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DIODE

STEP STRESS TESTING PROGRAM

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FINAL REPORT
FOR

JANTX 1N5552

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Prepared
For

GEORGE C. MARSHALL SPACE FLIGHT CENTER
NATIONAL AERONAUTICS AND SPACE ADMINISTRATION
Marshall Space Flight Center, Alabama 35812

DCA RELIABILITY LABORATORY
SPECIAL PRODUCTS DIVISION
975 BENICIA AVE
SUNNYVALE, CALIFORNIA 94086

FOREWORD

This is a summary of the work performed on NASA Contract NAS8-31944. The investigation was conducted for the National Aeronautics and Space Administration, George C. Marshall Space Flight Center, Huntsville, Alabama. The Contracting Officer's Technical Representative was Mr. F. Villella.

The short-term objective of this preliminary study of transistors, diodes, and FETS was to evaluate the reliability of these discrete devices, from different manufacturers, when subjected to power and temperature step stress tests.

The long-term objective is to gain more knowledge of accelerated stress testing for use in future testing of varieties of discrete devices, as well as to determine which type of stress should be applied to a particular type of device or design.

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1.0 INTRODUCTION

DCA Reliability Laboratory, under Contract NAS8-31944 for NASA/Marshall Space Flight Center, has compiled data for the purpose of evaluating the effect of power/temperature step stress when applied to a variety of semiconductor devices. This report covers the switching diode JANTX1N5554 manufactured by SEMTECH and MICRO SEMICONDUCTOR.

A total of 48 samples from each manufacturer were submitted to the process outlined in Table 1. In addition, two control sample units were maintained for verification of the electrical parametric testing.

2.0 TEST REQUIREMENTS

2.1 Electrical

All test samples were subjected to the electrical tests outlined in Table 2 after completing the prior power/temperature step stress point. These tests were performed using the Fairchild Model 600 high-speed computer-controlled tester. Additional bench testing was also required on the devices.

2.2 Stress Circuit

The test circuit shown in Figure 1 was used to power all of the test devices during the power/temperature stress conditions. The voltage was set by V_F and the current was varied in order to comply with the specified power rating for this device. At least one of the devices was subjected to maximum rated power (MRP). All remaining devices were subjected to no less than 90% of MRP. See Figure 1 for load resistance values and voltages.

2.3 Group I - Power Stress

Thirty-two units, 16 from each manufacturer, were submitted to the Power Stress Process. The diodes were stressed in 500-hour steps at 50, 100, 125, 150 and 175 percent of maximum rated power (MRP) for 2500 hours or until 50% or more of the devices in a sample lot failed.* Electrical measurements were performed on all specified electrical parameters after each power step. See Table 1.

2.4 Group II - Temperature Stress I

Thirty-two units, 16 from each manufacturer, were submitted to the Temperature Stress I Process. Group II was subjected to 1600 hours of stress at maximum rated power in increments of 160 hours. The temperature was increased in steps of 25°C, commencing at 75°C and terminating at 300°C or until 50% or more of the devices failed.* Electrical measurements were performed on all specified electrical parameters after each temperature step. See Table 1.

2.5 Group III - Temperature Stress II

Thirty-two units, 16 from each manufacturer, were submitted to the Temperature Stress II Process. Group III was subjected to 112 hours of stress at maximum rated power in increments of 16 hours. The temperature was increased in steps of 25°C, commencing at 150°C and terminating at 300°C or until 50% or more of the devices in a sample lot failed.* Electrical measurements were performed on all specified electrical parameters after each temperature step. See Table 1.

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* Conditions for failure:
A) Open or short
B) Leakage exceeds the maximum limit by 100 times
C) Other parameters exceed MIL limits by 50% or more.

3.0 DISCUSSION OF TEST RESULTS

3.1 Group I - Power Stress

3.1.1 Semtech. The Semtech sample lot completed 1650 hours of Group I Testing before the lot was stopped because of six catastrophic failures and two visual rejects (due to handling). The first two failures occurred 50 hours into the 100% MRP step. Serial numbers 6715 and 6717 failed because of excessive I_R leakage. The next failure occurred 50 hours into the 125% MRP step. Serial number 6719 failed because of excessive I_R leakage. The next failure occurred 10 hours into the 150% MRP step. Serial number 6718 failed because of excessive I_R leakage. The next failure occurred 25 hours into the 150% MRP step. Serial number 6716 was removed from the Group I Testing as a visual catastrophic failure.* The last failure occurred 150 hours into the 150% MRP step. Serial number 6713 was removed from the Group I Testing as a visual catastrophic failure.* Typical characteristics of this sample lot's performance were:

1) The mean value for I_R changed 616.53nA from an initial mean of 89.32nA to a final mean of 705.85nA.

2) The mean value for V_{F1} changed 0.003V from an initial mean of 1.083V to a final mean of 1.080V.

3) The mean value for V_{F2} changed 6.9mV from an initial mean of 812.2mV to a final mean of 819.1mV.

The control units for this sample lot remained constant throughout the entire Group I Testing.

* See Table 8 for explanation

3.1.2 Micro Semiconductor. The Micro Semiconductor sample lot completed 2000 hours of Group I Testing before the lot was stopped because of seven catastrophic failures and one MIL-STD-19500 limit failure. Serial number 6764 was removed from the Group I Testing 10 hours into the 150% MRP step as a MIL-STD-19500 limit failure. The first catastrophic failure occurred 250 hours into the 150% MRP step. Serial number 6750 was removed from the Group I Testing as a visual catastrophic failure.* The last six failures occurred 500 hours into the 150% MRP step. Serial numbers 6751, 6752, 6753, 6755, and 6762 were removed from the Group I Testing as visual catastrophic failures.* Serial number 6761 failed the minimum V_F limit. Typical characteristics of this sample lot's performance were:

1) The mean value for I_R changed 92.49nA from an initial mean of 48.01nA to a final mean of 140.5nA.

2) The mean value for V_{F1} changed 0.109V from an initial mean of 1.037V to a final mean of 0.928V.

3) The mean value for V_{F2} changed 97.5mV from an initial mean of 832.5mV to a final mean of 735.0mV.

The control units for this sample lot remained constant throughout the entire Group I Testing.

3.1.3 Statistical Summary - Group I. Table 4 outlines the results of Group I - Power Stress Process for each of the electrical parameters and all measurement points for both Semtech and Micro Semiconductor.

3.2 Group II - Temperature Stress I

3.2.1 Semtech. The Semtech Sample lot completed the entire 1600-hour Group II Testing with a total of two

* See Table 8 for explanation

catastrophic failures. The first failure occurred 160 hours into the 200°C-temperature step. Serial number 6721 failed because of excessive I_R leakage. The last failure occurred 160 hours into the 275°C-temperature step. Serial number 6725 failed because of excessive I_R leakage. Serial numbers 6805 and 6806 were removed from the Group II Testing, 160 hours into the 175°C-temperature step as MIL-STD-19500 limit failures. Typical characteristics of this sample lot's performance were:

1) The mean value for I_R changed 29.3μA from an initial mean of 118.0nA to a final mean of 29.45μA.

