PPM 92-301

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Paramax Systems
Corporation

4700 Boston Way
Lanham MD 20706

Memorandum

PARAMAX
A Unisys Company

PPM-92-301

DATE: Dec. 11, 1992
TO: T. Denis / 311-2
FROM: K. Sahu
SUBJECT: Radiation Report on GOES
Part No. JTXV2N2219AL
Control No. 7345

cc: A. Sharma/311
Library/300.1

A radiation evaluation was performed on 2N2219 (NPN Transistor) to determine the total dose tolerance of these parts. The total dose testing was performed using a Cobalt-60 gamma-ray source. Testing was performed using the test procedure supplied by the GOES Project (Appendix A). During the radiation testing, eight parts were irradiated under bias (see Appendix A for bias configuration and radiation schedule), and two parts were used as control samples. The total dose radiation steps were 10, 20, 40 and 60 krads*. After 60 krads, parts were annealed at ambient room temperature for 168 hours. The dose rate was between 0.44 and 0.89 krads/hour, depending on the total dose level. After each radiation exposure and annealing treatment, parts were electrically tested at ambient room temperature according to the test conditions and the specification limits** listed in Appendix A.

No significant changes were observed in Ve (emitter-to-base voltage) throughout all irradiation and annealing steps. Ve ranged from 656.3 to 659.8 mV and circuit ambient temperature (T(circuit)) ranged from 18.1°C to 18.7°C throughout all irradiation steps. All irradiated parts passed all electrical tests except HFEs3 and HFEs4 throughout all irradiation and annealing steps. Four parts (SN 1153, 1156, 1171 and 2466) failed to meet the minimum specification limit of 100 for HFEs3 and HFEs4 after the final annealing step. Values of HFEs3 ranged from 92.51 to 94.97 and values of HFEs4 ranged from 94.7 to 97.47. For details of the test results, refer to Table I and Appendix B.

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*The term rads, as used in this document, means rads(silicon).
**These are manufacturers' non-irradiated data specification limits. No post-irradiation limits were provided by the manufacturer at the time these tests were performed.

Any further details about this evaluation can be obtained upon request. If you have any questions, please call me at (301) 731-8954.

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TABLE I: Summary of Electrical Measurements After Total Dose Exposures and Annealing Steps for 2N2219 1/

				Total Dose Exposure (TDE), krads								Anneal	
	Spec. Lim./2		0 (Pre-Rad.)		10		20		40		60		168 hrs. @25°C	
Parameters	min	max	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd	mean	sd
T(circuit) °C			18.6		18.3		18.7		18.1		18.1		20.3	
Ve mV			659.7	3.1	659.6	1.7	658.7	1.6	659.8	1.6	658.7	4.3	656.3	1.6
VBRCBO V	75	-	PASS										PASS	
VBREBO V	6	-	PASS										PASS	
VBRCEO V	50	-	PASS										PASS	
ICES nA	0	10	1.73	.12									1.39	.12
ICBO nA	0	10	1.81	.21									1.45	.21
IEBO nA	0	10	0.17	.32									0.18	.32
HFEs1	50	-	121.9	10									72.4	10
HFEs2	75	325	127.7	10									88.3	10
HFEs3	100	-	132.4	10									102.1	10
HFEs4	100	300	128.5	11									104.9	11
HFEs5	30	-	69.38	8.7									60.81	8.7
VCESAT1 V	0	0.3	0.144	.01									0.149	.01
VCESAT2 V	0	1.0	0.376	.02									0.385	.02
VBESAT1 V	0.6	1.2	0.879	0									0.885	0
VBESAT2 V	0	2.0	1.131	.01									1.142	.01

See Note 3/

Notes:

1/ The mean and standard deviation values were calculated over the six parts irradiated in this testing. The control samples remained constant throughout the testing and are not included in this table.

2/ These are manufacturers' non-irradiated data sheet specification limits. No post-irradiation limits were provided by the manufacturer at the time the tests were performed

3/ The electrical parameters VBRCBO through VBESAT2 were measured at only two steps: i) Pre-irradiation and ii) Post-anneal, 168 hours at ambient room temperature as per the GOES Project requirements. The two parameters measured at all steps were circuit ambient temperature (T(circuit)) and base-to-emitter voltage (Ve) of each transistor. For more details onn these measurements, refer to Appendix B.

Appendix A

JANS2N2219AL
NPN TRANSISTOR

GOES X128 Driver Transistor Radiation Test

Prepared by: Loren Linstrom Date: 16 Oct 92
Loren Linstrom

Concurrence: Bernard G. Johnson Date: 19 Oct 92
Bernard Johnson

Concurrence: _____ Date: _____
Stephen Brown

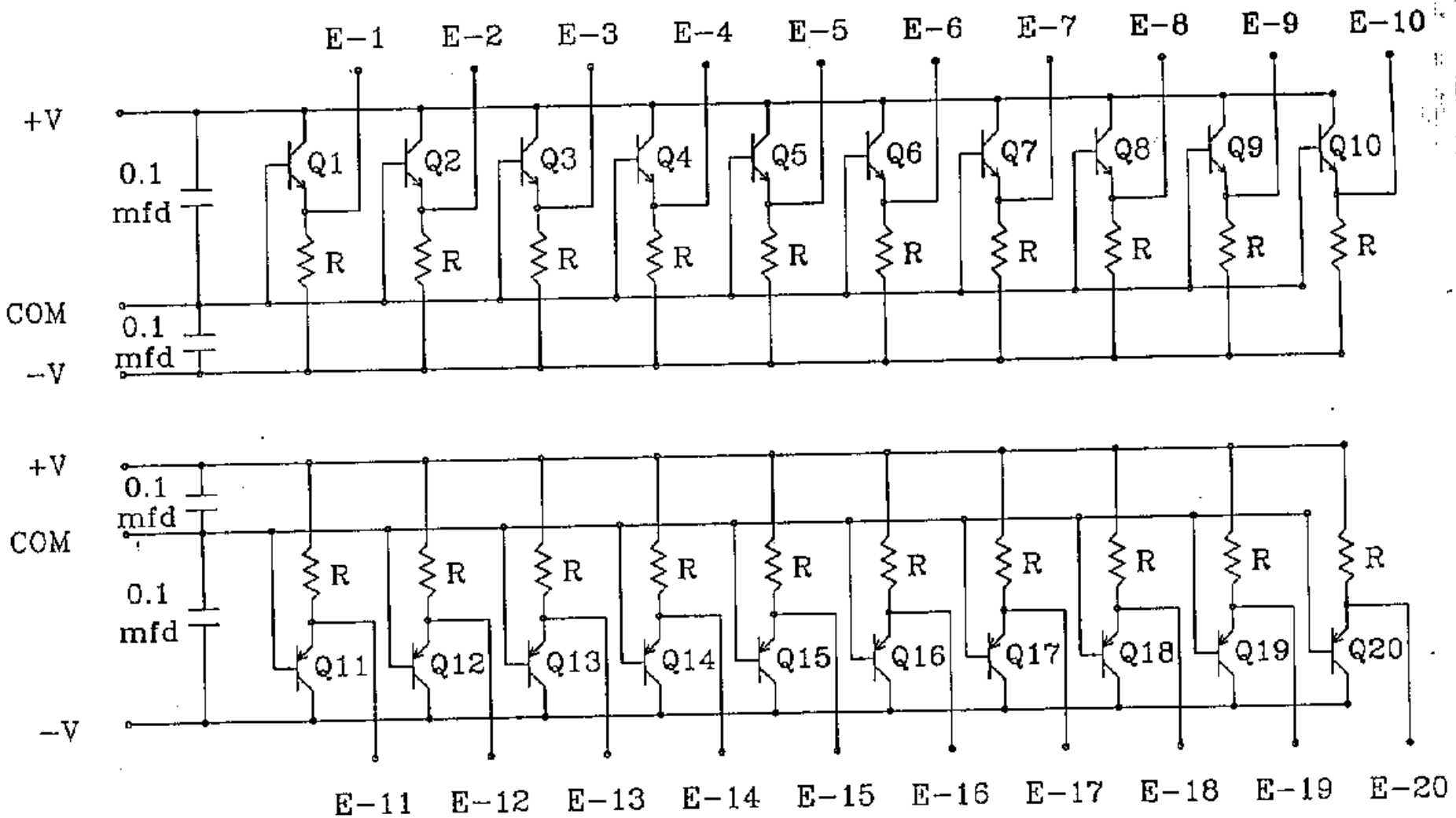
Inst Systems: Robert W Ross Date: 10/19/92
Robert Ross

F. Assurance: _____ Date: _____
Douglas McCuistion

X128 RAD TEST

Measure the effect of Co-60 radiation
on base to emitter voltage of GOES
X128 inductosyn drive transistors

October 16, 1992
Goddard Space Flight Center
Greenbelt, MD



NPN (Q1 – Q10) 2N2219AL PNP (Q11 – Q20) 2N2905AL R = 3.5 kohms

X128 TRANSISTOR RADIATION TEST CIRCUIT 15 OCT 92

GOES X128 Driver Transistor Radiation Test 16 OCT 92

1. Fabricate "X128 TRANSISTOR RADIATION TEST CIRCUIT" per attached print. Circuits may be laid out on one or two boards. Provide sockets for all transistors.

