PFM-92-302

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Paramax Systems
Corporation

4700 Boston Way
Lanham MD 20706

Memorandum

PARAMAX
A Unisys Company

PPM-92-302

DATE: Dec. 11, 1992
TO: J. Denis/311.2
FROM: K. Sahu
SUBJECT: Radiation Report on GOES
Part No. JTXV2N2905AL
Control No. 7344

cc: A. Sharma/311
Library/300.1

A radiation evaluation was performed on 2N2905 (PNP 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 649.2 to 653.6 mV and circuit ambient temperature (T(circuit)) ranged from 18.1°C to 19.1°C throughout all irradiation steps. All irradiated parts passed all other electrical tests throughout all irradiation and annealing steps. A slight degradation was observed in HFE, although no parts exceeded the specification limits. For details of the test results, refer to Table I and Appendix B.

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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*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.

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TABLE I: Summary of Electrical Measurements After Total Dose Exposures and Annealing Steps for 2N2905 1/

Parameters		Spec. Lim./2 min	max	Total Dose Exposure (TDE), krads: 0 (Pre-Rad.) mean	sd	10 mean	sd	20 mean	sd	40 mean	sd	60 mean	sd	Anneal 168 hrs. @25°C mean	sd
T(circuit)	°C			19.1		18.1		18.7		18.4		18.3		20.6	
Ve	mV			651.8	2.5	653.6	2.6	652.0	2.6	652.8	2.6	653.0	2.5	649.2	2.8
VBRCBO	V	60	-	PASS										PASS	
VBREBO	V	5	-	PASS										PASS	
VBRCEO	V	50	-	PASS										PASS	
ICBO	nA	0	10	0.21	.04									0.60	.09
IEBO	nA	0	50	-0.70	.15									-0.84	.18
ICES	nA	0	1	1.78	.18									2.15	.25
HFEs1		75	-	195.5	30									146.8	19
HFEs2		100	450	202.3	28									165.2	20
HFEs3		100	-	202.5	25									172.9	20
HFEs4		100	300	155.8	15									136.8	12
HFEs5		50	-	68.81	7.9									61.44	6.9
VCESAT1	V	0	0.4	0.168	.01									0.174	.01
VCESAT2	V	0	1.6	0.482	.05									0.541	.09
VBESAT1	V	0	1.3	0.888	0									0.889	0
VBESAT2	V	0	2.6	1.048	0									1.044	0

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 emitter-to-base voltage (Ve) of each transistor. For more details on these measurements, refer to Appendix B.

Appendix A

JANS2N2905AL
PNP TRANSISTOR

GOES X128 Driver Transistor Radiation Test

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

Concurrence: Bernard L. Johnson Date: 19 Oct 92
Bernard Johnson
301 286 9036

Concurrence: _____ Date: _____
Stephen Brown

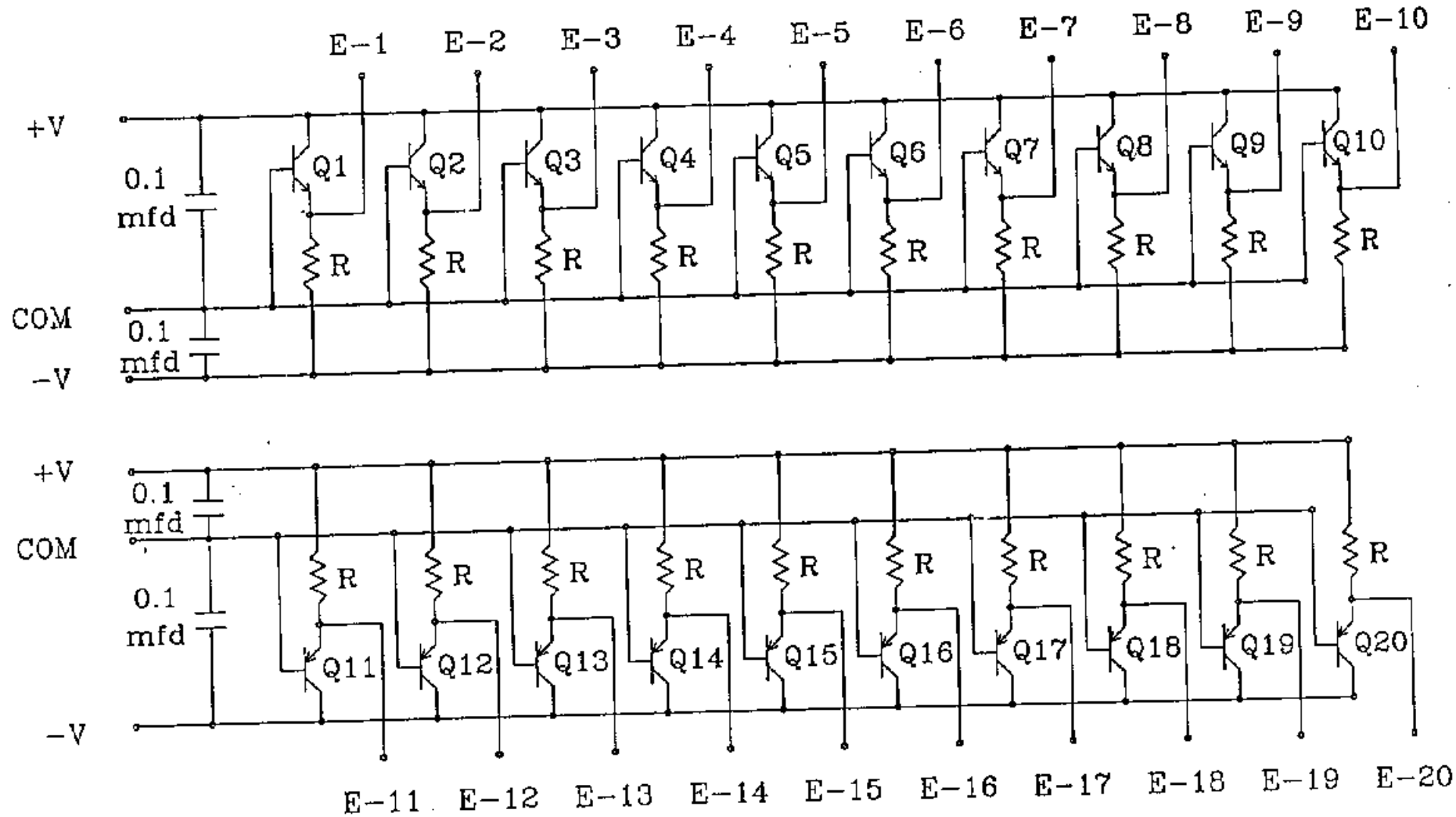
Inst Systems: Robert W Ross Date: 10/19/92
Robert Ross

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.

