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REPORT NO. BPAD 863-4-15125R

DESIGN AND DEVELOPMENT
OF
EXPERIMENTAL SYSTEM AMPLIFIERS SYSTEM PACKAGES
SERIAL NUMBERS 4, 5, AND 7

OCTOBER 1963

THE Bendix CORPORATION
BENDIX PRODUCTS AEROSPACE DIVISION
SOUTH BEND 20, INDIANA

Contract No. NP-2
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Submitted To

Aerojet-General Corporation
Azusa, California

By

The Bendix Corporation
Bendix Products Aerospace Division
South Bend, Indiana

Prepared Under
Direction of: D. W. Howard
Project Engineer

Approved by: A. J. Wetzel
Project Supervisor

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SECTION 1

SYSTEM AMPLIFIER IDENTIFICATION

1.1 INTRODUCTION

A System Amplifier package is composed of four separate but related amplifier assemblies which regulate the thrust of the NERVA engine by controlling the critical parameters of chamber pressure and temperature.

The temperature loop contains a pre-amplifier and an error amplifier as does the pressure loop. The pre-amplifiers perform the function of averaging two or more input signals and also provide a significant power gain. The error or control amplifiers compare the feedback signals supplied by the pre-amplifiers with a reference generated in the engine programmer and provide an electrical output signal proportional to the error which drives the appropriate actuator subsystems. In addition, loop stabilization is incorporated into the error amplifiers in the form of lag-lead compensation.

The following abbreviations are used throughout this report to denote system amplifier type:

PSA - Pressure Signal Amplifier
PCA - Pressure Control Amplifier
TSA - Temperature Signal Amplifier
TCA - Temperature Control Amplifier

1.2 SYSTEM AMPLIFIER MODEL AND PART NUMBERS

Model and part numbers have been assigned to the System Amplifiers to identify the development status of the various amplifier assemblies. The appropriate serial numbers and reference to the schematic diagrams are presented in Table I.

TABLE I

EXPERIMENTAL SYSTEM AMPLIFIERS - MODEL AND SERIAL NUMBERS

Amplifier & S/N		Model	Part No.	Electrical Schematic	Development Status
PSA	4	EP-A2	2775017-1	2779216	Experimental (Sheet Metal Case)
PSA	5	EP-A2	2775017-2	2779216	Experimental
PSA	7	EP-A2	2775017-3	2779216	Experimental
PCA	4	EC-A2	2775019-1	2779218	Experimental (Sheet Metal Case)
PCA	5	EC-A2	2775019-2	2779218	Experimental
PCA	7	EC-A2	2775019-3	2779218	Experimental
TSA	4	EW-A2	2775016-1	2779215	Experimental (Sheet Metal Case)
TSA	5	EW-A2	2775016-2	2779215	Experimental
TSA	7	EW-A2	2775016-3	2779215	Experimental
TCA	4	None	2775018-1	2779217	Experimental (Sheet Metal Case)
TCA	5	None	2775018-2	2779217	Experimental
TCA	7	None	2775018-3	2779217	Experimental

The variations in the experimental amplifiers, as denoted by the issue change on the part number, reflect the evaluation from the sheet metal case (-1), to the cast base (-2), and the addition of another thermocouple to measure the amplifier base temperature (-3).

1.3 APPLICABLE SPECIFICATIONS

The specifications for the experimental design were derived from the breadboard system amplifier specifications, NPI-110 through NPI-113. The experimental specifications carry the numbers CNPD-143 through CNPD-146, and are subject to modification as a result of computer tie-in studies, design improvements as a result of the development test program, and variations in packaging concepts due to relocation and/or remote handling requirements.

SECTION 2

DEVELOPMENT PROGRAM

2.1 ENVIRONMENTAL TESTING

System Amplifier environmental tests were conducted using the in-house S/N 6 system package. In addition, all deliverable hardware of the experimental design was evaluated at +75° F, -260° F, and at +250° F. These tests on complete amplifier assemblies were supplemented by radiation tests at the Ground Test Reactor in Fort Worth and development testing of amplifier components. The results of the later tests are documented in the Final Report which describes Bendix participation during the Fiscal 1963 period.

2.1.1 Extreme Temperature Tests

2.1.1.1 Temperature Soak Tests

The amplifier performance data presented in Sections 5 through 7 were obtained after the amplifier assembly had stabilized at temperature extremes of -260° F and/or +250° F. The transitions from room temperature to the extremes were made over a period of thirty (30) to sixty (60) minutes with the heat transfer medium being gaseous nitrogen or heated air.

2.1.1.2 Thermal Shock

The in-house TSA and PSA amplifiers were subjected to a thermal shock from +80° F to liquid nitrogen at -320° F.

The purpose of this test was twofold. First, should supplementary cooling in the form of cold hydrogen be required, this test would approximate the temperature transient at the amplifier interface during an engine re-start in space. It has been assumed that the mounting pad would be cooled thereby eliminating the need for a pneumatic connection to the amplifier. The heat flow path is from the engine mounting pad through the amplifier base and to the various magnetic stages and components. Secondly, the thermal time constant of the various amplifier components can be determined. This data is used to supplement the analysis of gamma heating studies made in support of irradiation tests.

2.1.2 Radiation Effects Tests

Radiation effects testing of amplifier components and stages have been conducted at the Western New York Nuclear Research Center and at the Ground Test Reactor in Fort Worth, Texas. The results of these tests are discussed in WANL TME-250 dated 16 January 1963 and BPAD Report No. 863-4-15090R published in September 1963.

In addition, a complete set of radiation hardened breadboard System Amplifiers (S/N 2) were irradiated in the GTR in August 1963. Although the data has not been completely reduced, preliminary analysis indicates that the PSA and TSA amplifiers performed satisfactorily to beyond 1 x 10^{16} nvft (0.1 mev). However, in the case of the TCA, relatively high temperatures (600° F) were induced in the core of the rate transformer at the 3 megawatt power level and is due to the extremely low thermal conductivity of the lockfoam potting material and the lack of a thermal path to the amplifier case. The construction of the rate transformer is shown in Figure 1.

Other component temperatures, including magnetic cores, resistors, and capacitors were within the allowable ratings with the one exception of a capacitor which was 33° F overtemperature.

Bendix Report No. 863-4-15070R dated 15 August 1963 summarizes the preliminary results of the breadboard System Amplifiers radiation test.

Further experimental data on rate transformer core heating under nuclear radiation will be obtained during the September 1963 test of the Experimental System Amplifiers (S/N 5) in the GTR. A rate transformer of a modified design incorporating a thermal path from the core to the case will be installed in the PCA. The original rate transformer will be removed and mounted on the pallet adjacent to the amplifier. Thermocouple measurements will provide an indication of the thermal transfer efficiency of the modified design. Figure 2 illustrates the differences in construction between the standard and the modified rate transformers and the location of the thermocouple instrumentation.

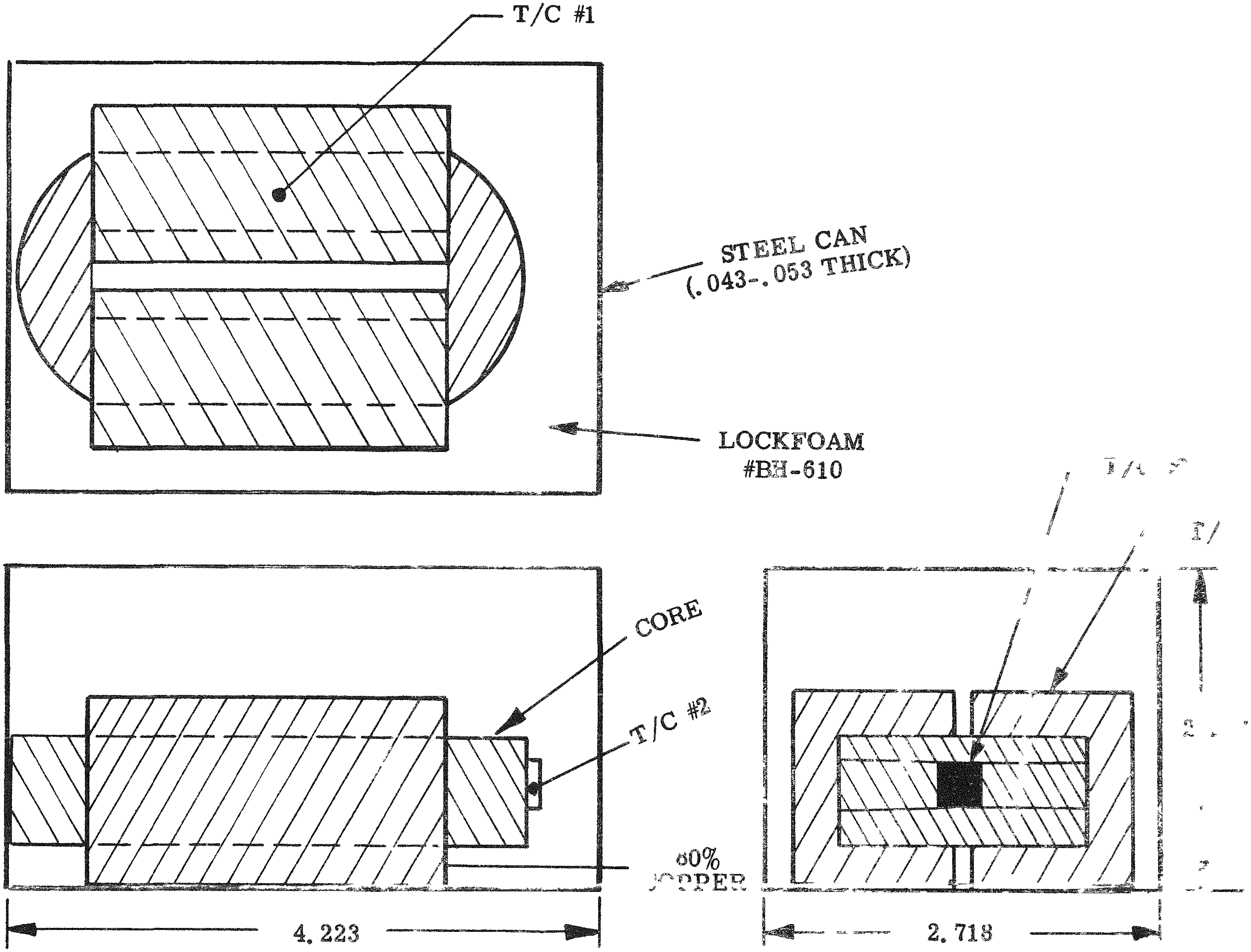
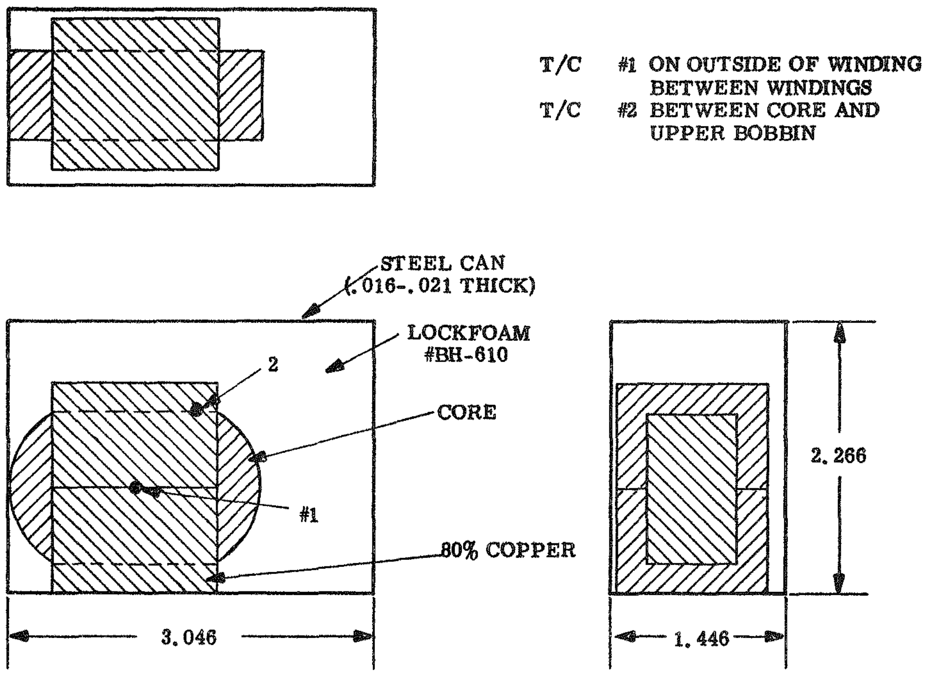
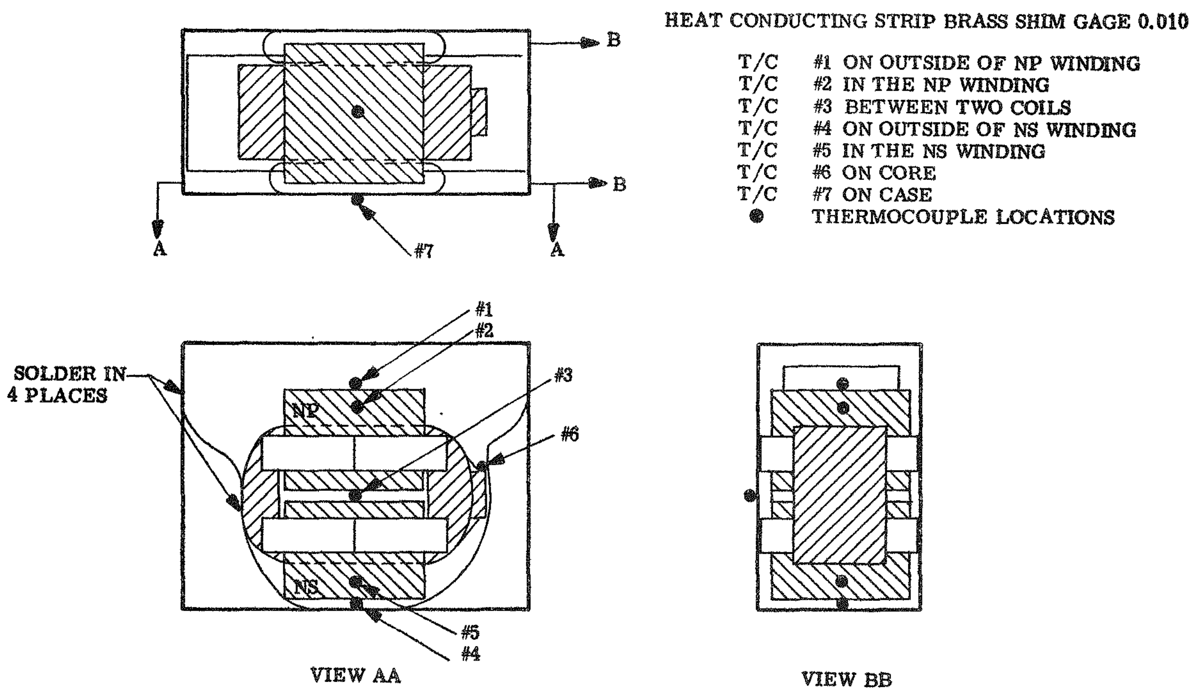


FIGURE 1 TCA RATE TRANSFORMER - CROSS SECTION



STANDARD DESIGN



MODIFIED DESIGN

FIGURE 2 PCA RATE TRANSFORMER

2.1.3 Vibration Tests

The turbine power control valve servo amplifier was selected as the amplifier design to evaluate under vibration because of the representative magnetic stages used in the package. Further, much performance data has been accumulated over the environmental temperature range on this type of amplifier.

A mock-up of this amplifier, illustrated in Figure 3, was vibrated in two of the three mutually perpendicular planes. A structural failure in the second plane prevented vibration in the third plane. Each plane was scanned at 0.125 inch double amplitude to the 15 G-line from 20 to 2000 cycles per second. Resonant points were noted and studied under stroboscopic lighting as well as being measured with an accelerometer. The results of the vibration test are discussed below.

2.1.3.1 Plane 1 - Perpendicular to Base

Minor resonant points occurred in the frequency range of 350 to 470 cps at the 15 G level near the power transformer end of the terminal board as well as at the opposite end. A snap was heard at about 400 cps and another at 800 cps, however, investigation after completion of the scan did not reveal any obvious structural failures. See Figure 4.

2.1.3.2 Plane 2 - Transverse to Longitudinal Axis of Amplifier

The amplifier was mounted to the shake table as shown in Figure 5. Minor resonant points occurred in the same frequency ranges and locations as in Plane 1. At 782 cps and 15 G's, a loud snap was heard near the transformer end of the package. A failure was detected in the fastening device brazed to the transformer case. This fracture is illustrated in Figure 6. Failures were also noted at the opposite end of the assembly in the vicinity of the magnetic amplifier stages. Again, the fastener had ruptured at the point of attachment to the amplifier base plate. See Figures 7 and 8.

The terminal board, magnetic stage headers and the auxiliary terminal board on the side of the amplifier structure suffered no damage.

