

General Disclaimer

One or more of the Following Statements may affect this Document

- This document has been reproduced from the best copy furnished by the organizational source. It is being released in the interest of making available as much information as possible.
- This document may contain data, which exceeds the sheet parameters. It was furnished in this condition by the organizational source and is the best copy available.
- This document may contain tone-on-tone or color graphs, charts and/or pictures, which have been reproduced in black and white.
- This document is paginated as submitted by the original source.
- Portions of this document are not fully legible due to the historical nature of some of the material. However, it is the best reproduction available from the original submission.

(NASA-CR-161134) DIODE STEP STRESS PROGRAM
FOR JANTX1N746A Final Report (DCA
Reliability Lab., Sunnyvale, Calif.) 34 p
HC A03/NF A01 CSCI 09A

N79-18213

Unclas
G3/33 14168

DIODE STEP STRESS TESTING PROGRAM

MSFC/NASA CONTRACT NUMBER
NAS8-31944

FINAL REPORT
FOR
JANTX 1N746A

JANUARY 1979

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 report 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 is 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 discrete devices, as well as to determine which type of stress should be applied to a particular device or design.

This report is divided as follows: description of tests, figures, tables, and appendix.



TABLE OF CONTENTS

	<u>Page</u>
1.0 INTRODUCTION	1
2.0 TEST REQUIREMENTS	1
2.1 Electrical	1
2.2 Stress Circuit	1
2.3 Group I - Power Stress	2
2.4 Group II - Temperature Stress I	2
2.5 Group III - Temperature Stress II	2
3.0 DISCUSSION OF TEST RESULTS	3
3.1 Group I - Power Stress	3
3.1.1 Siemens	3
3.1.2 Motorola	3
3.1.3 Statistical Summary - Group I	4
3.2 Group II - Temperature Stress I	4
3.2.1 Siemens	4
3.2.2 Motorola	5
3.2.3 Statistical Summary - Group II	5
3.3 Group III - Temperature Stress II	5
3.3.1 Siemens	5
3.3.2 Motorola	6
3.3.3 Statistical Summary - Group III	6
4.0 FINAL DATA SUMMARY	7
5.0 CONCLUSIONS	7



LIST OF ILLUSTRATIONS

<u>Figure</u>	<u>Title</u>	<u>Page</u>
1	Power/Temperature Stress Circuit for JANTX1N746A	10
2	Cumulative Percent Failures Versus Junction Temperature, Siemens	11
3	Time Steps Versus Junction Temperature, Siemens	12
4	Cumulative Percent Failures Versus Junction Temperature, Motorola	13
5	Time Steps Versus Junction Temperature, Motorola	14
A-1	S/N 1135. Magnification 12X	29
A-2	S/N 6590. Magnification 12X	29

LIST OF TABLES

<u>Table</u>	<u>Title</u>	<u>Page</u>
1	Test Flow Diagram	15
2	Parameters and Test Conditions	16
3	Power Stress Burn-In Conditions	16
4	Group I - Power Stress Data Summary	18
5	Group II - Temperature Stress I Data Summary	20
6	Group III - Temperature Stress II Data Summary	21
7	Final Data Summary	22
8	Step Stress Catastrophic Failure Summary	23
9	Step Stress Parametric Failure Summary	24



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 diode JANTX1N746A manufactured by Siemens and Motorola.

A total of 48 samples from each manufacturer was 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_Z 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 a total of 2500 hours or until 50% or more of the devices in the sample lot failed.* Electrical measurements were performed on all specified electrical parameters after each power step. See Table 1. (*See Notes at end of text.)

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 II - 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.

3.0 DISCUSSION OF TEST RESULTS

3.1 Group I - Power Stress

3.1.1 Siemens. The Siemens sample lot completed the entire 2500-hour Group I Testing with one catastrophic failure. The failure occurred 150 hours into the 175% MRP step. Serial Number 1127 failed the maximum I_R limit. Typical characteristics of this sample lot's performance were:

- 1) The mean value for I_R changed .481nA from an initial mean of 1.424nA to a final mean of 1.905nA.
 - 2) The mean value for B_V changed .002V from an initial mean of 3.246V to a final mean of 3.248V.
- The control units for this sample lot remained constant throughout the entire Group I Testing.

3.1.2 Motorola. The Motorola sample lot completed the entire 2500-hour Group I Testing with one catastrophic failure. The failure occurred 150 hours into the 175% MRP step. Serial Number 6553 failed the maximum I_R limit. Typical characteristics of this sample lots performance were:

- 1) The mean value for I_R changed .884nA from an initial mean of 1.574nA to a final mean of 2.458nA.
- 2) The mean value for B_V did not change, from an initial mean of 3.312V to a final mean of 3.312V.



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 Testing for each of the electrical parameters and all of the measurement points for both Siemens and Motorola.

3.2 Group II - Temperature Stress I

3.2.1 Siemens. The Siemens sample lot completed 1440 hours of Group II Testing before the lot was stopped because more than 50% of the devices failed. The first two failures occurred 160 hours into the 200°C-temperature step. Serial Numbers 1130 and 1141 failed the maximum I_R unit. The next two failures occurred 160 hours into the 225°C-temperature step. Serial Numbers 1136 and 1139 failed the maximum I_R limit. Serial Number 1145 failed the maximum B_V limit. The last eight failures occurred 160 hours into the 275°C-temperature step. Serial Numbers 1132, 1133, 1134, 1135, 1142, and 1144 failed the maximum I_R limit. Serial Numbers 1140 and 1143 failed the minimum B_V limit. Typical characteristics of this sample lot's performance were:

1) The mean value for I_R changed 659.998mA from an initial mean of 1.377μA to a final mean of 660.0mA.

2) The mean value for B_V changed 2.096V from an initial mean of 3.214V to a final mean of 1.118V.

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



3.2.2 Motorola. The Motorola sample lot completed 1280 hours of Group II Testing before the lot was stopped because more than 50% of the devices failed. The first three failures occurred 160 hours into the 225°C-temperature step. Serial Numbers 6561 and 6584 failed the maximum I_R limit. Serial Number 6583 failed the minimum B_V limit. The last six failures occurred 160 hours into the 250°C-temperature step. Serial Numbers 6558, 6563, 6586, 6589, and 6590 failed the maximum I_R limit. Serial Number 6562 failed the minimum B_V limit. Typical characteristics of this sample lot's performance were:

- 1) The mean value for I_R changed 22.928mA from an initial mean of 1.578 μ A to a final mean of 22.93mA.
- 2) The mean value for B_V changed .017V from an initial mean of 3.321V to a final mean of 3.304V. 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 Siemens and Motorola.