1.1. Install NPN transistors (2N2219AL, Q1 through Q10) in sockets, and record individual numbers from sides of case:

Ckt	Serial #	Ckt	Serial #
Q1:	~~1154~~ 2466	Q6:	1171
Q2:	1153	Q7:	2464
Q3:	1156	Q8:	2465
Q4:	1158	Q9:	~~2466~~
Q5:	1164	Q10:	X

SN2+ WAS CUSTOMER SAMPLES

N/A 1.2. Install PNP transistors (2N2905AL, Q11 through Q20) in sockets, and record individual numbers from sides of case:

Ckt	Serial #	Ckt	Serial #
Q11:		Q16:	
Q12:		Q17:	
Q13:		Q18:	
Q14:		Q19:	
Q15:		Q20:	

1.3. Inspect circuit(s) for compliance to print.

Initials: GB Date: 11-16

1.4. Connect +5 v dc power supply with current meter between +V and COM on NPN circuit.

Accomplished: OK

1.5. Connect -5 v dc power supply with current meter between -V and COM on NPN circuit.

Accomplished: OK

1.6. Record current from each power supply for NPN circuit:

+5 v p.s. 10.43 ma (approximately 15 ma expected)

-5 v p.s. 10.55 ma (approximately 15 ma expected)

N/A 1.7. Connect +5 v dc power supply with current meter between +V and COM on PNP circuit.

Accomplished: _____

1.8. Connect -5 v dc power supply with current meter between -V and COM on PNP circuit.

Accomplished: _____

1.9. Record current from each power supply for PNP circuit:

+5 v p.s. _____ ma (approximately 15 ma expected)

-5 v p.s. _____ ma (approximately 15 ma expected)

1.10. If measured current from steps 1.6 or 1.9 exceeds 20 ma, consult with design engineer, otherwise proceed to CO-60 test.

OK to proceed, Initials: GD Date: 11-16

2. Setup circuits for exposure and make pre-exposure baseline measurements.

Begin baseline - Initials: GD Date: 11-16

2.1 Adjust a laboratory power supply to 5.00 volts output and attach it (with a current meter either on the supply or in series) between +V and COM terminals on both the NPN and PNP circuits.

Accomplished: OK

2.2 Adjust a laboratory power supply to 5.00 volts output and attach it (with a current meter either on the supply or in series) between -V and COM terminals on both the NPN and PNP circuits.

Accomplished: OK

GOES X128 Driver Transistor Test (Continued)

2.3 Record the voltage between +V and COM to the nearest millivolt:

+V to COM: 5.00 volts

2.4 Record the voltage between -V and COM to the nearest millivolt:

-V to COM: 5.00 volts

2.5 Record the current in the +V supply:

+V supply: 10.41 ma

SHIELDED LEAD AND GROUND OB

2.6 Record the current in the -V supply:

-V supply: ~~10.43~~ 10.46 ma

2.7 Record to the nearest ~~0.1~~ degree Celsius the temperature from a thermometer placed in the same ambient environment as the circuit: ±.1 °C

Circuit ambient temperature: ~~18.9~~ 18.6 degrees C

2.8 Record voltage between each emitter and circuit COM with 0.1 mV precision:

E-1:	666.3 mV	E-11:	N/A mV
E-2:	660.6 mV	E-12:	mV
E-3:	660.8 mV	E-13:	mV
E-4:	658.9 mV	E-14:	mV
E-5:	657.2 mV	E-15:	mV
E-6:	659.8 mV	E-16:	mV
E-7:	656.4 mV	E-17:	mV
E-8:	657.9 mV	E-18:	mV
E-9:	mV	E-19:	mV
E-10:	mV	E-20:	mV

GOES X128 Driver Transistor Test (Continued)

3. Leave the circuits powered and expose them to approximately 10 krads (Si) with the CO-60 source. (RUN #1)

Dosage rate _____ rads (Si) / min (typical 20-30)

Total Dosage 10 k rads (Si) (~10)

4. Measure electrical parameters of circuits:

4.1. Record the voltage between +V and COM to the nearest millivolt:

+V to COM: 5.000 volts

4.2. Record the voltage between -V and COM to the nearest millivolt:

-V to COM: 5.000 volts

4.3. Record the current in the +V supply:

+V supply: 10.399 ma

4.4. Record the current in the -V supply:

-V supply: 10.460 ma

4.5 Record to the nearest ~~0.1~~ degree Celsius the temperature from a thermometer placed in the same ambient environment as the circuit: ±0.1°C

Circuit ambient temperature: 18.3 degrees C

4.6. Record voltage between each emitter and circuit COM with 0.1 mV precision:

E-1:	661.7 mV	E-11:	N/A mV
E-2:	661.1 mV	E-12:	_____ mV
E-3:	661.1 mV	E-13:	_____ mV
E-4:	659.2 mV	E-14:	_____ mV
E-5:	657.9 mV	E-15:	_____ mV

E-6:	660.7 mV	E-16:	N/A mV
E-7:	657.3 mV	E-17:	mV
E-8:	658.6 mV	E-18:	mV
E-9:	mV	E-19:	mV
E-10:	mV	E-20:	mV

5. Leave the circuits powered and expose them to approximately 10 krads (Si) more with the CO-60 source. (RUN #2)

Dosage rate _____ rads (Si) / min (typical 20-30)

Dosage this exposure: 10 k rads (Si) (~10)

Total dosage to date: 20 k rads (Si) (~20)

6. Measure electrical parameters of circuits:

6.1. Record the voltage between +V and COM to the nearest millivolt:

+V to COM: 5.000 volts

6.2. Record the voltage between -V and COM to the nearest millivolt:

-V to COM: 5.000 volts

6.3. Record the current in the +V supply:

+V supply: 10.400 ma

6.4. Record the current in the -V supply:

-V supply: 10.467 ma

6.5 Record to the nearest ~~0.1~~ degree Celsius the temperature from a thermometer placed in the same ambient environment as the circuit: ± 0.1°C

Circuit ambient temperature: 18.7 degrees C

6.6. Record voltage between each emitter and circuit COM with 0.1 mV precision:

E-1:	660.4 mV	E-11:	N/A mV
E-2:	659.9 mV	E-12:	mV
E-3:	660.2 mV	E-13:	mV
E-4:	658.4 mV	E-14:	mV
E-5:	656.9 mV	E-15:	mV
E-6:	659.8 mV	E-16:	mV
E-7:	656.3 mV	E-17:	mV
E-8:	657.6 mV	E-18:	mV
E-9:	mV	E-19:	mV
E-10:	mV	E-20:	mV

7. Leave the circuits powered and expose them to approximately 20 krads (Si) more with the CO-60 source. (RUN #3)

Dosage rate _____ rads (Si) / min (typical 20-40)

Dosage this exposure: 20 k rads (Si) (~20)

Total dosage to date: 40 k rads (Si) (~40)

