Bendix

Aerospace Systems Division

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HIGH TEMPERATURE OPERATION OF EASEP TRANSMITTERS

This EATM contains analyses and test data performed to CCP 98/510-17 to determine operating characteristics of ALSEP Data transmitters in the high temperature environment possible at EASEP initial deployment.

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SUMMARY

High temperature functional tests were performed on Prototype Transmitter SN-5 and Qualification Transmitter SN-8. Safe adequate performance was obtained to the test limit of 77°C. The extrapolation of data to the flight model units (which consume more power) show adequate margin on the hottest running transistor junction, the power doubler 2N4012. It is therefore probable that the high temperature, expected in the LM SEQ bay and hence the EASEP interior at deployment and start of operation, will impose no incipient premature failure of the data transmitters.

TESTS AND TEST DATA

Transmitters SN-5 prototype and SN-8 Qualification Model were subjected to tests which measured their significant operating parameter from ambient temperature up to 77° Celsius. The data is shown in Tables 1 and 2 respectively.

TABLE I

TRANSMITTER SN-5 DATA

29V Current	252 ma	278ma	* 285ma	319 ma	** 269ma
12V Current	31 ma	32 ma	32.5ma	33 ma	32.5ma
Output Power	-5.1 (30.3)	-5.3 (30.1)	-5.45 (29.95)	-5.4 (30)	-6.2 (29.2)
Peak Deviation	1.2 V (radians)	1.15 V	1.2V	1.2V	1.2V
Frequency Hz	175.1152 (X 13)	175.1139	175.1143	175.1149	175.1149
(TM-1) AGC Level	1.849V	1.932V	2.039V	2.276V	1.947V
(TM-2) Heat-Sink Temp.	2.683V (27°C)	4.193V (53.5°C)	4.809V (64.5°C)	4.903V (66.5°C)	5.14V (69°C)
(TM-3) Power Doubler(I)	2.852V 156ma	3.071V 161ma	3.050V 159ma	3.104V 161ma	2.948V 156ma
(TM-4) Xtal Temp.	2.760V (28°C)	4.054V (53°C)	4.544V (64°C)	4.618V (65.5°C)	4.799V (68.5°C)

* After 10 minutes of "on" time, current went to 307 ma and output power dropped to 29.9 dbm.

** This transmitter was not able to maintina rf output power within specification at the high temperature as was SN-8. Input power also dropped off. (Apparently insufficient AGC gain and/or improper high temperature tuning).

TABLE 2

TRANSMITTER SN-8 DATA

29V Current	219ma	233ma	259ma	271ma	279ma	281ma
12V Current	31ma	32ma	32ma	33ma	33ma	33ma
Output Power	-5.2 (30.2dbm)	-5.3 (30.1)	-5.3 (30.1)	-5.3 (30,1)	-5.3 (30,1)	-5.3 (30.1)
Peak Deviation	1.25V (radians)	1.25V	1.25V	1.25V	1.35V	1.35V
Frequency Hz	175.1149 (X13)	175.1143	175.1139	175.1140	175.1144	175.1143
(TM-1) AGC Level	1.189V	1.307V	1.664V	2.025V	2.342V	2.177V
(TM-2) Heat-Sink Temp.	2.42V (32°C)	3.252V (49°C)	3.969V (66°C)	4.199V (70°C)	4.306V (76°C)	4.322V (77°C)
(TM-3) Power Doubler I	2.016V (134ma)	2.331V (144ma)	2.815V (160ma)	3.044V (168ma)	3.160V (174ma)	3.244V (176ma)
(TM-4) Xtal Temp.	2.893V (31°C)	3.713V (48°C)	4.350V (63°C)	4.55V (70°C)	4.641V (73°C)	4.656V (74°C)

SN-8 transmitter operated normally and within specification throughout the high temperature testing.

THERMAL ANALYSIS

ITT rates the 2N4012 transistor used in SN-11 and 15 (all flight models) as follows:

1. 8.5 watts at 74°C (165°)
2. Typical thermal resistance 12°C/watt (distribution of product)
3. At 25°C, the transistor has a 14.5 watt capability which is 3 watts over the specification sheet.
4. The thermal time constant at 25°C (case temp.) is .49 sec.

SN-11 ANALYSIS

From Fig. 3 the Xmtr SN-11 Doubler current at 77°C (170°F) is extrapolated to 212 ma.

