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COMPILATION OF CALIBRATION DATA FOR AEROBEE FLIGHT 4.13 GP-GT

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BY

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GODDARD SPACE FLIGHT CENTER

GREENBELT, MARYLAND

COMPILATION OF CALIBRATION DATA FOR AEROBEE FLIGHT 4.13 GP-GT

By

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National Aeronautics and Space Administration
Goddard Space Flight Center

SUMMARY

An Aerobee 150A, designated Flight 4.13 GP-GT, was flown as an Aerobee performance vehicle and was heavily instrumented by personnel of GSFC's Sounding Rocket Instrumentation Section. This document contains a compilation of calibration data and curves for instrumentation aboard this rocket. In addition, payload telemetry channel allocations, pertaining to this report, are also contained.

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FOR AEROBEE FLIGHT 4.13 GP-GT

INTRODUCTION

This document presents a compilation of calibration data and curves for instrumentation flown on Aerobee 150A, Flight 4.13 GP-GT. Launched from Wallops Island, Virginia on 26 September 1964, Flight 4.13's payload carried pressure and temperature transducers, solar aspect sensors, magnetometers, and a pitch-yaw ogive. Calibration curves and data (Figures 1 through 34) are supplied so that the experimenters can reduce acquired raw data.

Primary objectives of Flight 4.13 GP-GT were to gather extensive propulsion data on the Aerobee 150A, as well as vehicle environment data; i.e., temperatures, pressures, and acceleration.

TELEMETRY REQUIREMENTS

Flight 4.13 GP-GT carried one FM/FM telemetry system and two Pulse Position Modulation (PPM) telemetry systems for data transmission. The FM/FM system contained 13 subcarrier frequency bands all of which were allocated to instrumentation. Table 1 provides a breakdown of IRIG frequencies and allocations of the FM/FM telemetry system, which was modulated on a frequency of 256.2 mcs. Tables 2 and 3 provide segment allocations of commutated IRIG bands on the FM/FM telemetry system. In Table 1 note that IRIG band 14 was also commutated, but since data on band 14 does not pertain to this report, segment allocations are not listed.

The PPM telemetry systems were designated as SST I and SST II, transmitting on frequencies of 240.2 mcs and 231.4 mcs, respectively. Each PPM system contained 15 channels, which were allocated as shown in Table 4. Note that Channel 15 of SST II was commutated. Segment allocations for Channel 15 are provided in Table 5.

TEMPERATURE AND PRESSURE SENSORS

Temperature and pressure sensors, flown on Aerobee 150A Flight 4.13 GP-GT are defined and located as follows:

T_{s2} - Aft Skin Temperature; measured skin temperature of aft section of sustainer and was located on the under surface of shroud III.

T_{s1} - Forward Skin Temperature; measured skin temperature of forward section of sustainer and was located on the under surface of shroud III.

T_{fb} - Fuel Bottle Temperature; measured temperature at the fuel tank and was located under shroud III.

T_{hb2} - Aft Helium Bottle Temperature; measured temperature of the aft section of the helium tank and was located under shroud III.

T_{ob} - Oxidizer Bottle Temperature; measured temperature of the oxidizer tank and was located under shroud III.

T_{fc} - Fin Cuff Temperature; measured temperature of fin III and was located on the underside of the leading edge of the fin cuff.

T_{tp} - Tail Can Bulkhead Temperature; measured temperature inside the tail can and was located between shrouds II and III on the aft bulkhead.

T_{hr} - Helium Regulator Temperature; measured temperature of the helium-fuel pipe and was mounted on the pipe.

T_{hb1} - Forward Skirt Helium Bottle Temperature; measured the temperature of the helium tank in the forward skirt and was mounted on the top bulkhead of the tank.

T_{co} - Coolant Outlet Temperature; measured the temperature of the coolant outlet in the tail can and was mounted on the coolant outlet pipe.

T_{ci} - Coolant Inlet Temperature; measured the temperature of the coolant inlet in the tail can and was mounted on coolant inlet pipe.

P_{gr} - Gas Regulator Pressure; measured the regulated helium upstream pressure of the check valve in the regulator.

P_{gb} - Helium Tank Pressure; measured the pressure from the helium bottle in the regulator.

P_{gf1} - Fuel Gas Line Pressure; measured the regulated helium downstream pressure from the check valve in the regulator.

P_{gf2} - Fuel Line Pressure; measured the fuel flow from the fuel tank in the sustainer.

P_{o1} - Oxidizer Line Pressure; measured the pressure of the oxidizer line and was located in the tail can plumbing.

P_{oj} - Oxidizer Injector Pressure; measured the pressure of the oxidizer injected into the thrust chamber.

P_{fj} - Fuel Injector Pressure; measured the pressure of the fuel injected into the thrust chamber.

P_{fci} - Fuel Coolant Inlet Pressure; measured the pressure of the coolant inlet fuel to the thrust chamber.

P_{fco} - Fuel Coolant Outlet Pressure; measured the pressure of the coolant outlet fuel to the thrust chamber.

P_{c} - Chamber Pressure; measured the chamber pressure in the tail can.

P_{b} - Booster Pressure; measured the booster chamber pressure and was located on the booster's forward bulkhead.

CONCLUSION

This document is a preliminary issue for raw data reduction. Documents pertaining to performance instrumentation engineering and instrumentation flight are forthcoming. The instrumentation performance engineering report will detail the engineering requirements to provide precise acceleration, temperature, and pressure devices. Flight performance reports detail the background of the payload instrumentation; personnel participating in the program; detailed discussions of the experiment, telemetry, instrumentation, and other payload areas as applicable; timer sequences; integration operations; and field operations.

Table 1. FM/FM Telemetry System Frequency and Band Allocations

FREQUENCY	IRIG BAND	ALLOCATION
70 kcs	18	Solar aspect information
52.5 kcs	17	Accelerometer X-Axis
40 kcs	16	Accelerometer Y-Axis
30 kcs	15	Accelerometer Z-Axis
22 kcs	14	Commutated (not provided in this report)
14.5 kcs	13	Commutated (see Table 2)
10.5	12	Sodium Hot oven
7.35 kcs	11	Sodium Cold oven
5.4 kcs	10	P_b, switched to commutator at T +3 seconds (see Table 3)
3.9 kcs	9	Nike valve monitor, switched at T +3 seconds to ACS roll position
3.0 kcs	8	Helium Regulator Temperature (T_{hr})
2.3 kcs	7	Forward Skirt Helium Bottle Temperature (T_{hbl})
1.7 kcs	6	Coolant Outlet Temperature (T_{co})

Table 2. IRIG Band 13 Commutator Segment Allocations

SEGMENT	ALLOCATION
1, 4	Ground
2	2.5 volts calibration level
3	5.0 volts calibration level
5, 6, 11, 12, 16, 17, 18, 22, 23, 24 (cross-strapped)	Yaw ogive
7, 8, 13, 14, 15, 19, 20, 21, 25, 26 (cross-strapped)	Pitch ogive
9, 10, 27, 28 (cross-strapped)	Tip eject monitor valve
29, 30	5-volt pedestal (sync)

Table 3. IRIG Band 10 Commutator Segment Allocations

SEGMENT	ALLOCATION
1, 2, 11, 12, 13 (cross-strapped)	Inside Temperature Forward (T_{s1})
3, 4, 14, 15, 16 (cross-strapped)	Inside Temperature Aft (T_{s2})
5, 6, 17, 18 (cross-strapped)	Aft Helium Bottle Temperature (T_{hb2})
7, 8, 20, 21, 22 (cross-strapped)	Fuel Bottle Temperature (T_{fb})
9, 10, 23, 24, 25 (cross-strapped)	Oxidizer Bottle Temperature (T_{ob})
19	Ground
29	500 ohms calibration level
30	1100 ohms calibration level

Table 4. PPM Telemetry Systems Channel Allocations

CHANNEL	ALLOCATIONS	
	SST I	SST II
1	Gas Bottle Pressure (P_{gb})	High Energy Rate Output
2	Gas Regulator Pressure (P_{gr})	Low Energy Rate Output
3	Fuel Line Pressure (P_{gf2})	High Energy Rate Output
4	Gas Line Pressure (P_{gfl})	Low Energy Rate Output
5	Fuel Coolant Inlet Pressure (P_{fci})	High Energy Rate Output
6	Fuel Coolant Outlet Pressure (P_{fco})	Low Energy Rate Output
7	Fuel Injector Pressure (P_{fj})	High Energy Rate Output
8	Chamber Pressure (P_c)	Low Energy Rate Output
9	Oxidizer Line Pressure (P_{ol})	High Energy Rate Output
10	Oxidizer Injector Pressure (P_{oj})	Low Energy Rate Output
11	Load Cell A/switched to ACS at burnout	Longitudinal Magnetometer
12	Load Cell B/switched to ACS at burnout	Lateral Magnetometer
13	Load Cell C/switched to ACS at burnout	High Energy Rate Output
14	Load Cell D/switched to g-reduction timer at burnout	Low Energy Rate Output
15	Coolant Inlet Temperature (T_{ci})	Commutated (see Table #5)

NOTE: Channels 1, 5, 9 and 13 were cross-strapped to increase frequency response (SST II).
Channels 2, 6, 10 and 14 were cross-strapped to increase frequency response (SST II).

Table 5. SST II Channel 15 Commutator Segment Allocations

SEGMENT	ALLOCATIONS
1, 4	150 ohms calibration level
2	100 ohms calibration level
3	50 ohms calibration level
5, 7, 11, 13, 15, 17, 19, 21, 23, 25 (cross-strapped)	Fin Cuff Temperature (T_{fc})
6, 8, 10, 12, 14, 16, 18, 20, 22, 24, 26, 28 (cross-strapped)	Tail Can Bulkhead Temperature (T_{tp})
9	Ground
29	50 ohms calibration level
30	130 ohms calibration level
27	Open

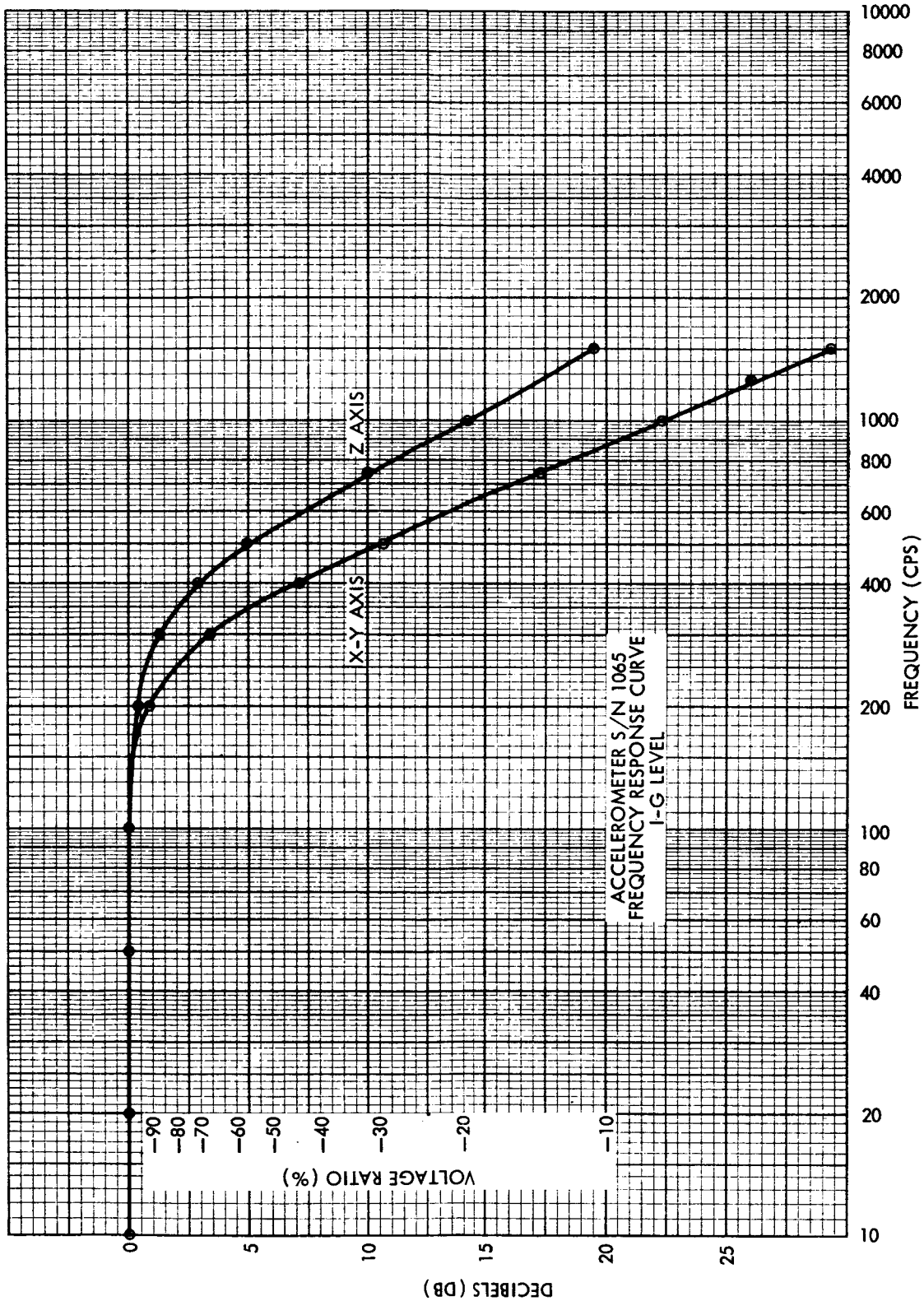

Figure 1. Accelerometer Frequency Response Curve

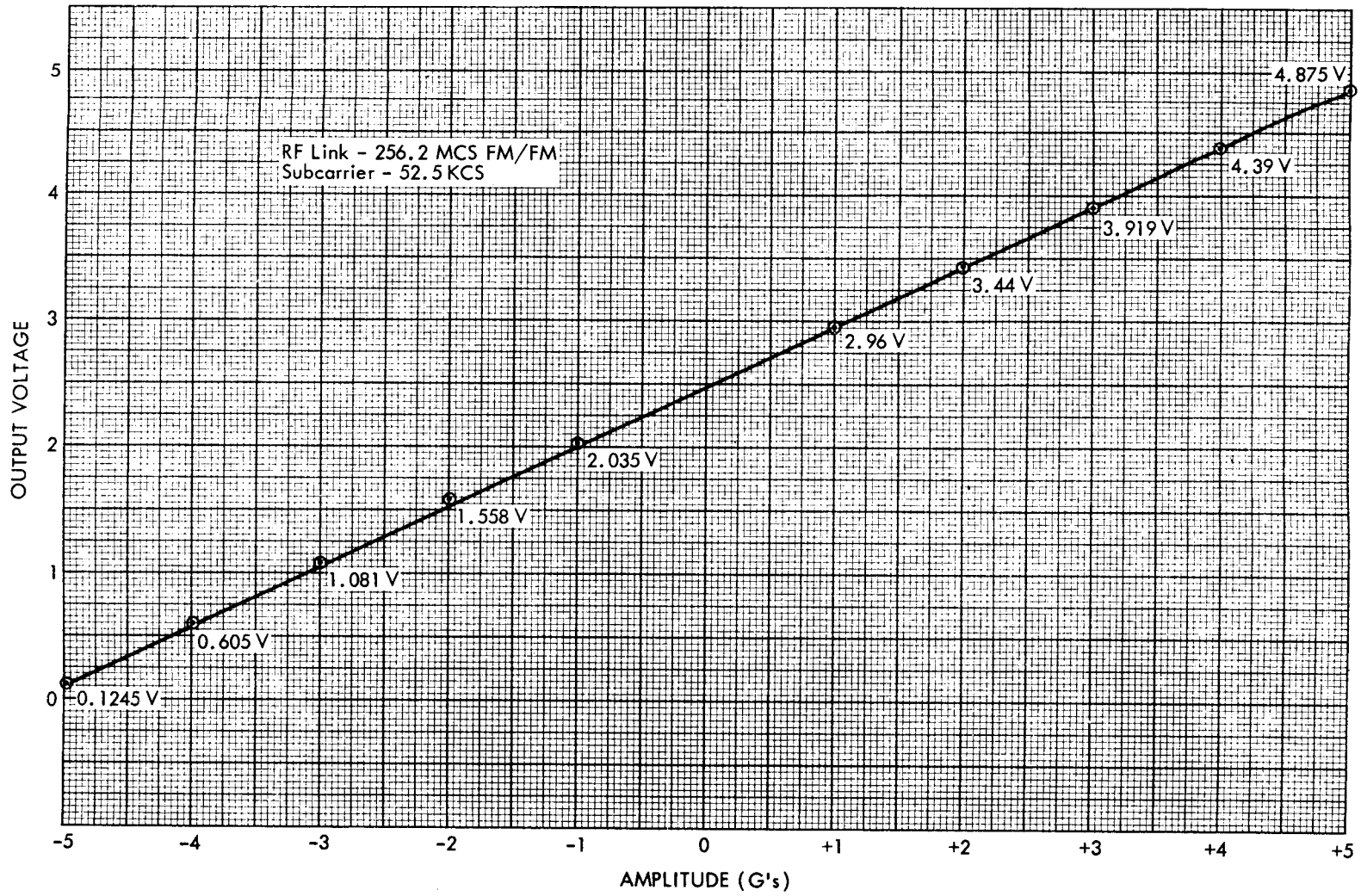

Figure 2. Accelerometer Assembly 1065 X-Axis (S/N 1121) Amplitude Calibration Curve