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

Ckt	Serial #	Ckt	Serial #
Q1:		Q6:	
Q2:		Q7:	
Q3:		Q8:	
Q4:		Q9:	
Q5:		Q10:	

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

Ckt	Serial #	Ckt	Serial #
Q11:	509	Q16:	449
Q12:	184	Q17:	464
Q13:	245	Q18:	502
Q14:	257	Q19:	501
Q15:	430	Q20:	38

SN 33+131 control samples

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

Initials: GB Date: 11-16

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

Accomplished: _____

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

Accomplished: _____

N/A ~~1.6.~~ Record current from each power supply for NPN circuit:

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

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

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

Accomplished: ok

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

Accomplished: ok

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

+5 v p.s. 10.65 ma (approximately 15 ma expected)

-5 v p.s. 10.47 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: GB Date: 11-16

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

Begin baseline - Initials: GB 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: 5.004 volts

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

-V to COM: 5.0008 volts

2.5 Record the current in the +V supply: SHORTED LEADS APPLIED BYPASS D3

+V supply: ~~10.5~~ 10.54 ma

2.6 Record the current in the -V supply:

-V supply: ~~10.48~~ 10.39 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: ~~19.9~~ 19.1 degrees C

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

E-1:	N/A mV	E-11:	~~5.649.6~~ mV
E-2:	mV	E-12:	650.2 mV
E-3:	mV	E-13:	653.2 mV
E-4:	mV	E-14:	652.4 mV
E-5:	mV	E-15:	652.9 mV
E-6:	mV	E-16:	656.5 mV
E-7:	mV	E-17:	649.2 mV
E-8:	mV	E-18:	650.3 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: 10.533 ma

4.4. Record the current in the -V supply:

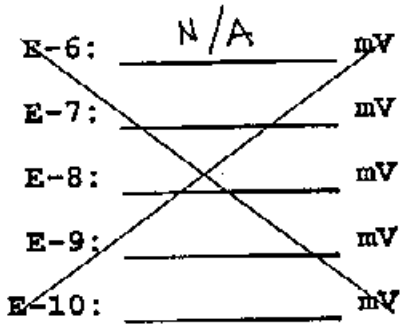
-V supply: 10.382 ma

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: 18.1 degrees C

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

E-1:	N/A mV	E-11:	651.1 mV
E-2:	____ mV	E-12:	651.8 mV
E-3:	____ mV	E-13:	654.8 mV
E-4:	____ mV	E-14:	654.0 mV
E-5:	____ mV	-E-15:	654.6 mV



E-6:	N/A mV	E-16:	658.7 mV
E-7:	____ mV	E-17:	651.2 mV
E-8:	____ mV	E-18:	652.2 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: 10.538 ma

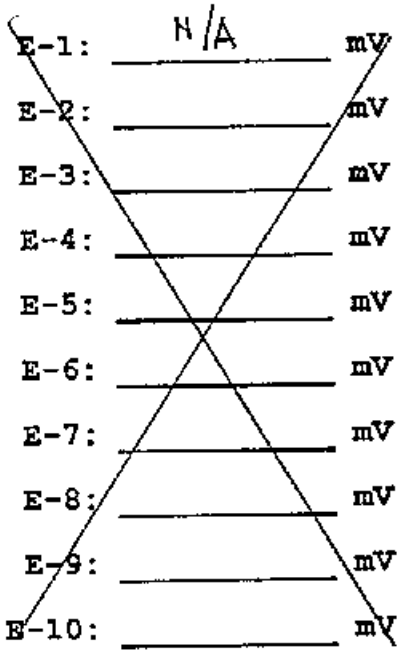
6.4. Record the current in the -V supply:

-V supply: 10.384 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:	N/A mV	E-11:	649.5 mV
E-2:	____ mV	E-12:	650.3 mV
E-3:	____ mV	E-13:	653.2 mV
E-4:	____ mV	E-14:	652.4 mV
E-5:	____ mV	E-15:	653.0 mV
E-6:	____ mV	E-16:	657.3 mV
E-7:	____ mV	E-17:	649.8 mV
E-8:	____ mV	E-18:	650.8 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:

GOES X128 Driver Transistor Test (Continued)

+V supply: 10.538 ma

8.4. Record the current in the -V supply:

-V supply: 10.378 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~~ 18.4 degrees C

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

E-1:	N/A mV	E-11:	650.3 mV
E-2:	____ mV	E-12:	650.9 mV
E-3:	____ mV	E-13:	653.9 mV
E-4:	____ mV	E-14:	653.2 mV
E-5:	____ mV	E-15:	653.8 mV
E-6:	____ mV	E-16:	658.1 mV
E-7:	____ mV	E-17:	650.6 mV
E-8:	____ mV	E-18:	651.5 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: 10.535 ma

10.4. Record the current in the -V supply:

-V supply: 10.375 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: 18.3 degrees C

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

E-1:	N/A mV	E-11:	650.7 mV
E-2:	mV	E-12:	651.2 mV
E-3:	mV	E-13:	654.1 mV
E-4:	mV	E-14:	653.4 mV
E-5:	mV	E-15:	653.9 mV
E-6:	mV	E-16:	658.2 mV
E-7:	mV	E-17:	650.8 mV
E-8:	mV	E-18:	651.7 mV
E-9:	mV	E-19:	mV
E-10:	mV	E-20:	mV

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 : JTXV2N2905AL

PART NAME : PNP TRANSISTOR

JOB NUMBER : EE33108 CONTROL NO. : 7344

PROJECT : GOES

LOT DATE CODE : 8626

MANUFACTURER : MOTOROLA

PART SPECIFICATION : MIL - S - 19500 / 290C

CONTROL SAMPLES : 2 PARTS (S/N : 33 , & 131)

QUANTITY TESTED : 8 PARTS (S/N : 509 , 184 , 245 , 257 , 430 , 449 , 464 , 502) .

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 : All 8 radiated parts passed all electrical tests up to 60 Krads .
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~~ ELECTRICAL TEST ambient room temperature		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. : JANS2N2905AL
PART TYPE : PNP TRANSISTOR (SWITCHING)
SPEC NO. : MIL – S – 19500 / 290C
Table I / group A / subgroup 2 .
DATE : 13 – JUN – 79
AMENDMENT NO. : 3
DATE : 15 – APR – 83