8. Measure electrical parameters of circuits:

8.1. Record the voltage between +V and COM to the nearest millivolt:

+V to COM: 5.000 volts

8.2. Record the voltage between -V and COM to the nearest millivolt:

-V to COM: 5.000 volts

8.3. Record the current in the +V supply:

+V supply: 10.380 ma

8.4. Record the current in the -V supply:

-V supply: 10.461 ma

8.5 Record to the nearest 0.1 degree Celsius the temperature from a thermometer placed in the same ambient environment as the circuit: ± 0.1°C

Circuit ambient temperature: ~~18.0~~ 18.1 degrees C

8.6. Record voltage between each emitter and circuit COM with 0.1 mV precision:

E-1:	661.5 mV	E-11:	N/A mV
E-2:	661.0 mV	E-12:	mV
E-3:	661.2 mV	E-13:	mV
E-4:	659.4 mV	E-14:	mV
E-5:	657.9 mV	E-15:	mV
E-6:	661.0 mV	E-16:	mV
E-7:	657.4 mV	E-17:	mV
E-8:	658.8 mV	E-18:	mV
E-9:	mV	E-19:	mV
E-10:	mV	E-20:	mV

9. Leave the circuits powered and expose them to approximately 20 krads (Si) more with the CO-60 source. (RUN #4)

Dosage rate _____ rads (Si) / min (typical 20-40)

Dosage this exposure: 20 k rads (Si) (~20)

Total dosage to date: 60 k rads (Si) (~60)

10. Measure electrical parameters of circuits:

GOES X128 Driver Transistor Test (Continued)

10.1. Record the voltage between +V and COM to the nearest millivolt:

+V to COM: 5.000 volts

10.2. Record the voltage between -V and COM to the nearest millivolt:

-V to COM: 5.000 volts

10.3. Record the current in the +V supply:

+V supply: 10.370 ma

10.4. Record the current in the -V supply:

-V supply: 10.461 ma

10.5 Record to the nearest ~~0.1~~ degree Celsius the temperature from a thermometer placed in the same ambient environment as the circuit: ± 0.1°C

Circuit ambient temperature: 18.1 degrees C

10.6. Record voltage between each emitter and circuit COM with 0.1 mV precision:

E-1:	661.7 mV	E-11:	N/A mV
E-2:	661.2 mV	E-12:	mV
E-3:	661.4 mV	E-13:	mV
E-4:	659.6 mV	E-14:	mV
E-5:	658.1 mV	E-15:	mV
E-6:	660.9 mV	E-16:	mV
E-7:	657.5 mV	E-17:	mV
E-8:	658.8 mV	E-18:	mV
E-9:	mV	E-19:	mV
E-10:	mV	E-20:	mV

GOES X128 Driver Transistor Test (Continued)

11. Plot circuit temperature as a function of dose

12. Plot emitter voltage as a function of dose for each transistor

Appendix B

RADIATION TEST REPORT

PART NUMBER : JTXV2N2219AL

PART NAME : NPN TRANSISTOR

JOB NUMBER : EE33109 CONTROL NO. : 7345

PROJECT : GOES

LOT DATE CODE : 8344

MANUFACTURER : MOTOROLA

PART SPECIFICATION : MIL - S - 19500 / 251G

CONTROL SAMPLES : 2 PARTS (S/N : 2 , & 1151)

QUANTITY TESTED : 8 PARTS (S/N : 2466 , 1153 , 1156 , 1158 , 1164 , 1171 , 2464 , 2465) .

ENGINEER : ANH PHUNG PHONE : 731 - 8983

REQUESTER : DENIS PHONE : 286 - 2093

TEST SPECIFICATION : RADIATION SPECIFICATION

RADIATION SOURCE : COBALT-60 GAMMA RAY, GSFC BLDG 22

RADIATION DOSE RATE: SEE TABLE I

RADIATION SCHEDULE : SEE TABLE I

ELECTRICAL TESTS : SEE TABLE II

RESULTS : The Hfe3 and Hfe4 reading decreased out of specified limit at Post annealing electrical tests on ATE CIS-systems) for parts number 1153 , 1156 , 1171 , and 2466 .
See "Circuit temperature vs. dose" and "Emitter voltage vs. dose" graphs for additional details .

TABLE I. RADIATION SCHEDULE

EVENTS :	DOSE RATE (RADS/HR) :	DATE :
INITIAL ELECTRICAL TEST		11-16-92
IRRADIATE 10 Krads	540 Rads / Hr	11-16-92
POST 10 K ELECTRICAL TEST		11-17-92
IRRADIATE 20 Krads	435 Rads / Hr	11-17-92
POST 20 K ELECTRICAL TEST		11-18-92
IRRADIATE 40 Krads	889 Rads / Hr	11-18-92
POST 40 K ELECTRICAL TEST		11-19-92
IRRADIATE 60 Krads	870 Rads / Hr	11-19-92
POST 60 K ELECTRICAL TEST		11-20-92
168 Hrs ANNEALING @ ~~25 °C~~ ambient room temperature		11-20-92
POST 168 Hrs @ ~~25 °C~~ ambient room temperature ELECTRICAL TEST		11-27-92

ALL PARTS RADIATED UNDER BIAS, SEE FIGURE 1.

168 Hrs ANNEALING PERFORMED @ ~~25°C~~ ambient room temperature UNDER BIAS, SEE FIGURE 1.

GODDARD SPACE FLIGHT CENTER
OFFICE OF FLIGHT ASSURANCE
TEST & INSPECTION

ELECTRICAL TABLE

PART NO. : JANS2N2219AL
PART TYPE : NPN TRANSISTOR (SWITCHING)
SPEC NO. : MIL – S – 19500 / 251G
Table I / group A / subgroup 2 .
DATE : 23 – APR – 79
AMENDMENT NO. : 2
DATE : 07 – APR – 83

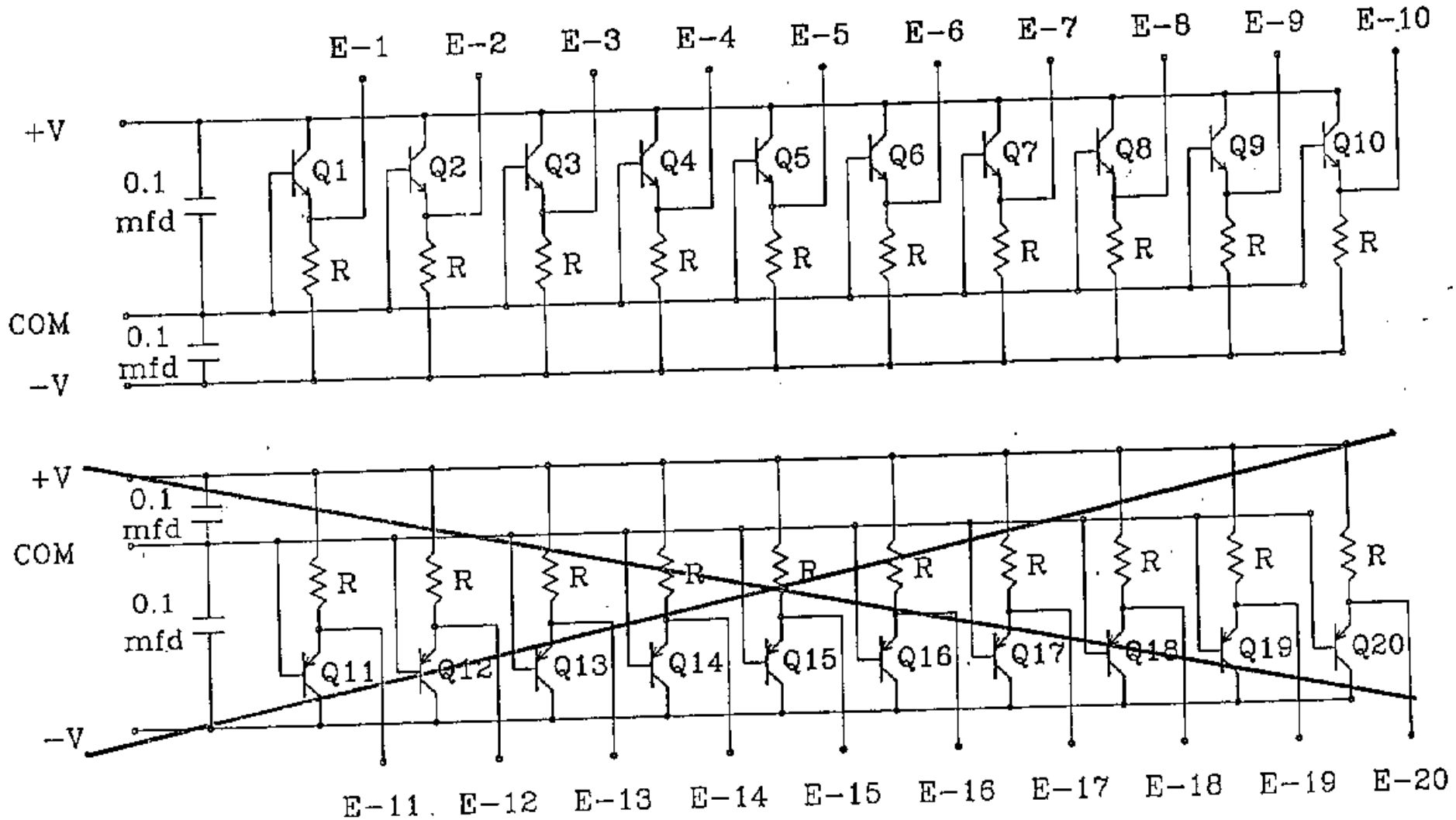
PCN NO. : 9206 – 2219
JOB NO. : EE33109
PROJECT : GOES
ENGINEER : ANH PHUNG
DATE : 26 – OCT – 92
REQUESTER : DENIS