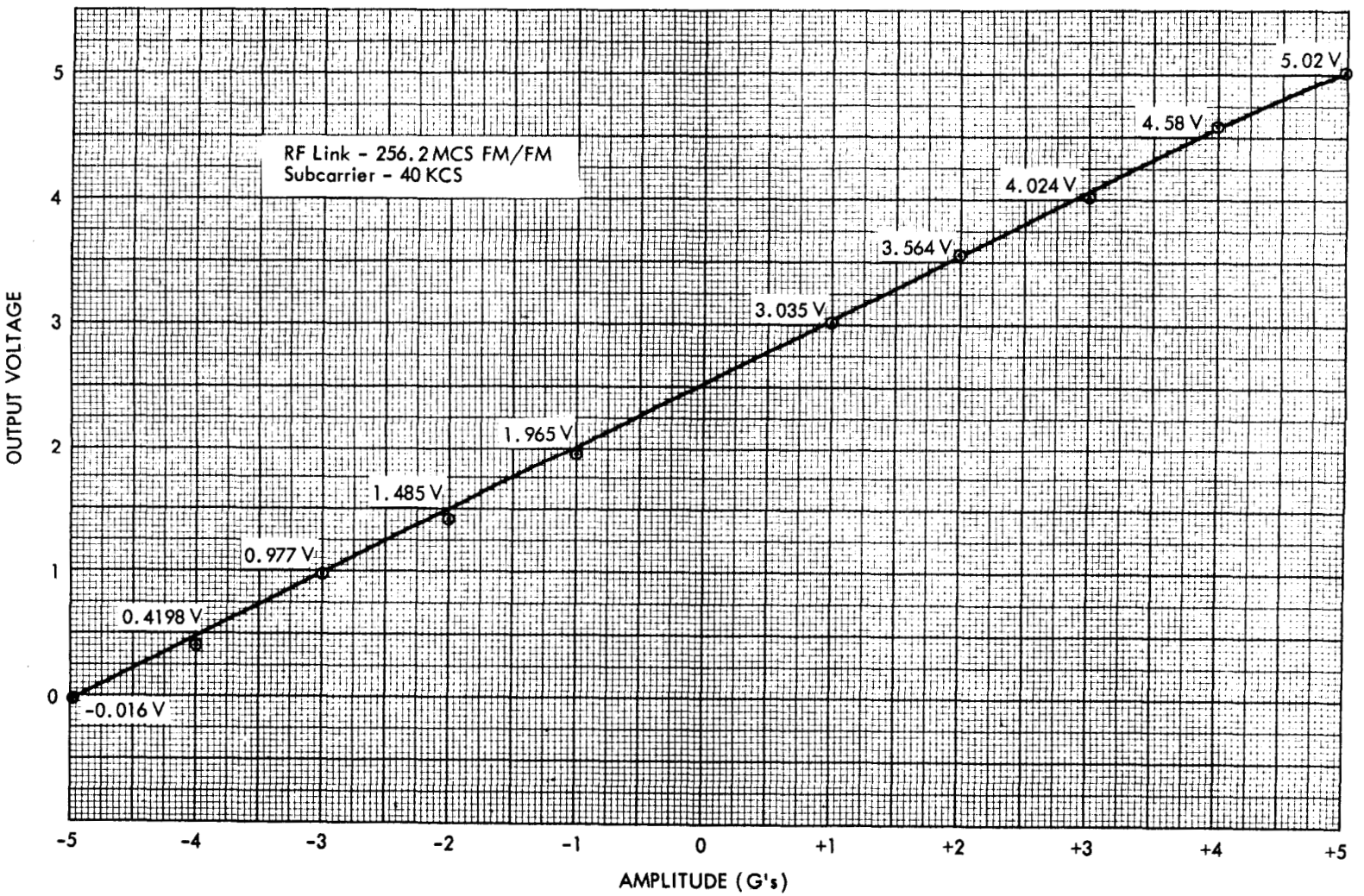

Figure 3. Accelerometer Assembly 1065 Y-Axis (S/N 1063) Amplitude Calibration Curve

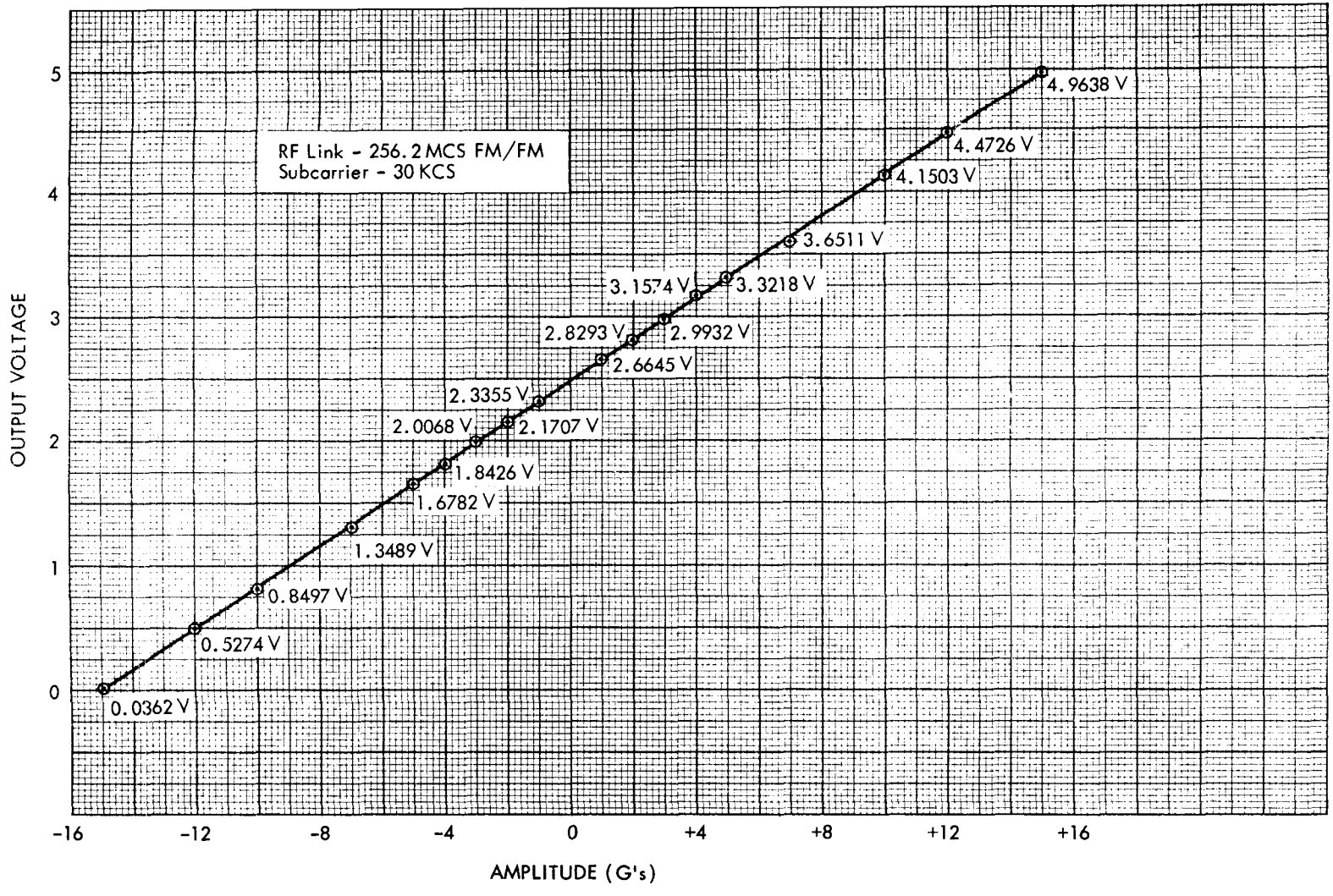

Figure 4. Accelerometer Assembly 1065 Z-Axis (S/N 1003) Amplitude Calibration Curve

