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STABILITY OF SOME EPOXY-ENCAPSULATED DIODE THERMOMETERS

B. W. Mangum and G. A. Evans, Jr.

U.S. DEPARTMENT OF COMMERCE
National Bureau of Standards
Gaithersburg, Maryland

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National Aeronautics and
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Langley Research Center
Hampton, Virginia 23665

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Temperature and Pressure Division
Gaithersburg, MD 20899

February 1986

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Langley Research Center
Hampton, VA 23665-5225

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OBJECTIVE

The objective of this project was the evaluation of the stability upon thermal cycling and handling of ten small, epoxy-encapsulated silicon diode thermometers (Model DT-500FP-HRC-7 from Lake Shore Cryotronics, Inc.)* at six temperatures in the range from liquid nitrogen temperatures to about 60 °C . The nominal temperatures of measurement were - 196 °C, -78 °C, 0 °C, 20 °C, 40 °C, and 60 °C, as measured on the International Practical Temperature Scale of 1968. Diodes were to be thermally cycled 15 to 20 times. Since NASA anticipates that the uncertainty in their temperature measurements will be ± 50 mK, uncertainties as large as ± 10 mK in the measurements of our evaluation can be accommodated without deleteriously affecting the value of the results of the investigation.

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*Certain commercial equipment, instruments, or materials are identified in this paper in order to adequately specify the experimental procedure. Such identification does not imply recommendation or endorsement by the National Bureau of Standards, nor does it imply that the materials or equipment identified are necessarily the best available for the purpose.

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STABILITY OF SOME EPOXY-ENCAPSULATED DIODE THERMOMETERS

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ABSTRACT

An investigation of the stability of 10 silicon diode thermometers upon normal handling and upon thermal cycling between liquid nitrogen temperatures and 60 °C was conducted. The diodes underwent 28 thermal cycles and during that time, only one experienced instabilities equivalent to as small as ± 0.045 K. The other nine diodes had instabilities which ranged from about ± 0.09 K to ± 0.20 K.

INTRODUCTION

The surface temperature of airfoils must be known accurately in order to properly investigate and evaluate aircraft designs. Models are usually tested in a facility such as the National Transonic Facility located at the Langley Research Center of NASA, in which cold nitrogen gas is used as the fluid. The surface temperatures of interest are usually in the range from about 77 K to

325 K. In order to accurately measure the surface temperatures of the airfoils, adequately characterized thermometers must be employed. The types of thermometers available for such measurements are limited; they must be small, rugged, sensitive, stable, and respond rapidly. One thermometer that might possibly meet these requirements is the silicon diode thermometer.

The objective of this project was to determine the stability upon thermal cycling and handling of ten small, epoxy-encapsulated silicon diode thermometers at six temperatures in the range from liquid nitrogen temperatures to about 60 °C. The nominal temperatures of measurement were -196 °C, -78 °C, 0 °C, 20 °C, 40 °C, and 60 °C.

EXPERIMENTAL DETAILS

Equipment Used In Investigation

thermometry

The temperatures at which tests were conducted were measured with a long-stem standard platinum resistance thermometer (SPRT) [1] which had been calibrated at the National Bureau of Standards in the Platinum Resistance Thermometer Calibration Laboratory. The resistances of the SPRT were measured with a Neil Brown Instrument systems, Inc. automatic ac resistance bridge* [2] that has a resolution of 0.1 mK.

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temperature-regulated environments

The thermal environments of the diodes were provided by different methods, depending on the temperature of measurement. For all cases, except at liquid nitrogen temperatures, the diodes were immersed in a low-viscosity silicone oil during measurements. At liquid nitrogen temperatures, the diodes were immersed directly in the liquid nitrogen. During measurements at each of the temperatures, the SPRT was located in the fluid with, and encircled by, the 10 diodes under test.

At - 78 °C, the refrigerant was solid CO_2 in alcohol. During the measurements at this temperature, the diodes and the SPRT were immersed in the low-viscosity silicone oil in a brass cylinder that was surrounded by the refrigerant. The silicone oil was stirred by means of a magnetic stirrer which was well removed from the diodes.

At 0 °C, an experimental arrangement similar to that used at -78 °C was employed, except that the refrigerant in this case was ice.

During measurements at the three temperatures just discussed, the temperatures were not regulated with a temperature controller but, nevertheless, they were constant to within 2 or 3 mK.

At temperatures above 0 °C, the thermal environments were provided by a Rosemount Inc. oil bath, in which the temperatures were regulated with a Tronac, Inc. Temperature Controller. The temperatures were constant to 1 or 2 mK over the time of the measurements.

voltage measurements

A Cryocal, Inc. constant current source, Model CS 1000B, was used to supply the 10 uA current required by the diodes. This unit provided a current with an instability of at most 10 ppm. The voltages across the diodes were measured with an HP 3456A Digital Voltmeter (DVM). A scanner, HP Model 3495A, was used for switching the appropriate potential leads of the diodes to the DVM. Similar but upgraded versions of these latter two instruments were purchased to be incorporated by NASA personnel in an automated system at NASA. Those instruments purchased are listed in Table 1. The measurements which we conducted on the diodes were automated to a great extent.

The current that passed through the diode thermometers was monitored by measuring the voltage across an ESI standard resistor, Model SR104, that was connected in series with the diodes. The SR104 is a transportable 10,000 ohm standard resistor with a small but known temperature dependence. The voltages across the SR104 were measured with the DVM.

diodes

The diodes investigated were those specified by NASA, and are listed in Table 2. In our measurements, the 10 silicon diodes were wired as 4-lead devices. They were connected in series with each other and with the constant current source. The potential leads of each diode were connected to the DVM through the scanner. Two of the diode thermometers were calibrated by the supplier prior to delivery (see Table 2).

Experimental Arrangement

Since the small silicon diode thermometers that we investigated for stability upon thermal cycling and normal handling were tested over the range from liquid nitrogen temperatures to 60 °C, different techniques were used above and at or below 0 °C. For testing at liquid nitrogen temperatures, the 10 diodes were inserted into small wells of a 2-cm deep wooden ring which was attached by means of three small thin-walled stainless steel tubes to a top Dewar-cap assembly. For solid CO_2 temperatures and at 0 °C, an assembly similar to that used at liquid nitrogen temperatures was used except that the bottom ring was lucite instead of wood and, additionally, the diodes extended through the ring by about 2 cm. These support systems were fitted into either Dewars or other containers which contained either liquid nitrogen or a low-viscosity silicone oil during tests. In order to avoid large thermal shocks, the diode assembly was inserted slowly into the relevant fluid. In the case of liquid nitrogen, the wooden holder also aided in slowing the cooling of the diodes.

For tests above 0 °C, the diodes were held in position in the oil bath by a thin ring of lucite through which small holes had been drilled to accommodate the diodes. The diodes were located such that they extended about 3 cm below the lucite ring.

During measurements above, at, and below 0 °C, the SPRT was located such that the platinum sensing element was at or near the same vertical position as the diodes and along the axis of the wooden or plastic rings. Although the fluid baths, with the exception of the liquid nitrogen bath, were stirred and, thus, were uniform in temperature within 1 to 3 mK throughout the baths, this

arrangement of SPRT and diodes further ensured that the temperature measured with the SPRT was very nearly the same as that experienced by the diodes.

Experimental Procedure

The thermal cycling of the diodes was performed by cooling them to liquid nitrogen temperatures and then making measurements on them; removing the diodes from liquid nitrogen, blowing room-temperature air over them to warm them to room temperature and remove any moisture present, placing them in the lucite holder, inserting them into room-temperature oil followed by inserting them in an oil bath at solid CO_2 temperatures and making measurments on them; removing the diodes from the oil at solid CO_2 temperatures, blowing room-temperature air over them to warm them to room-temperature and remove any moisture present, inserting them in room-temperature oil, then inserting them in an oil bath at the ice point and making measurements on them; removing the diodes from the oil at the ice point, placing them in the holder for use in the temperature-regulated oil bath, placing them in an oil bath at 20 ^{o}C and making measurements on them; and then heating the temperature-regulated oil bath containing the diodes first to 40 ^{o}C and then to 60 ^{o}C and making measurements respectively at those temperatures. When measurements at 60 ^{o}C were completed, the diodes were removed from the oil bath and left at room temperature overnight, ready to repeat the process the next day. Each experiment with the diodes experiencing temperature changes as just described, i.e., from room temperature to liquid nitrogen temperature to room temperature to solid CO_2 temperature to room temperature to the ice point temperature to

room temperature to 20 °C to 40 °C and to 60 °C, constituted one thermal cycle. A given thermal cycle was conducted over a period of one day and it required a full day of work.

RESULTS AND DISCUSSION

We encountered numerous measurement problems during the first several thermal cycles. These were related to earth loops and pick-up. Although one never totally eliminates such problems with diodes since they are rectifiers, the problems can be and were reduced to manageable levels. In our case, after the appropriate shielding and grounding, those problems accounted for changes amounting to the equivalent of only a few mK ($\pm$ 5 mK, maximum). We found that it was necessary to use shielded cables exclusively and to ground all of the equipment involved in the measurements at one point only. It is desirable to shield the leads to the diode thermometers over their entire length, but that is not generally practicable, however, if the diodes are to be used as thermometers. They can be shielded, however, over most of their length and, in our case, the unshielded portions were located inside the fairly-well-enclosed thermal environment. In this investigation, some 11 thermal cycles were performed before we were sufficiently satisfied that our reduction of these sources of uncertainty was adequate. We then obtained stability data for 17 thermal cycles, labelled cycles 12 through 28.

Data obtained for the 10 diode thermometers during the thermal cycle experiments numbered 12 through 28 are presented in Table A1 in the appendix. Although the temperatures in the liquid nitrogen, solid CO_2 and the ice point

baths were uniform and stable to within 2 or 3 mK during any given experiment, there were larger variations from day to day. These were due to various causes, one of which was changes in atmospheric pressure. Such variations were not present in the temperature-regulated oil bath used at the higher temperatures. Consequently, the data obtained at 20 °C, 40 °C and 60 °C on different days for each diode thermometer may be compared directly without having to make any corrections for small differences in bath temperature.

The results obtained for the 10 diode thermometers at 20 °C for thermal cycles 12 through 28 are presented in Figures 1-10; those obtained at 40 °C are presented in Figures 11-20; and those obtained at 60 °C are presented in Figures 21-30. The sensitivity of the diodes at these temperatures is approximately - 2.85 mV/K. Consequently, one can see that at 20 °C the total variation among the 10 diodes ranged from the equivalent of about 265 mK to 370 mK. The mean value was approximately 310 mK, or ± 0.155 K. Diode number 10 appears to be by far the most stable but there was one datum point, the point for thermal cycle number 25, which was very different from the other values and can probably be considered an outlier and thus can be ignored. Except for that point, the variation for diode number 10 is about ± 0.045 K.

The data obtained for the 10 diodes at 40 °C varied by the equivalent of from about 90 mK to 280 mK. The mean value was about 210 mK or ± 0.105 K. Diode number 10 was substantially more stable than the other diodes, its instability being ± 0.045 mK. The instabilities for the other nine diodes were clustered around the value ± 0.114 K, more than twice that for diode number 10.

The data obtained for the 10 diodes at 60 °C varied by the equivalent of from about 90 mK to 385 mK, with a mean value of about 300 mK or ± 0.150 K.

Except for diode thermometer number 10, all of the diodes behaved in a comparable manner, with their instabilities clustered around a value of about ± 0.16 K. Diode number 10 was consistently more stable than the other diodes and was more in line with what one would expect to obtain. Its instability was ± 0.045 K. Diodes numbered 9 and 10 were the ones which the supplier had calibrated prior to delivery.

Although we have not presented any graphs of data at temperatures below 20 °C, it can be seen from the data of Table A1 that instabilities at those temperatures are comparable to those discussed above.

As can be seen from the figures and as indicated above, the diodes exhibited substantially greater stability at 40 °C than they did at the other temperatures. The reason for this is not understood. The nonuniformity and instability of the temperature in the oil bath can not explain this behavior because there is essentially no difference in the quality of these features at 20 °C, 40 °C and 60 °C. Furthermore, even if the instability of the temperature-regulated oil bath were greater at 20 °C and 60 °C, the magnitude of the difference would be only a few millikelvins and, thus, could not account for the large differences observed for the diodes. Handling the diodes can't account for the differences in behavior at the different temperatures above 0 °C either since the diodes were not removed from the oil bath between measurements at those temperatures. Thermal shock can't account for the differences either since the diodes were not removed from the oil bath during the time the temperature of the bath was being changed from one temperature to the next and the amount of time required for the bath to come to a new (higher) test temperature and reach equilibrium was about one hour.

The calibration data provided by the supplier for diodes 9 and 10 are

given in Tables 3 and 4, respectively. These may be compared with the data obtained in our investigation. It appears that the calibration data for diode number 9 is not, in fact, for number 9 since the values given in the table are far different from those that we obtained. The calibration table for diode number 10 is probably for that diode but the calibration was really quite inaccurate.

CONCLUSIONS

The instabilities of the 10 small epoxy-encapsulated diode thermometers upon thermal cycling between liquid nitrogen temperatures and 60 ^{o}C and upon normal handling were considerably larger than we had anticipated. Based on conversations with suppliers, we had anticipated instabilities on the order of $\pm$ 10 mK. Our results indicate that the instabilites, in general, are some 10 to 20 times larger. In addition to the problems of instabilities, special care must be taken when using diode thermometers to reduce the possibility of pick-up. This latter problem can be reduced to manageable levels, however.

Diodes generally have been used at cryogenic temperatures and it may be that if they were mounted in a cryostat or on some massive support such that they would be cooled much more slowly than that accomplished in the experiments reported here, they might be considerably more stable than those observed in these experiments and they might live up to our previous expectations. In the experiments at NASA in which the use of diodes is contemplated, the rate of cooling of the thermometers would probably be much less than what we attained.

Silicon diode thermometers of a construction other than the small epoxy-encapsulated ones might be more stable. Those mounted in a BeO ceramic header set into a gold-plated copper cylinder with epoxy lead strain relief or those mounted in a TO-46 package might put less strain on the diode and its connections to the leads and thus yield greater stability. Diode thermometers of such construction should be tested and they should be tested by cycling to liquid helium temperatures. By such experiments, those diode thermometers which are unstable as a result of construction (contacts, etc.) should be quickly detected. It is recommended that an investigation of a selection of such diode thermometers from the various manufacturers be undertaken.

ACKNOWLEDGMENTS

Funding for this project was provided by the National Aeronautics and Space Administration, Langley Research Center, Hampton, VA 23665-5225.

REFERENCES

1. J. L. Riddle, G. T. Furukawa amd H. H. Plumb, Platinum Resistance Thermometry, Nat. Bur. Stand. (U.S.) Monogr. 126, 1973 (Superintendent of Documents, U.S. Government Printing Office, Washington, DC 20402).

2. N.L. Brown, A.J. Fougere, J.W. McLeod and R.J Robbins, An Automatic Resistance Thermometer Bridge, in Temperature, Its Meassurement and Control in Science and Industry, (American Institute of Physics, New York, 1982), Vol. 5, Part 2, pp. 719-727.

Table 1. Equipment purchased on project and delivered to NASA. The equipment was purchased from Hewlett-Packard Company.

Item	Quantity
Model 3457A Digital Multimeter	1
Option 909, Rack Flange and Front Handle Kit, for Model 3457A	1
Option 910, Service/Operating Manuals, for Model 3457A	1
Part No. HP 10833B, 2-Meter HP-IB Cable, for Model 3457A	1
Part No. 11002A, Test Leads, Dual Banana to Probe and Alligator, for Model 3457A	1
Model 3488A Switch/Control Unit	1
Option 010, 10-Channel Relay Multiplexer Module, for Model 3488A	4
Option 015, Breadbord Module, for Model 3488A	1
Option 908, Rack Flange Kit, for Model 3488A	1

Table 2. Silicon diode thermometers investigated for stability.

Company	Diode	Quantity
Lake Shore Cryotronics, Inc.	Model DT-500FP-HRC-7 uncalibrated Serial numbers (NBS #) D46442 (1), D46443 (2) D46444 (3), D46445 (4) D46449 (5), D46456 (8) D46554 (6), D46555 (7)	8
Lake Shore Cryotronics, Inc.	Model DT-500FP-HRC-7 calibrated, Type 77E (75-330 K) Serial Numbers (NBS #) D35367 (10), D36312 (9)	2

Table 3. Calibration table supplied by Lake Shore Cryotronics, Inc. for diode thermometer number 9.

CALIBRATION REPORT

LAKE SHORE CRYOTRONICS, INC.
64 E. Walnut St.
Westerville, Ohio USA

CERTIFICATE OF CALIBRATION

CALIBRATION REPORT NO. RUN829 -20

MODEL DT-500FP-HRC-7

SENSOR TYPE: SILICON DIODE SERIAL NO. D35367

This temperature sensor has been calibrated against standards maintained by Lake Shore Cryotronics, Inc.

All calibrations provided by Lake Shore are based on the 1976 Provisional 0.5K to 30K Temperature Scale (EPT-76) and the International Practical Temperature Scale of 1968 (IPTS-68) for temperatures above 30K. At lower temperatures (below 0.5K), a cerium magnesium nitrate magnetic thermometer has been used in conjunction with NBS superconducting fixed points SRM768 to generate a scale.

Each scale is currently maintained on a set of germanium or platinum resistance standards, as appropriate, which are routinely checked by intercomparison and periodically calibrated by the United States National Bureau of Standards or Great Britain's National Physical Laboratory.

Lake Shore's calibration facility and procedures for diode and resistance sensor calibrations above 1.2K are maintained traceable in accord with MIL STD 45662.

Date: JUN 21 1985

Calibrated by: J. K. Krause
Metrologist

Approved by: J. K. Krause
Senior Scientist

S.DT-500FP-HRC-7 D35367 10 UA RUN#27

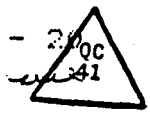
DEVICE NO. 20

	TEMP	WEIGHT	OUTPUT
51	65.1763	1.0	1.01678
52	70.2151	1.0	1.00472
53	75.1469	1.0	0.992685
54	80.2529	1.0	0.980023
55	85.3205	1.0	0.967276
56	90.2967	1.0	0.954613
57	95.3128	1.0	0.941741
58	100.235	1.0	0.929006
59	110.482	1.0	0.902249
60	120.468	1.0	0.875896
61	130.403	1.0	0.849419
62	140.641	1.0	0.821903
63	150.657	1.0	0.794745
64	160.651	1.0	0.767408
65	170.501	1.0	0.740290
66	180.906	1.0	0.711441
67	190.872	1.0	0.683647
68	200.836	1.0	0.655723
69	210.795	1.0	0.627793
70	220.873	1.0	0.599617
71	230.763	1.0	0.572311
72	240.884	1.0	0.544959
73	250.814	1.0	0.518730
74	260.729	1.0	0.492901
75	270.752	1.0	0.466709
76	280.612	1.0	0.440542
77	290.579	1.0	0.413567
78	300.639	1.0	0.385739
79	310.671	1.0	0.357586
80	320.615	1.0	0.329358
81	330.555	1.0	0.300899

LAKE SHORE CRYOTRONICS, INC.
64 E. WALNUT ST.
WESTERVILLE, OHIO 43081

MODEL NO. DT-500FP-HRC-7 SERIAL NO. D35367
CALIBRATION CURRENT 10 UA CALIBRATION RUN#29
CALIBRATION RANGE 75.00 TO 330.00 TEST ENGINEER J. K.

TEMPERATURE	VOLTAGE	DV/DT(MV/DEG)
75.00	0.99305	-2.46
77.35	0.98725	-2.48
80.00	0.98065	-2.50
85.00	0.96809	-2.53
90.00	0.95537	-2.55
95.00	0.94255	-2.58
100.0	0.92962	-2.59
105.0	0.91660	-2.61
110.0	0.90352	-2.62
115.0	0.89036	-2.64
120.0	0.87714	-2.65
125.0	0.86384	-2.66
130.0	0.85050	-2.67
135.0	0.83709	-2.69
140.0	0.82363	-2.70
145.0	0.81012	-2.71
150.0	0.79653	-2.72
155.0	0.78289	-2.73
160.0	0.76919	-2.74
165.0	0.75546	-2.75
170.0	0.74167	-2.76
175.0	0.72784	-2.77
180.0	0.71396	-2.78
185.0	0.70005	-2.79
190.0	0.68608	-2.80
195.0	0.67208	-2.80
200.0	0.65807	-2.80
205.0	0.64405	-2.81
210.0	0.63002	-2.80
215.0	0.61602	-2.80
220.0	0.60205	-2.79
225.0	0.58816	-2.77
230.0	0.57440	-2.74
235.0	0.56078	-2.71
240.0	0.54732	-2.68
245.0	0.53401	-2.64
250.0	0.52086	-2.62
255.0	0.50783	-2.60
260.0	0.49480	-2.60
265.0	0.48178	-2.61



TEMPERATURE	VOLTAGE	DV/DT(MV/DEG)
270.0	0.46869	-2.63
275.0	0.45550	-2.65
280.0	0.44218	-2.67
285.0	0.42876	-2.70
290.0	0.41515	-2.73
295.0	0.40141	-2.76
300.0	0.38752	-2.79
305.0	0.37354	-2.80
310.0	0.35948	-2.82
315.0	0.34533	-2.84
320.0	0.33111	-2.85
325.0	0.31683	-2.86
330.0	0.30249	-2.87

Table 4. Calibration table supplied by Lake Shore Cryotronics, Inc. for diode thermometer number 10.

CALIBRATION REPORT

LAKE SHORE CRYOTRONICS, INC.
64 E. Walnut St.
Westerville, Ohio USA

CERTIFICATE OF CALIBRATION

CALIBRATION REPORT NO. RUN870 - 8

MODEL DT-500FP-HRC-7

SENSOR TYPE: SILICON DIODE SERIAL NO. D36312

This temperature sensor has been calibrated against standards maintained by Lake Shore Cryotronics, Inc.

All calibrations provided by Lake Shore are based on the 1976 Provisional 0.5K to 30K Temperature Scale (EPT-76) and the International Practical Temperature Scale of 1968 (IPTS-68) for temperatures above 30K. At lower temperatures (below 0.5K), a cerium magnesium nitrate magnetic thermometer has been used in conjunction with NBS superconducting fixed points SRM768 to generate a scale.

Each scale is currently maintained on a set of germanium or platinum resistance standards, as appropriate, which are routinely checked by intercomparison and periodically calibrated by the United States National Bureau of Standards or Great Britain's National Physical Laboratory.

Lake Shore's calibration facility and procedures for diode and resistance sensor calibrations above 1.2K are maintained traceable in accord with MIL STD 45662.

Date: JUN 21 1985

Calibrated by: Larry A. Smith
Metrologist

Approved by: J. K. Krause
Senior Scientist

DT-500FP-HRC-7 D36312 10 UA RUN670

DEVICE NO. 8

	TEMP	WEIGHT	OUTPUT
43	60.2320	1.0	1.04227
44	65.4704	1.0	1.03119
45	70.4944	1.0	1.02039
46	75.4050	1.0	1.00966
47	80.4957	1.0	0.998354
48	85.5528	1.0	0.986959
49	90.5182	1.0	0.975636
50	95.5278	1.0	0.964097
51	100.439	1.0	0.952691
52	110.680	1.0	0.928648
53	120.652	1.0	0.904950
54	130.581	1.0	0.881089
55	140.810	1.0	0.856259
56	150.811	1.0	0.831749
57	160.816	1.0	0.807023
58	170.659	1.0	0.782497
59	181.057	1.0	0.756388
60	191.017	1.0	0.731215
61	200.986	1.0	0.705864
62	210.957	1.0	0.680388
63	221.022	1.0	0.654587
64	230.908	1.0	0.629245
65	241.023	1.0	0.603431
66	250.942	1.0	0.578390
67	260.873	1.0	0.553706
68	270.898	1.0	0.529177
69	280.774	1.0	0.505232
70	290.720	1.0	0.481081
71	300.779	1.0	0.456383
72	310.784	1.0	0.431397
73	320.723	1.0	0.406121
74	330.680	1.0	0.380362

LAKE SHORE CRYOTRONICS, INC.
64 E. WALNUT ST.
WESTERVILLE, OHIO 43081

MODEL NO. DT-500FP-HRC-7 SERIAL NO. DA4312
CALIBRATION CURRENT 10 UA CALIBRATION RUN#7
CALIBRATION RANGE 75.00 TO 330.00 TEST ENGINEER: K.