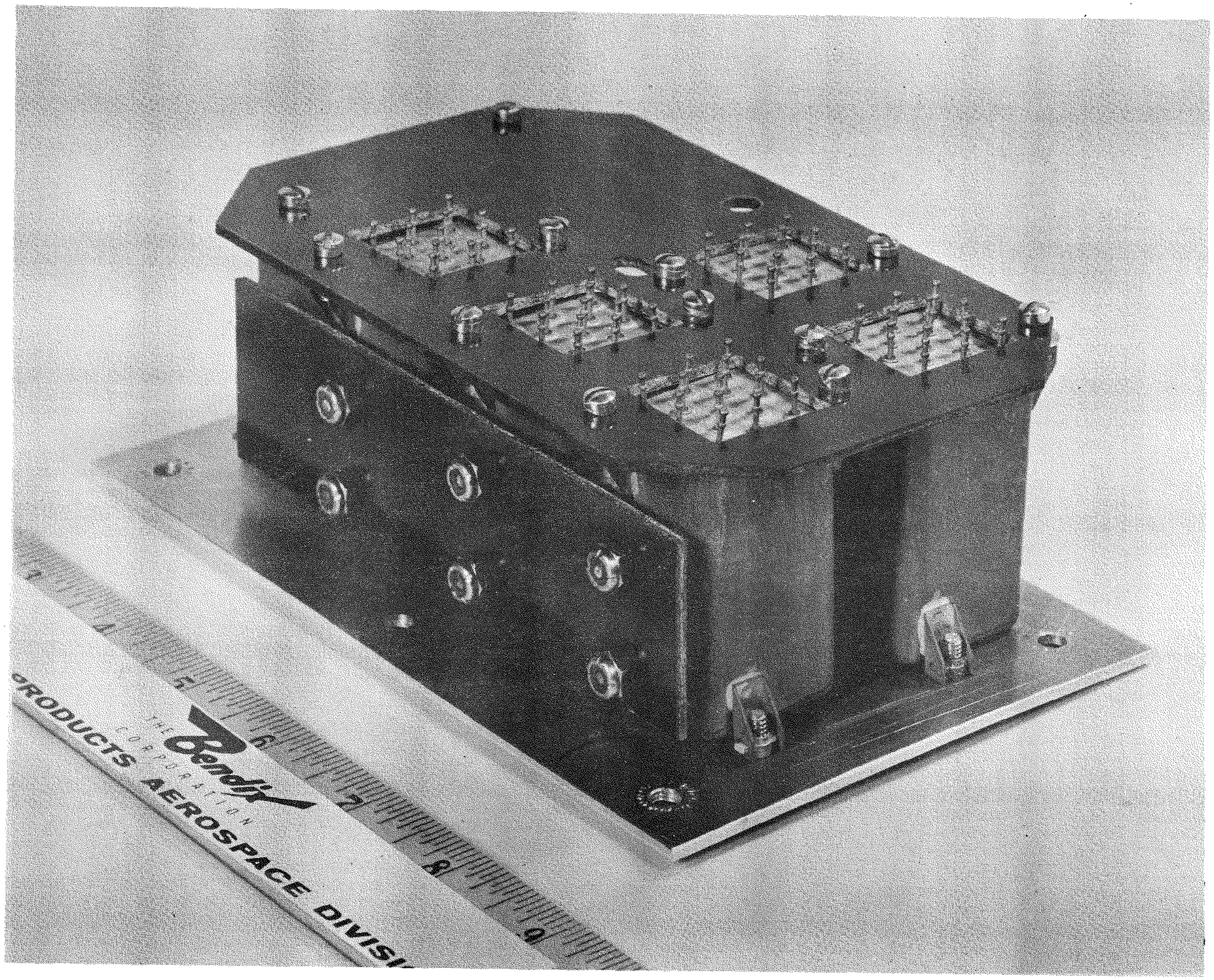


FIGURE 3 TPCV MOCK-UP FOR VIBRATION TEST

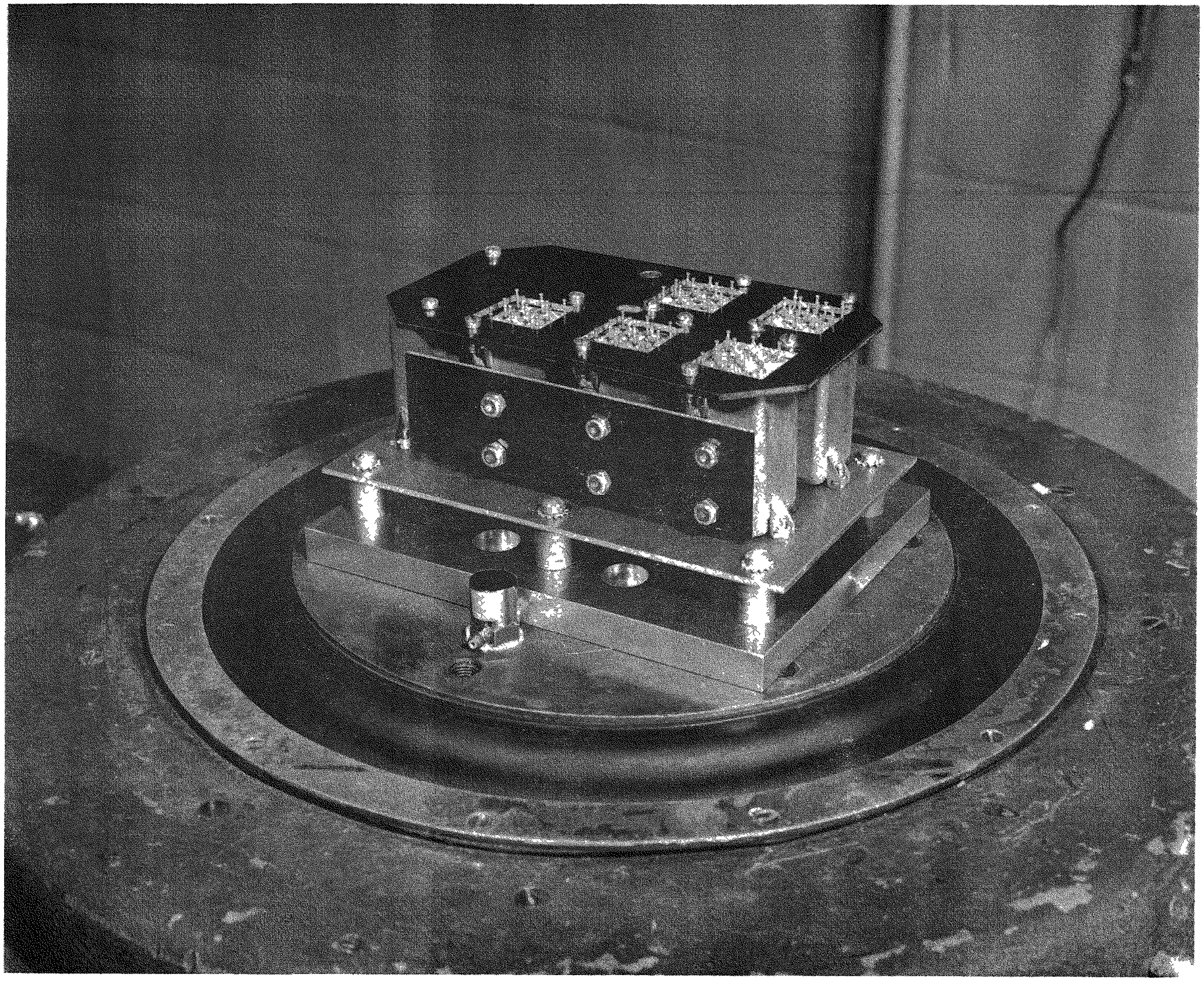


FIGURE 4 TPCV MOCK-UP - AFTER VIBRATION IN PERPENDICULAR PLANE

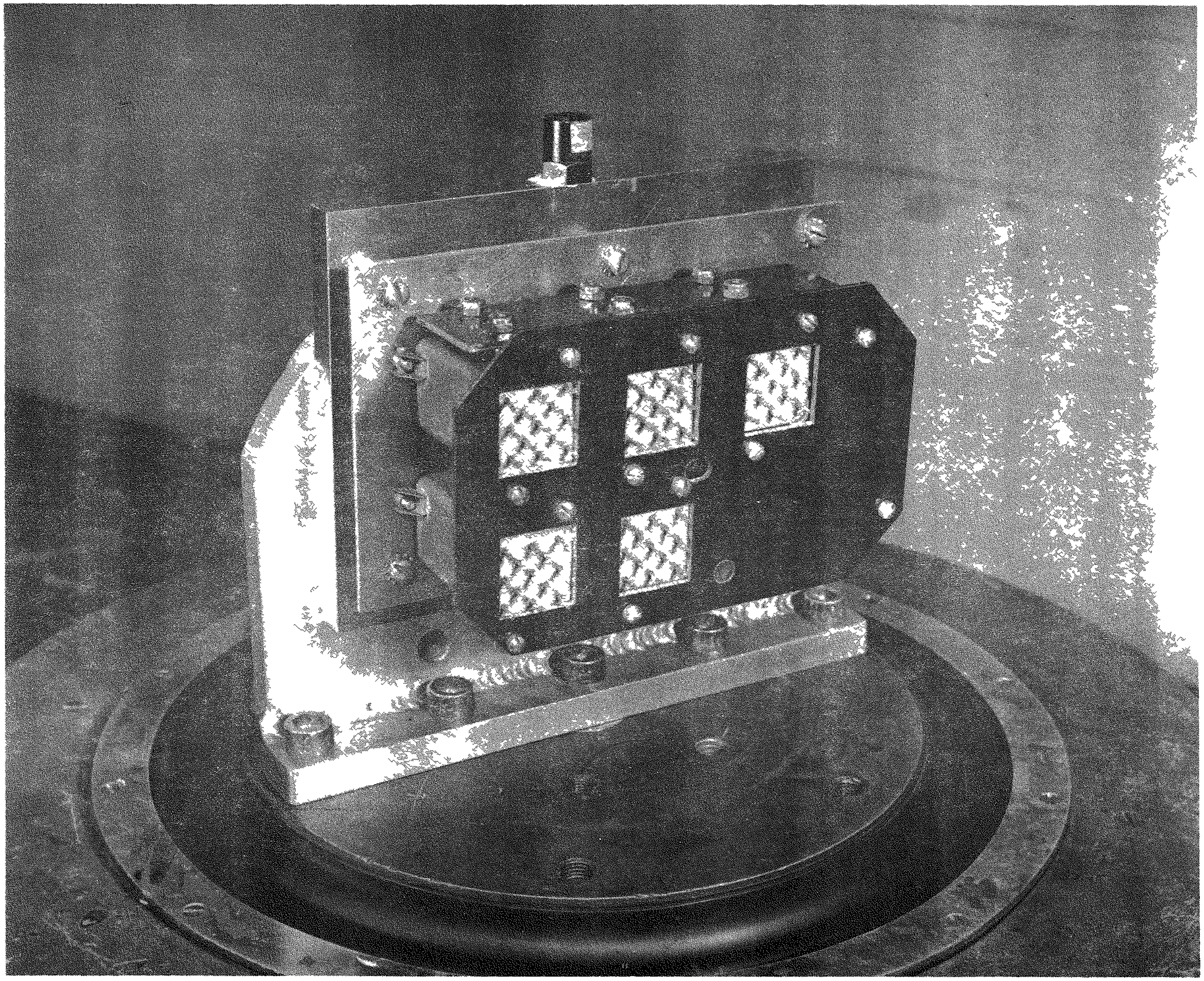


FIGURE 5 TPCV MOCK-UP - MOUNTED IN TRANSVERSE PLANE

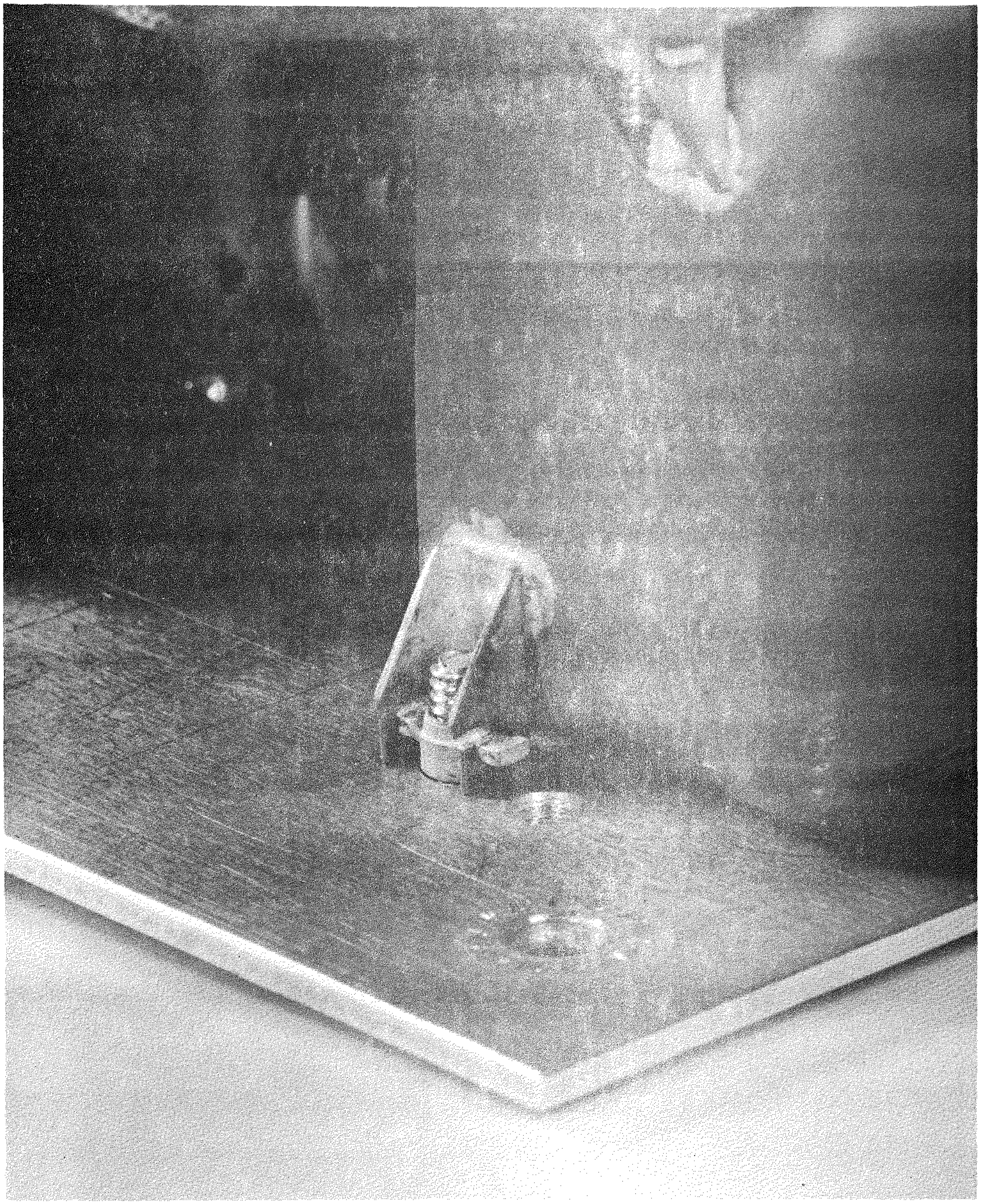


FIGURE 6 TRANSFORMER MOUNTING BRACKET FAILURE

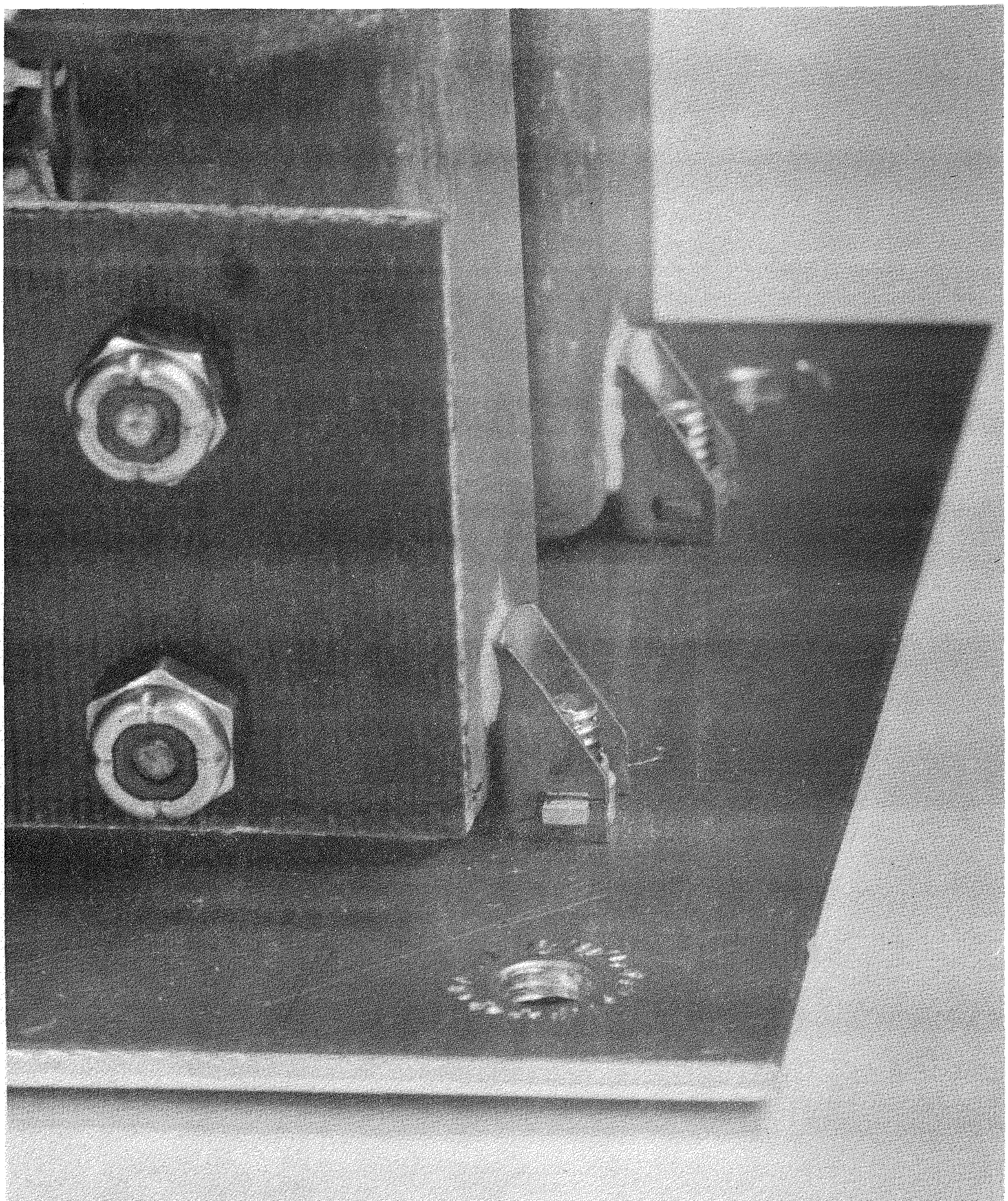


FIGURE 7 MAGNETIC STAGE MOUNTING BRACKET FAILURE - LEFT VIEW

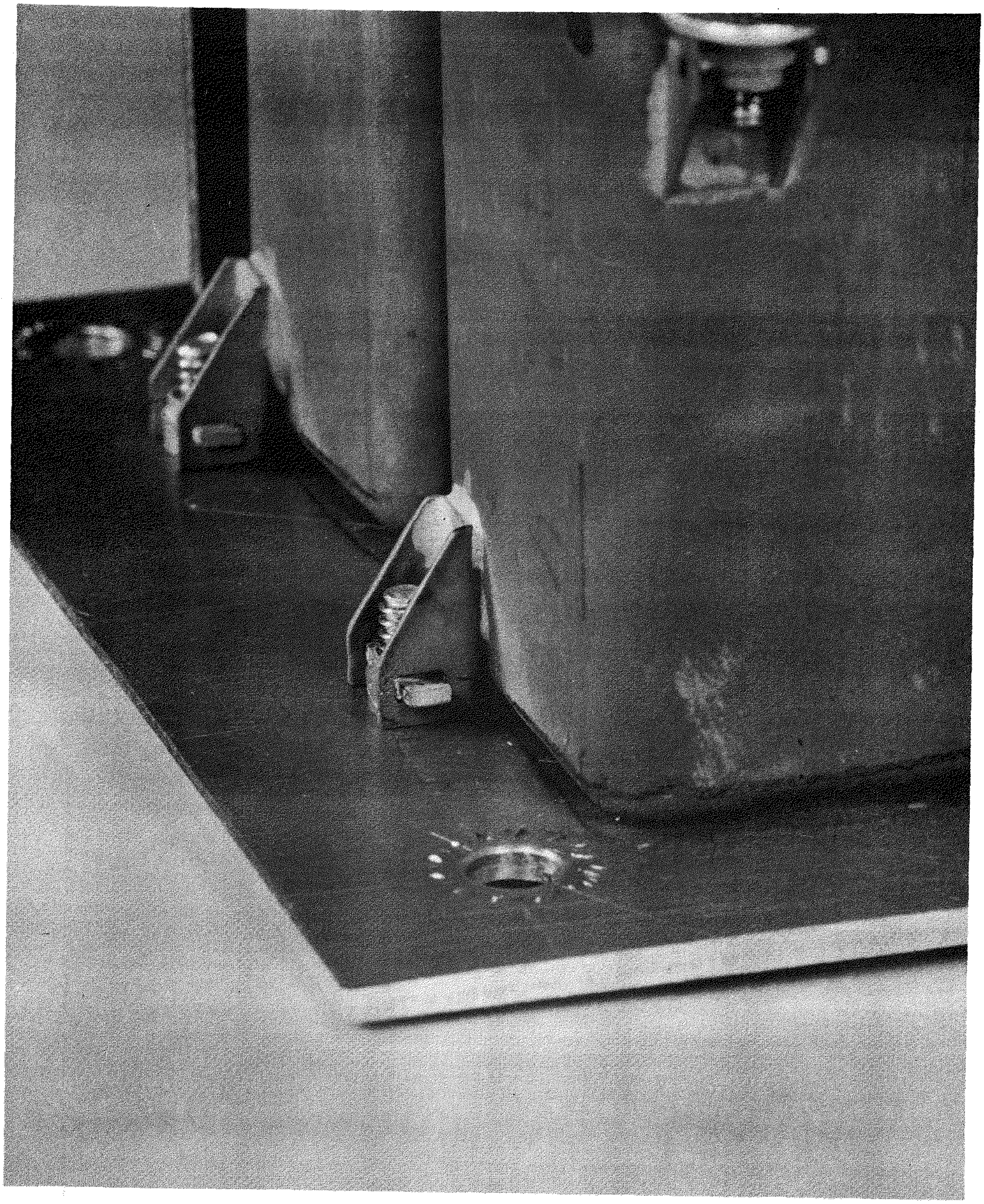


FIGURE 8   MAGNETIC STAGE MOUNTING BRACKET FAILURE - RIGHT VIEW

The results of the vibration test indicated a structural weakness in the fastening devices brazed to the magnetic stages and to the power transformer case.

Based upon the results of this test, it was recommended that a lug type mount having a much larger cross section at the hold-down points be incorporated into the design of the experimental amplifiers.

2.2 MECHANICAL DESIGN

2.2.1 Remote Handling

The System Amplifiers must be designed for convenient handling with standard remote handling equipment. The amplifier, when mounted on the customer's mounting pad, is attached by four captivated 12-point bolts. These bolts are designed for use with mid-grip helicoil inserts mounted in the engine interface pad. A handling tab is provided on the amplifier cover for use as a grip point for the remote handling manipulator.

Close tolerance guide pin holes provide assurance of proper alignment of the electrical connector and the mounting bolts. Two buide pin holes, located on one side of the base, are used and furnish the remote handling operator maximum visibility of the alignment pins during the orientation and subsequent attachment of the amplifier to the engine interface. The electrical connector is a straight disconnect type which does not require rotational action to form a positive lock.

Continued coordination with Aerojet-General will be maintained to effect design changes based upon amplifier relocation, change in handling tools and/or procedures, and additional design modifications as dictated as a result of the development test program.

2.2.2 Structural Concept

The build-up of the amplifier is based on a "sandwich" construction which utilizes the magnetic stages as structural members. The integrity of this type construction was proven as a result of the vibration testing discussed in Section 2.1.3. As a result of this testing, the hold-down brackets were replaced with a heavier lug screw. This is a sturdier type hold-down and also provides intimate thermal contact of the stage cans to the bottom plate to effect better heat transfer from the stages to the amplifier case.

Open circuit board construction is used for accessibility and variation of the critical circuit components during computer tie-in studies.

The magnetic amplifier stages are encapsulated in metal cans which provide mechanical isolation and moisture sealing for the cores and windings. The metal can is also the member which provides the attaching means for the circuit board. The circuit board and the stage assemblies are mounted to a bottom metal plate, which contains the radiation tolerant connector (male section). The combination of upper circuit board, stage cans and the bottom metal plate form the "chassis assembly".

The experimental case has been designed for ease in remote handling as described in Section 2.2.1. The cast base plate is equipped with four captive hold-down screws which secure the amplifier to the engine mounting plate. These can be adapted to the remote manipulator via a standard 12-point socket. The cover is secured to the cast base by fourteen machine screws. When the cover is removed, the chassis assembly and all of the components are completely accessible.

In the experimental series amplifiers, thermocouples are mounted on several components, cores, and windings to monitor operational temperatures. These are brought out through a milled slot in the cast base.

2.2.3 Amplifier Adjustment

The mechanical design concepts are influenced by many factors such as environment, space envelope, and remote handling techniques.

An additional requirement affecting the mechanical arrangement of components is the capability of modifying various electrical characteristics of the amplifier. These modifications include, but are not limited to DC forward gain, amplifier roll-off frequency, and variation of the lead-lag networks used for loop stabilization.

Further, since the silicon diodes incorporated in the magnetic amplifiers are in the experimental phase of development, provisions are made to allow removal of the diodes following environmental tests in order to determine changes in critical diode parameters.

SECTION 3

DISPOSITION OF EXPERIMENTAL SYSTEM AMPLIFIERS

The Experimental System Amplifiers, S/N's 4, 5, 6, and 7, have been allocated for specific developmental tests as noted below.

3.1 S/N 4 - SYSTEM PACKAGE

The S/N 4 System Package is scheduled for extreme temperature environmental tests at Aerojet-General Corporation. Gain stability, frequency response, and null shift as a function of ambient temperature will be determined.

3.2 S/N 5 - SYSTEM PACKAGE

The S/N 5 Amplifiers will be evaluated under nuclear radiation in the Ground Test Reactor during September 1963. Performance data will be taken to beyond 1×10^{16} $nv_f t$ (0.1 mev).

3.3 S/N 6 - SYSTEM PACKAGE

System Package, S/N 6, has been retained by Bendix for development testing. Tests which have been performed are amplifier performance over the specified ambient temperature range, thermal shock, and vibration.

3.4 S/N 7 - SYSTEM PACKAGE

The S/N 7 Amplifiers are scheduled for non-radiation environmental testing at Aerojet-General Corporation.

SECTION 4

DESCRIPTION OF EXPERIMENTAL SYSTEM AMPLIFIERS

The function of the various system amplifiers with relation to the overall engine control loop, as well as the theory of operation of each of the amplifiers, has been described in BPAD Report No. 863-4-15076R.

The development from a breadboard amplifier to a design capable of operation in the NERVA radiation environment was described in BPAD Report No. 863-4-15096R.

The experimental amplifiers have been further developed to sustain the rigors of thermal shock, continued exposure to cryogenic and high temperatures and the ability to endure vibration inputs of 15 G's out to 2000 cps.

Additional testing will include exposure to salt spray, humidity, fungus, etc. as specified in the appropriate military Environmental Test Specifications.

4.1 S/N 4 - SYSTEM AMPLIFIER PACKAGE

The S/N 4 System Amplifiers utilize the "sandwich" construction concept described in Section 2.2.2. The TSA, PCA, and TCA are identical in overall dimensions although the number and type of components differ as does the total weight of the various assemblies. The PSA contains only one magnetic amplifier stage with an output filter and is enclosed in a smaller case. The connectors for all of the system amplifiers are identical, however, the wiring is such that only one common test cable is required since power input, signal output, and signal input pins have been standardized.

Figures 9 through 11 illustrate the component arrangement and construction of the PSA amplifier.