Ta = 25°C , Unless otherwise specified.

NO.	PARAMETER	TEST CONDITION			MIN	MAX	UNIT	METHOD MIL-STD-750
1	VBRcbo	Ic = 10 uA	Cond. D		75		V	3001
2	VBRebo	Ie = 10 uA	Cond. D		6		V	3026
3	VBRceo	Ic = 10 mA	Cond. D	Pulsed	50		V	3011
4	Icbo1	Vcb = 60 V	Cond. D			10	nA	3036
5	Ices	Vce = 50 V	Cond. B			10	nA	3041
6	Iebo	Veb = 4 V	Cond. D			10	nA	3061
7	Hfe1	Vce = 10 V	Ic = 0.1 mA		50			3076
8	Hfe2	Vce = 10 V	Ic = 1 mA		75	325		3076
9	Hfe3	Vce = 10 V	Ic = 10 mA		100			3076
10	Hfe4	Vce = 10 V	Ic = 150 mA	Pulsed	100	300		3076
11	Hfe5	Vce = 10 V	Ic = 500 mA	Pulsed	30			3076
12	Vce (sat)1	Ic = 150 mA	Ib = 15 mA	Pulsed		0.3	V	3071
13	Vce (sat)2	Ic = 500 mA	Ib = 50 mA	Pulsed		1.0	V	3071
14	Vbe (sat)1	Ic = 150 mA	Ib = 15 mA Cond. A	Pulsed	0.6	1.2	V	3066
15	Vbe (sat)2	Ic = 500 mA	Ib = 50 mA Cond. A	Pulsed		2.0	V	3066

Delta limits : Delta Icbo1 = +/– 5 nA or +/– 100 % , whichever is greater .
Delta Hfe4 = +/– 15 % .

Pulsed : t pulse = 800 uS , max .
Duty cycle = 2 % , max .