TEMPERATURE	VOLTAGE	DV/DT(MV/DEG)
75.00	1.0105	-2.20
77.35	1.0054	-2.22
80.00	0.99946	-2.24
85.00	0.98821	-2.26
90.00	0.97682	-2.29
95.00	0.96532	-2.31
100.0	0.95371	-2.33
105.0	0.94202	-2.35
110.0	0.93025	-2.36
115.0	0.91842	-2.37
120.0	0.90651	-2.39
125.0	0.89453	-2.40
130.0	0.88249	-2.41
135.0	0.87039	-2.43
140.0	0.85823	-2.44
145.0	0.84602	-2.45
150.0	0.83374	-2.46
155.0	0.82142	-2.47
160.0	0.80905	-2.48
165.0	0.79662	-2.49
170.0	0.78415	-2.50
175.0	0.77162	-2.51
180.0	0.75905	-2.52
185.0	0.74644	-2.53
190.0	0.73379	-2.53
195.0	0.72110	-2.54
200.0	0.70838	-2.55
205.0	0.69562	-2.55
210.0	0.68284	-2.56
215.0	0.67002	-2.56
220.0	0.65721	-2.56
225.0	0.64439	-2.56
230.0	0.63157	-2.56
235.0	0.61878	-2.55
240.0	0.60603	-2.54
245.0	0.59335	-2.53
250.0	0.58075	-2.51
255.0	0.56825	-2.49
260.0	0.55586	-2.47
265.0	0.54356	-2.45

TEMPERATURE	VOLTAGE	DV/DT(MV/DEG)
270.0	0.53137	-2.43
275.0	0.51924	-2.42
280.0	0.50711	-2.42
285.0	0.49499	-2.43
290.0	0.48284	-2.44
295.0	0.47062	-2.45
300.0	0.45831	-2.47
305.0	0.44590	-2.49
310.0	0.43337	-2.52
315.0	0.42073	-2.54
320.0	0.40797	-2.56
325.0	0.39511	-2.58
330.0	0.38213	-2.60

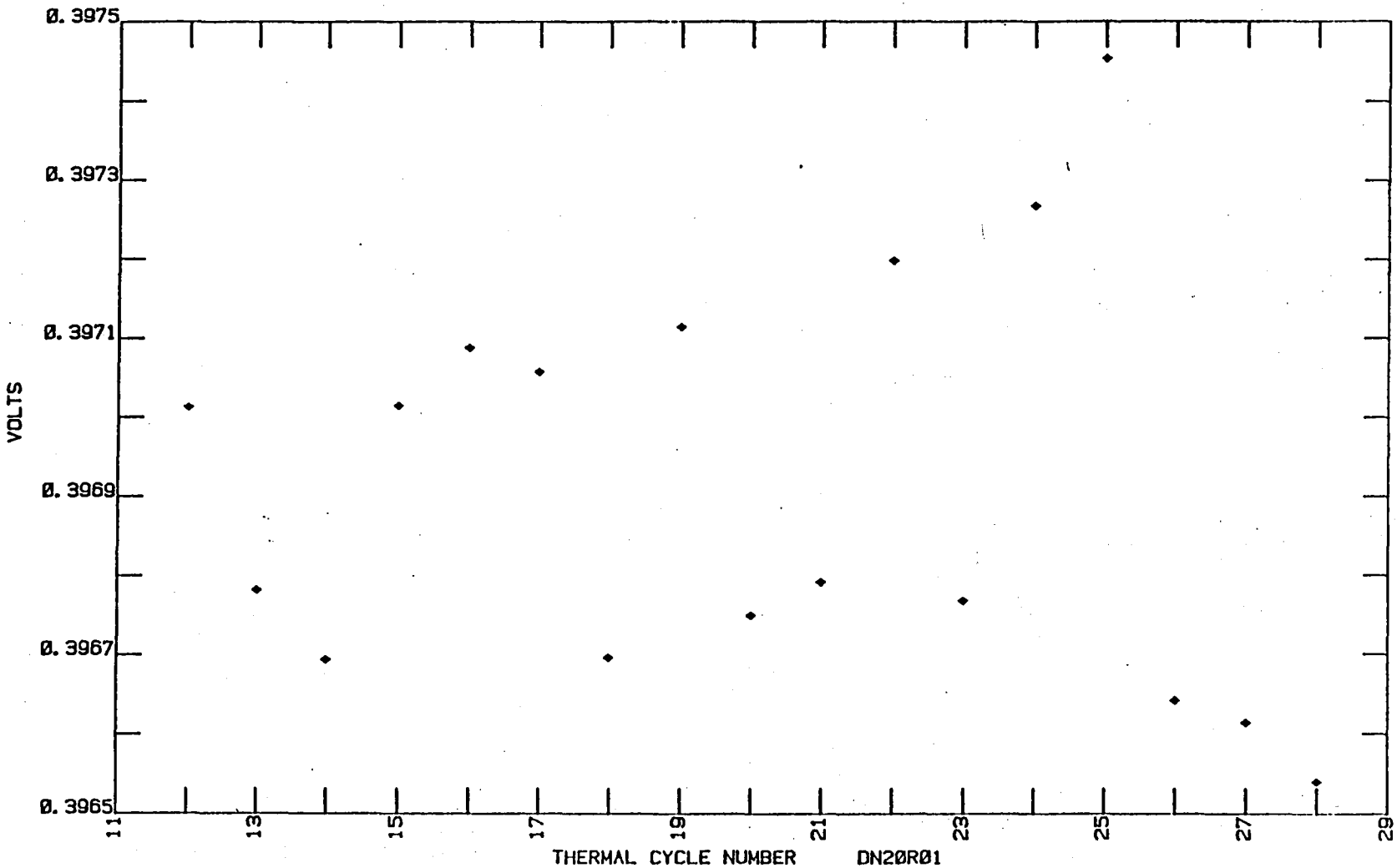


Figure 1. Results obtained at 20 °C during thermal cycling of diode number 1.

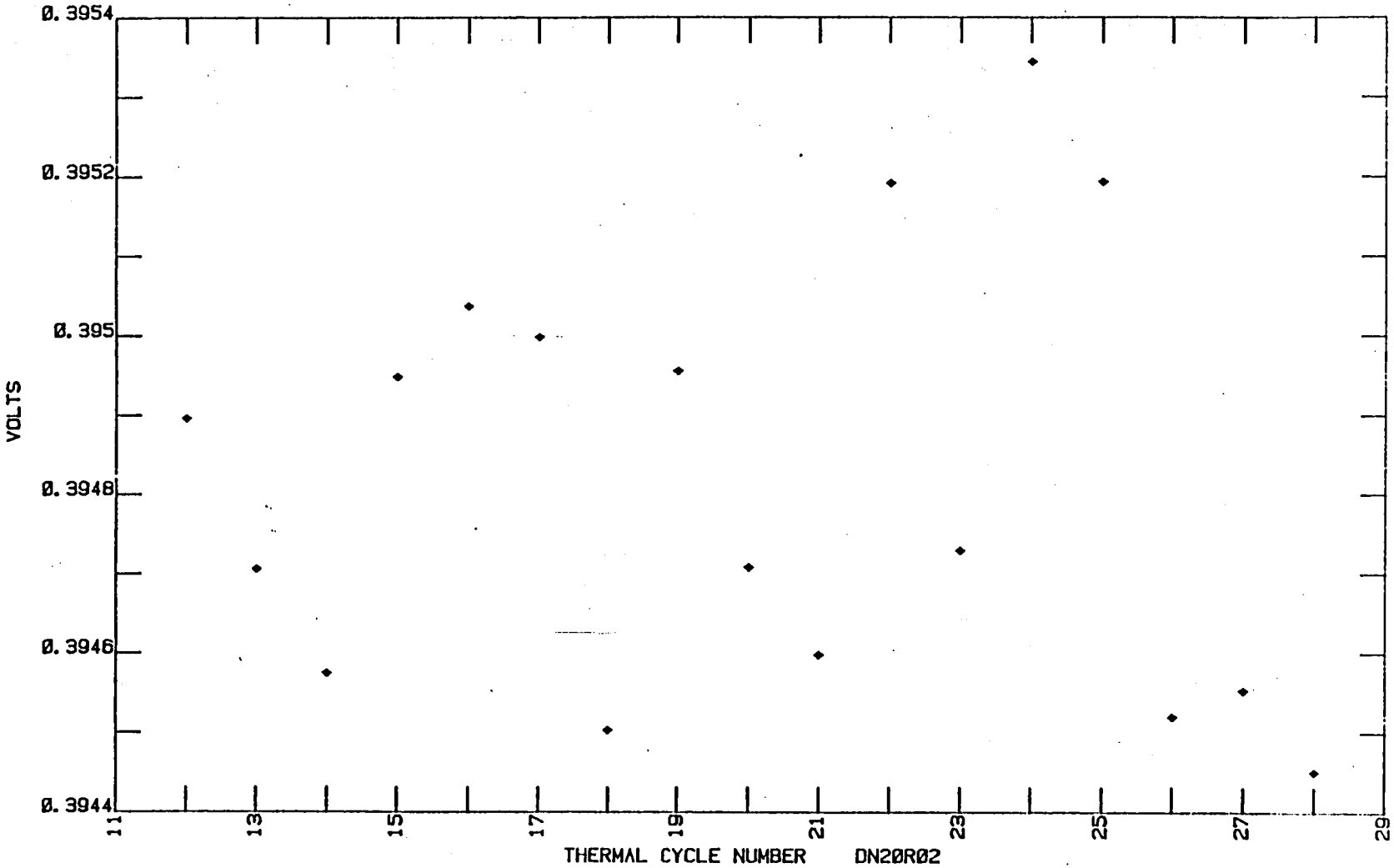


Figure 2. Results obtained at 20 °C during thermal cycling of diode number 2.

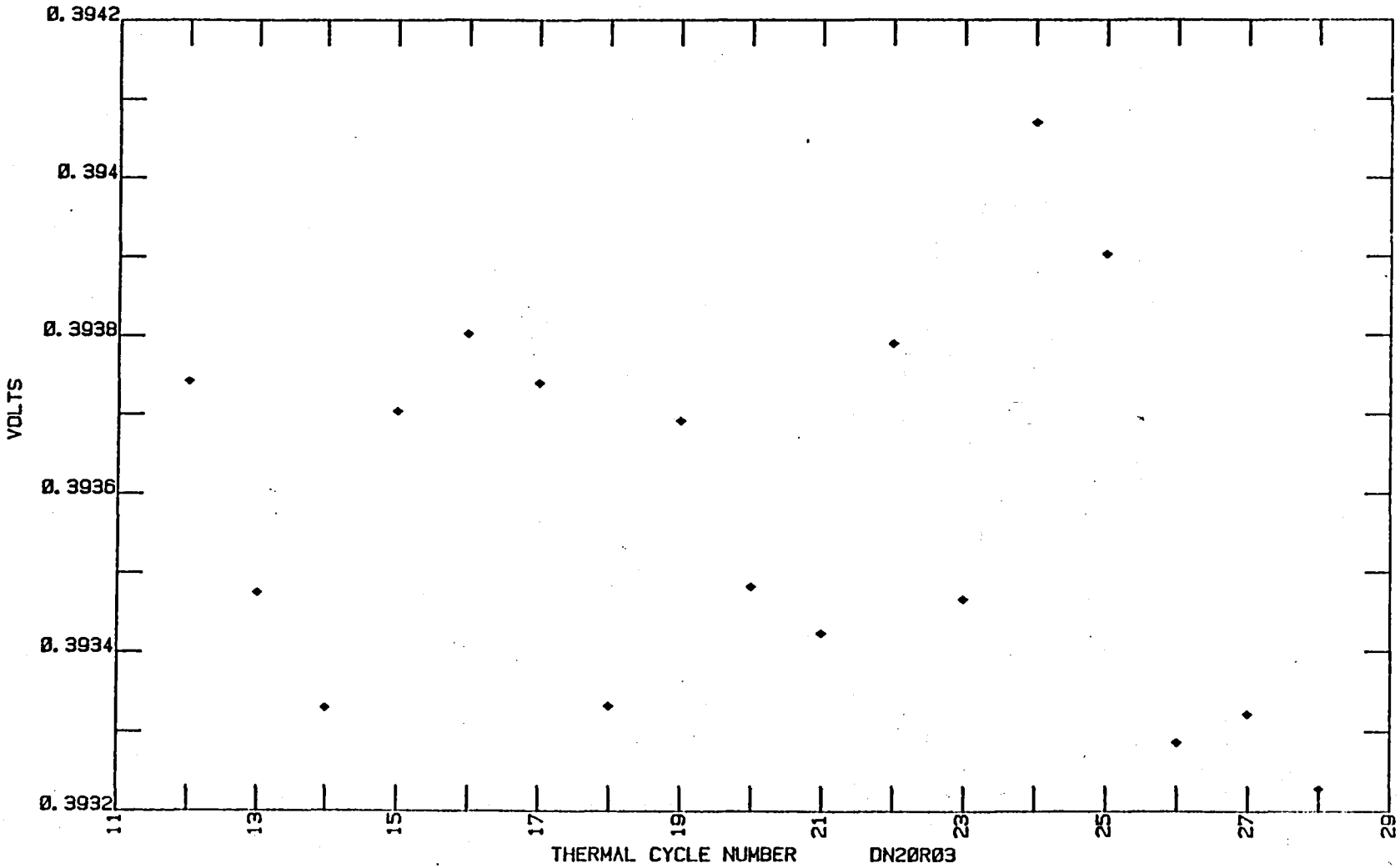


Figure 3. Results obtained at 20 °C during thermal cycling of diode number 3.

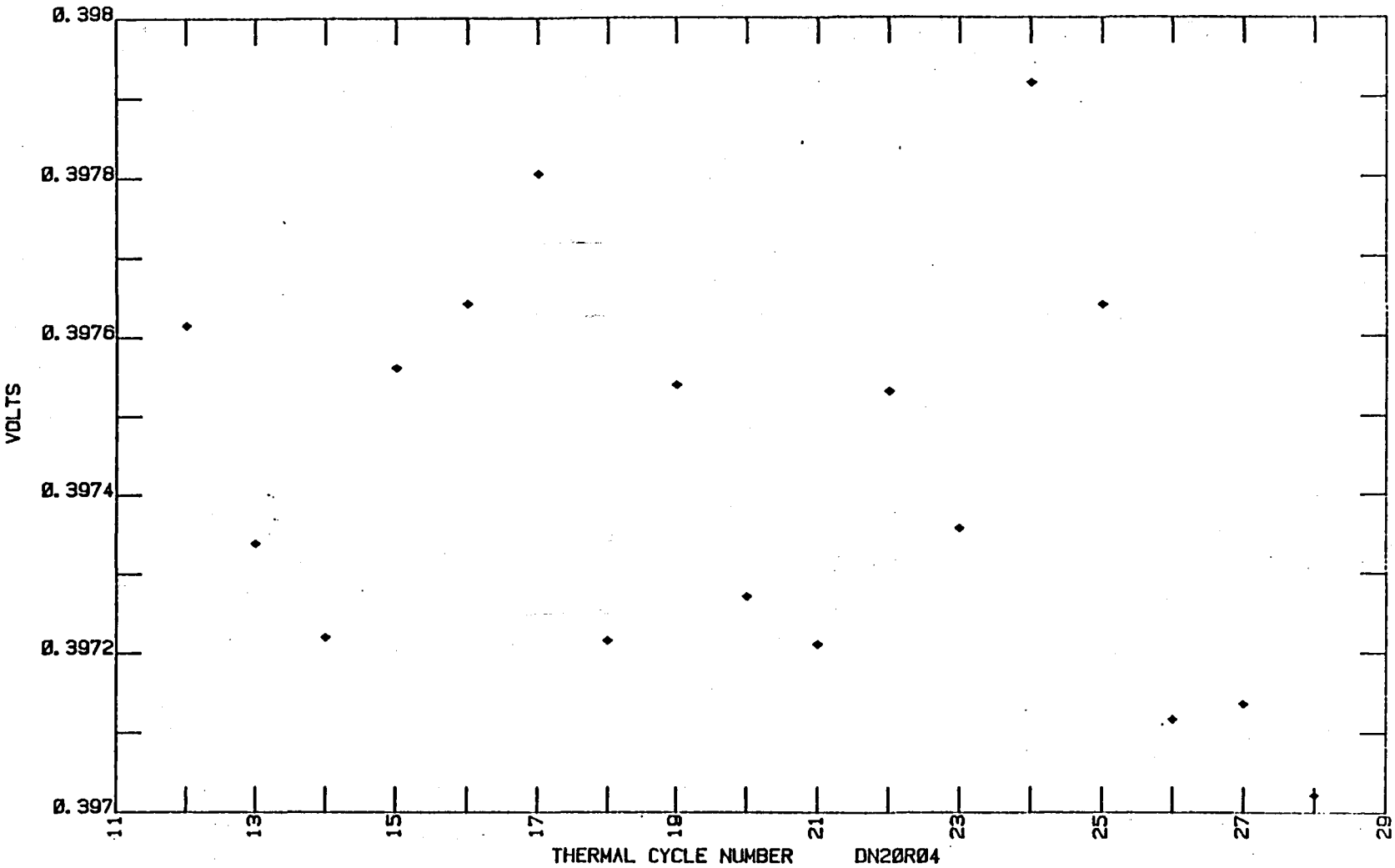


Figure 4. Results obtained at 20 °C during thermal cycling of diode number 4.

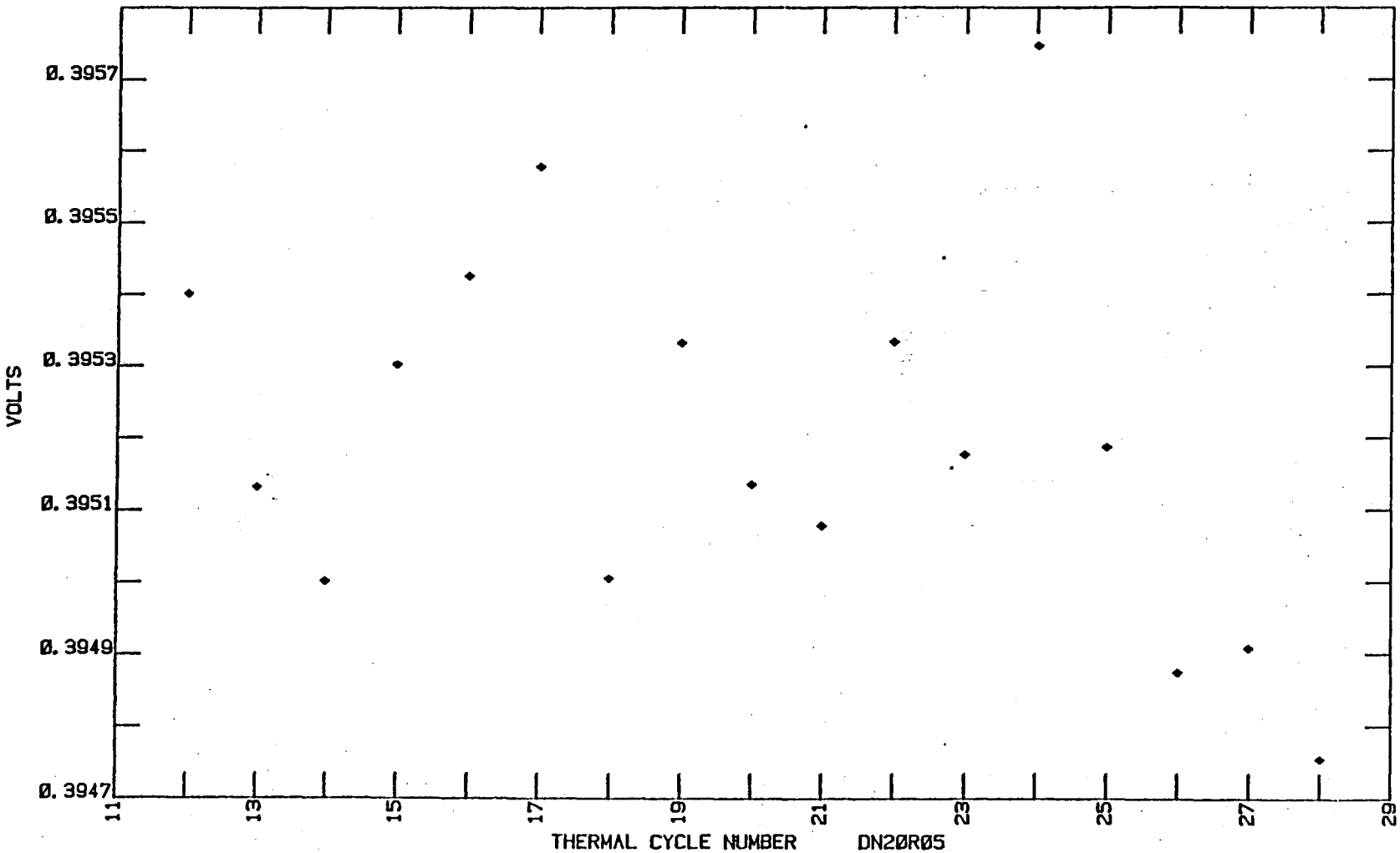


Figure 5. Results obtained at 20 °C during thermal cycling of diode number 5.

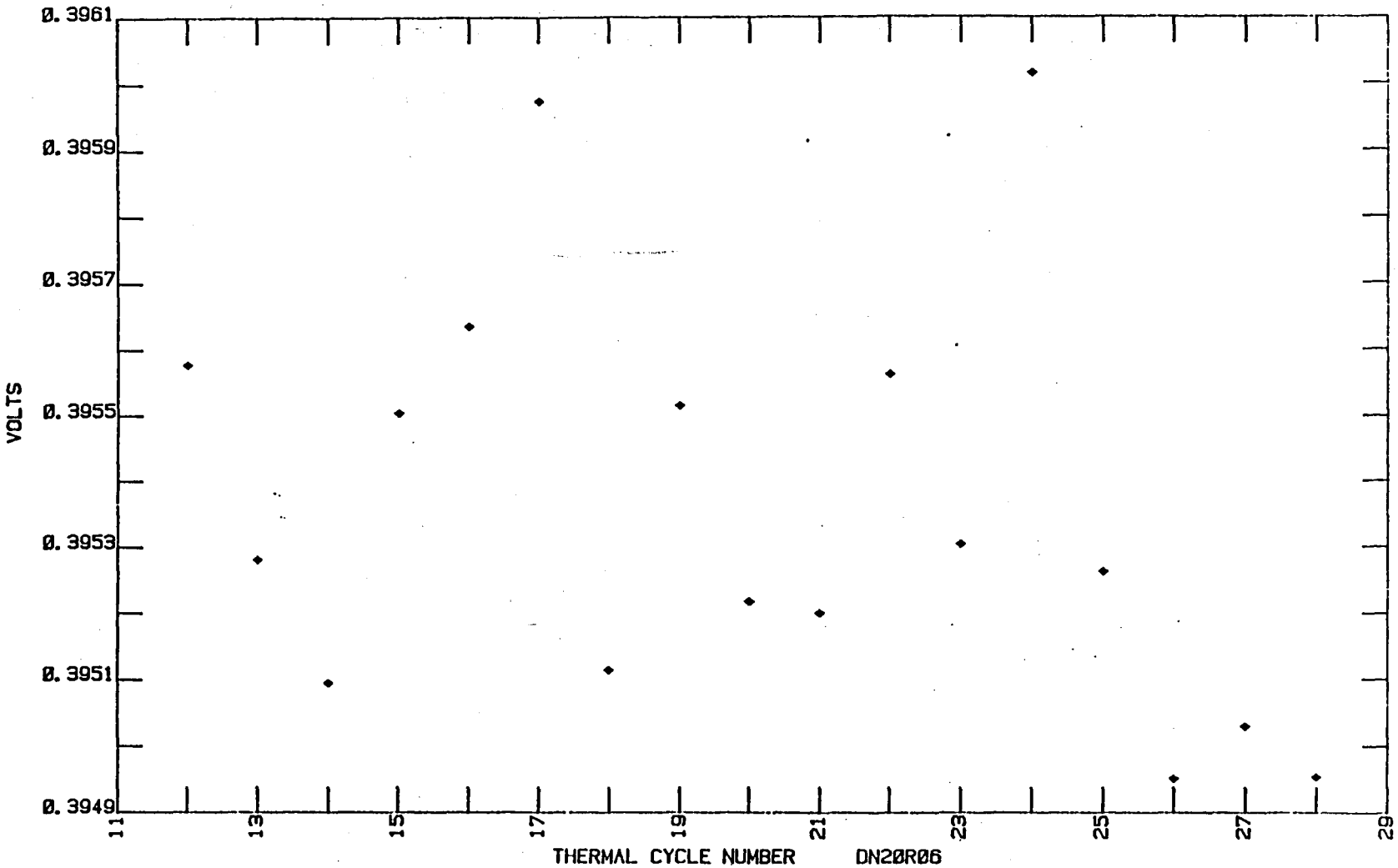


Figure 6. Results obtained at 20 °C during thermal cycling of diode number 6.

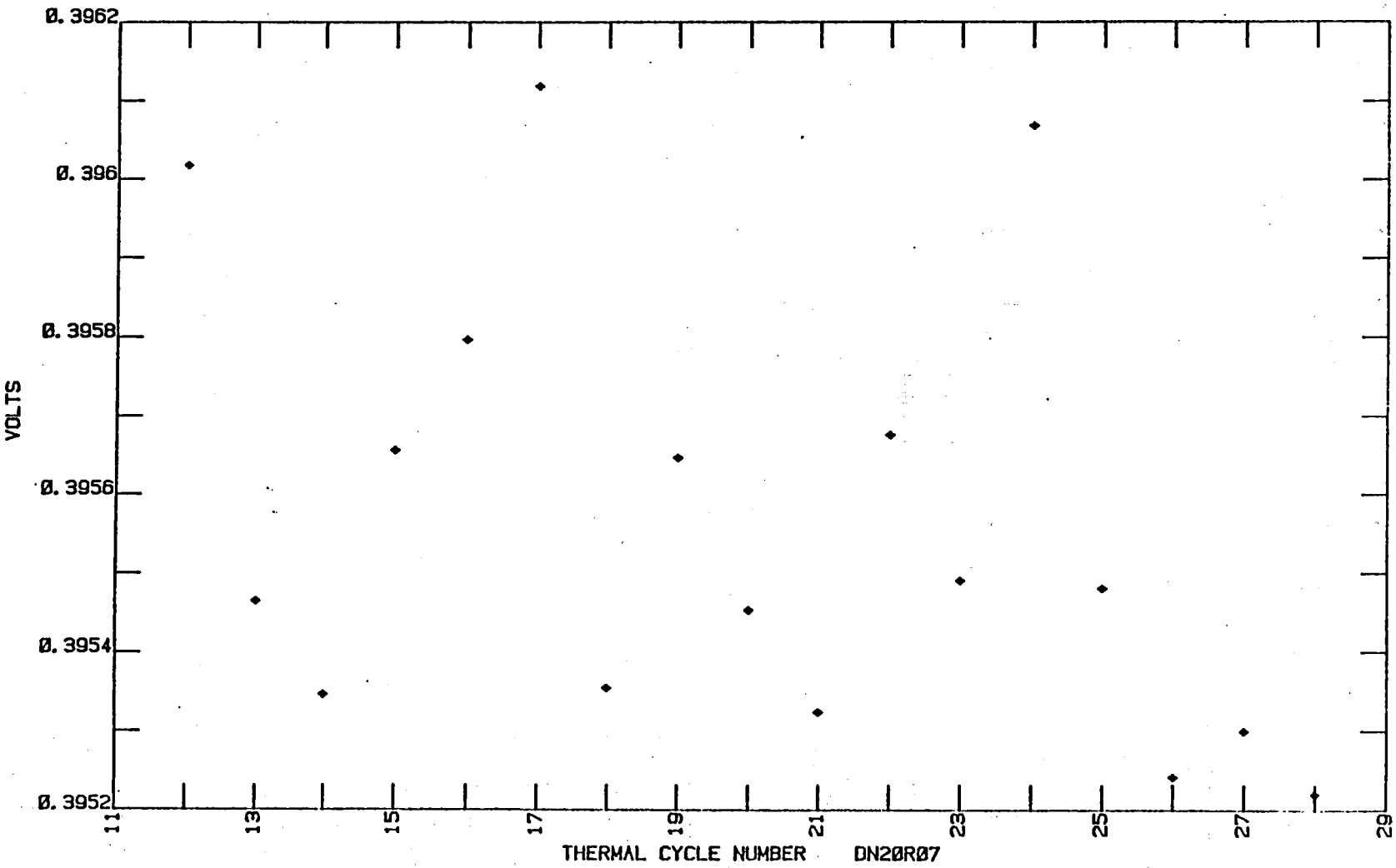


Figure 7. Results obtained at 20 °C during thermal cycling of diode number 7.

