°F. Thus, the monotonically increasing response curve seems to be characteristic of the probe response in air. The initial cooling trend appears to be depth-dependent. It may also be concluded from these data that the probe is not in thermal equilibrium with the well in air at touchdown. Furthermore, it is not in thermal equilibrium with the well after fifteen minutes at a calibration depth. The problem of obtaining compatible data in air on successive logging days in the same well, then, seems to be related to the problem of achieving thermal equilibrium at a given calibration depth.

Offset between Continuous and Equilibrium Temperatures. The problem of comparing the continuous logging method to the equilibrium logging method in air may be approached in terms of temperature differences instead of absolute temperatures. Figure 20 is a plot of the difference between the equilibrium final temperature and the continuous temperature vs. depth for the upper part of the air column of the Red Wash well. The difference between the two temperatures is observed to increase with depth at a decreasing rate. While the plot does not appear to provide conclusive evidence, it does suggest perhaps the possibility that a constant difference is eventually attained between the continuous and equilibrium temperatures.

Temperature Gradients. The above possibility may be pursued in terms of the temperature gradients observed with the two logging methods. If the gradient obtained using the continuous method approaches and becomes equal to the gradient observed using the equilibrium method, then a constant temperature offset results. Table 11 represents gradients calculated for the two methods through three air sections of the Red Wash well. Figures 21, 22, and 23 are plots of these data showing the regression lines of X on Y and their slopes. It may be observed from these data that (1) the gradient of the continuous log is generally less than the gradient of the equilibrium log, (2) the gradients generally tend to increase with depth within each section and across sections, (3) the gradient obtained in the continuous mode increases with depth at a higher rate than the equilibrium gradient, and (4) the gradients obtained by the two methods approach a common gradient value. Observation #1 might be explained by considering that, between two given calibration depths, the probe in the equilibrium mode undergoes a component of temperature increase which the probe in continuous mode does not experience. That is, in equilibrium mode a temperature increment occurs between the touchdown temperature and the final temperature which is nonexistent in the continuous mode. Observation #2 may provide evidence for a geothermal gradient at Red Wash that increases moderately from 700 feet to 1200 feet, continues to increase but at a higher rate from 1400 feet to 1800 feet, then remains at a nearly constant value from 2000 feet to 2300 feet. Observation #3 is equivalent to noting that the change between successive temperature increments for the continuous mode is greater than it is for the equilibrium mode. This might be explained in terms of an equilibrium time response which is superimposed upon the dynamic response of the probe as it is traveling downhole. The data under consideration here, however, do not provide sufficient evidence to support such a mechanism. Observation #4 is a direct result of observation #3. Extrapolation of the converging curves to a common gradient raises the question of whether the curves subsequently diverge or proceed with a common slope. It may be concluded from the preceding four observations that the gradient data presented here is insufficient for purposes of evaluating continuous temperature data with respect to equilibrium temperature data in air.

DISCUSSION

<u>Water Level</u>. A second method of determining water level may be briefly mentioned here. As a means of verifying the water level obtained in a downhole mode, the uphole temperature data may be examined for a temperature reversal. This refers to a short heating trend that occurs within the overall cooling trend of the uphole data and may be considered

to be a direct result of the change in the thermal properties of the media surrounding the probe. Thus, as the probe leaves the water, its thermal inertia causes it to heat slightly as its rate of cooling suddenly acquires a reduced value in air.

Downhole temperature reversals were noted in the Red Wash (Figure 6) and Cache wells (Figure 13) immediately above the water level. The reversal was not obtained, however, on successive days in the Red Wash well (Figures 11 and 12). The relation, if any, of the reversal to the water level therefore remains questionable although it may merit further investigation over a broader data base.

Water Data. The data obtained in water appears to be fairly conclusive with respect to an evaluation of the continuous logging mode vs. the equilibrium logging mode. The continuous logging method may be considered to provide results that are no greater than 0.03% of the TD temperatures obtained in the equilibrium mode in water. Considering that the continuous method is a more efficient logging technique in terms of logging time, it is to be preferred over the equilibrium method.

The primary source of error that is unique to the continuous mode lies in the operator error associated with activating the temperature recording device at the proper depth interval. If this error is ± 1 foot, then an error of ± 0.01 °F is possible. This source of error may be practically eliminated, however, by automating the triggering process.

Air Data. The data obtained in air does not provide conclusive evidence for interpreting and evaluating the continuous logging mode. One difficulty with this lies in the incompatibility of data for successive days of logging. The reason for the non-coincidence of temperatures at calibration depths between days may be related to the ease with which an air column may be disturbed by the logging process. Further study of this aspect of the problem, perhaps in terms of convection cells in air, would seem to be quite complex and theoretical.

A possibly promising approach to interpreting temperature data in air may lie in further study of the time response of the probe. Data was obtained in the present study for the Red Wash well which indicated that the temperature continued to increase, after an initial thirty-second cooling period, as long as thirty-nine minutes after touchdown at 1300 feet. It may be useful to extend the time interval at the calibration depths sufficiently to observe the complete response of the probe. Alternatively, a time constant for the probe might be experimentally determined by observing the time response of the probe to a step function of temperature in the laboratory. A knowledge of the probe response may provide a means of interpreting a continuous temperature log in air by using a deconvolution process of extracting the actual downhole temperature data from the observed data.

Subtle difficulties may be involved in determining the response characteristic of the probe in air. It is conceivable that the temperature vs. time curve may not approach an asymptotic value but continue to absorb heat from nearby sources such as the lead weights that are mounted above the probe on the cable. Another such difficulty may be indicated by existing probe response data in air for the wells mentioned in this paper and for other wells. That is, the probe response in air may be dependent upon well geometry factors, including the effects of casing, tubing, and well-bore diameter. Further consideration must be given to these factors if the interpretation of either continuous or equilibrium temperature logging data in air for a given well is to be possible.

The most promising approach to interpreting temperature data in air would seem to be that involving temperature gradients rather than absolute temperatures. If the continuous gradient approaches the value of the equilibrium gradient in air, as evidence presented in this paper seems to indicate, then the equilibrium log may be related to the continuous log and the true gradient may be determined from either one. The longest section through which the two logs may be compared using the present data is 500 feet. The section is too short to provide sufficient evidence for equal gradients, indicating the need for further data in air through a longer depth interval.