3.3 Group III - Temperature Stress II

3.3.1 Siemens. The Siemens sample lot completed the entire 112-hour Group III Testing with eight catastrophic failures. The first two failures occurred 16 hours into the 250°C-temperature step. Serial Number 1147 failed the maximum I_R limit.



Serial Number 1149 failed the minimum B_V limit. The next two failures occurred 16 hours into the 275°C-temperature step. Serial Numbers 1150 and 1160 failed the maximum I_R limit. The last four failures occurred 16 hours into the 300°C-temperature step. Serial Numbers 1138, 1148, 1153, and 1154 failed the maximum I_R limit. Typical characteristics of this sample lot's performance were:

- 1) The mean value for I_R changed 35.453 μ A from an initial mean of 1.447 μ A to a final mean of 36.90 μ A.
- 2) The mean value for B_V changed .001V from an initial mean of 3.240V to a final mean of 3.239V. The control units for this sample lot remained constant throughout the entire Group III Testing.

3.3.2 Motorola. The Motorola sample lot completed the entire 112-hour Group III testing with a total of two catastrophic failures. The first failure occurred 16 hours into the 225°C-temperature step. Serial Number 6566 failed the maximum I_R limit. The last failure occurred 16 hours into the 300°C-temperature step. Serial Number 6594 failed the maximum I_R limit. Typical characteristics of this sample lot's performance were:

- 1) The mean value for I_R changed 6.544 μ A from an initial mean of 1.591 μ A to a final mean of 8.135 μ A.
- 2) The mean value for B_V changed .005V from an initial mean of 3.320V to a final mean of 3.315V. 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 Siemens and Motorola.

4.0 FINAL DATA SUMMARY

Table 7 summarizes the change in the mean value from the zero-hour data to the final data. The graphs of Figures 2, 3, 4, and 5 plot cumulative percent failures versus elapsed time for Group II - Temperature Stress I, and Group III - Temperature Stress II. Tables 8 and 9 summarize the failures encountered from all three stress groups. The test devices are separated into two groups: catastrophic failures, shown in Table 8, and parametric failures, shown in Table 9. The data from Table 8 was used as a source for the graphs in Figures 2, 3, 4, and 5.

5.0 CONCLUSIONS

Both Siemens and Motorola held up well in the Group I Testing with each manufacturer experiencing one catastrophic failure. Although both manufacturers completed the entire Group III Testing, Siemens' sample lot experienced eight catastrophic failures and the Motorola sample lot experienced two.

Because of the apparent I_R leakage failure mode, failure analysis was done for the Group II Testing. In this testing, both sample lots had to be stopped because of more than 50% of the devices in each sample lot failing before the end of the test. Many of the Siemens samples exhibited metal flow away from the die and up the internal lead.



For many of the Motorola diodes, metal has climbed partially up the internal lead, thus depleting the top metal connection of the die. Both Siemens' and Motorola's diodes failed because of the effects of high temperature which has melted the internal die metal. The molten metal acting over many hours has alloyed into the silicon dice and shorted them out. A plot showing cumulative failure distribution for both Siemens and Motorola sample lots (Figures 2 and 3, and 4 and 5, respectively). Figures 2 and 3 display the data for the Siemens sample lot used to calculate an activation energy of 1.81eV. Figures 4 and 5 display the data for the Motorola sample lot used to calculate an activation energy of 1.24 eV.

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 failure point. The regression line was calculated using the least square method.

In Figure 2, the Group II failure point at 450° was not calculated into the regression line because of a change in the failure mechanism.



The activation energy was calculated from the formula:

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

- Where: t_1 = step of Group II - Temp Stress I = 160 hrs.
 t_2 = step of Group III - Temp Stress II = 16 hrs.
 T_1 = temperature in $^\circ\text{C}$ of 16% failure for Group II.
 T_2 = temperature in $^\circ\text{C}$ of 16% failure for Group III.

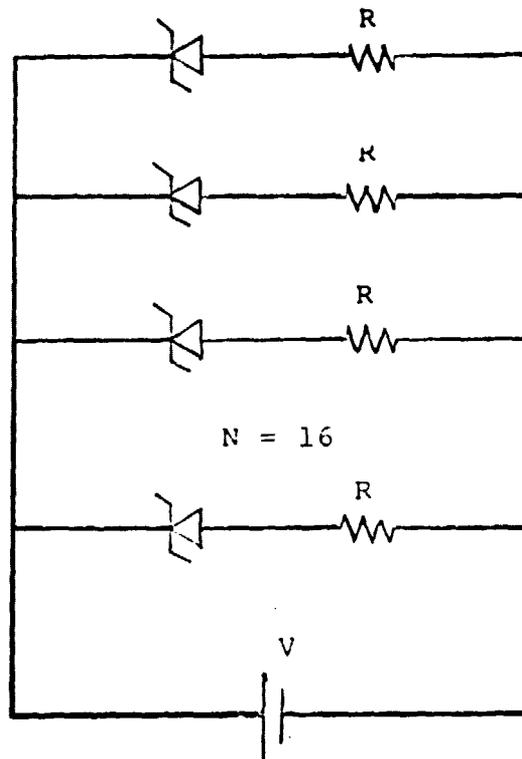
NOTE:

*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.