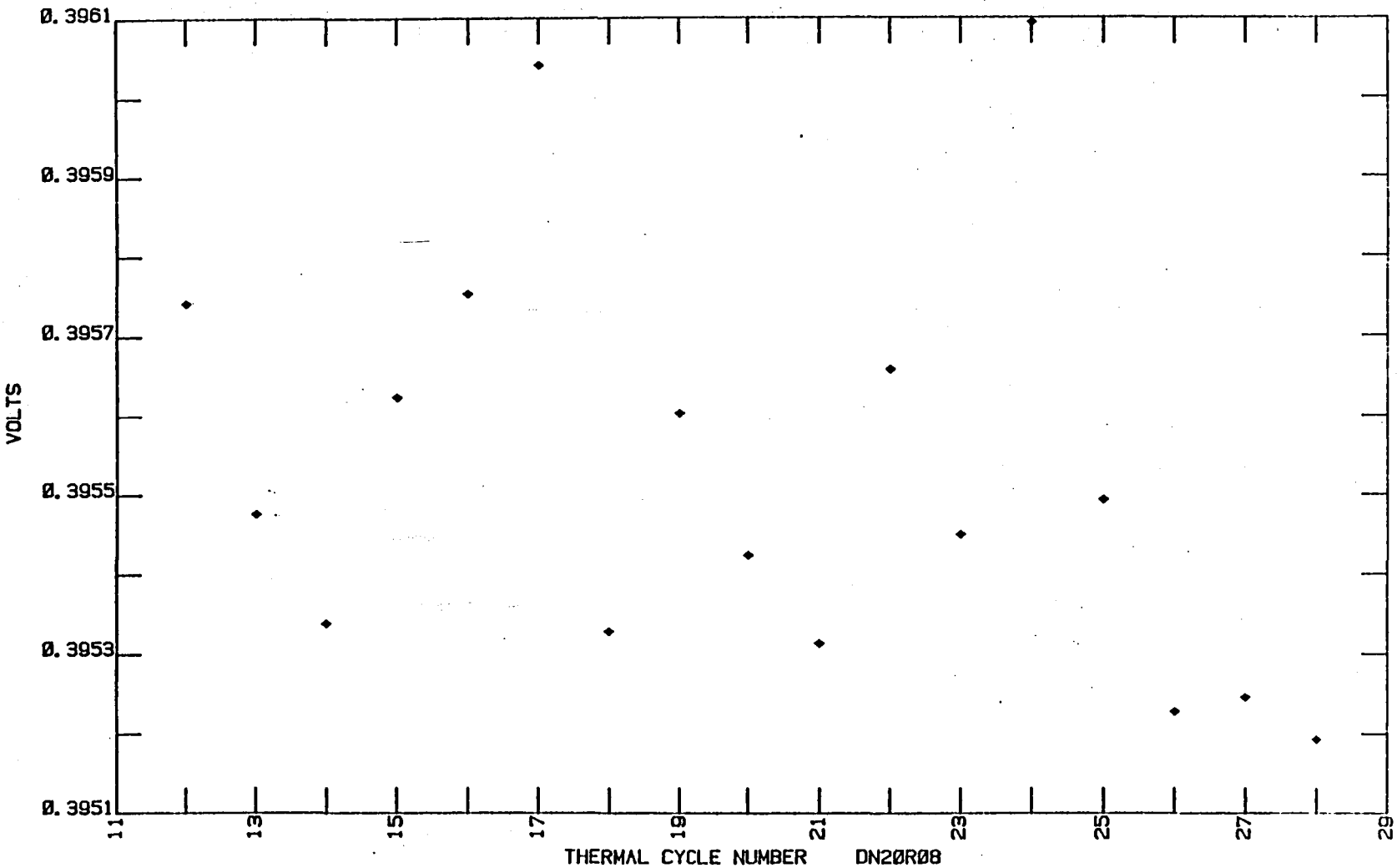


Figure 8. Results obtained at 20 °C during thermal cycling of diode number 8.

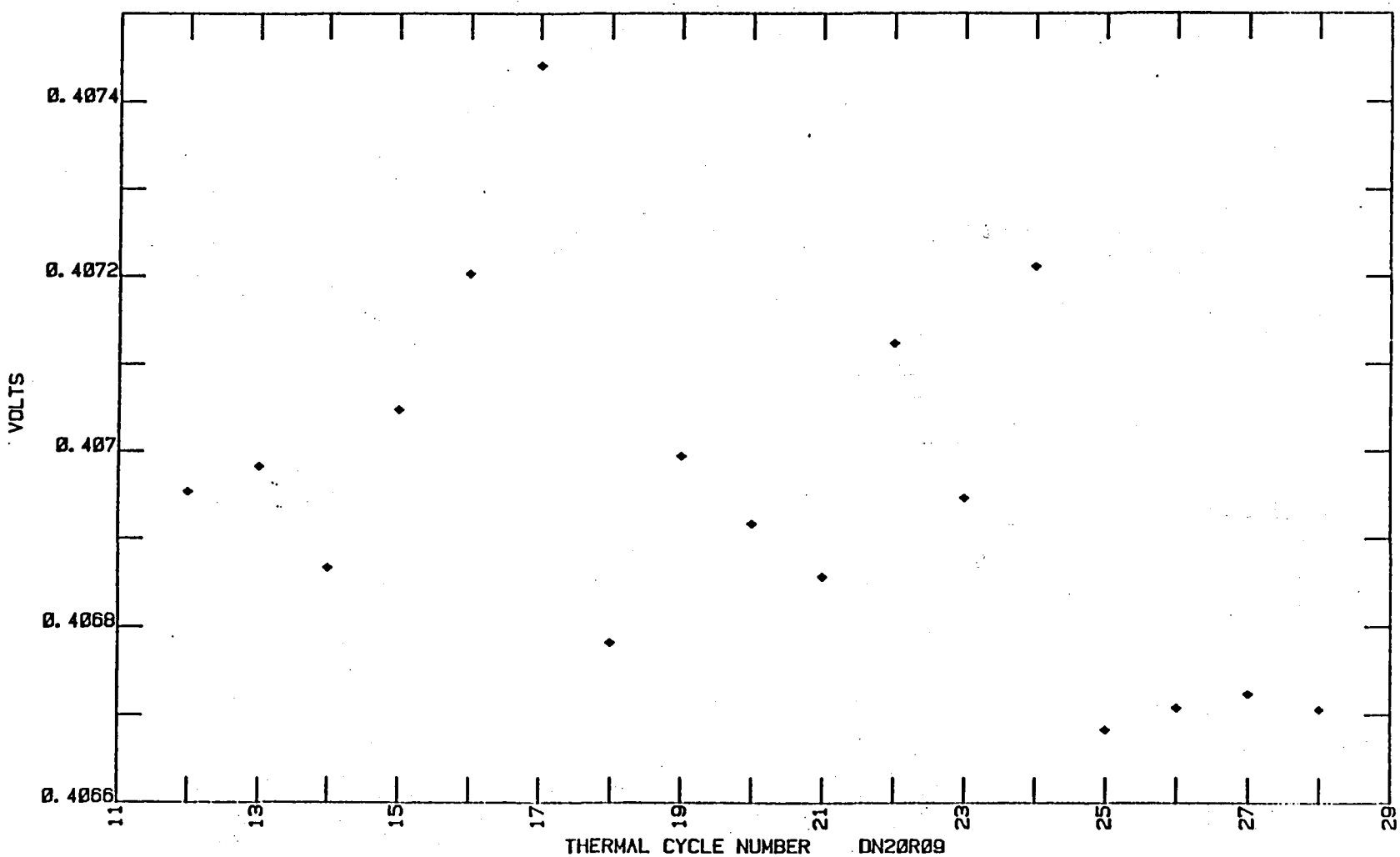


Figure 9. Results obtained at 20 °C during thermal cycling of diode number 9.

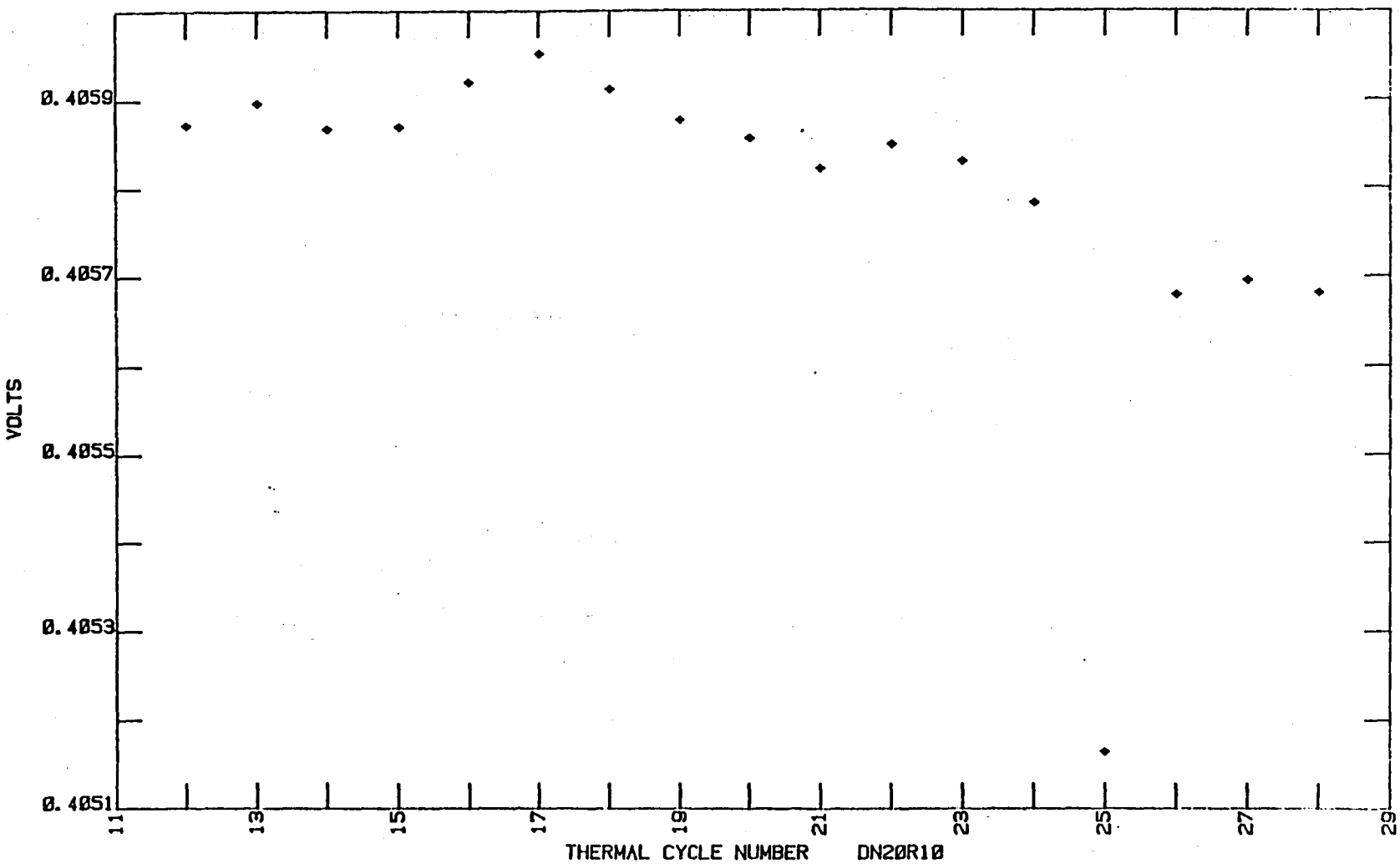


Figure 10. Results obtained at 20 °C during thermal cycling of diode number 10.

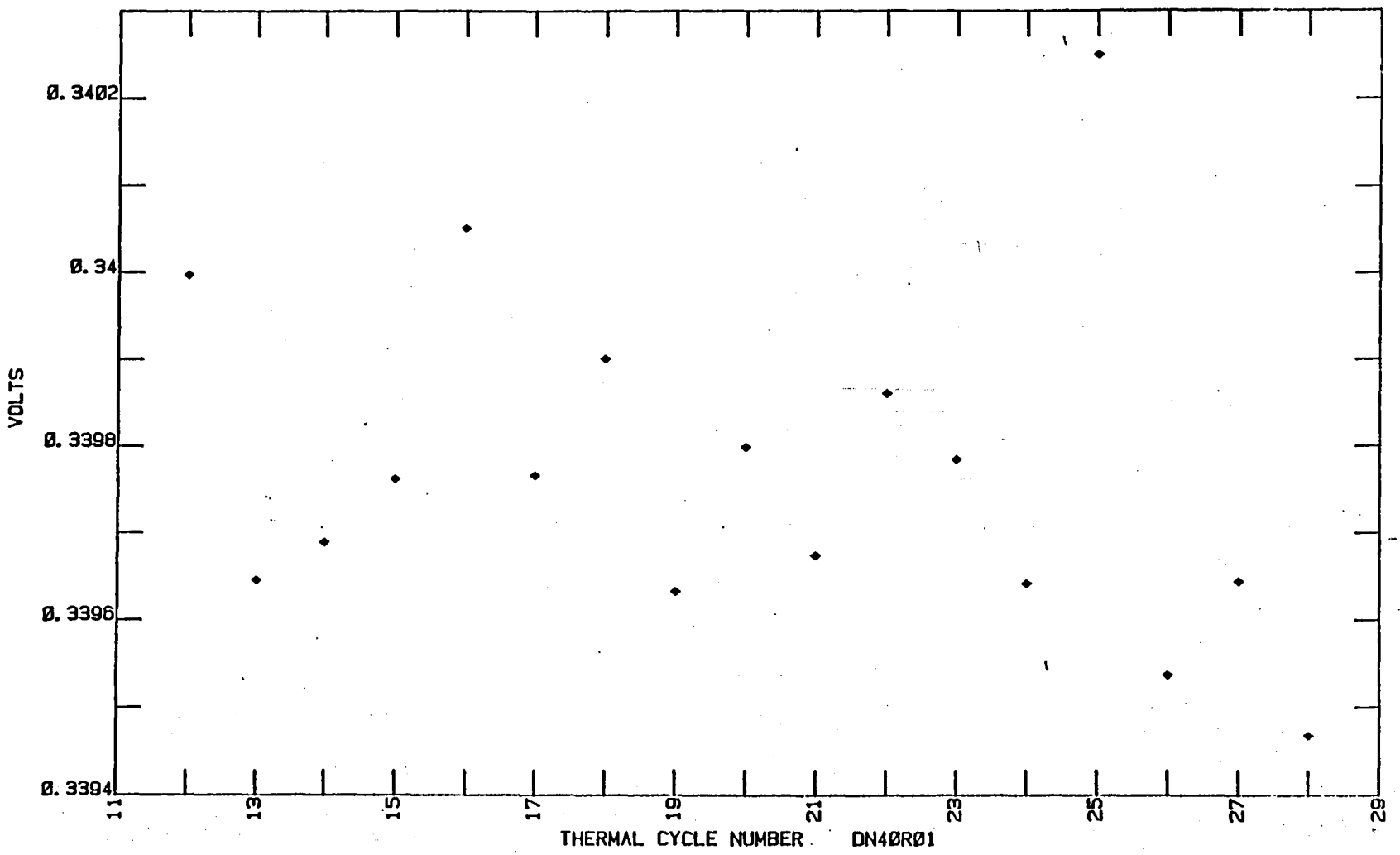


Figure 11. Results obtained at 40 °C during thermal cycling of diode number 1.

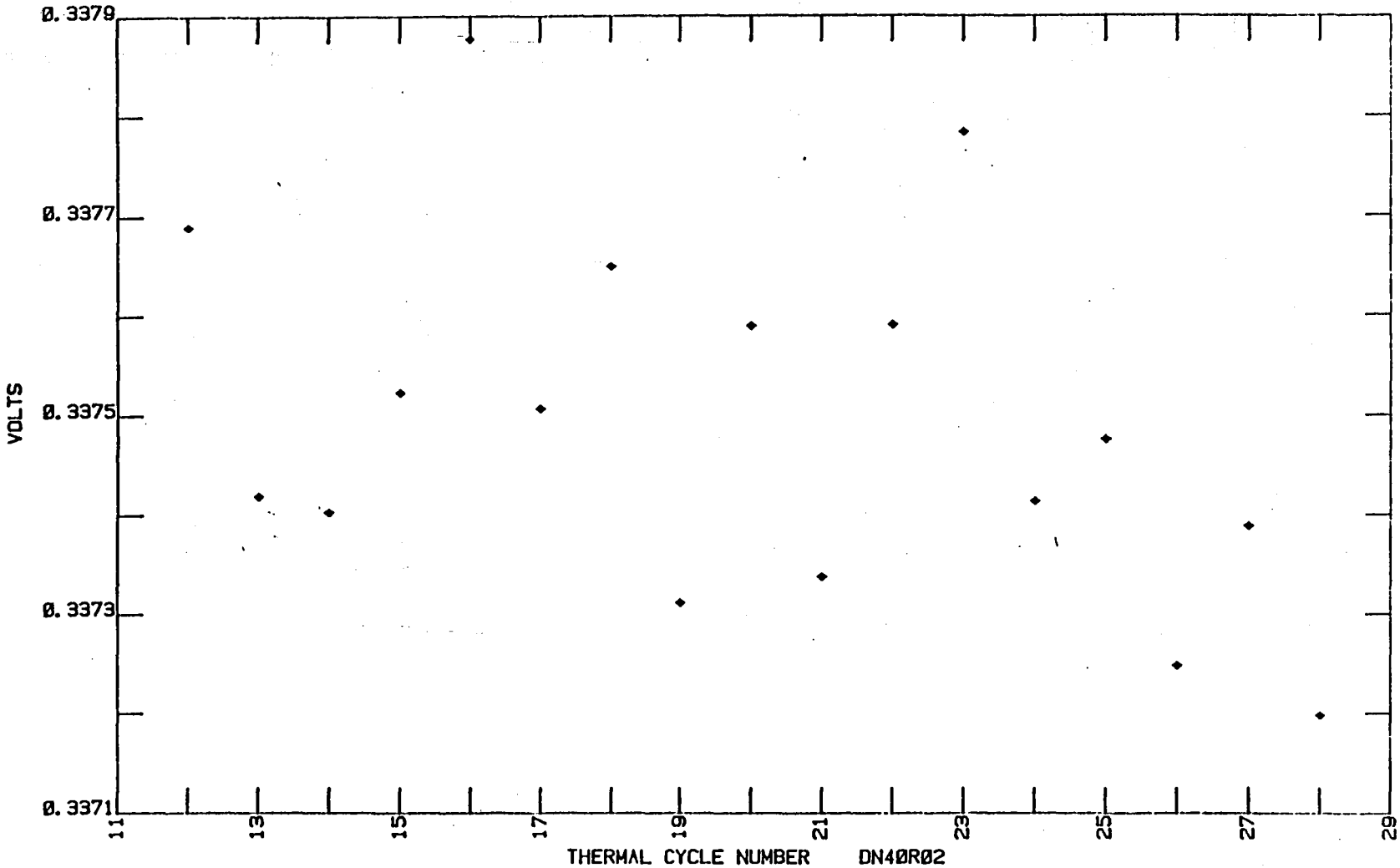


Figure 12. Results obtained at 40 °C during thermal cycling of diode number 2.

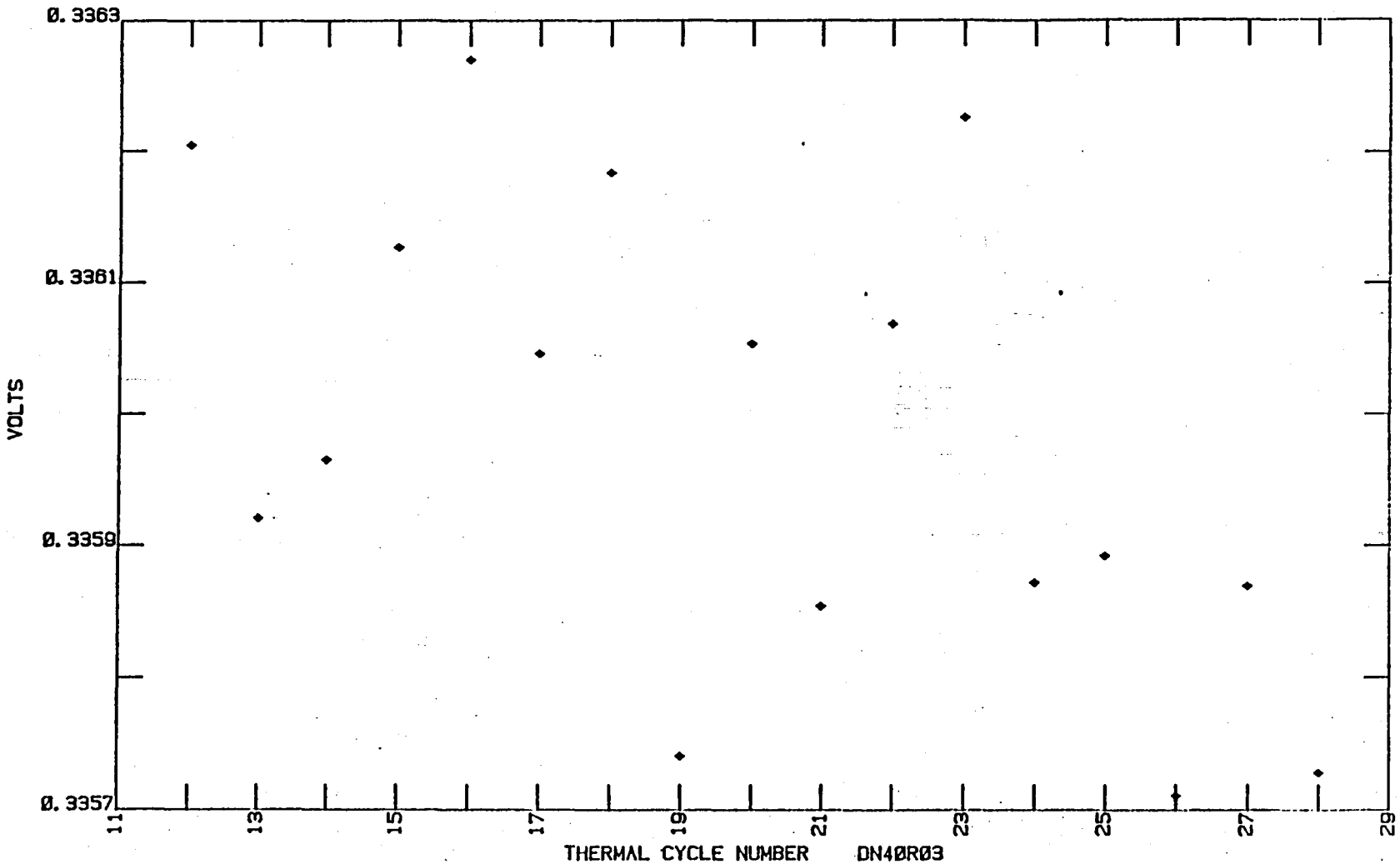


Figure 13. Results obtained at 40 °C during thermal cycling of diode number 3.