Input DC = .212 x 29	=	6.148 watts
Drive input power	≈	+ 1.000 watts
		7.148
RF out to x4	≈	- 2.3 watts
Net dissipated in Junction	≈	4.848 watts

4.9 watts x 12°C/watt = 58.8°C Temp rise.

58.8°C	junction rise
77.0°C	base plate temperature
5.0°C	case-to-baseplate rise
140.8°C	Junction Temperature

SN-15 ANALYSIS

From Fig. 4 the Xmtr SN-15 Doubler Current at 77°C (170°F) is extrapolated to 220 ma.

Input DC = .220 x 29	=	6.380 watts
Drive Input Power	≈	+ 1.000 watts
		7.38
RF out to x4	≈	-2.3 watts
Net dissipated in junction	≈	5.08 watts

5.1 watts x 12°C/watt = 61.2 °C Temp. rise.

61.2°C	junction rise
77.0°C	baseplate temperature
5.0°C	case-to-baseplate rise
143.2°C	Junction temperature

The maximum junction temperature rating is 200°C.

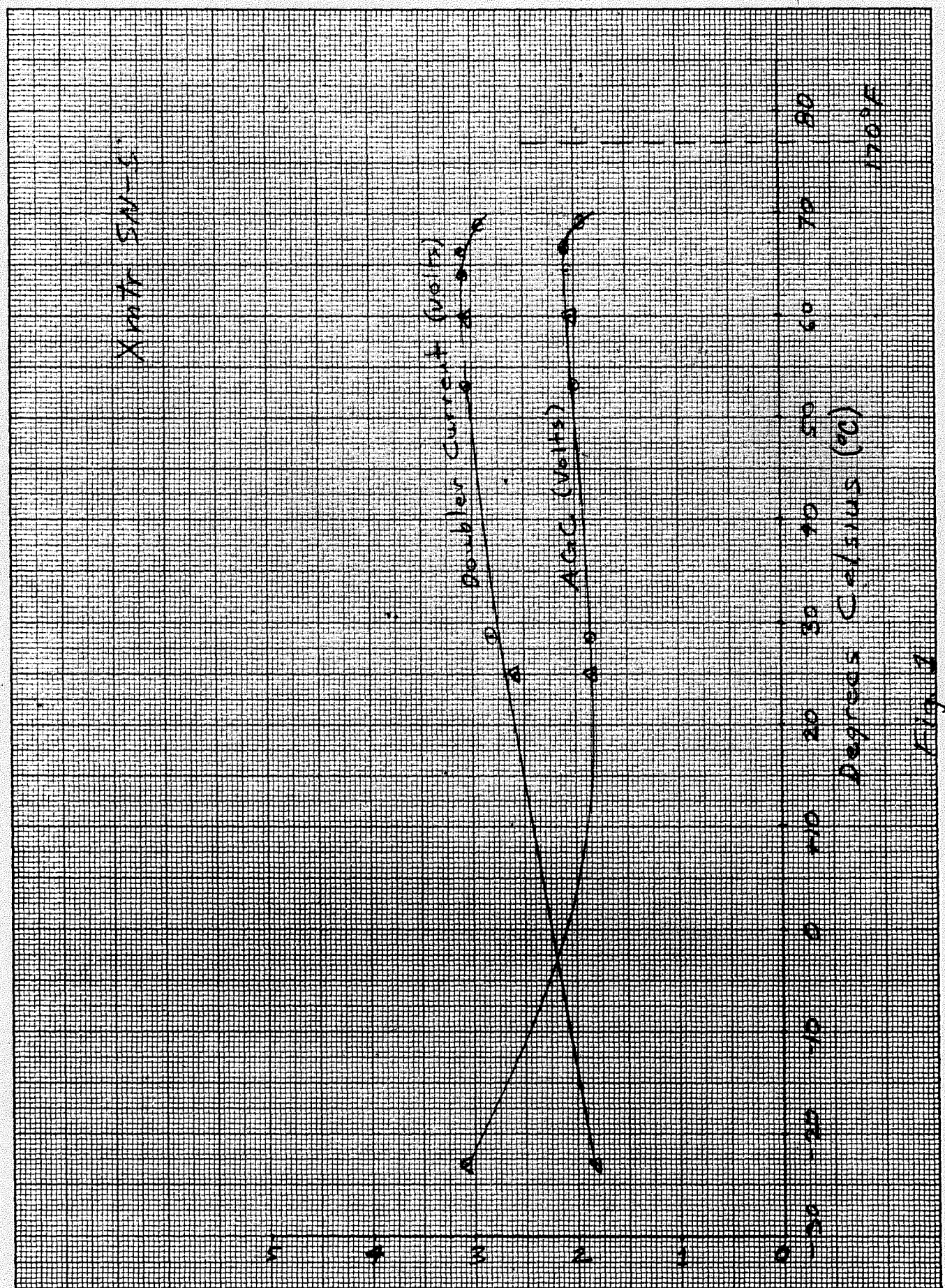
CONCLUSIONS:

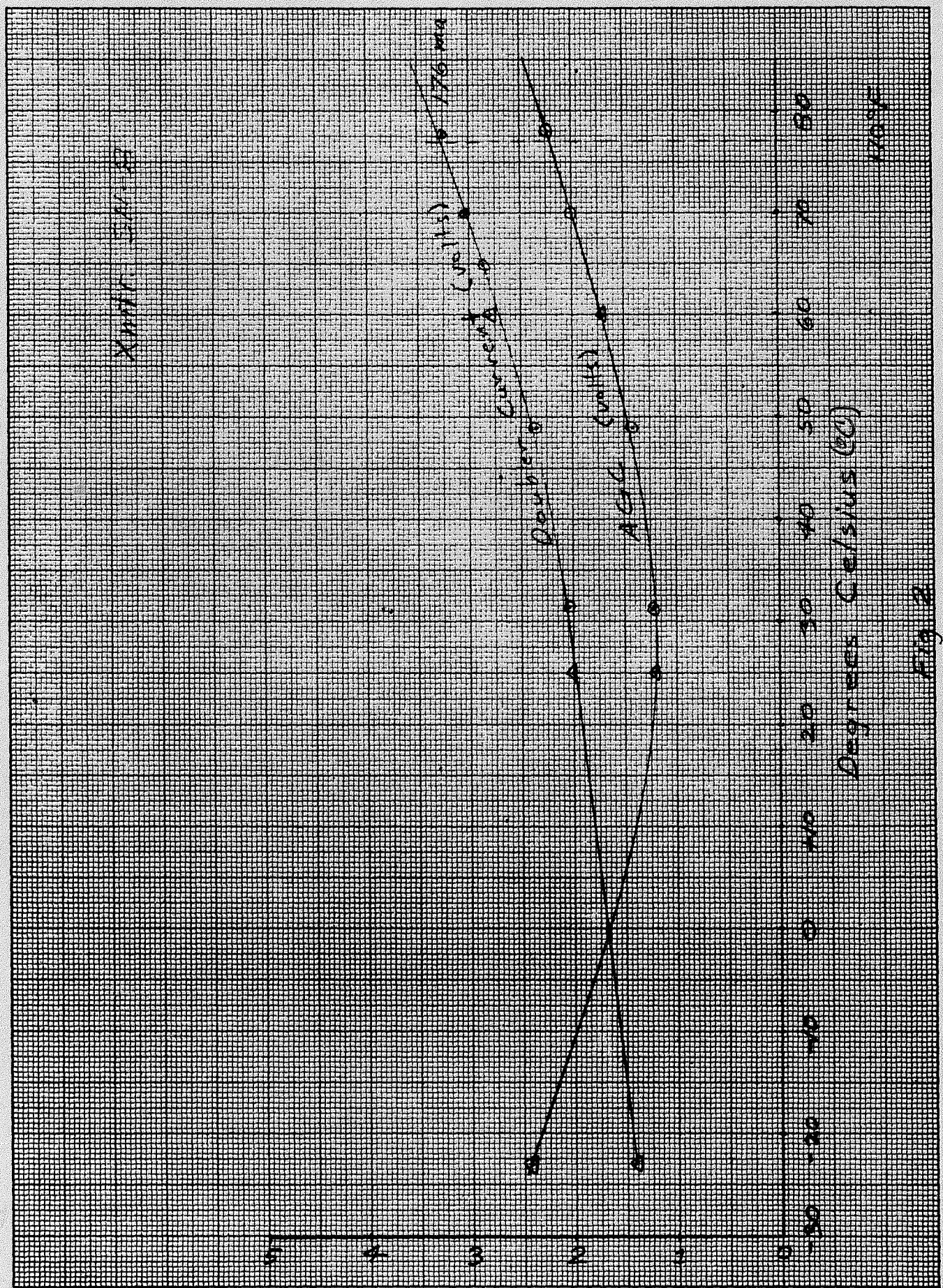
The tests of SN-5 and SN-8 showed neither unit performing in a manner that would indicate over-temperature or runaway of the 2N4012 power doubler transistor. SN-8 performed normally up through 77°C. SN-5 showed a power input and r.f. power output dropoff starting at about +67°C. This could probably be corrected by retuning over the higher temperature range. For the sample of 2 tested, the results of safe operation at the out-of-specification high temperature is encouraging.