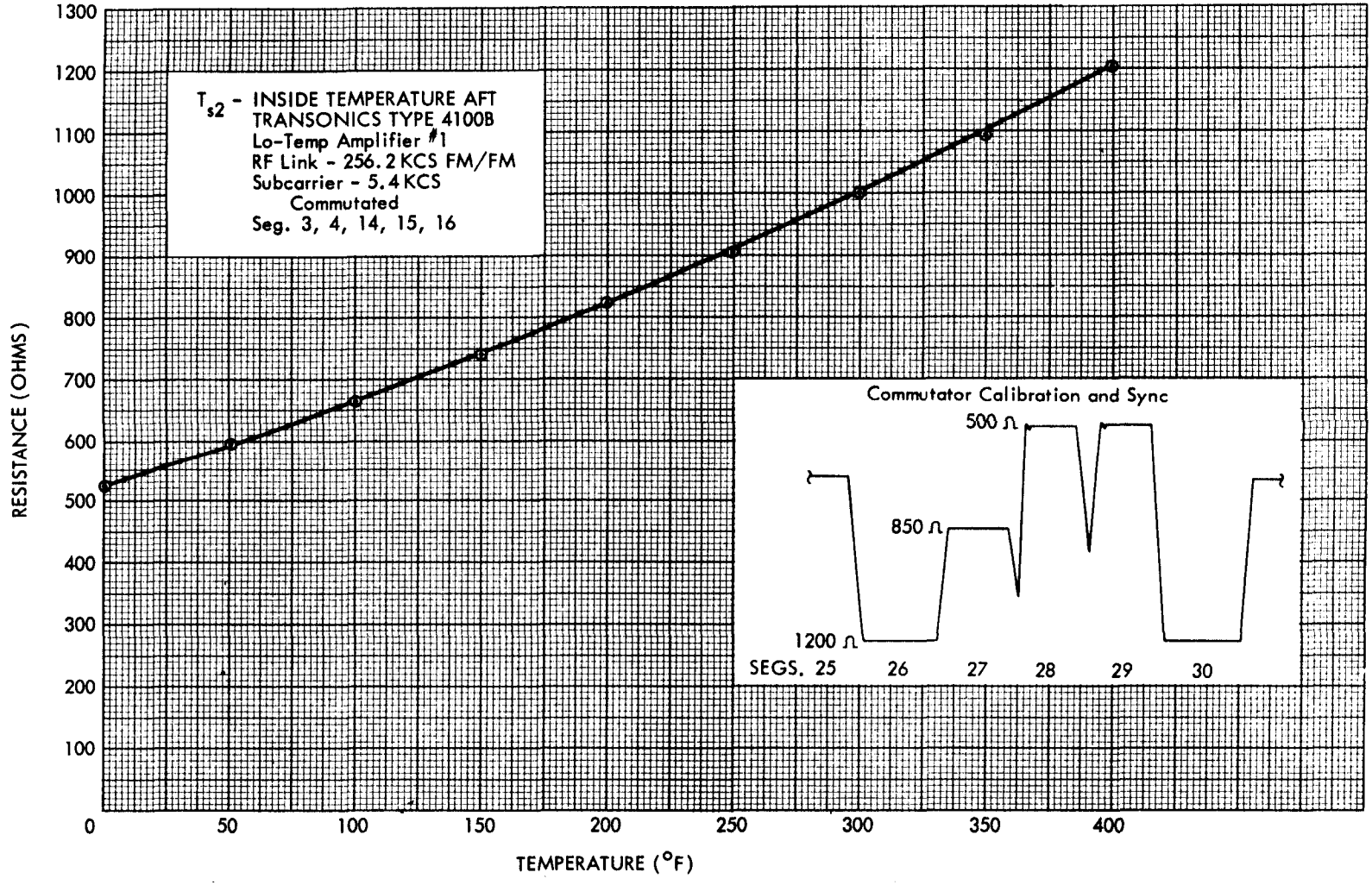

Figure 5. Skin Temperature Aft (S/N 44895) Calibration Curve

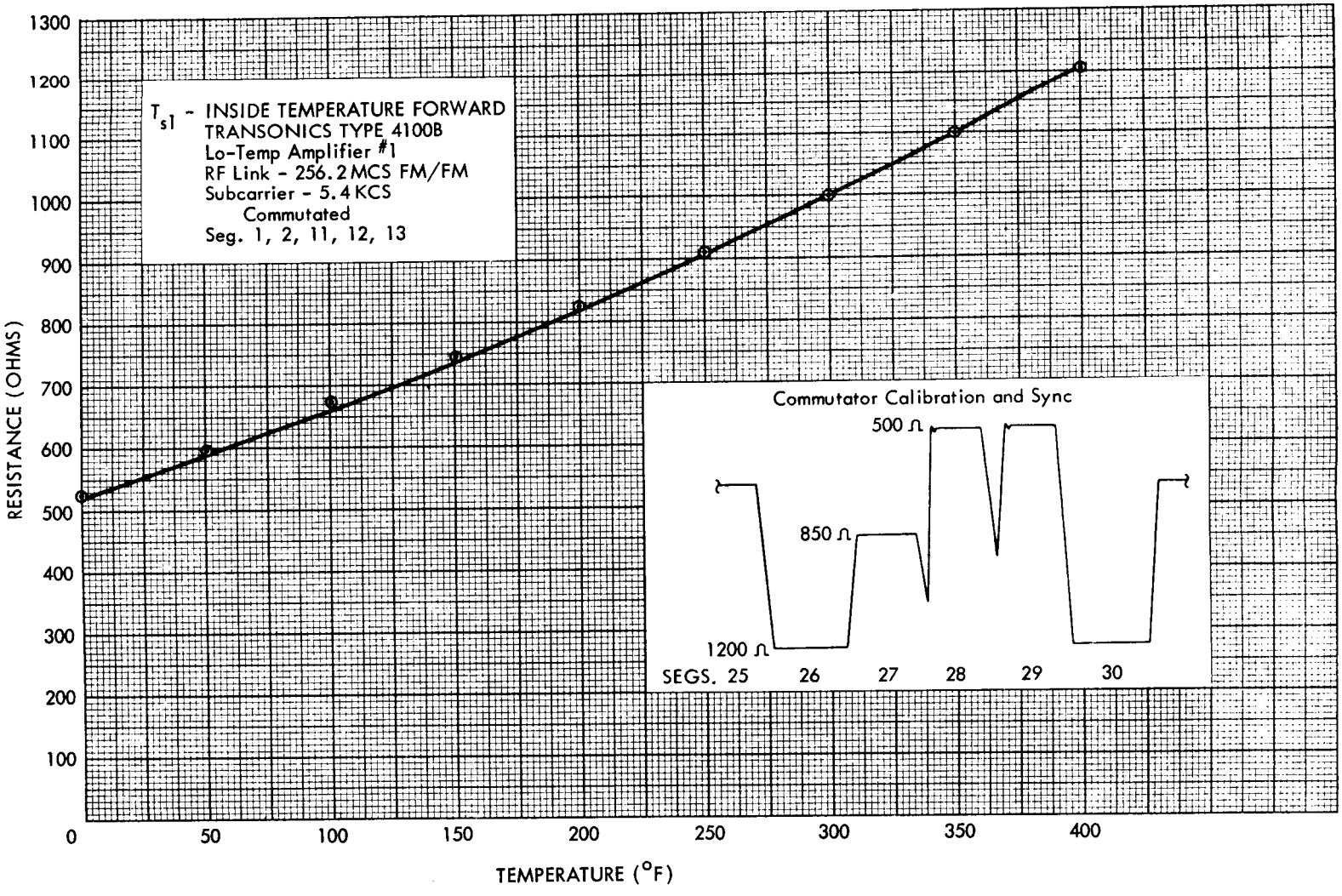

Figure 6. Skin Temperature Forward (S/N 47839) Calibration Curve

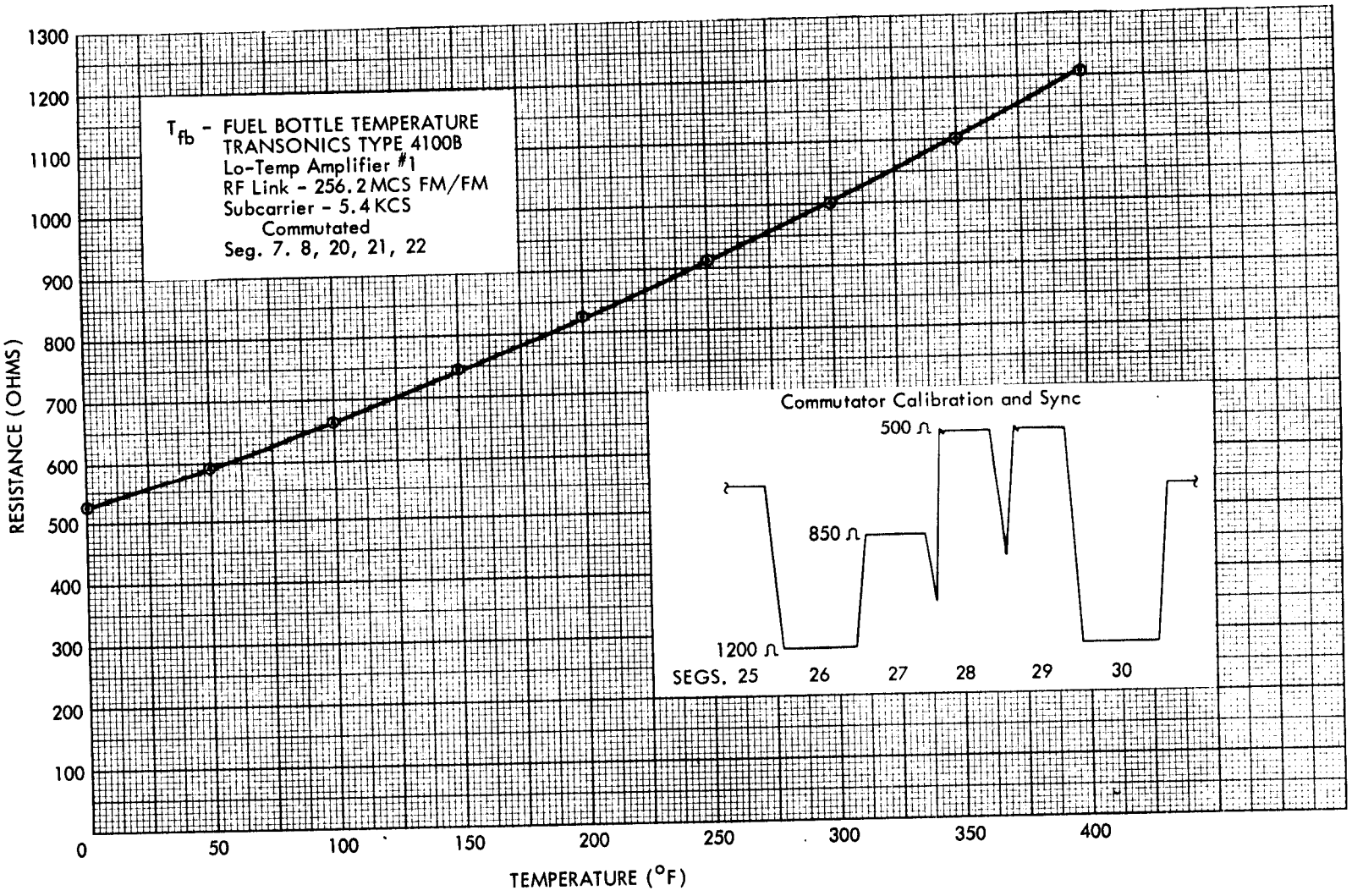

Figure 7. Fuel Bottle Temperature (S/N 47830) Calibration Curve

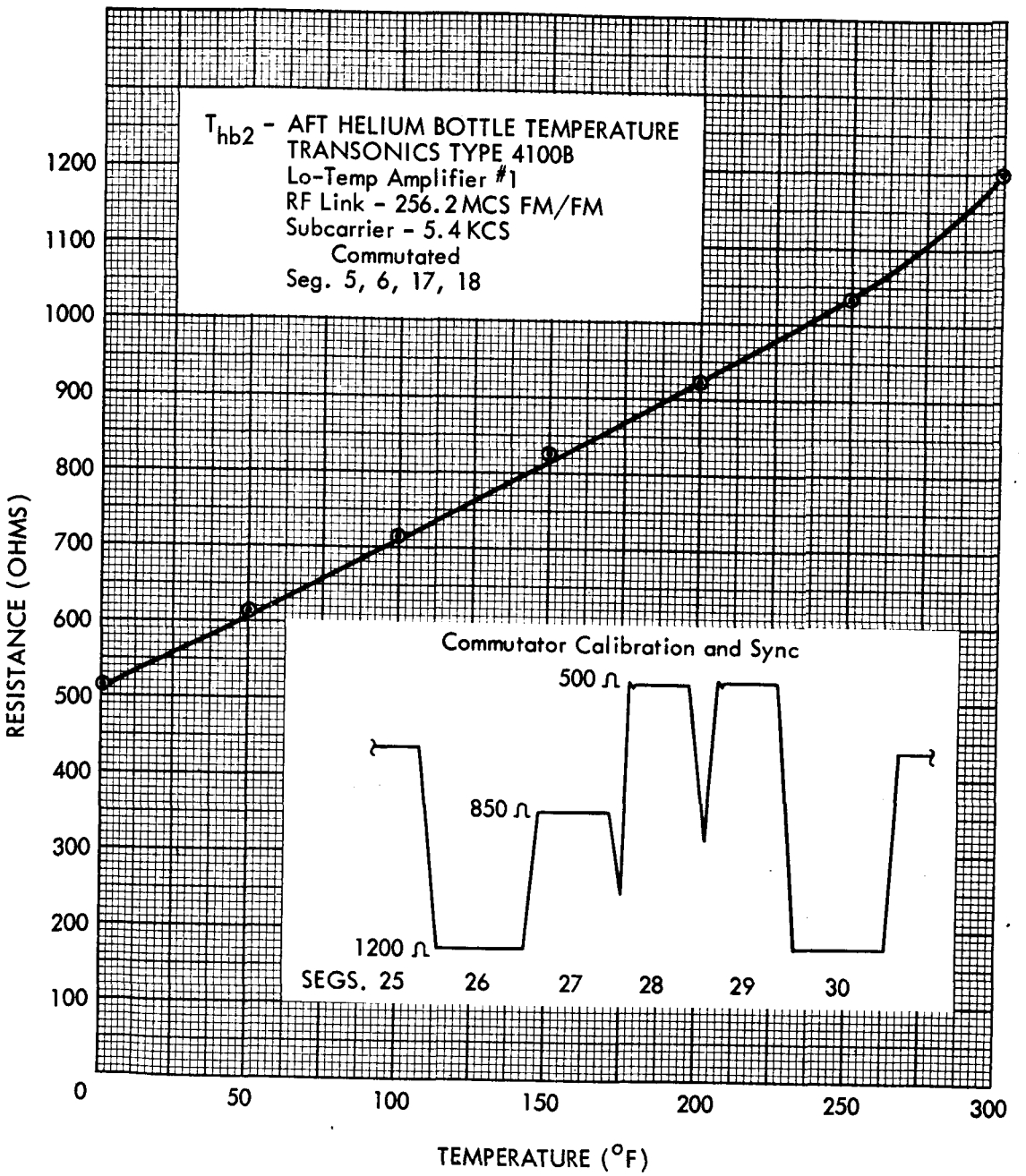

Figure 8. Aft Helium Bottle Temperature (S/N 44878) Calibration Curve

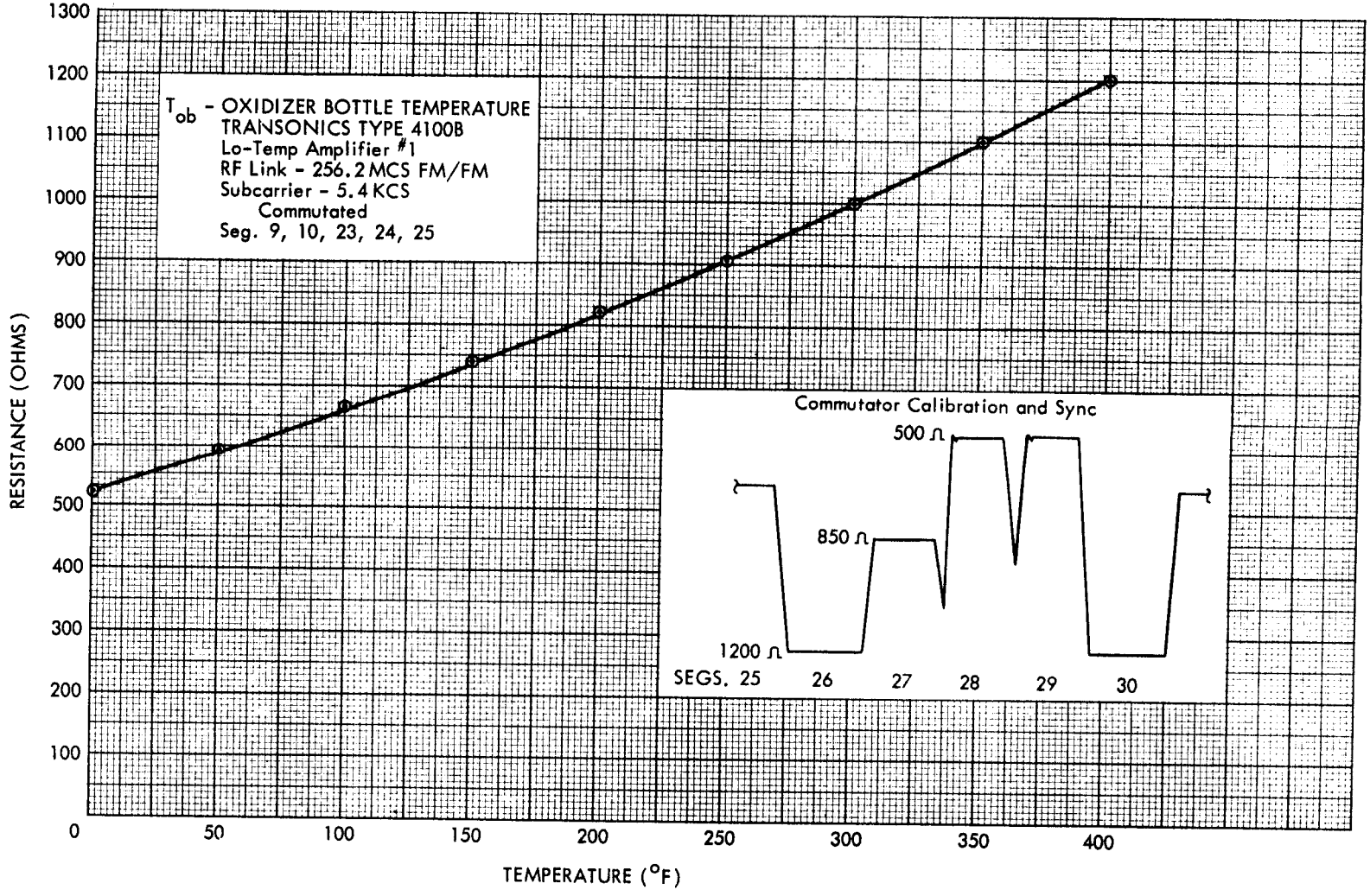

Figure 9. Oxidizer Bottle Temperature (S/N 44896) Calibration Curve

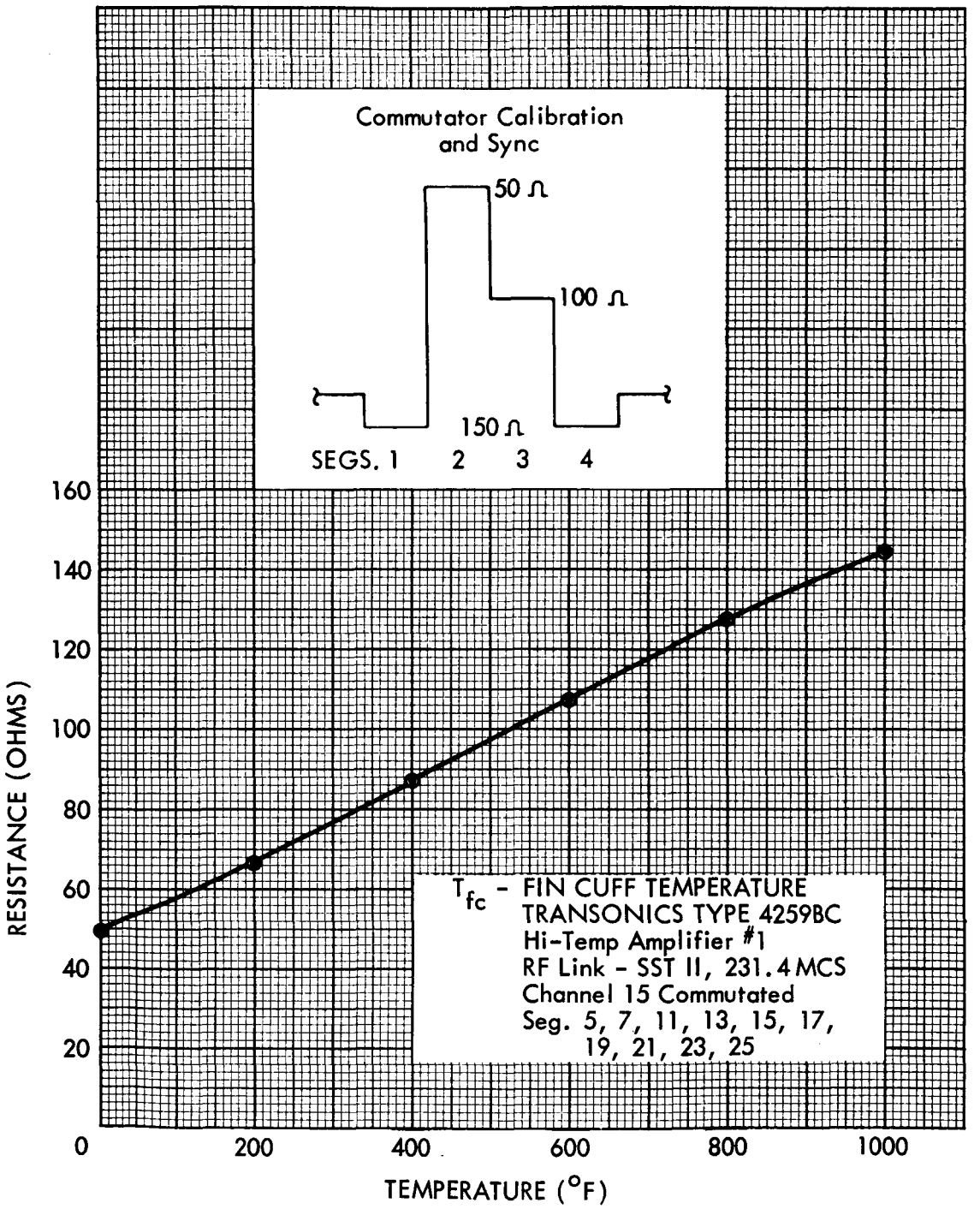

Figure 10. Fin Cuff Temperature (S/N 48792) Calibration Curve

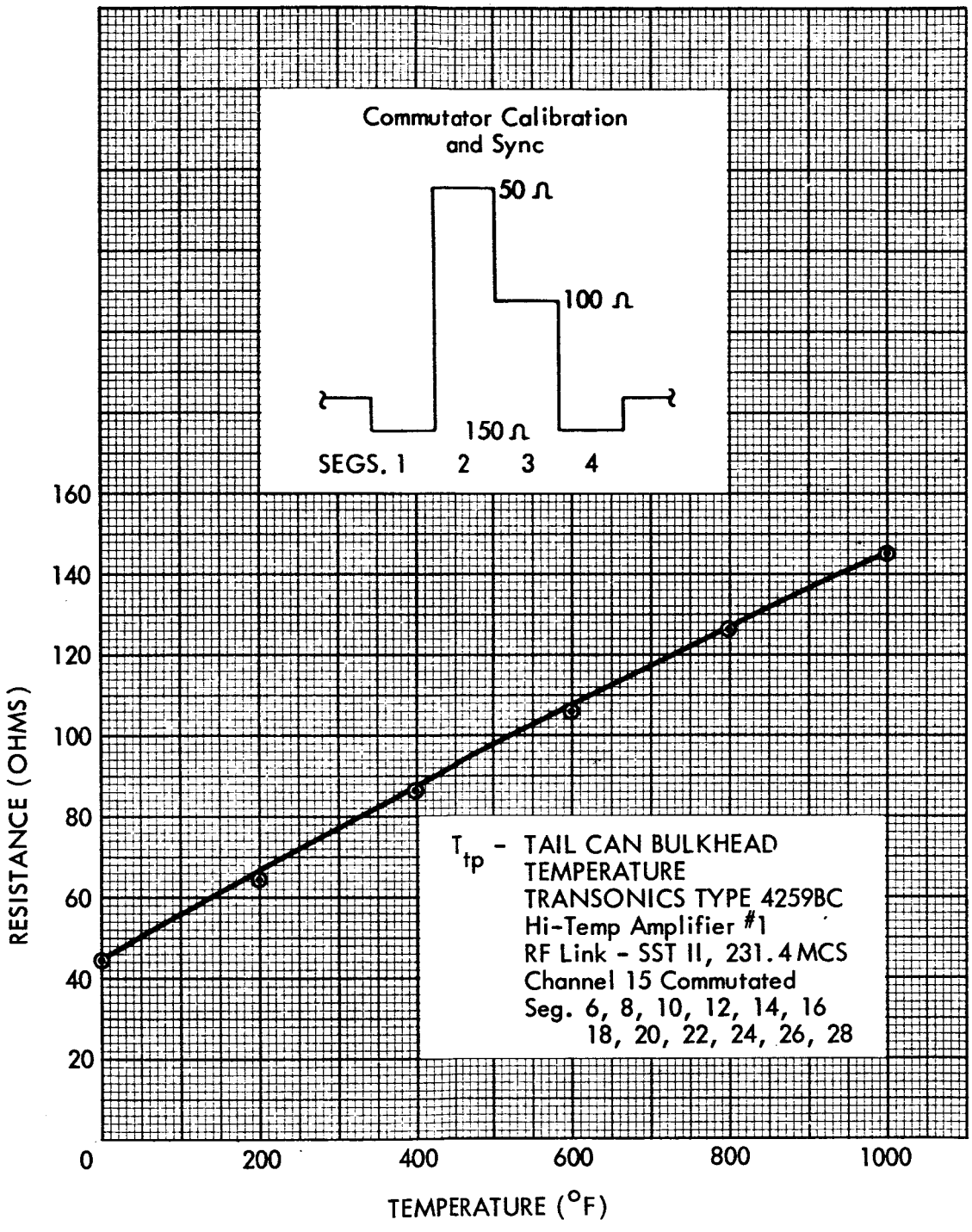

Figure 11. Tail Can Bulkhead Temperature (S/N 48794) Calibration Curve

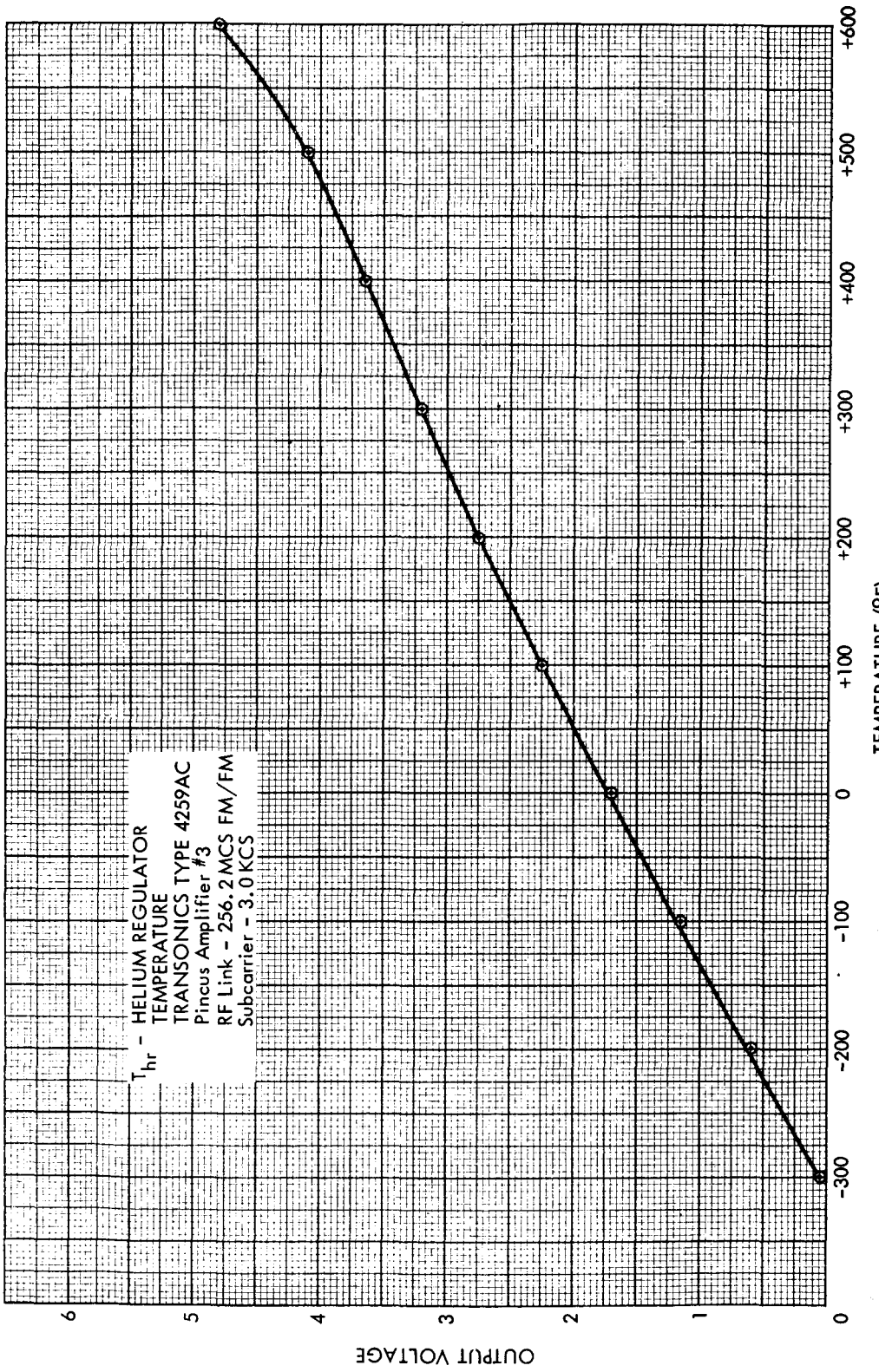

Figure 12. Helium Regulator Temperature (S/N 52316) Calibration Curve

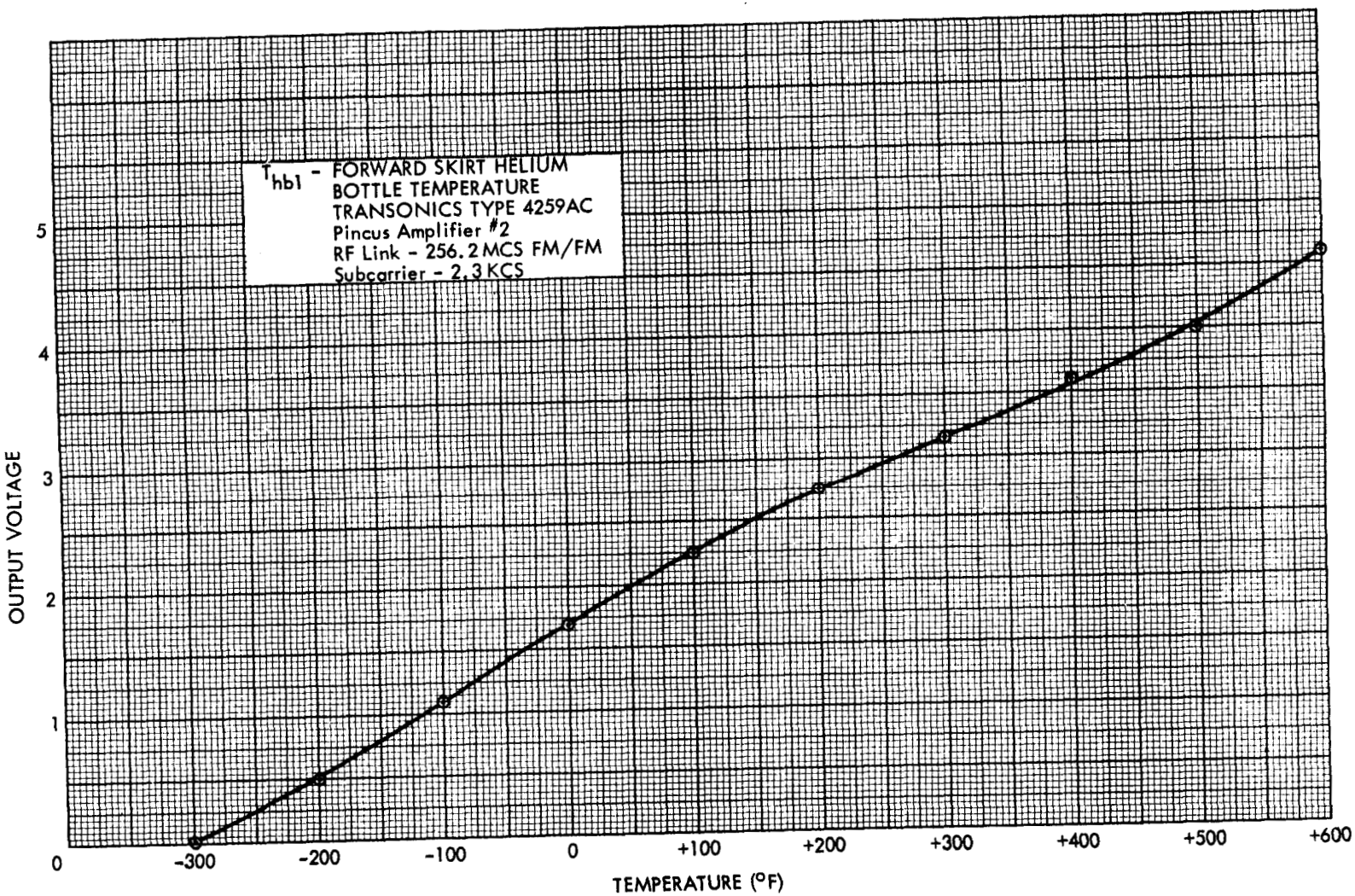