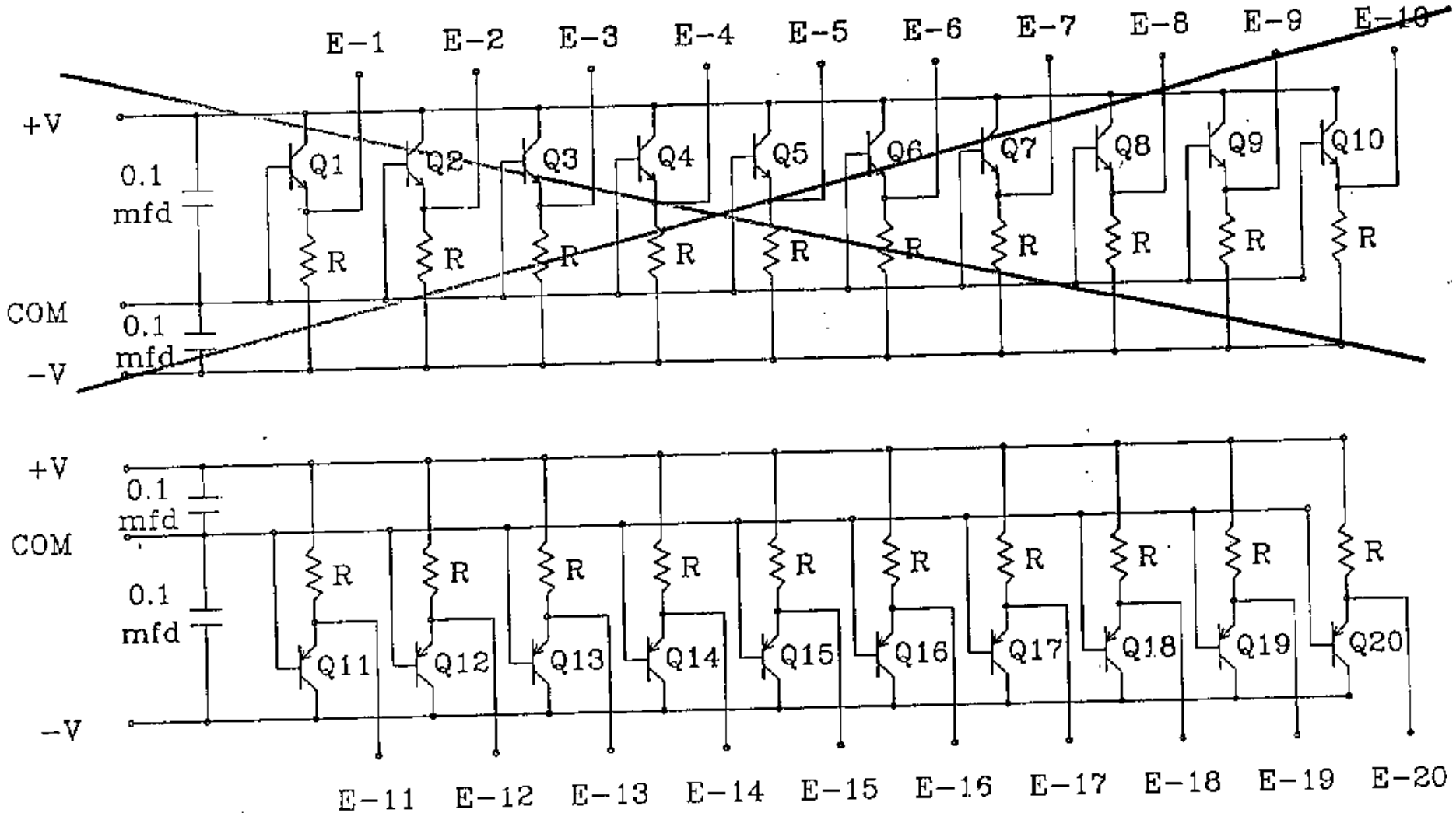
PCN NO. : 9204 – 2905
JOB NO. : EE33108
PROJECT : GOES
ENGINEER : ANH PHUNG
DATE : 26 – OCT – 92
REQUESTER : DENIS

Ta = 25°C , Unless otherwise specified.

NO.	PARAMETER	TEST CONDITION			MIN	MAX	UNIT	METHOD MIL-STD-750
1	VBRcbo	Ic = 10 uA	Cond. D		60		V	3001
2	VBRebo	Ie = 10 uA	Cond. D		5		V	3026
3	VBRceo	Ic = 10 mA	Cond. D	Pulsed	60		V	3011
4	Icbo1	Vcb = 50 V	Cond. D			10	nA	3036
5	Ices	Vce = 60 V	Cond. C			1	uA	3041
6	Iebo	Veb = 3.5 V	Cond. D			50	nA	3061
7	Hfe1	Vce = 10 V	Ic = 0.1 mA		75			3076
8	Hfe2	Vce = 10 V	Ic = 1 mA		100	450		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	50			3076
12	Vce (sat)1	Ic = 150 mA	Ib = 15 mA	Pulsed		0.4	V	3071
13	Vce (sat)2	Ic = 500 mA	Ib = 50 mA	Pulsed		1.6	V	3071
14	Vbe (sat)1	Ic = 150 mA	Ib = 15 mA Cond. A	Pulsed		1.3	V	3066
15	Vbe (sat)2	Ic = 500 mA	Ib = 50 mA Cond. A	Pulsed		2.6	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