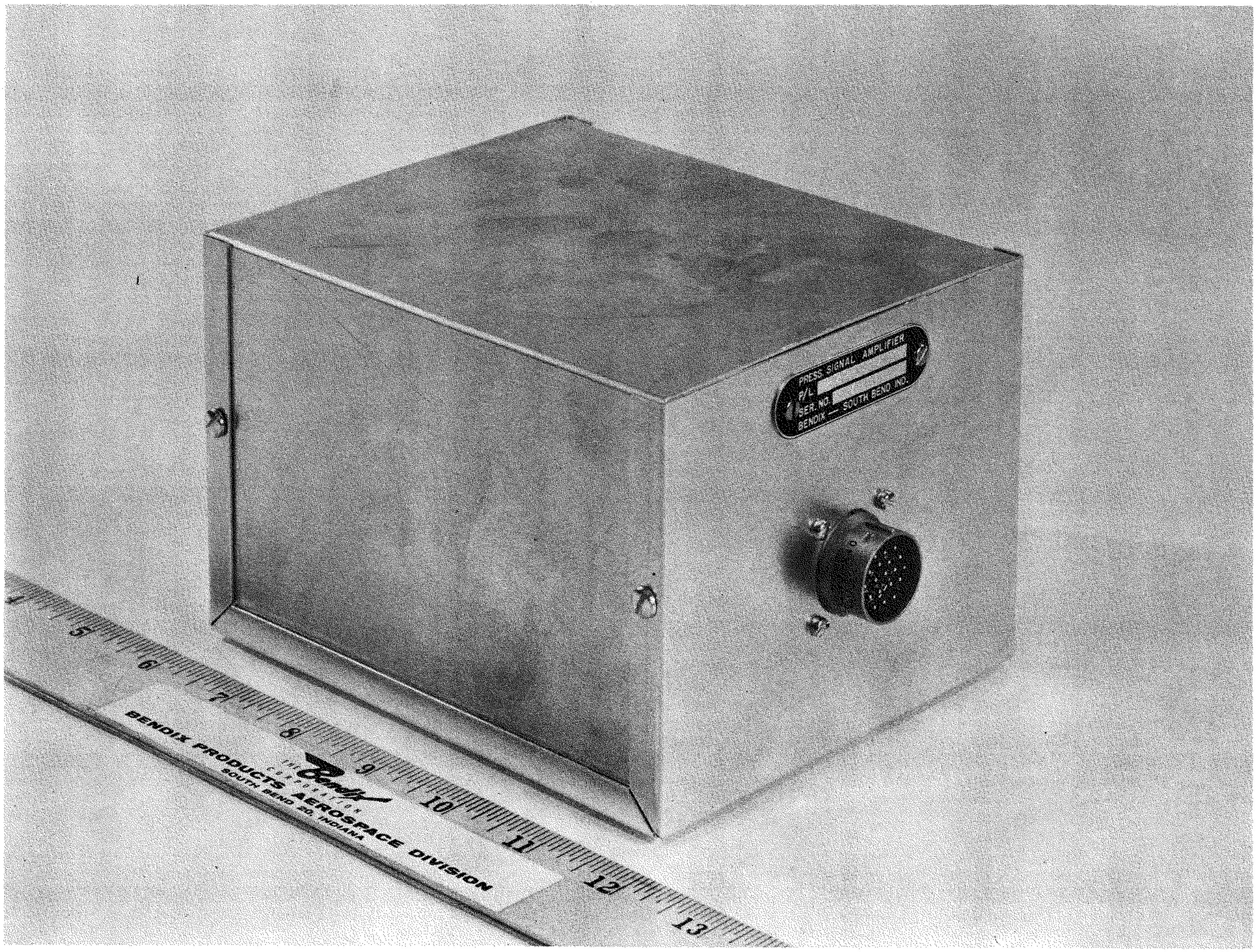


FIGURE 9 PSA AMPLIFIER, S/N 4 - COMPLETE ASSEMBLY

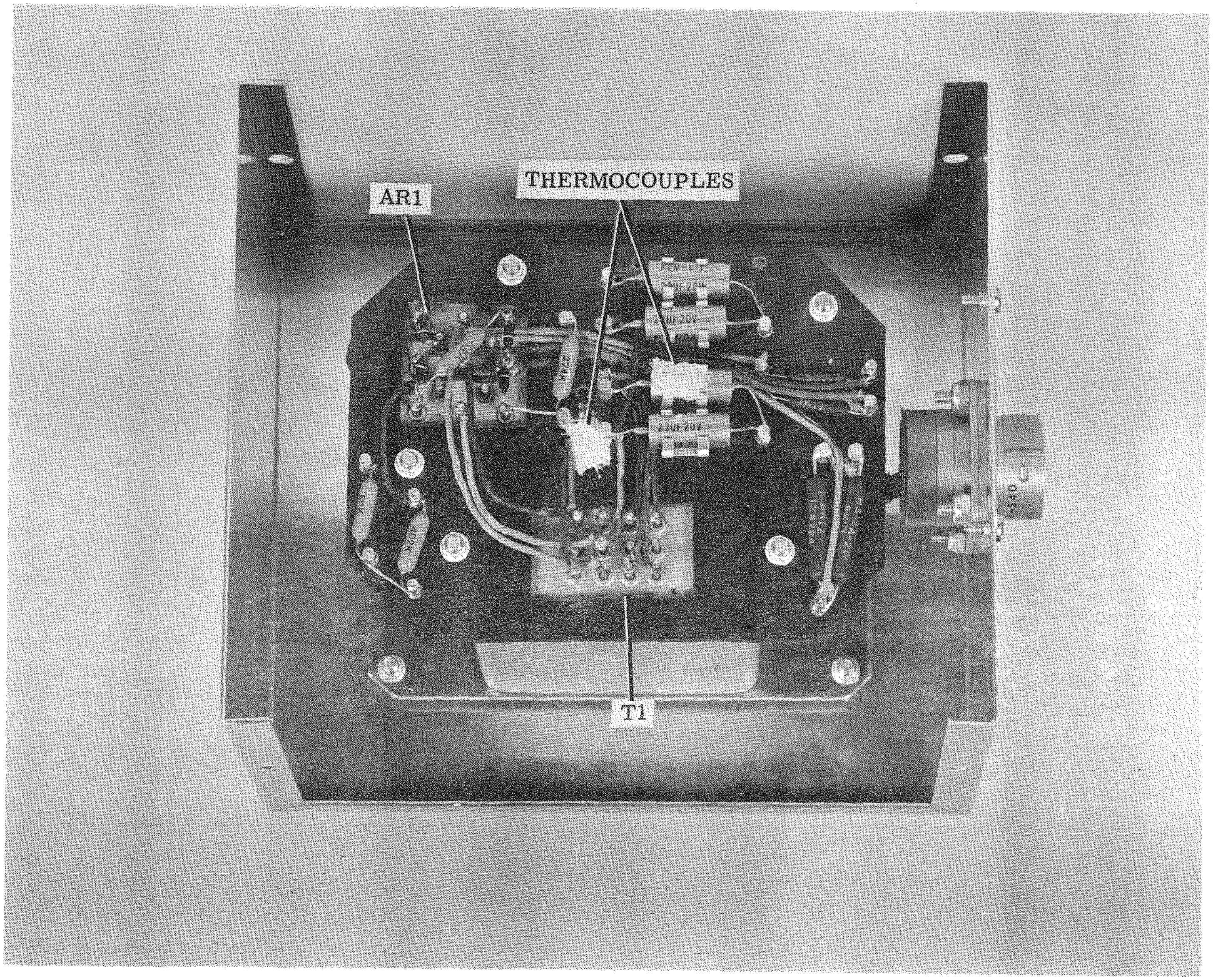


FIGURE 10 PSA AMPLIFIER, S/N 4 - TOP VIEW

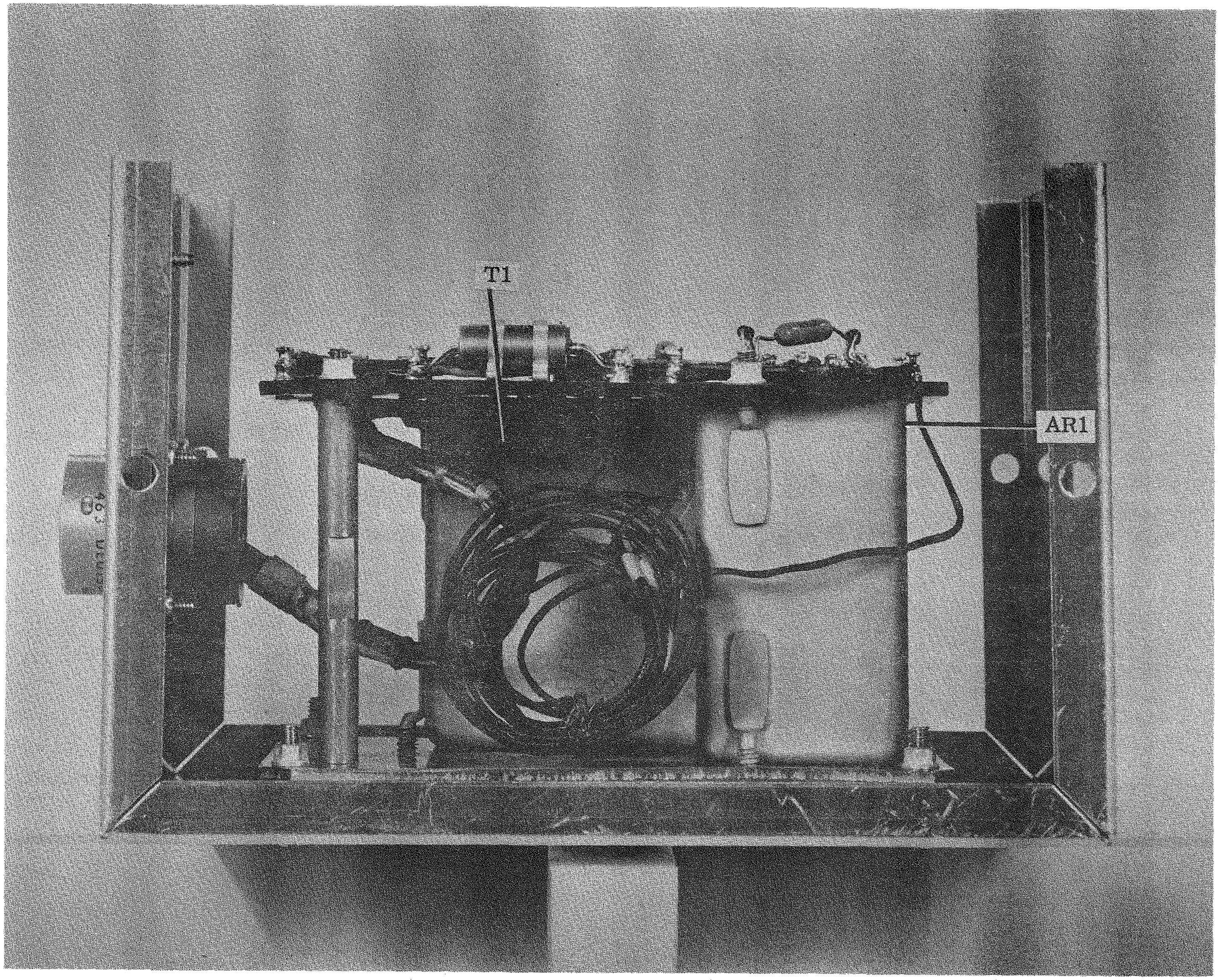


FIGURE 11 PSA AMPLIFIER, S/N 4 - SIDE VIEW

The construction of the PCA is illustrated in Figures 12 through 14.

The TSA enclosure is the same as the PCA illustrated in Figure 12. Figures 15 and 16 show component arrangement and interior construction.

The TCA terminal board and chassis assembly is illustrated in Figures 17 and 18. The packaged assembly is similar in appearance to the PCA shown in Figure 12.

The thermocouple instrumentation for the PSA, PCA, TSA, and TCA is shown in Figures 10, 13, 15, and 17.

The schematic diagrams of the System Amplifiers are shown in Figures 19 through 22. These schematics also identify the location of the radiation tolerant diodes as well as the points at which gain and feedback adjustments can be made.

4.2 S/N 5 AND S/N 7 - SYSTEM AMPLIFIER PACKAGES

The major differences in the S/N 5 and the S/N 7 Experimental System Amplifiers compared with the S/N 4 Package is the enclosure. The latest design includes provisions for remote handling, shock, vibration tolerance and more effective heat transfer paths from the individual amplifier components to the cast mounting base. The PCA, TSA, and TCA utilize the same cover and base assembly. The PSA is smaller because of the single magnetic stage required to meet the electrical performance. The electrical connector is mounted in the amplifier base and is guided to the mating receptacle by means of tapered pins mounted on the engine interface.

The thermocouple instrumentation leads are brought out through a milled slot in the amplifier base which may be sealed off for other environmental tests such as humidity, salt spray, and sand and dust.

Figures 23 through 25 show the mechanical packaging and component arrangement of the PSA amplifier.

The PCA amplifier is illustrated in Figures 26, 27, and 28. The various magnetic stages are identified in Figure 27.