Figure 13. Forward Skirt Helium Bottle Temperature (S/N 52313) Calibration Curve

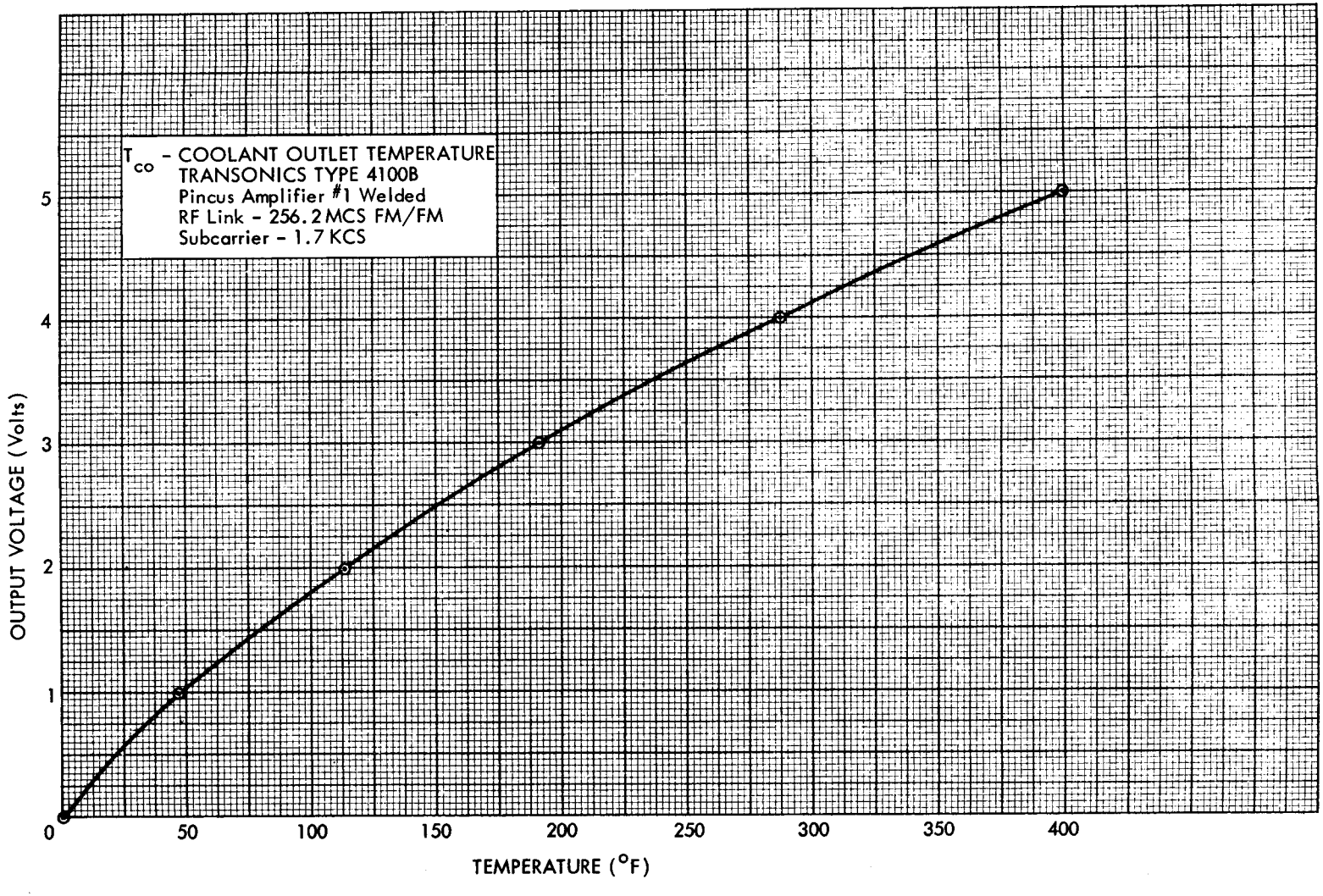

Figure 14. Coolant Outlet Temperature (S/N 44893) Calibration Curve

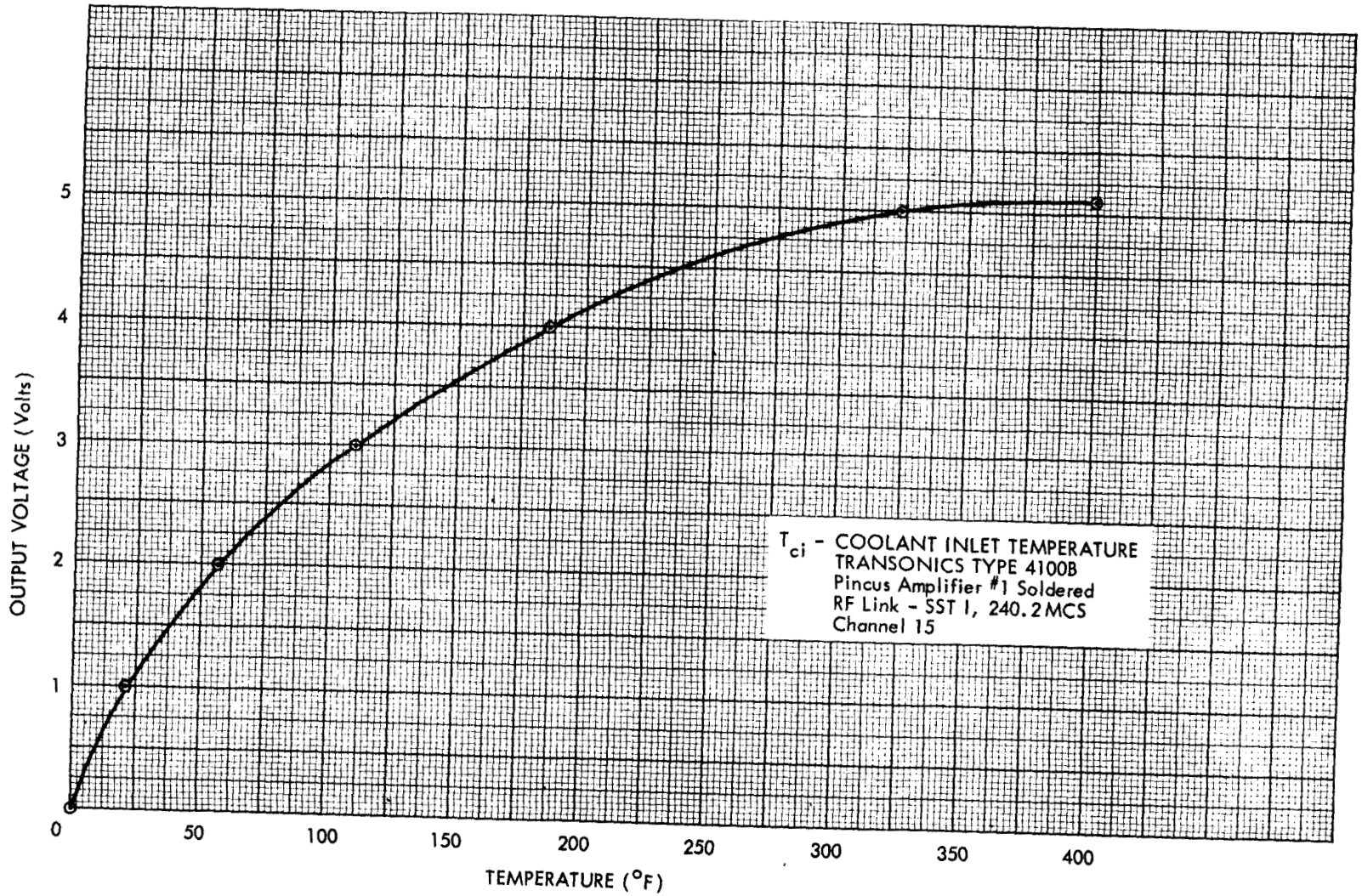

Figure 15. Coolant Inlet Temperature (S/N 44894) Calibration Curve

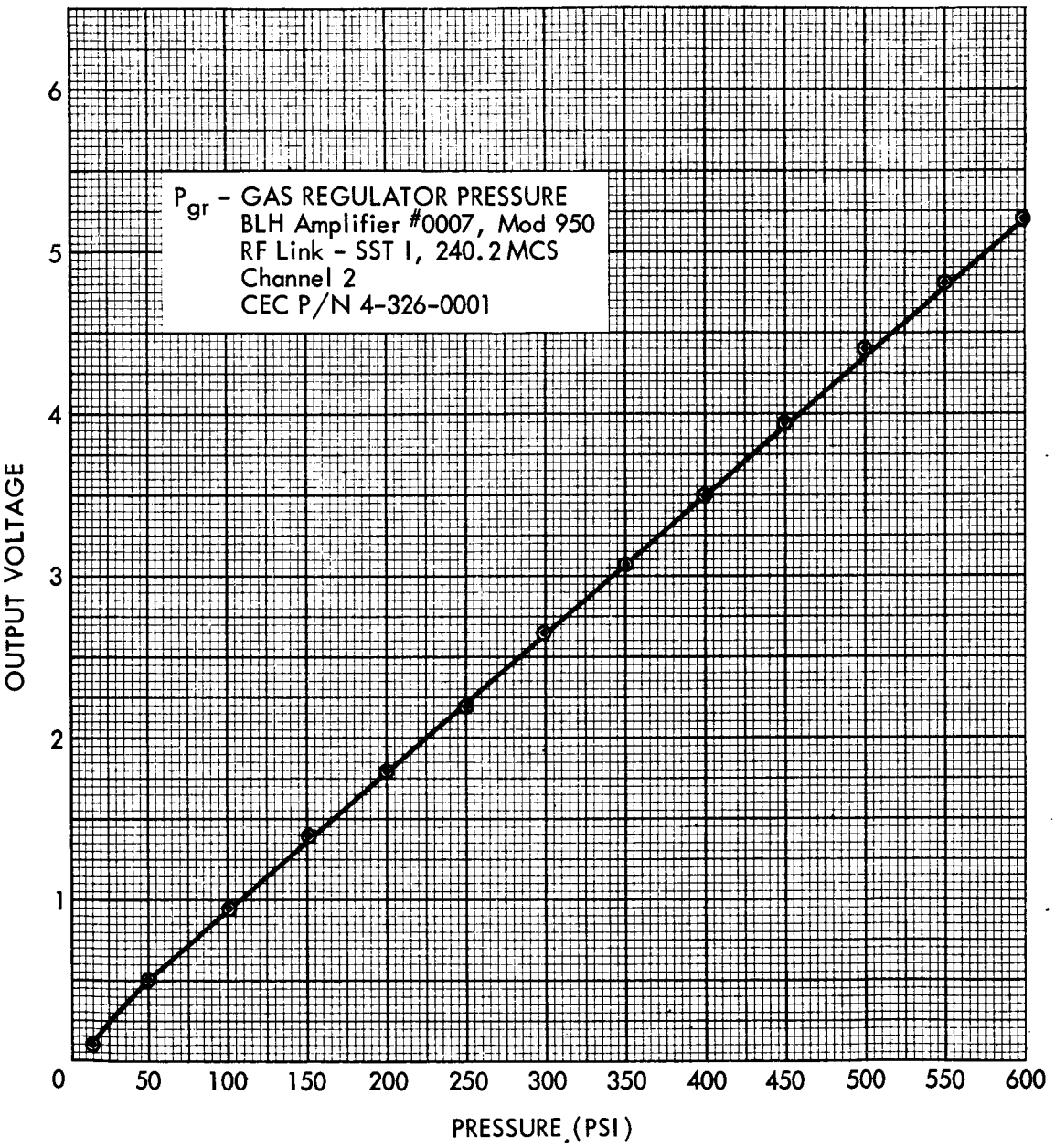

Figure 16. Gas Regulator Pressure (S/N 11081) Calibration Curve

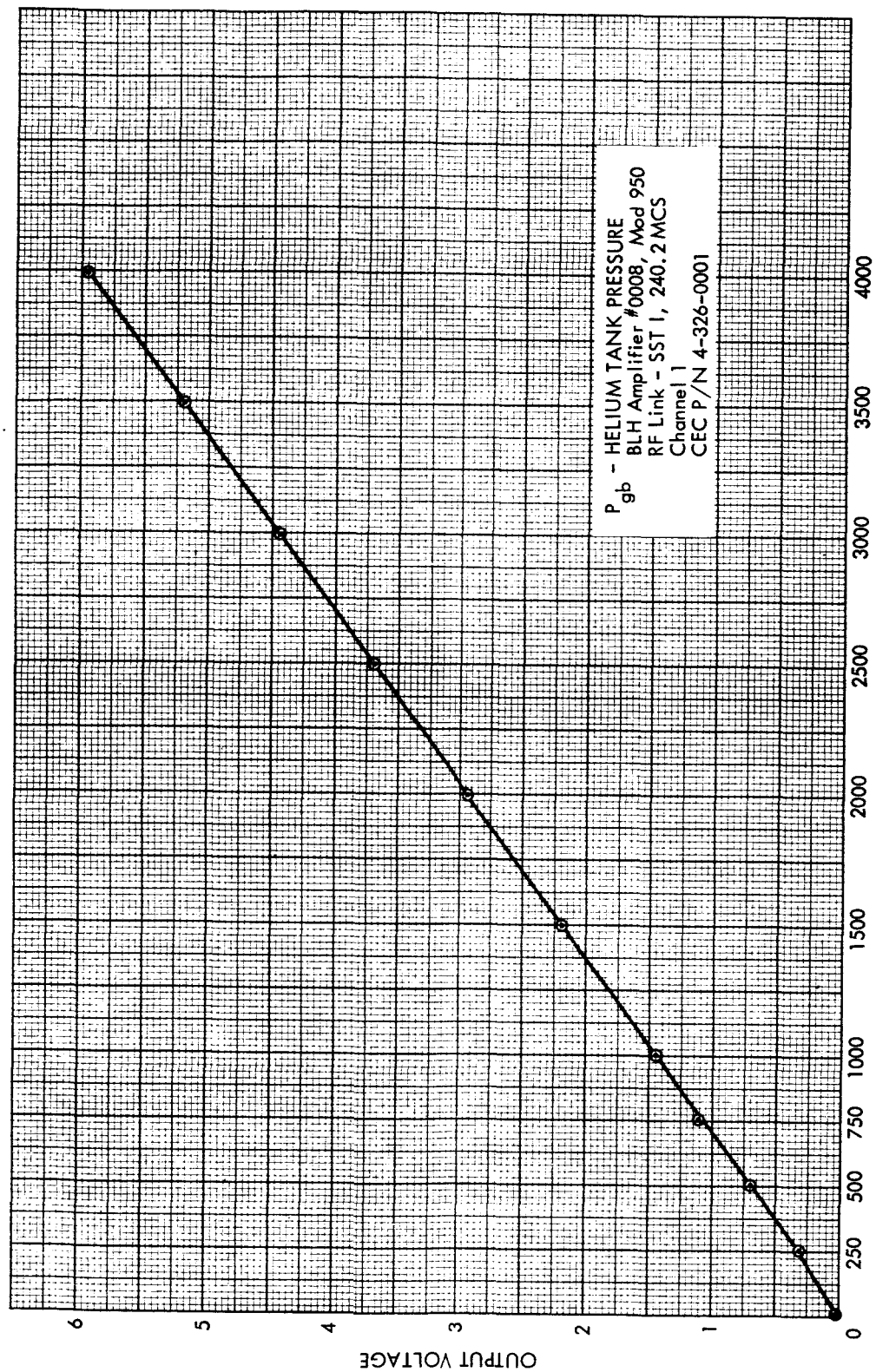

Figure 17. Helium Tank Pressure (S/N 7411) Calibration Curve

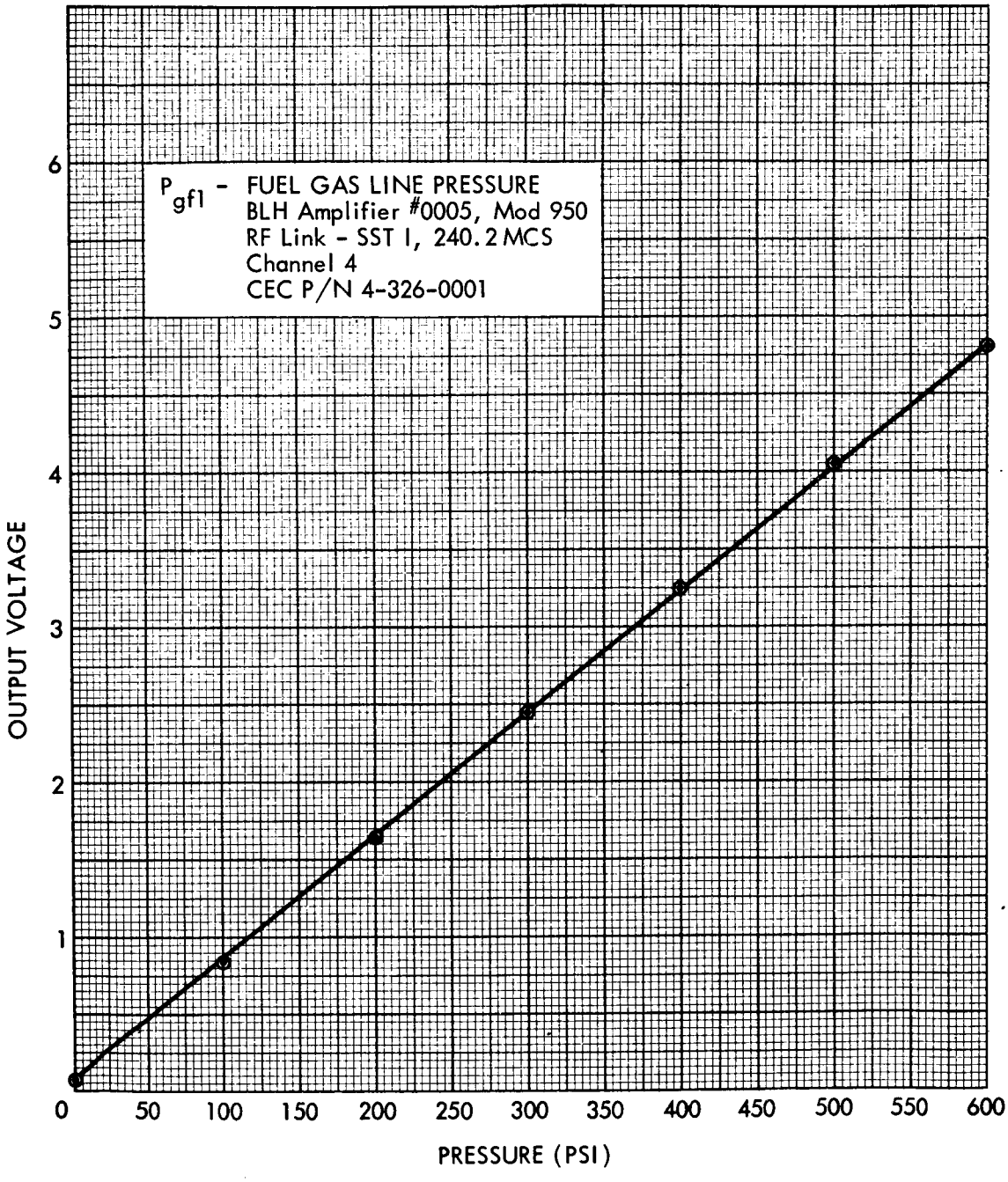

Figure 18. Fuel Gas Line Pressure (S/N 11081) Calibration Curve

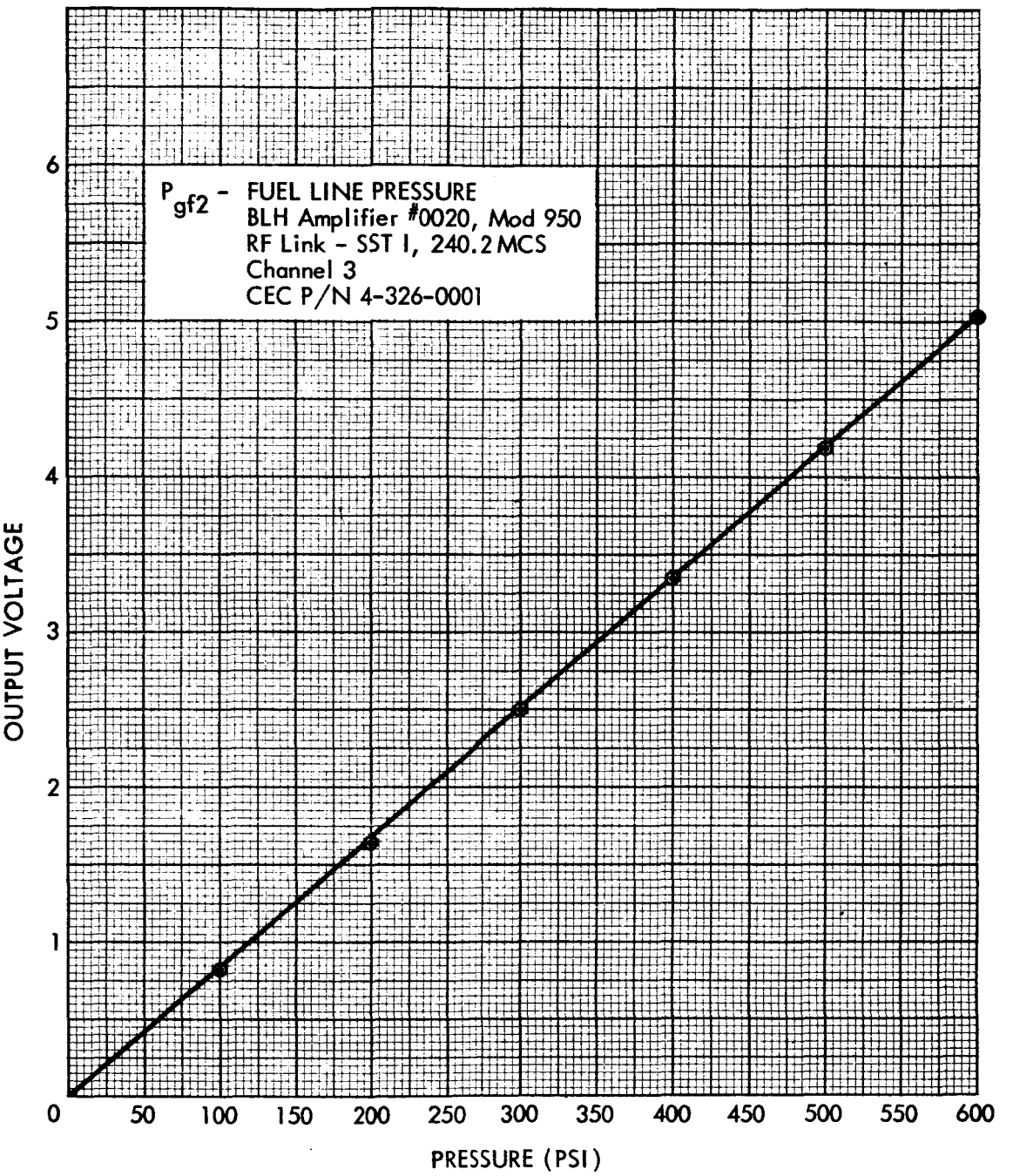

Figure 19. Fuel Line Pressure (S/N 11474) Calibration Curve

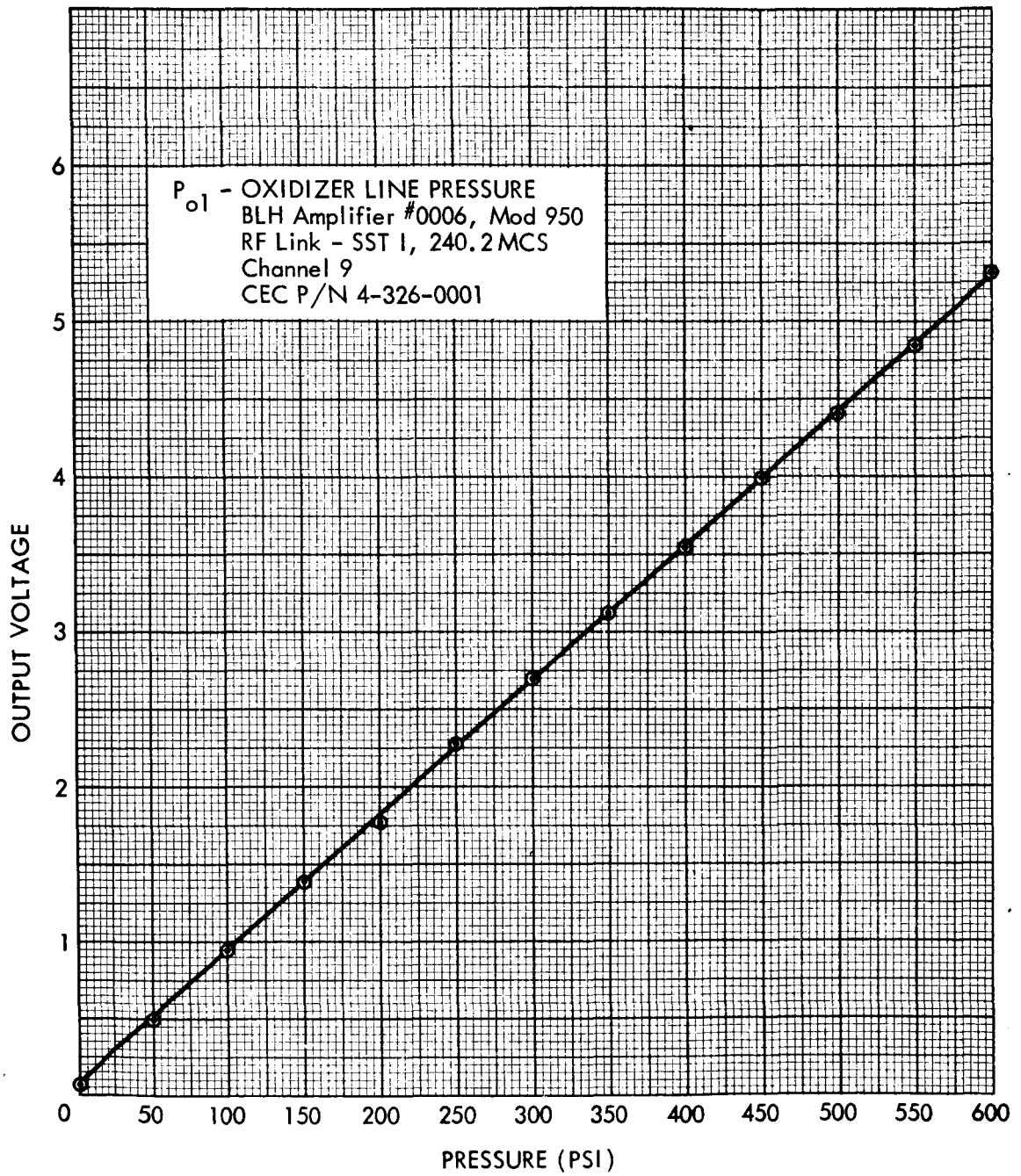

Figure 20. Oxidizer Line Pressure (S/N 11086) Calibration Curve

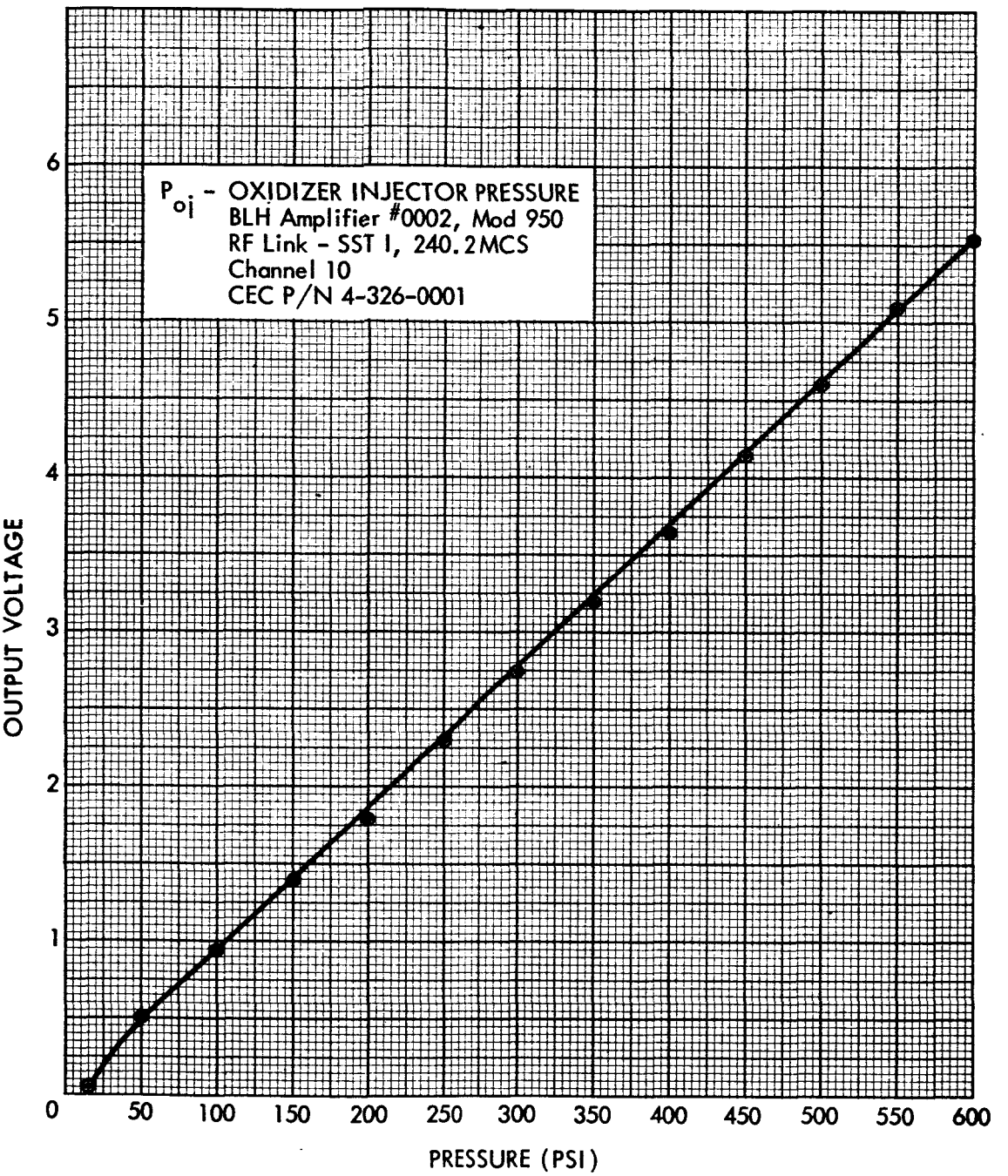

Figure 21. Oxidizer Injector Pressure (S/N 11090) Calibration Curve

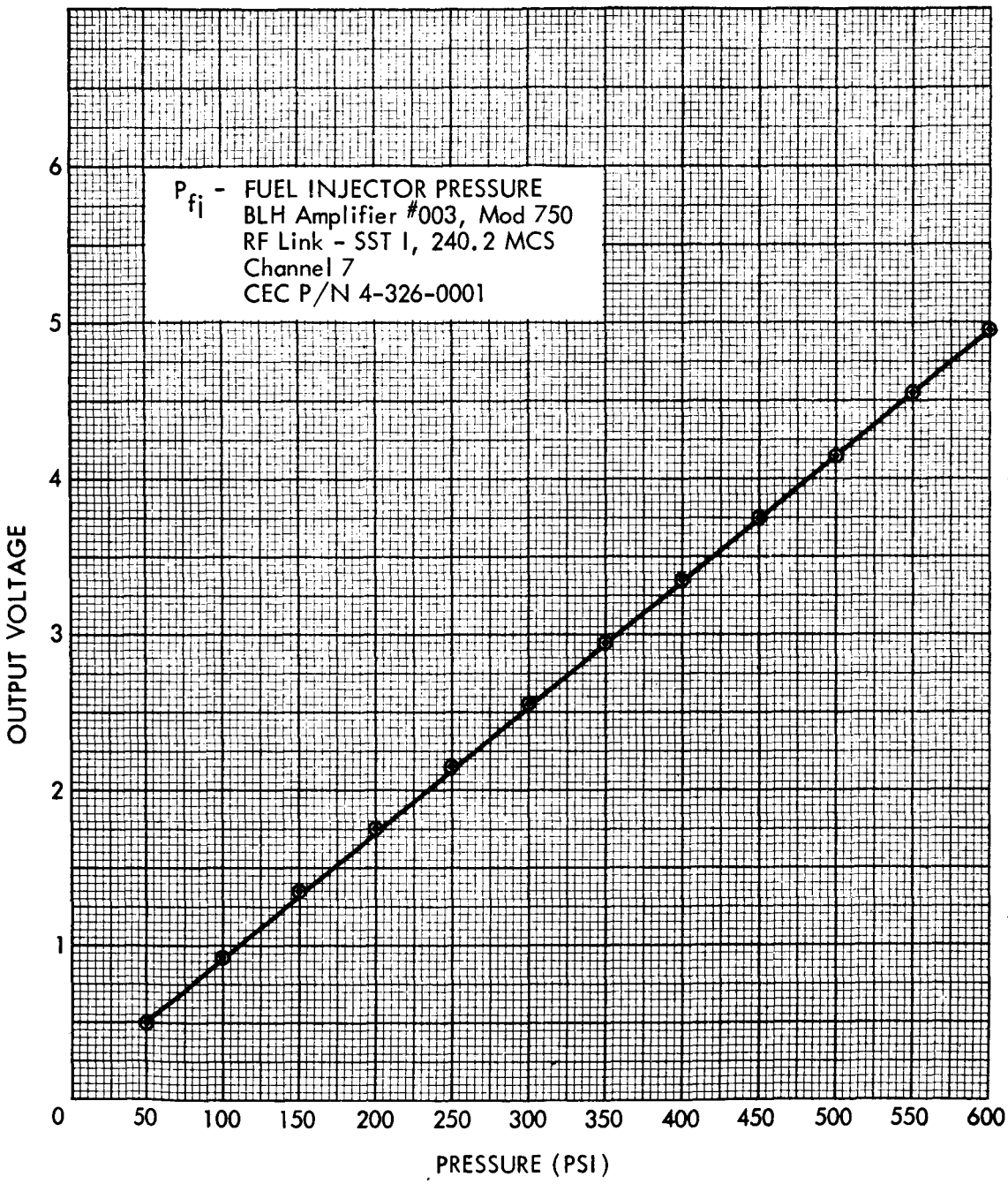