X126 TRANSISTOR RADIATION TEST CIRCUIT 15 OCT 92

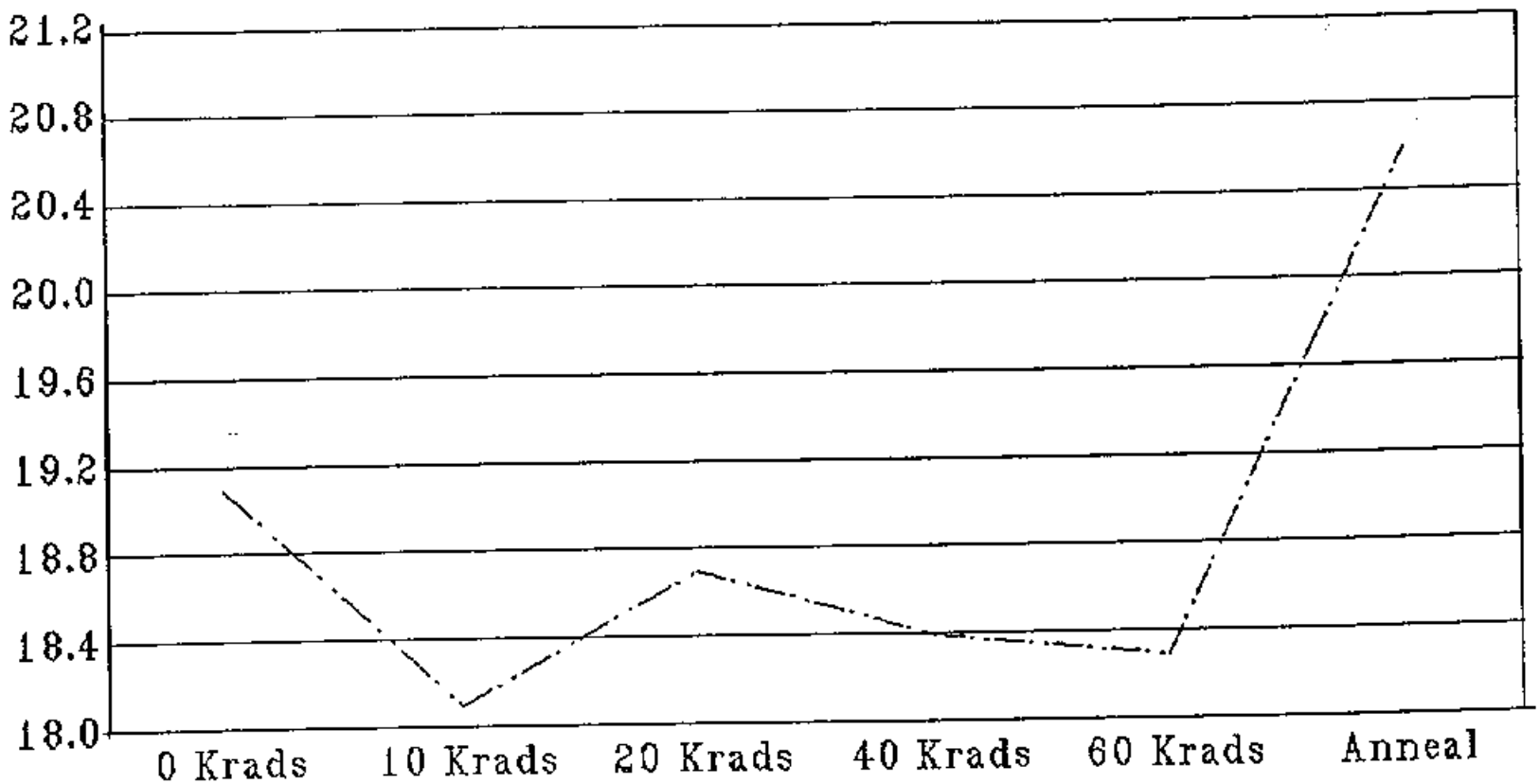
JTXV2N2905AL

PNP – 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	+10.540 mA	+10.533 mA	+10.538 mA	+10.538 mA	+10.535 mA	+10.546 mA
	– Ips	–10.390 mA	–10.382 mA	–10.384 mA	–10.378 mA	–10.375 mA	–10.397 mA
	Ta	19.1 °C	18.1 °C	18.7 °C	18.4 °C	18.3 °C	20.6 °C
509	EMITTER – COM	649.6 mV	651.1 mV	649.5 mV	650.3 mV	650.7 mV	646.7 mV
184	EMITTER – COM	650.2 mV	651.8 mV	650.3 mV	650.9 mV	651.2 mV	647.6 mV
245	EMITTER – COM	653.2 mV	654.8 mV	653.2 mV	653.9 mV	654.1 mV	650.7 mV
257	EMITTER – COM	652.4 mV	654.0 mV	652.4 mV	653.2 mV	653.4 mV	649.9 mV
430	EMITTER – COM	652.9 mV	654.6 mV	653.0 mV	653.8 mV	653.9 mV	650.8 mV
449	EMITTER – COM	656.5 mV	658.7 mV	657.3 mV	658.1 mV	658.2 mV	654.3 mV
464	EMITTER – COM	649.2 mV	651.2 mV	649.8 mV	650.6 mV	650.8 mV	646.2 mV
502	EMITTER – COM	650.3 mV	652.2 mV	650.8 mV	651.5 mV	651.7 mV	647.1 mV
	Ta	19. 0°C					23 °C
33 C.S.	EMITTER – COM	649.6 mV					641.8 mV
131 C.S.	EMITTER – COM	652.5 mV					645.0 mV