NPN (Q1 – Q10) 2N2219AL PNP (Q11 – Q20) 2N2905AL R = 3.5 kohms

X128 TRANSISTOR RADIATION TEST CIRCUIT 15 OCT 92

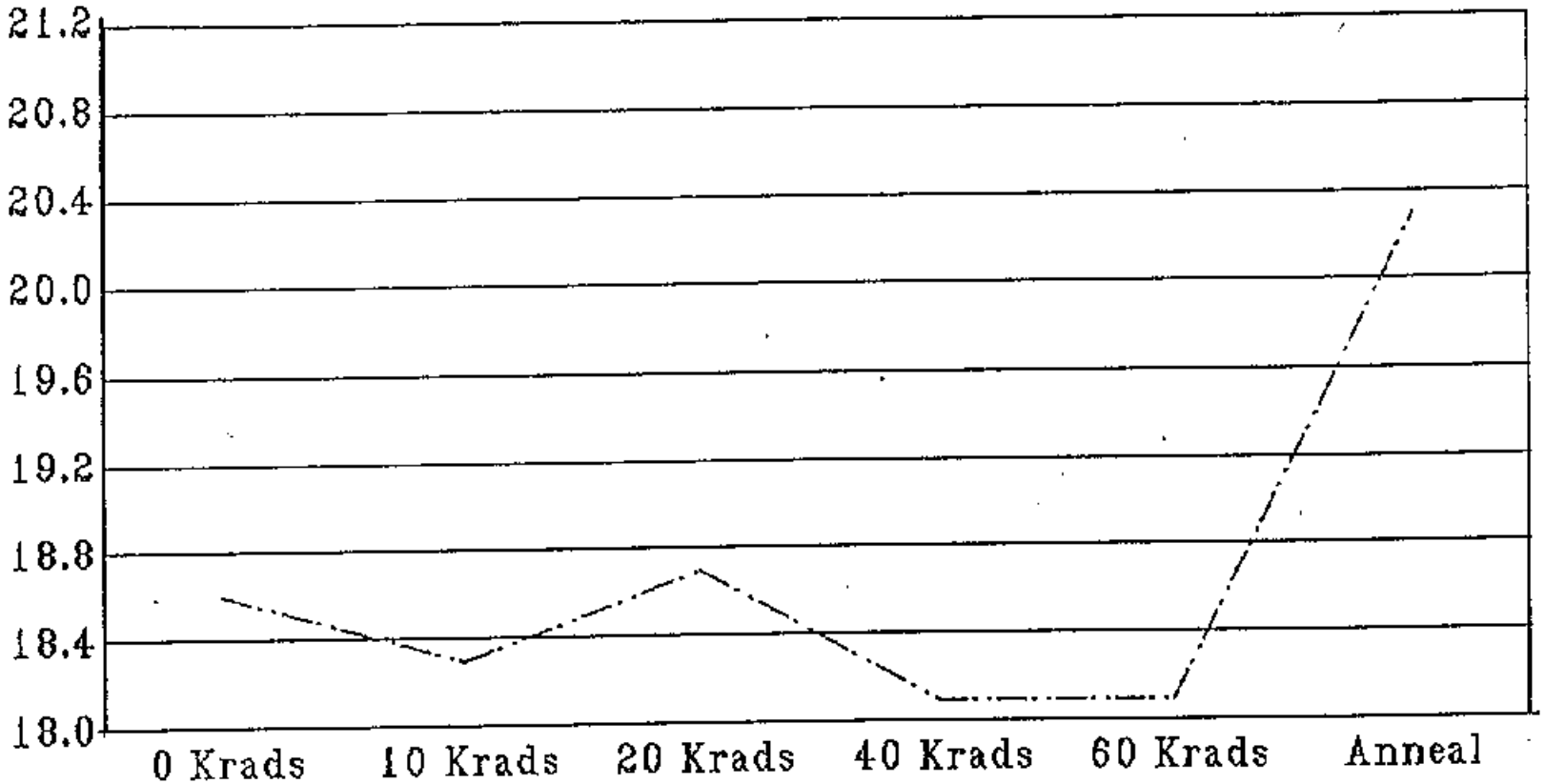
JTXV2N2219AL

NPN – TRANSISTOR

S / N	PARAMETER	INITIAL E.M.	RUN # 1	RUN # 2	RUN # 3	RUN # 4	POST ANN E.M.
	+ Vps	+5.0 V	+5.0 V	+5.0 V	+5.0 V	+5.0 V	+5.0 V
	– Vps	–5.0 V	–5.0 V	–5.0 V	–5.0 V	–5.0 V	–5.0 V
	+ Ips	+10.410 mA	+10.399 mA	+10.400 mA	+10.380 mA	+10.370 mA	+10.390 mA
	– Ips	–10.460 mA	–10.460 mA	–10.467 mA	–10.461 mA	–10.461 mA	–10.474 mA
	Ta	18.6 °C	18.3 °C	18.7 °C	18.1 °C	18.1 °C	20.3 °C
2466	EMITTER – COM	666.3 mV	661.7 mV	660.4 mV	661.5 mV	661.7 mV	657.9 mV
1153	EMITTER – COM	660.6 mV	661.1 mV	659.9 mV	661.0 mV	661.2 mV	657.5 mV
1156	EMITTER – COM	660.8 mV	661.1 mV	660.2 mV	661.2 mV	661.4 mV	657.7 mV
1158	EMITTER – COM	658.9 mV	659.2 mV	658.4 mV	659.4 mV	659.6 mV	656.0 mV
1164	EMITTER – COM	657.2 mV	657.4 mV	656.9 mV	657.9 mV	658.1 mV	654.7 mV
1171	EMITTER – COM	659.8 mV	660.7 mV	659.8 mV	661.0 mV	660.9 mV	657.5 mV
2464	EMITTER – COM	656.4 mV	657.3 mV	656.3 mV	657.4 mV	657.5 mV	653.9 mV
2465	EMITTER – COM	657.9 mV	658.6 mV	657.6 mV	658.8 mV	648.8 mV	655.1 mV
	Ta	18.5 °C					23.4 °C
2 C.S.	EMITTER – COM	660.9 mV					652.1 mV
1151 C.S.	EMITTER – COM	660.4 mV					651.6 mV

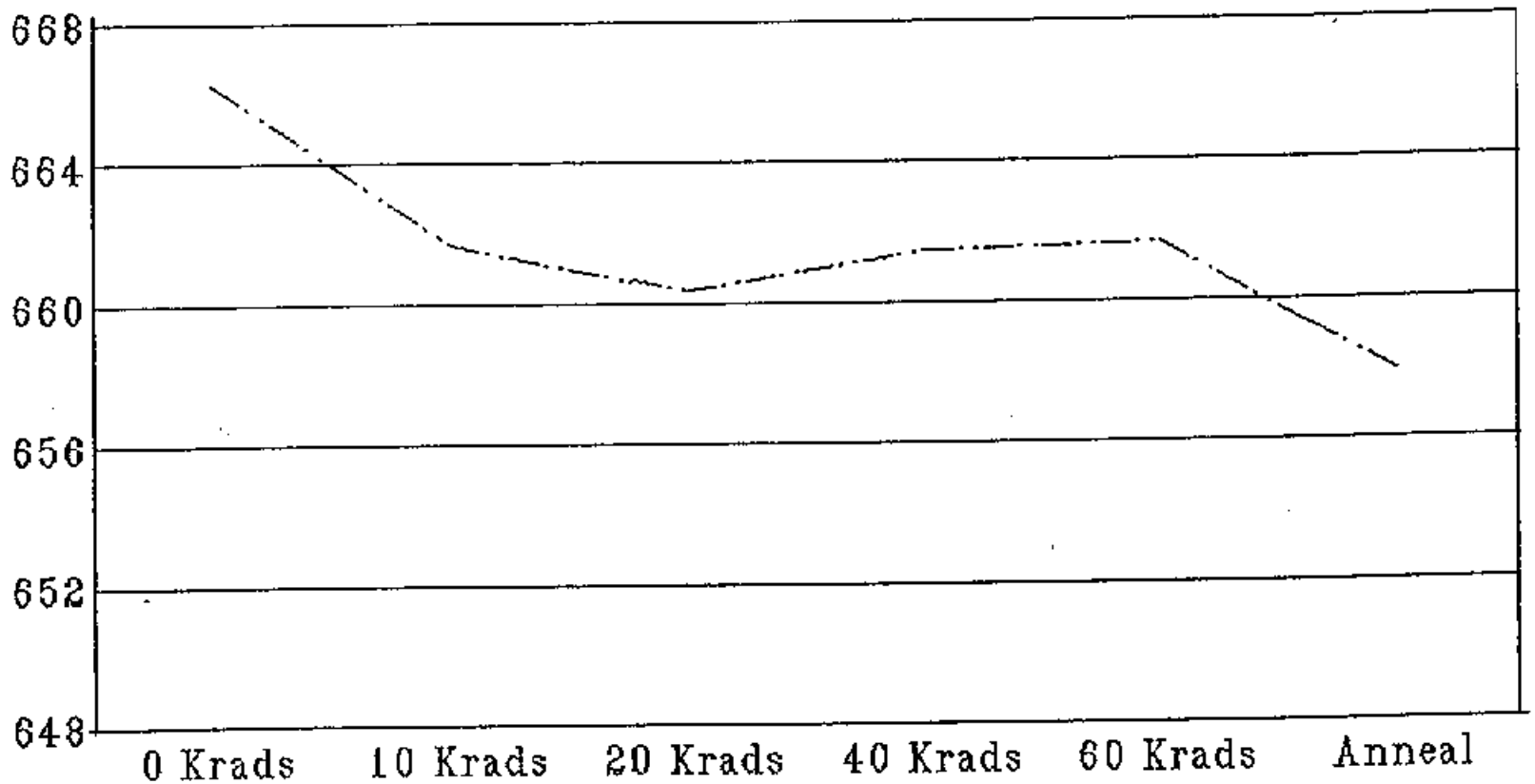
CONTROL SAMPLES S / N : 2 , & 1151 .