2) The mean value for V_{F1} changed 0.001V from an initial mean of 1.076V to a final mean of 1.075V.

3) The mean value for V_{F2} changed 0.6mV from an initial mean of 874.2mV to a final mean of 874.8mV.

The control units for this sample lot remained constant throughout the entire Group II Testing.

3.2.2 Micro Semiconductor. The Micro Semiconductor sample lot completed the entire 1600-hour Group II Testing with no catastrophic failures. Typical characteristics of this sample lot's performance were:

1) The mean value for I_R changed 4.96μA from an initial mean of 20.78nA to a final mean of 4.977μA.

2) The mean value for V_{F1} changed 0.047V from an initial mean of 1.040V to a final mean of 1.087V.

3) The mean value for V_{F2} changed 13.1mV from an initial mean of 891.3mV to a final mean of 904.4mV.

The control units for this sample lot remained constant throughout the entire Group II Testing.

3.2.3 Statistical Summary - Group II. Table 5 outlines the results of Group II - temperature Stress I Testing for each of the electrical parameters and all of the measurement points for both Semtech and Micro Semiconductor.

3.3 Group III - Temperature Stress II

3.3.1 Semtech. The Semtech sample lot completed the entire 112-hour Group III Testing with seven catastrophic failures. The first six failures occurred 16 hours into the 150°C-temperature step. Serial numbers 6728, 6730, 6732, 6733, 6734, and 6814 failed because of excessive I_R leakage. The last failure occurred 16 hours into the 175°C-temperature step. Serial number 6731 failed because of excessive I_R leakage. Typical characteristics of this sample lot's performance were:

1) The mean value for I_R changed 7.340nA from an initial mean of 89.07nA to a final mean of 96.41nA.

2) The mean value for V_{F1} changed 0.029V from an initial mean of 1.083V to a final mean of 1.112V.

3) The mean value for V_{F2} changed 17.0mV from an initial mean of 875.9mV to a final mean of 892.9mV.

The control units for this sample lot remained constant throughout the entire Group III Testing.

3.3.2 Micro Semiconductor. The Micro Semiconductor sample lot completed the entire 112-hour Group III Testing with no catastrophic failures. Typical characteristics of this sample lot's performance were:

1) The mean value for I_R changed 26.74nA from an initial mean of 31.47nA to a final mean of 58.21nA.

2) The mean value for V_{F1} changed 0.012V from an initial mean of 1.044V to a final mean of 1.056V.

3) The mean value for V_{F2} changed 0.10mV from an initial mean of 886.2mV to a final mean of 886.3mV.

The control units for this sample lot remained constant throughout the entire Group III Testing.

3.3.3 Statistical Summary - Group III. Table 6 outlines the results of Group III - Temperature Stress II Testing for each of the electrical parameters and all of the measurement points for both Semtech and Micro Semiconductor.

4.0 FINAL DATA SUMMARY

Table 7 statistically summarizes the change in the mean value from the zero-hour data to the final data. The graphs of Figures 2 and 4 plot the cumulative percent failures versus the temperature stress level for Group II - Temperature Stress I, and Group III - Temperature Stress II. The graphs of Figures 3 and 5 plot the time step for Group II (160 hours) and Group III (16 hours) versus the temperatures T_1 and T_2 calculated from Figures 2 and 4. Tables 8 and 9 summarize the failures encountered for all three stress groups. The failures are separated into two categories: catastrophic failures in Table 8 and parametric failures in Table 9. The data from Table 8 was used as a source for the graphs in Figures 2 and 4. Figures 2 and 4 were used as a source for the graphs in 3 and 5 respectively. Junction temperature is plotted on an inverse hyperbolic scale.

5.0 CONCLUSIONS

A study of the test reveals the Micro Semiconductor sample lot performed better than the Semtech lot. Both manufacturers were stopped in Group I Testing, but MSC had no catastrophic failures in either Group II or Group III. Because of the absence of these MSC failures and the Semtech failure mode of excessive reverse leakage current, only Group I was submitted to failure analysis.

In the case of the one analyzed Semtech sample and all of the analyzed MSC samples, the silicon die was still within acceptable electrical limits when the external lead became detached due to exceeding the melting temperature of the connecting metal.

The curve tracer pattern of the remaining analyzed Semtech diodes indicates that these devices failed due to a combination of junction damage and surface contamination, with the junction damage predominating.

A plot of the cumulative failure distribution for Groups II and III was made for the Semtech sample lot, but the regression lines could not be drawn because of an insufficient number of main failure points. Since the Groups II and III tests of the MSC lots had no failures, no plot could be made (Figures 4 and 5). Likewise, the activation energies for both manufacturers could not be calculated.

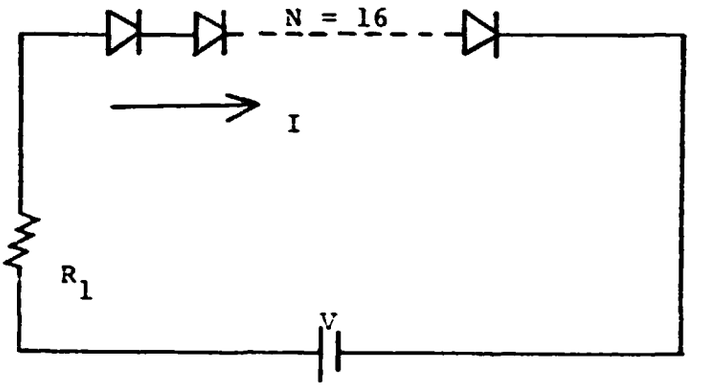
A broken circle around a marked point on the graph indicates a freak failure not calculated as part of the regression line. A solid circle around a marked point indicates an isolated main failure point. The

regression line is calculated using the least squares method.

The activation energy was calculated from the formula:

$$E = \left[\ell n \left(\frac{t_1}{t_2} \right) \right] \left[\frac{8.63 \text{ X } 10^{-5} \text{ eV/}^{o}\text{K}}{\left(\frac{1}{T_1+273} \right) - \left(\frac{1}{T_2+273} \right)} \right] \text{ eV}$$