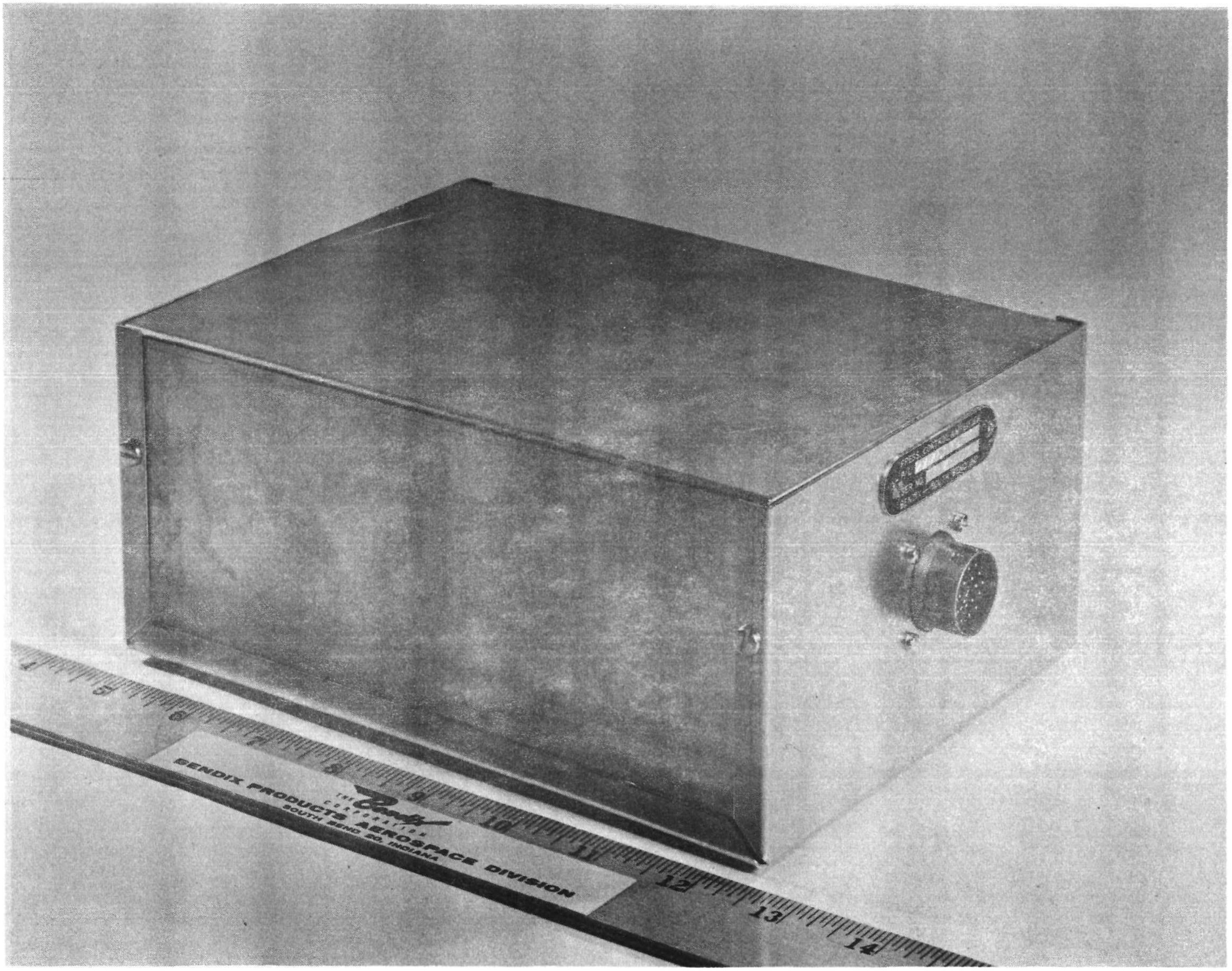


FIGURE 12 PCA AMPLIFIER, S/N 4 - COMPLETE ASSEMBLY

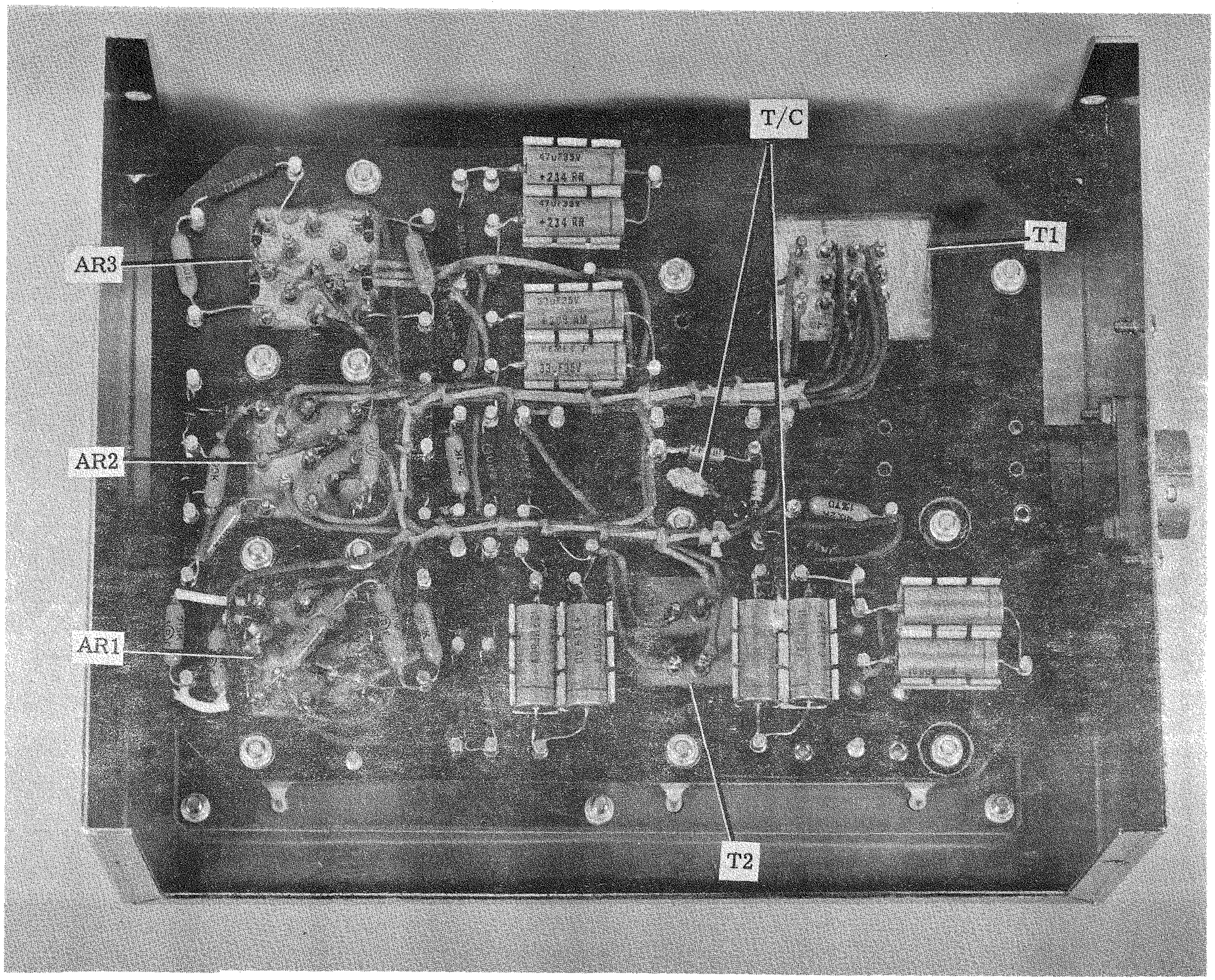


FIGURE 13 PCA AMPLIFIER, S/N 4 - TOP VIEW

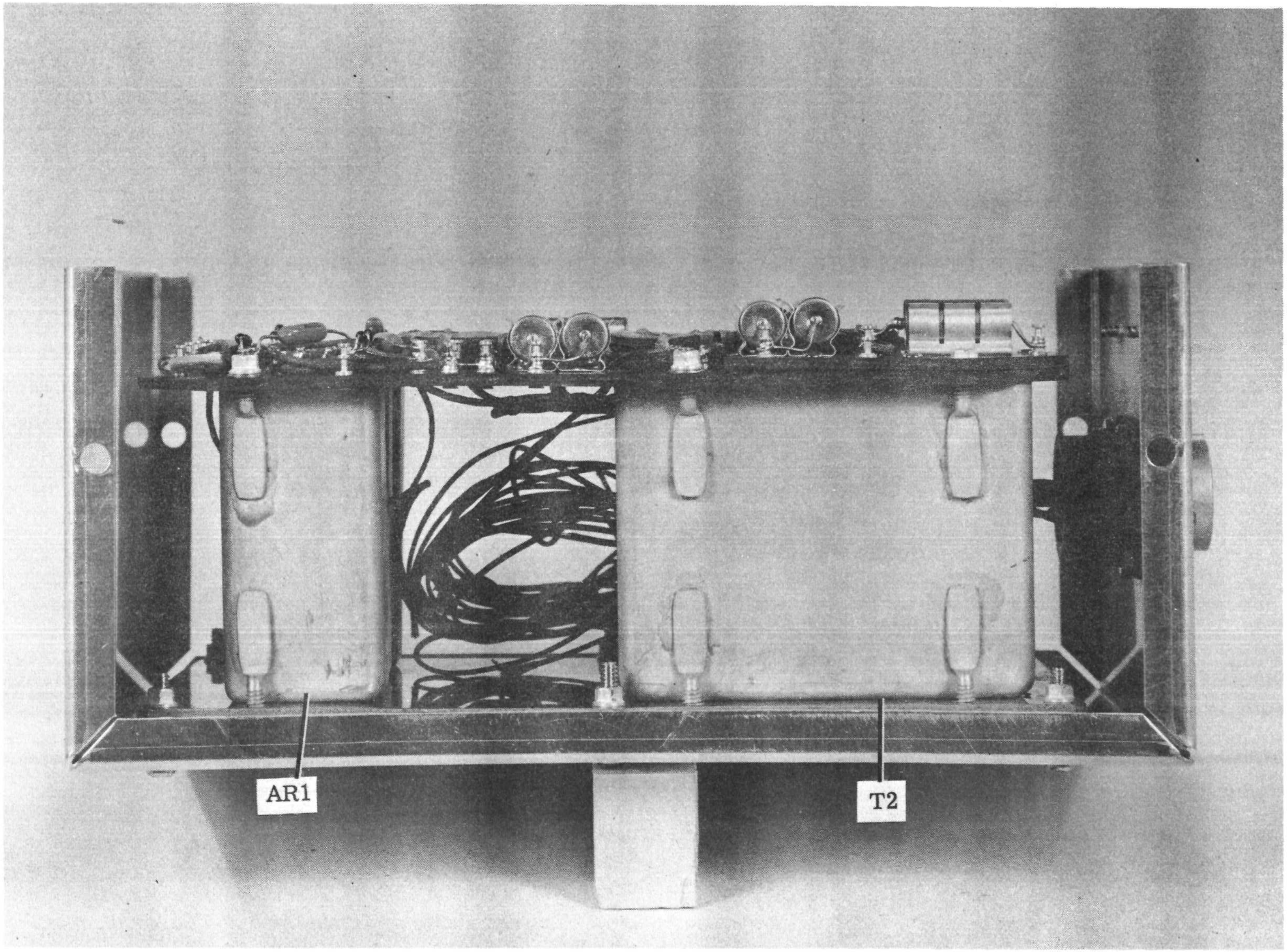


FIGURE 14 PCA AMPLIFIER, S/N 4 - SIDE VIEW

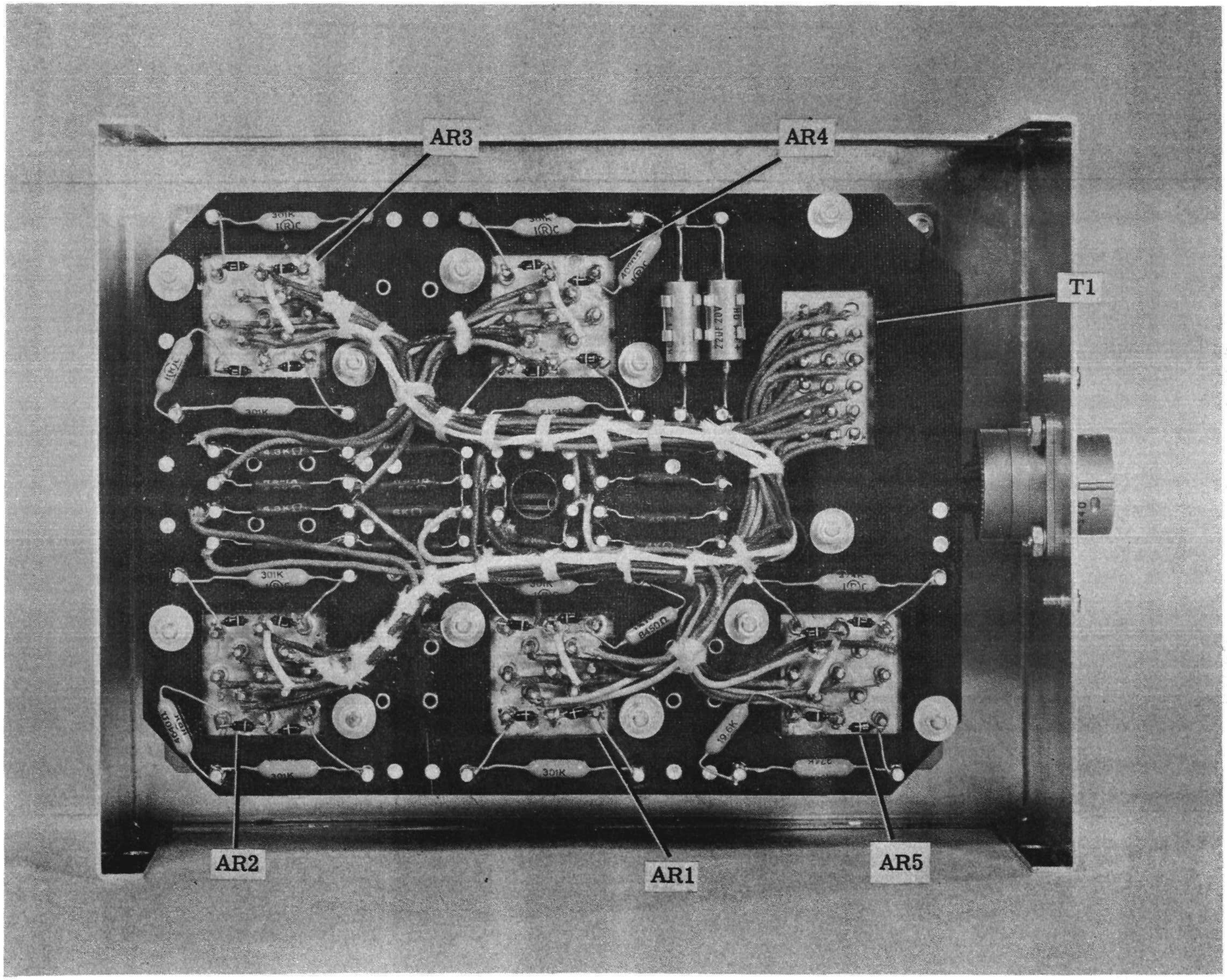


FIGURE 15 TSA AMPLIFIER, S/N 4 - TOP VIEW

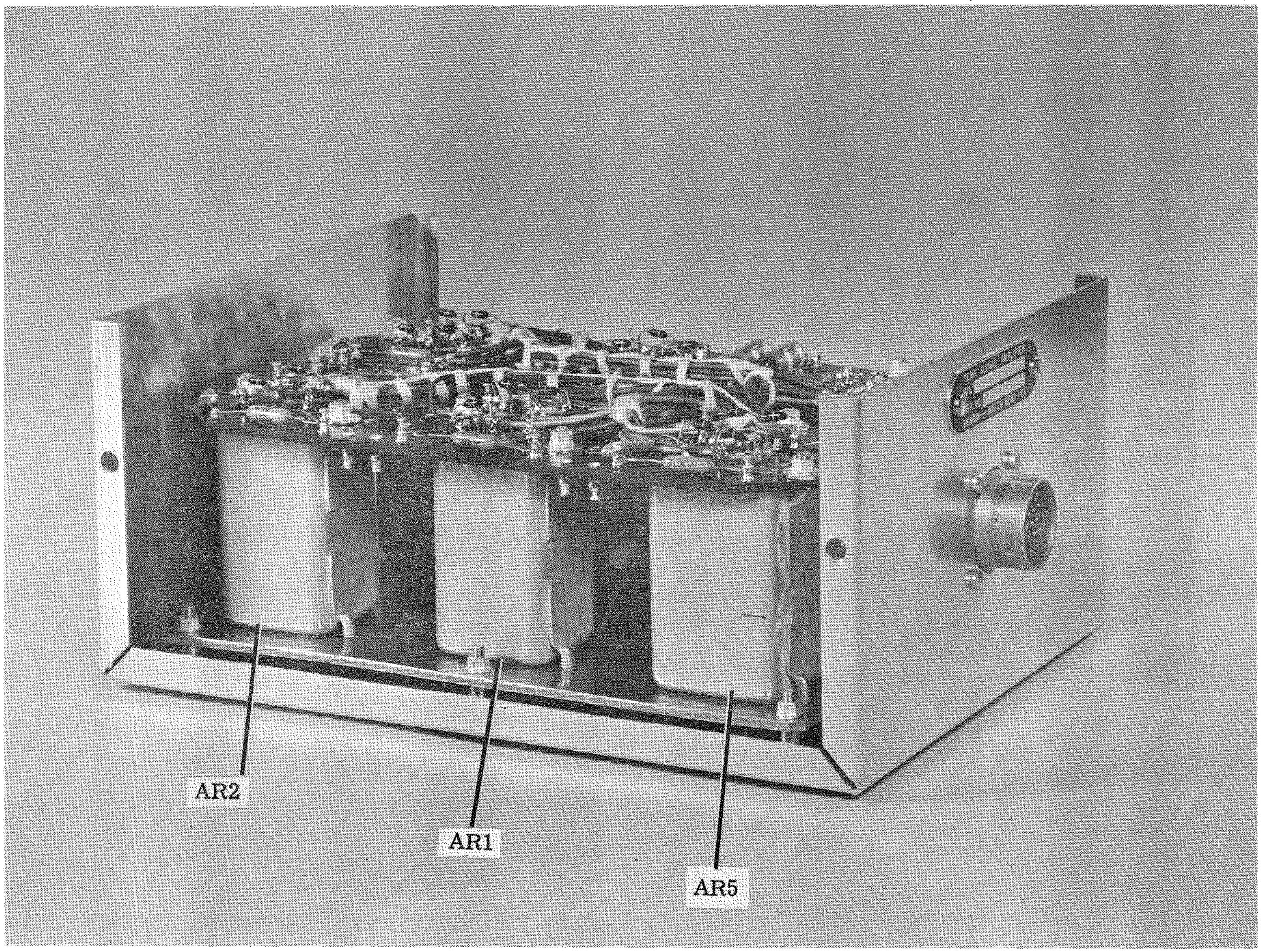


FIGURE 16 TSA AMPLIFIER, S/N 4 - SIDE VIEW

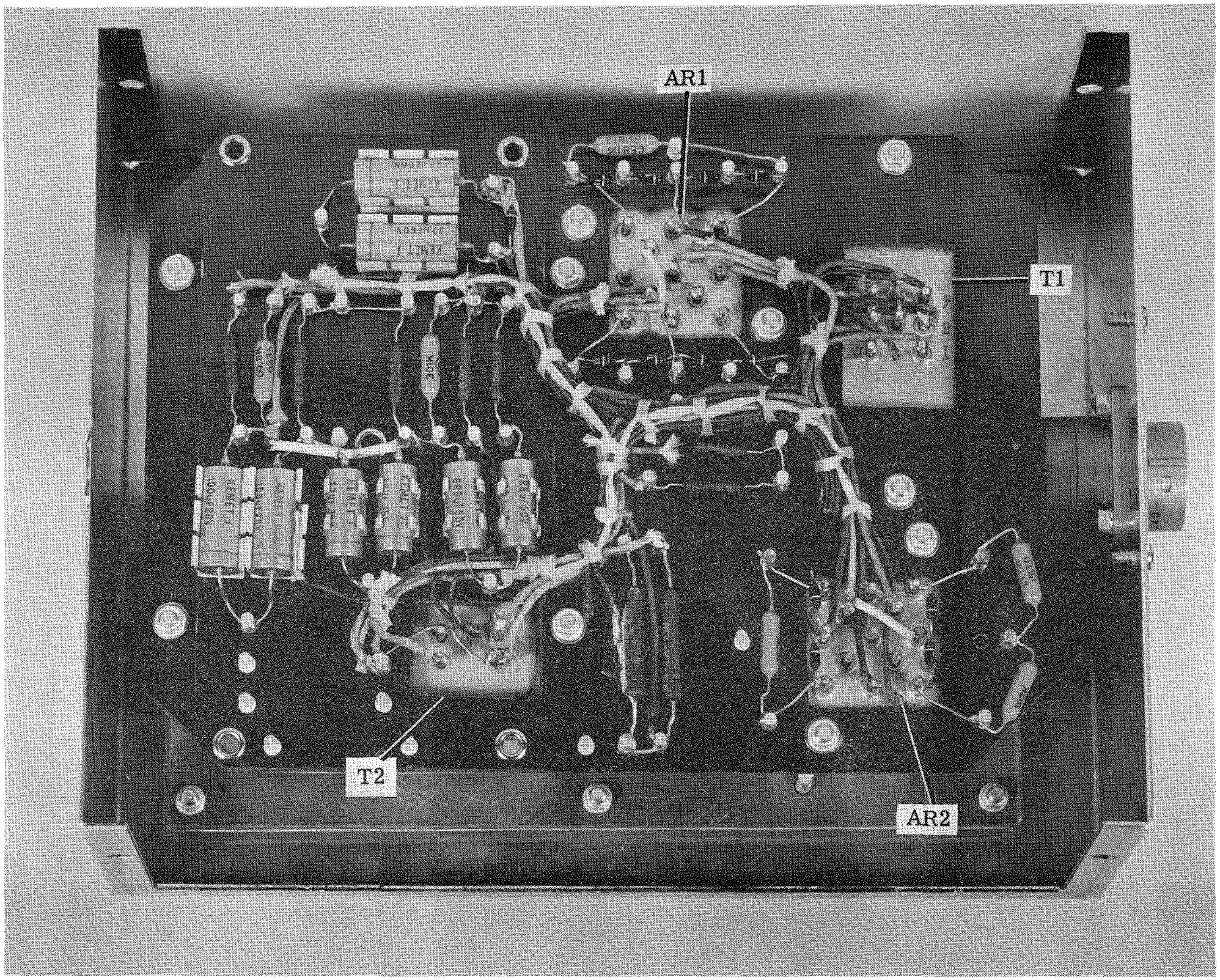


FIGURE 17   TCA AMPLIFIER, S/N 4 - TOP VIEW

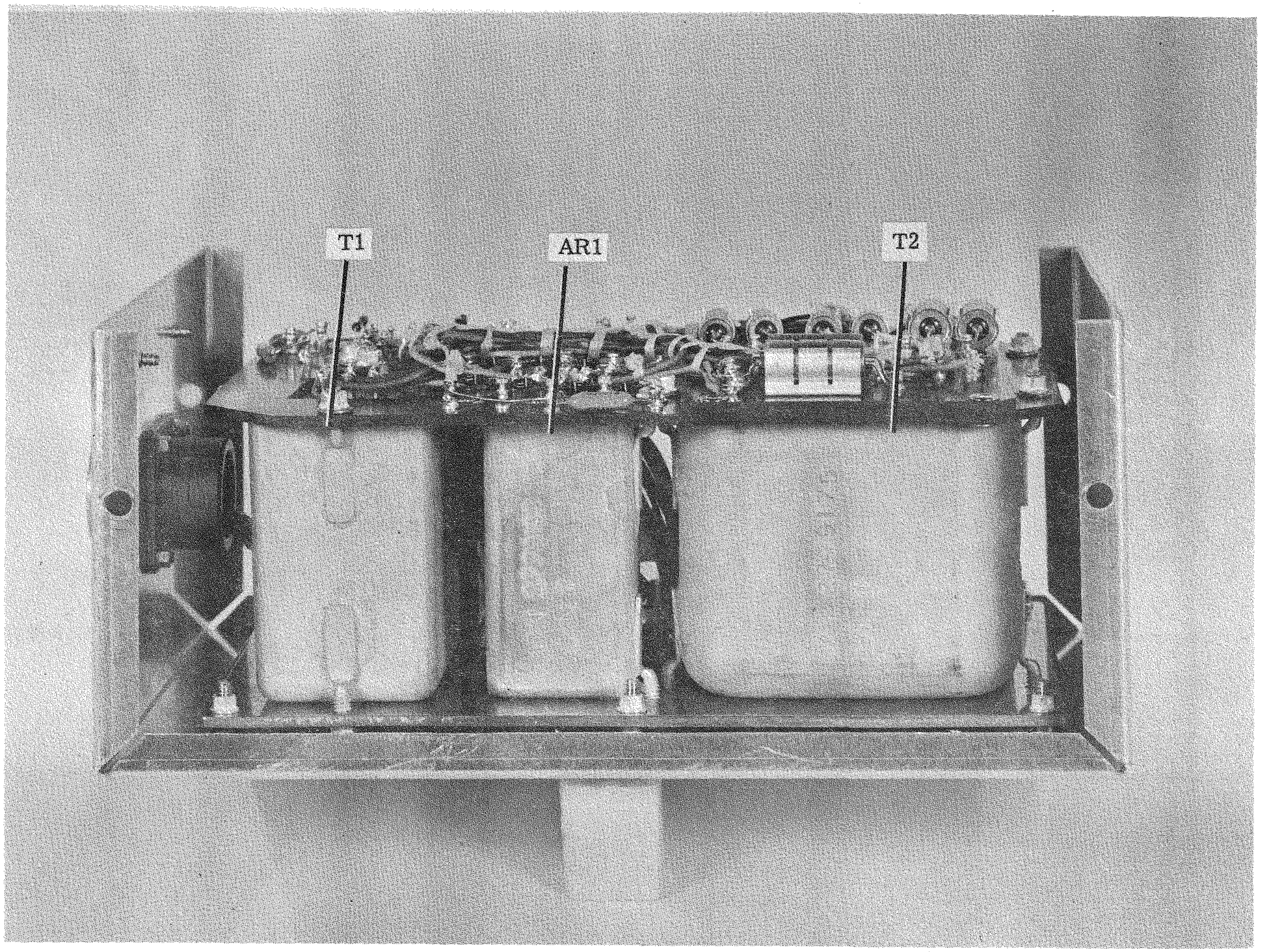


FIGURE 18 TCA AMPLIFIER, S/N 4 - SIDE VIEW

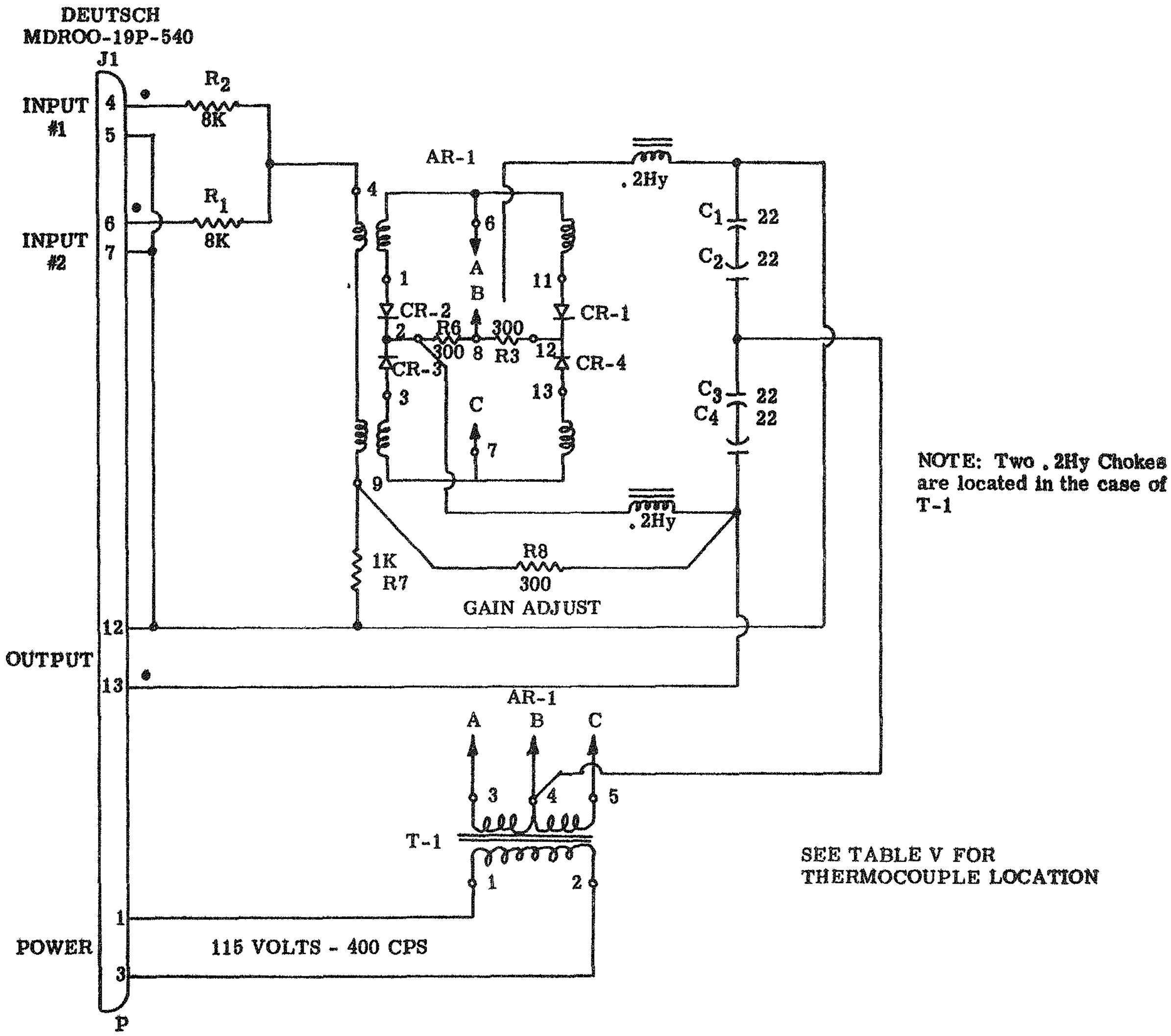


FIGURE 19 PSA, S/N 4 - SCHEMATIC DIAGRAM

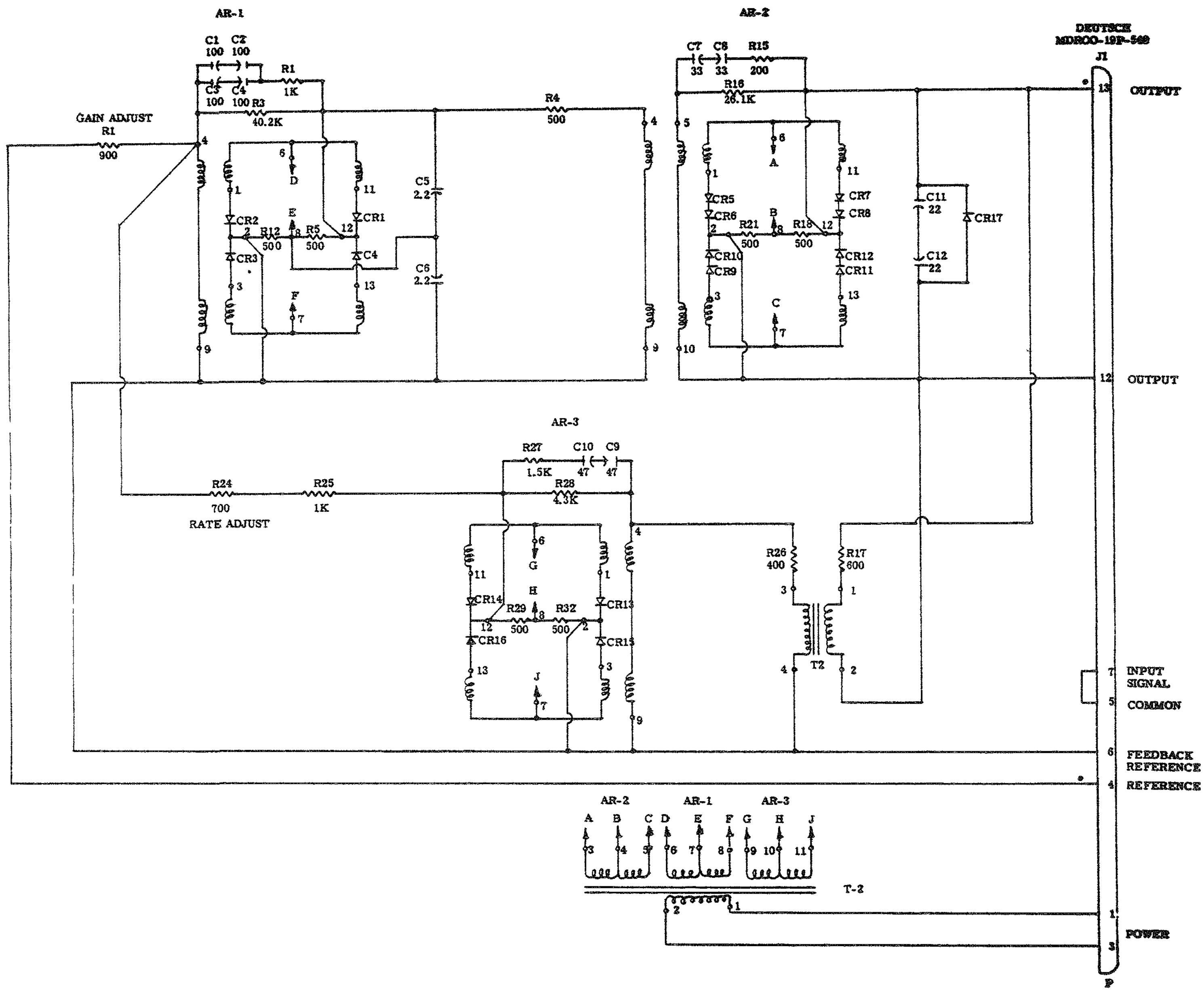


FIGURE 20 PCA, S/N 4 - SCHEMATIC DIAGRAM

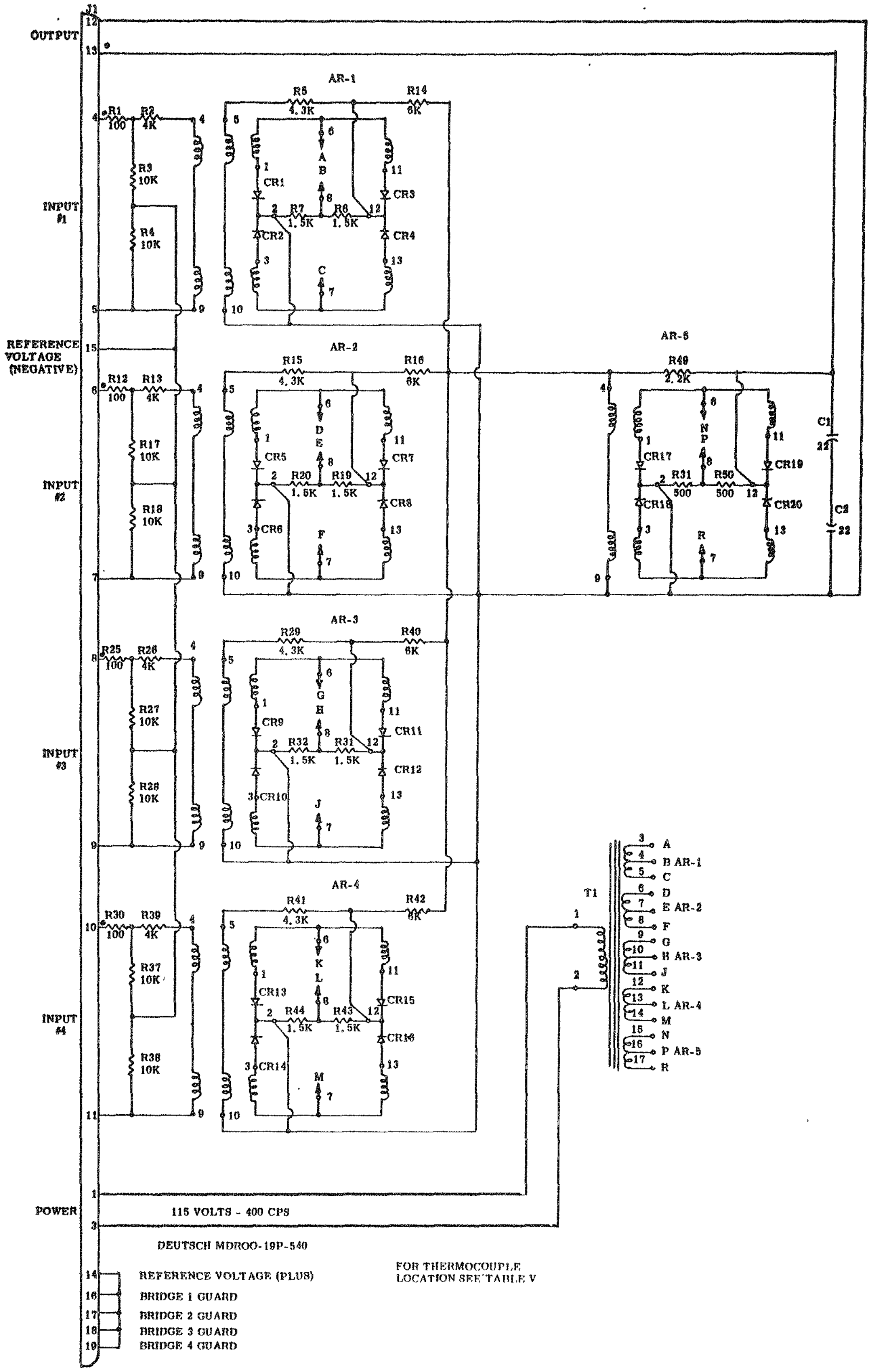


FIGURE 21 TSA, S/N 4 - SCHEMATIC DIAGRAM

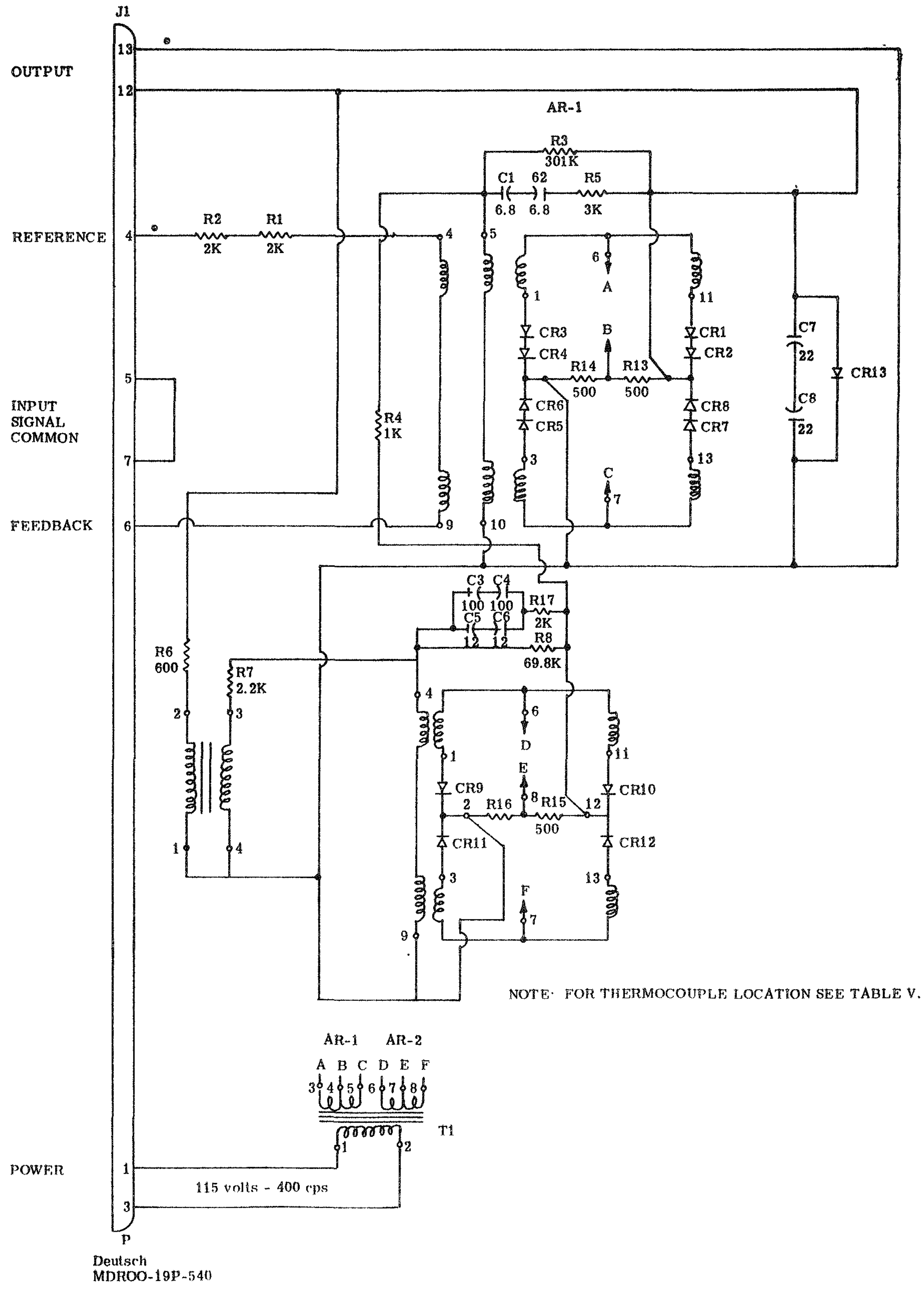


FIGURE 22 TCA, S/N 4 - SCHEMATIC DIAGRAM

The TSA and TCA amplifiers are shown in Figures 29 and 30. The exterior of these amplifiers are identical to the PCA with respect to size and connector location.

All of the system amplifiers, as well as the TPCV drive amplifier, are wired in accordance with the chart shown below.

WIRING SCHEDULE FOR
DEUTSCH MDR00-19P-540 CONNECTOR

Pin No.	Use
1	115 Volt, 400 Cps Power
2	Spare
3	115 Volt, 400 Cps Power
4	Input Number 1
5	Input Number 1 Return/Ground
6	Input Number 2
7	Input Number 2 Return/Ground
8	Input Number 3
9	Input Number 3 Return/Ground
10	Input Number 4
11	Input Number 4 Return/Ground
12	Signal Output - Low Side or Ground
13	Signal Output - High Side
14	Reference Positive
15	Reference Negative
16	Torque Motor Output Number 1/or Guard No. 1
17	Torque Motor Output Number 2/or Guard No. 2
18	Torque Motor Center Tap/or Guard No. 3
19	Torque Motor Center Tap/or Guard No. 4

Special tools, Deutsch P/N's M15513-20 and M15515-20 are required for pin insertion and removal.