Figure 22. Fuel Injector Pressure (S/N 11093) Calibration Curve

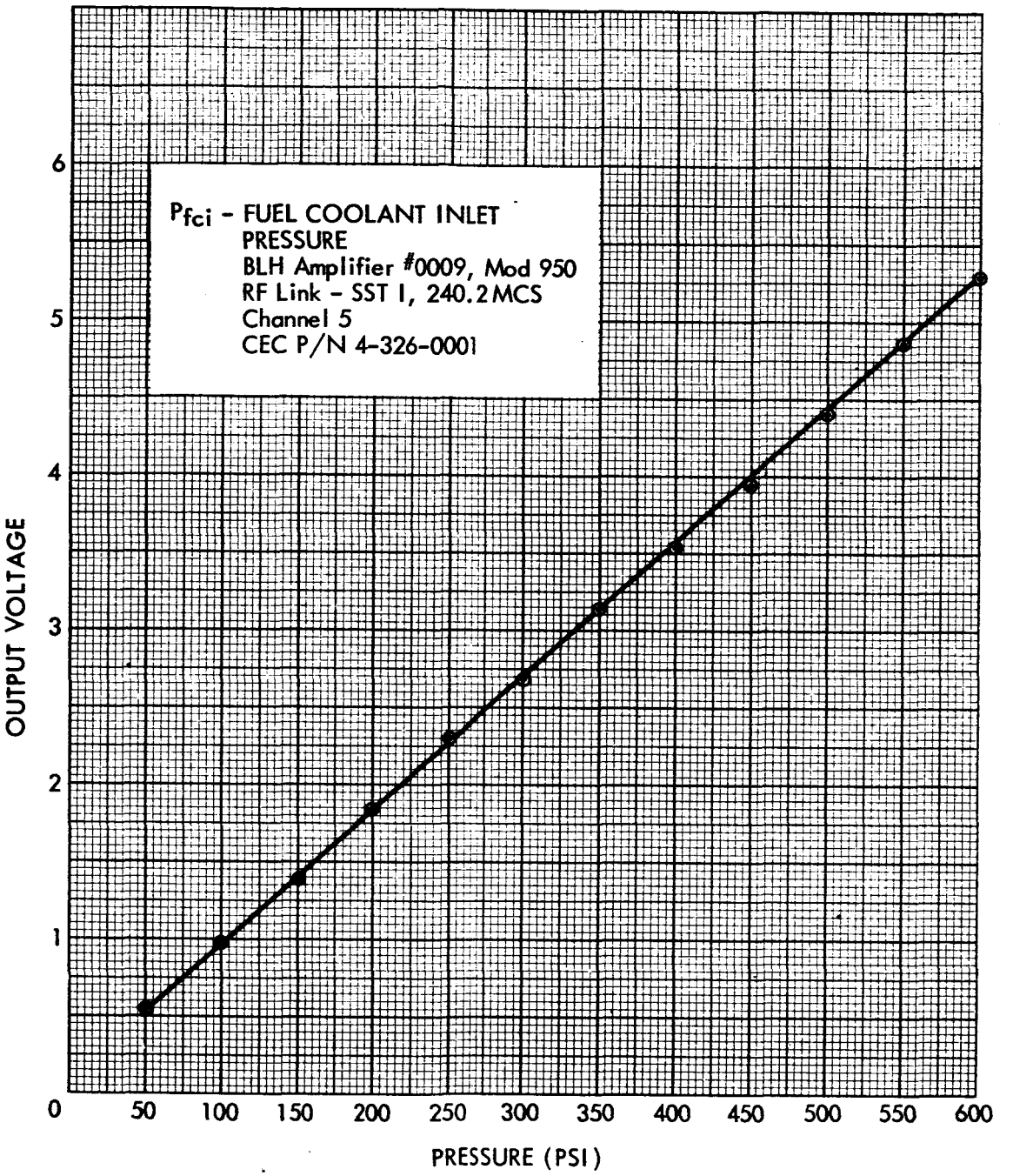

Figure 23. Fuel Coolant Inlet Pressure (S/N 11094) Calibration Curve

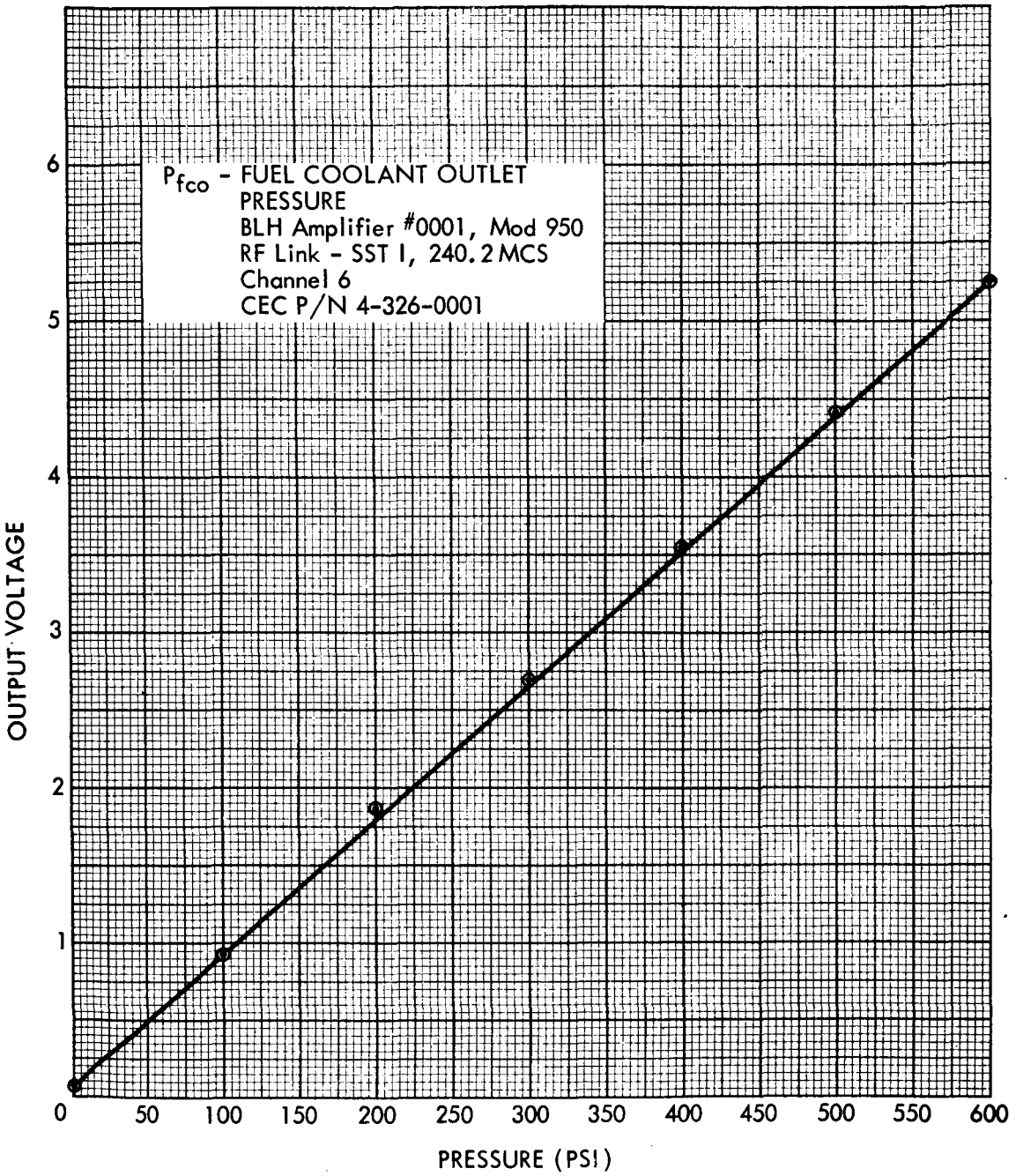

Figure 24. Fuel Coolant Outlet Pressure (S/N 11089) Calibration Curve

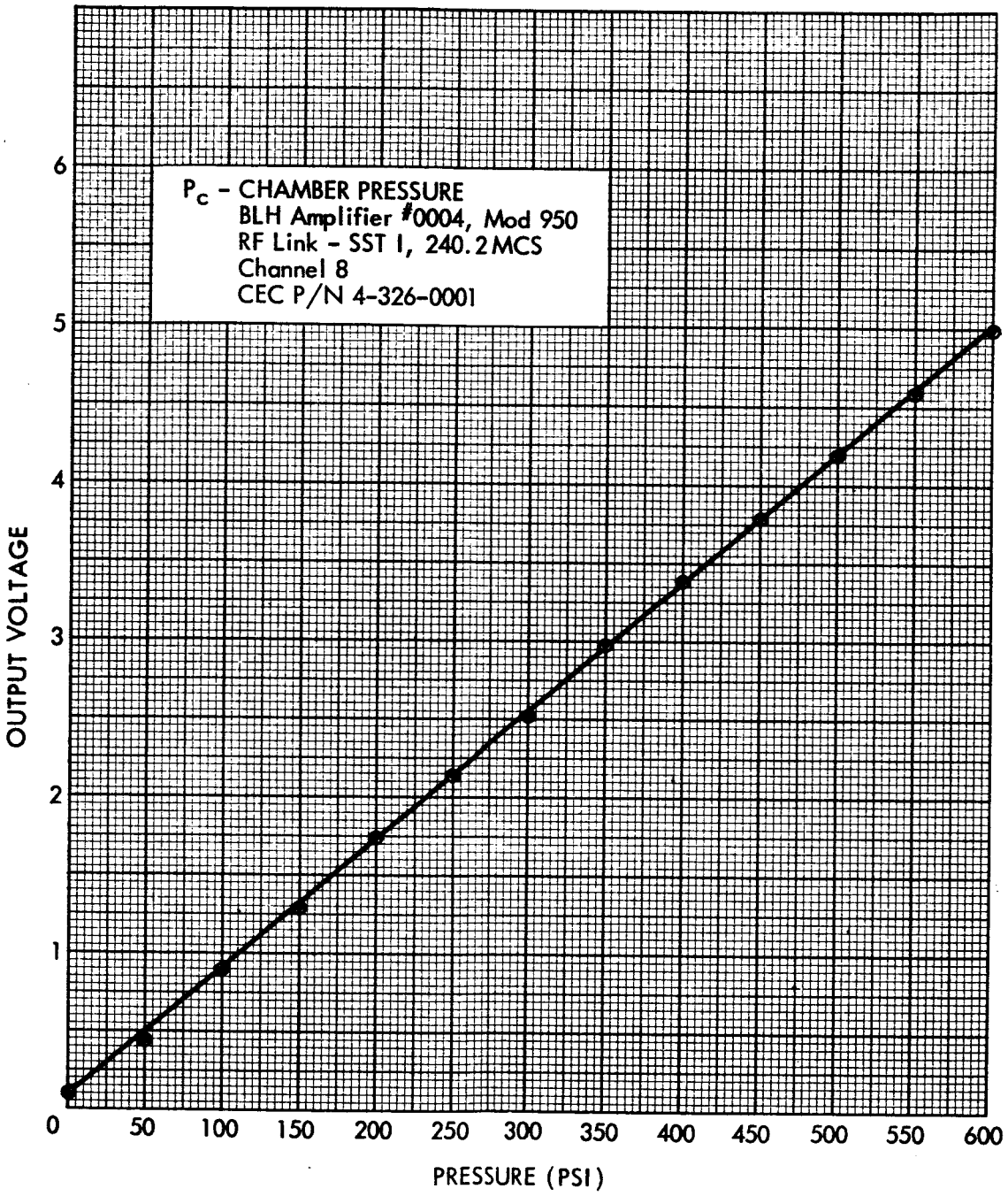

Figure 25. Chamber Pressure (S/N 11088) Calibration Curve

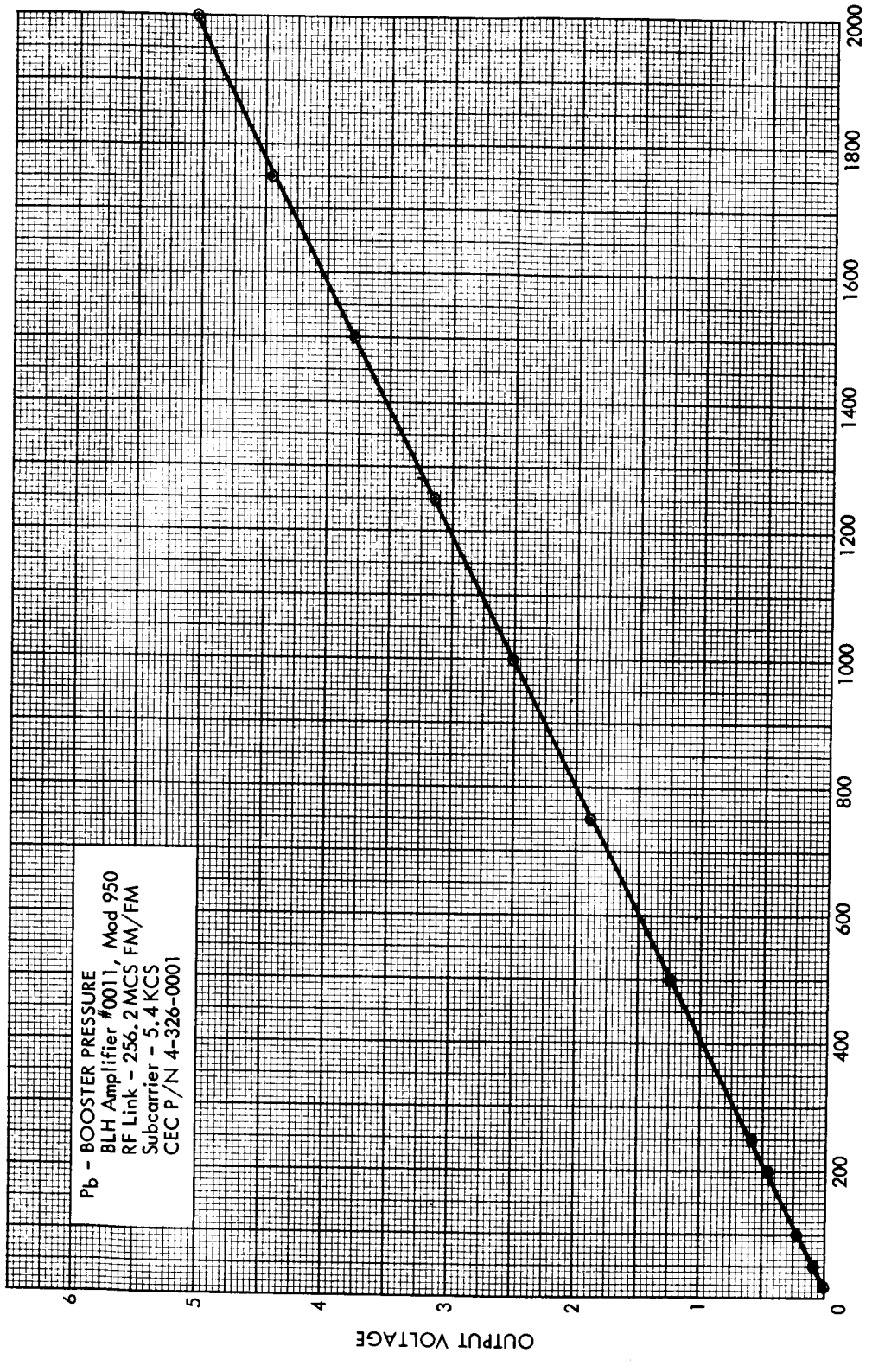

Figure 26. Booster Pressure (S/N 12529) Calibration Curve

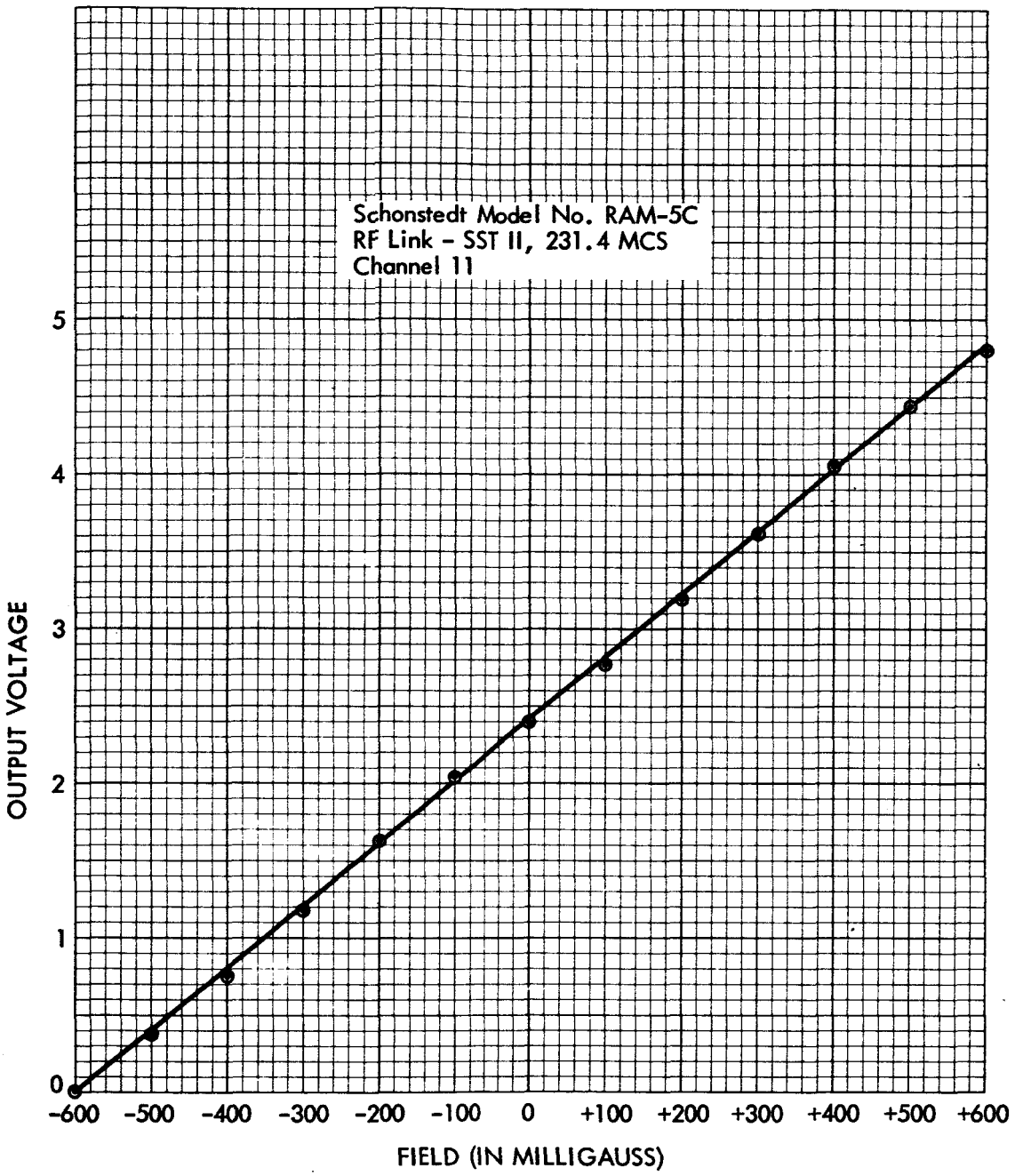

Figure 27. Lateral Magnetometer (S/N 401) Calibration Curve

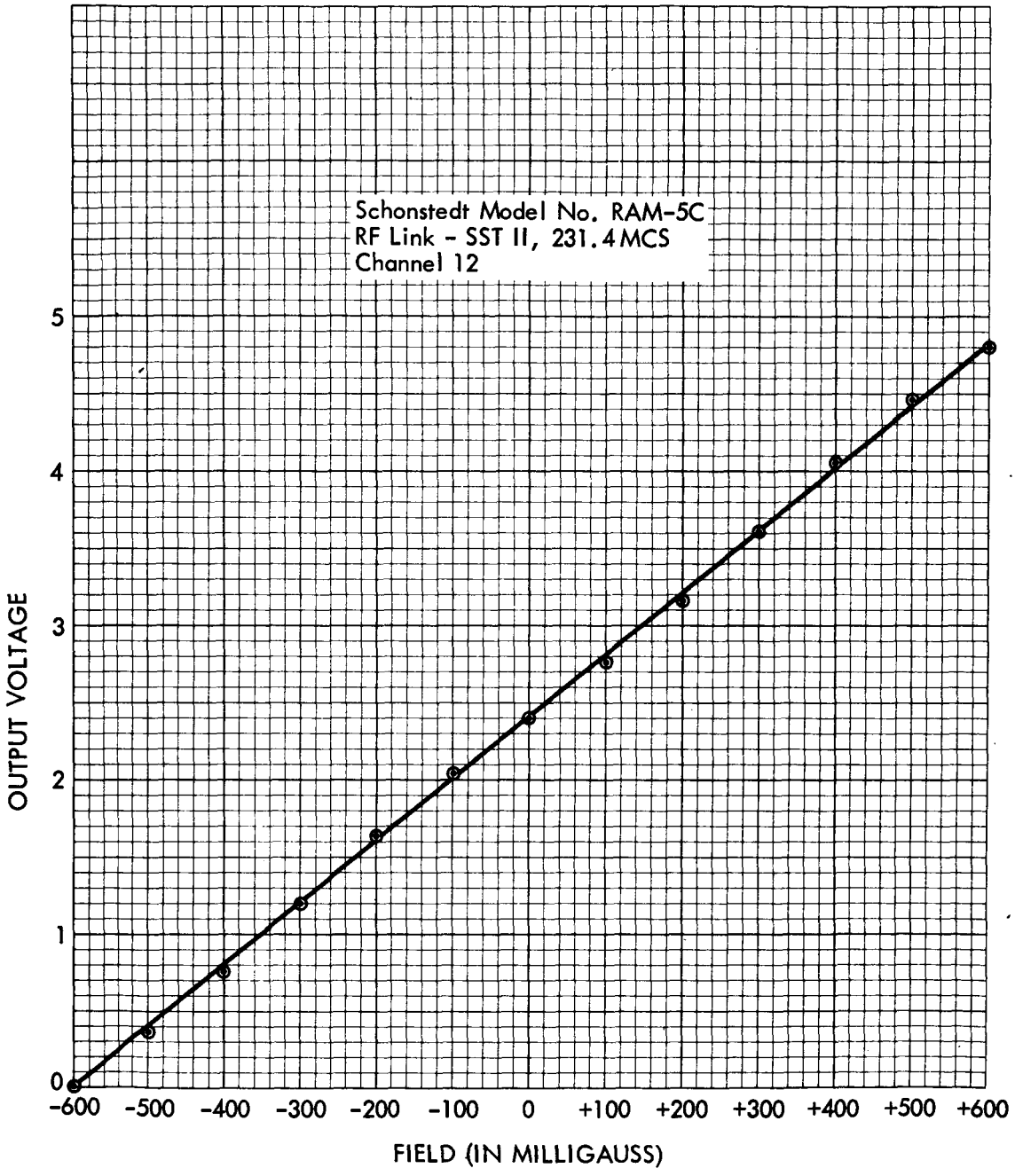

Figure 28. Longitudinal Magnetometer (S/N 404) Calibration Curve

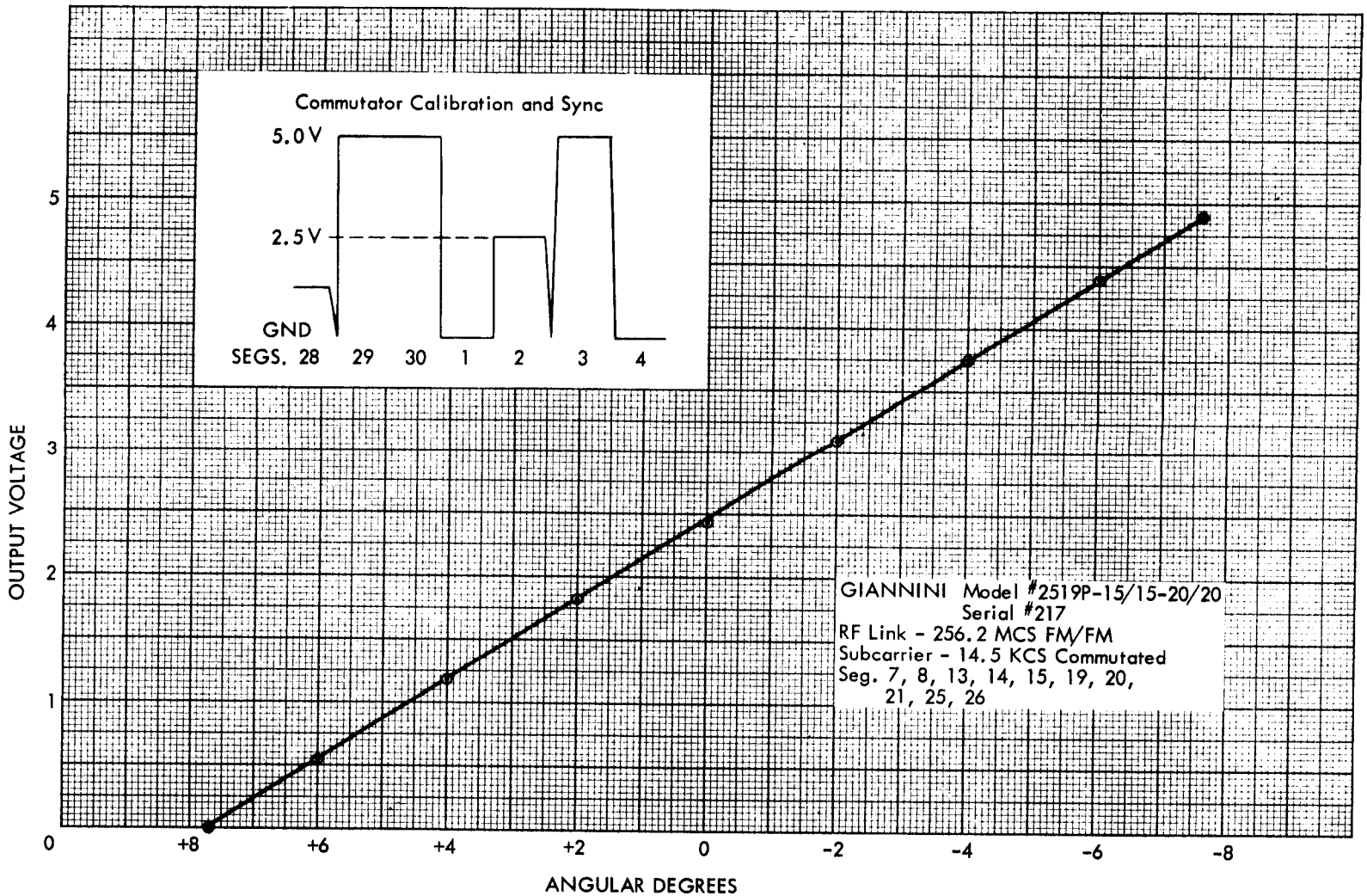

Figure 29. Pitch Ogive Calibration Curve

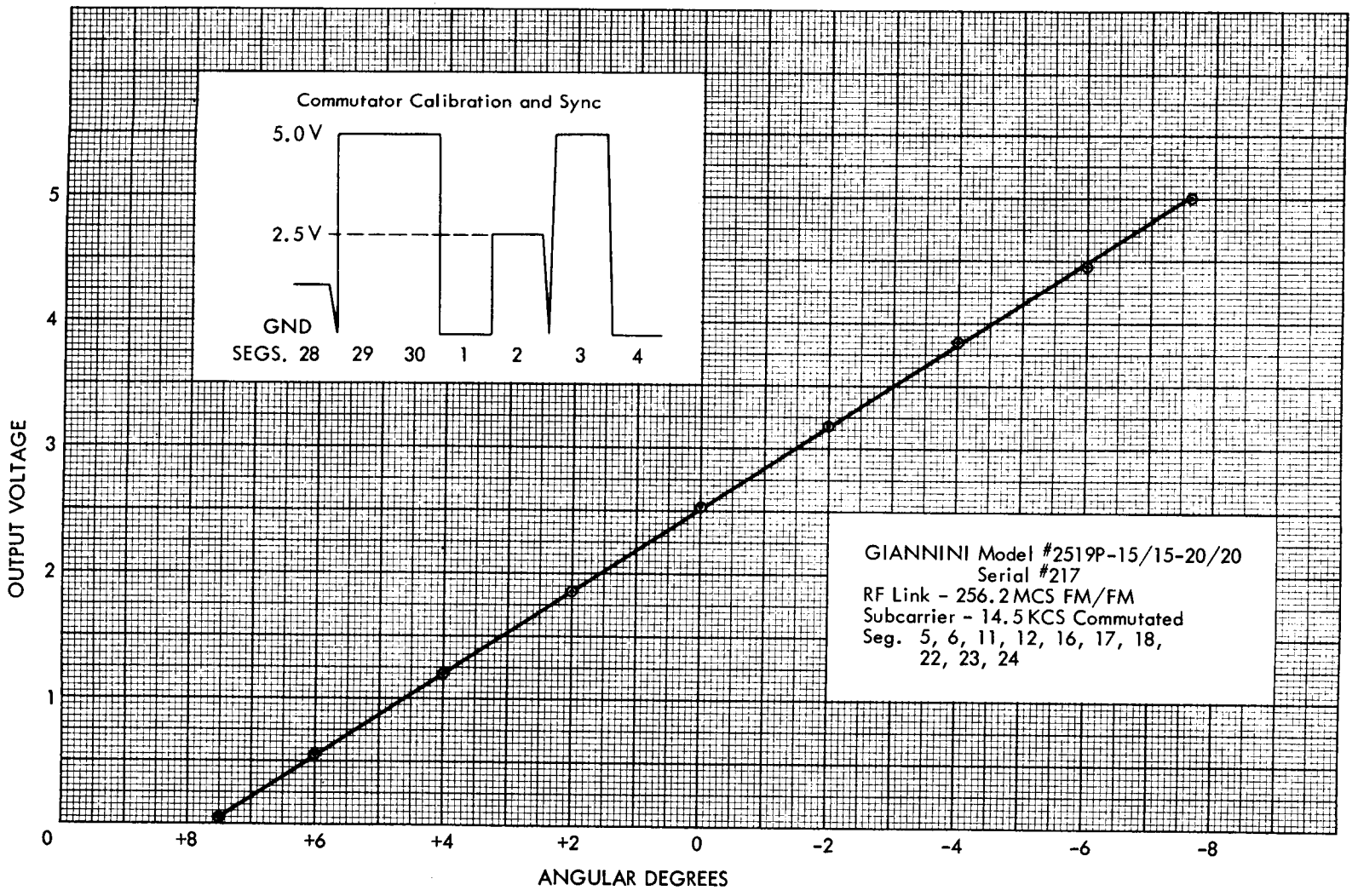

Figure 30. Yaw Ogive Calibration Curve

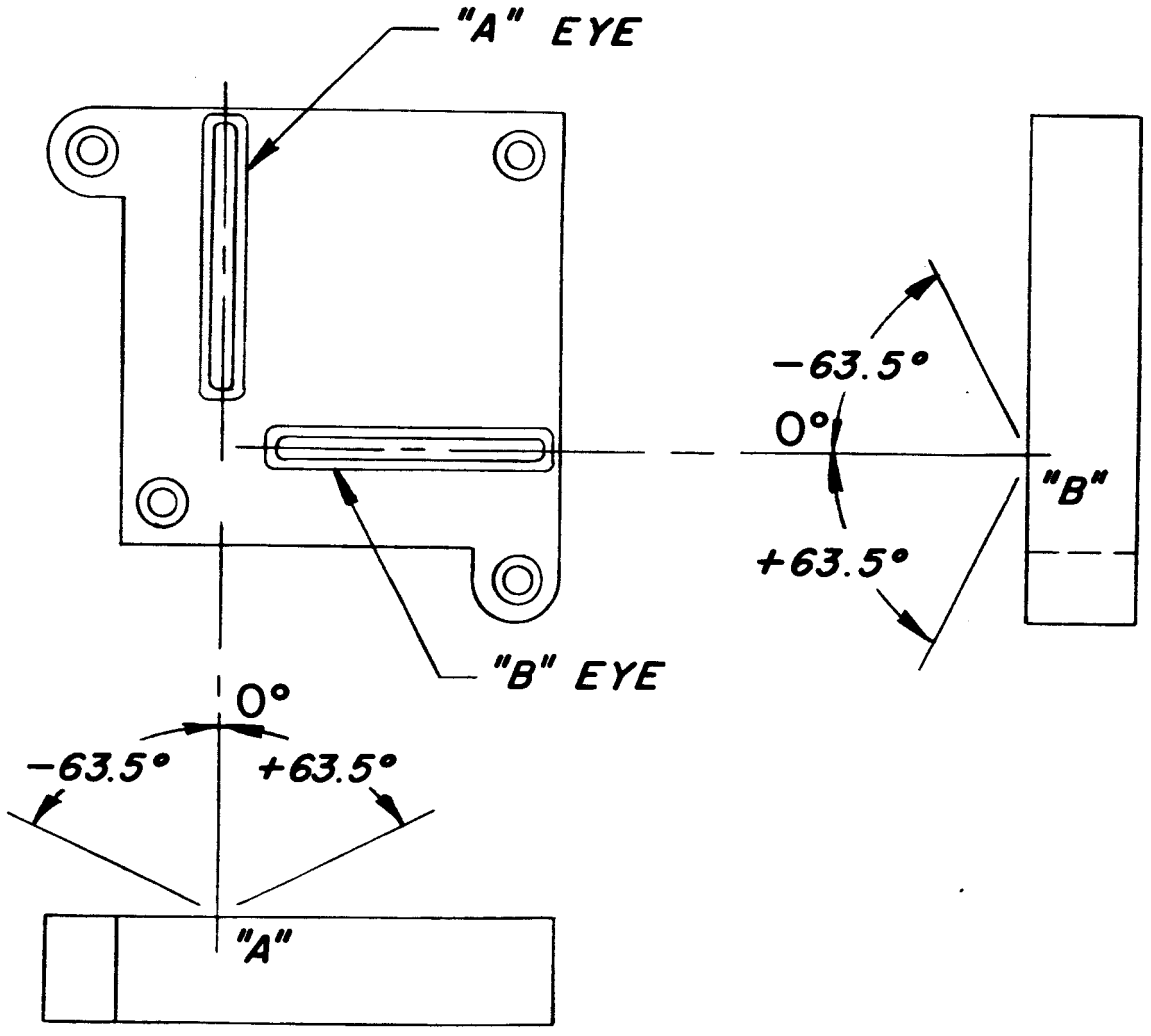

Figure 31. Solar Aspect Sensor, Model 133E Code Reference Diagram