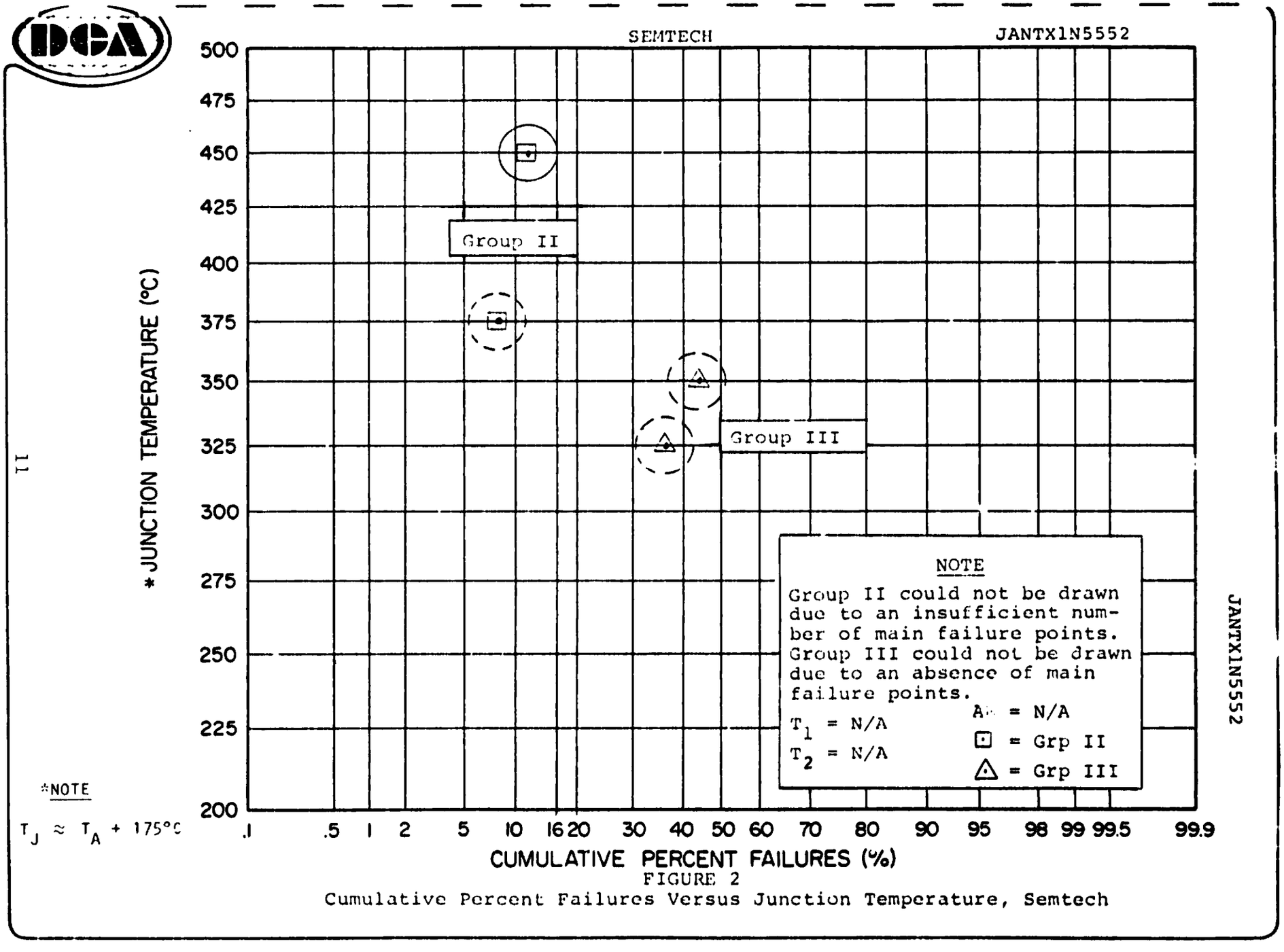
SWITCHING DIODES



$R_1 = iV/_I \pm 1\%$

$P_d = IE$

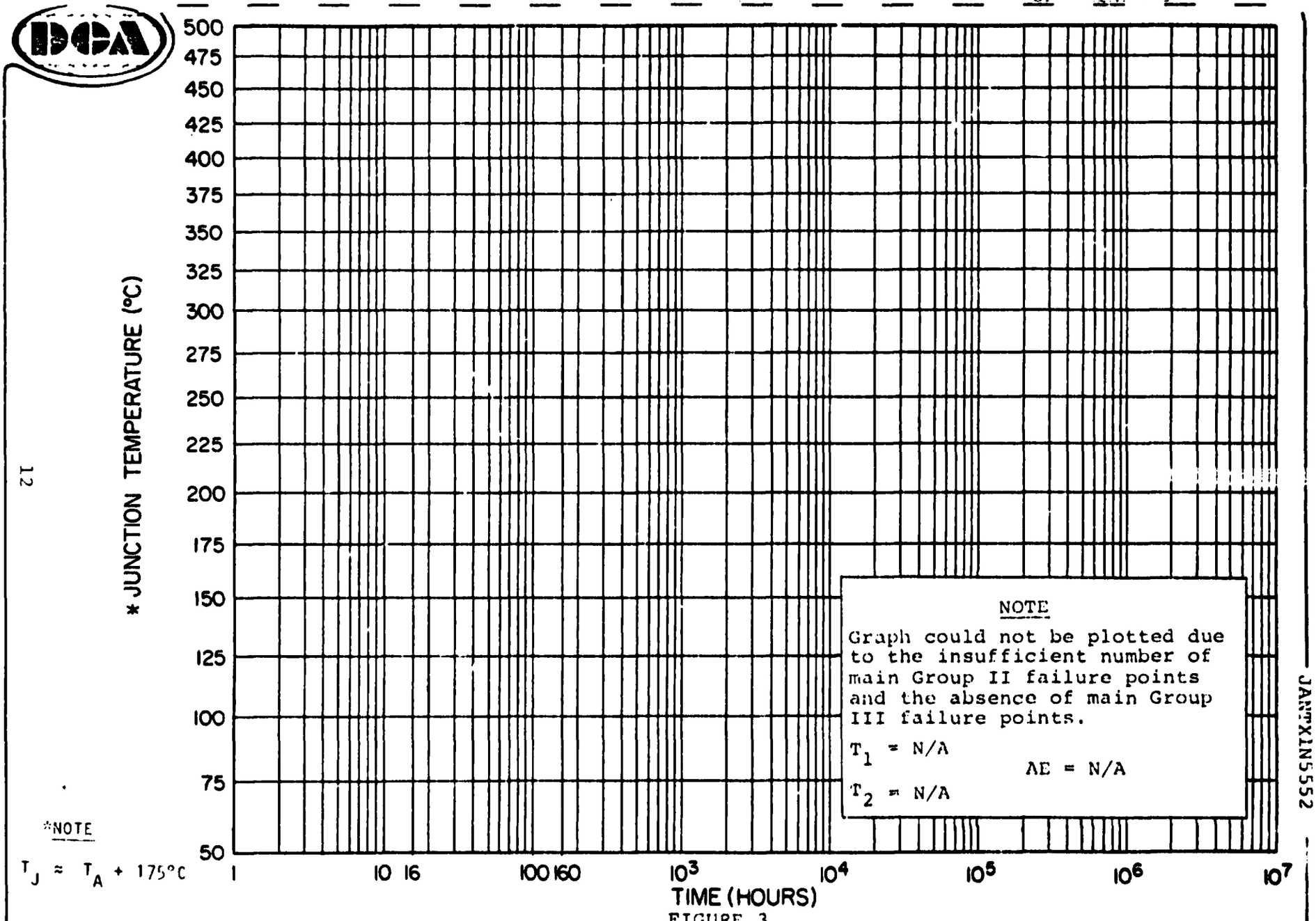
FIGURE 1
Power and Temperature Stress Circuit