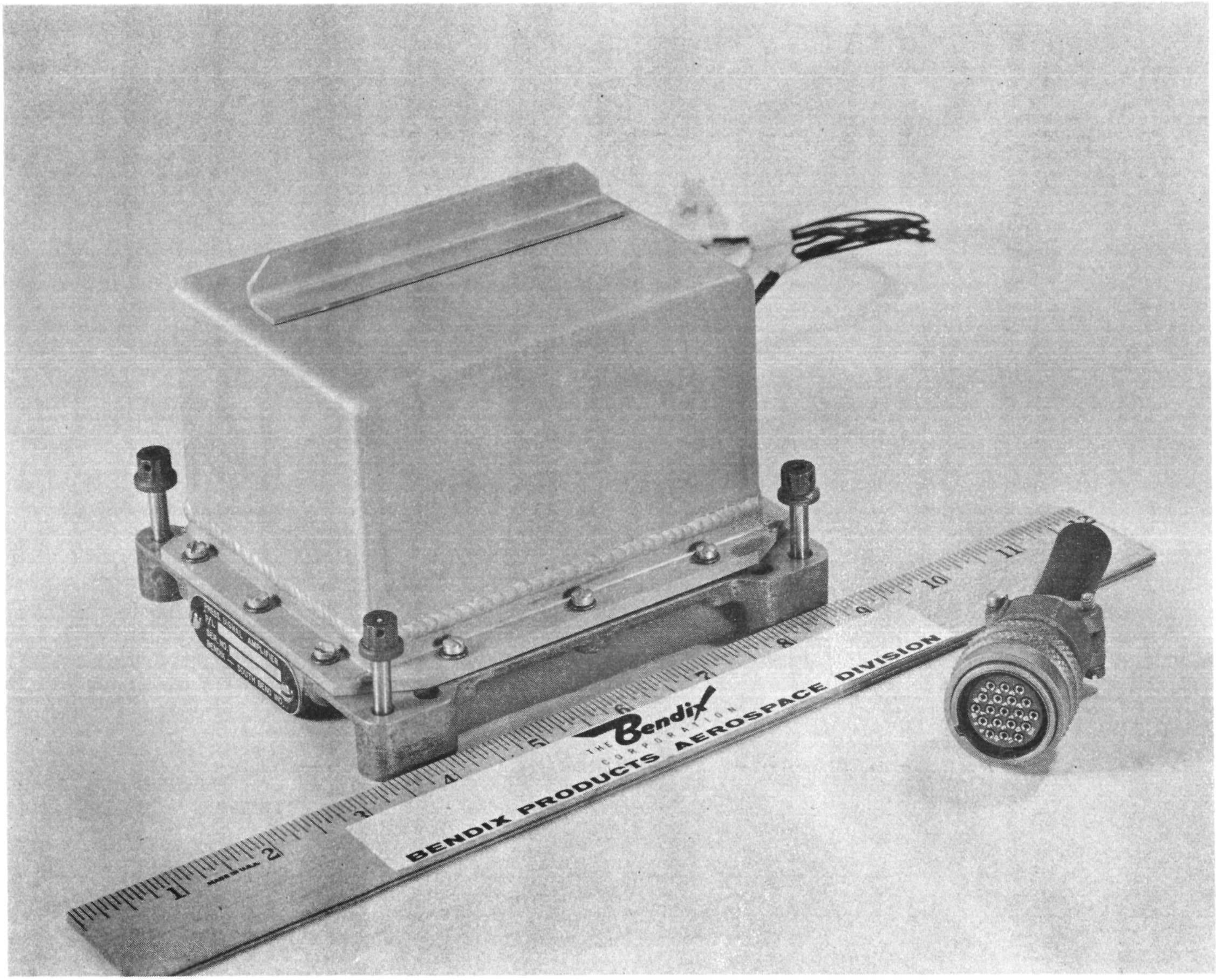


FIGURE 23 PSA AMPLIFIER, S/N 7 - COMPLETE ASSEMBLY

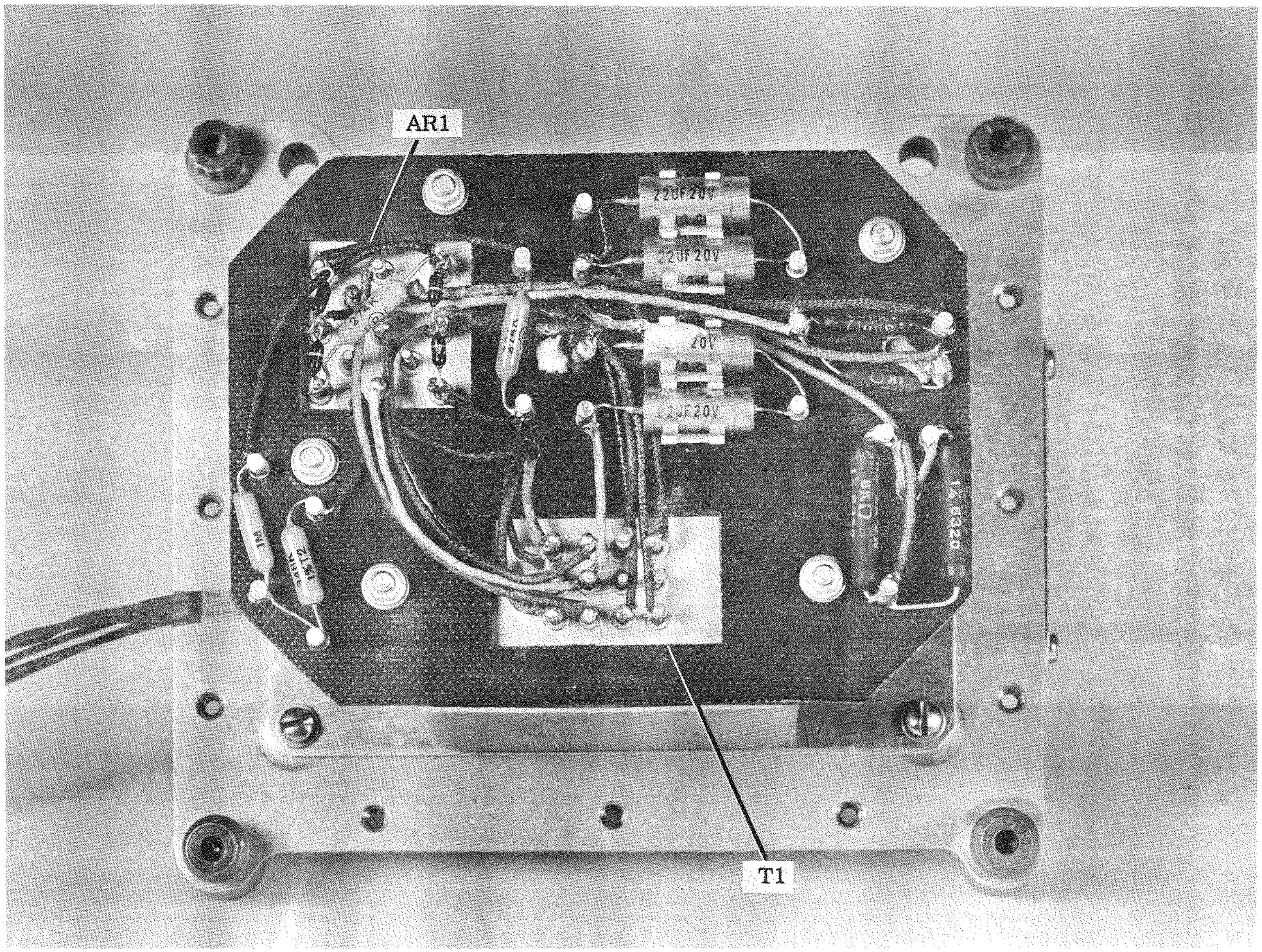


FIGURE 24 PSA AMPLIFIER, S/N 7 - TOP VIEW

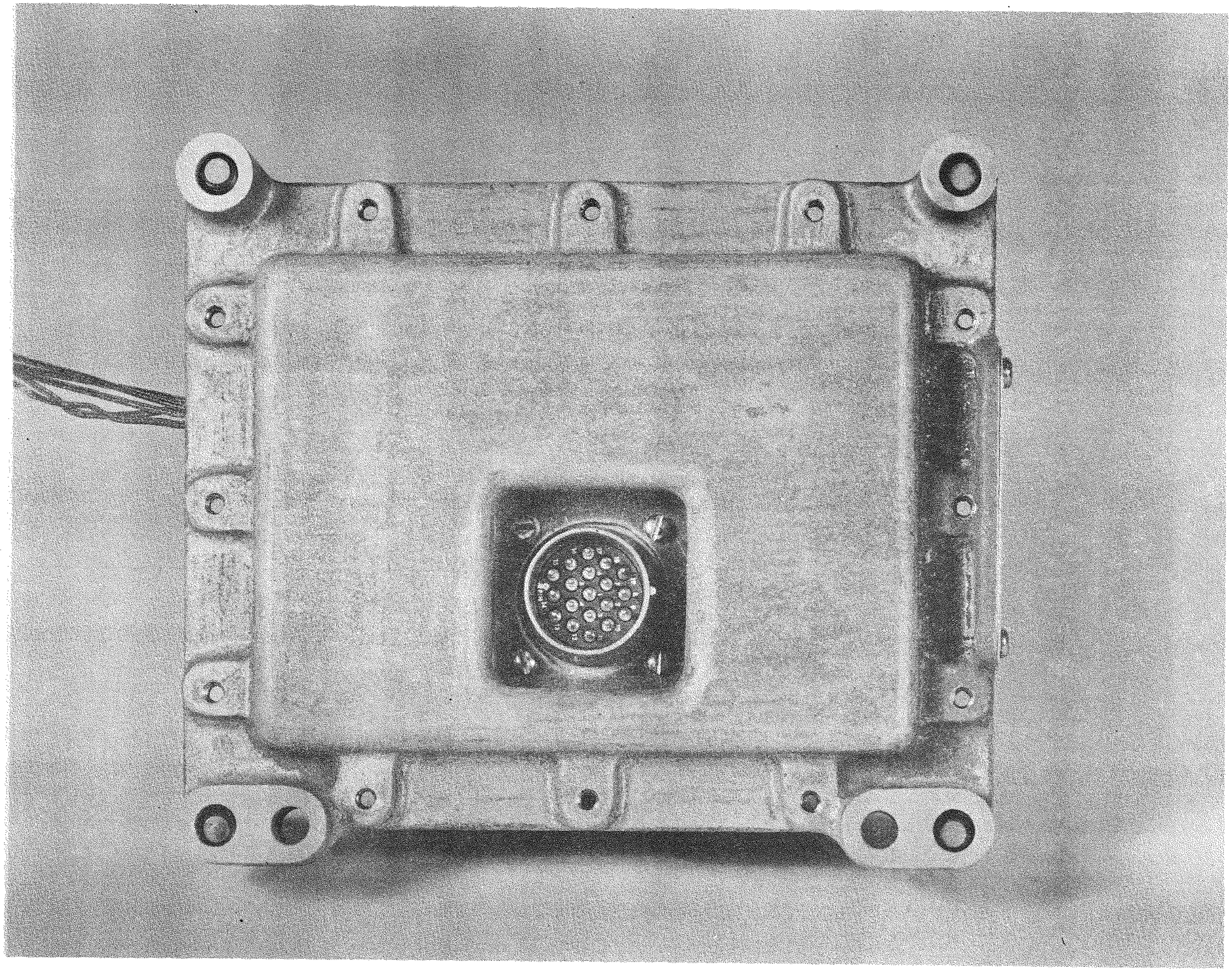


FIGURE 25 PSA AMPLIFIER, S/N 7 - BOTTOM VIEW

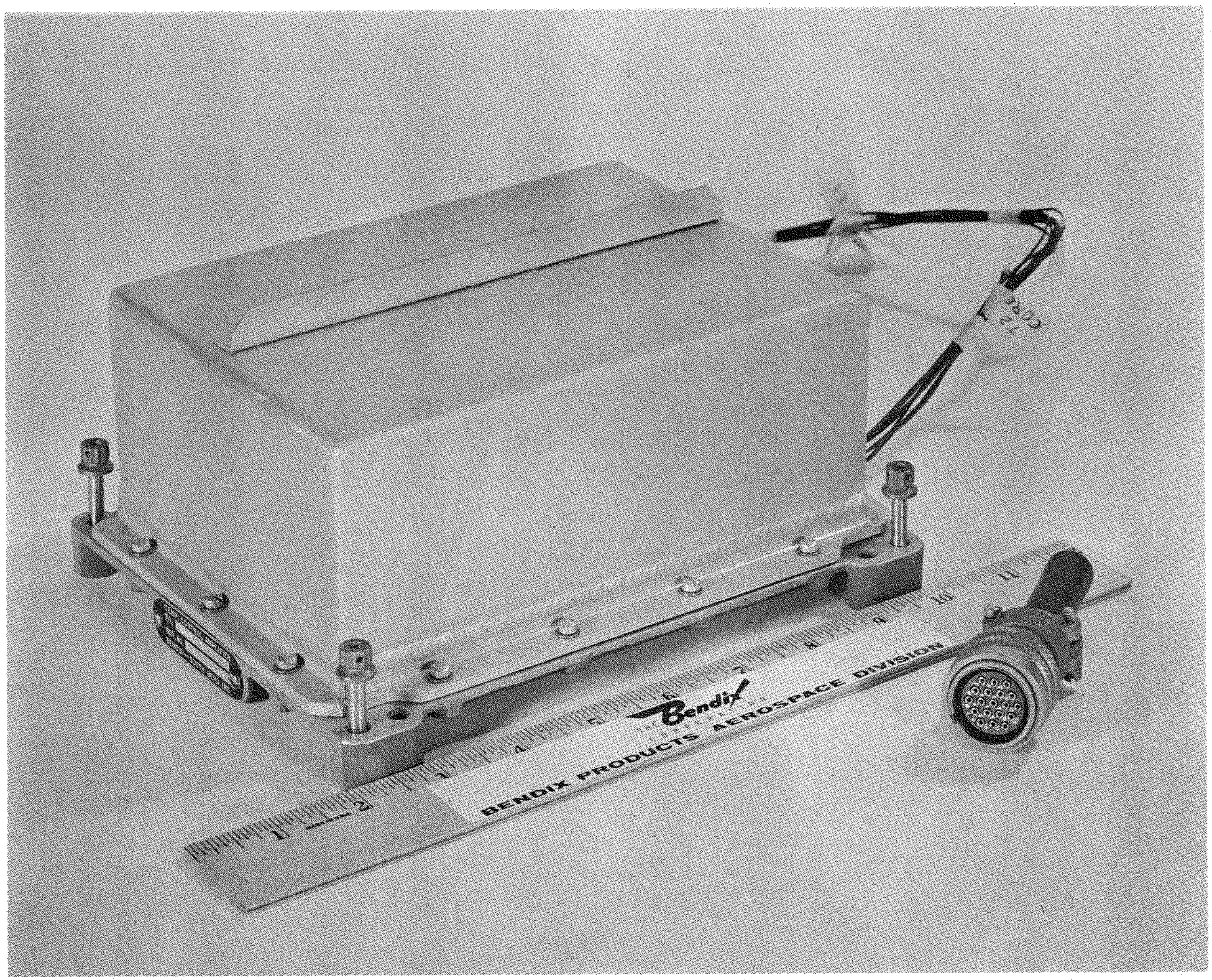


FIGURE 26 PCA AMPLIFIER, S/N 7 - COMPLETE ASSEMBLY

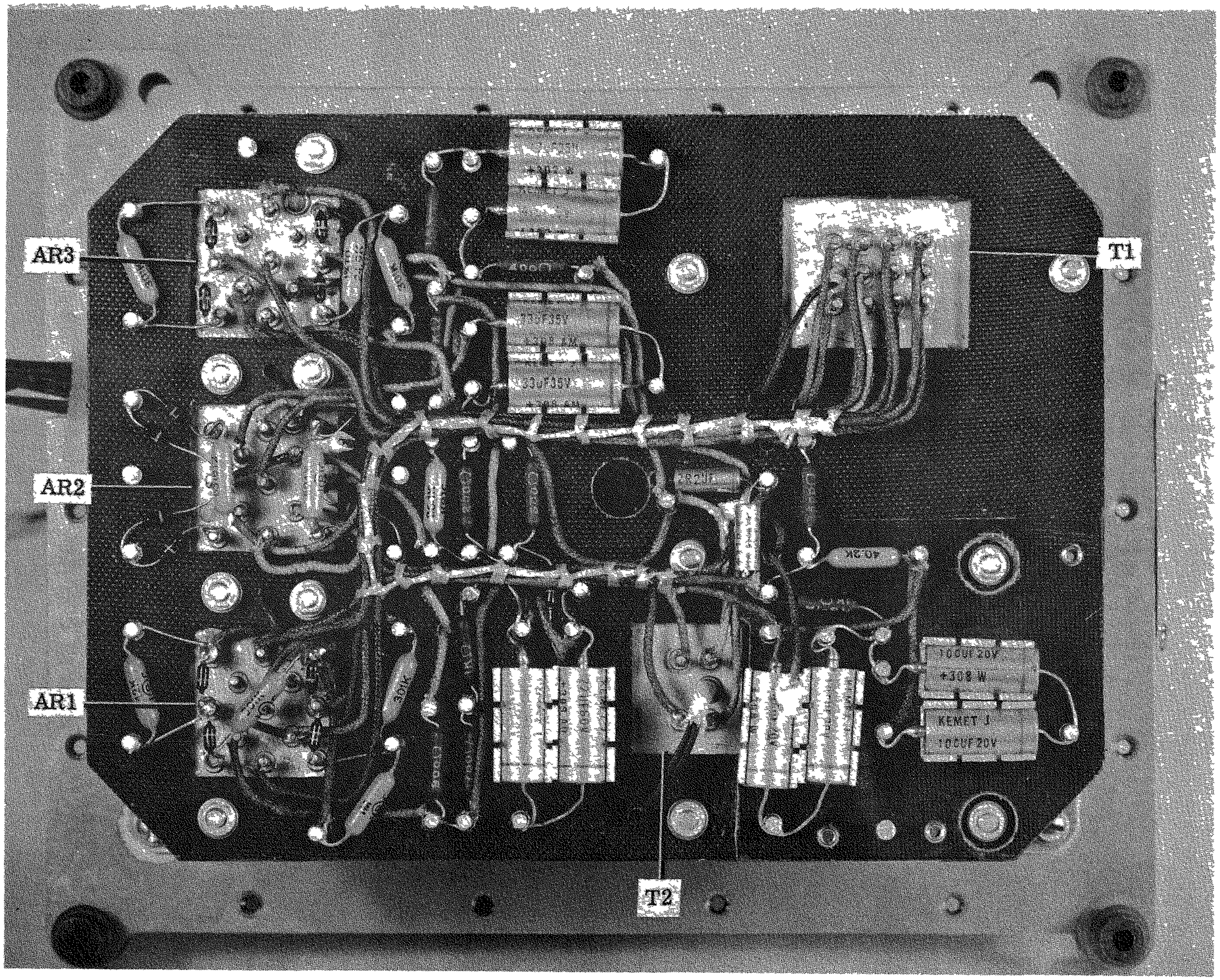


FIGURE 27 PCA AMPLIFIER, S/N 7 - TOP VIEW

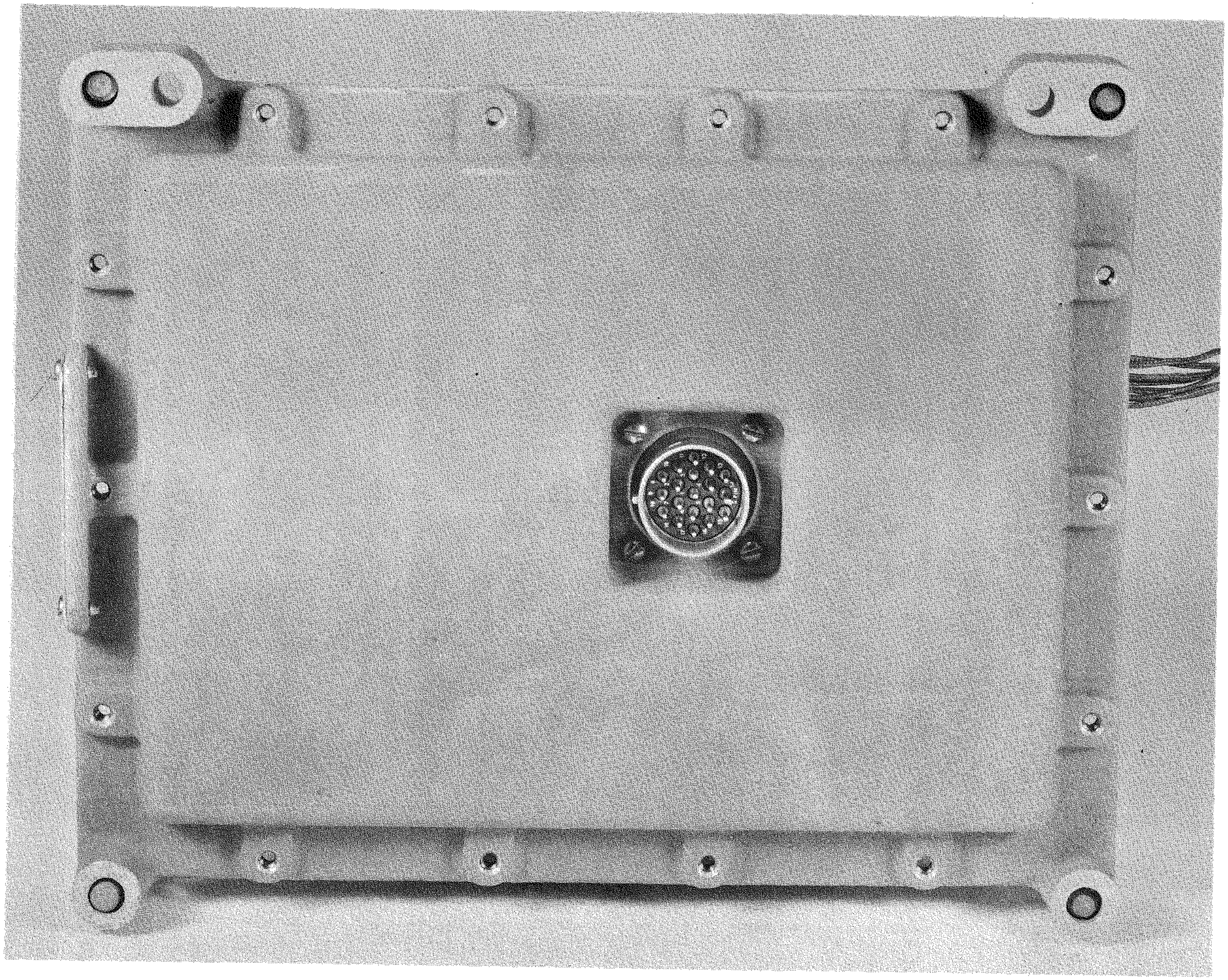


FIGURE 28 PCA AMPLIFIER, S/N 7 - BOTTOM VIEW

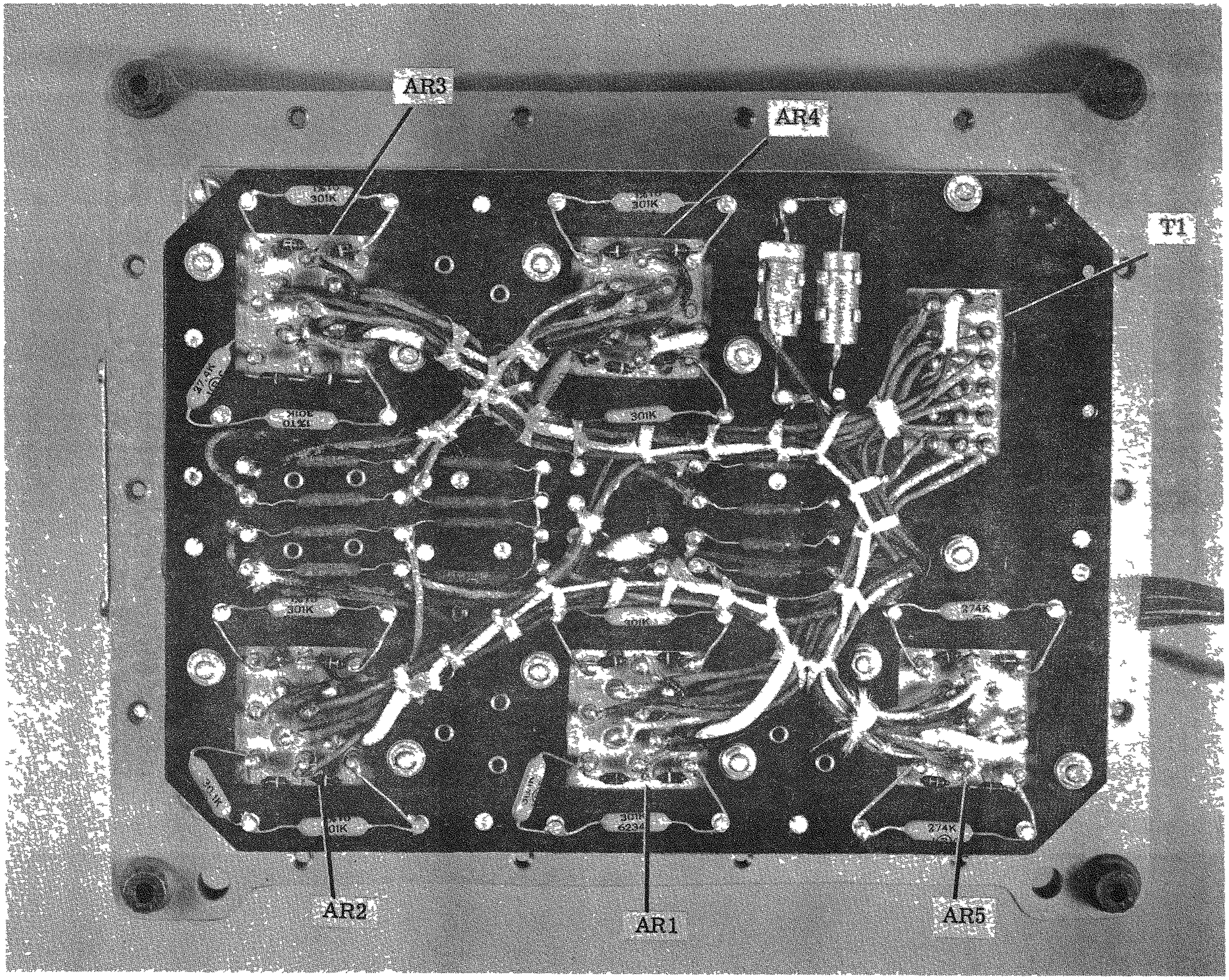


FIGURE 29 TSA AMPLIFIER, S/N 7 - TOP VIEW

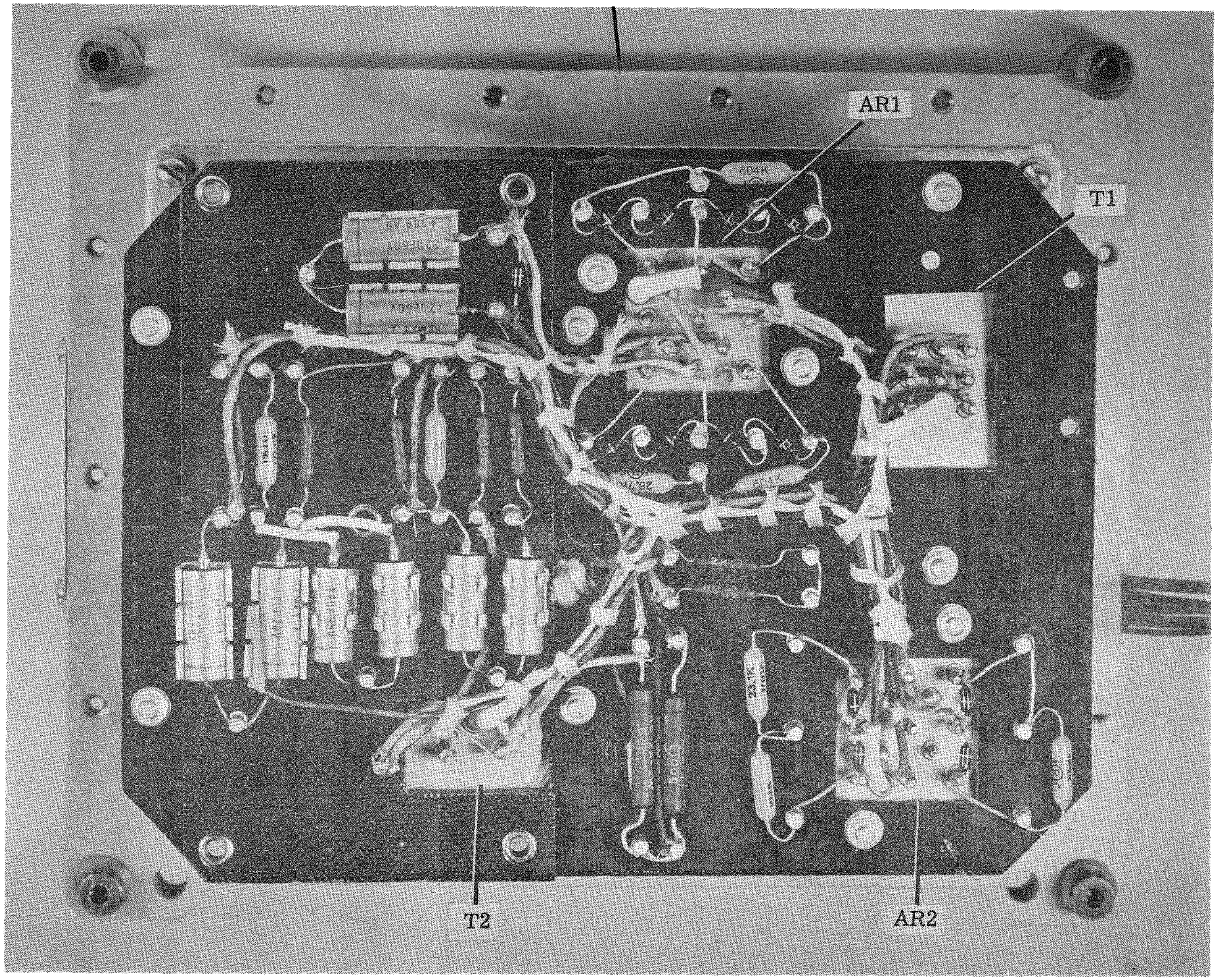


FIGURE 30 TCA AMPLIFIER, S/N 7 - TOP VIEW

4.3 RADIATION TOLERANT DIODE

The most sensitive component in the magnetic amplifier is the experimental silicon diode used to rectify the AC output voltage of the individual magnetic stages. Complete documentation is maintained on these devices to allow performance analysis and correlation of amplifier degradation as a result of exposure to nuclear radiation. Although the total accumulated fast neutron dose for the NERVA requirement (near the gimbal) is approximately 5×10^{13} $nv_{f}t$, the diode specification is based upon satisfactory performance out to 1×10^{16} $nv_{f}t$. This allows a comfortable margin for error in dosimetry during radiation tsts and provides for additional capability in terms of longer engine operating schedules and/or increased power levels.

The pre-irradiation limits of the critical diode parameters are:

Forward Voltage @ 250 ma:	0.95 volts @ 25°C maximum
Reverse Current @ 100 volts:	0.10 μ amps @ 25°C maximum
Reverse Current @ 100 volts:	10.0 μ amps @ 125°C maximum

Pre-irradiation diode characteristics, identification and location are listed in Tables II, III, and IV.

4.4 THERMOCOUPLE INSTRUMENTATION

Copper-constantan thermocouples made of #30 AWG have been mounted on representative resistors and capacitors and also inserted in several magnetic amplifier stages and power transformers to sample component temperature rise as a function of gamma radiation. Extension leads two foot long are brought out through a milled slot in the amplifier base for connection to the test cable harness. See Figures 9 through 18.

In many instances, the "hot" junction of the thermocouple is at electrical ground potential. It is important that the thermocouple recorder used in conjunction with these thermocouples have a balanced floating input type amplifier.

The thermocouple locations and identifications are shown in Table V.

TABLE II

DIODE IDENTIFICATION - SYSTEM AMPLIFIER PACKAGE S/N 4

Amplifier Type	Diode Ident.	Diode S/N	V_F (Volts) @ 25°C @ 250 ma	I_R (μ amps) @ 25°C @ 100 V	I_R (μ amps) @ 125°C @ 100 V
TSA					
P/N 2775016-1	CR-1	80	.901	.002	.21
Schematic	CR-2	81	.931	.011	.26
Diagram: 2779215	CR-3	82	.872	.032	.34
	CR-4	83	.872	.014	.29
	CR-5	84	.909	.007	.25
	CR-6	85	.899	.046	.80
	CR-7	86	.909	.001	.16
	CR-8	87	.900	.006	.30
	CR-9	88	.911	.006	.27
	CR-10	89	.932	.004	.31
	CR-11	90	.869	.011	.30
	CR-12	91	.908	.007	.25
	CR-13	92	.919	.034	.77
	CR-14	93	.909	.036	.56
	CR-15	94	.890	.030	.48
	CR-16	95	.899	.004	.28
	CR-17	96	.909	.002	.24
	CR-18	97	.939	.016	.36
	CR-19	98	.881	.002	.25
	CR-20	99	.890	.028	.42
PSA					
P/N 2775017-1	CR-1	114	.889	.030	.36
Schematic	CR-2	100	.909	.006	.25
Diagram: 2779216	CR-3	113	.909	.002	.20
	CR-4	115	.889	.005	.24
TCA					
P/N 2775018-1	CR-1	120	.871	.004	.20
Schematic	CR-2	121	.911	.062	.47
Diagram: 2779217	CR-3	116	.901	.002	.22
	CR-4	117	.911	.023	.31
	CR-5	119	.899	.011	.27

TABLE II (Continued)

Amplifier Type	Diode Ident.	Diode S/N	V_F (Volts) @ 25°C @ 250 ma	I_R (μ amps) @ 25°C @ 100 V	I_R (μ amps) @ 125°C @ 100 V
TCA (Continued)	CR-6	118	.911	.009	.23
	CR-7	123	.909	.004	.25
	CR-8	122	.901	.007	.24
	CR-9	125	.900	.001	.24
	CR-10	127	.871	.001	.21
	CR-11	126	.899	.006	.22
	CR-12	128	.909	.002	.20
	CR-13	124	.921	.013	.34
PCA					
P/N 2775019-1	CR-1	28	.899	.001	.30
Schematic	CR-2	26	.889	.062	.94
Diagram: 2779218	CR-3	27	.929	.001	.30
	CR-4	29	.899	.011	.70
	CR-5	30	.929	.002	.30
	CR-6	31	.890	.025	.46
	CR-7	35	.901	.047	1.20
	CR-8	36	.922	.014	.50
	CR-9	33	.909	.009	.36
	CR-10	32	.911	.017	.50
	CR-11	38	.879	.007	.40
	CR-12	37	.882	.008	.40
	CR-13	39	.879	.002	.32
	CR-14	41	.939	.020	.49
	CR-15	40	.889	.003	.30
	CR-16	42	.909	.045	.87
	CR-17	34	.889	.001	.25

TABLE III

DIODE IDENTIFICATION - SYSTEM AMPLIFIER PACKAGE S/N 5

Amplifier Type	Diode Ident.	Diode S/N	V_F (Volts) @ 25°C @ 250 ma	I_R (μ amps) @ 25°C @ 100 V	I_R (μ amps) @ 125°C @ 100 V
TSA					
P/N 2775016-2	CR-1	352	.892	.006	1.35
Schematic	CR-2	353	.874	.008	2.50
Diagram: 2779215	CR-3	354	.899	.013	1.70
	CR-4	355	.932	.008	2.00
	CR-5	356	.891	.010	2.50
	CR-6	357	.934	.009	1.90
	CR-7	358	.919	.007	1.90
	CR-8	359	.899	.011	2.00
	CR-9	360	.920	.007	2.50
	CR-10	361	.940	.008	2.50
	CR-11	362	.944	.006	2.85
	CR-12	363	.922	.005	1.50
	CR-13	364	.929	.007	2.00
	CR-14	365	.944	.007	1.60
	CR-15	366	.920	.010	2.00
	CR-16	367	.882	.008	2.50
	CR-17	368	.889	.015	3.00
	CR-18	369	.909	.006	1.55
	CR-19	370	.903	.007	1.15
	CR-20	371	.880	.007	2.00
PSA					
P/N 2775017-2	CR-1	340	.924	.006	1.20
Schematic	CR-2	338	.912	.008	2.50
Diagram: 2779216	CR-3	339	.929	.010	1.50
	CR-4	341	.899	.007	3.20

TABLE III (Continued)