ZENER DIODES



$$R = VZ \div 1.75 I_{Z_{MAX}} \pm 50\%$$

$$P_d = VZ^2 \div R$$

FIGURE 1

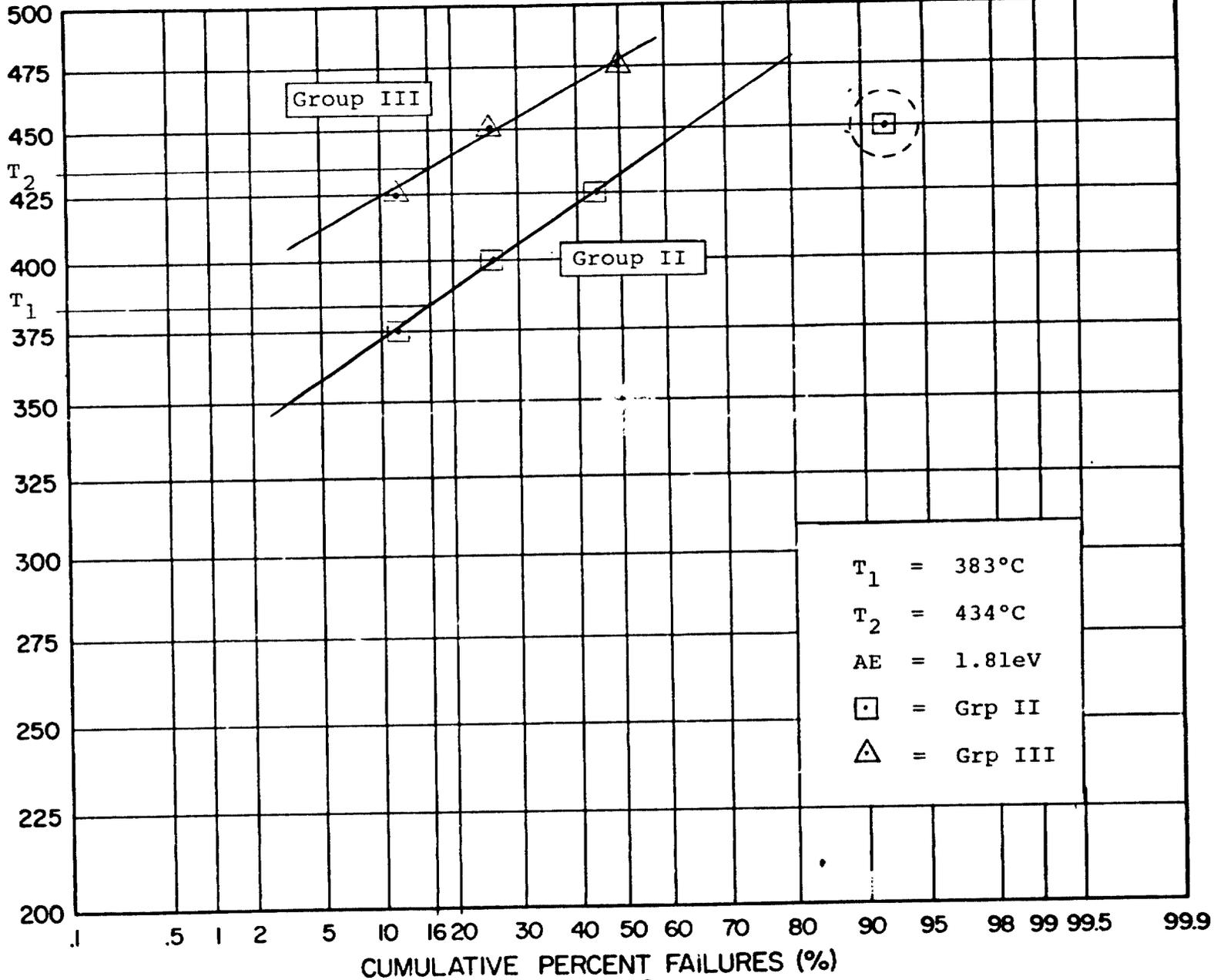
Power and Temperature Stress Circuit
for JANTX1N746A



SIEMENS

JANTX1N746A

* JUNCTION TEMPERATURE (°C)



11

*NOTE

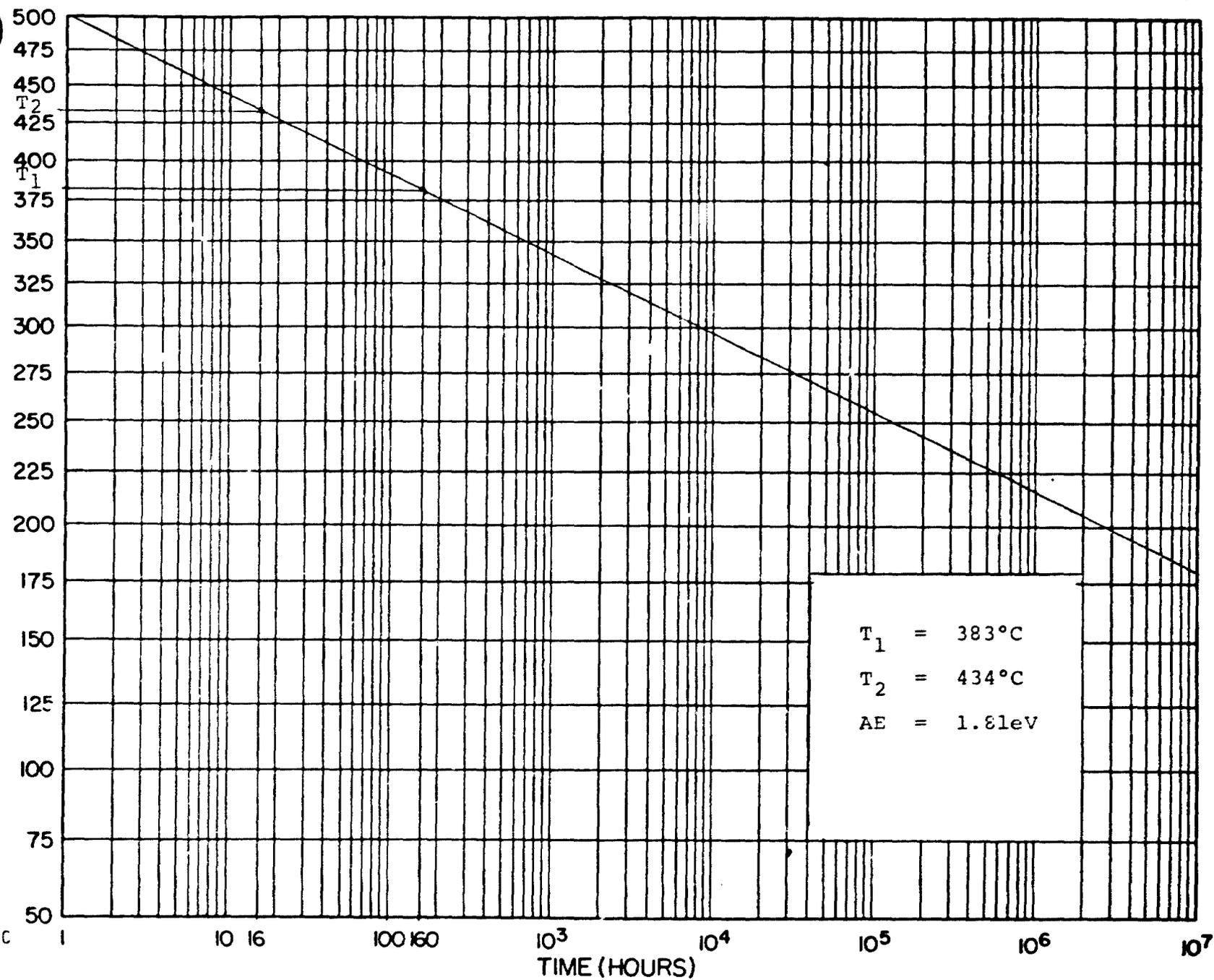
$T_J \approx T_A + 175^\circ\text{C}$

FIGURE 2
Cumulative Percent Failures Versus Junction Temperature, Siemens

JANTX1N746A



* JUNCTION TEMPERATURE (°C)