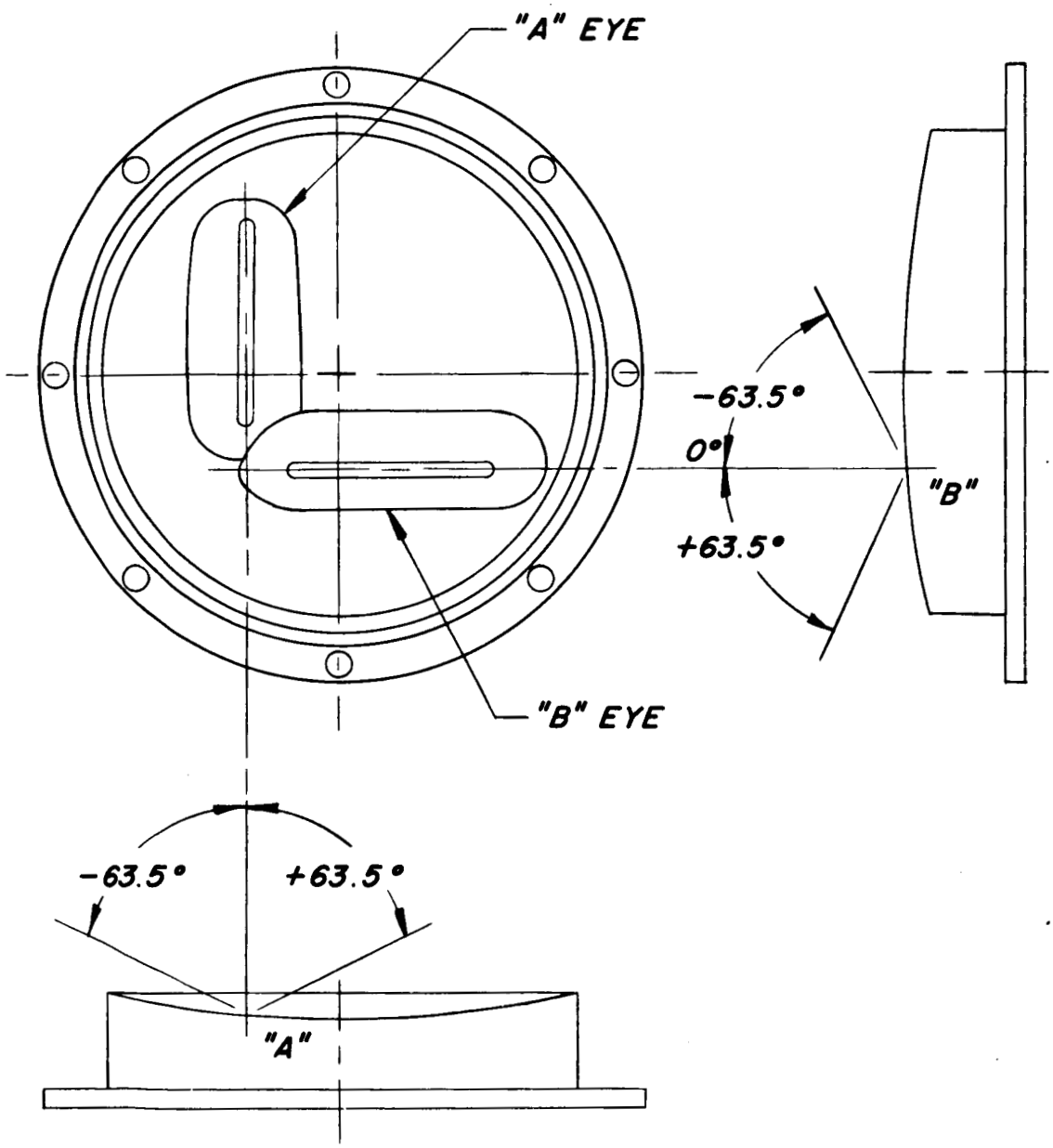

Figure 32. Solar Aspect Sensor, Model 133 F Code Reference Diagram

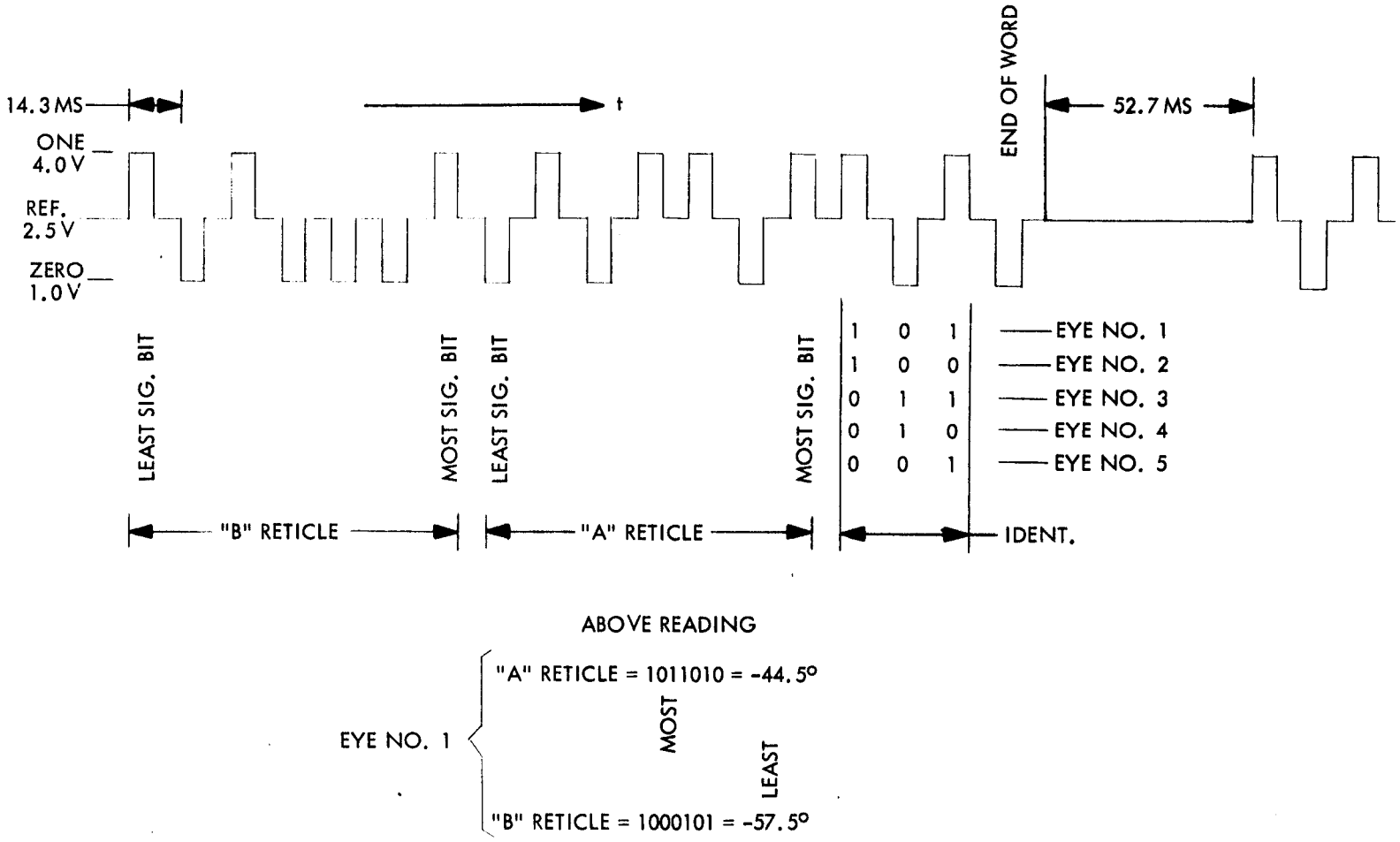

Figure 33. Adcole Models 133E and F Grey Code Pulse Train

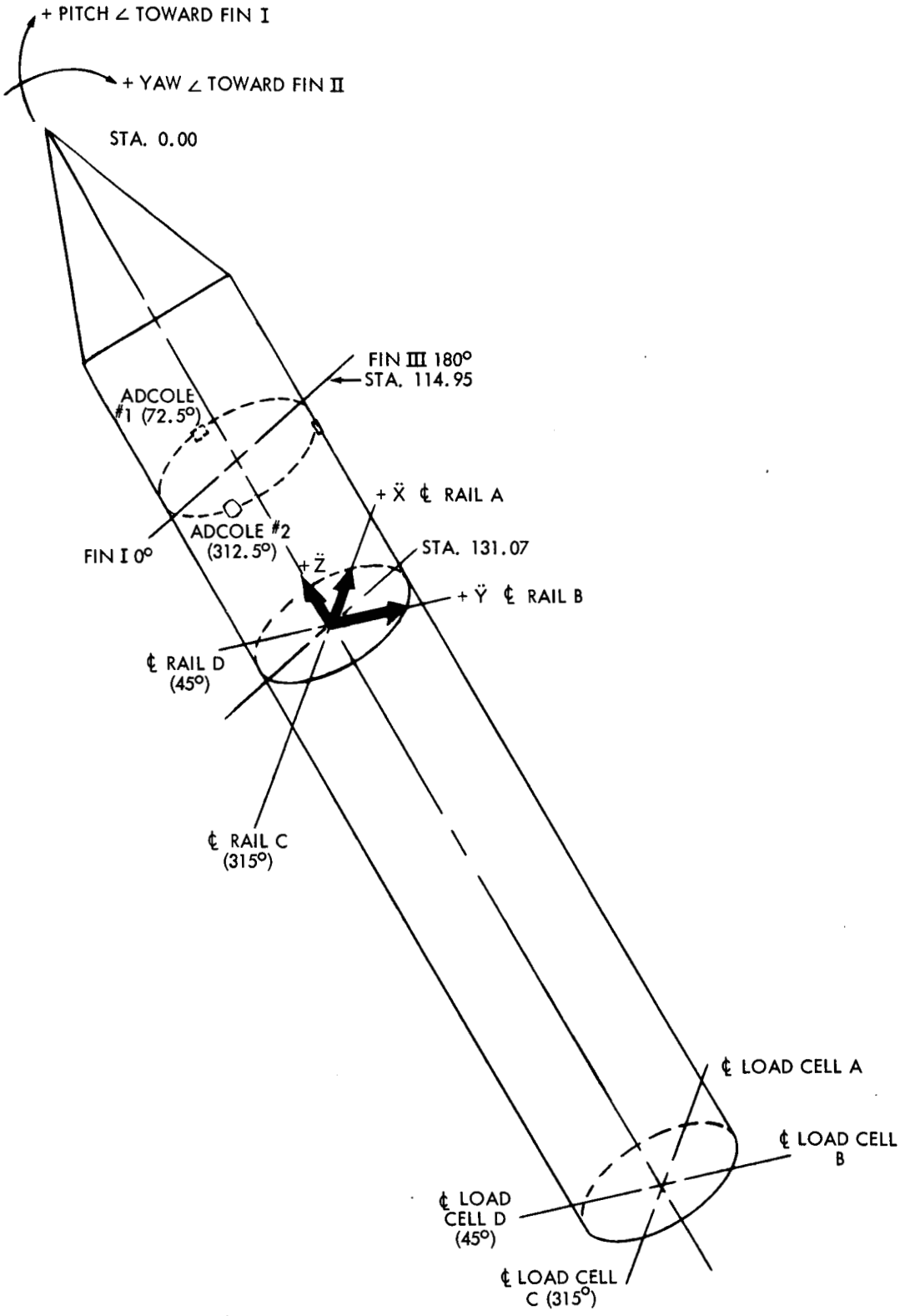

Figure 34. Transducer Orientation

Table 6. Code Table For Adcole Solar Aspect Sensors Models 133 E & F

(Sheet 1 of 6)

0000000	+63.5°
0000001	+62.5°
0000010	+60.5°
0000011	+61.5°
0000100	+56.5°
0000101	+57.5°
0000110	+59.5°
0000111	+58.5°
0001000	+48.5°
0001001	+49.5°
0001010	+51.5°
0001011	+50.5°
0001100	+55.5°
0001101	+54.5°
0001110	+52.5°
0001111	+53.5°
0010000	+32.5°
0010001	+33.5°
0010010	+35.5°
0010011	+34.5°
0010100	+39.5°
0010101	+38.5°
0010110	+36.5°
0010111	+37.5°

Table 6. Code Table For Adcole Solar Aspect Sensors Models 133 E & F

(Sheet 2 of 6)

0011000	+47.5°
0011001	+46.5°
0011010	+44.5°
0011011	+45.5°
0011100	+40.5°
0011101	+41.5°
0011110	+43.5°