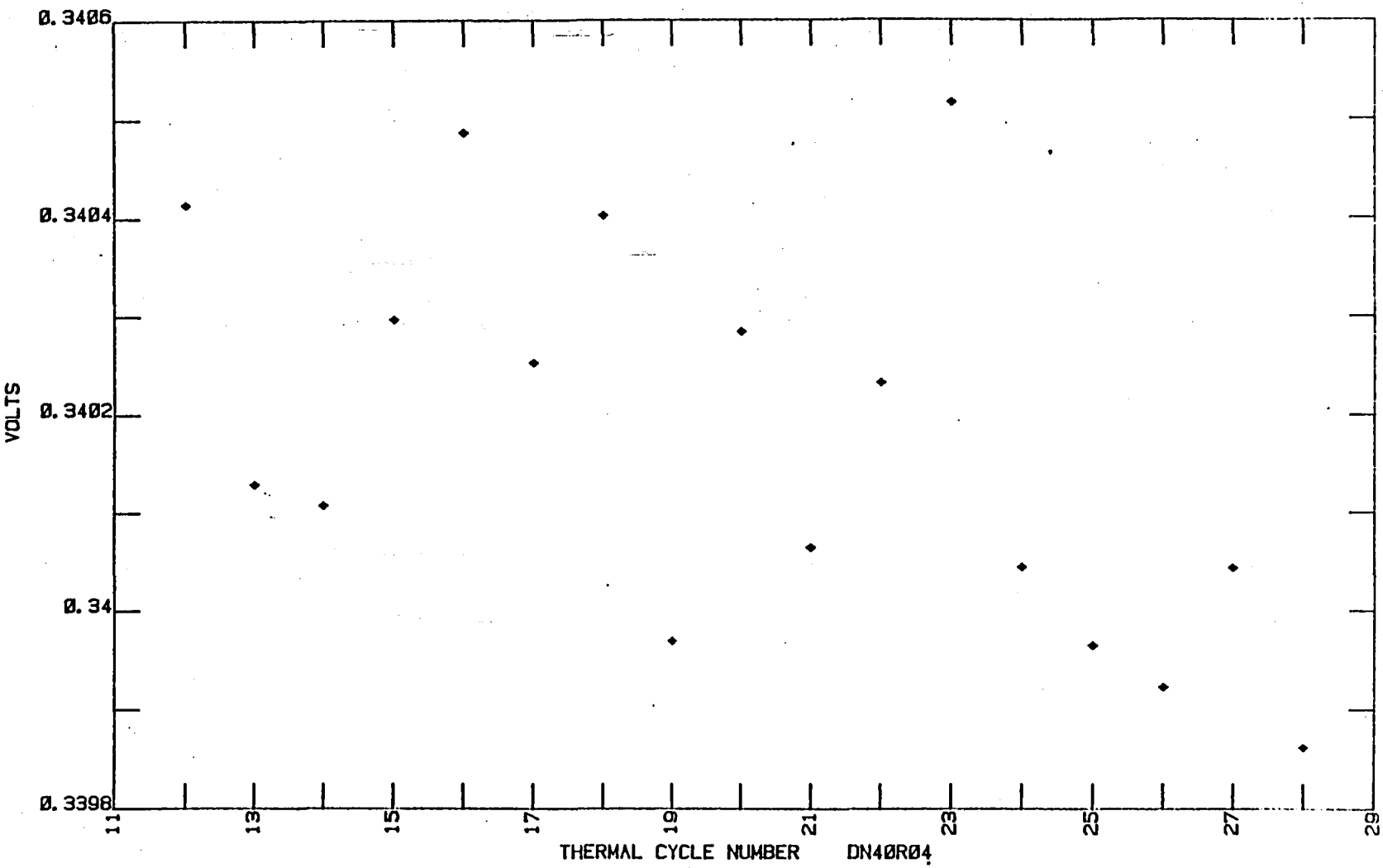


Figure 14. Results obtained at 40 °C during thermal cycling of diode number 4.

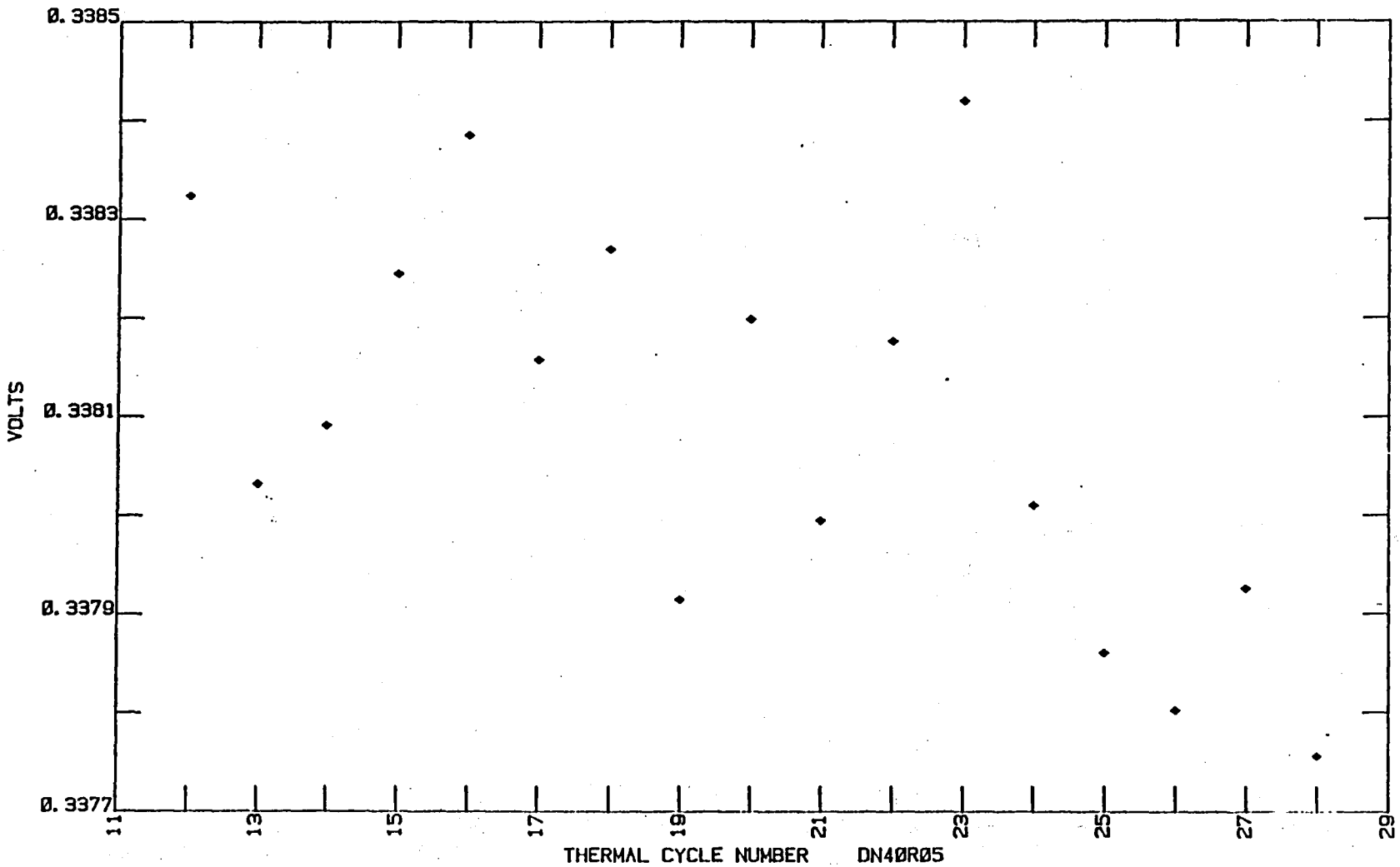


Figure 15. Results obtained at 40 °C during thermal cycling of diode number 5.

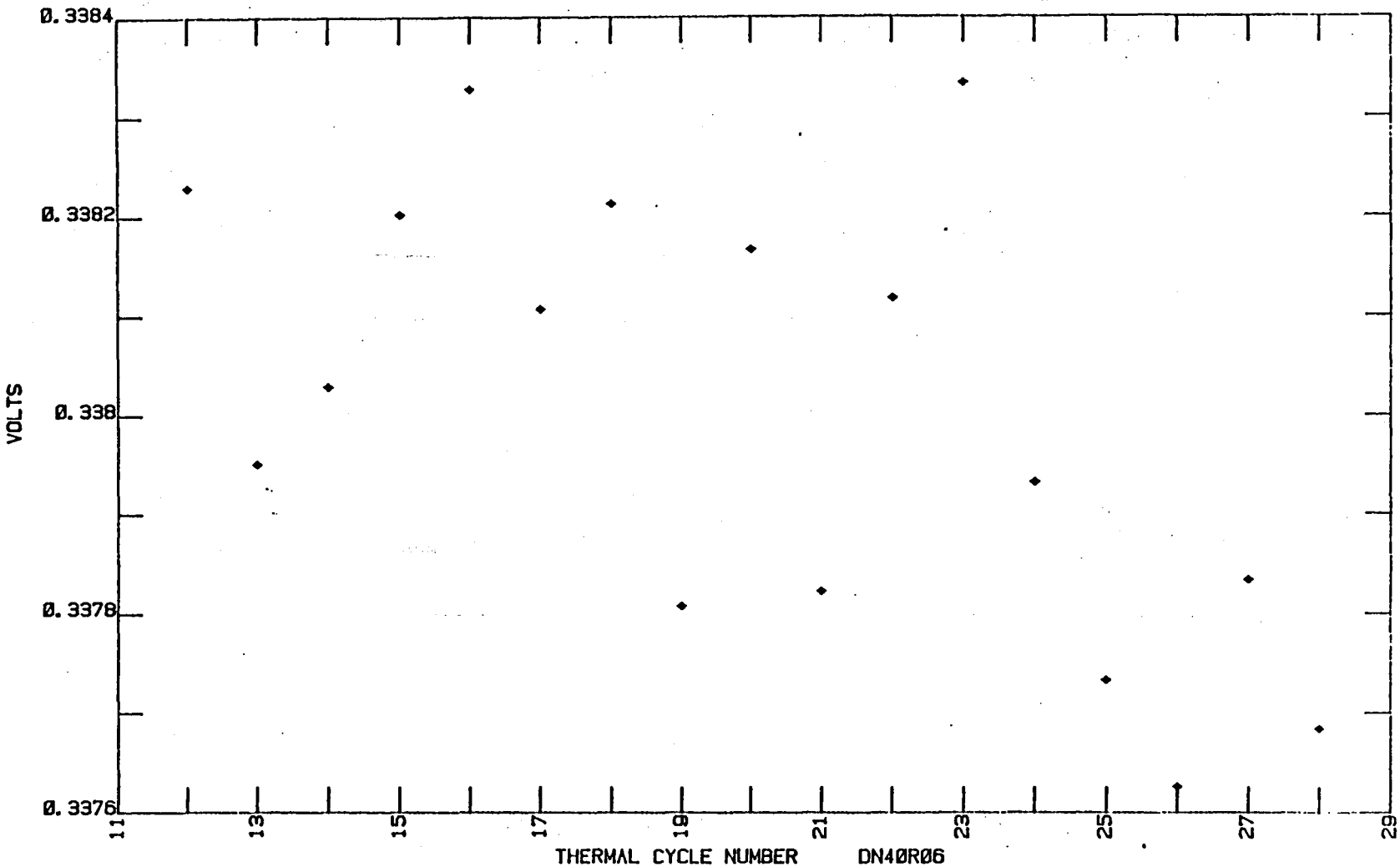


Figure 16. Results obtained at 40 °C during thermal cycling of diode number 6.

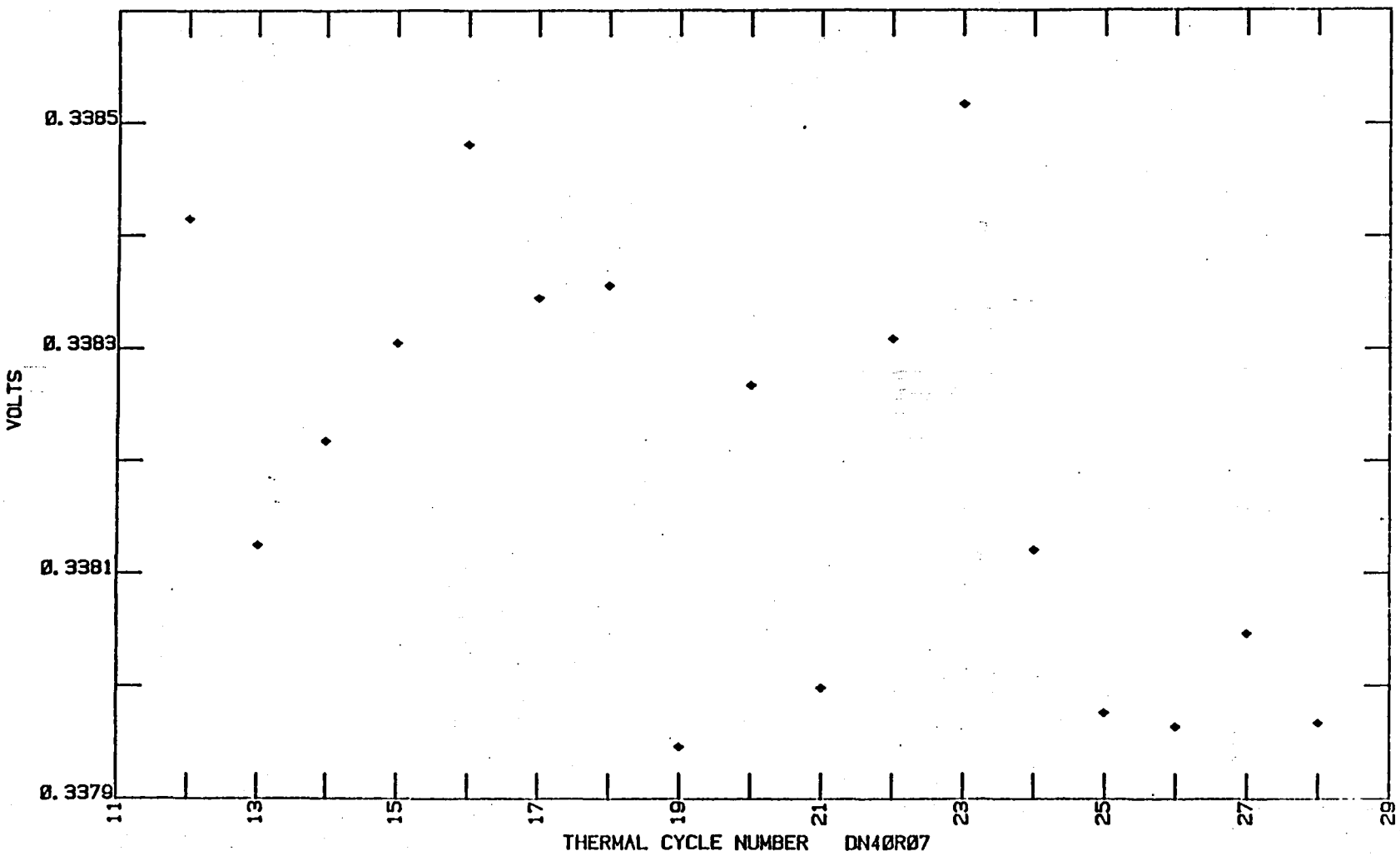


Figure 17. Results obtained at 40 °C during thermal cycling of diode number 7.

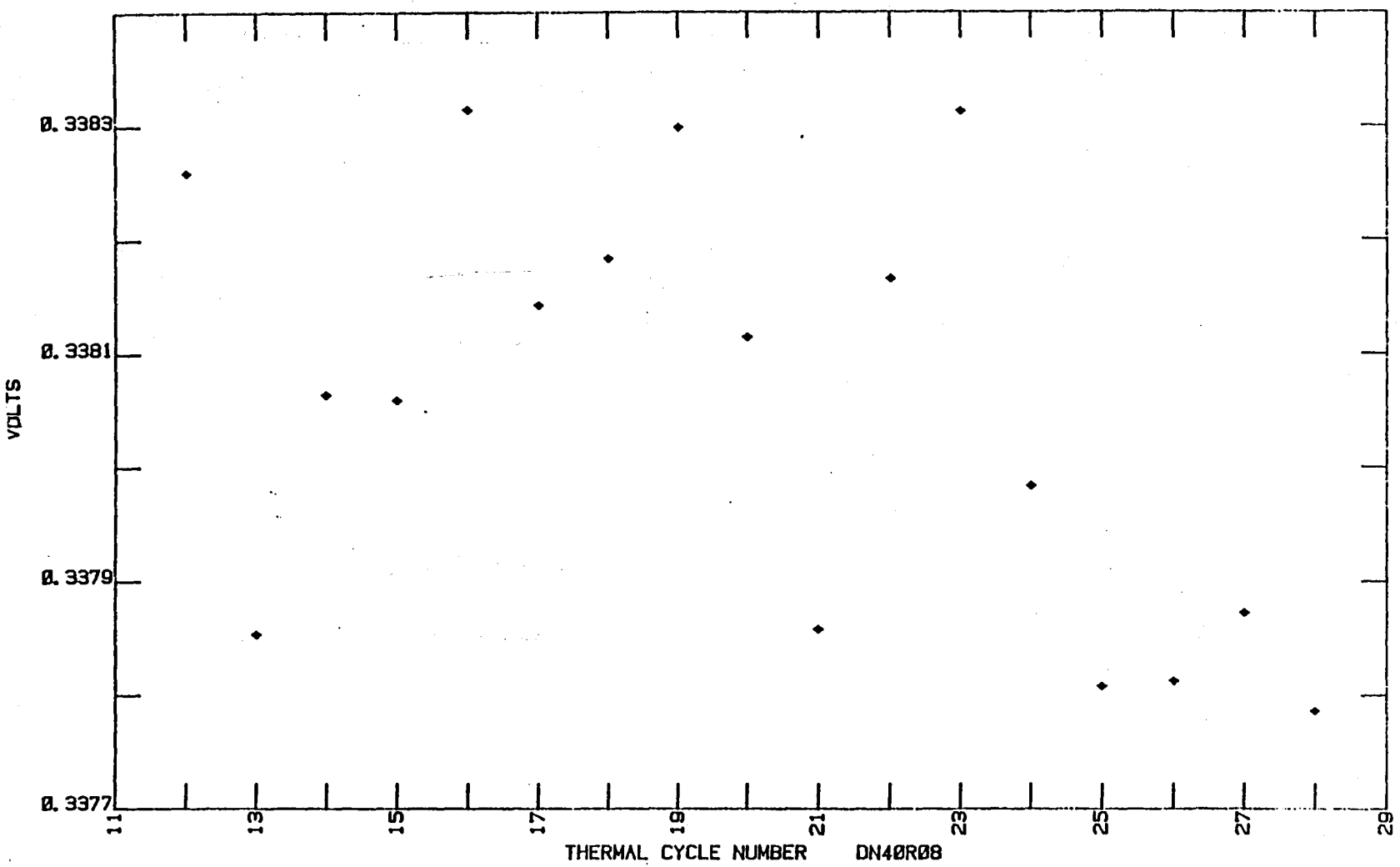


Figure 18. Results obtained at 40 °C during thermal cycling of diode number 8.

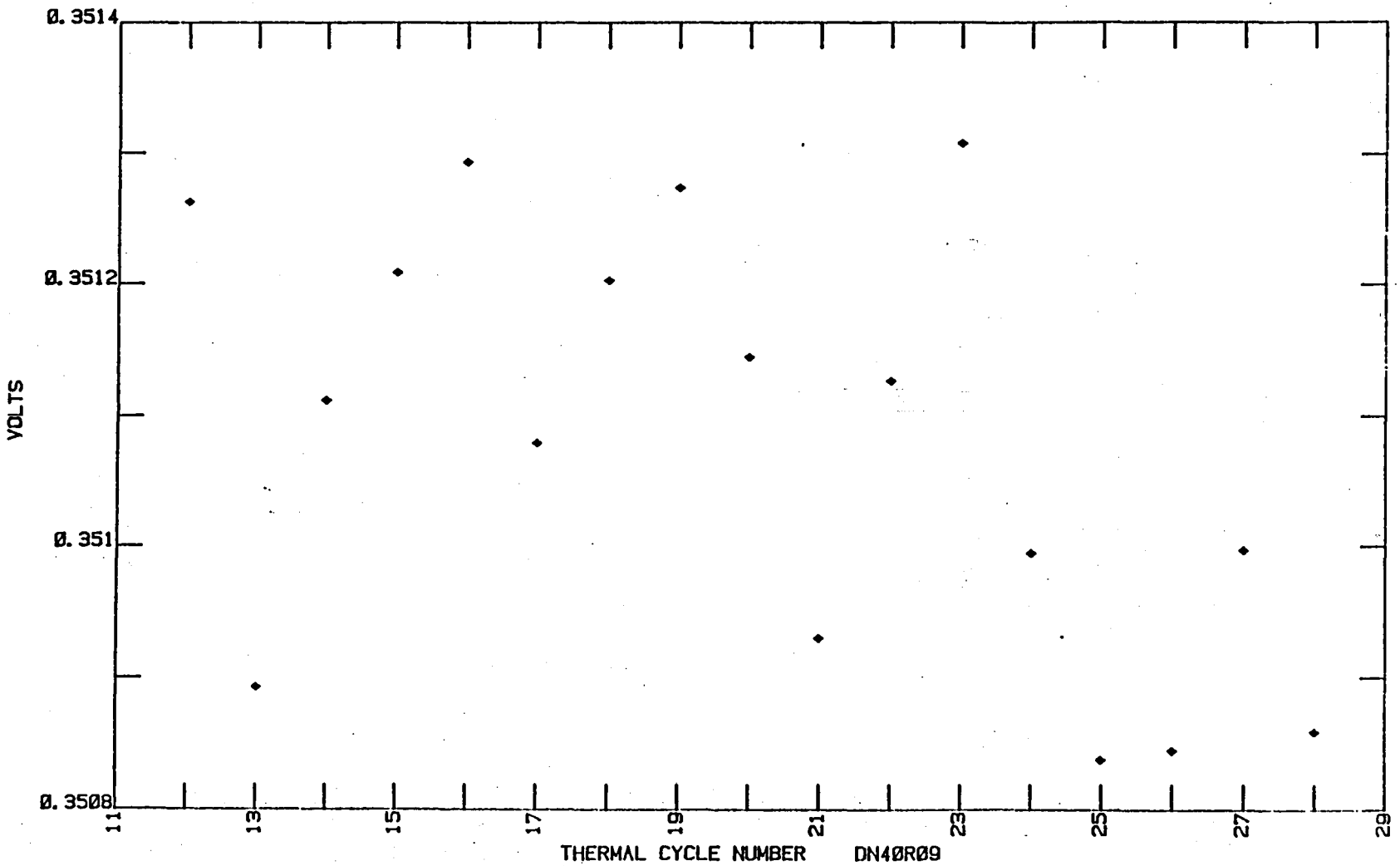


Figure 19. Results obtained at 40 °C during thermal cycling of diode number 9.

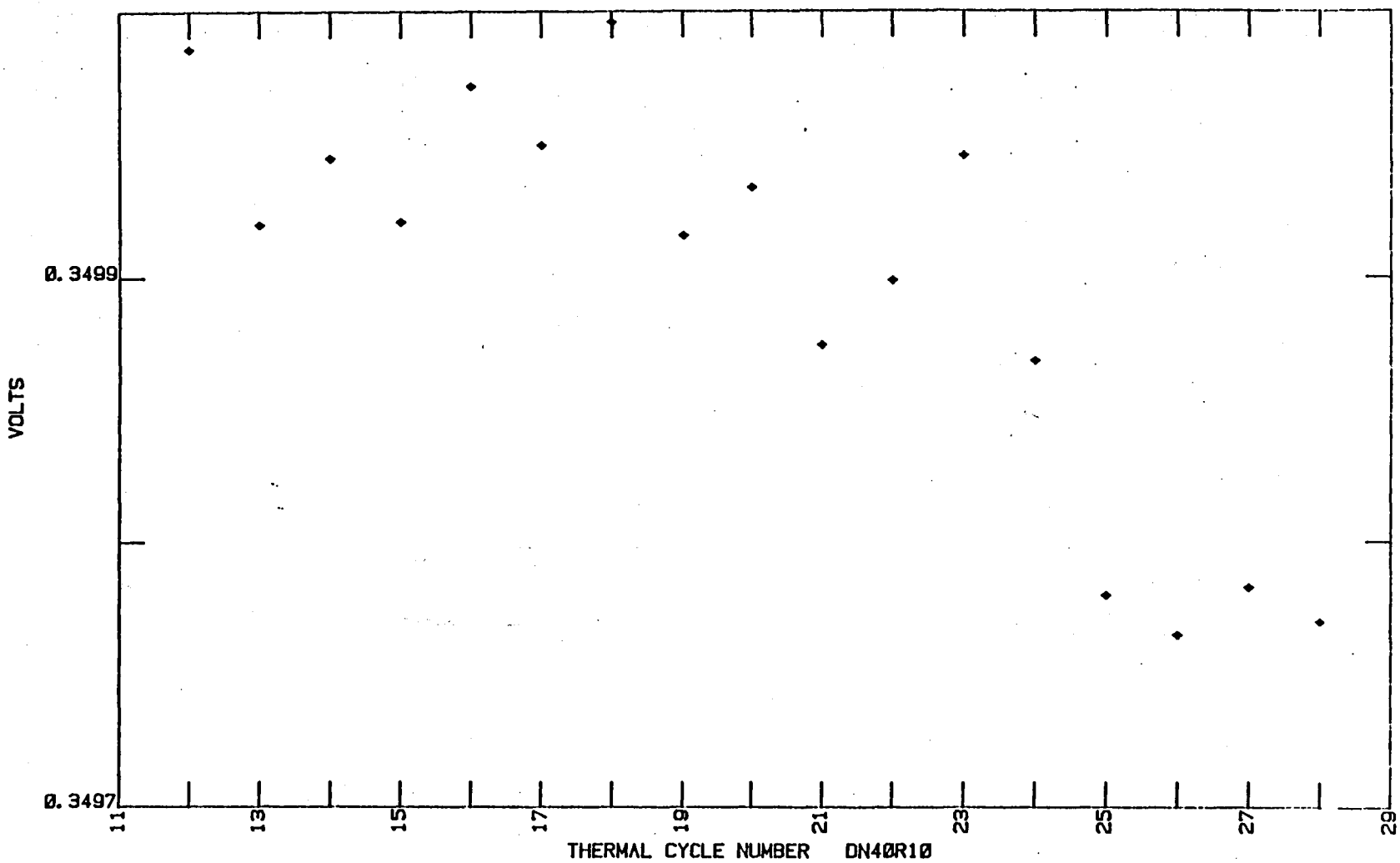


Figure 20. Results obtained at 40 °C during thermal cycling of diode number 10.