*NOTE

$T_J \approx T_A + 175°C$

FIGURE 2
Cumulative Percent Failures Versus Junction Temperature, Semtech

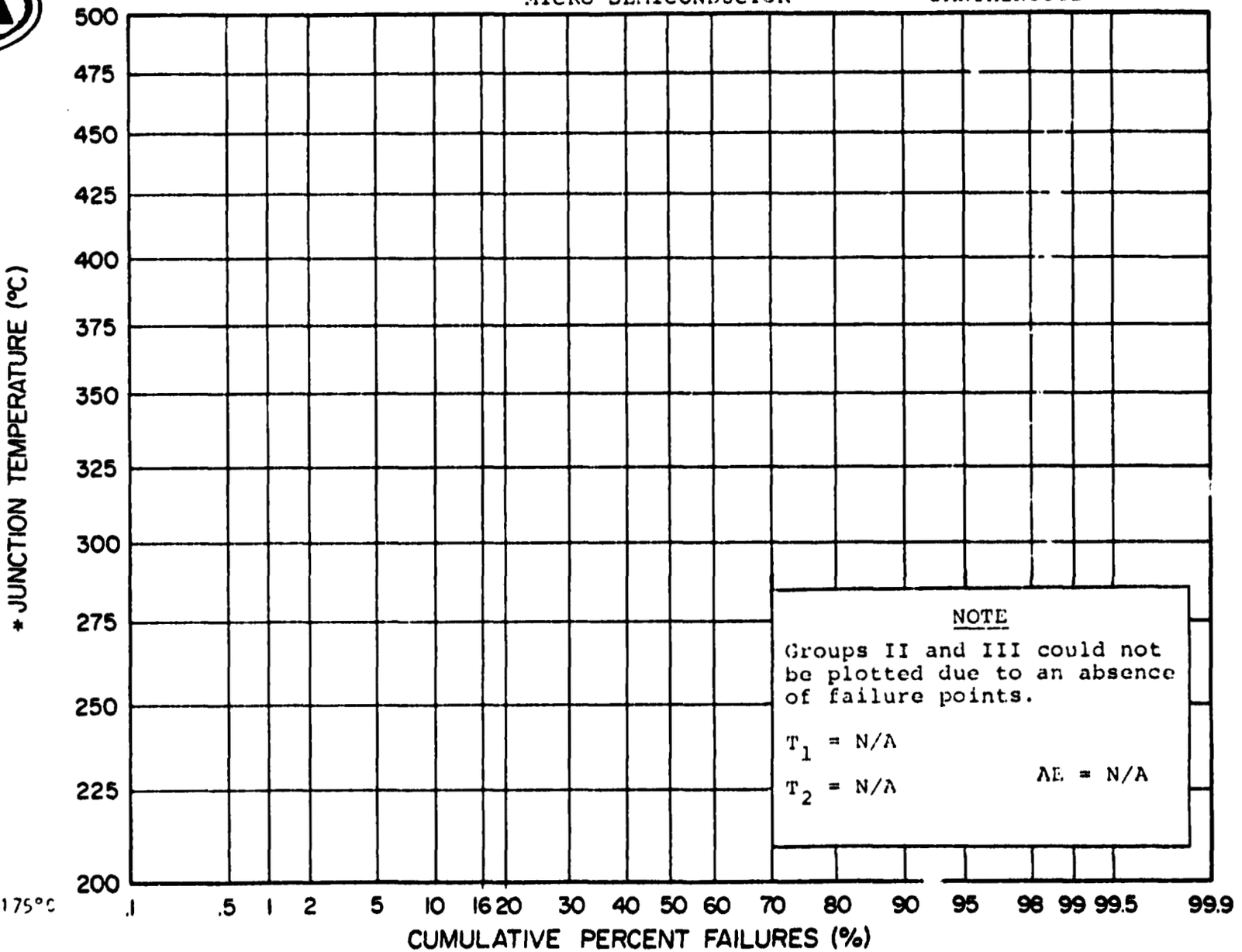


*NOTE

$T_J \approx T_A + 175°C$

FIGURE 3

Time Steps Versus Junction Temperature, Semtech



*NOTE

$T_J \approx T_A + 175°C$

JANTX1N5552

FIGURE 4

Cumulative Percent Failures Versus Junction Temperature, Micro Semiconductor

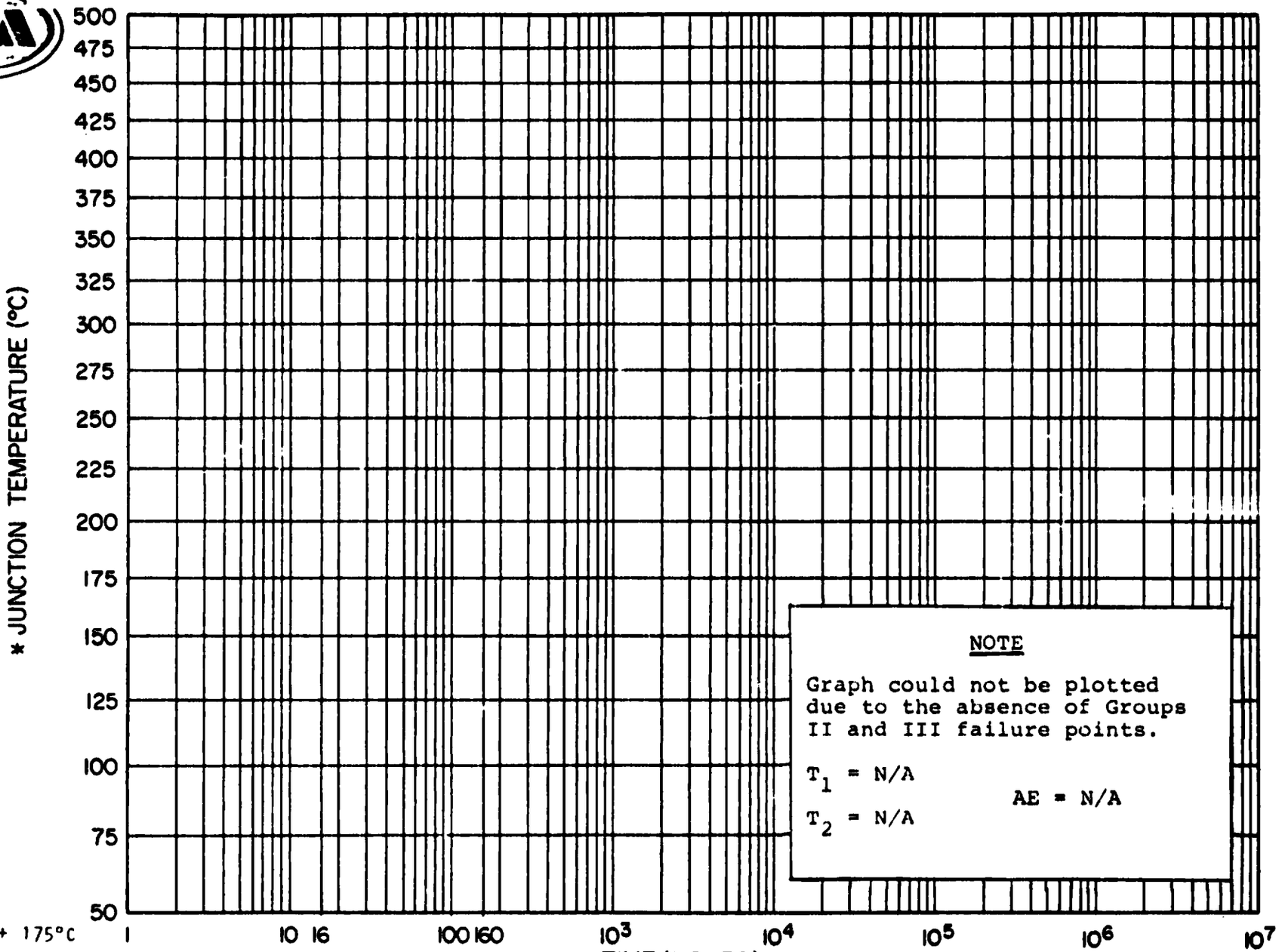
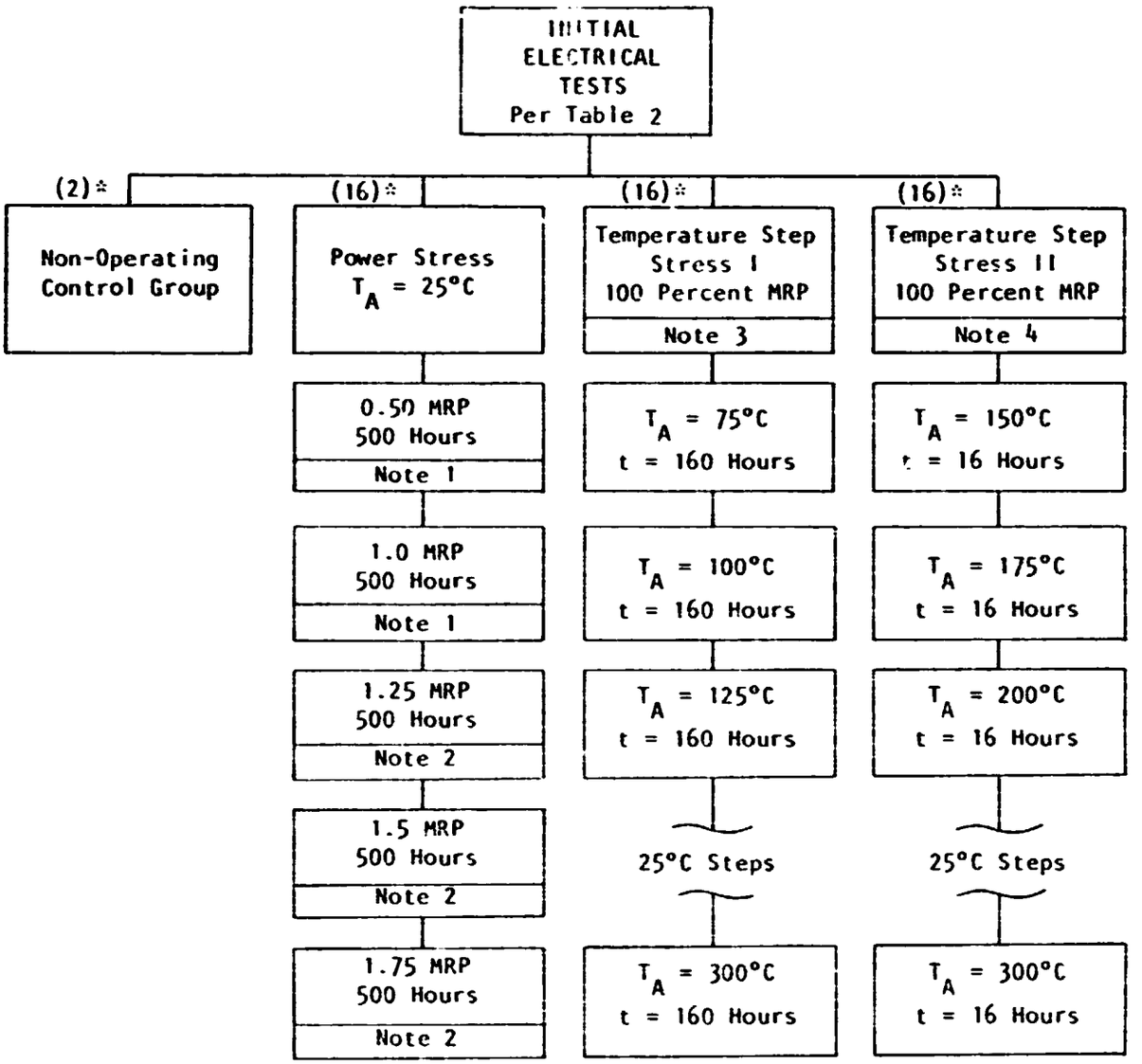


FIGURE 5
Time Steps Versus Junction Temperature, Micro Semiconductor

TABLE 1
TEST FLOW DIAGRAM



*Quantity per manufacturer (Semtech and Micro Semiconductor)

NOTES:

1) Electrical measurements per Table 2 were made at 50, 150, 250 and 500 hours.
2) Electrical measurements per Table 2 were made at 10, 25, 50, 150, 250 and 500 hours.
3) Electrical measurements per Table 2 were made at the end of each 160 hours.
4) Electrical measurements per Table 2 were made at the end of each 16 hours.

TABLE 2 Parameter and Test Conditions

PARAMETER	CONDITIONS	SPECIFICATION LIMIT MIN	SPECIFICATION LIMIT MAX	CATASTROPHIC* LIMIT MIN	CATASTROPHIC* LIMIT MAX	UNIT
I_R	@ V_R=600V		1.0		100	µA
V_{F1}	@ I_F=9.A PULSED	.6	1.2	.3	1.8	V(PK)
V_{F2}	@ I_0=2.0A NOT PULSED	.6	1.2	.3	1.8	V

* In addition, any open or short shall be considered catastrophic

TABLE 3 Power Stress Burn-In Conditions

V_F=1.0V	
I_F=	% P_D
1.8A	50
3.6A	100
4.5A	125
5.4A	150
6.3A	175

NOTE
FOR TABLES
4 THROUGH 7

The minimum/maximum initial and final data generally have an absolute accuracy of $\pm$ 1% of the reading and $\pm$ one digit except for readings greater the 9.99mA which have an absolute accuracy of $\pm$ 2% of the reading and $\pm$ one digit. The data also has a resolution for four digits. The standard diviations, means, delta means, and average means are, therefore, valid indicators of trends over time and temperature, excepting the minor statistical computer error of supplying a constant number of significant digits.