$T_1 = 383^\circ\text{C}$
 $T_2 = 434^\circ\text{C}$
 $AE = 1.81\text{eV}$

*NOTE

$T_J = T_A + 175^\circ\text{C}$

TIME (HOURS)

FIGURE 3
Time Steps Versus Junction Temperature, Siemens

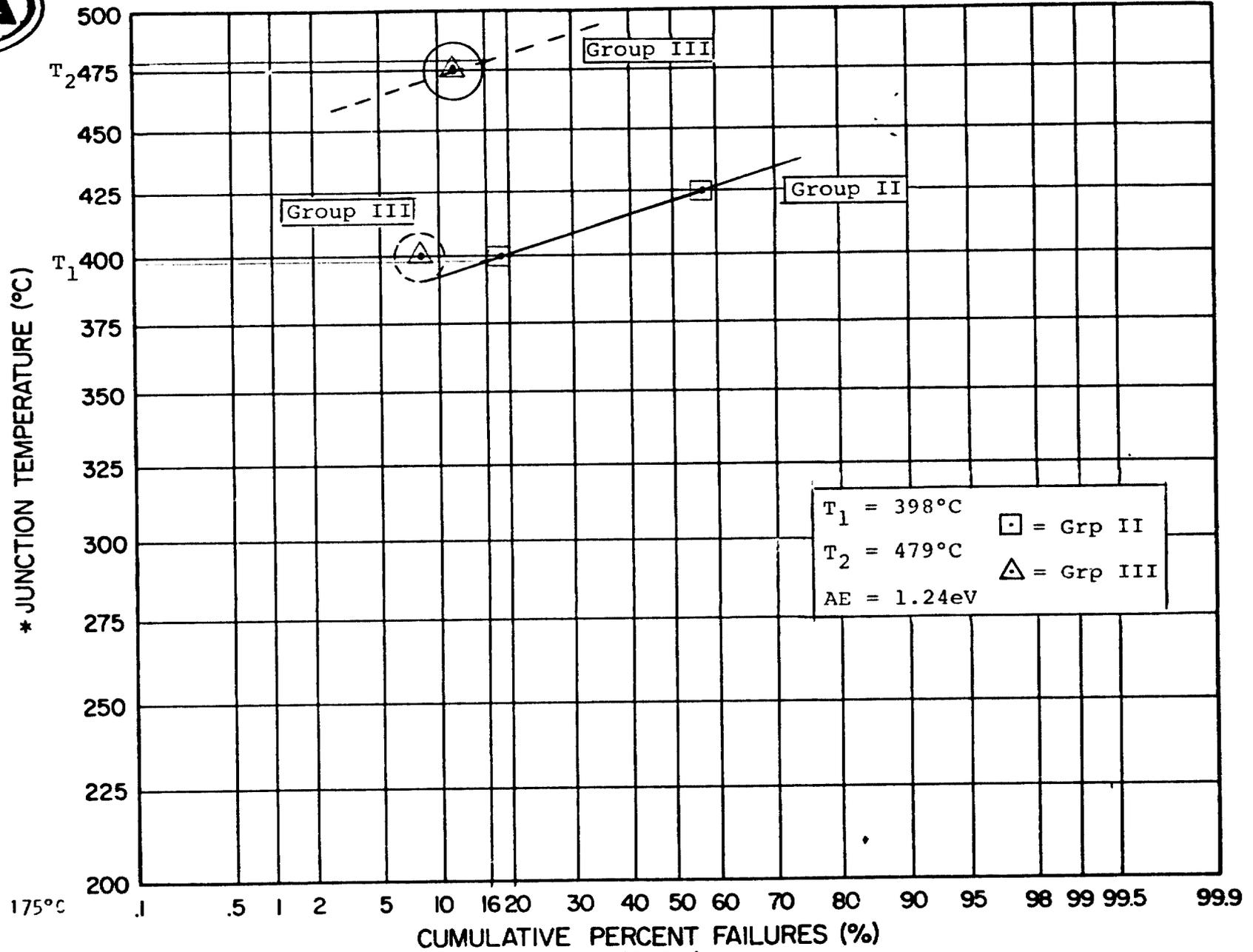
12

JANIXIN746A



MOTOROLA

JANTX1N746A



*NOTE

$$T_J \approx T_A + 175^\circ\text{C}$$

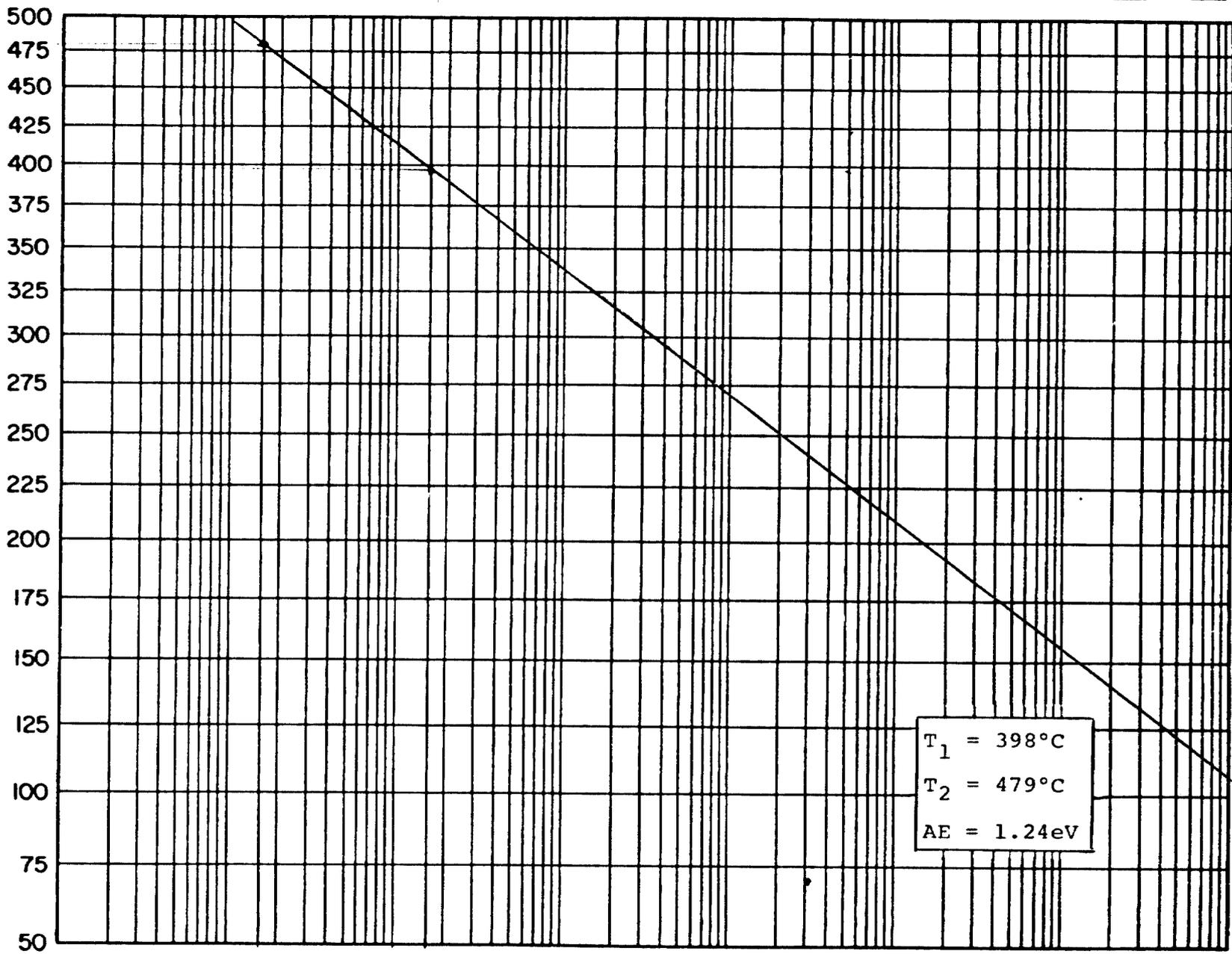
FIGURE 4