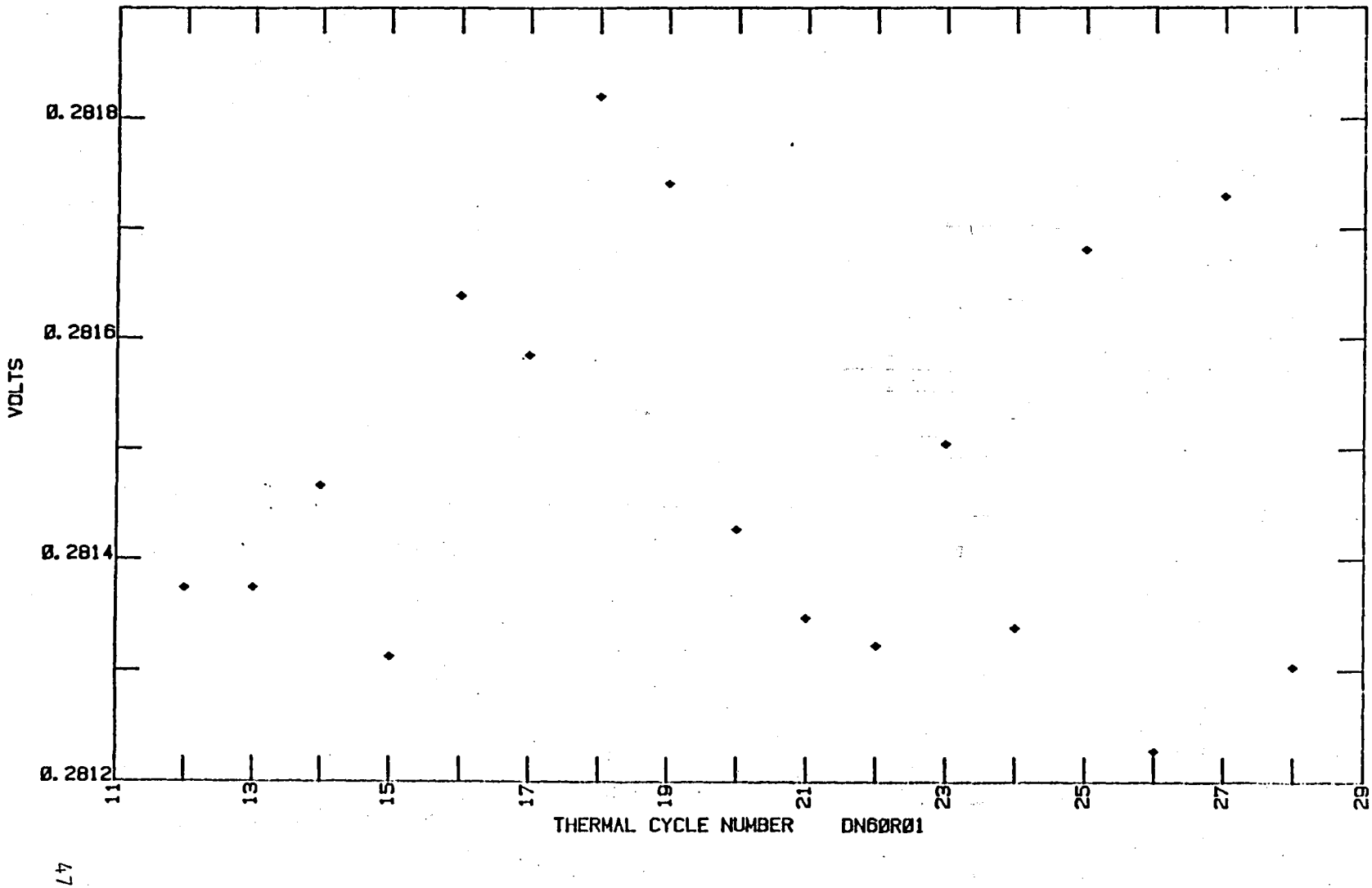


Figure 21. Results obtained at 60 °C during thermal cycling of diode number 1.

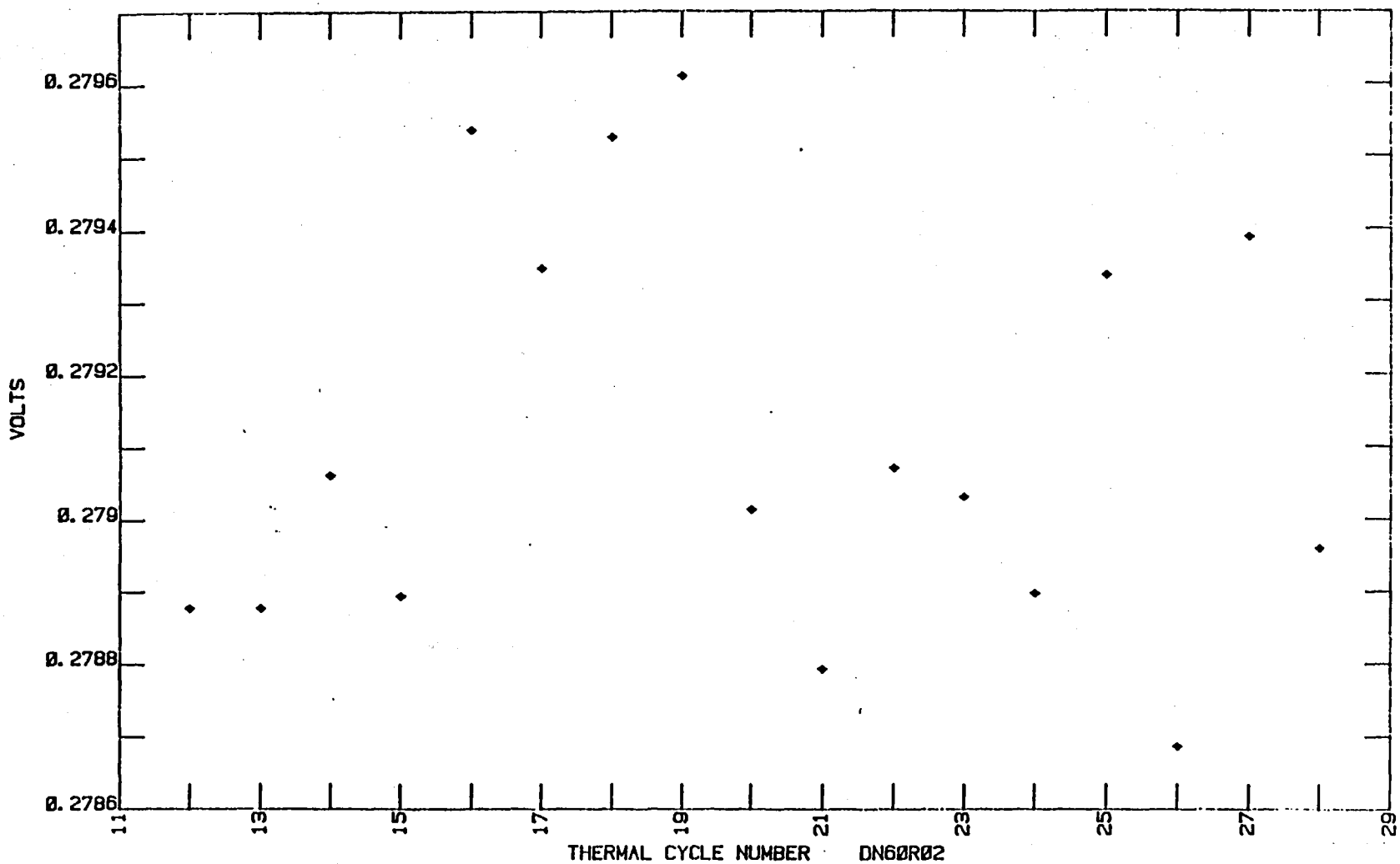


Figure 22. Results obtained at 60 °C during thermal cycling of diode number 2.

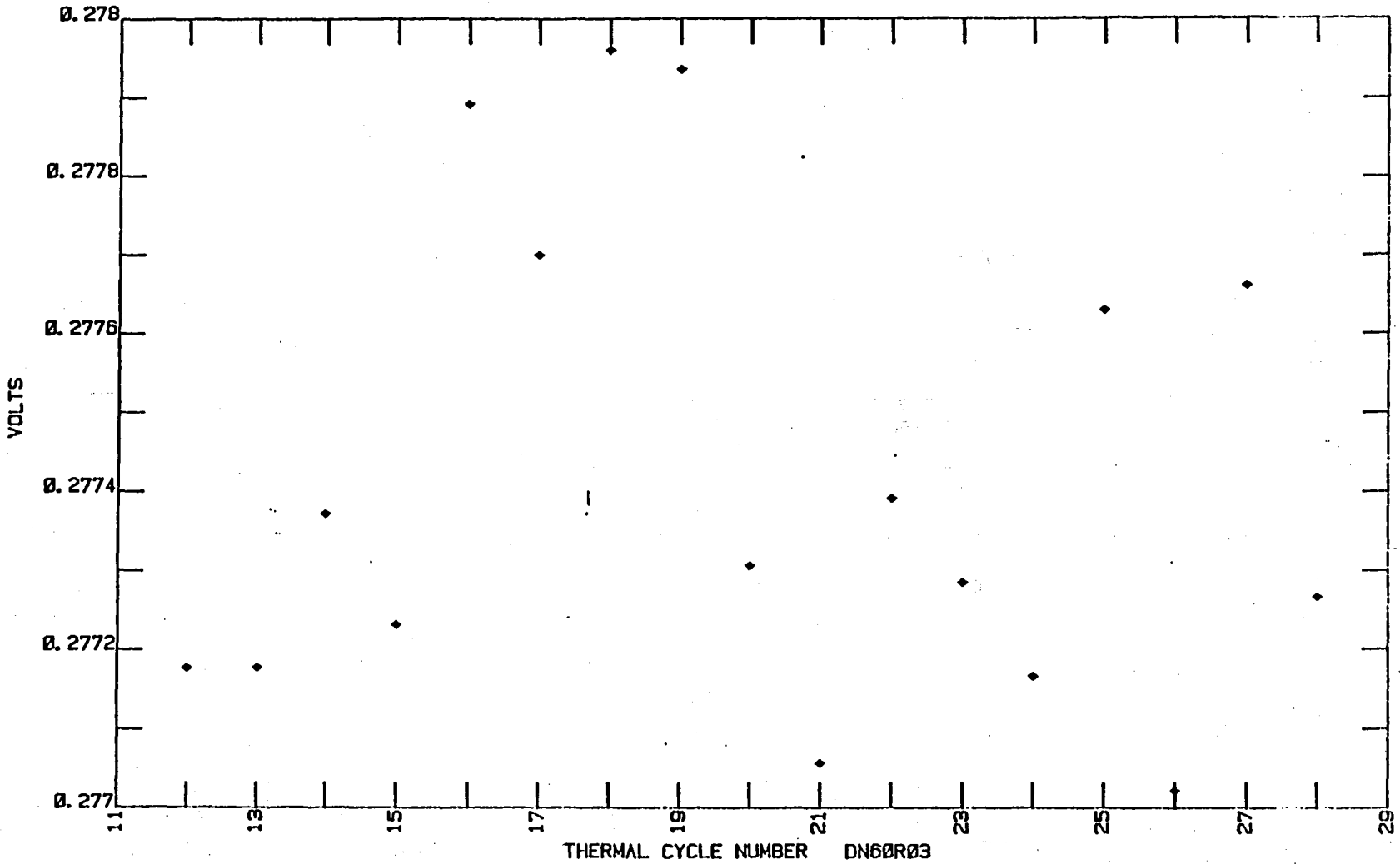


Figure 23. Results obtained at 60 °C during thermal cycling of diode number 3.

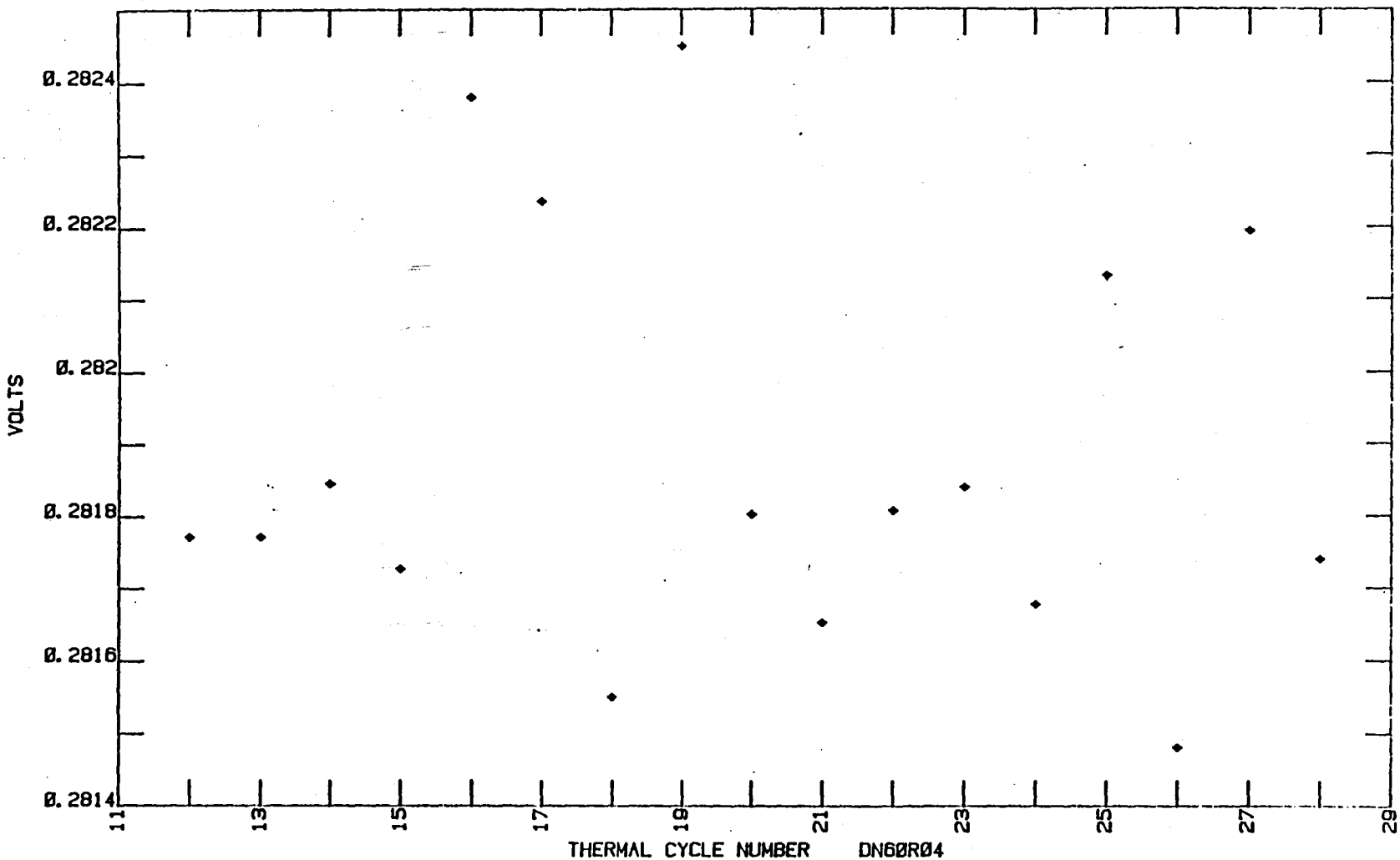


Figure 24. Results obtained at 60 °C during thermal cycling of diode number 4.

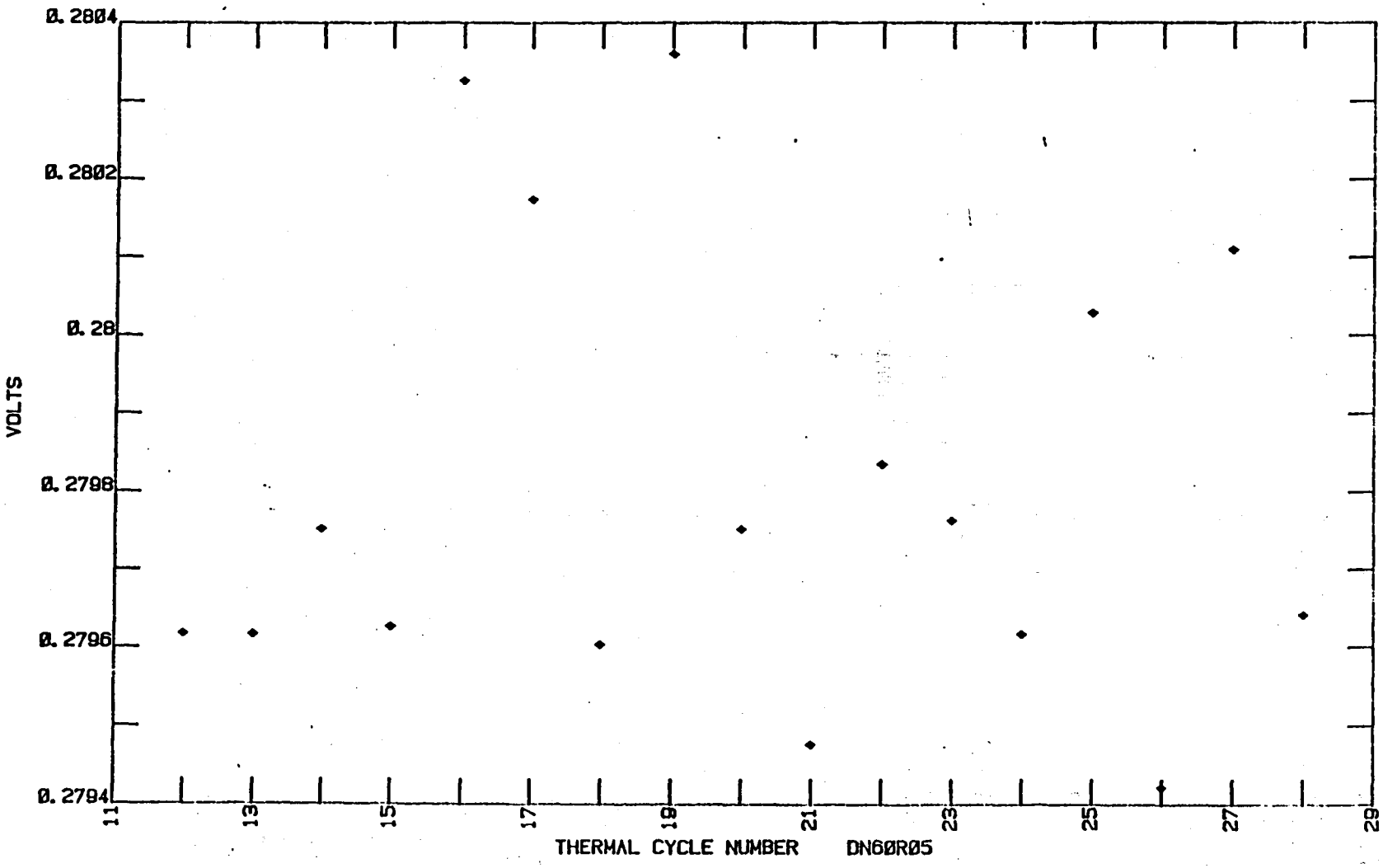


Figure 25. Results obtained at 60 °C during thermal cycling of diode number 5.

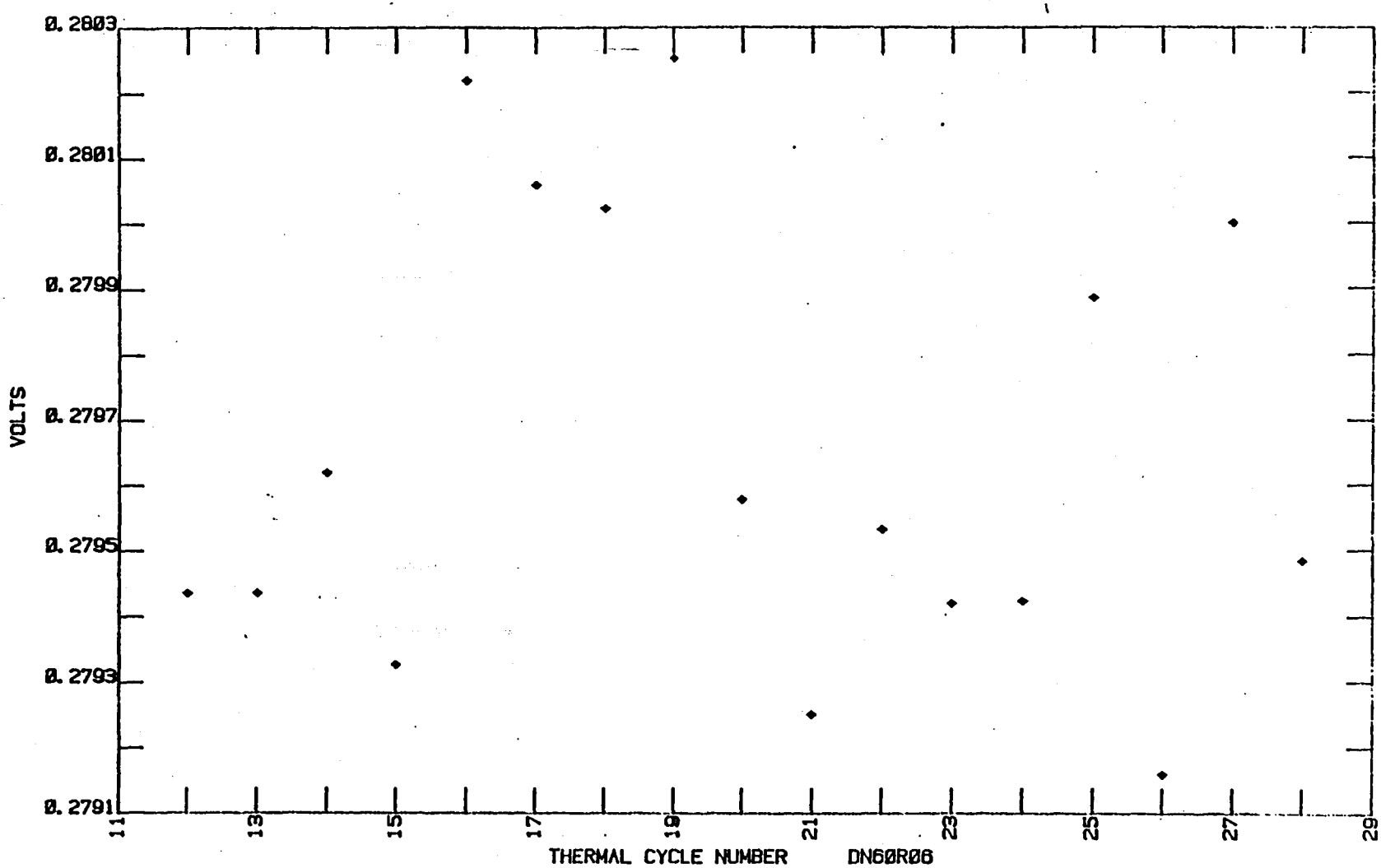


Figure 26. Results obtained at 60 °C during thermal cycling of diode number 6.

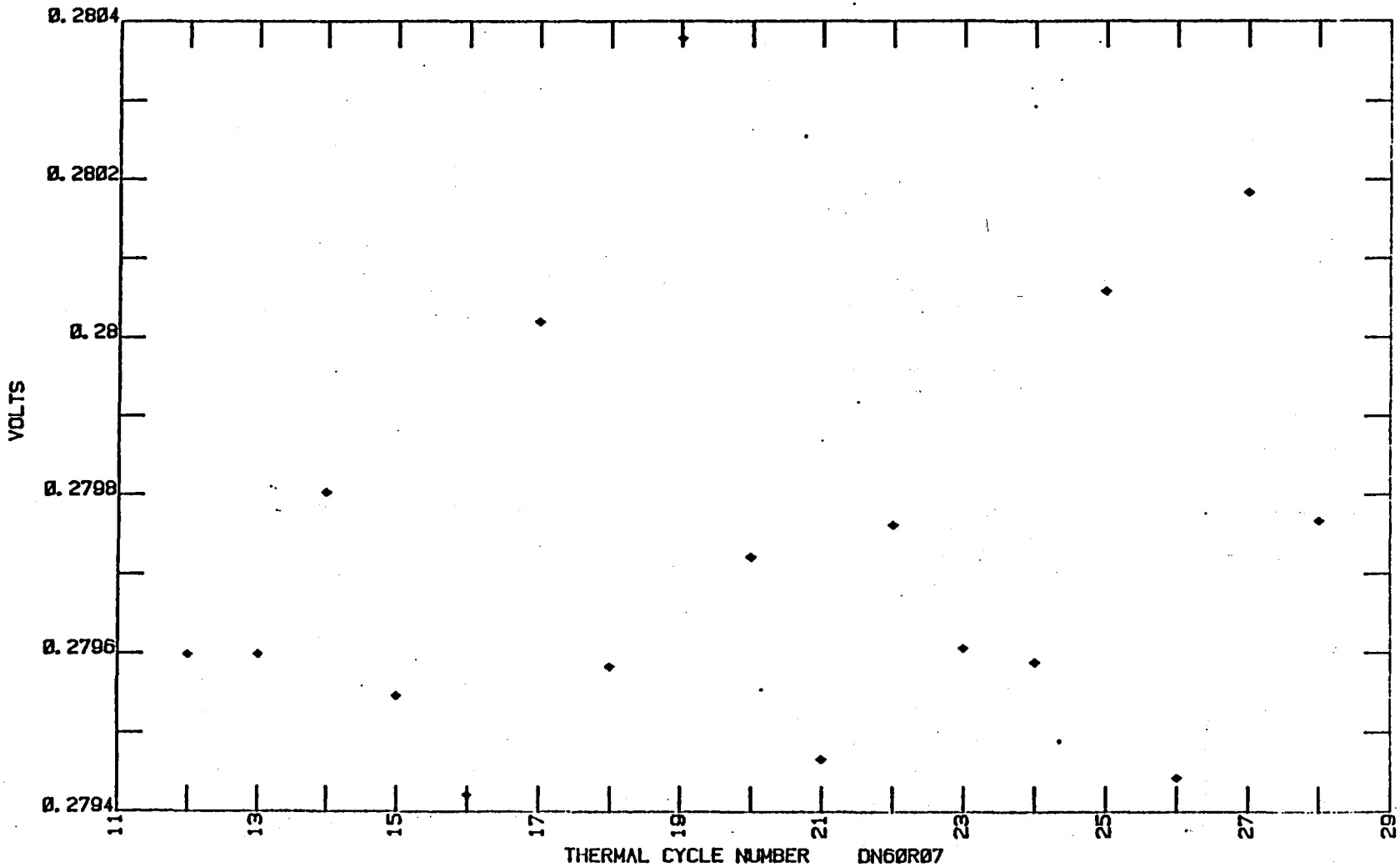


Figure 27. Results obtained at 60 °C during thermal cycling of diode number 7.