TABLE 4
GROUP I – POWER STRESS DATA SUMMARY

PARAMETER	I_R=1.0μA (MAX)		V_{F1}=.6V(MIN) 1.2V(MAX)		V_{F2}=.6V(MIN) 1.2V(MAX)			
CONDITIONS AND LIMIT	@V_R=600V		@I_F=9.0A (PULSED)		@I_O=2.0A (NOT PULSED)			
IDENTIFICATION	SEM	MSC	SEM	MSC	SEM	MSC		
INITIAL DATA								
MIN VALUE	34.70nA	13.20nA	1.050V	0.996V	800.0mV	828.0mV		
MAX VALUE	306.00nA	461.00nA	1.150V	1.060V	831.9mV	838.2mV		
MEAN	89.32nA	48.01nA	1.083V	1.037V	812.2mV	832.5mV		
STD DEV	69.41nA	106.80nA	0.030V	0.013V	7.7mV	3.1mV		
INTERIM DATA								
POWER 50 TO 125% Δ MEAN VALUE								
50% POWER								
50 Hours	25.28nA	14.45nA	0.014V	0.010V	0.2mV	0.3mV		
150 Hours	103.48nA	15.78nA	0.020V	0.015V	-0.5mV	0.6mV		
250 Hours	181.88nA	13.91nA	0.022V	0.019V	2.9mV	3.5mV		
500 Hours	330.88nA	318.49nA	0.018V	0.013V	-3.3mV	-4.2mV		
100% POWER								
550 Hours	*177.61μA	25.86nA	0.036V	0.005V	7.6mV	0.7mV		
650 Hours	149.11μA	30.11nA	0.048V	0.003V	6.2mV	-1.7mV		
750 Hours	148.11μA	28.23nA	0.059V	0.020V	15.2mV	6.8mV		
1000 Hours	173.51μA	22.80nA	0.056V	-0.002V	4.2mV	-9.4mV		
125% POWER								
1010 Hours	216.31μA	23.82nA	0.053V	0.016V	17.4mV	8.1mV		
1025 Hours	3.09μA	28.18nA	0.034V	0.021V	15.4mV	7.6mV		
1050 Hours	*12.58μA	40.46nA	0.034V	0.016V	16.0mV	7.5mV		
1150 Hours	116.48nA	25.10nA	0.015V	-0.020V	8.3mV	-13.2mV		
1250 Hours	316.18nA	35.63nA	0.021V	0.020V	12.8mV	10.2mV		
1500 Hours	209.28nA	53.79nA	0.007V	0.010V	11.6mV	6.0mV		

(continued on second sheet)

(continued from first sheet)

TABLE 4 (Cont'd)
GROUP I – POWER STRESS DATA SUMMARY

PARAMETER	I_R=1.0μA (MAX)		V_{F1}=.6V(MIN) 1.2V(MAX)		V_{F2}=.6V(MIN) 1.2V(MAX)			
CONDITIONS AND LIMITS	@V_R=600V		@I_F=9.0A (PULSED)		@I_O=2.0A (NOT PULSED)			
IDENTIFICATION	SEM	MSC	SEM	MSC	SEM	MSC		
INITIAL DATA								
MIN VALUE	34.70nA	13.20nA	1.050V	0.996V	800.0mV	828.0mV		
MAX VALUE	306.00nA	461.00nA	1.150V	1.060V	831.9mV	838.2mV		
MEAN	89.32nA	48.01nA	1.083V	1.037V	812.2mV	832.5mV		
STD DEV	69.41nA	106.80nA	0.030V	0.013V	7.7mV	3.1mV		
INTERIM DATA								
POWER 150 TO 175% Δ MEAN VALUE								
150% POWER								
1510 Hours	*27.82μA	54.19nA	0.018V	0.005V	9.8mV	6.8mV		
1525 Hours	686.58nA	55.69nA	0.015V	0.008V	16.6mV	11.2mV		
1550 Hours	533.58nA	57.09nA	0.016V	0.012V	13.9mV	8.0mV		
1650 Hours	616.53nA	72.39nA	0.003V	-0.003V	6.9mV	1.0mV		
1750 Hours	Job Stopped	75.39nA	Job Stopped	0.017V	Job Stopped	15.1mV		
2000 Hours	↓ ↓ ↓	92.49nA	↓ ↓ ↓	*-0.109V	↓ ↓ ↓	*-97.5mV		
175% POWER								
2010 Hours	↓ ↓ ↓	Job Stopped	↓ ↓ ↓	Job Stopped	↓ ↓ ↓	Job Stopped		
2025 Hours		↓ ↓ ↓		↓ ↓ ↓		↓ ↓ ↓		
2050 Hours								
2150 Hours								
2250 Hours								
2500 Hours								
FINAL DATA								
MIN VALUE	70.80nA	28.2nA	1.05V	0.000V	798.0mV	1.0mV		
MAX VALUE	3.97μA	374.0nA	1.12V	1.070V	881.0mV	842.0mV		
MEAN	705.85nA	140.5nA	1.08V	0.928V	819.1mV	735.0mV		
STD DEV	1.16μA	109.9nA	0.02V	0.351V	24.5mV	277.4mV		

NOTE: Catastrophic Rejects removed from data.

TABLE 5

GROUP II TEMP STRESS I DATA SUMMARY

PARAMETERS	I_R=1.0μA (MAX)		V_{F1}=.6V(MIN) 1.2V(MAX)		V_{F2}=.6V(MIN) 1.2V(MAX)			
CONDITIONS AND LIMITS	@V_R=600V		@I_F=9.0A (PULSED)		@I_O=2.0A (NOT PULSED)			
IDENTIFICATION	SEM	MSC	SEM	MSC	SEM	MSC		
INITIAL DATA								
MIN VALUE	27.4nA	13.70nA	0.976V	0.999V	840.0mV	883.0mV		
MAX VALUE	986.0nA	51.10nA	1.140V	1.090V	898.0mV	905.0mV		
MEAN	118.0nA	20.78nA	1.076V	1.040V	874.2mV	891.3mV		
STD DEV	224.9nA	8.98nA	0.045V	0.030V	14.2mV	5.2mV		
INTERIM DATA (INITIAL TO FINAL)								
Δ MEAN VALUE								
Total Hrs. Temp.								
160 Hours 75°C	15.6nA	26.69nA	0.010V	0.016V	6.6mV	-0.5mV		
320 Hours 100°C	36.2nA	25.14nA	0.014V	0.017V	15.4mV	1.3mV		
480 Hours 125°C	17.1nA	19.67nA	0.015V	0.018V	8.1mV	2.0mV		
640 Hours 150°C	44.8nA	17.98nA	0.013V	0.026V	4.7mV	5.5mV		
800 Hours 175°C	627.5μA	16.52nA	0.009V	0.024V	3.2mV	3.9mV		
960 Hours 200°C	*713.6μA	14.51nA	-0.003V	0.010V	-0.7mV	-0.2mV		
1120 Hours 225°C	61.4nA	10.13nA	0.006V	0.017V	3.1mV	1.8mV		
1280 Hours 250°C	8.7nA	137.22nA	0.011V	0.021V	5.7mV	3.3mV		
1440 Hours 275°C	*37.7μA	6.27μA	0.000V	0.038V	2.8mV	9.5mV		
1600 Hours 300°C	29.3μA	4.96μA	-0.001V	0.047V	0.6mV	13.1mV		
FINAL DATA								
FINAL TEMP	300°C	300°C	300°C	300°C	300°C	300°C		
MIN VALUE	78.70nA	0.666μA	0.982V	1.030V	840.0mV	884.0mV		
MAX VALUE	381.00μA	21.500μA	1.140V	1.130V	895.0mV	924.0mV		
MEAN	29.45μA	4.977μA	1.075V	1.087V	874.8mV	904.4mV		
STD DEV	101.50μA	4.701μA	0.043V	0.029V	15.2mV	10.7mV		