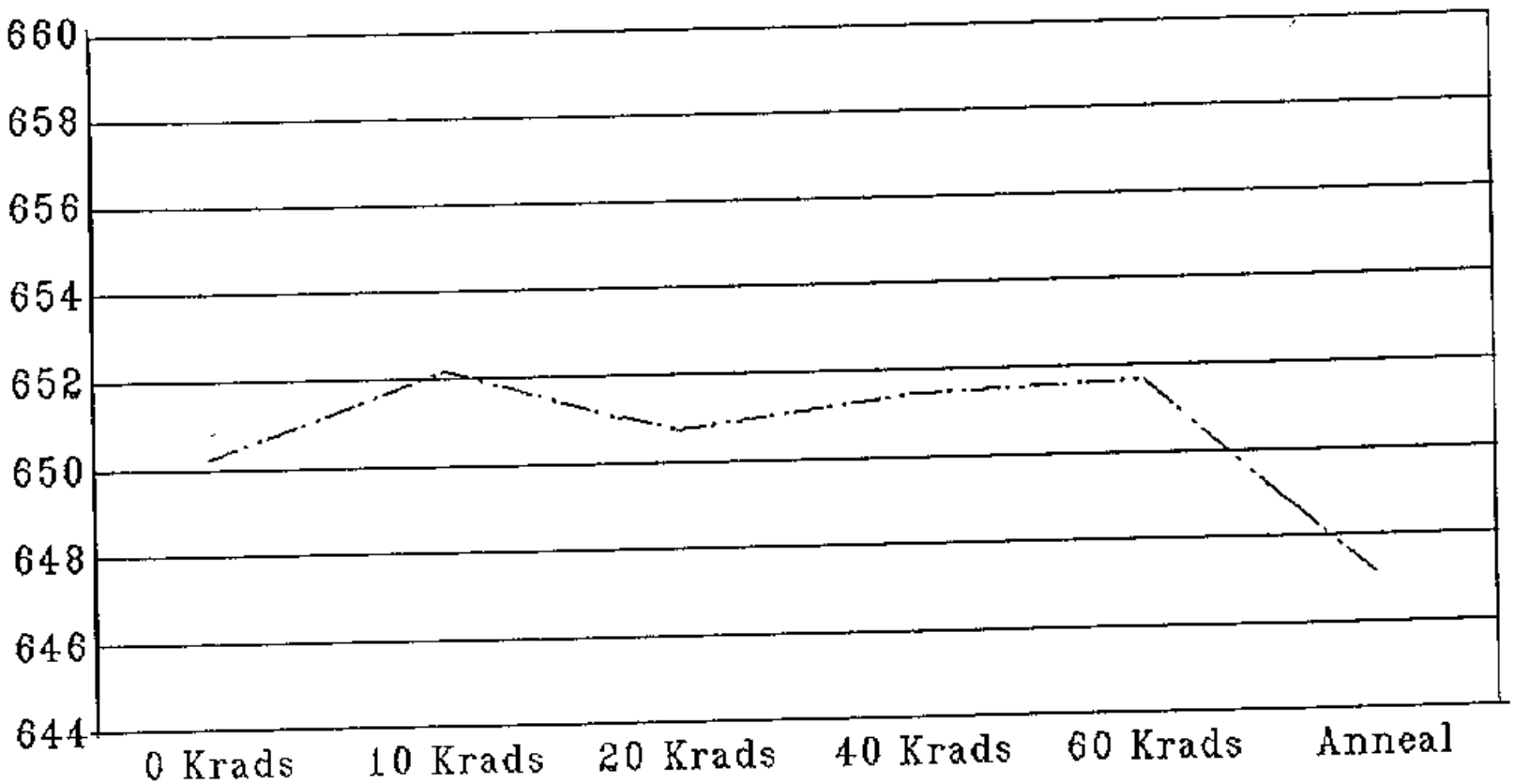
CONTROL SAMPLES S / N : 33, & 131

Circuit temperature vs. dose



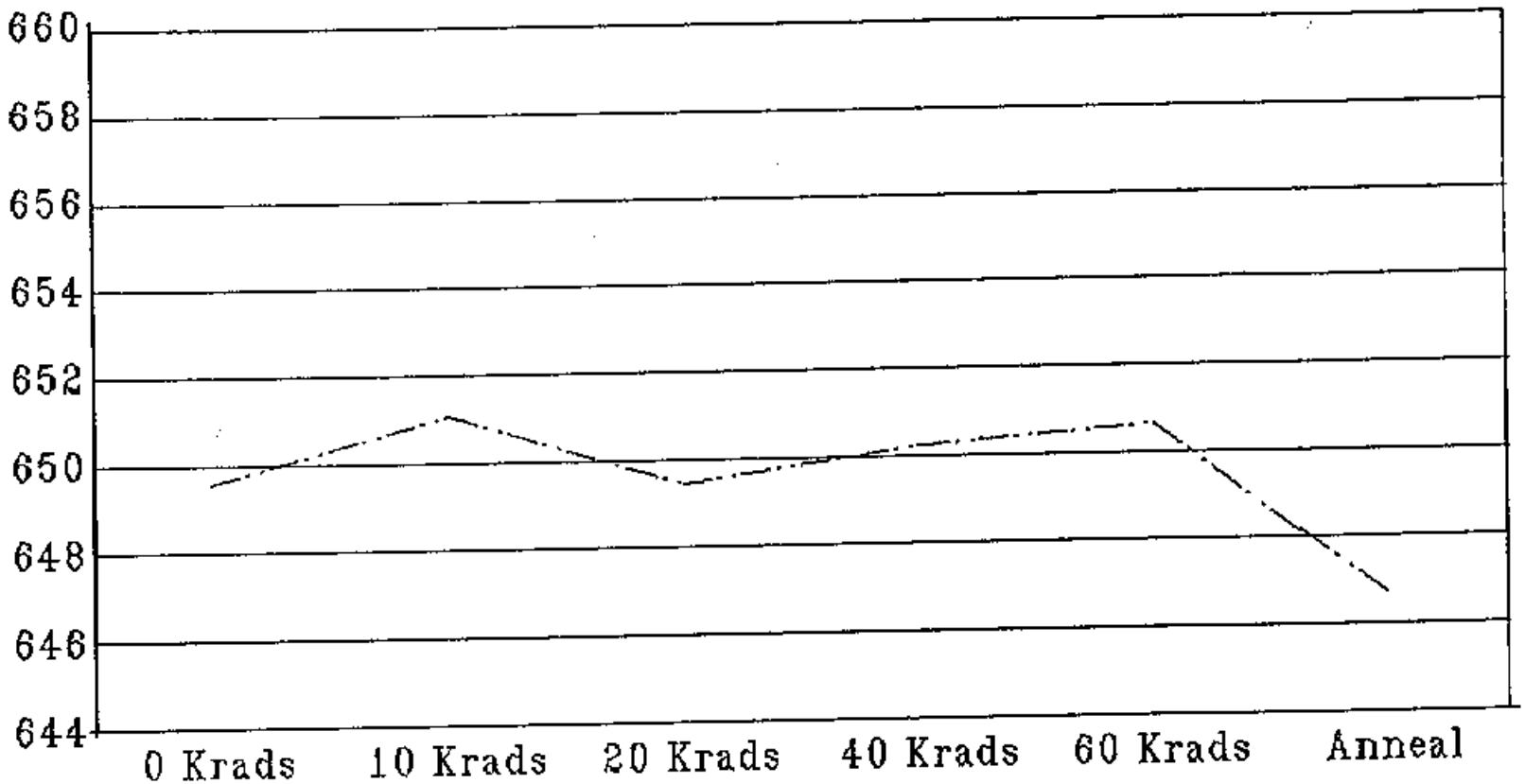
—·· Circuit temperature JTXV2N2905AL

Emitter voltage vs. dose