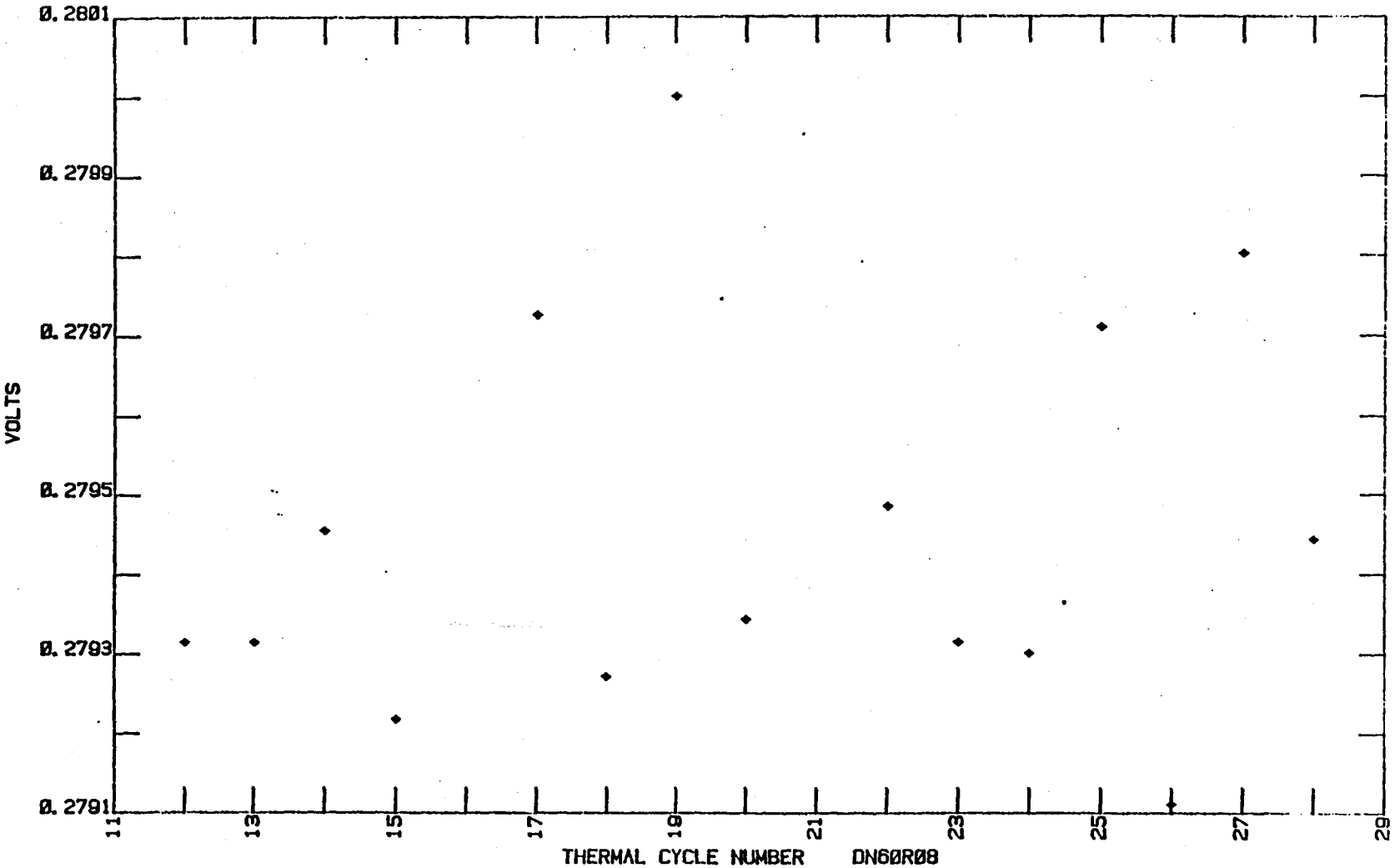


Figure 28. Results obtained at 60 °C during thermal cycling of diode number 8.

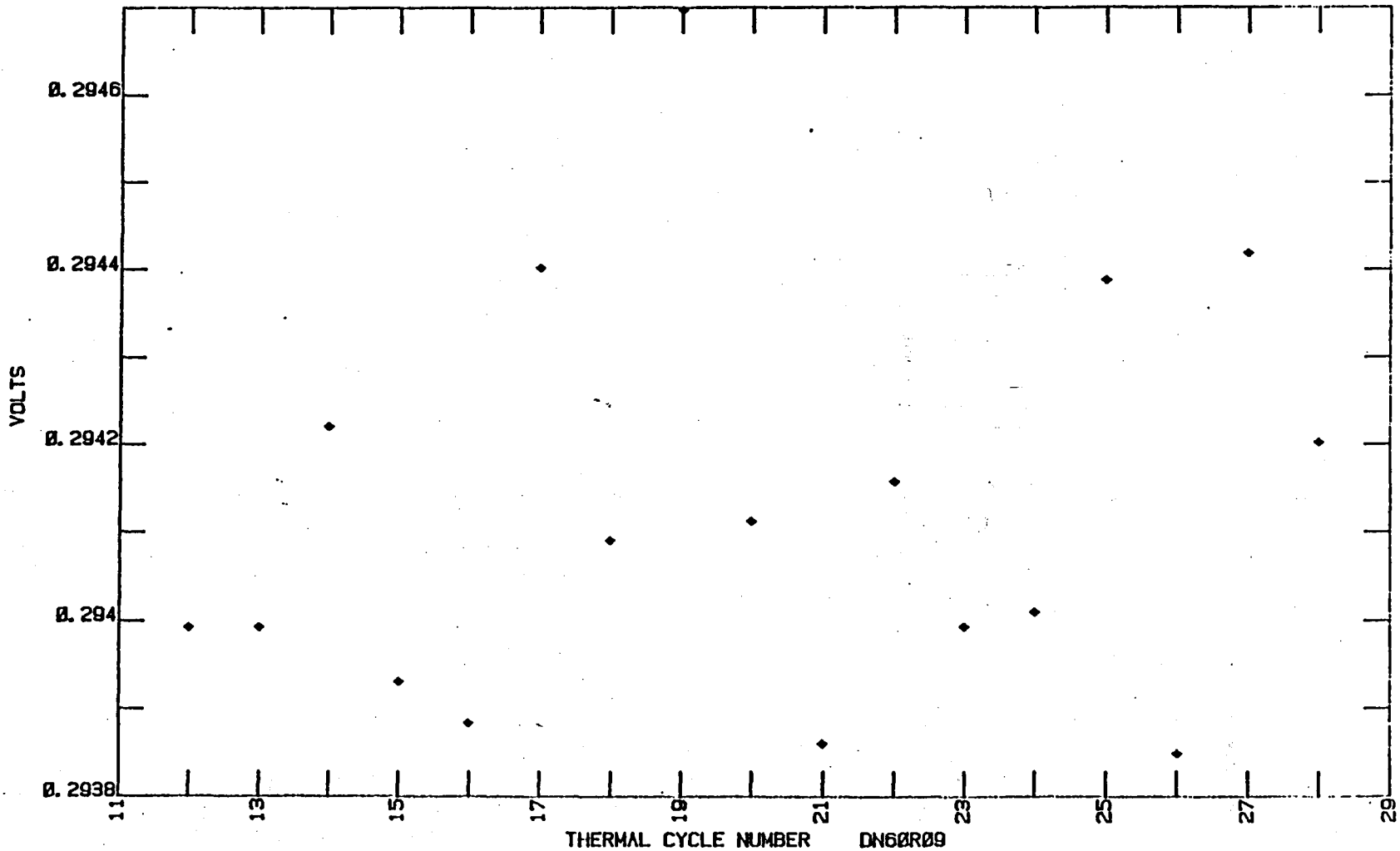


Figure 29. Results obtained at 60 °C during thermal cycling of diode number 9.

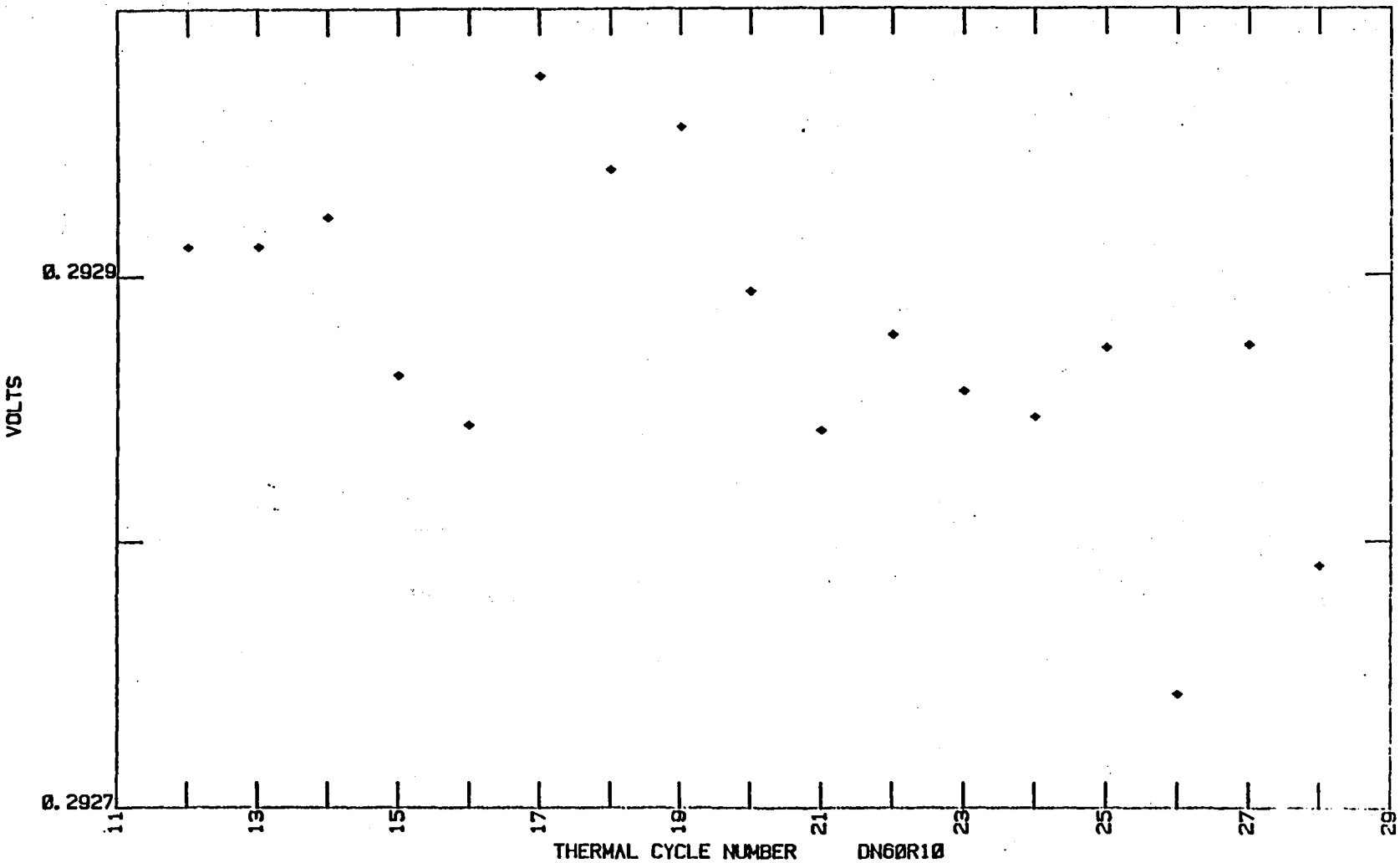


Figure 30. Results obtained at 60 °C during thermal cycling of diode number 10.

APPENDIX

Table A1. Data obtained for the 10 diode thermometers during thermal cycles 12 through 28.

```
>>RUN
ENTER THE FILENAME OF THE DATA TO BE READ : DN-T012
ENTER THE FILENAME OF 1ST PLOT FILE : DN0T012
ENTER THE FILENAME OF 2ND PLOT FILE : DN1T012
ENTER THE FILENAME OF 3RD PLOT FILE : DN2T012
ENTER THE FILENAME OF 4TH PLOT FILE : DN3T012
ENTER THE FILENAME OF 5TH PLOT FILE : DN4T012
ENTER THE FILENAME OF 6TH PLOT FILE : DN5T012
ENTER THE FILENAME OF 7TH PLOT FILE : DN6T012
ENTER THE FILENAME OF 8TH PLOT FILE : DN7T012
ENTER THE FILENAME OF 9TH PLOT FILE : DN8T012
ENTER THE FILENAME OF 10TH PLOT FILE : DN9T012
NUMBER              VOLTS               TEMPERATURE              TIME
DATA FOR DIODE NUMBER     1
27                  0.982172            -195.71736291197         085332
42                  0.665563            -78.698136583204         102350
57                  0.451559            7.4127967113976E-03      111840
72                  0.397013            20                       124327
87                  0.339997            40                       135908
102                 0.281374            60                       151846


DATA FOR DIODE NUMBER     2
28                  0.980902            -195.71736291197         085332
43                  0.66335             -78.698136583204         102350
58                  0.449316            7.4127967113976E-03      111840
73                  0.394896            20                       124327
88                  0.337689            40                       135908
103                 0.278878            60                       151846


DATA FOR DIODE NUMBER     3
29                  0.981021            -195.71736291197         085332
44                  0.662931            -78.698136583204         102350
59                  0.448471            7.4127967113976E-03      111840
74                  0.393742            20                       124327
89                  0.336205            40                       135908
104                 0.277177            60                       151846


DATA FOR DIODE NUMBER     4
30                  0.982293            -195.71736291197         085332
45                  0.666119            -78.698136583204         102350
60                  0.451974            7.4127967113976E-03      111840
```

75	0.397615	20	124327
90	0.340414	40	135908
105	0.281771	60	151846

DATA FOR DIODE NUMBER 5

31	0.981114	-195.71736291197	085332
46	0.663572	-78.698136583204	102350
61	0.449577	7.4127967113976E-03	111840
76	0.395401	20	124327
91	0.338324	40	135908
106	0.279617	60	151846

DATA FOR DIODE NUMBER 6

32	0.981383	-195.71736291197	085332
47	0.664599	-78.698136583204	102350
62	0.4501	7.4127967113976E-03	111840
77	0.395577	20	124327
92	0.338229	40	135908
107	0.279436	60	151846

DATA FOR DIODE NUMBER 7

33	0.981649	-195.71736291197	085332
48	0.664643	-78.698136583204	102350
63	0.450253	7.4127967113976E-03	111840
78	0.396018	20	124327
93	0.338415	40	135908
108	0.279599	60	151846

DATA FOR DIODE NUMBER 8

34	0.981695	-195.71736291197	085332
49	0.664606	-78.698136583204	102350
64	0.450382	7.4127967113976E-03	111840
79	0.395741	20	124327
94	0.33826	40	135908
109	0.279315	60	151846

DATA FOR DIODE NUMBER 9

35	0.985042	-195.71736291197	085332
50	0.673155	-78.698136583204	102350
65	0.46072	7.4127967113976E-03	111840
80	0.406954	20	124327
95	0.351263	40	135908
110	0.293993	60	151846

DATA FOR DIODE NUMBER 10

36	0.985279	-195.71736291197	085332
51	0.672427	-78.698136583204	102350
66	0.459789	7.4127967113976E-03	111840
81	0.405873	20	124327
96	0.349986	40	135908
111	0.292911	60	151846

830 End

```
>>RUN
ENTER THE FILENAME OF THE DATA TO BE READ : DN-T013
ENTER THE FILENAME OF 1ST PLOT FILE : DN0T013
ENTER THE FILENAME OF 2ND PLOT FILE : DN1T-1  013
ENTER THE FILENAME OF 3RD PLOT FILE : DN2T013
ENTER THE FILENAME OF 4TH PLOT FILE : DN3T013
ENTER THE FILENAME OF 5TH PLOT FILE : DN4T013
ENTER THE FILENAME OF 6TH PLOT FILE : DN5T013
ENTER THE FILENAME OF 7TH PLOT FILE : DN6T013
ENTER THE FILENAME OF 8TH PLOT FILE : DN7T013
ENTER THE FILENAME OF 9TH PLOT FILE : DN8T013
ENTER THE FILENAME OF 10TH PLOT FILE : DN9T013
NUMBER                VOLTS                TEMPERATURE              TIME
DATA FOR DIODE NUMBER      1
27                    0.982482             -195.6362443254          085037
42                    0.664422             -78.225686736174         102615
57                    0.451362             1.0995762501784E-03      112245
72                    0.396782             20                       124651
87                    0.339646             40                       140150


DATA FOR DIODE NUMBER      2
28                    0.980956             -195.6362443254          085037
43                    0.662706             -78.225686736174         102615
58                    0.449195             1.0995762501784E-03      112245
73                    0.394706             20                       124651
88                    0.337419             40                       140150


DATA FOR DIODE NUMBER      3
29                    0.981561             -195.6362443254          085037
44                    0.662383             -78.225686736174         102615
59                    0.448308             1.0995762501784E-03      112245
74                    0.393475             20                       124651
89                    0.335921             40                       140150


DATA FOR DIODE NUMBER      4
30                    0.982663             -195.6362443254          085037
45                    0.665287             -78.225686736174         102615
60                    0.451727             1.0995762501784E-03      112245
75                    0.397339             20                       124651
90                    0.340129             40                       140150


DATA FOR DIODE NUMBER      5
31                    0.981672             -195.6362443254          085037
46                    0.662188             -78.225686736174         102615
61                    0.449405             1.0995762501784E-03      112245
76                    0.395132             20                       124651
91                    0.338032             40                       140150


DATA FOR DIODE NUMBER      6
32                    0.981801             -195.6362443254          085037
47                    0.663294             -78.225686736174         102615
62                    0.449822             1.0995762501784E-03      112245
77                    0.395281             20                       124651
92                    0.33795              40                       140150
```

```
DATA FOR DIODE NUMBER      7
33                    0.982086          -195.6362443254       085037
48                    0.663275          -78.225686736174      102615
63                    0.45003           1.0995762501784E-03   112245
78                    0.395465          20                    124651
93                    0.338125          40                    140150


DATA FOR DIODE NUMBER      8
34                    0.982115          -195.6362443254       085037
49                    0.663474          -78.225686736174      102615
64                    0.450099          1.0995762501784E-03   112245
79                    0.395476          20                    124651
94                    0.337854          40                    140150


DATA FOR DIODE NUMBER      9
35                    0.985261          -195.6362443254       085037
50                    0.672159          -78.225686736174      102615
65                    0.460467          1.0995762501784E-03   112245
80                    0.406983          20                    124651
95                    0.350893          40                    140150


DATA FOR DIODE NUMBER      10
36                    0.98524           -195.6362443254       085037
51                    0.671475          -78.225686736174      102615
66                    0.459751          1.0995762501784E-03   112245
81                    0.405897          20                    124651
96                    0.34992           40                    140150


***630 End***
```

```
>>RUN
ENTER THE FILENAME OF THE DATA TO BE READ : DN-T014
ENTER THE FILENAME OF 1ST PLOT FILE : DN0T014
ENTER THE FILENAME OF 2ND PLOT FILE : DN1T014
ENTER THE FILENAME OF 3RD PLOT FILE : DN2T014
ENTER THE FILENAME OF 4TH PLOT FILE : DN3T014
ENTER THE FILENAME OF 5TH PLOT FILE : DN4T014
ENTER THE FILENAME OF 6TH PLOT FILE : DN5T014
ENTER THE FILENAME OF 7TH PLOT FILE : DN6T014
ENTER THE FILENAME OF 8TH PLOT FILE : DN7T014
ENTER THE FILENAME OF 9TH PLOT FILE : DN8T014
ENTER THE FILENAME OF 10TH PLOT FILE : DN9T014
NUMBER                VOLTS                 TEMPERATURE              TIME
DATA FOR DIODE NUMBER      1
27                    0.981726              -195.68992862837         085457
42                    0.66466               -78.295702656872         103451
57                    0.451521              0.018637082763721        112921
72                    0.396694              20                       125125
87                    0.339689              40                       140733
102                   0.281467              60                       152923


DATA FOR DIODE NUMBER      2
28                    0.980234              -195.68992862837         085457
43                    0.66262               -78.295702656872         103451
58                    0.449537              0.018637082763721        112921
73                    0.394575              20                       125125
88                    0.337403              40                       140733
103                   0.279061              60                       152923


DATA FOR DIODE NUMBER      3
29                    0.980621              -195.68992862837         085457
44                    0.662193              -78.295702656872         103451
59                    0.448655              0.018637082763721        112921
74                    0.39333               20                       125125
89                    0.335965              40                       140733
104                   0.277373              60                       152923


DATA FOR DIODE NUMBER      4
30                    0.981005              -195.68992862837         085457
45                    0.665005              -78.295702656872         103451
60                    0.452187              0.018637082763721        112921
75                    0.39722               20                       125125
90                    0.340109              40                       140733
105                   0.281845              60                       152923


DATA FOR DIODE NUMBER      5
31                    0.980831              -195.68992862837         085457
46                    0.662459              -78.295702656872         103451
61                    0.449773              0.018637082763721        112921
76                    0.395002              20                       125125
91                    0.338091              40                       140733
106                   0.279752              60                       152923


DATA FOR DIODE NUMBER      6
32                    0.981081              -195.68992862837         085457
```

47	0.66348	-78.295702656872	103451
62	0.450239	0.018637082763721	112921
77	0.395095	20	125125
92	0.338029	40	140733
107	0.279619	60	152923

DATA FOR DIODE NUMBER 7

33	0.981265	-195.68992862837	085457
48	0.663543	-78.295702656872	103451
63	0.450422	0.018637082763721	112921
78	0.395347	20	125125
93	0.338217	40	140733
108	0.279803	60	152923

DATA FOR DIODE NUMBER 8

34	0.981332	-195.68992862837	085457
49	0.663686	-78.295702656872	103451
64	0.450503	0.018637082763721	112921
79	0.395339	20	125125
94	0.338065	40	140733
109	0.279455	60	152923

DATA FOR DIODE NUMBER 9

35	0.984772	-195.68992862837	085457
50	0.672368	-78.295702656872	103451
65	0.46084	0.018637082763721	112921
80	0.406867	20	125125
95	0.351112	40	140733
110	0.294221	60	152923

DATA FOR DIODE NUMBER 10

36	0.98518	-195.68992862837	085457
51	0.671834	-78.295702656872	103451
66	0.459793	0.018637082763721	112921
81	0.405868	20	125125
96	0.349945	40	140733
111	0.292922	60	152923

530 End

```
>>RUN
ENTER THE FILENAME OF THE DATA TO BE READ : DN-T015
ENTER THE FILENAME OF 1ST PLOT FILE : DN0T015
ENTER THE FILENAME OF 2ND PLOT FILE : DN1T015
ENTER THE FILENAME OF 3RD PLOT FILE : DN2T015
ENTER THE FILENAME OF 4TH PLOT FILE : DN3T015
ENTER THE FILENAME OF 5TH PLOT FILE : DN4T015
ENTER THE FILENAME OF 6TH PLOT FILE : DN5T015
ENTER THE FILENAME OF 7TH PLOT FILE : DN6T015
ENTER THE FILENAME OF 8TH PLOT FILE : DN7T015
ENTER THE FILENAME OF 9TH PLOT FILE : DN8T015
ENTER THE FILENAME OF 10TH PLOT FILE : DN9T015
NUMBER              VOLTS               TEMPERATURE          TIME
DATA FOR DIODE NUMBER     1
27                  0.983218            -195.7783896195      085835
42                  0.665553            -78.432341387718     101955
57                  0.451389            -9.70738516625E-03   111320
72                  0.397015            20                   130728
87                  0.339762            40                   141746
102                 0.281312            60                   153522


DATA FOR DIODE NUMBER     2
28                  0.981636            -195.7783896195      085835
43                  0.663922            -78.432341387718     101955
58                  0.449816            -9.70738516625E-03   111320
73                  0.394948            20                   130728
88                  0.337523            40                   141746
103                 0.278894            60                   153522


DATA FOR DIODE NUMBER     3
29                  0.981933            -195.7783896195      085835
44                  0.662905            -78.432341387718     101955
59                  0.448974            -9.70738516625E-03   111320
74                  0.393704            20                   130728
89                  0.336127            40                   141746
104                 0.277231            60                   153522


DATA FOR DIODE NUMBER     4
30                  0.98308             -195.7783896195      085835
45                  0.664948            -78.432341387718     101955
60                  0.452482            -9.70738516625E-03   111320
75                  0.397561            20                   130728
90                  0.340297            40                   141746
105                 0.281727            60                   153522


DATA FOR DIODE NUMBER     5
31                  0.981907            -195.7783896195      085835
46                  0.662293            -78.432341387718     101955
61                  0.449974            -9.70738516625E-03   111320
76                  0.395302            20                   130728
91                  0.338245            40                   141746
106                 0.279626            60                   153522


DATA FOR DIODE NUMBER     6
32                  0.981857            -195.7783896195      085835
```