NOTE: CATASTROPHIC REJECTS REMOVED FROM DATA

TABLE 6

GROUP III TEMP STRESS II DATA SUMMARY

PARAMETERS	I_R=1.0μA (MAX)		V_{F1}=.6V(MIN) 1.2V(MAX)		V_{F2}=.6V(MIN) 1.2V(MAX)			
CONDITIONS AND LIMITS	@V_R=600V		@I_F=9 0A (PULSED)		@I_0=2.0A (NOT PULSED)			
IDENTIFICATION	SEM	MSC	SEM	MSC	SEM	MSC		
INITIAL DATA								
MIN VALUE	37.80nA	11.80nA	0.999V	0.999V	841.0mV	878.0mV		
MAX VALUE	319.00nA	183.00nA	1.150V	1.100V	987.0mV	902.0mV		
MEAN	89.07nA	31.47nA	1.083V	1.044V	875.9mV	886.2mV		
STD DEV	63.80nA	39.44nA	0.039V	0.031V	14.6mV	6.8mV		
INTERIM DATA (INITIAL TO FINAL)								
Δ MEAN VALUE								
Total Hrs. Temp.								
16 150°C	*1.976mA	-6.89nA	0.014V	0.011V	-0.2mV	-0.3mV		
32 175°C	*1.926mA	-3.34nA	0.564V	0.011V	568.1mV	0.1mV		
48 200°C	-16.450nA	-6.81nA	0.023V	0.015V	4.4mV	0.4mV		
64 225°C	57.230nA	-2.72nA	0.020V	0.007V	1.4mV	1.4mV		
80 250°C	-18.560nA	6.21nA	0.022V	0.004V	2.6mV	0.7mV		
96 275°C	-10.430nA	12.75nA	0.012V	0.001V	4.3mV	1.9mV		
112 300°C	7.340nA	26.74nA	0.029V	0.012V	17.0mV	0.1mV		
FINAL DATA								
FINAL TEMP	300°C	300°C	300°C	300°C	300°C	300°C		
MIN VALUE	67.50nA	14.40nA	1.070V	0.999V	858.0mV	877.0mV		
MAX VALUE	152.00nA	584.00nA	1.160V	1.100V	998.0mV	900.0mV		
MEAN	96.41nA	58.21nA	1.112V	1.056V	892.9mV	886.3mV		
STD DEV	22.11nA	135.90nA	0.028V	0.027V	39.4mV	7.0mV		

NOTE: CATASTROPHIC REJECTS REMOVED FROM DATA

FINAL DATA SUMMARY

TABLE 7

PARAMETER	SPECIFICATIONS LIMIT		UNITS	MEAN INT. DATA	AVERAGE IN MEAN VALUE					
					SEM	MSC	SEM	MSC	SEM	MSC
	MIN	MAX			POWER STRESS		TEMP STRESS I		TEMP STRESS II	
I_R		1.0	µA		*+50.638	+.05419	*+140.83	+1.1497	*+557.43	+.00371
V_{F1}	.6	1.2	V(PK)		+.02683	+.0040	+.00740	+.02340	+.09771	+.00871
V_{F2}	.6	1.2	V		+.00896	-.00163	*+.00495	+.00397	+.08537	+.00061

* CATASTROPHIC REJECT(S) REMOVED FROM DATA

TABLE 8 STEP STRESS CATASTROPHIC FAILURE SUMMARY JAN TX1N5552

GROUP I POWER STRESS

TEST STEP	MFR A		MFR B	
	QTY.	NOTE	QTY.	NOTE
50% 50 hr.	0	-	0	-
100 hr.	0	-	0	-
100 hr.	0	-	0	-
250 hr.	0	-	0	-
100% 50 hr.	2	A	0	-
100 hr.	0	-	0	-
100 hr.	0	-	0	-
250 hr.	0	-	0	-
125% 10 hr.	0	-	0	-
15 hr.	0	-	0	-
25 hr.	1	A	0	0
100 hr.	0	-	0	
100 hr.	0	-	0	-
250 hr.	0	-	0	-
150% 10 hr.	1	A	0	-
15 hr.	1	B	0	-
25 hr.	0	-	0	-
100 hr.	1	B	0	-
100 hr.	Job Stopped		1	B
250 hr.			5 1	B C
175% 10 hr.			Job Stopped	
15 hr.				
25 hr.				
100 hr.				
100 hr.				
250 hr.				

GROUP II 160 HR. TEMP. STEPS

TEST STEP TA	MFR A		MFR B	
	QTY.	NOTE	QTY.	NOTE
75° C	0	-	0	-
100° C	0	-	0	-
125°C	0	-	0	-
150°C	0	-	0	-
175°C	0	-	0	-
200°C	1	A	0	-
225°C	0	-	0	-
250°C	0	-	0	-
275°C	1	A	0	-
300°C	0	-	0	-

NOTES: A. I_R >100μA

B. VISUAL*

C. V_F <.3V

GROUP III 16 HR. TEMP. STEPS

TEST STEP TA	MFR A		MFR B	
	QTY.	NOTE	QTY.	NOTE
150°C	6	A	0	-
175°C	1	A	0	-
200°C	0	-	0	-
225°C	0	-	0	-
250°C	0	-	0	-
275°C	0	-	0	-
300°C	0	-	0	-

MFR "A" → SEMTECH

MFR "B" → MICRO SEMICONDUCTOR

* External Lead Detached From Stress.

DLA

DLL 9 STEP STRESS PARAMETRIC FAILURE SUMMARY JAN TX1N5552

GROUP I POWER STRESS

TEST STEP	MFR A		MFR B	
	QTY.	NOTE	QTY.	NOTE
50% 50 hr.	0	-	0	-
100 hr.	1	A	0	-
100 hr.	0	-	0	-
250 hr.	0	-	0	-
100% 50 hr.	0	-	0	-
100 hr.	0	-	0	-
100 hr.	0	-	0	-
250 hr.	0	-	0	-
125% 10 hr.	0	-	0	-
15 hr.	0	-	0	-
25 hr.	1	A	0	-
100 hr.	0	-	0	-
100 hr.	0	-	1	A
250 hr.	1	A	0	-
150% 10 hr.	1	A	1	B
15 hr.	0	-	0	-
25 hr.	0	-	0	-
100 hr.	0	-	0	-
100 hr.	Job Stopped		0	-
250 hr.			0	-
175% 10 hr.			Job Stopped	
15 hr.				
25 hr.				
100 hr.				
100 hr.				
250 hr.				