Circuit temperature vs. dose



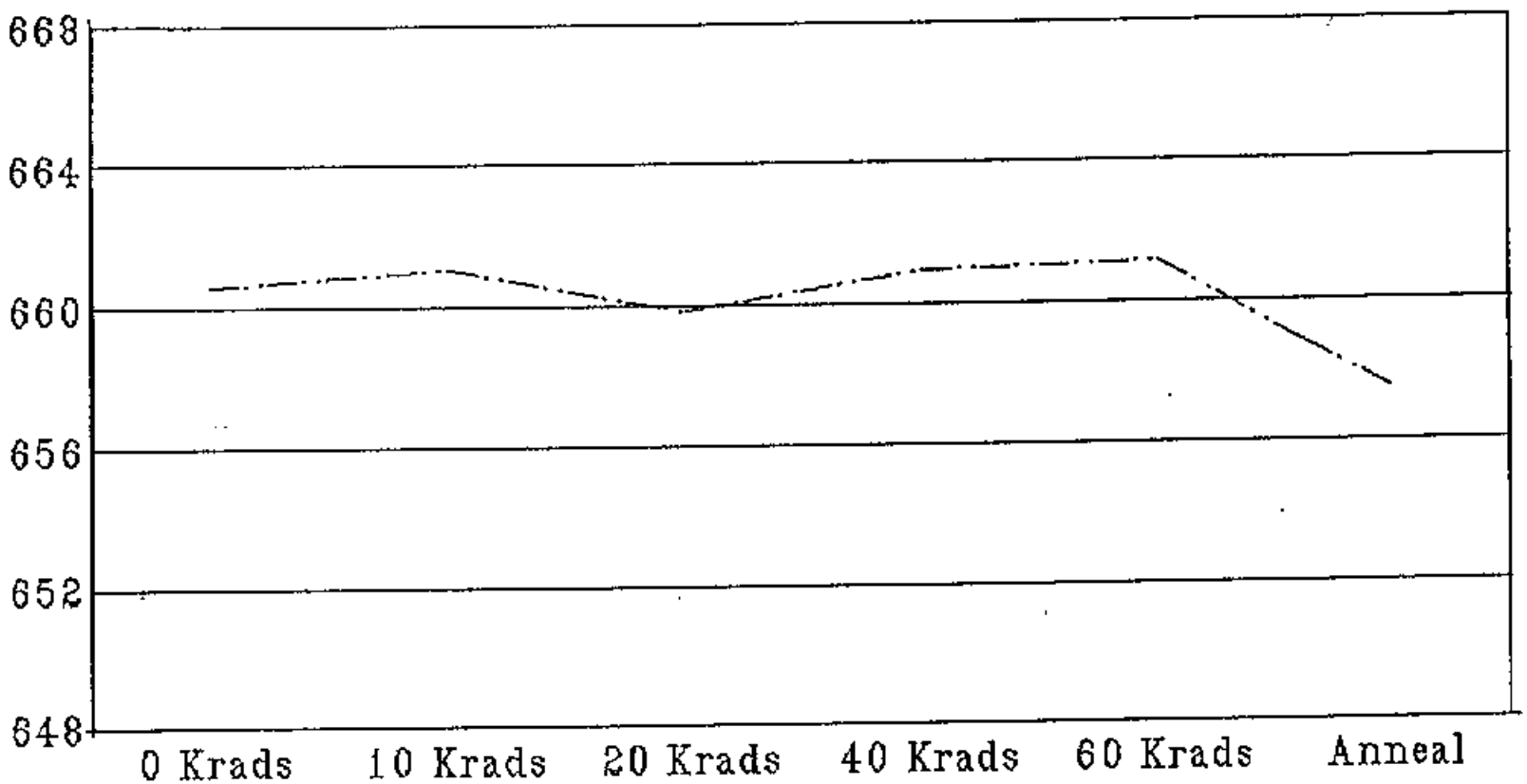
—·· Circuit temperature JTXV2N2219AL

Emitter voltage vs. dose



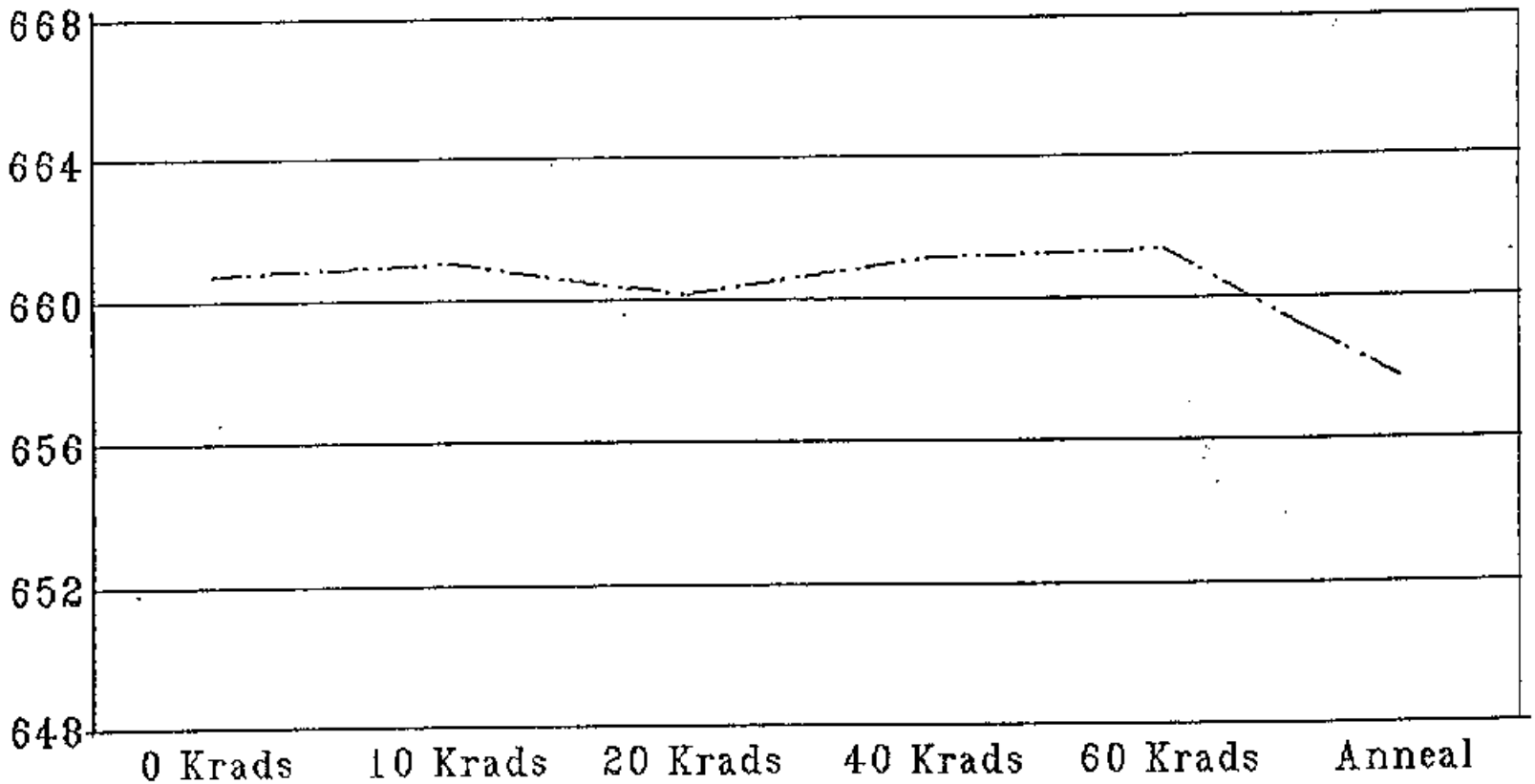
—·· Serial no. 2466 JTXV2N2219AL

Emitter voltage vs. dose



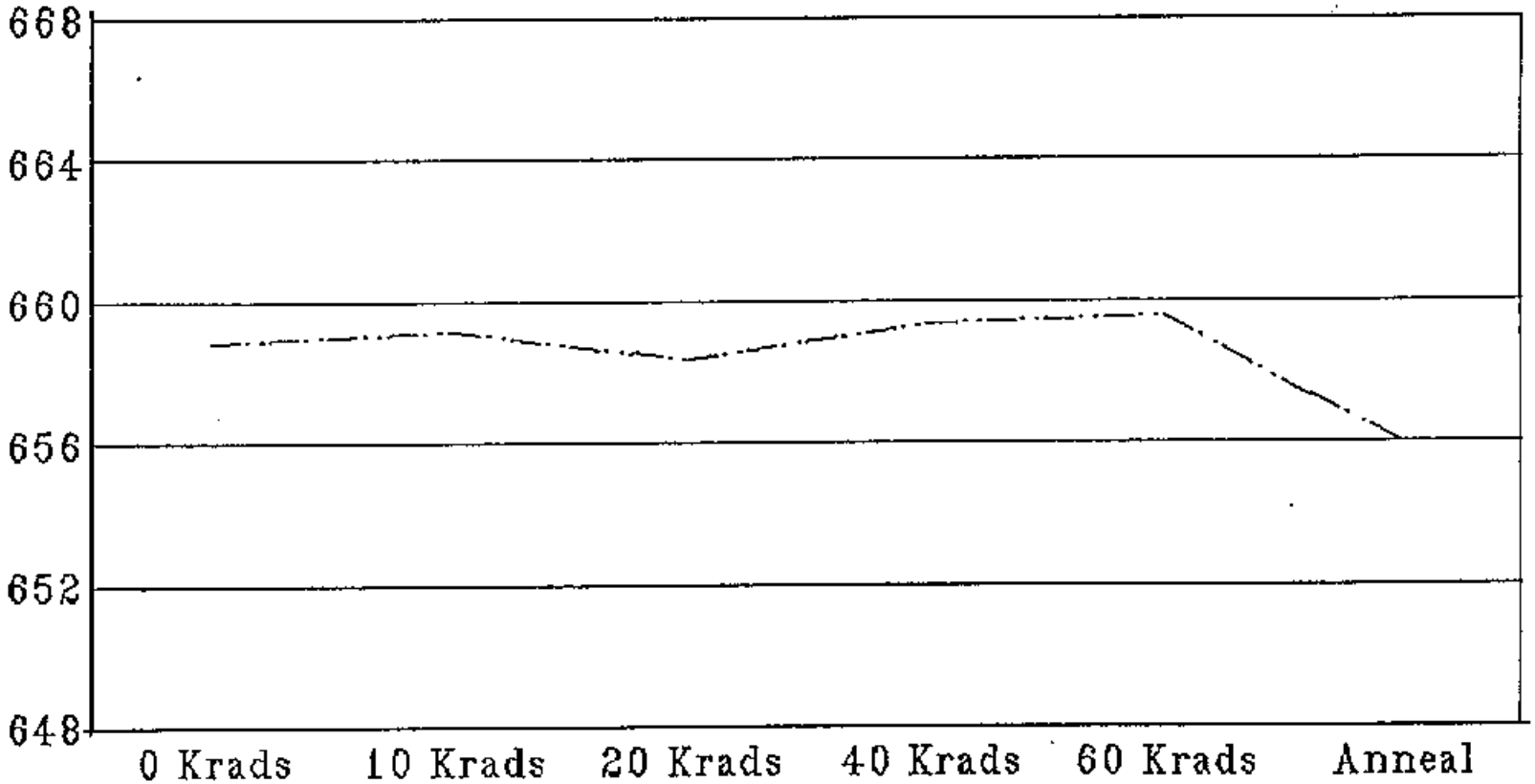