47	0.663148	-78.432341387718	101955
62	0.450565	-9.70738516625E-03	111320
77	0.395504	20	130728
92	0.338202	40	141746
107	0.279327	60	153522

DATA FOR DIODE NUMBER 7

33	0.98207	-195.7783896195	085835
48	0.663548	-78.432341387718	101955
63	0.450679	-9.70738516625E-03	111320
78	0.395656	20	130728
93	0.338305	40	141746
108	0.279546	60	153522

DATA FOR DIODE NUMBER 8

34	0.982224	-195.7783896195	085835
49	0.663195	-78.432341387718	101955
64	0.450776	-9.70738516625E-03	111320
79	0.395624	20	130728
94	0.33806	40	141746
109	0.279218	60	153522

DATA FOR DIODE NUMBER 9

35	0.98549	-195.7783896195	085835
50	0.672314	-78.432341387718	101955
65	0.461088	-9.70738516625E-03	111320
80	0.407048	20	130728
95	0.351209	40	141746
110	0.293931	60	153522

DATA FOR DIODE NUMBER 10

36	0.985678	-195.7783896195	085835
51	0.67199	-78.432341387718	101955
66	0.459849	-9.70738516625E-03	111320
81	0.40587	20	130728
96	0.349921	40	141746
111	0.292863	60	153522

630 End

```
>>RUN
ENTER THE FILENAME OF THE DATA TO BE READ : DN-T016
ENTER THE FILENAME OF 1ST PLOT FILE : DN0T016
ENTER THE FILENAME OF 2ND PLOT FILE : DN1T016
ENTER THE FILENAME OF 3RD PLOT FILE : DN2T016
ENTER THE FILENAME OF 4TH PLOT FILE : DN3T016
ENTER THE FILENAME OF 5TH PLOT FILE : DN4T016
ENTER THE FILENAME OF 6TH PLOT FILE : DN5T016
ENTER THE FILENAME OF 7TH PLOT FILE : DN6T016
ENTER THE FILENAME OF 8TH PLOT FILE : DN7T016
ENTER THE FILENAME OF 9TH PLOT FILE : DN8T016
ENTER THE FILENAME OF 10TH PLOT FILE : DN9T016
NUMBER              VOLTS              TEMPERATURE              TIME
DATA FOR DIODE NUMBER     1
27                  0.981986           -195.72089222783         090048
42                  0.664468           -78.326142129156         102318
57                  0.451622           -3.2412089668258E-03     111615
72                  0.397088           20                       124422
87                  0.340051           40                       135752
102                 0.281639           60                       153130


DATA FOR DIODE NUMBER     2
28                  0.980879           -195.72089222783         090048
43                  0.662244           -78.326142129156         102318
58                  0.449886           -3.2412089668258E-03     111615
73                  0.395037           20                       124422
88                  0.337877           40                       135752
103                 0.279538           60                       153130


DATA FOR DIODE NUMBER     3
29                  0.981232           -195.72089222783         090048
44                  0.661824           -78.326142129156         102318
59                  0.448951           -3.2412089668258E-03     111615
74                  0.393802           20                       124422
89                  0.33627            40                       135752
104                 0.277892           60                       153130


DATA FOR DIODE NUMBER     4
30                  0.982556           -195.72089222783         090048
45                  0.664698           -78.326142129156         102318
60                  0.45379            -3.2412089668258E-03     111615
75                  0.397642           20                       124422
90                  0.340487           40                       135752
105                 0.28038            60                       153130


DATA FOR DIODE NUMBER     5
31                  0.981526           -195.72089222783         090048
46                  0.662316           -78.326142129156         102318
61                  0.450369           -3.2412089668258E-03     111615
76                  0.395426           20                       124422
91                  0.338385           40                       135752
106                 0.280325           60                       153130


DATA FOR DIODE NUMBER     6
32                  0.981848           -195.72089222783         090048
```

```
47                    0.663259        -78.326142129156     102318
62                    0.450988        -3.2412089662586E-03 111615
77                    0.395635        20                   124422
92                    0.338328        40                   135752
107                   0.280218        60                   153130


DATA FOR DIODE NUMBER     7
33                    0.982013        -195.72089222783     090048
48                    0.663293        -78.326142129156     102318
63                    0.450943        -3.2412089662586E-03 111615
78                    0.395797        20                   124422
93                    0.338481        40                   135752
108                   0.279421        60                   153130


DATA FOR DIODE NUMBER     8
34                    0.982013        -195.72089222783     090048
49                    0.663421        -78.326142129156     102318
64                    0.451006        -3.2412089662586E-03 111615
79                    0.395753        20                   124422
94                    0.338315        40                   135752
109                   0.279063        60                   153130


DATA FOR DIODE NUMBER     9
35                    0.985404        -195.72089222783     090048
50                    0.672211        -78.326142129156     102318
65                    0.461278        -3.2412089662586E-03 111615
80                    0.407203        20                   124422
95                    0.351294        40                   135752
110                   0.293884        60                   153130


DATA FOR DIODE NUMBER     10
36                    0.985386        -195.72089222783     090048
51                    0.671727        -78.326142129156     102318
66                    0.459885        -3.2412089662586E-03 111615
81                    0.40552         20                   124422
96                    0.349972        40                   135752
111                   0.292844        60                   153130

***630 End***
```

```
>>RUN
ENTER THE FILENAME OF THE DATA TO BE READ : DN-T017
ENTER THE FILENAME OF 1ST PLOT FILE : DN0T017
ENTER THE FILENAME OF 2ND PLOT FILE : DN1T017
ENTER THE FILENAME OF 3RD PLOT FILE : DN2T017
ENTER THE FILENAME OF 4TH PLOT FILE : DN3T017
ENTER THE FILENAME OF 5TH PLOT FILE : DN4T017
ENTER THE FILENAME OF 6TH PLOT FILE : DN5T017
ENTER THE FILENAME OF 7TH PLOT FILE : DN6T017
ENTER THE FILENAME OF 8TH PLOT FILE : DN7T017
ENTER THE FILENAME OF 9TH PLOT FILE : DN8T017
ENTER THE FILENAME OF 10TH PLOT FILE : DN9T017
NUMBER              VOLTS               TEMPERATURE          TIME
DATA FOR DIODE NUMBER     1
27                  0.98167             -195.62975768839     085922
42                  0.663794            -78.247488471118     102858
57                  0.451273            -7.583041257834E-03  111734
72                  0.397058            20                   124404
87                  0.339766            40                   135437
102                 0.281585            60                   151355


DATA FOR DIODE NUMBER     2
28                  0.980436            -195.62975768839     085922
43                  0.661434            -78.247488471118     102858
58                  0.449017            -7.583041257834E-03  111734
73                  0.394999            20                   124404
88                  0.337507            40                   135437
103                 0.279348            60                   151355


DATA FOR DIODE NUMBER     3
29                  0.980635            -195.62975768839     085922
44                  0.661057            -78.247488471118     102858
59                  0.448313            -7.583041257834E-03  111734
74                  0.393739            20                   124404
89                  0.336046            40                   135437
104                 0.2777              60                   151355


DATA FOR DIODE NUMBER     4
30                  0.981751            -195.62975768839     085922
45                  0.663905            -78.247488471118     102858
60                  0.451807            -7.583041257834E-03  111734
75                  0.397805            20                   124404
90                  0.340253            40                   135437
105                 0.282237            60                   151355


DATA FOR DIODE NUMBER     5
31                  0.980279            -195.62975768839     085922
46                  0.661335            -78.247488471118     102858
61                  0.449449            -7.583041257834E-03  111734
76                  0.395578            20                   124404
91                  0.338158            40                   135437
106                 0.280174            60                   151355


DATA FOR DIODE NUMBER     6
32                  0.981167            -195.62975768839     085922
```

```
-7                      0.662065        -78.247488471118        102858
32                      0.449925        -7.583041257834E-03     111734
77                      0.395974        20                      124404
92                      0.338107        40                      135437
107                     0.280059        60                      151355


DATA FOR DIODE NUMBER     7
33                      0.981323        -195.62975768839        085922
48                      0.662234        -78.247488471118        102858
63                      0.450125        -7.583041257834E-03     111734
78                      0.396119        20                      124404
93                      0.338345        40                      135437
108                     0.28002         60                      151355


DATA FOR DIODE NUMBER     8
34                      0.981258        -195.62975768839        085922
49                      0.662559        -78.247488471118        102858
64                      0.450226        -7.583041257834E-03     111734
79                      0.396041        20                      124404
94                      0.338143        40                      135437
109                     0.279727        60                      151355


DATA FOR DIODE NUMBER     9
35                      0.984584        -195.62975768839        085922
50                      0.671401        -78.247488471118        102858
65                      0.460646        -7.583041257834E-03     111734
80                      0.407441        20                      124404
95                      0.351079        40                      135437
110                     0.294402        60                      151355


DATA FOR DIODE NUMBER     10
36                      0.985174        -195.62975768839        085922
51                      0.67143         -78.247488471118        102858
66                      0.459787        -7.583041257834E-03     111734
81                      0.405952        20                      124404
96                      0.34995         40                      135437
111                     0.292975        60                      151355

***630 End***
```

```
>>RUN
ENTER THE FILENAME OF THE DATA TO BE READ : DN-T018
ENTER THE FILENAME OF 1ST PLOT FILE : DN0T018
ENTER THE FILENAME OF 2ND PLOT FILE : DN1T018
ENTER THE FILENAME OF 3RD PLOT FILE : DN2T018
ENTER THE FILENAME OF 4TH PLOT FILE : DN3T018
ENTER THE FILENAME OF 5TH PLOT FILE : DN4T018
ENTER THE FILENAME OF 6TH PLOT FILE : DN5T018
ENTER THE FILENAME OF 7TH PLOT FILE : DN6T018
ENTER THE FILENAME OF 8TH PLOT FILE : DN7T018
ENTER THE FILENAME OF 9TH PLOT FILE : DN8T018
ENTER THE FILENAME OF 10TH PLOT FILE : DN9T018
NUMBER              VOLTS               TEMPERATURE              TIME
DATA FOR DIODE NUMBER     1
27                  0.982627            -195.80452673782         090417
42                  0.664314            -78.458389845886         102029
57                  0.451224            -0.013562730198816       112058
72                  0.396696            20                       124157
87                  0.339901            40                       135134
102                 0.28182             60                       151144

DATA FOR DIODE NUMBER     2
28                  0.981411            -195.80452673782         090417
43                  0.66212             -78.458389845886         102029
58                  0.449067            -0.013562730198816       112058
73                  0.394503            20                       124157
88                  0.33765             40                       135134
103                 0.279528            60                       151144

DATA FOR DIODE NUMBER     3
29                  0.98163             -195.80452673782         090417
44                  0.661695            -78.458389845886         102029
59                  0.448128            -0.013562730198816       112058
74                  0.393332            20                       124157
89                  0.336184            40                       135134
104                 0.27796             60                       151144

DATA FOR DIODE NUMBER     4
30                  0.982819            -195.80452673782         090417
45                  0.664685            -78.458389845886         102029
60                  0.451684            -0.013562730198816       112058
75                  0.397216            20                       124157
90                  0.340403            40                       135134
105                 0.28155             60                       151144

DATA FOR DIODE NUMBER     5
31                  0.981778            -195.80452673782         090417
46                  0.662029            -78.458389845886         102029
61                  0.449366            -0.013562730198816       112058
76                  0.395006            20                       124157
91                  0.33827             40                       135134
106                 0.279603            60                       151144

DATA FOR DIODE NUMBER     6
32                  0.981972            -195.80452673782         090417
```

47	0.66289	-78.458389845886	102029
62	0.449732	-0.013562730198816	112058
77	0.395115	20	124157
92	0.338213	40	135134
107	0.280023	60	151144

DATA FOR DIODE NUMBER 7

33	0.982136	-195.80452673782	090417
48	0.663203	-78.458389845886	102029
63	0.449954	-0.013562730198816	112058
78	0.395355	20	124157
93	0.338356	40	135134
108	0.279583	60	151144

DATA FOR DIODE NUMBER 8

34	0.982218	-195.80452673782	090417
49	0.6633	-78.458389845886	102029
64	0.450057	-0.013562730198816	112058
79	0.395329	20	124157
94	0.338184	40	135134
109	0.279272	60	151144

DATA FOR DIODE NUMBER 9

35	0.985549	-195.80452673782	090417
50	0.672065	-78.458389845886	102029
65	0.460427	-0.013562730198816	112058
80	0.406782	20	124157
95	0.351203	40	135134
110	0.294091	60	151144

DATA FOR DIODE NUMBER 10

36	0.985672	-195.80452673782	090417
51	0.672068	-78.458389845886	102029
66	0.459793	-0.013562730198816	112058
81	0.405912	20	124157
96	0.349996	40	135134
111	0.29294	60	151144

630 End

```
))P RUN
ENTER THE FILENAME OF THE DATA TO BE READ : DN-T019
ENTER THE FILENAME OF 1ST PLOT FILE : DN0T019
ENTER THE FILENAME OF 2ND PLOT FILE : DN1T019
ENTER THE FILENAME OF 3RD PLOT FILE : DN2T019
ENTER THE FILENAME OF 4TH PLOT FILE : DN3T019
ENTER THE FILENAME OF 5TH PLOT FILE : DN4T019
ENTER THE FILENAME OF 6TH PLOT FILE : DN5T019
ENTER THE FILENAME OF 7TH PLOT FILE : DN6T019
ENTER THE FILENAME OF 8TH PLOT FILE : DN7T019
ENTER THE FILENAME OF 9TH PLOT FILE : DN8T019
ENTER THE FILENAME OF 10TH PLOT FILE : DN9T019
NUMBER              VOLTS               TEMPERATURE              TIME
DATA FOR DIODE NUMBER     1
27                  0.982272            -195.79532659034         090402
42                  0.664601            -78.523866236764         102208
57                  0.451579            -5.041899449764E-03      111921
72                  0.397115            20                       124516
87                  0.339633            40                       135807
102                 0.281741            60                       150926


DATA FOR DIODE NUMBER     2
28                  0.981045            -195.79532659034         090402
43                  0.662492            -78.523866236764         102208
58                  0.449504            -5.041899449764E-03      111921
73                  0.394956            20                       124516
88                  0.337312            40                       135807
103                 0.279611            60                       150926


DATA FOR DIODE NUMBER     3
29                  0.981241            -195.79532659034         090402
44                  0.662116            -78.523866236764         102208
59                  0.448719            -5.041899449764E-03      111921
74                  0.393692            20                       124516
89                  0.335741            40                       135807
104                 0.277936            60                       150926


DATA FOR DIODE NUMBER     4
30                  0.982348            -195.79532659034         090402
45                  0.665001            -78.523866236764         102208
60                  0.452234            -5.041899449764E-03      111921
75                  0.39754             20                       124516
90                  0.33997             40                       135807
105                 0.282449            60                       150926


DATA FOR DIODE NUMBER     5
31                  0.981368            -195.79532659034         090402
46                  0.662467            -78.523866236764         102208
61                  0.450419            -5.041899449764E-03      111921
76                  0.395333            20                       124516
91                  0.337915            40                       135807
106                 0.28036             60                       150926


DATA FOR DIODE NUMBER     6
32                  0.981585            -195.79532659034         090402
```

47	0.663204	-78.523866236764	102208
62	0.45104	-5.041899449764E-03	111921
77	0.395516	20	124516
92	0.337808	40	135807
107	0.280253	60	150926

DATA FOR DIODE NUMBER 7

33	0.981687	-195.79532659034	090402
48	0.663471	-78.523866236764	102208
63	0.451126	-5.041899449764E-03	111921
78	0.395647	20	124516
93	0.337946	40	135807
108	0.280379	60	150926

DATA FOR DIODE NUMBER 8

34	0.981623	-195.79532659034	090402
49	0.663633	-78.523866236764	102208
64	0.451112	-5.041899449764E-03	111921
79	0.395604	20	124516
94	0.338299	40	135807
109	0.280001	60	150926

DATA FOR DIODE NUMBER 9

35	0.985107	-195.79532659034	090402
50	0.672417	-78.523866236764	102208
65	0.460733	-5.041899449764E-03	111921
80	0.406995	20	124516
95	0.351274	40	135807
110	0.294697	60	150926

DATA FOR DIODE NUMBER 10

36	0.985568	-195.79532659034	090402
51	0.672227	-78.523866236764	102208
66	0.459795	-5.041899449764E-03	111921
81	0.405877	20	124516
96	0.349916	40	135807
111	0.292956	60	150926

630 End

```
>>RUN
ENTER THE FILENAME OF THE DATA TO BE READ : DN-T020
ENTER THE FILENAME OF 1ST PLOT FILE : DN0T020
ENTER THE FILENAME OF 2ND PLOT FILE : DN1T020
ENTER THE FILENAME OF 3RD PLOT FILE : DN2T020
ENTER THE FILENAME OF 4TH PLOT FILE : DN3T020
ENTER THE FILENAME OF 5TH PLOT FILE : DN4T020
ENTER THE FILENAME OF 6TH PLOT FILE : DN5T020
ENTER THE FILENAME OF 7TH PLOT FILE : DN6T020
ENTER THE FILENAME OF 8TH PLOT FILE : DN7T020
ENTER THE FILENAME OF 9TH PLOT FILE : DN8T020
ENTER THE FILENAME OF 10TH PLOT FILE : DN9T020
NUMBER                VOLTS                  TEMPERATURE              TIME
DATA FOR DIODE NUMBER      1
27                    0.988027               -195.74988984897         085343
42                    0.664161               -78.341159197956         101931
57                    0.451311               4.522603656094 8E-03     111444
72                    0.39675                20                       123505
87                    0.339799               40                       133543
102                   0.281427               60                       143535


DATA FOR DIODE NUMBER      2
28                    0.980818               -195.74988984897         085343
43                    0.661816               -78.341159197956         101931
58                    0.449089               4.522603656094 8E-03     111444
73                    0.394709               20                       123505
88                    0.33759                40                       133543
103                   0.279014               60                       143535


DATA FOR DIODE NUMBER      3
29                    0.980965               -195.74988984897         085343
44                    0.661542               -78.341159197956         101931
59                    0.448247               4.522603656094 8E-03     111444
74                    0.393482               20                       123505
89                    0.336054               40                       133543
104                   0.277306               60                       143535


DATA FOR DIODE NUMBER      4
30                    0.98811                -195.74988984897         085343
45                    0.664319               -78.341159197956         101931
60                    0.451753               4.522603656094 8E-03     111444
75                    0.397272               20                       123505
90                    0.340285               40                       133543
105                   0.281502               60                       143535


DATA FOR DIODE NUMBER      5
31                    0.981812               -195.74988984897         085343
46                    0.661927               -78.341159197956         101931
61                    0.448329               4.522603656094 8E-03     111444
76                    0.393136               20                       123505
91                    0.338186               40                       133543
106                   0.279752               60                       143535


DATA FOR DIODE NUMBER      6
32                    0.981402               -195.74988984897         085343
```

47	0.662837	-78.341159197956	101931
62	0.449833	4.522603656094 8E-03	111444
77	0.395218	20	123505
92	0.338167	40	133543
107	0.279578	60	143535

DATA FOR DIODE NUMBER 7

33	0.981637	-195.74988984897	085343
48	0.662987	-78.341159197956	101931
63	0.449877	4.522603656094 8E-03	111444
78	0.393454	20	123505
93	0.338268	40	133543
108	0.279572	60	143535

DATA FOR DIODE NUMBER 8

34	0.981633	-195.74988984897	085343
49	0.662951	-78.341159197956	101931
64	0.450021	4.522603656094 8E-03	111444
79	0.395424	20	123505
94	0.338115	40	133543
109	0.279344	60	143535

DATA FOR DIODE NUMBER 9

35	0.984876	-195.74988984897	085343
50	0.671952	-78.341159197956	101931
65	0.460402	4.522603656094 8E-03	111444
80	0.406917	20	123505
95	0.351145	40	133543
110	0.294112	60	143535

DATA FOR DIODE NUMBER 10

36	0.985373	-195.74988984897	085343
51	0.671763	-78.341159197956	101931
66	0.459736	4.522603656094 8E-03	111444
81	0.405856	20	123505
96	0.349084	40	133543
111	0.292894	60	143535

```
>>RUN
ENTER THE FILENAME OF THE DATA TO BE READ : DN-T021
ENTER THE FILENAME OF 1ST PLOT FILE : DN0T021
ENTER THE FILENAME OF 2ND PLOT FILE : DN1T021
ENTER THE FILENAME OF 3RD PLOT FILE : DN2T021
ENTER THE FILENAME OF 4TH PLOT FILE : DN3T021
ENTER THE FILENAME OF 5TH PLOT FILE : DN4T021
ENTER THE FILENAME OF 6TH PLOT FILE : DN5T021
ENTER THE FILENAME OF 7TH PLOT FILE : DN6T021
ENTER THE FILENAME OF 8TH PLOT FILE : DN7T021
ENTER THE FILENAME OF 9TH PLOT FILE : DN8T021
ENTER THE FILENAME OF 10TH PLOT FILE : DN9T021
NUMBER                VOLTS                TEMPERATURE                TIME
DATA FOR DIODE NUMBER      1
27                    0.982385             -195.80173504176           083734
42                    0.664689             -78.446668319666           094921
57                    0.451466             7.0301860261164E-03        104523
72                    0.396792             20                         115843
87                    0.339674             40                         130537
102                   0.281347             60                         140654


DATA FOR DIODE NUMBER      2
28                    0.981136             -195.80173504176           083734
43                    0.662954             -78.446668319666           094921
58                    0.449307             7.0301860261164E-03        104523
73                    0.394598             20                         115843
88                    0.337338             40                         130537
103                   0.278793             60                         140654


DATA FOR DIODE NUMBER      3
29                    0.981313             -195.80173504176           083734
44                    0.662493             -78.446668319666           094921
59                    0.448449             7.0301860261164E-03        104523
74                    0.393423             20                         115843
89                    0.335854             40                         130537
104                   0.277057             60                         140654


DATA FOR DIODE NUMBER      4
30                    0.982439             -195.80173504176           083734
45                    0.665457             -78.446668319666           094921
60                    0.452055             7.0301860261164E-03        104523
75                    0.397211             20                         115843
90                    0.340065             40                         130537
105                   0.281652             60                         140654


DATA FOR DIODE NUMBER      5
31                    0.981403             -195.80173504176           083734
46                    0.662837             -78.446668319666           094921
61                    0.449609             7.0301860261164E-03        104523
76                    0.395079             20                         115843
91                    0.337995             40                         130537
106                   0.279476             60                         140654


DATA FOR DIODE NUMBER      6
32                    0.981758             -195.80173504176           083734
```

```
47                    0.663775          -78.446668319666     094921
62                    0.450131          7.0301860261164E-03  104523
77                    0.395201          20                   115843
92                    0.337823          40                   130537
107                   0.279251          60                   140654


DATA FOR DIODE NUMBER     7
33                    0.981828          -195.80173504176     083734
48                    0.663857          -78.446668319666     094921
63                    0.450309          7.0301860261164E-03  104523
78                    0.395324          20                   115843
93                    0.337998          40                   130537
108                   0.279466          60                   140654


DATA FOR DIODE NUMBER     8
34                    0.981928          -195.80173504176     083734
49                    0.664017          -78.446668319666     094921
64                    0.450394          7.0301860261164E-03  104523
79                    0.395313          20                   115843
94                    0.337858          40                   130537
109                   0.279091          60                   140654


DATA FOR DIODE NUMBER     9
35                    0.985171          -195.80173504176     083734
50                    0.672725          -78.446668319666     094921
65                    0.460793          7.0301860261164E-03  104523
80                    0.406857          20                   115843
95                    0.35093           40                   130537
110                   0.29386           60                   140654


DATA FOR DIODE NUMBER     10
36                    0.985552          -195.80173504176     083734
51                    0.672075          -78.446668319666     094921
66                    0.459742          7.0301860261164E-03  104523
81                    0.405822          20                   115843
96                    0.349875          40                   130537
111                   0.292842          60                   140654

***630 End***
```

```
>>RUN
ENTER THE FILENAME OF THE DATA TO BE READ : DN-T022
ENTER THE FILENAME OF 1ST PLOT FILE : DN0T022
ENTER THE FILENAME OF 2ND PLOT FILE : DN1T022
ENTER THE FILENAME OF 3RD PLOT FILE : DN2T022
ENTER THE FILENAME OF 4TH PLOT FILE : DN3T022
ENTER THE FILENAME OF 5TH PLOT FILE : DN4T022
ENTER THE FILENAME OF 6TH PLOT FILE : DN5T022
ENTER THE FILENAME OF 7TH PLOT FILE : DN6T022
ENTER THE FILENAME OF 8TH PLOT FILE : DN7T022
ENTER THE FILENAME OF 9TH PLOT FILE : DN8T022
ENTER THE FILENAME OF 10TH PLOT FILE : DN9T022
NUMBER                VOLTS                 TEMPERATURE           TIME
DATA FOR DIODE NUMBER      1
27                    0.982117              -195.6994186036       085053
42                    0.663691              -78.317271898494      102202
57                    0.451603              0.012966566275887     112323
72                    0.397199              20                    124836
87                    0.339861              40                    135124
102                   0.281322              60                    145955


DATA FOR DIODE NUMBER      2
28                    0.98092               -195.6994186036       085053
43                    0.661535              -78.317271898494      102202
58                    0.449572              0.012966566275887     112323
73                    0.395192              20                    124836
88                    0.337591              40                    135124
103                   0.279071              60                    145955


DATA FOR DIODE NUMBER      3
29                    0.981163              -195.6994186036       085053
44                    0.661273              -78.317271898494      102202
59                    0.44868               0.012966566275887     112323
74                    0.39379               20                    124836
89                    0.336069              40                    135124
104                   0.277391              60                    145955


DATA FOR DIODE NUMBER      4
30                    0.98232               -195.6994186036       085053
45                    0.664207              -78.317271898494      102202
60                    0.452238              0.012966566275887     112323
75                    0.397531              20                    124836
90                    0.340233              40                    135124
105                   0.281808              60                    145955


DATA FOR DIODE NUMBER      5
31                    0.981277              -195.6994186036       085053
46                    0.661617              -78.317271898494      102202
61                    0.449852              0.012966566275887     112323
76                    0.395335              20                    124836
91                    0.338177              40                    135124
106                   0.279835              60                    145955


DATA FOR DIODE NUMBER      6
32                    0.981608              -195.6994186036       085053
```