Amplifier Type	Diode Ident.	Diode S/N	V_F (Volts) @ 25°C @ 250 ma	I_R (μ amps) @ 25°C @ 100 V	I_R (μ amps) @ 125°C @ 100 V
TCA	CR-1	176	.934	.008	2.10
P/N 2775018-2	CR-2	177	.913	.008	2.50
Schematic	CR-3	172	.943	.008	2.40
Diagram: 2779218	CR-4	173	.919	.008	2.20
	CR-5	175	.919	.009	2.00
	CR-6	174	.950	.007	1.85
	CR-7	179	.912	.010	2.60
	CR-8	178	.914	.010	2.40
	CR-9	181	.914	.008	2.70
	CR-10	183	.950	.007	2.50
	CR-11	182	.912	.010	2.60
	CR-12	184	.922	.007	1.92
	CR-13	180	.904	.006	2.70
PCA					
P/N 2775019-2	CR-1	153	.950	.006	1.60
Schematic	CR-2	151	.890	.009	1.75
Diagram: 2779218	CR-3	152	.907	.006	1.60
	CR-4	154	.950	.006	1.65
	CR-5	155	.934	.009	1.60
	CR-6	156	.950	.009	1.65
	CR-7	160	.900	.014	1.60
	CR-8	161	.901	.004	1.30
	CR-9	158	.912	.007	1.24
	CR-10	157	.911	.008	1.65
	CR-11	163	.950	.008	3.00
	CR-12	162	.911	.005	1.50
	CR-13	164	.944	.008	3.00
	CR-14	166	.943	.006	1.50
	CR-15	165	.934	.006	1.70
	CR-16	167	.910	.006	1.20
	CR-17	159	.950	.006	1.25

TABLE IV

DIODE IDENTIFICATION - SYSTEM AMPLIFIER PACKAGE S/N 7

Amplifier Type	Diode Ident.	Diode S/N	V_F (Volts) @ 25°C @ 250 ma	I_R (μ amps) @ 25°C @ 100 V	I_R (μ amps) @ 125°C @ 100 V
TSA					
P/N 2775016-3	CR-1	257	.909	.010	1.25
Schematic	CR-2	258	.949	.008	1.65
Diagram: 2779215	CR-3	259	.871	.017	1.80
	CR-4	260	.922	.012	1.77
	CR-5	245	.929	.008	1.45
	CR-6	246	.920	.007	1.13
	CR-7	247	.889	.005	.87
	CR-8	248	.909	.008	1.25
	CR-9	253	.939	.011	1.50
	CR-10	254	.899	.009	1.80
	CR-11	255	.889	.010	1.40
	CR-12	256	.922	.006	1.10
	CR-13	249	.911	.008	1.35
	CR-14	250	.949	.005	1.15
	CR-15	251	.939	.006	1.05
	CR-16	252	.880	.006	1.10
	CR-17	261	.910	.007	1.40
	CR-18	262	.912	.006	1.94
	CR-19	263	.899	.013	1.45
	CR-20	264	.912	.007	1.50
PSA					
P/N 2775017-3	CR-1	374	.901	.009	2.00
Schematic	CR-2	372	.871	.006	1.65
Diagram: 2779216	CR-3	373	.891	.009	2.30
	CR-4	375	.895	.006	2.00

TABLE IV (Continued)

Amplifier Type	Diode Ident.	Diode S/N	V_F (Volts) @ 25°C @ 250 ma	I_R (μ amps) @ 25°C @ 100 V	I_R (μ amps) @ 125°C @ 100 V
TCA					
P/N 2775018-3	CR-1	189	.903	.009	2.50
Schematic	CR-2	190	.904	.010	2.60
Diagram: 2779217	CR-3	185	.909	.007	2.45
	CR-4	186	.941	.008	3.00
	CR-5	188	.882	.006	2.50
	CR-6	187	.883	.011	3.00
	CR-7	192	.909	.006	2.70
	CR-8	191	.933	.009	2.90
	CR-9	197	.949	.006	.77
	CR-10	195	.950	.009	1.15
	CR-11	194	.943	.011	.84
	CR-12	196	.929	.009	1.10
	CR-13	193	.942	.005	.65
PCA					
P/N 2775019-3	CR-1	217	.889	.011	.82
Schematic	CR-2	215	.950	.019	1.25
Diagram: 2779218	CR-3	216	.909	.012	1.49
	CR-4	218	.920	.006	1.15
	CR-5	219	.939	.006	1.80
	CR-6	220	.898	.009	1.45
	CR-7	224	.949	.006	1.50
	CR-8	225	.901	.014	1.55
	CR-9	222	.949	.011	1.65
	CR-10	221	.950	.008	1.90
	CR-11	227	.940	.006	1.80
	CR-12	226	.929	.009	1.15
	CR-13	228	.899	.009	2.10
	CR-14	230	.930	.007	1.60
	CR-15	229	.929	.004	.60
	CR-16	231	.919	.006	1.45
	CR-17	223	.912	.009	1.58

TABLE V

THERMOCOUPLE LOCATION

Amplifier	Thermocouple No.	Location
PSA	1	AR-1 Core
	2	Terminal Board (Between AR-1 and T-1)
	3	T-1 Transformer Core
	4	C-2 Capacitor Body
	5 **	Amplifier Base Plate
PCA	1	AR-1 Core
	2	AR-2 Core
	3	Terminal Board (Between T-2 and AR-1)
	4	T-1 Transformer Core
	5 *	T-2 Transformer Core
	6 *	T-2 Transformer Winding
	7	C-1 Capacitor Body
	8	R-21 Resistor Body
	9 **	Amplifier Base Plate
TSA	1	AR-1 Core
	2	AR-2 Winding (Outside)
	3	AR-5 Core
	4	Terminal Board (Center)
	5	T-1 Transformer Core
	6	C-2 Capacitor Body
	7 **	Amplifier Base Plate
TCA	1	AR-1 Core
	2	AR-2 Core
	3	Terminal Board (Center)
	4	T-1 Transformer Core
	5	T-2 Transformer Core
	6	T-2 Transformer Winding
	7	C-4 Capacitor Body
	8	R-13 Resistor Body
	9 *	Amplifier Base Plate

* The Rate Transformer, T-2, in the S/N 5 Pressure Control Amplifier will be replaced by a similar component which has additional thermocouples for providing temperature profile data. The location of these thermocouples are shown in Figure 2.

** These thermocouples are installed in the S/N 7 System Package only and are identified by the part number change from -2 to -3. See Section 1.

SECTION 5

PERFORMANCE OF SYSTEM AMPLIFIER PACKAGE S/N 4

5.1 PSA, S/N 4, PERFORMANCE DATA

The PSA, S/N 4, performance was measured at -260° F, 75° F, and again at +250° F. The test results have been tabulated and presented in Table VI and Figures 31 through 34.

TABLE VI

PSA, P/N 2775017-1 STATIC CHARACTERISTICS

Ambient Temp.	-260°F			+75°F			+250°F		
Line Voltage	103	115	127	103	115	127	103	115	127
Line Frequency	360	400	440	360	400	440	360	400	440
Input Null (millivolts)	-15.1	-11.3	-2.73	-4.27	-0.30	+6.36	-10.6	-8.85	-6.51
Gain (volts/volt @ +4.0 volts output)	1.31	1.31	1.32	1.31	1.31	1.32	1.28	1.28	1.28
Linearity - % (Ref: 5.75 volts)	0.34	0.27	0.23	0.19	0.14	0.10	0.34	0.22	0.19
Saturation Level (volts)	11.3	12.1	12.8	8.80	9.50	10.1	7.40	8.50	9.40

PSA PERFORMANCE DATA

Output Ripple Voltage (Reflected to 10-ohm command source)	3.3 millivolts
Input Impedance	
Non-Operating (Higher when operating)	12.2 K ohms (per channel)
Output Impedance	
Operating	12 ohms
Roll-Off Frequency (3 DB point)	20 cps
Power Consumption	
Null	1.5 watts
Saturation	2.0 watts
Weight	1.8 pounds

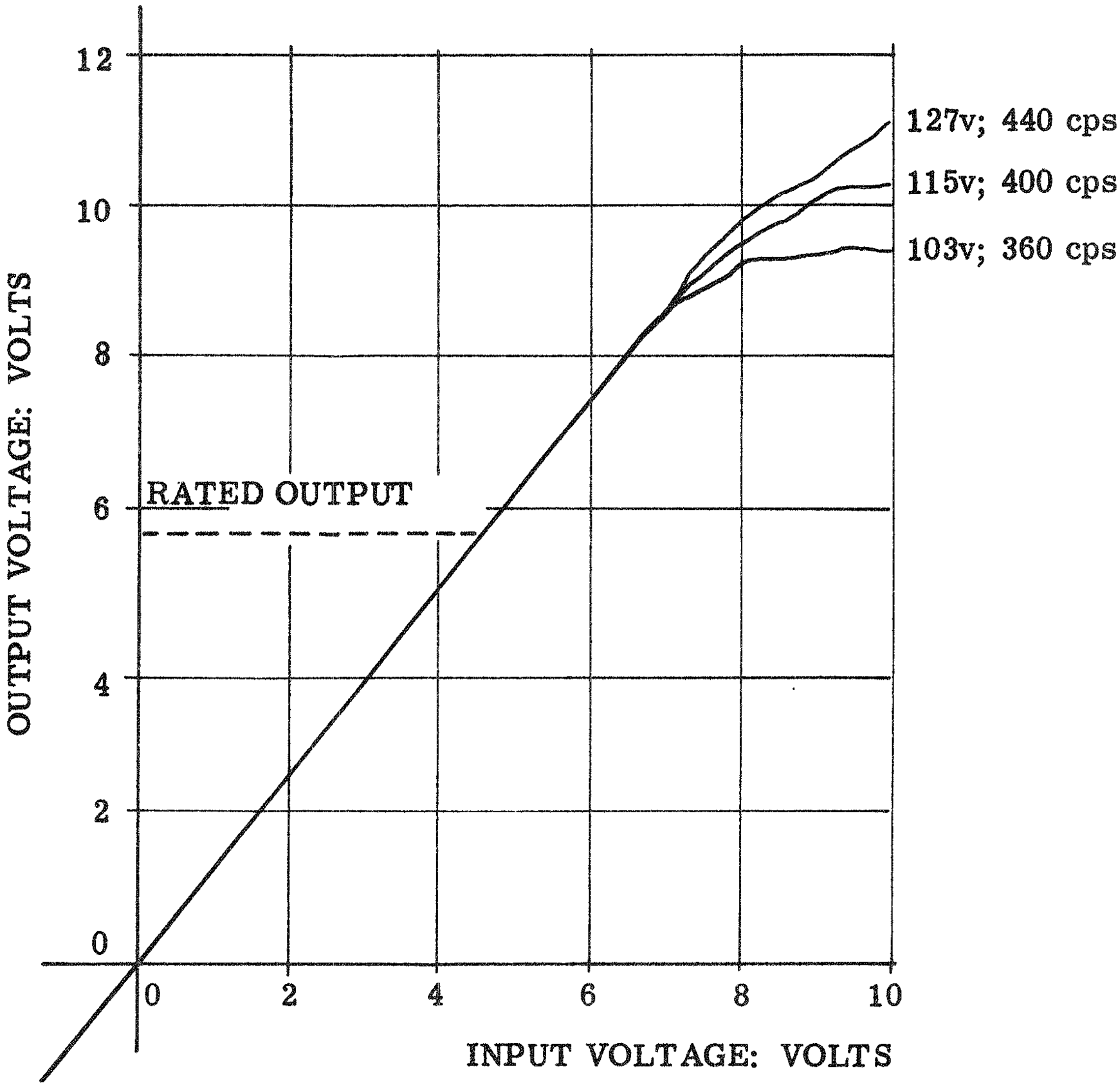


FIGURE 31 PSA, S/N 4 - LINEARITY AT +75° F.

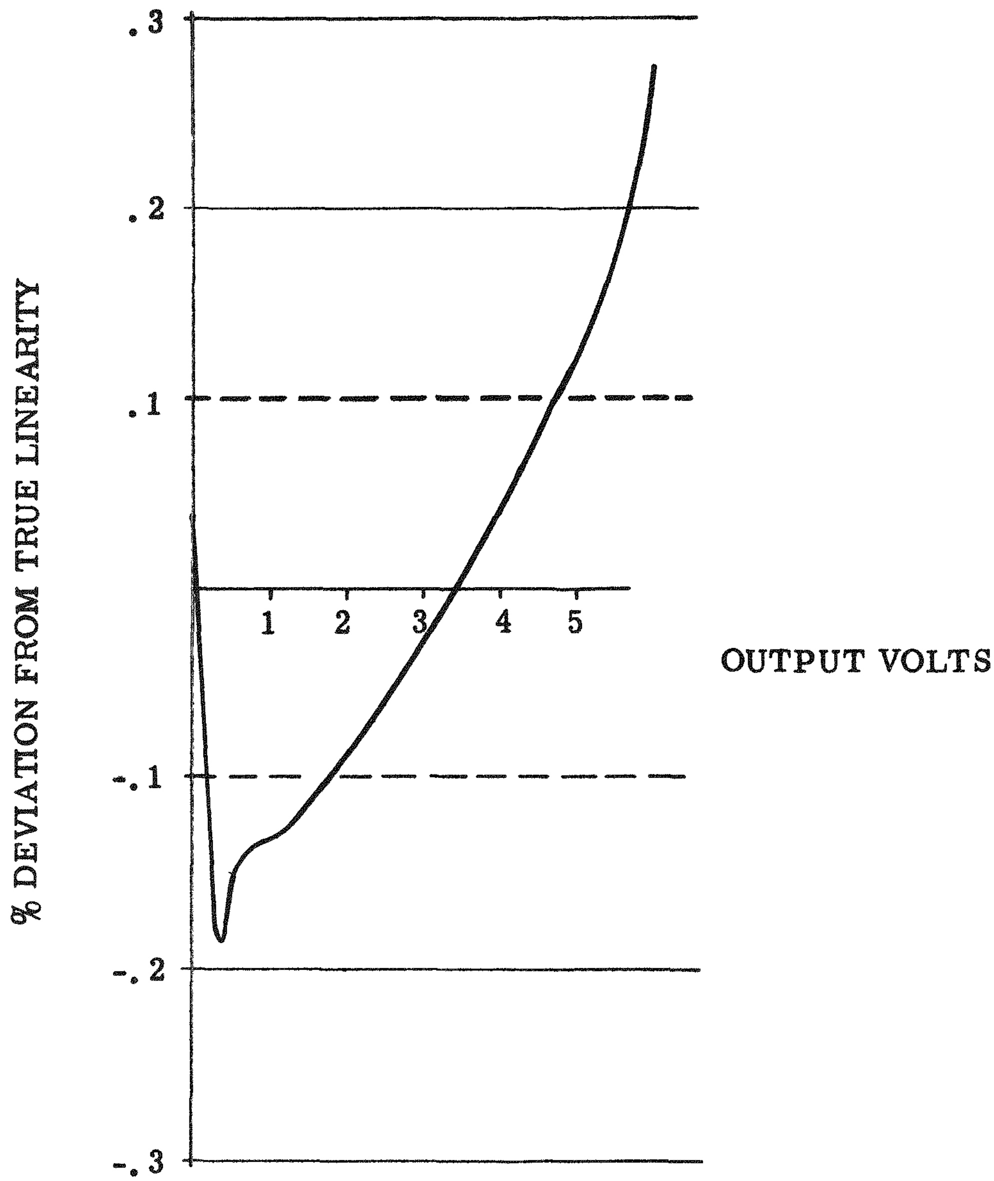


FIGURE 32 PSA, S/N 4 - LINEARITY DEVIATION AT -260° F.