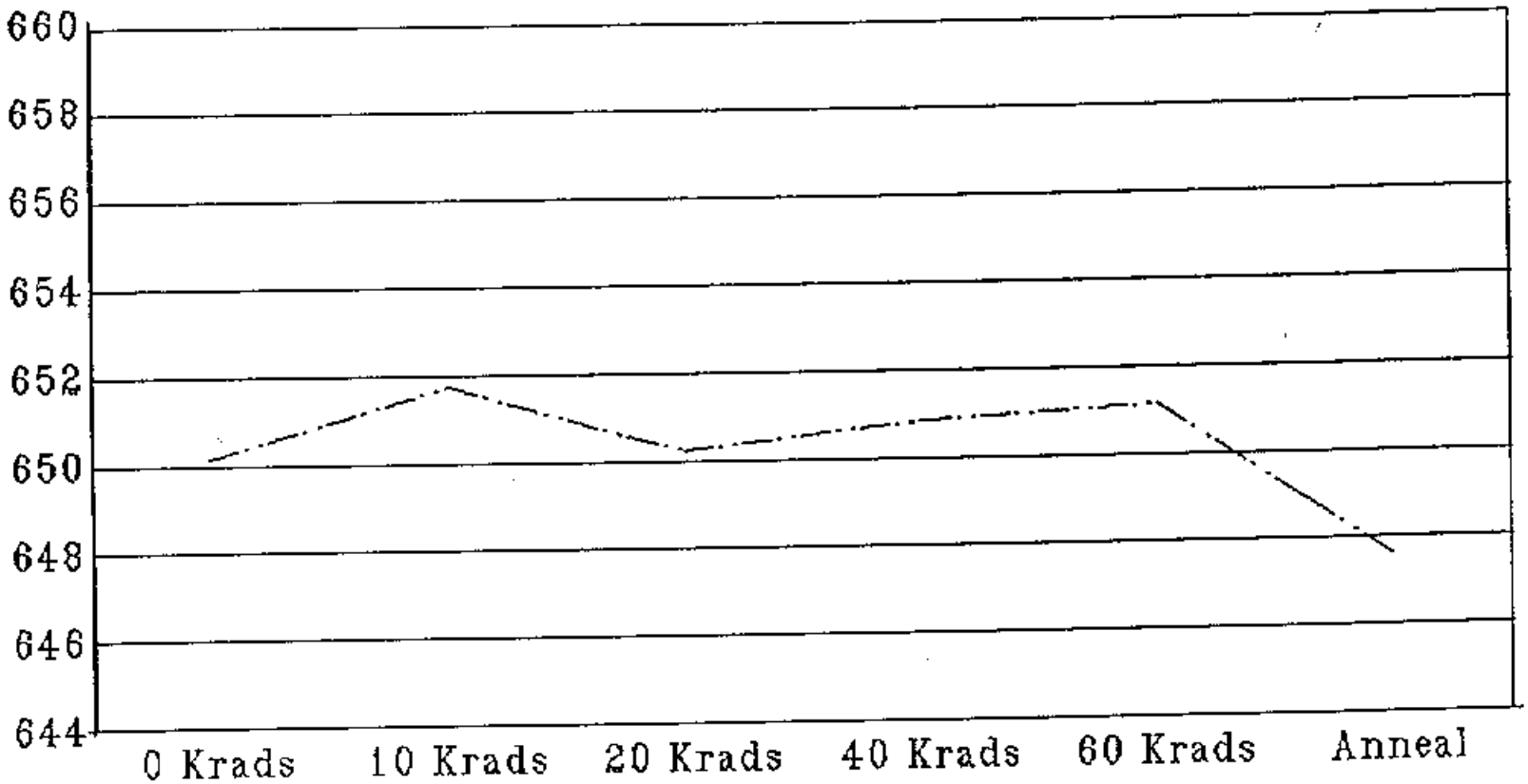
—·· Serial no. 502 JTXV2N2905AL

Emitter voltage vs. dose



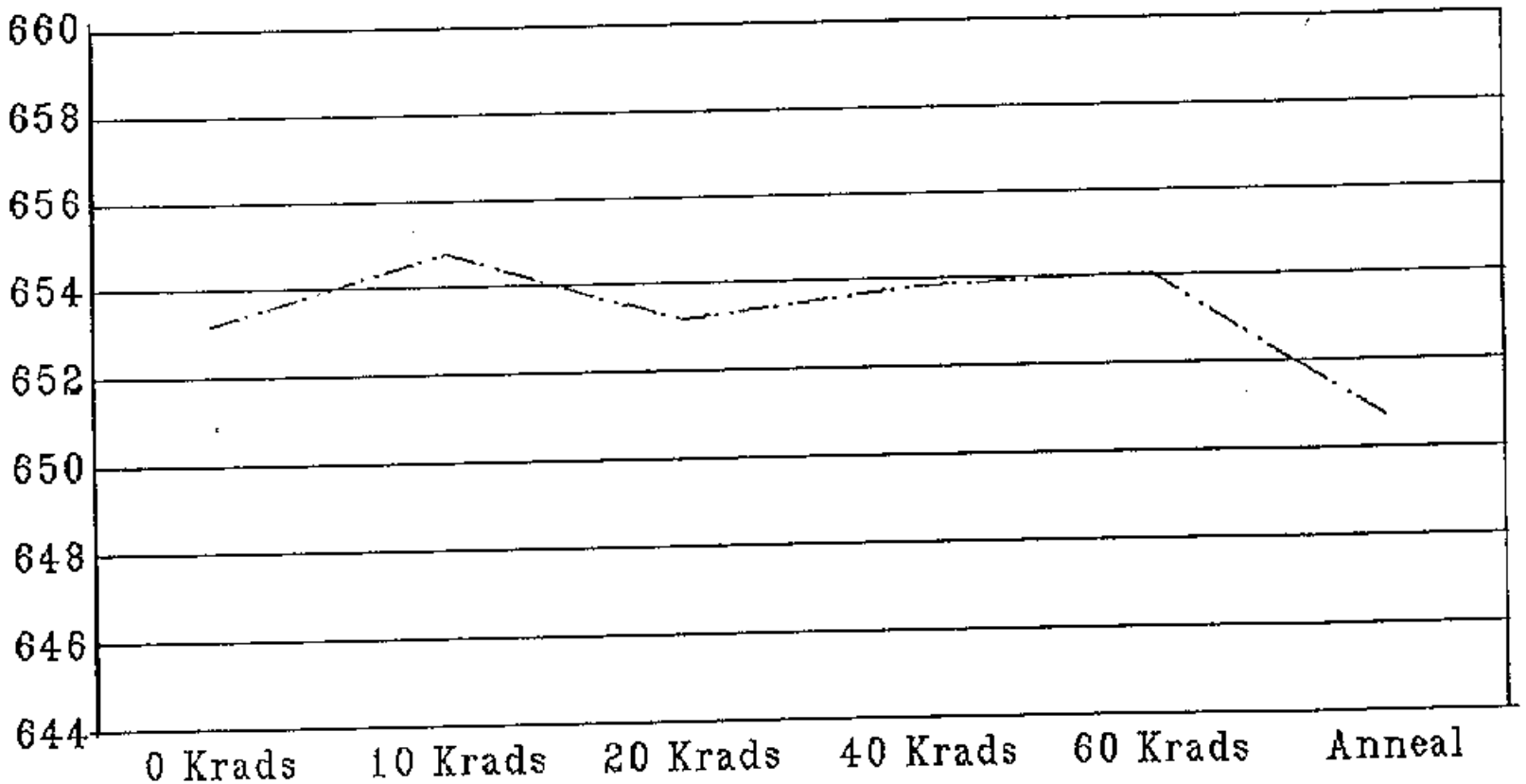
—·· Serial no. 509 JTXV2N2905AL

Emitter voltage vs. dose



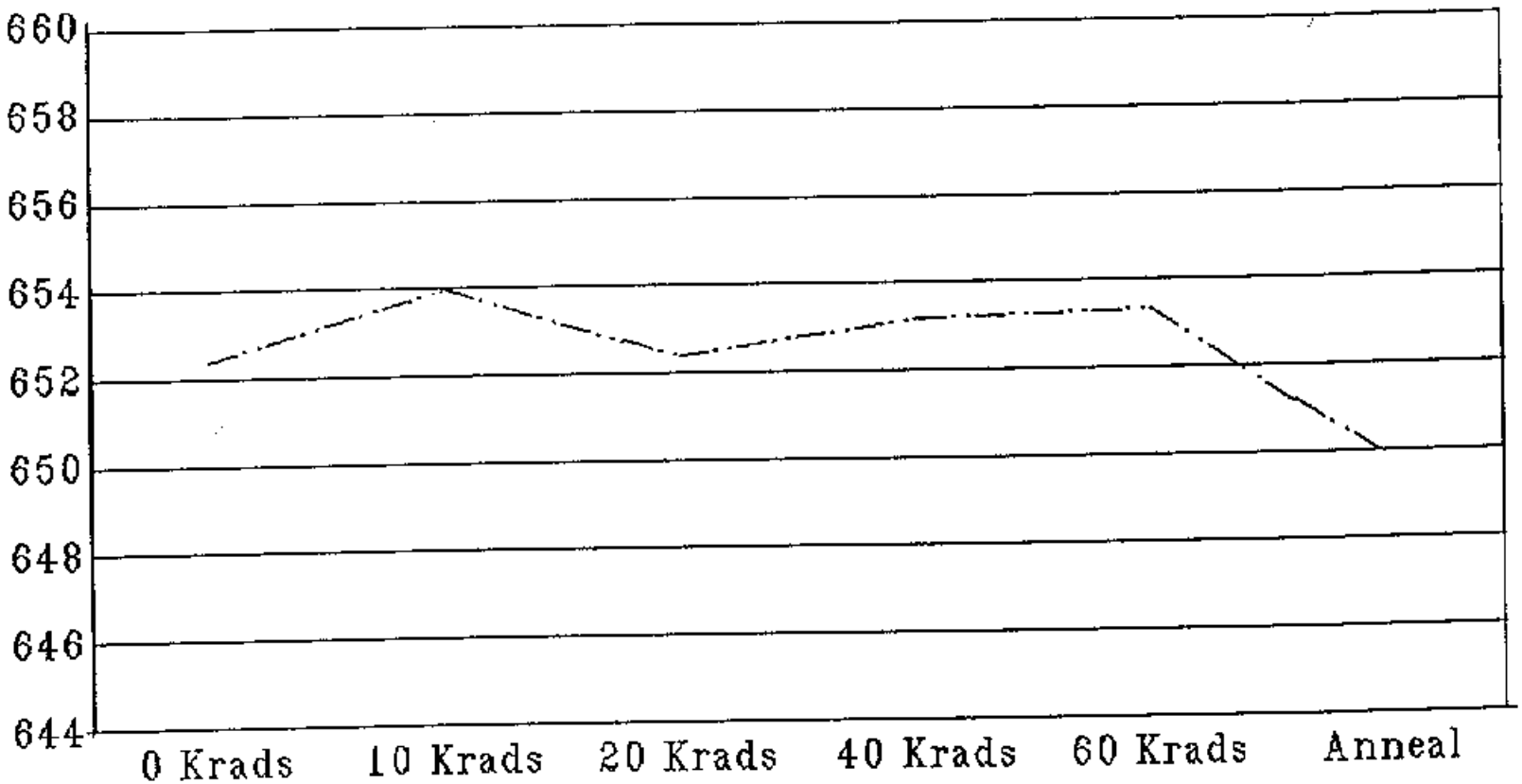