Cumulative Percent Failures Versus Junction Temperature, Motorola

JANTX1N746A



* JUNCTION TEMPERATURE (°C)

T₂
T₁



T₁ = 398°C
T₂ = 479°C
AE = 1.24eV

*NOTE

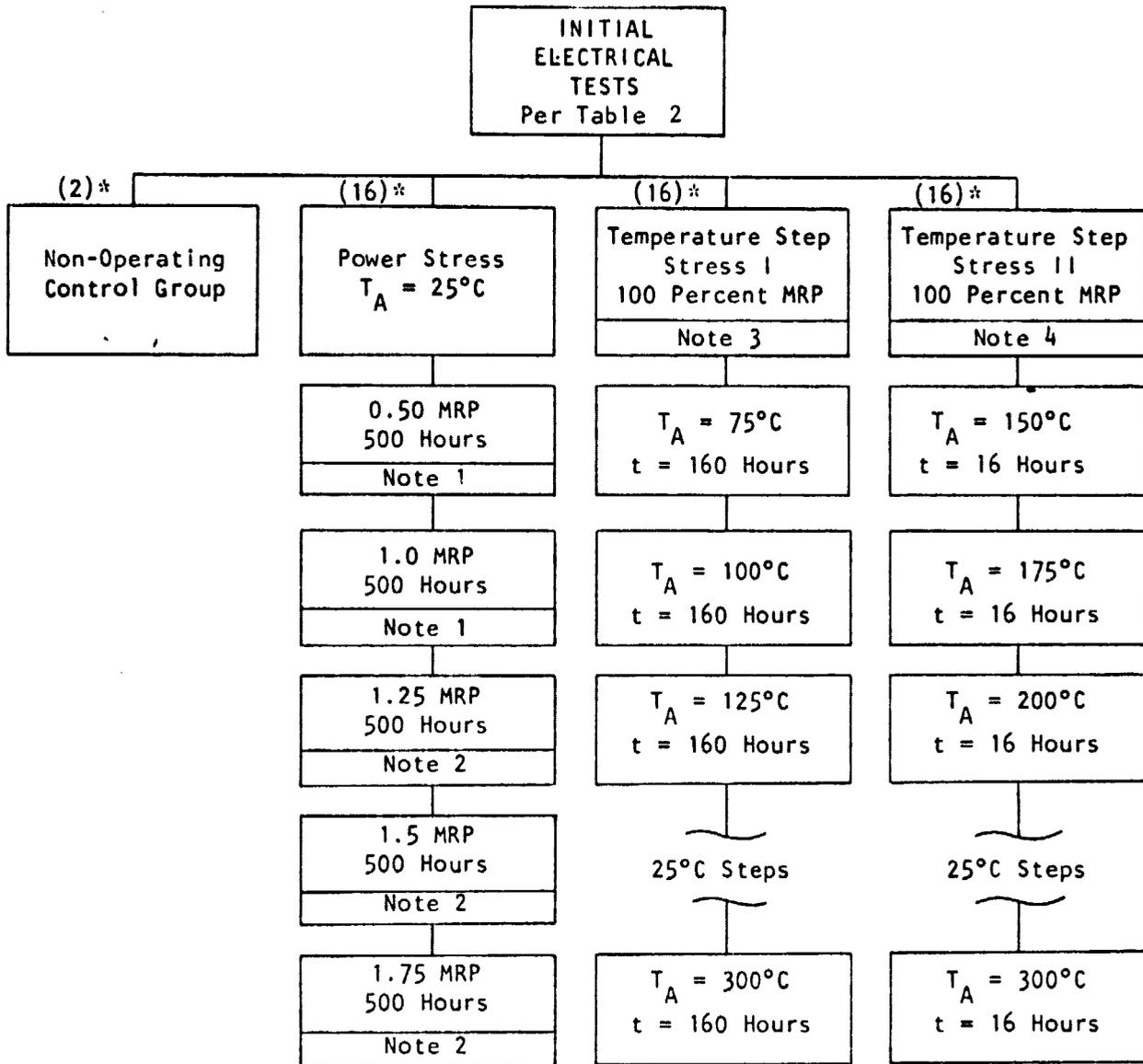
$T_J \approx T_A + 175^\circ\text{C}$

JANTXIN746A

FIGURE 5
Time Steps Versus Junction Temperature, Motorola



TABLE 1
TEST FLOW DIAGRAM



*Quantity per manufacturer (SIEMENS and MOTOROLA)