(CONCLUSIONS cont'd.)

The AGC and Power Doubler current plots of the EASEP transmitters SN-11 and SN-15 were extrapolated to 77°C, and should represent the greatest doubler current expected to be drawn by these units. The shape of the curves (drawn through three temperature test points) appear typical of properly tuned transmitters and therefore add to the confidence level of the extrapolated current value.

Calculations based on the extrapolated current values show that both transmitters should operate well within the safe rating of the highest stressed component, the 2N4012 transistor doubler at the 77°C temperature expected at Lunar turn-on.





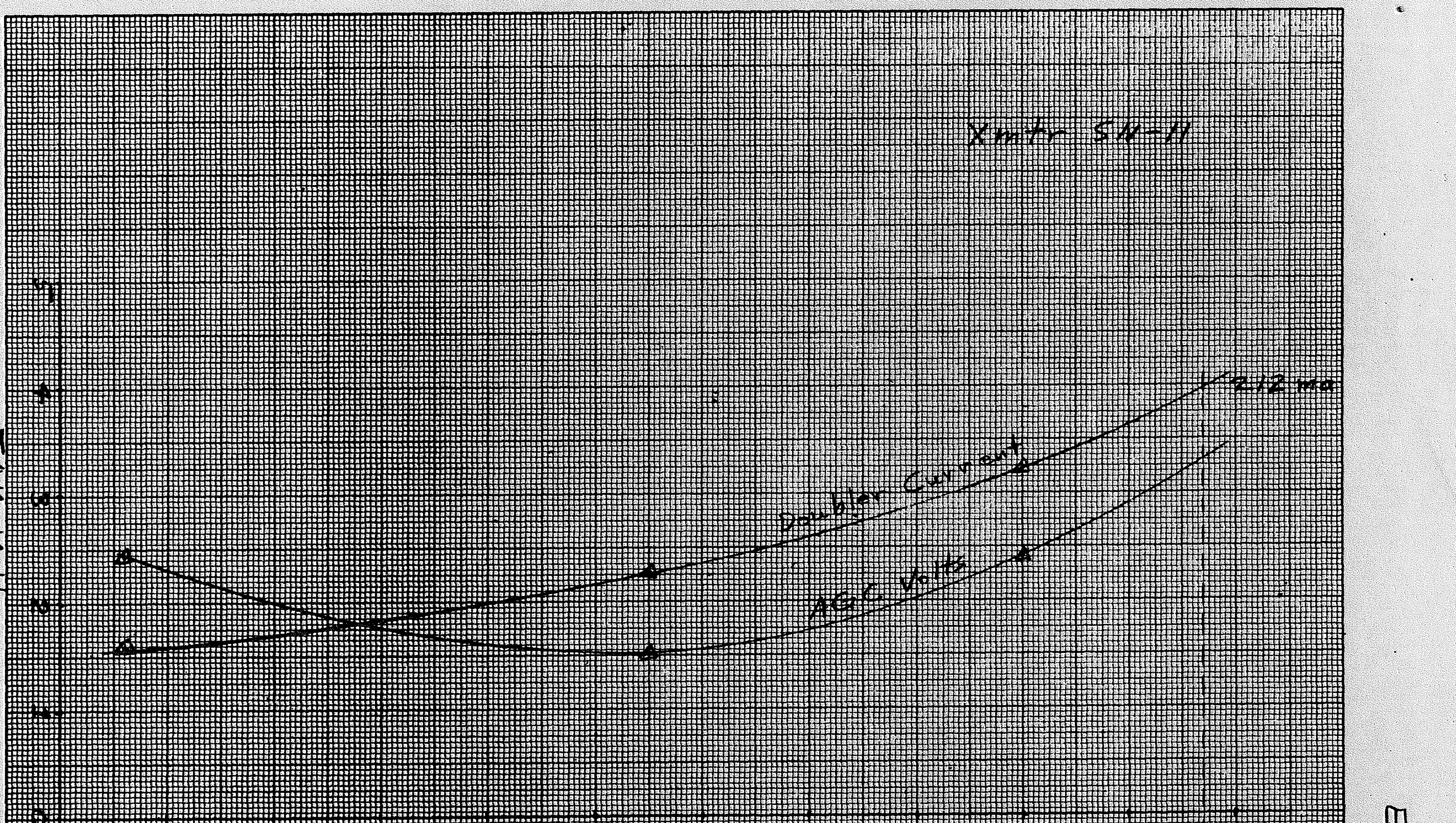


Fig. 3

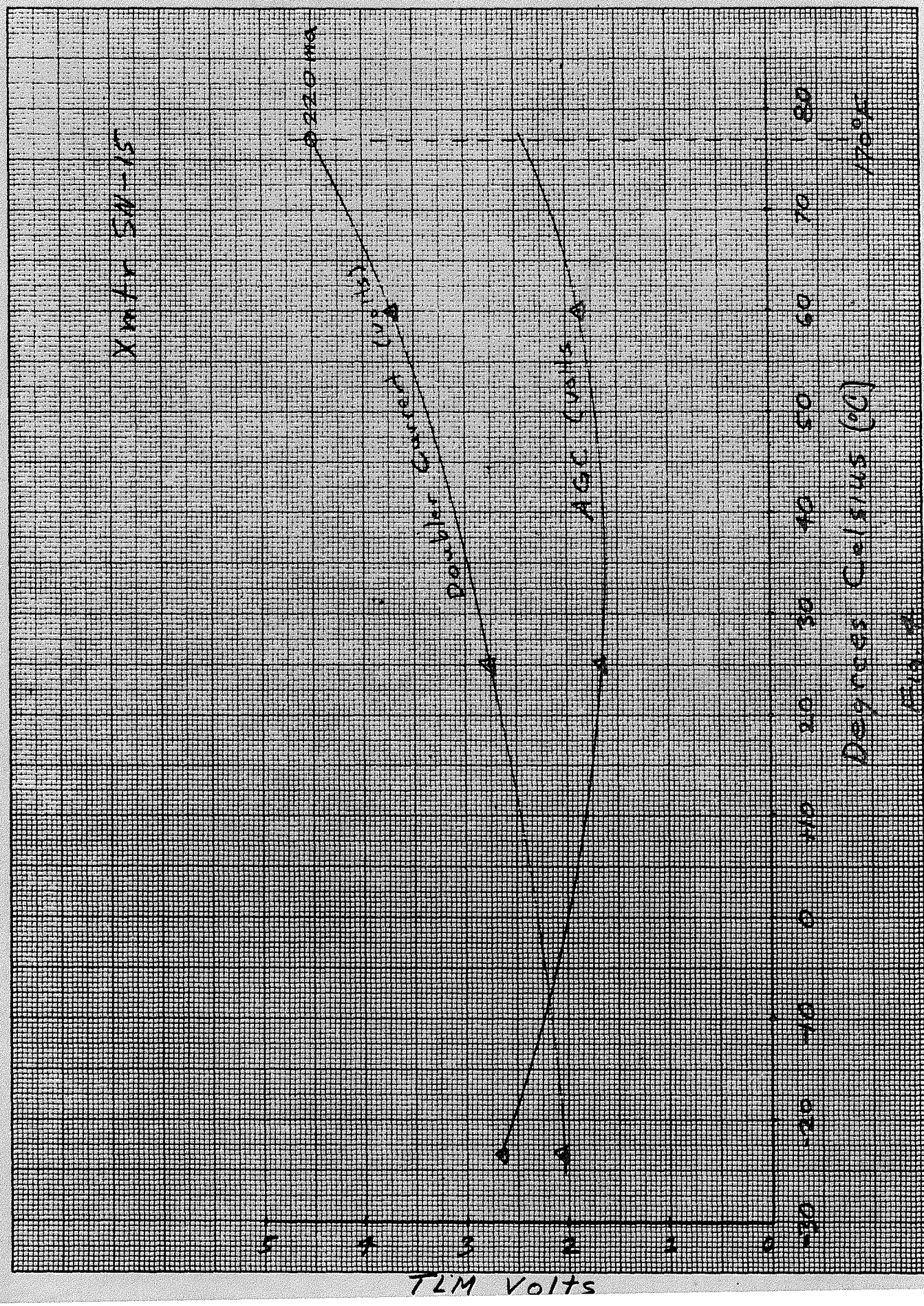


Fig. 8