0011111	+42.5°
0100000	+0.5°
0100001	+1.5°
0100010	+3.5°
0100011	+2.5°
0100100	+7.5°
0100101	+6.5°
0100110	+4.5°
0100111	+5.5°
0101000	+15.5°
0101001	+14.5°
0101010	+12.5°
0101011	+13.5°
0101100	+8.5°
0101101	+9.5°
0101110	+11.5°
0101111	+10.5°

Table 6. Code Table For Adcole Solar Aspect Sensors Models 133 E & F (Sheet 3 of 6)

0110000	+31.5°
0110001	+29.5°
0110010	+27.5°
0110011	+28.5°
0110100	+24.5°
0110101	+25.5°
0110110	+26.5°
0110111	+25.5°
0111000	+16.5°
0111001	+17.5°
0111010	+19.5°
0111011	+18.5°
0111100	+23.5°
0111101	+22.5°
0111110	+20.5°
0111111	+21.5°
1000000	-63.5°
1000001	-62.5°
1000010	-60.5°
1000011	-61.5°
1000100	-56.5°
1000101	-57.5°
1000110	-59.5°
1000111	-58.5°
1001000	-48.5°

Table 6. Code Table For Adcole Solar Aspect Sensors Models 133 E & F

(Sheet 4 of 6)

1001001	-49.5°
1001010	-51.5°
1001011	-50.5°
1001100	-55.5°
1001101	-54.5°
1001110	-52.5°
1001111	-53.5°
1010000	-32.5°
1010001	-33.5°
1010010	-35.5°
1010011	-34.5°