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
PARAMETERS AND TEST CONDITIONS

JANTX1N746A

PARAMETER	CONDITIONS	SPEC. LIMIT		CAT. LIMIT		UNITS
		MIN	MAX	MIN	MAX	
I_R	@ $V_R = 1.0V$		5		500	μA
B_V	@ $I_Z = 20.0 mA$	3.14	3.46	1.57	5.19	V

NOTES:

1/ In addition, any open or short shall be considered catastrophic.

TABLE 3
POWER STRESS BURN-IN CONDITIONS

$V_Z = 3.3V$	
I_Z	Percent P_D
60.6mA	50
121.0mA	100
151.0mA	125
181.0mA	150
212.0mA	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 than 9.99mA which have an absolute accuracy of $\pm 2\%$ of the reading and \pm one digit. The data also have a resolution for four digits. The standard deviations, 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	$I_R = 5.0\mu A$ (MAX)		$B_V = 3.14$ (MIN) 3.46 (MAX)					
CONDITIONS AND LIMIT	@ $V_R = 1.0V$		@ $I_Z = 20.0mA$					
IDENTIFICATION	SIEMENS	MOTOROLA	SIEMENS	MOTOROLA				
INITIAL DATA								
MIN VALUE	.673 μA	1.260 μA	3.167V	3.256V				
MAX VALUE	2.590 μA	1.930 μA	3.394V	3.367V				
MEAN	1.424 μA	1.574 μA	3.246V	3.312V				
STD DEV	.457 μA	.187 μA	.049V	.034V				
INTERIM DATA								
POWER 50 TO 125% Δ MEAN VALUE								
50% POWER								
50 HRS	.010 μA	.015 μA	.003V	.005V				
150 HRS	.019 μA	.009 μA	.002V	.002V				
250 HRS	.047 μA	.019 μA	.004V	.003V				
500 HRS	.044 μA	-.007 μA	.004V	.004V				
100% POWER								
550 HRS	.070 μA	-.018 μA	.003V	.005V				
650 HRS	-.002 μA	-.055 μA	.006V	.007V				
750 HRS	-.051 μA	-.073 μA	.005V	.007V				
1000 HRS	-.017 μA	-.047 μA	.005V	.007V				
125% POWER								
1010 HRS	-.035 μA	-.062 μA	.008V	.009V				
1025 HRS	-.009 μA	-.093 μA	.007V	.007V				
1050 HRS	-.030 μA	.237 μA	.001V	.003V				
1150 HRS	-.062 μA	.014 μA	.007V	.008V				
1250 HRS	-.030 μA	.042 μA	.007V	.009V				
1500 HRS	-.030 μA	.086 μA	.004V	.007V				

(continued on second sheet)



TABLE 4 (Cont'd)

(continued from first sheet)

GROUP I - POWER STRESS DATA SUMMARY

Page 2 of 2

PARAMETER	$I_R = 5.0\mu\text{A}(\text{MAX})$		$B_V = 3.14(\text{MIN}) \ 3.46(\text{MAX})$					
CONDITIONS AND LIMITS	@ $V_R = 1.0\text{V}$		@ $I_Z = 20.0\text{mA}$					
IDENTIFICATION	SIEMENS	MOTOROLA	SIEMENS	MOTOROLA				
INITIAL DATA								
MIN VALUE	.673 μA	1.250 μA	3.167V	3.256V				
MAX VALUE	2.590 μA	1.930 μA	3.394V	3.367V				
MEAN	1.424 μA	1.574 μA	3.246V	3.312V				
STD DEV	.457 μA	.187 μA	.049V	.034V				
INTERIM DATA								
POWER 150 TO 175% Δ MEAN VALUE								
150% POWER								
1510 HRS	.004 μA	.080 μA	.005V	.007V				
1525 HRS	-.049 μA	.079 μA	.003V	.005V				
1550 HRS	.047 μA	.244 μA	.016V	.010V				
1650 HRS	.002 μA	.158 μA	.018V	.005V				
1750 HRS	-.109 μA	.070 μA	.012V	.004V				
2000 HRS	.095 μA	.137 μA	.011V	.005V				
175% POWER								
2010 HRS	.933 μA	.202 μA	.007V	.004V				
2025 HRS	.734 μA	3.262 μA	.005V	.002V				
2050 HRS	.279 μA	4.719 μA	.008V	.004V				
2150 HRS	*202.176 μA	*118.226 μA	-.013V	-.005V				
2250 HRS	.435 μA	.436 μA	.002V	.002V				
2500 HRS	.481 μA	.884 μA	.002V	.000V				
FINAL DATA								
MIN VALUE	1.000 μA	1.270 μA	3.179V	3.253V				
MAX VALUE	4.390 μA	11.500 μA	3.321V	3.373V				
MEAN	1.905 μA	2.458 μA	3.248V	3.312V				
STD DEV	1.007 μA	2.473 μA	.037V	.037V				

* NOTE: CATASTROPHIC REJECT(S) REMOVED FROM DATA AFTER THIS POINT.