—·· Serial no. 1153 JTXV2N2219AL

Emitter voltage vs. dose



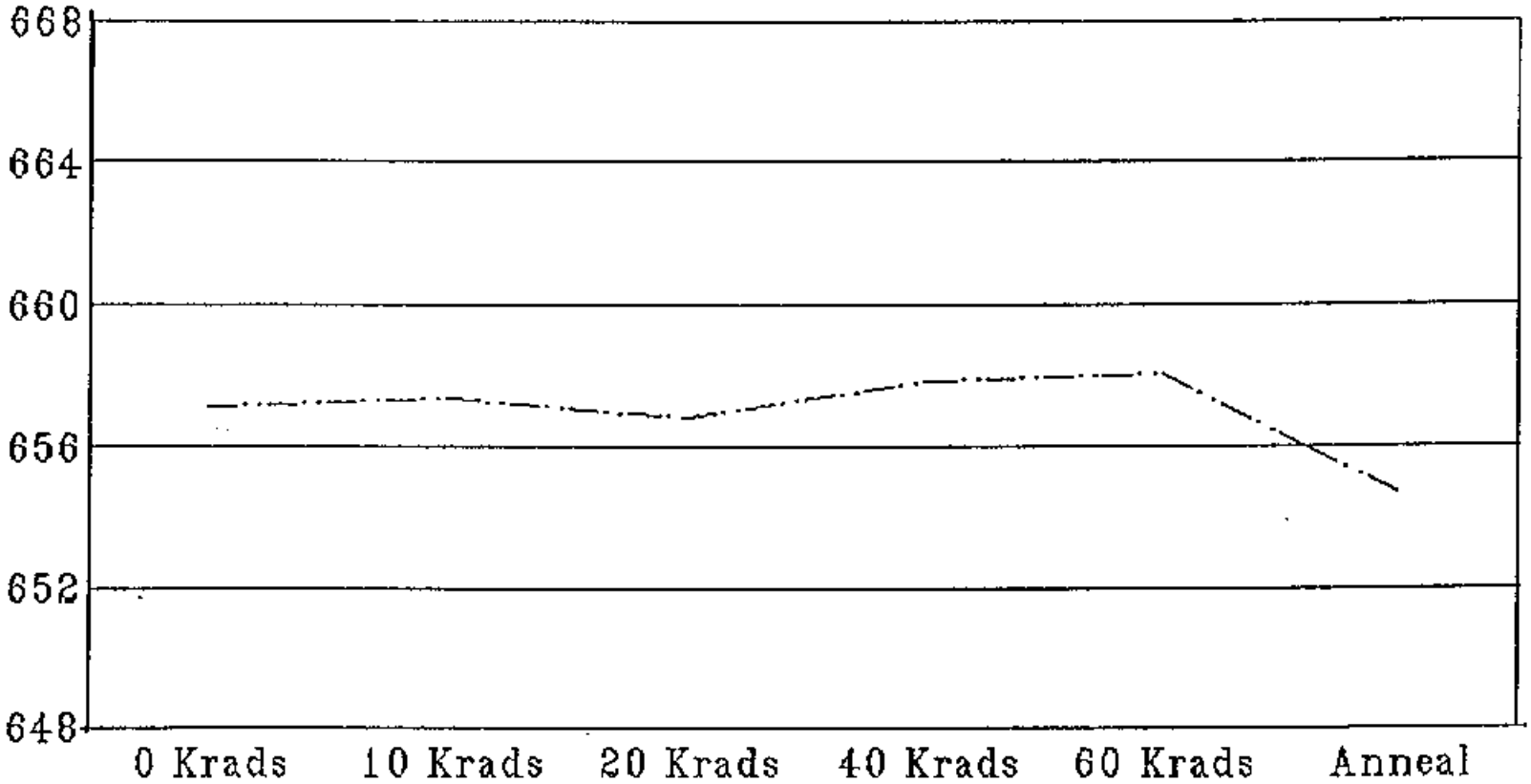
—·· Serial no. 1156 JTXV2N2219AL

Emitter voltage vs. dose



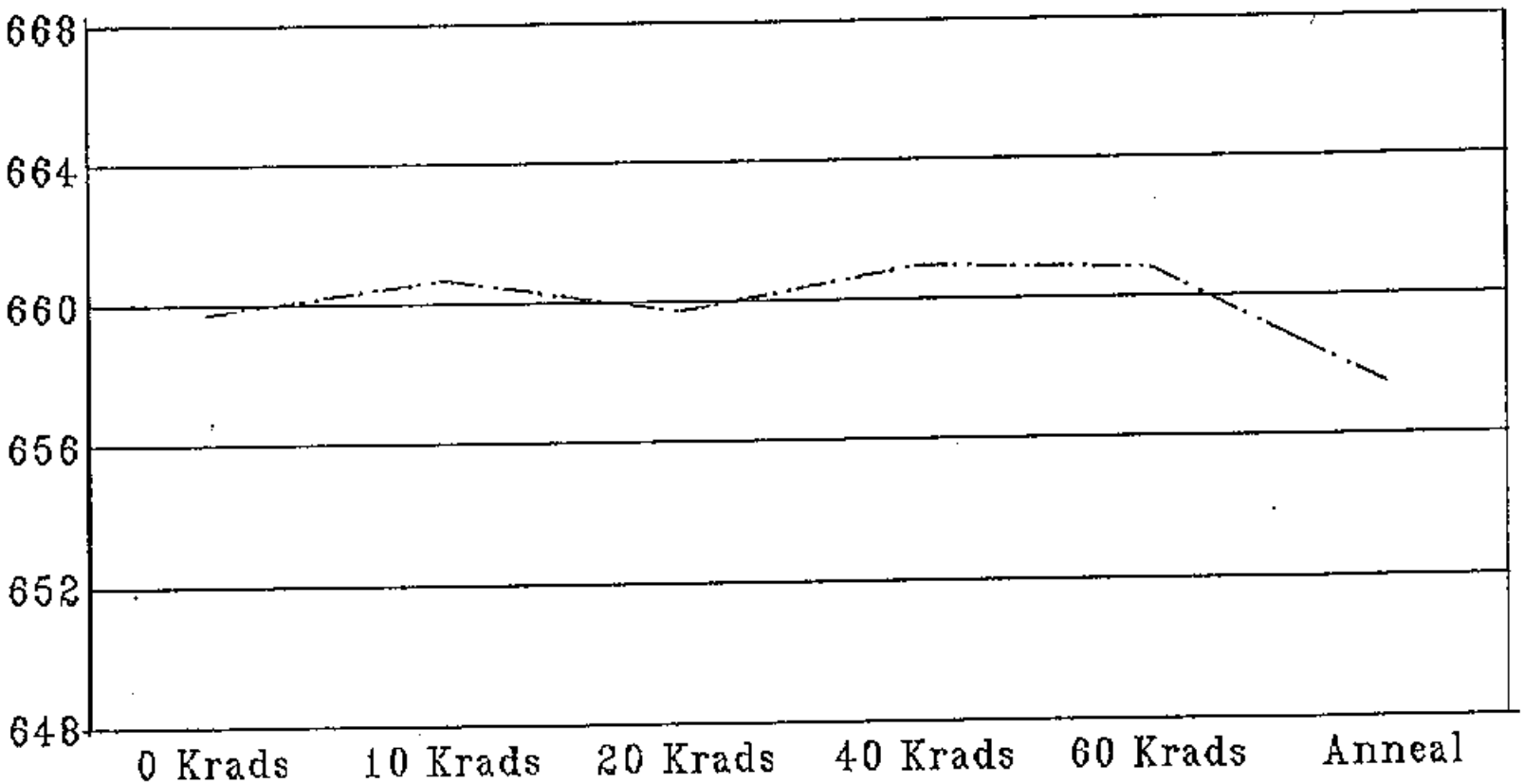
—·· Serial no. 1158 JTXV2N2219AL

Emitter voltage vs. dose