1010100	-39.5°
1010101	-38.5°
1010110	-36.5°
1010111	-37.5°
1011000	-47.5°
1010001	-46.5°
1011010	-44.5°
1011011	-45.5°
1011100	-40.5°
1011101	-41.5°
1011110	-43.5°
1011111	-42.5°
1100000	-0.5°

Table 6. Code Table For Adcole Solar Aspect Sensors Models 133 E & F

(Sheet 5 of 6)

1100001	-1.5°
1100010	-3.5°
1100011	-2.5°
1100100	-7.5°
1100101	-6.5°
1100110	-4.5°
1100111	-5.5°
1101000	-15.5°
1101001	-14.5°
1101010	-12.5°
1101011	-13.5°
1101100	-8.5°
1101101	-9.5°
1101110	-11.5°
1101111	-10.5°
1110000	-31.5°
1110001	-30.5°
1110010	-28.5°
1110011	-29.5°
1110100	-24.5°
1110101	-25.5°
1110110	-27.5°
1110111	-26.5°
1111000	-16.5°

Table 6. Code Table For Adcole Solar Aspect Sensors Models 133 E & F

(Sheet 6 of 6)

1111001	-17.5°
1111010	-19.5°
1111011	-18.5°
1111100	-23.5°
1111101	-22.5°
1111110	-20.5°
1111111	-21.5°

NOTE:

Extreme right-hand digit is Most Significant Digit (MSD)

Extreme left-hand digit is Least Significant Digit (LSD)