TABLE 5

GROUP II TEMP STRESS I DATA SUMMARY

PARAMETERS	$I_R = 5.0\mu A$ (MAX)		$B_V = 3.14$ (MIN) 3.46 (MAX)					
CONDITIONS AND LIMITS	@ $V_R = 1.0V$		@ $I_Z = 20.0mA$					
IDENTIFICATION	SIEMENS	MOTOROLA	SIEMENS	MOTOROLA				
INITIAL DATA								
MIN VALUE	.825 μA	1.170 μA	3.163V	3.259V				
MAX VALUE	1.950 μA	2.010 μA	3.412V	3.389V				
MEAN	1.377 μA	1.578 μA	3.214V	3.321V				
STD DEV	.278 μA	.231 μA	.068V	.039V				
INTERIM DATA (INITIAL TO FINAL)								
Δ MEAN VALUE								
TOTAL HRS TEMP (T_A)								
160 75 $^{\circ}C$	-.006 μA	-.019 μA	.031V	.004V				
320 100 $^{\circ}C$	-.006 μA	-.025 μA	.029V	.004V				
480 125 $^{\circ}C$	-.017 μA	-.057 μA	.030V	.008V				
640 150 $^{\circ}C$	1.238 μA	-.052 μA	.028V	.003V				
800 175 $^{\circ}C$	6.274 μA	.003 μA	.016V	.002V				
960 200 $^{\circ}C$	*666.023 μA	.026 μA	.026V	-.004V				
1120 225 $^{\circ}C$	*143.523 μA	* 124.622 μA	.019V	-.001V				
1280 250 $^{\circ}C$	*16.208mA	* 22.928mA	.009V	*-.017V				
1440 275 $^{\circ}C$	*659.998mA	JOB STOPPED	*-2.096V	JOB STOPPED				
1600 300 $^{\circ}C$	JOB STOPPED	JOB STOPPED	JOB STOPPED	JOB STOPPED				
FINAL DATA								
FINAL TEMP (T_A)	275 $^{\circ}C$	250 $^{\circ}C$	275 $^{\circ}C$	250 $^{\circ}C$				
MIN VALUE	.01 μA	1.04 μA	.015V	3.254V				
MAX VALUE	990.00mA	99.90mA	3.323V	3.370V				
MEAN	660.00mA	22.93mA	1.118V	3.304V				
STD DEV	466.70mA	39.96mA	1.559V	.039V				

*NOTE: CATASTROPHIC REJECT(S) REMOVED FROM DATA AFTER THIS POINT.

20

1-0081 Form 1001

JAN 1964

TABLE 6
GROUP III TEMP STRESS II DATA SUMMARY

PARAMETERS	$I_R = 5.0\mu A$ (MAX)		$B_V = 3.14V$ (MIN) 3.46(MAX)					
CONDITIONS AND LIMITS	@ $V_R = 1.0V$		@ $I_Z = 20.0mA$					
IDENTIFICATION	SIEMENS	MOTOROLA	SIEMENS	MOTOROLA				
INITIAL DATA								
MIN VALUE	.977 μA	1.260 μA	3.168V	3.260V				
MAX VALUE	2.450 μA	1.980 μA	3.368V	3.393V				
MEAN	1.447 μA	1.591 μA	3.240V	3.320V				
STD DEV	.390 μA	.195 μA	.046V	.042V				
INTERIM DATA (INITIAL TO FINAL)								
Δ MEAN VALUE								
TOTAL HRS TEMP (T_A)								
16 150 $^{\circ}C$	-.034 μA	-.065 μA	-.000V	.002V				
32 175 $^{\circ}C$	-.033 μA	-.060 μA	.001V	.003V				
48 200 $^{\circ}C$.186 μA	.567 μA	.003V	.003V				
64 225 $^{\circ}C$.358 μA	*6.130 μA	.003V	-.001V				
80 250 $^{\circ}C$	*6.744 μA	-.101 μA	*-.117V	-.005V				
96 275 $^{\circ}C$	*21.993 μA	-.014 μA	-.003V	-.074V				
112 300 $^{\circ}C$	*35.453 μA	*6.544 μA	-.001V	-.005V				
FINAL DATA								
FINAL TEMP (T_A)	300 $^{\circ}C$	300 $^{\circ}C$	300 $^{\circ}C$	300 $^{\circ}C$				
MIN VALUE	1.19 μA	1.280 μA	3.170V	3.256V				
MAX VALUE	99.90 μA	99.900 μA	3.283V	3.395V				
MEAN	36.90 μA	8.135 μA	3.239V	3.315V				
STD DEV	44.78 μA	24.530 μA	.034V	.042V				

*NOTE: CATASTROPHIC REJECT(S) REMOVED FROM DATA AFTER THIS POINT.

21

1-0081 Form VCA

JAN 1974



TABLE 7
FINAL DATA SUMMARY

PARAMETER	SPECIFICATIONS LIMIT		U N I T S	MEAN INT. DATA	AVERAGE Δ IN MEAN VALUE					
	MIN	MAX			POWER STRESS		TEMPERATURE STRESS I		TEMPERATURE STRESS II	
					SIEMENS	MOTOROLA	SIEMENS	MOTOROLA	SIEMENS	MOTOROLA
I_R		5.0	MA		*+7.8828	*+4.9448	*1891.7	*+2881.6	*+9.2381	*+1.8573
B_V	3.14	3.46	V		+0.00546	+0.00485	-.2120	-.00013	-.01629	-.0110

* NOTE: CATASTROPHIC REJECT(S) REMOVED FROM DATA AFTER THIS POINT.



TABLE 8 STEP STRESS CATASTROPHIC FAILURE SUMMARY

JANTXIN746A

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.	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.	0	-	0	-
100 hr.	0	-	0	-
100 hr.	0	-	0	-
250 hr.	0	-	0	-
150% 10 hr.	0	-	0	-
15 hr.	0	-	0	-
25 hr.	0	-	0	-
100 hr.	0	-	0	-
100 hr.	0	-	0	-
250 hr.	0	-	0	-
175% 10 hr.	0	-	0	-
15 hr.	0	-	0	-
25 hr.	0	-	0	-
100 hr.	1	A	1	A
100 hr.	0	-	0	-
250 hr.	0	-	0	-

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	2	A	0	-
225°C	2	A	2	1 A C
250°C	2	1 A B	5	1 A C
275°C	6	2 A C	JOB STOPPED	
300°C	JOB STOPPED		JOB STOPPED	

NOTES: A - $I_R > 500 \mu A$
 B - $R_V > 5.19V$
 C - $B_V < 1.57V$

GROUP III 16 HR. TEMP. STEPS

TEST STEP TA	MFR A		MFR B	
	QTY.	NOTE	QTY.	NOTE
150°C	0	-	0	-
175°C	0	-	0	-
200°C	0	-	0	-
225°C	0	-	1	A
250°C	1	1 A C	0	-
275°C	2	A	0	-
300°C	4	A	1	A