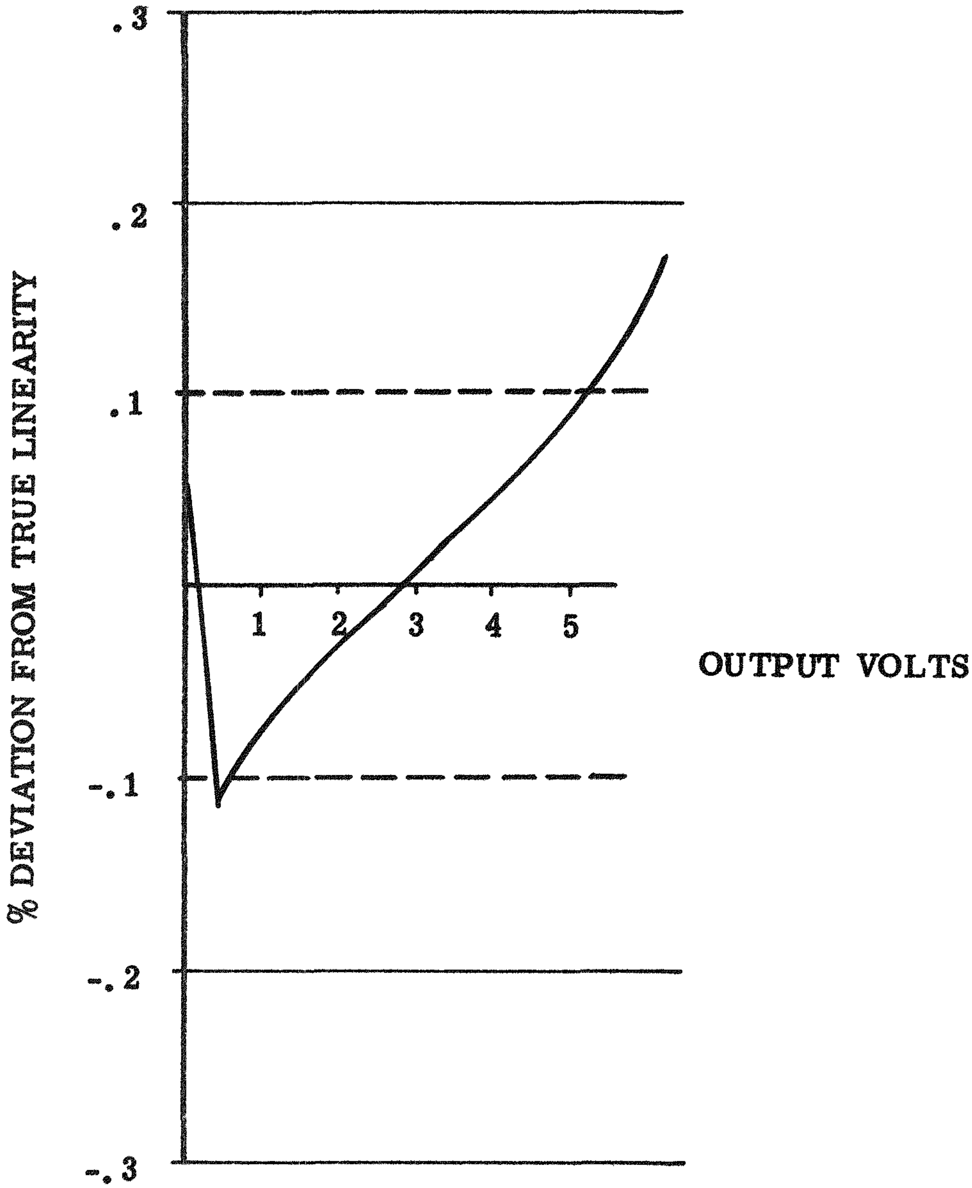


FIGURE 33 PSA, S/N 4 - LINEARITY DEVIATION AT +75° F.

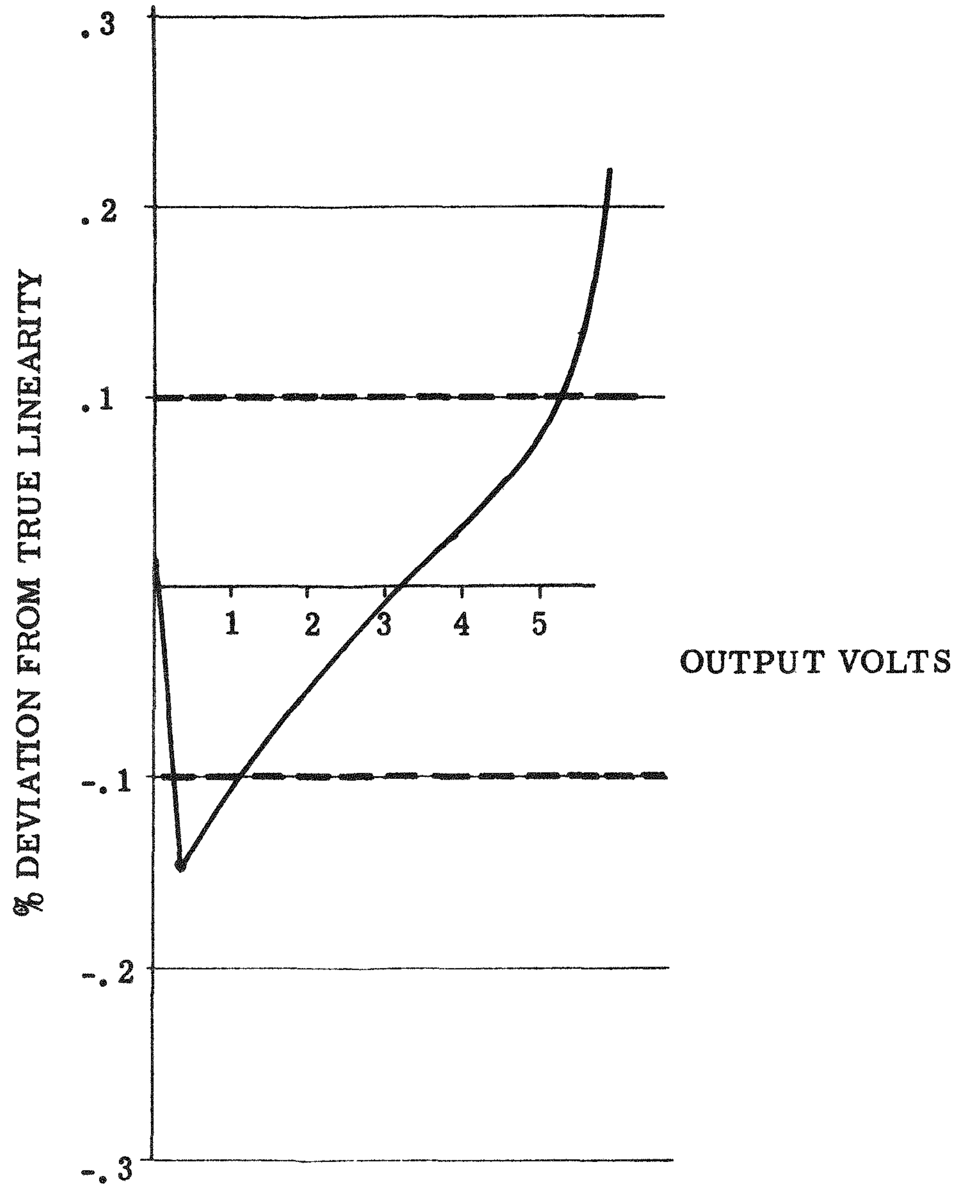


FIGURE 34 PSA, S/N 4 - LINEARITY DEVIATION AT +250° F.

5.2 PCA, S/N 4, PERFORMANCE DATA

The PCA, S/N 4, performance was measured at -260° F +75° F, and +250° F. Test data for the three ambient temperatures are presented in Table VII and in Figures 35 and 36.

TABLE VII

PCA, P/N 2775019-1, STATIC CHARACTERISTICS

Ambient Temp.	-260°F			+75°F			+250°F		
Line Voltage Line Frequency	103 360	115 400	127 440	103 360	115 400	127 440	103 360	115 400	127 440
Input Null (millivolts)	-4.45	-4.30	-4.20	-0.74	-0.17	-0.17	+0.36	0.62	+0.81
Zero Frequency Gain(volts/volt)	4570	4710	4710	3080	3230	3080	1350	1430	1100
Rate Gain (.159 cps)(volts/sec./volt)	10	10	10	19	20	21	23	23	24
Proportional Gain (5 cps)(volts/volt)	2.1	2.1	2.1	3.2	3.1	3.3	3.4	3.4	3.2
Saturation Level (volts)	13.6	13.6	16.9	11.4	12.8	14.1	10.4	11.6	13.0
Cut-Off Voltage	-1.00	-1.00	-1.00	-0.75	-0.75	-0.75	-0.62	-0.62	-0.62

PCA PERFORMANCE DATA

Output Ripple Voltage (Reflected to 10-ohm command source)	11 millivolts
Input Impedance Non-Operating	1600 ohms
Output Impedance Operating	-50 ohms
Transfer Function	See Figure 35
Dynamic Linearity	See Figure 36
Power Consumption Null Saturation	 3.0 watts 5.0 watts
Weight	3.5 pounds

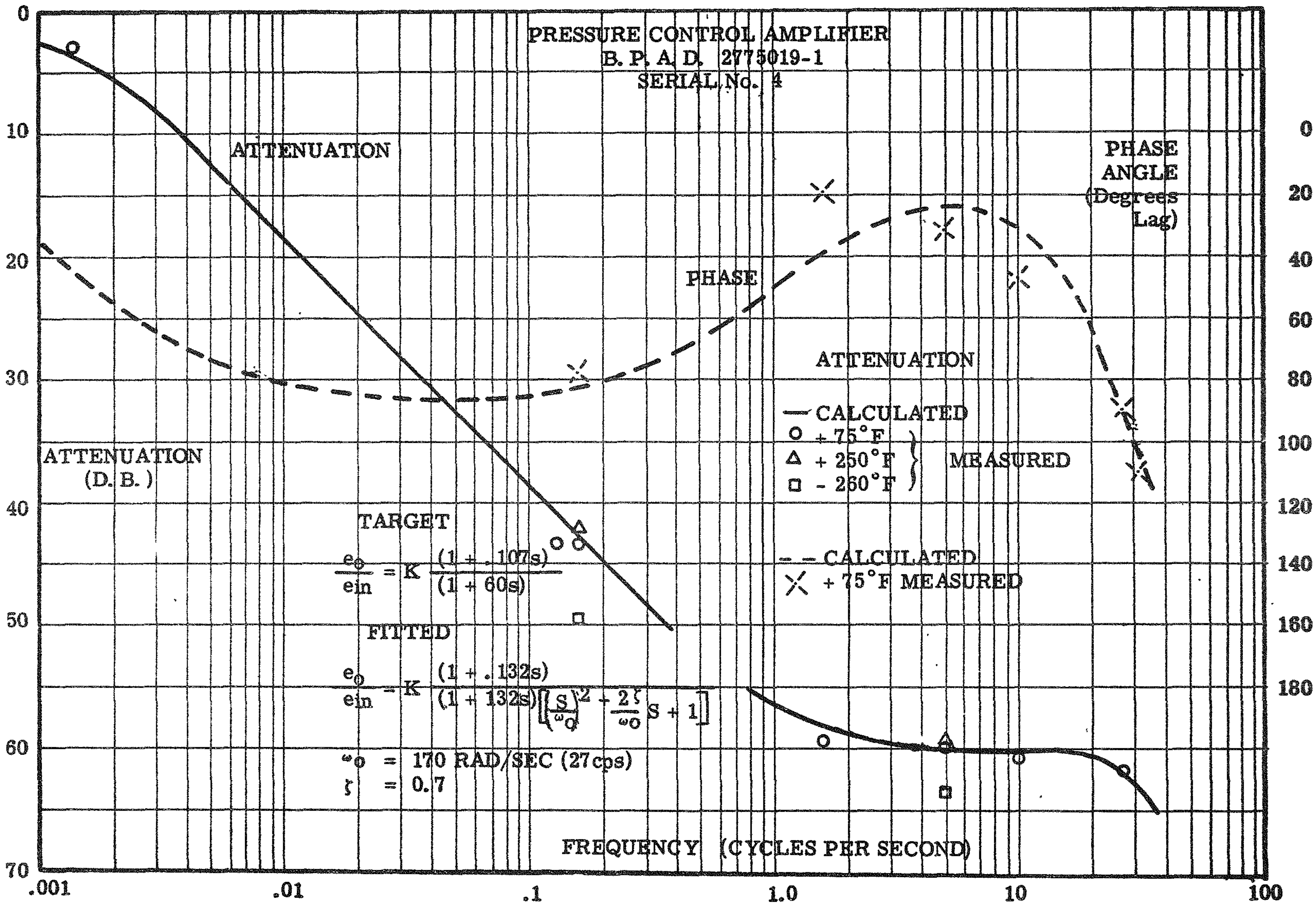


FIGURE 35 PCA, S/N 4 - FREQUENCY RESPONSE

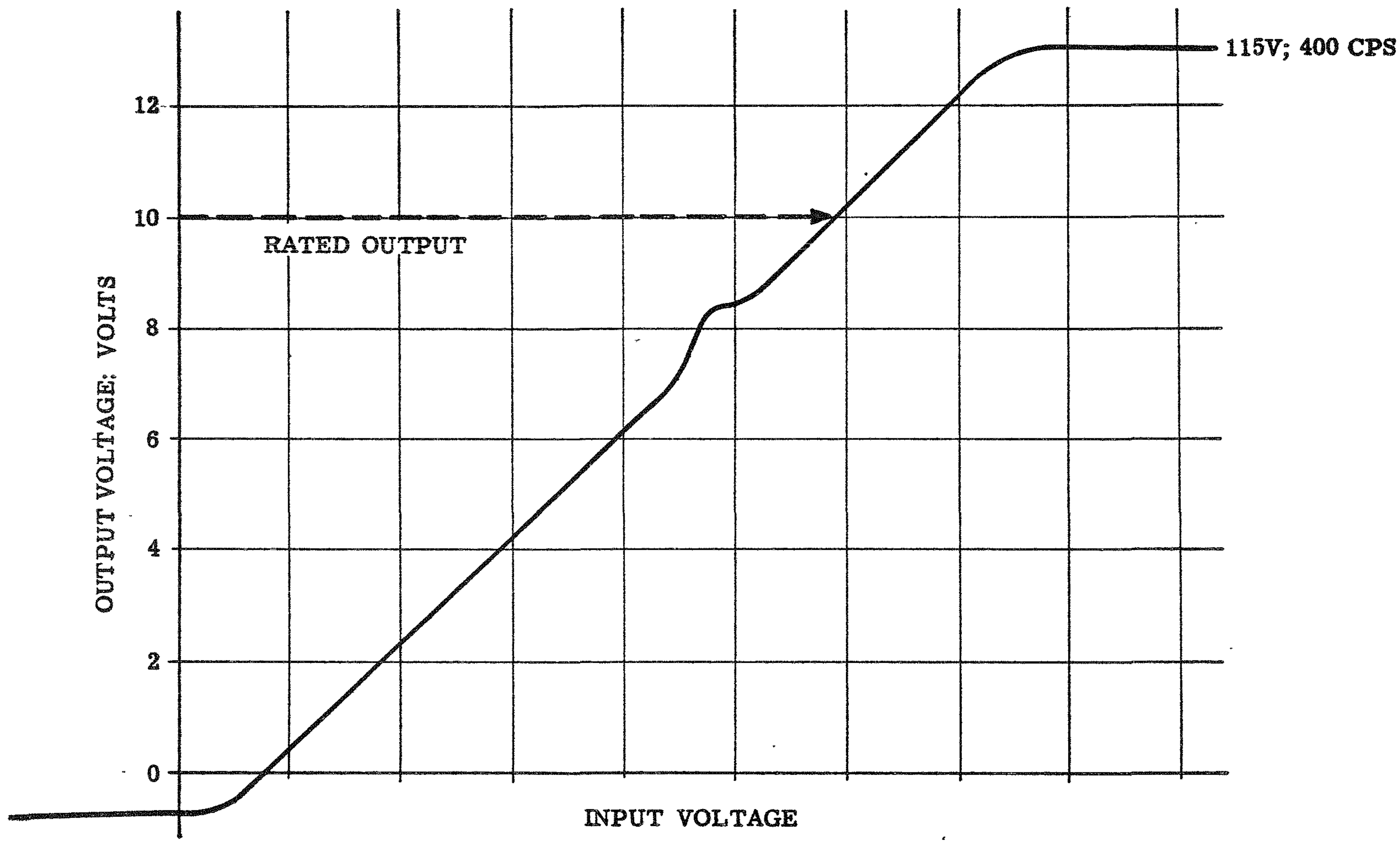


FIGURE 36 PCA, S/N 4 - DYNAMIC LINEARITY

5.3 TSA, S/N 4, PERFORMANCE DATA

The TSA, S/N 4, performance was measured at -260° F, 75° F, and +250° F. The test results are given in Table VIII and Figures 37 through 40.

TABLE VIII

TSA, P/N 2775016-1, STATIC CHARACTERISTICS

Ambient Temp.	-260°F			+75°F			+250°F		
Line Voltage Line Frequency	103 360	115 400	127 440	103 360	115 400	127 440	103 360	115 400	127 440
Input Null (millivolts)	4.38	4.57	4.40	2.32	-0.15	-0.54	2.00	1.15	0.73
Gain (volts/volt) (@ 4.0 V. output)	1.24	1.25	1.25	1.30	1.30	1.30	1.30	1.30	1.30
Linearity - % (@ 6.6 V output)	0.19	0.09	0.07	0.02	0.07	0.11	0.07	0.10	0.11
Saturation Level (volts)	9.4	11.0	12.7	9.0	10.1	11.3	8.6	9.8	11.0

TSA PERFORMANCE DATA

Output Ripple Voltage (Reflected to 10-ohm command source)	1.6 millivolts
Input Impedance	
Operating	6200 ohms
Non-Operating	6200 ohms
Output Impedance	
Operating	2.4 ohms
Roll-Off Frequency	53 cps
Power Consumption	
Null	1.8 watts
Saturation	2.0 watts
Weight	3.15 pounds

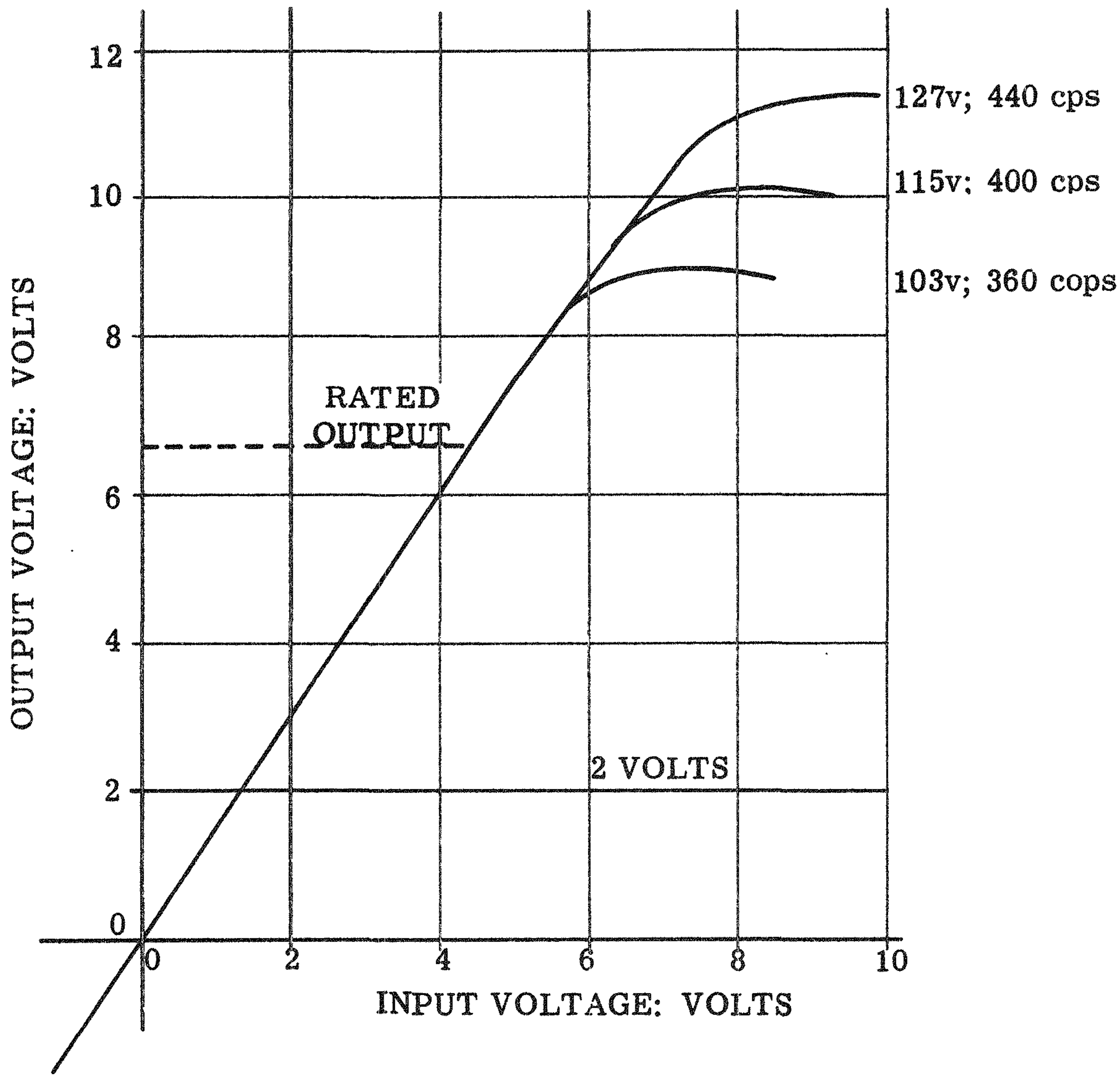


FIGURE 37 TSA, S/N 4 - LINEARITY AT +75° F.

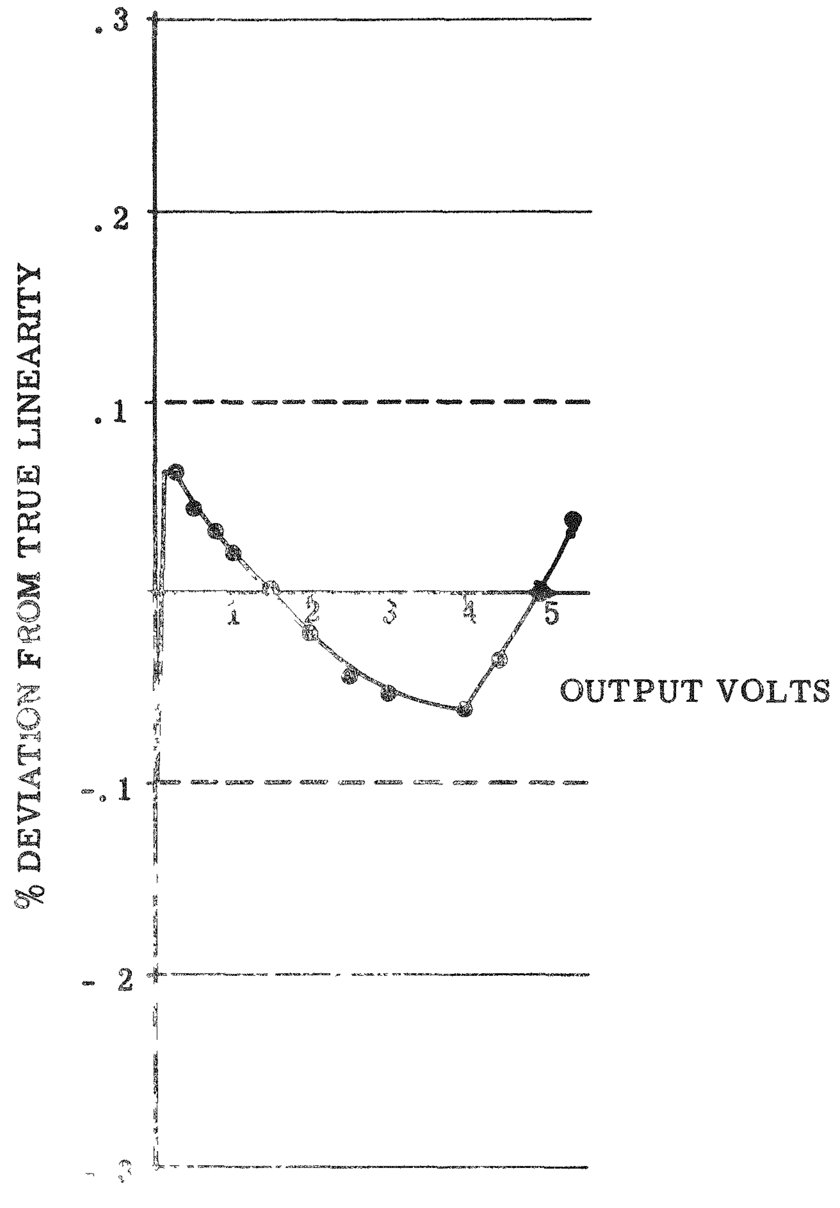


FIGURE 38 TSA, S/N 4 - LINEARITY DEVIATION AT -260° F.