—·· Serial no. 184 JTXV2N2905AL

Emitter voltage vs. dose



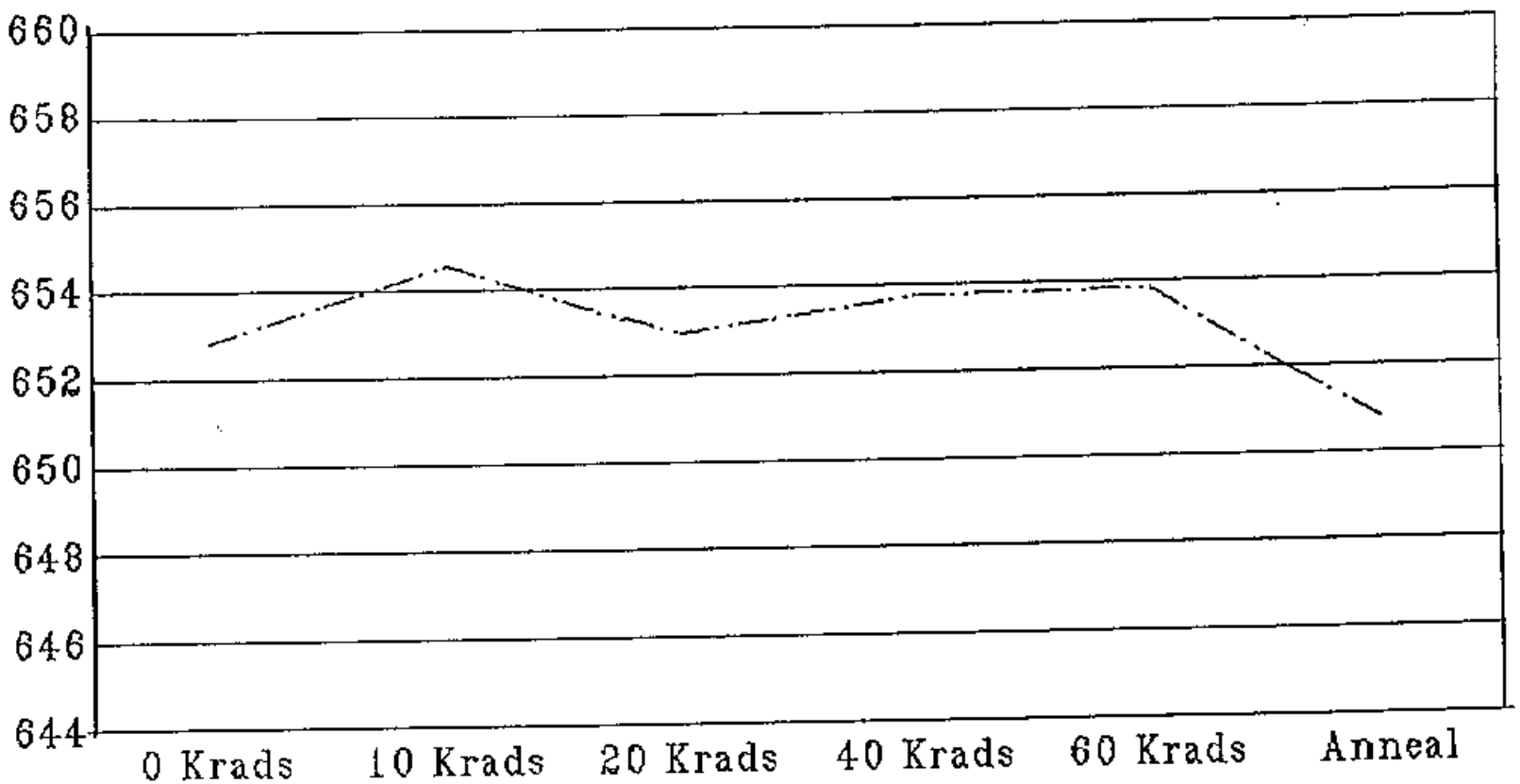
—·· Serial no. 245 JTXV2N2905AL

Emitter voltage vs. dose



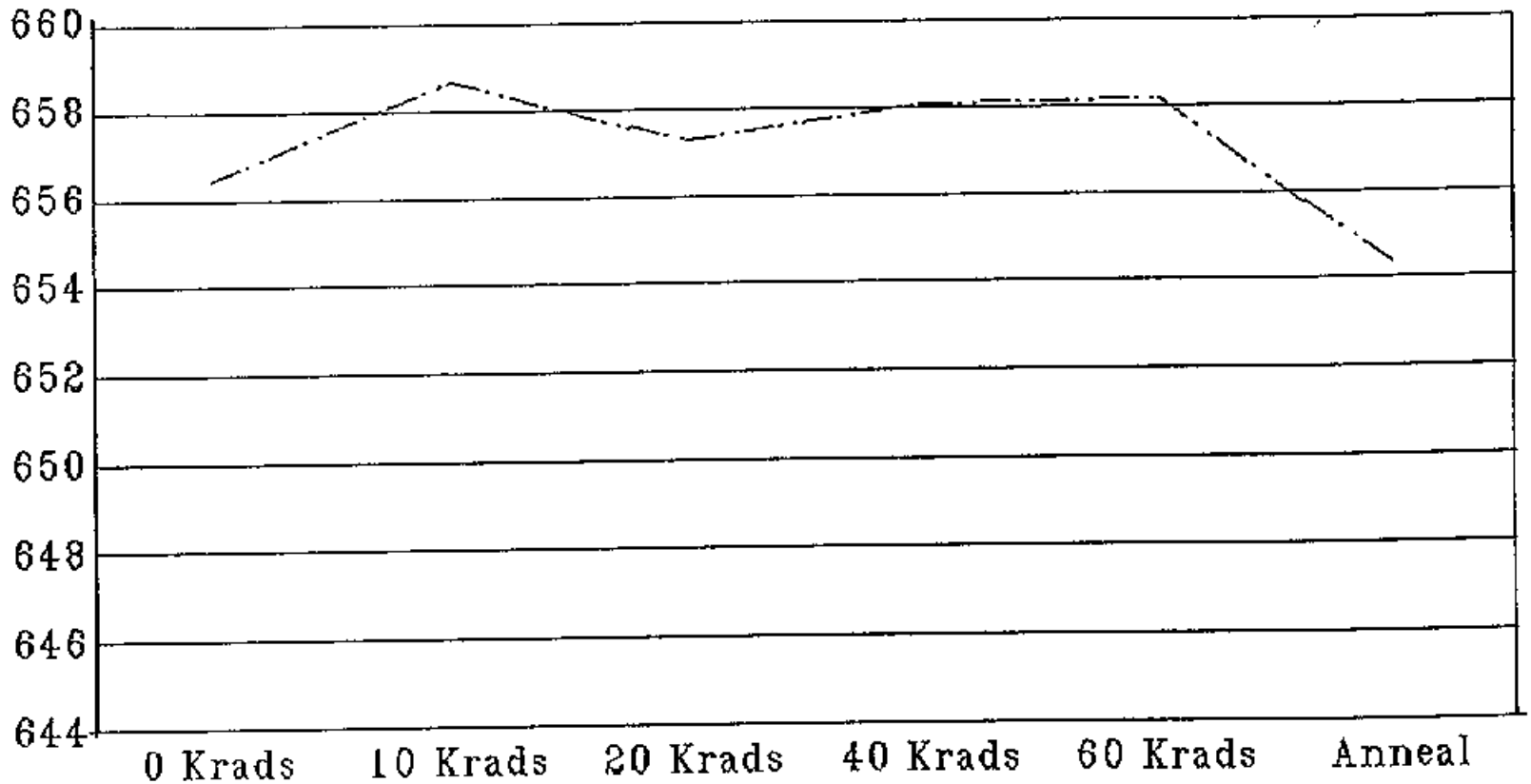
—·· Serial no. 257 JTXV2N2905AL