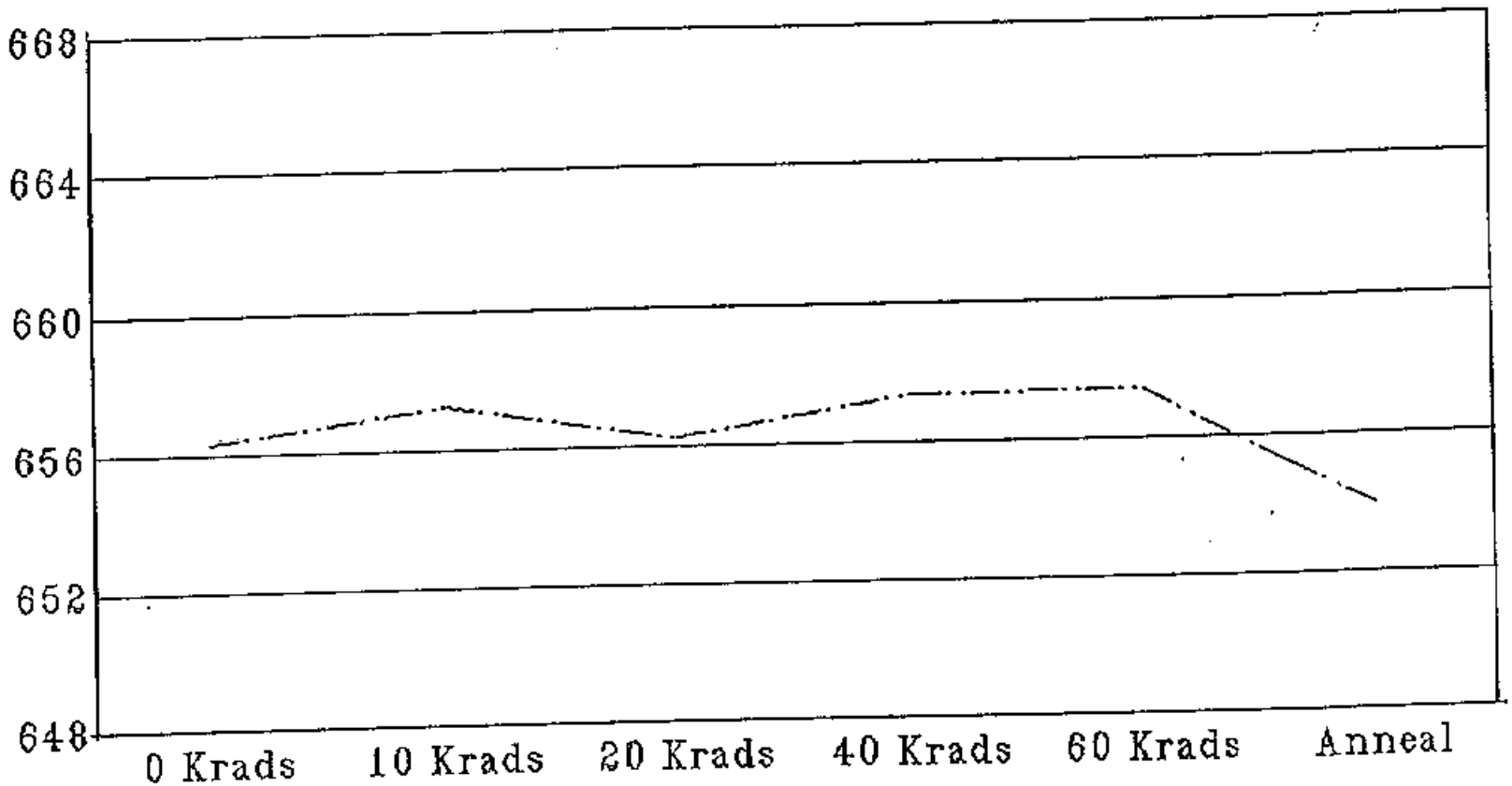
---- Serial no. 1164 JTXV2N2219AL

Emitter voltage vs. dose



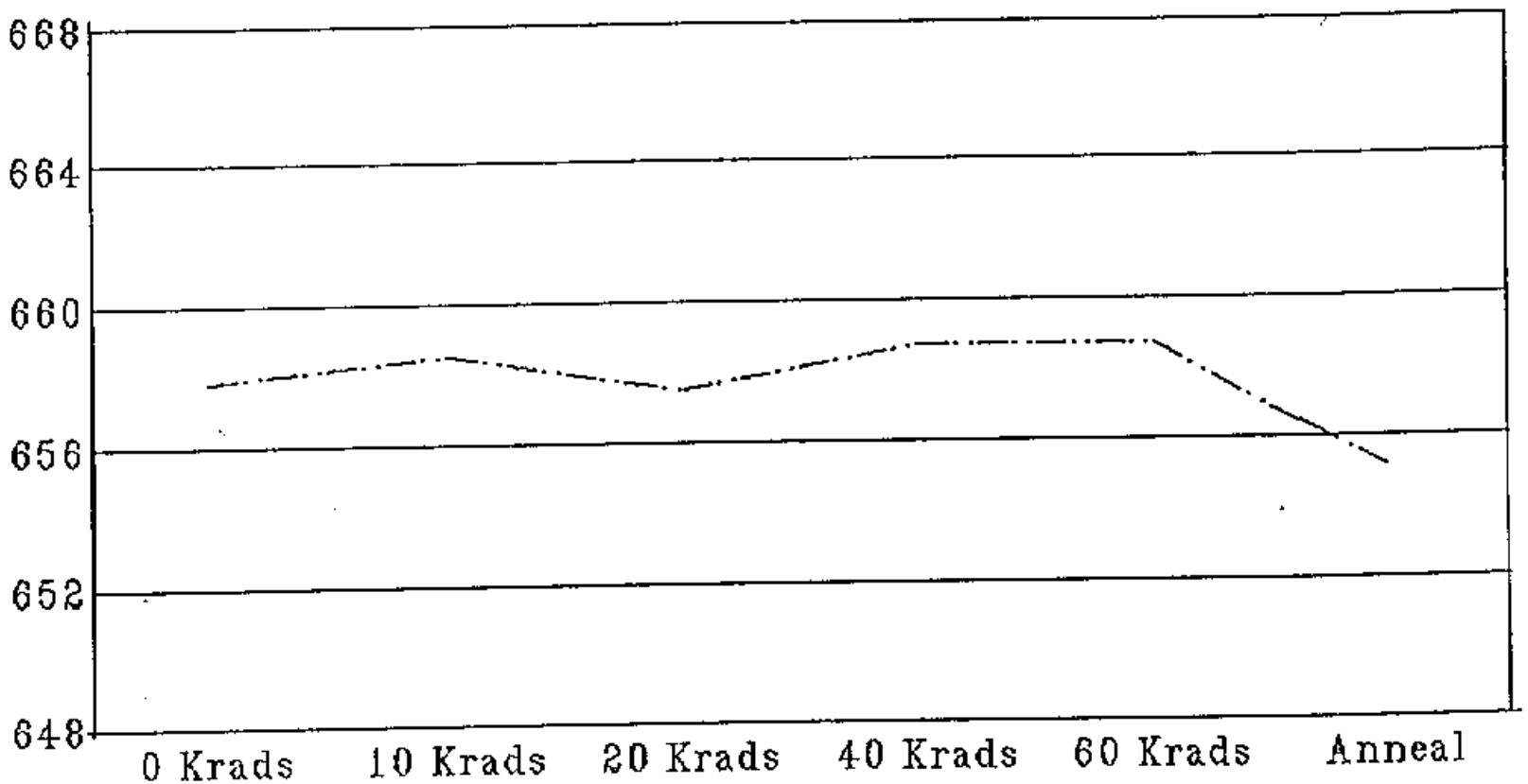
—·· Serial no. 1171 JTXV2N2219AL

Emitter voltage vs. dose



—·· Serial no. 2464 JTXV2N2219AL

Emitter voltage vs. dose



—·· Serial no. 2465 JTXV2N2219AL