GROUP II 160 HR. TEMP. STEPS

TEST STEP TA	MFR A		MFR B	
	QTY.	NOTE	QTY.	NOTE
75° C	0	-	0	-
100° C	0	-	0	-
125 °C	0	-	0	-
150 °C	0	-	0	-
175 °C	2 / 2	A / C	0	-
200 °C	0	-	0	-
225 °C	0	-	0	-
250 °C	0	-	0	-
275 °C	0	-	12	A
300 °C	0	-	3	A

GROUP III 48 HR. TEMP. STEPS

TEST STEP TA	MFR A		MFR B	
	QTY.	NOTE	QTY.	NOTE
150°C	1	A	0	-
175°C	1	A	0	-
200 °C	0	-	0	-
225 °C	0	-	0	-
250 °C	0	-	0	-
275 °C	0	-	0	-
300 °C	0	-	0	-

MFR "A" → SEMTECH

MFR "B" → MICRO SEMICONDUCTOR

NOTES: A. I_R MAXIMUM LIMIT FAILURE

B. S/N 6764 REMOVED AS MIL-STD-19500 FAILURE

C. S/N 6805 and 6806 REMOVED AS MIL-STD-19500 FAILURES

APPENDIX A

FAILURE ANALYSIS

MSFC STEP-STRESS TEST
FAILURE ANALYSIS
DIODES

Date 9 January 1979

J/N 2CN242-22-A P/N 1N5552 MFR SEMTECH

FAILURE VERIFICATION: End Point: 100uA Max. End Points: 0.3-1.8V

S/N	PIV -volts-		I_r @ 600 V.dc	V_f @ 9.0Adc			Initial Rej. @ Test Seq. No.:	Initial Rej. for
6715	> 800(Uns) (R)		500uA				19(125% MRP 1010 Hrs)	I_R
6716	720		0.5uA	Cannot test			33 (150%MRP 525 Hrs.)	Lead off.
6719	> 750		3.0mA				23 (125%MRP 1050 Hrs.)	I_R

VISUAL INSPECTION

All these Semtech samples have lost their external paint. In addition S/N 6716 has lost one external lead at the connecting Joint (see Figure 1).

*h_{FE} trace present. Cannot meet stated test conditions. (Leaky)
**h_{FE} trace very leaky.

D = drift H = hysteresis Inv = inversion R = resistive S = soft Uns = unstable

MSFC STEP-STRESS TEST
FAILURE ANALYSIS
DIODES

Date 9 January 1979

J/N 2CN242-22A P/N 1N5552 MFR Micro Semiconductor

FAILURE VERIFICATION — End Point: 100uA Max. — End Points: 0.3-1.8V

S/N	PIV -volts-		I_r @ 600 V.dc	V_f @ 9.0A dc			Initial Rej. @ Test Seq. No.:	Initial Rej. for
6750	> 1100		< 100nA	Cannot test			39 (150% MRP 1750hr	Lead off.
6755	> 1100		< 100nA	Cannot test			41 (150% MRP 2000hr	Lead off.
6762	> 1100		< 100nA	Cannot test			41 (150% MRP 200 hr.	Lead off.

VISUAL INSPECTION

All three Micro Semiconductor samples lost their external paint, and one external lead came off each sample at the connecting joint (see Figure 2).

*h_{FE} trace present. Cannot meet stated test conditions. (Leaky)
**h_{FE} trace very leaky.

D = drift H = hysteresis Inv = inversion R = resistive S = soft Uns = unstable

CONCLUSIONS

In the case of Semtech S/N 6716, and all the Micro Semiconductor samples, the silicon die was still within acceptable electrical limits when the external lead became detached due to exceeding the melting temperature of the connecting metal.

The curve tracer pattern of Semtech S/N 6715 and 6719 indicates that these devices failed due to a combination of junction damage and surface contamination, with the junction damage predominating.

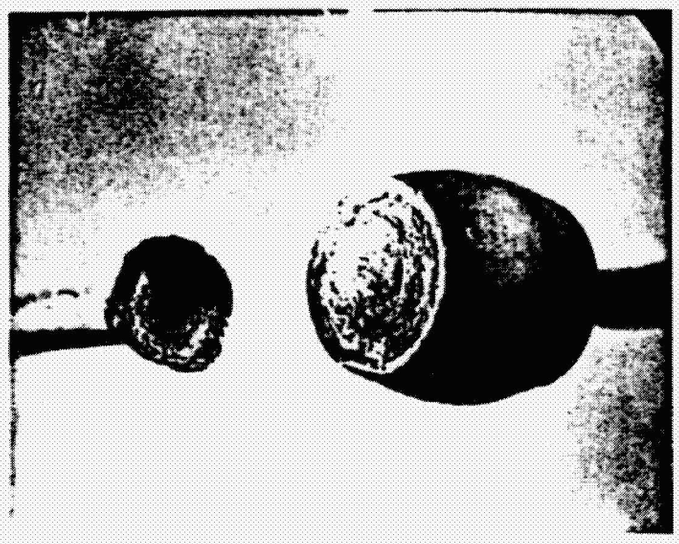


FIGURE A-1

S/N 6716. Semtech Diode, 8X. The external lead connecting joint has failed.

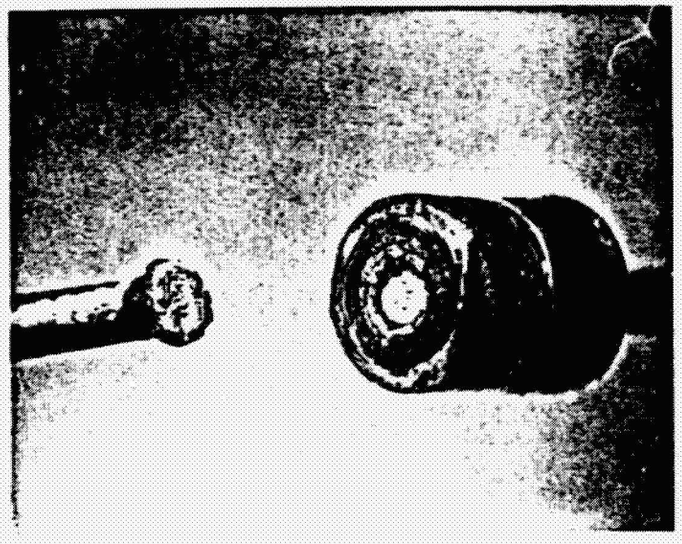


FIGURE A-2

S/N 6755. Micro Semiconductor Diode, 8X. The external lead connecting joint has failed.