Emitter voltage vs. dose



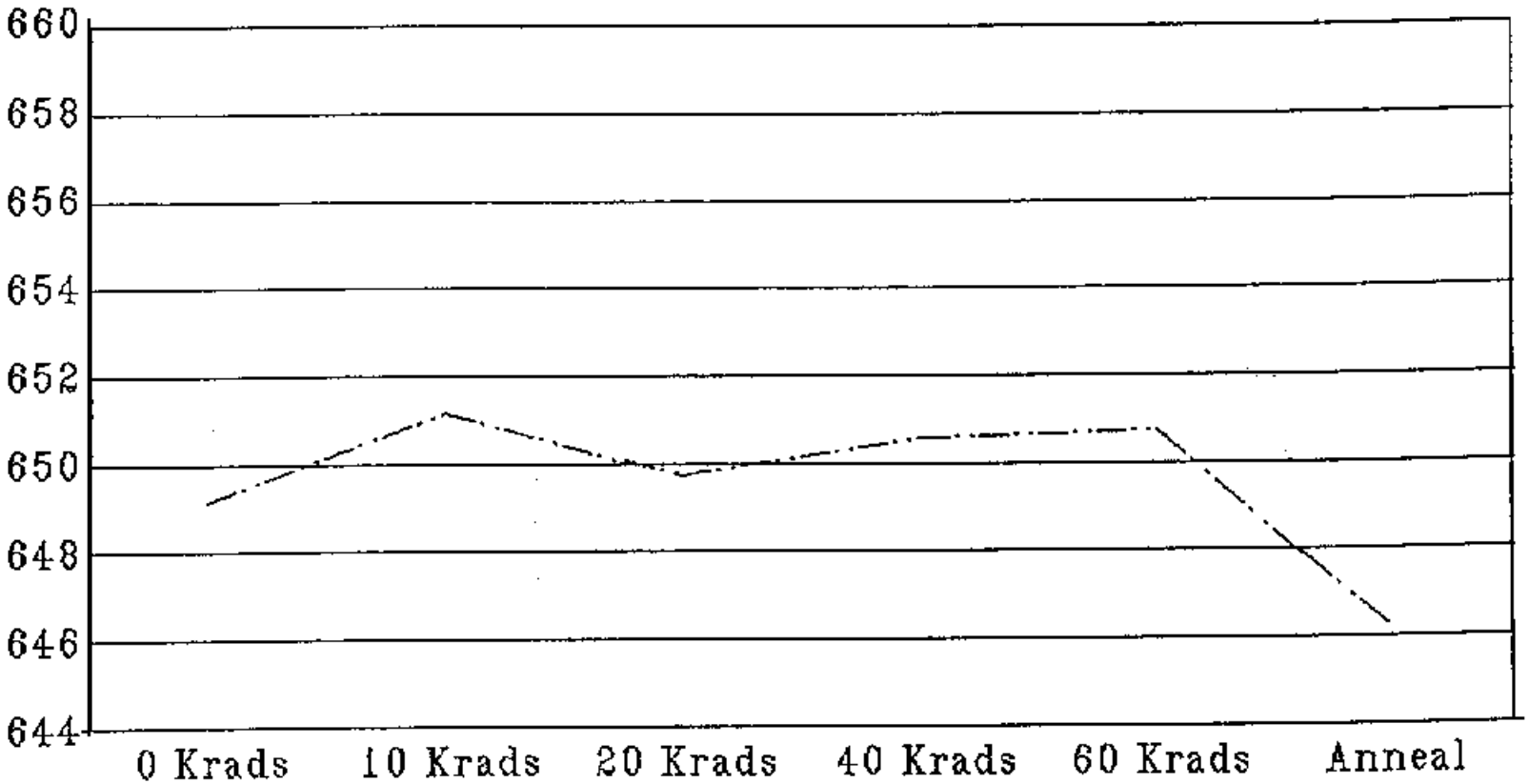
—·· Serial no. 430 JTXV2N2905AL

Emitter voltage vs. dose



—·· Serial no. 449 JTXV2N2905AL

Emitter voltage vs. dose



—·· Serial no. 464 JTXV2N2905AL