47	0.662666	-78.317271898494	102202
62	0.450397	0.012966566275887	112323
77	0.395563	20	124836
92	0.338118	40	135124
107	0.279533	60	145955

DATA FOR DIODE NUMBER 7

33	0.981716	-195.6994186036	085053
48	0.662739	-78.317271898494	102202
63	0.450509	0.012966566275887	112323
78	0.395676	20	124836
93	0.338309	40	135124
108	0.279762	60	145955

DATA FOR DIODE NUMBER 8

34	0.981603	-195.6994186036	085053
49	0.662996	-78.317271898494	102202
64	0.450609	0.012966566275867	112323
79	0.395659	20	124836
94	0.338166	40	135124
109	0.279486	60	145955

DATA FOR DIODE NUMBER 9

35	0.984946	-195.6994186036	085053
50	0.671719	-78.317271898494	102202
65	0.460819	0.012966566275887	112323
80	0.407124	20	124836
95	0.351127	40	135124
110	0.294158	60	145955

DATA FOR DIODE NUMBER 10

36	0.985324	-195.6994186036	085053
51	0.671661	-78.317271898494	102202
66	0.459769	0.012966566275887	112323
81	0.405849	20	124836
96	0.349899	40	135124
111	0.292878	60	145955

630 End

```
>>RUN
ENTER THE FILENAME OF THE DATA TO BE READ : DN-T023
ENTER THE FILENAME OF 1ST PLOT FILE : DN0T023
ENTER THE FILENAME OF 2ND PLOT FILE : DN1T023
ENTER THE FILENAME OF 3RD PLOT FILE : DN2T023
ENTER THE FILENAME OF 4TH PLOT FILE : DN3T023
ENTER THE FILENAME OF 5TH PLOT FILE : DN4T023
ENTER THE FILENAME OF 6TH PLOT FILE : DN5T023
ENTER THE FILENAME OF 7TH PLOT FILE : DN6T023
ENTER THE FILENAME OF 8TH PLOT FILE : DN7T023
ENTER THE FILENAME OF 9TH PLOT FILE : DN8T023
ENTER THE FILENAME OF 10TH PLOT FILE : DN9T023
NUMBER              VOLTS              TEMPERATURE              TIME
DATA FOR DIODE NUMBER     1
27                  0.982573           -195.82477353923         084735
42                  0.664868           -78.53224411497          100732
57                  0.451259           2.2288946431952E-03      105947
72                  0.396768           20                       122510
87                  0.339785           40                       133324
102                 0.281505           60                       144243


DATA FOR DIODE NUMBER     2
28                  0.98126            -195.82477353923         084735
43                  0.662704           -78.53224411497          100738
58                  0.449123           2.2288946431952E-03      105947
73                  0.39473            20                       122510
88                  0.337783           40                       133324
103                 0.279031           60                       144243


DATA FOR DIODE NUMBER     3
29                  0.981407           -195.82477353923         084735
44                  0.662371           -78.53224411497          100738
59                  0.448272           2.2288946431952E-03      105947
74                  0.393466           20                       122510
89                  0.336226           40                       133324
104                 0.277285           60                       144243


DATA FOR DIODE NUMBER     4
30                  0.98321            -195.82477353923         084735
45                  0.665225           -78.53224411497          100738
60                  0.451817           2.2288946431952E-03      105947
75                  0.397358           20                       122510
90                  0.340517           40                       133324
105                 0.28184            60                       144243


DATA FOR DIODE NUMBER     5
31                  0.982287           -195.82477353923         084735
46                  0.662647           -78.53224411497          100738
61                  0.449424           2.2288946431952E-03      105947
76                  0.395178           20                       122510
91                  0.33842            40                       133324
106                 0.279763           60                       144243


DATA FOR DIODE NUMBER     6
32                  0.982567           -195.82477353923         084735
```

```
47                      0.663776        -78.53224411497         100738
62                      0.449833        2.228894643:952E-03     105947
77                      0.395305        20                      122510
92                      0.338334        40                      133324
107                     0.279421        60                      144243


DATA FOR DIODE NUMBER     7
33                      0.982751        -195.82477353923        084735
48                      0.663679        -78.53224411497         100738
63                      0.44999         2.228894631952E-03      105947
78                      0.395491        20                      122510
93                      0.338517        40                      133324
108                     0.279606        60                      144243


DATA FOR DIODE NUMBER     8
34                      0.982882        -195.82477353923        084735
49                      0.663912        -78.53224411497         100738
64                      0.450144        2.228894631952E-03      105947
79                      0.39545         20                      122510
94                      0.338313        40                      133324
109                     0.279316        60                      144243


DATA FOR DIODE NUMBER     9
35                      0.986027        -195.82477353923        084735
50                      0.672739        -78.53224411497         100738
65                      0.460545        2.228894631952E-03      105947
80                      0.406947        20                      122510
95                      0.351308        40                      133324
110                     0.293993        60                      144243


DATA FOR DIODE NUMBER     10
36                      0.985798        -195.82477353923        084735
51                      0.672287        -78.53224411497         100738
66                      0.45969         2.228894631952E-03      105947
81                      0.40583         20                      122510
96                      0.349946        40                      133324
111                     0.292857        60                      144243


***630 End***
```

```
>>RUN
ENTER THE FILENAME OF THE DATA TO BE READ : DN-T024
ENTER THE FILENAME OF 1ST PLOT FILE : DN0T024
ENTER THE FILENAME OF 2ND PLOT FILE : DN1T024
ENTER THE FILENAME OF 3RD PLOT FILE : DN2T024
ENTER THE FILENAME OF 4TH PLOT FILE : DN3T024
ENTER THE FILENAME OF 5TH PLOT FILE : DN4T024
ENTER THE FILENAME OF 6TH PLOT FILE : DN5T024
ENTER THE FILENAME OF 7TH PLOT FILE : DN6T024
ENTER THE FILENAME OF 8TH PLOT FILE : DN7T024
ENTER THE FILENAME OF 9TH PLOT FILE : DN8T024
ENTER THE FILENAME OF 10TH PLOT FILE : DN9T024
NUMBER                VOLTS                TEMPERATURE                TIME
DATA FOR DIODE NUMBER      1
27                    0.982512             -195.81057607572           084503
42                    0.664259             -78.475361347954           100630
57                    0.451772             4.6148234722816E-03        110248
72                    0.397268             20                         122209
87                    0.339642             40                         132641
102                   0.281338             60                         143302


DATA FOR DIODE NUMBER      2
28                    0.981281             -195.81057607572           084503
43                    0.662074             -78.475361347954           100630
58                    0.449803             4.6148234722816E-03        110248
73                    0.395344             20                         122209
88                    0.337414             40                         132641
103                   0.278898             60                         143302


DATA FOR DIODE NUMBER      3
29                    0.981479             -195.81057607572           084503
44                    0.661738             -78.475361347954           100630
59                    0.448594             4.6148234722816E-03        110248
74                    0.39407              20                         122209
89                    0.335872             40                         132641
104                   0.277166             60                         143302


DATA FOR DIODE NUMBER      4
30                    0.982561             -195.81057607572           084503
45                    0.664643             -78.475361347954           100630
60                    0.452233             4.6148234722816E-03        110248
75                    0.397918             20                         122209
90                    0.340045             40                         132641
105                   0.281678             60                         143302


DATA FOR DIODE NUMBER      5
31                    0.981706             -195.81057607572           084503
46                    0.6621               -78.475361347954           100630
61                    0.449735             4.6148234722816E-03        110248
76                    0.395747             20                         122209
91                    0.33801              40                         132641
105                   0.279617             60                         143302


DATA FOR DIODE NUMBER      6
32                    0.981919             -195.81057607572           084503
```

47	0.662987	-78.475361347954	100630
62	0.450229	4.6148234722816E-03	110248
77	0.396016	20	122209
92	0.337932	40	132641
107	0.279424	60	143302

DATA FOR DIODE NUMBER 7

33	0.981908	-195.81057607572	084503
48	0.663197	-78.475361347954	100630
63	0.450227	4.6148234722816E-03	110248
78	0.396069	20	122209
93	0.338121	40	132641
108	0.279588	60	143302

DATA FOR DIODE NUMBER 8

34	0.982137	-195.81057607572	084503
49	0.66341	-78.475361347954	100630
64	0.450301	4.6148234722816E-03	110248
79	0.396094	20	122209
94	0.337984	40	132641
109	0.279302	60	143302

DATA FOR DIODE NUMBER 9

35	0.985429	-195.81057607572	084503
50	0.672213	-78.475361347954	100630
65	0.460717	4.6148234722816E-03	110248
80	0.407212	20	122209
95	0.350995	40	132641
110	0.29401	60	143302

DATA FOR DIODE NUMBER 10

36	0.985507	-195.81057607572	084503
51	0.672012	-78.475361347954	100630
66	0.459759	4.6148234722816E-03	110248
81	0.405763	20	122209
96	0.349869	40	132641
111	0.292847	60	143302

830 End

```
>>RUN
ENTER THE FILENAME OF THE DATA TO BE READ : DN-T025
ENTER THE FILENAME OF 1ST PLOT FILE : DN0T025
ENTER THE FILENAME OF 2ND PLOT FILE : DN1T025
ENTER THE FILENAME OF 3RD PLOT FILE : DN2T025
ENTER THE FILENAME OF 4TH PLOT FILE : DN3T025
ENTER THE FILENAME OF 5TH PLOT FILE : DN4T025
ENTER THE FILENAME OF 6TH PLOT FILE : DN5T025
ENTER THE FILENAME OF 7TH PLOT FILE : DN6T025
ENTER THE FILENAME OF 8TH PLOT FILE : DN7T025
ENTER THE FILENAME OF 9TH PLOT FILE : DN8T025
ENTER THE FILENAME OF 10TH PLOT FILE : DN9T025
NUMBER                VOLTS                TEMPERATURE              TIME
DATA FOR DIODE NUMBER      1
37                    0.983404             -195.69064456368         084243
43                    0.664995             -78.2951505937           100302
57                    0.452013             2.0140411476762E-03      105754
72                    0.397454             20                       122055
87                    0.34025              40                       132257
102                   0.281681             60                       143547


DATA FOR DIODE NUMBER      2
28                    0.981589             -195.69064456368         084243
43                    0.662156             -78.2951505937           100302
58                    0.449317             2.0140411476762E-03      105754
73                    0.395193             20                       122055
88                    0.337476             40                       132257
103                   0.279336             60                       143547


DATA FOR DIODE NUMBER      3
29                    0.981514             -195.69064456368         084243
44                    0.661545             -78.2951505937           100302
59                    0.448244             2.0140411476762E-03      105754
74                    0.393903             20                       122055
89                    0.335892             40                       132257
104                   0.27763              60                       143547


DATA FOR DIODE NUMBER      4
30                    0.982368             -195.69064456368         084243
45                    0.664044             -78.2951505937           100302
60                    0.451606             2.0140411476762E-03      105754
75                    0.39764              20                       122055
90                    0.339955             40                       132257
105                   0.282133             60                       143547


DATA FOR DIODE NUMBER      5
31                    0.981397             -195.69064456368         084243
46                    0.661604             -78.2951505937           100302
61                    0.449251             2.0140411476762E-03      105754
76                    0.395188             20                       122055
91                    0.33786              40                       132257
106                   0.280029             60                       143547


DATA FOR DIODE NUMBER      6
32                    0.981825             -195.69064456368         084243
```

47	0.662438	-78.2951505937	100302
62	0.449947	2.0140411476762E-03	105754
77	0.395263	20	122055
92	0.337733	40	132257
107	0.279886	60	143547

DATA FOR DIODE NUMBER 7

33	0.981958	-195.69064456368	084243
48	0.662644	-78.2951505937	100302
63	0.450108	2.0140411476762E-03	105754
78	0.395481	20	122055
93	0.337976	40	132257
108	0.280059	60	143547

DATA FOR DIODE NUMBER 8

34	0.98222	-195.69064456368	084243
49	0.662811	-78.2951505937	100302
64	0.450119	2.0140411476762E-03	105754
79	0.395494	20	122055
94	0.337808	40	132257
109	0.279711	60	143547

DATA FOR DIODE NUMBER 9

35	0.984946	-195.69064456368	084243
50	0.67112	-78.2951505937	100302
65	0.460279	2.0140411476762E-03	105754
80	0.406683	20	122055
95	0.350838	40	132257
110	0.294388	60	143547

DATA FOR DIODE NUMBER 10

36	0.984082	-195.69064456368	084243
51	0.670116	-78.2951505937	100302
66	0.458868	2.0140411476762E-03	105754
81	0.405164	20	122055
96	0.34978	40	132257
111	0.293873	60	143547

SIM End

```
>>RUN
ENTER THE FILENAME OF THE DATA TO BE READ : DN-T026
ENTER THE FILENAME OF 1ST PLOT FILE : DN0T026
ENTER THE FILENAME OF 2ND PLOT FILE : DN1T026
ENTER THE FILENAME OF 3RD PLOT FILE : DN2T026
ENTER THE FILENAME OF 4TH PLOT FILE : DN3T026
ENTER THE FILENAME OF 5TH PLOT FILE : DN4T026
ENTER THE FILENAME OF 6TH PLOT FILE : DN5T026
ENTER THE FILENAME OF 7TH PLOT FILE : DN6T026
ENTER THE FILENAME OF 8TH PLOT FILE : DN7T026
ENTER THE FILENAME OF 9TH PLOT FILE : DN8T026
ENTER THE FILENAME OF 10TH PLOT FILE : DN9T026
NUMBER              VOLTS                TEMPERATURE              TIME
DATA FOR DIODE NUMBER     1
27                  0.981555             -195.5696953858          085002
42                  0.662791             -78.196971849084         102030
57                  0.451351             5.654745384373E-03       111705
72                  0.396642             20                       123822
87                  0.339537             40                       134137
102                 0.281228             60                       144714


DATA FOR DIODE NUMBER     2
28                  0.980069             -195.5696953858          085002
43                  0.661591             -78.196971849084         102030
58                  0.449287             5.654745384373E-03       111705
73                  0.39452              20                       123822
88                  0.337248             40                       134137
103                 0.278687             60                       144714


DATA FOR DIODE NUMBER     3
29                  0.98012              -195.5696953858          085002
44                  0.661217             -78.196971849084         102030
59                  0.448392             5.654745384373E-03       111705
74                  0.393287             20                       123822
89                  0.335711             40                       134137
104                 0.277032             60                       144714


DATA FOR DIODE NUMBER     4
30                  0.98152              -195.5696953858          085002
45                  0.664079             -78.196971849084         102030
60                  0.451966             5.654745384373E-03       111705
75                  0.397117             20                       123822
90                  0.339823             40                       134137
105                 0.281481             60                       144714


DATA FOR DIODE NUMBER     5
31                  0.980461             -195.5696953858          085002
46                  0.661476             -78.196971849084         102030
61                  0.449576             5.654745384373E-03       111705
76                  0.394875             20                       123822
91                  0.337802             40                       134137
106                 0.279432             60                       144714


DATA FOR DIODE NUMBER     6
32                  0.980566             -195.5696953858          085002
```

47	0.662283	-78.196971849084	102030
63	0.449992	5.654745384373E-03	111705
77	0.394952	20	123822
92	0.337686	40	134137
107	0.27916	60	144714

DATA FOR DIODE NUMBER 7

33	0.980741	-195.5696953858	085002
48	0.662383	-78.196971849084	102030
63	0.450245	5.654745384373E-03	111705
78	0.395242	20	123822
93	0.337964	40	134137
108	0.279443	60	144714

DATA FOR DIODE NUMBER 8

34	0.980768	-195.5696953858	085002
49	0.662644	-78.196971849084	102030
64	0.450318	5.654745384373E-03	111705
79	0.395229	20	123822
94	0.337813	40	134137
109	0.279111	60	144714

DATA FOR DIODE NUMBER 9

35	0.984195	-195.5696953858	085002
50	0.671396	-78.196971849084	102030
65	0.460693	5.654745384373E-03	111705
80	0.406708	20	123822
95	0.350845	40	134137
110	0.293849	60	144714

DATA FOR DIODE NUMBER 10

36	0.984729	-195.5696953858	085002
51	0.671147	-78.196971849084	102030
66	0.459858	5.654745384373E-03	111705
81	0.405879	20	123822
96	0.349755	40	134137
111	0.292743	60	144714

SOS End

```
)RUN
ENTER THE FILENAME OF THE DATA TO BE READ : DN-T027
ENTER THE FILENAME OF 1ST PLOT FILE : DN0T027
ENTER THE FILENAME OF 2ND PLOT FILE : DN1T027
ENTER THE FILENAME OF 3RD PLOT FILE : DN2T027
ENTER THE FILENAME OF 4TH PLOT FILE : DN3T027
ENTER THE FILENAME OF 5TH PLOT FILE : DN4T027
ENTER THE FILENAME OF 6TH PLOT FILE : DN5T027
ENTER THE FILENAME OF 7TH PLOT FILE : DN6T027
ENTER THE FILENAME OF 8TH PLOT FILE : DN7T027
ENTER THE FILENAME OF 9TH PLOT FILE : DN8T027
ENTER THE FILENAME OF 10TH PLOT FILE : DN9T027
NUMBER                VOLTS                 TEMPERATURE           TIME
DATA FOR DIODE NUMBER      1
27                    0.981887              -195.62699342302      085017
42                    0.664104              -78.260669421632      102758
57                    0.451711              0.029016664421044     112515
72                    0.396614              20                    124926
87                    0.339644              40                    135700
102                   0.28173               60                    150327


DATA FOR DIODE NUMBER      2
28                    0.980696              -195.62699342302      085017
43                    0.661957              -78.260669421632      102758
58                    0.449757              0.029016664421044     112515
73                    0.394553              20                    124926
88                    0.337389              40                    135700
103                   0.279389              60                    150327


DATA FOR DIODE NUMBER      3
29                    0.980968              -195.62699342302      085017
44                    0.661517              -78.260669421632      102758
59                    0.448796              0.029016664421044     112515
74                    0.393322              20                    124926
89                    0.335859              40                    135700
104                   0.277661              60                    150327


DATA FOR DIODE NUMBER      4
30                    0.98218               -195.62699342302      085017
45                    0.664414              -78.260669421632      102758
60                    0.452314              0.029016664421044     112515
75                    0.397136              20                    124926
90                    0.340044              40                    135700
105                   0.282195              60                    150327


DATA FOR DIODE NUMBER      5
31                    0.981146              -195.62699342302      085017
46                    0.661908              -78.260669421632      102758
61                    0.449897              0.029016664421044     112515
76                    0.394908              20                    124926
91                    0.337926              40                    135700
106                   0.28011               60                    150327


DATA FOR DIODE NUMBER      6
32                    0.98137               -195.62699342302      085017
```

47	0.662767	-76.260669421632	102758
62	0.450485	0.029016664421044	112515
77	0.39503	20	124926
92	0.337634	40	135700
107	0.280001	60	150327

DATA FOR DIODE NUMBER 7

33	0.981624	-195.62699342302	085017
48	0.66295	-78.260669421632	102758
63	0.450637	0.029016664421044	112515
78	0.3953	20	124926
93	0.338046	40	135700
108	0.280184	60	150327

DATA FOR DIODE NUMBER 8

34	0.981687	-195.62699342302	085017
49	0.663178	-78.260669421632	102758
64	0.450745	0.029016664421044	112515
79	0.395246	20	124926
94	0.337873	40	[illegible]
109	0.279803	60	[illegible]

DATA FOR DIODE NUMBER 9

35	0.984871	-195.62699342302	085017
50	0.671895	-78.260669421632	102758
65	0.461	0.029016664421044	112515
80	0.406724	20	124926
95	0.350397	40	135700
110	0.294419	60	150327

DATA FOR DIODE NUMBER 10

36	[illegible]	-195.62699342302	085017
51	[illegible]	-78.260669421632	102758
66	[illegible]	[illegible]	[illegible]
81	0.425695	20	[illegible]
96	0.367763	40	[illegible]
111	0.309874	60	[illegible]

[illegible]

```
>>RUN
ENTER THE FILENAME OF THE DATA TO BE READ : DN-T028
ENTER THE FILENAME OF 1ST PLOT FILE : DN0T028
ENTER THE FILENAME OF 2ND PLOT FILE : DN1T028
ENTER THE FILENAME OF 3RD PLOT FILE : DN2T028
ENTER THE FILENAME OF 4TH PLOT FILE : DN3T028
ENTER THE FILENAME OF 5TH PLOT FILE : DN4T028
ENTER THE FILENAME OF 6TH PLOT FILE : DN5T028
ENTER THE FILENAME OF 7TH PLOT FILE : DN6T028
ENTER THE FILENAME OF 8TH PLOT FILE : DN7T028
ENTER THE FILENAME OF 9TH PLOT FILE : DN8T028
ENTER THE FILENAME OF 10TH PLOT FILE : DN9T028
NUMBER                VOLTS                 TEMPERATURE           TIME
DATA FOR DIODE NUMBER     1
27                    0.982657              -195.77714738783      085345
42                    0.664469              -78.383510617526      100703
57                    0.451318              4.86891977328442E-03  110322
72                    0.39654               20                    123204
87                    0.339468              40                    134222
102                   0.281303              60                    145300


DATA FOR DIODE NUMBER     2
28                    0.981681              -195.77714738783      085345
43                    0.662359              -78.383510617526      100703
58                    0.449283              4.86891977328442E-03  110322
73                    0.394451              20                    123204
88                    0.337198              40                    134222
103                   0.27896               60                    145300


DATA FOR DIODE NUMBER     3
29                    0.981899              -195.77714738783      085345
44                    0.661964              -78.383510617526      100703
59                    0.448325              4.86891977328442E-03  110322
74                    0.393228              20                    123204
89                    0.335728              40                    134222
104                   0.277266              60                    145300


DATA FOR DIODE NUMBER     4
30                    0.983025              -195.77714738783      085345
45                    0.664689              -78.383510617526      100703
60                    0.451808              4.86891977328442E-03  110322
75                    0.397022              20                    123204
90                    0.339862              40                    134222
105                   0.28174               60                    145300


DATA FOR DIODE NUMBER     5
31                    0.982027              -195.77714738783      085345
46                    0.662349              -78.383510617526      100703
61                    0.449447              4.86891977328442E-03  110322
76                    0.394755              20                    123204
91                    0.337756              40                    134222
106                   0.279641              60                    145300


DATA FOR DIODE NUMBER     6
32                    0.983326              -195.77714738783      085345
```

```
47                      0.663212        -78.383510617526        100703
62                      0.449898        4.86891977328445-03     110322
77                      0.394954        20                      123204
92                      0.337684        40                      134222
107                     0.279485        60                      145300

DATA FOR DIODE NUMBER     7
33                      0.982464        -195.77714738783        085345
48                      0.663377        -78.383510617526        100703
63                      0.450058        4.86891977328445-03     110322
78                      0.39522         20                      123204
93                      0.337967        40                      134222
108                     0.279767        60                      145300

DATA FOR DIODE NUMBER     8
34                      0.982312        -195.77714738783        085345
49                      0.663574        -78.383510617526        100703
64                      0.450186        4.86891977328445-03     110322
79                      0.395193        20                      123204
94                      0.337786        40                      134222
109                     0.279444        60                      145300

DATA FOR DIODE NUMBER     9
35                      0.985513        -195.77714738783        085345
50                      0.672294        -78.383510617526        100703
65                      0.46055         4.86891977328445-03     110322
80                      0.406706        20                      123204
95                      0.350859        40                      134222
110                     0.294202        60                      145300

DATA FOR DIODE NUMBER     10
36                      0.985489        -195.77714738783        085345
51                      0.671821        -78.383510617526        100703
66                      0.459644        4.86891977328445-03     110322
81                      0.405681        20                      123204
96                      0.34977         40                      134222
111                     0.292791        60                      145300

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15. Supplementary Notes

Langley Technical Monitor: L. A. Dillon-Townes

16. Abstract

An investigation of the stability of 10 silicon diode thermometers upon normal handling and upon thermal cycling between liquid nitrogen temperatures and 60 °C was conducted. The diodes underwent 28 thermal cycles and during that time, only one experienced instabilitites equivalent to as small as ±0.045 K. The other nine diodes had instabilities which ranged from about ±0.09 K to ±0.20 K.

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