MFR "A" = SIEMENS
 MFR "B" = MOTOROLA



TABLE 9 STEP STRESS PARAMETRIC FAILURE SUMMARY

JANTX1N746A

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.	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.	0	-	1	A
100 hr.	0	-	0	-
100 hr.	0	-	0	-
250 hr.	0	-	0	-
150% 10 hr.	0	-	0	-
15 hr.	0	-	0	-
25 hr.	0	-	0	-
100 hr.	0	-	0	-
100 hr.	0	-	0	-
250 hr.	0	-	0	-
175% 10 hr.	1	A	0	-
15 hr.	1	A	1	A
25 hr.	0	-	1	A
100 hr.	0	-	0	-
100 hr.	0	-	0	-
250 hr.	0	-	0	-

GROUP II 160 HR. TEMP. STEPS

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

GROUP III 16 HR. TEMP. STEPS

TEST STEP T _A	MFR A		MFR B	
	QTY.	NOTE	QTY.	NOTE
150°C	0	-	0	-
175°C	0	-	0	-
200°C	0	-	1	A
225°C	1	A	0	-
250°C	0	-	0	-
275°C	1	A	1	B
300°C	3	A	0	-

MFR "A" = SIEMENS

MFR "B" = MOTOROLA

- NOTES:
- A - I_R MAXIMUM LIMIT FAILURE
 - B - B_V MINIMUM LIMIT FAILURE
 - C - NOTES A and B



APPENDIX
FAILURE ANALYSIS



JANTX1N746A

FAILURE ANALYSIS

Date 16 November 1978

J/N 2CN242-28B P/N 1N746A MFR SIEMENS

FAILURE VERIFICATION:

S/N	PIV ' -volts @20mA	I_R @ 1.0 V.dc	V_F @ _____dc	INITIAL REJ. AT TEST SEQUENCE NO.:	INITIAL REJ. FOR:
1133	0.16(R)	>700 μ A		19 (275°C - 1440 Hrs. Tot)	I_R
1135	0.17(R)	>700 μ A		19 (275°C - 1440 Hrs. Tot)	I_R
1142	0.17(R)	>700 μ A		19 (275°C - 1440 Hrs. Tot)	I_R
	End point Limits 1.57-519	End point Limit: 500 μ A Max.			

INTERNAL VISUAL INSPECTION:

All three Siemens samples exhibit metal flow away from the die and up the internal lead.
(See Figure A-1.)

*^hFE trace present. Cannot meet stated test conditions. (Leaky)
**^hFE trace very leaky.

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



JANTX1N746A

FAILURE ANALYSIS

Date 16 November 1978

J/N 2CN242-28B P/N 1N746A MFR MOTOROLA

FAILURE VERIFICATION:

S/N	PIV -volts- @ 20mA	I_R @ 1.0 V.dc	V_F @ _____dc	INITIAL REJ. AT TEST SEQUENCE NO.:	INITIAL REJ. FOR:
6558	0.14(R)	>700 μ A		17 (250 $^{\circ}$ C - 1280 Hrs. Tot)	I_R
6586	0.20(R)	>700 μ A		17 (250 $^{\circ}$ C - 1280 Hrs. Tot)	I_R
6590	0.28(R)	>700 μ A		17 (250 $^{\circ}$ C - 1280 Hrs. Tot)	I_R
	End point Limits: 1.57 - 5.19	End point Limit: 500 μ A Max.			

INTERNAL VISUAL INSPECTION:

The metal on all three Motorola diodes has climbed partially up the internal lead thus depleting the top connection of the die. No other significant anomalies were seen. (See Figure A-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

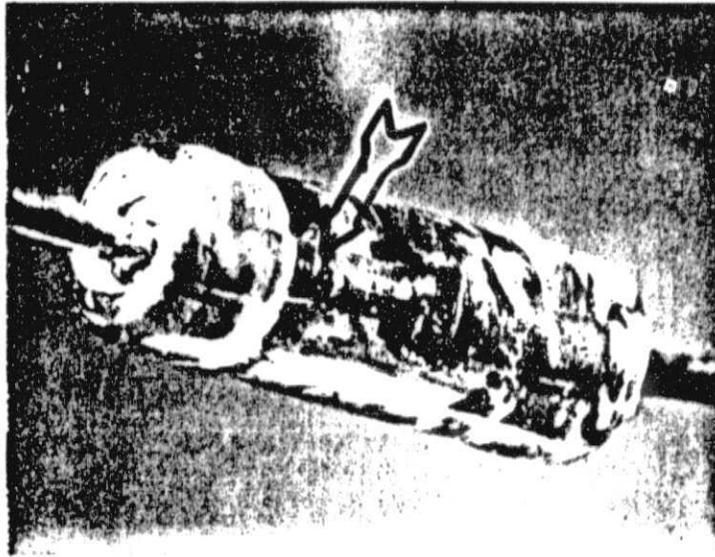


CONCLUSION:

All six of these Siemens and Motorola diodes failed because of the effects of high temperature which melted the internal die bond. The molten metal, acting over many hours, alloyed into the silicon dice and shorted them out.



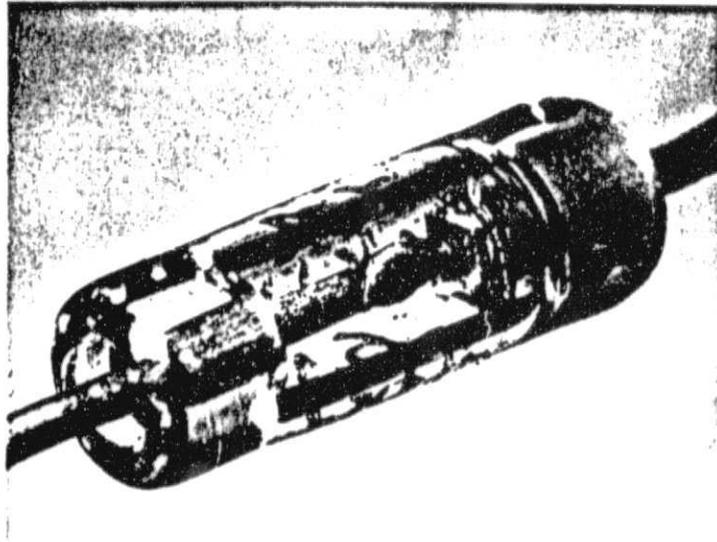
JANTX1N746A



OF P...

FIGURE 1

S/N 1135, TYPICAL SIEMENS SAMPLE, 12X.
Arrow indicates bead of metal
which has climbed off the die connection.



S/N 6590, TYPICAL MOTOROLA SAMPLE, 13X.
The top die bond has climbed to the
"spade" area of the internal lead.