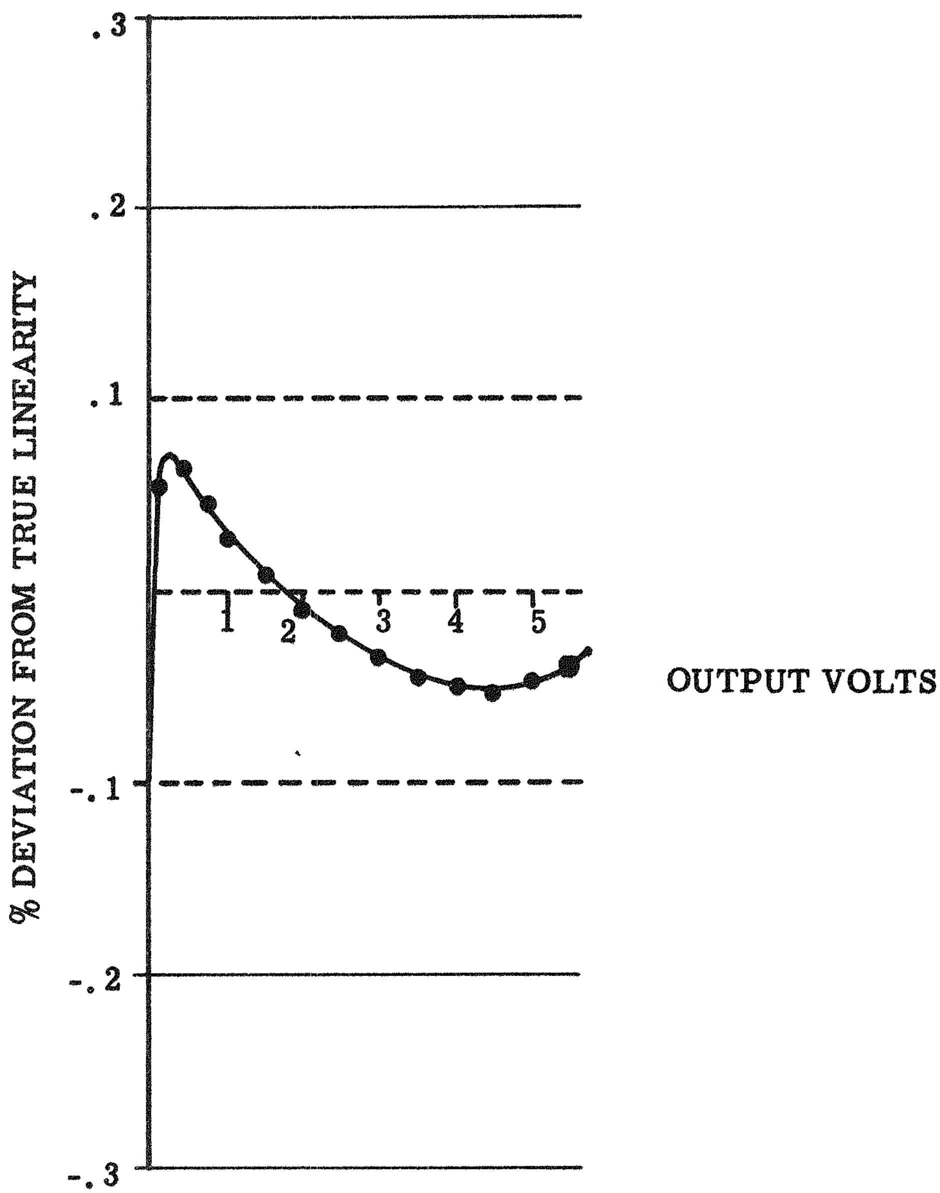


FIGURE 39 TSA, S/N 4 - LINEARITY DEVIATION AT +75° F.

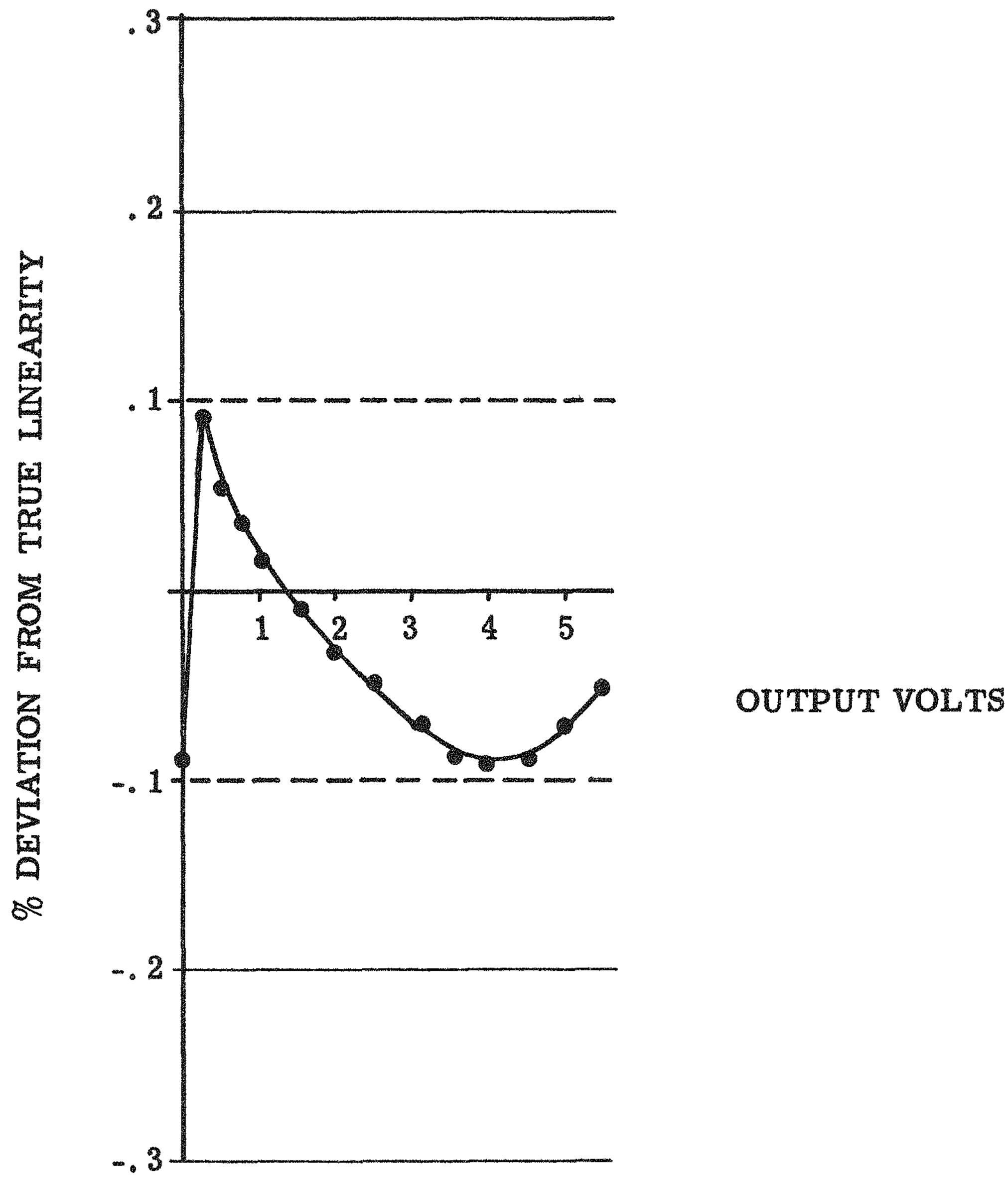


FIGURE 40 TSA, S/N 4 - LINEARITY DEVIATION AT +250° F.

5.4 TCA, S/N 4, PERFORMANCE DATA

The TCA, S/N 4, performance data were taken at -260° F, +75° F, and +250° F. The data are given in Table IX and in Figures 41 and 42.

TABLE IX

TCA, P/N 2775018-1, STATIC CHARACTERISTICS

Ambient Temp.	-260°F			+75°F			+250°F		
Line Voltage Line Frequency	103 360	115 400	127 440	103 360	115 400	127 440	103 360	115 400	127 440
Input Null (millivolts)	385	440	510	-2.5	19	38	-41	-40	-45
Zero Frequency Gain (volts/volt @ 8.0 V. output	8.04	8.99	10.13	17.76	19.95	22.10	18.14	19.05	20.00
Rate Gain (volt/ sec./volt @ 0.159 cps)	0.05	0.05	0.05	0.35	0.35	0.35	0.65	0.66	0.70
Proportional Gain (volts/volt @ 5.0 cps)	----	----	----	0.98	0.95	0.93	1.15	1.15	1.15
Saturation Voltage (volts)	14.6	16.5	18.6	12.2	13.6	15.2	11.1	12.4	13.7
Cut-Off Voltage (volts)	-1.01	-1.01	-1.02	-0.77	-0.76	-0.77	-0.60	-0.61	-0.62

TCA PERFORMANCE DATA

Output Ripple Voltage (Reflected to 10-ohm command source)	15 millivolts
Input Impedance	
Non-Operating	1600 ohms
Output Impedance	
Operating	0.8 ohm
Transfer Function	See Figure 41
Dynamic Linearity	See Figure 42
Power Consumption	
Null	3.0 watts
Saturation	5.0 watts
Weight	3.5 pounds

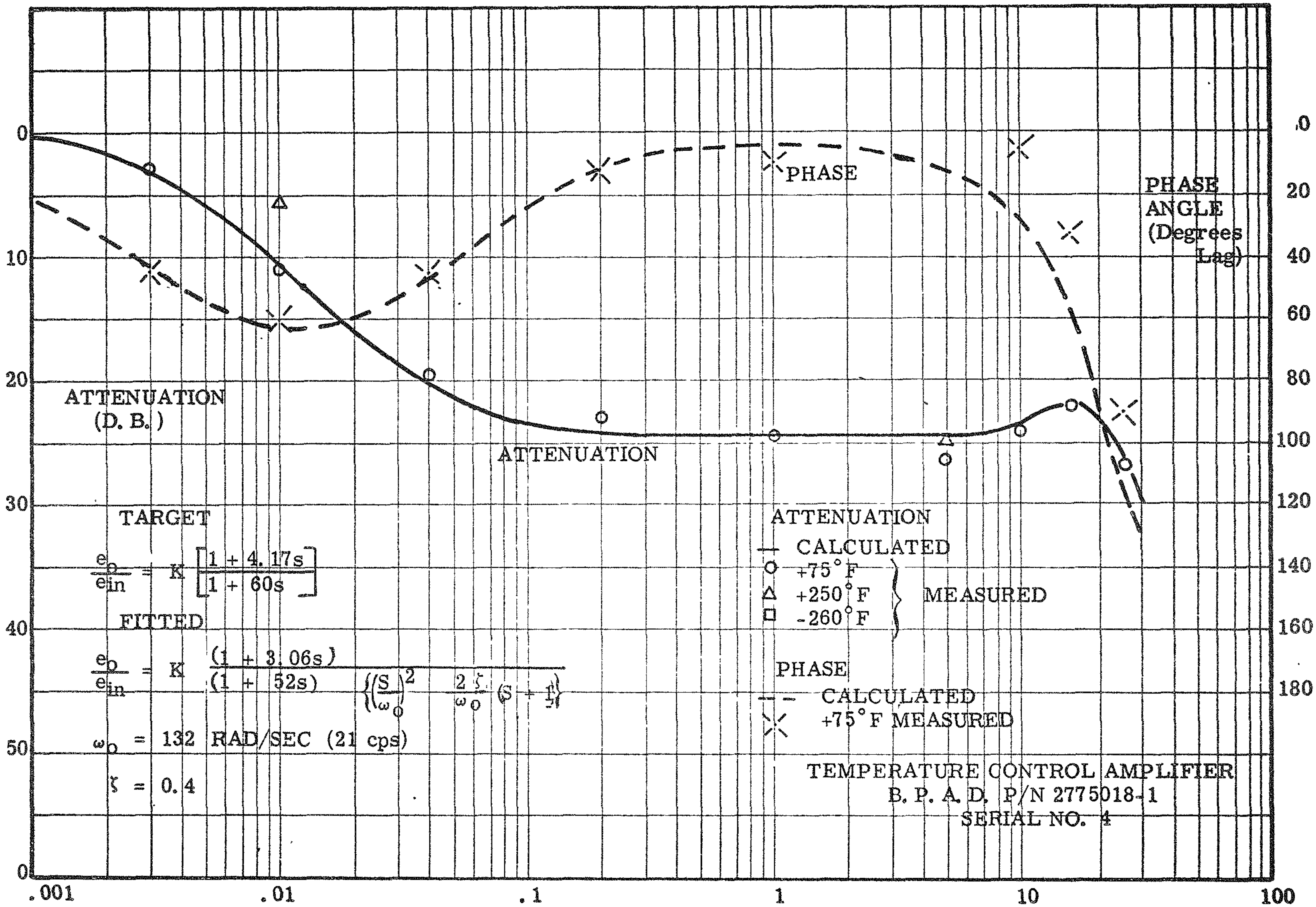


FIGURE 41 TCA, S/N 4 - FREQUENCY RESPONSE

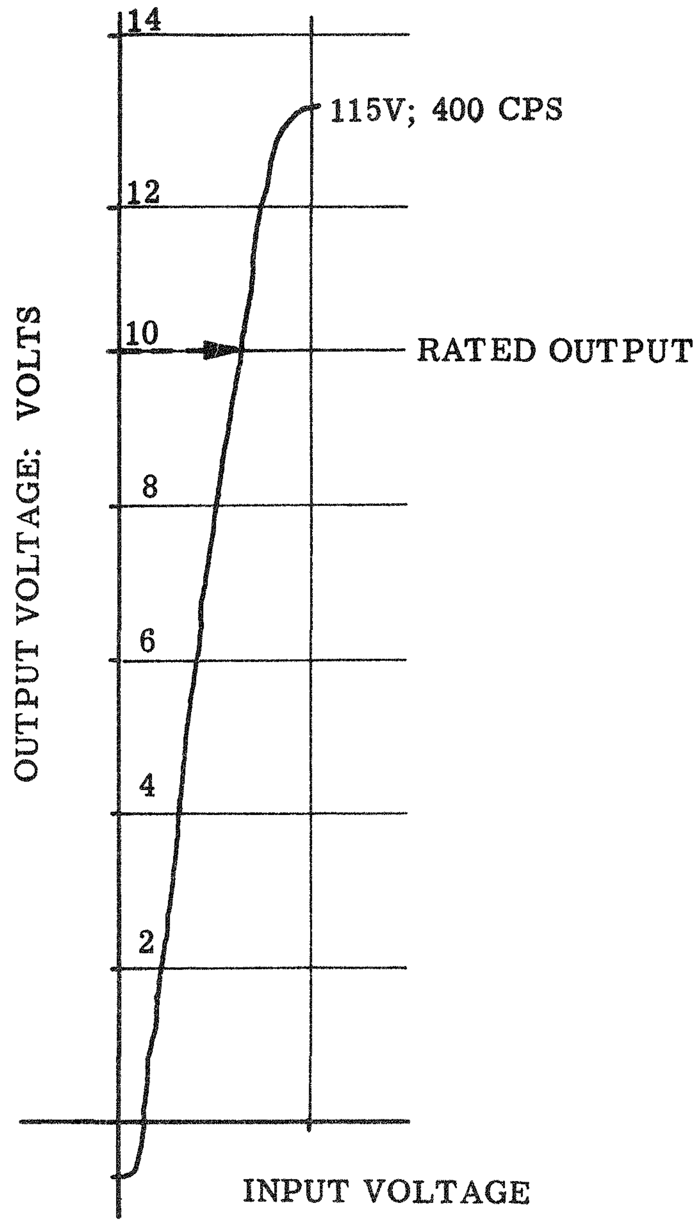


FIGURE 42 TCA, S/N 4 - DYNAMIC LINEARITY

SECTION 6

PERFORMANCE OF SYSTEM AMPLIFIER PACKAGE S/N 5

6.1 PSA, S/N 5, PERFORMANCE DATA

The PSA, S/N 5, performance was measured at -260° F, +75° F, and +250° F. The test results have been tabulated and presented in Table X and Figures 43 through 46.

TABLE X

PSA, P/N 2775017-2, STATIC CHARACTERISTICS

Ambient Temp.	-260°F			+75°F			+250°F		
Line Voltage Line Frequency	103 360	115 400	127 440	103 360	115 400	127 440	103 360	115 400	127 440
Input Null (millivolts)	10.6	11.4	11.2	-1.68	-0.38	1.82	-5.82	-4.73	-3.02
Gain (volts/volt @ +4.0 V output)	1.31	1.31	1.32	1.31	1.32	1.32	1.29	1.29	1.29
Linearity - % (Ref: 5.75 volts)	0.10	0.11	0.18	0.19	0.16	0.16	0.26	0.19	0.19
Saturation Level (volts)	11.3	12.4	14.3	9.2	10.5	10.9	8.00	9.00	9.75

PSA PERFORMANCE DATA

Output Ripple Voltage (Reflected to 10-ohm command source)	3.3 millivolts
Input Impedance	
Non-Operating (Higher when operating)	12.2 K ohms (per channel)
Output Impedance	
Operating	18 ohms
Roll-Off Frequency (3 DB point)	18.5 cps
Power Consumption	
Null	2.0 watts
Saturation	2.5 watts
Weight	2.3 pounds

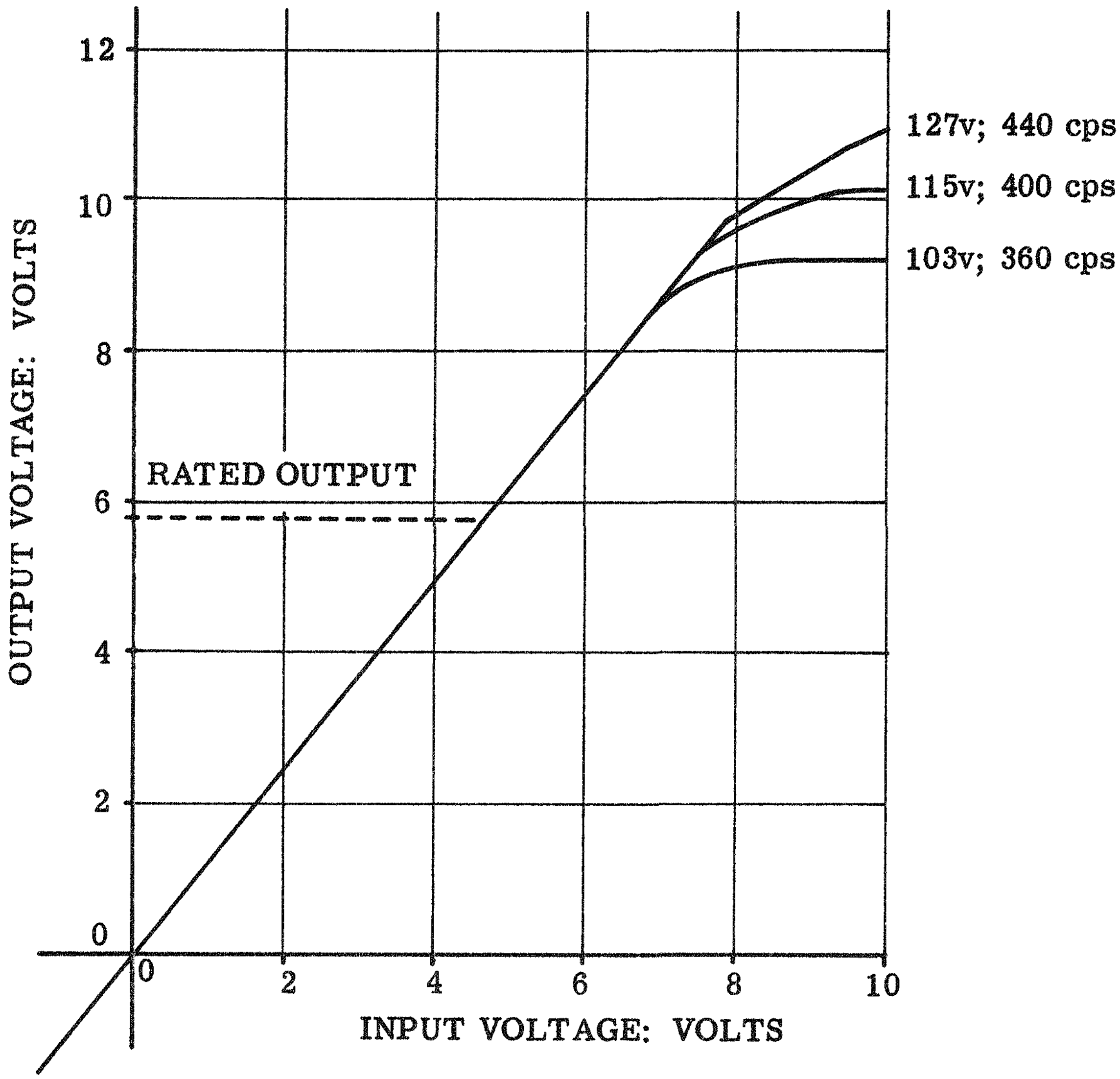


FIGURE 43 PSA, S/N 5 - LINEARITY AT +75° F.

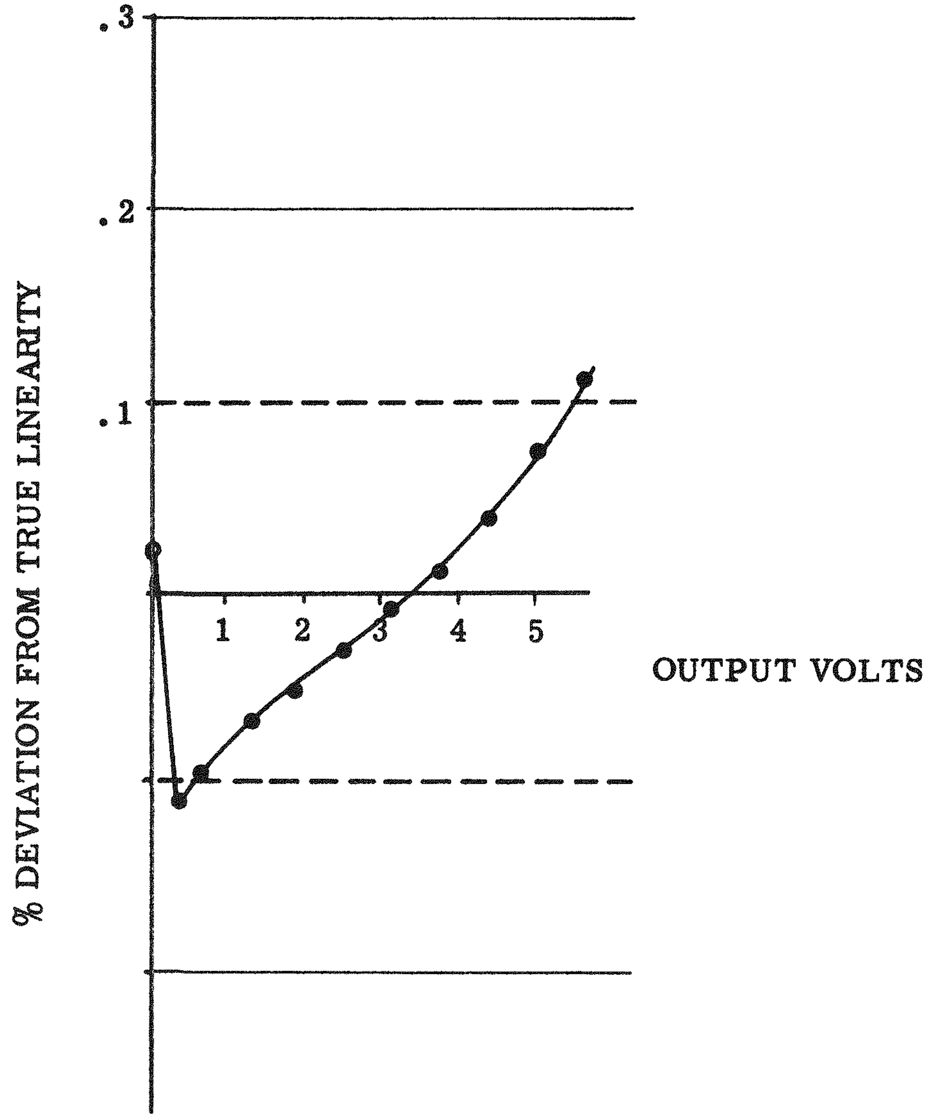


FIGURE 44 PSA, S/N 5 - LINEARITY DEVIATION AT -260° F.

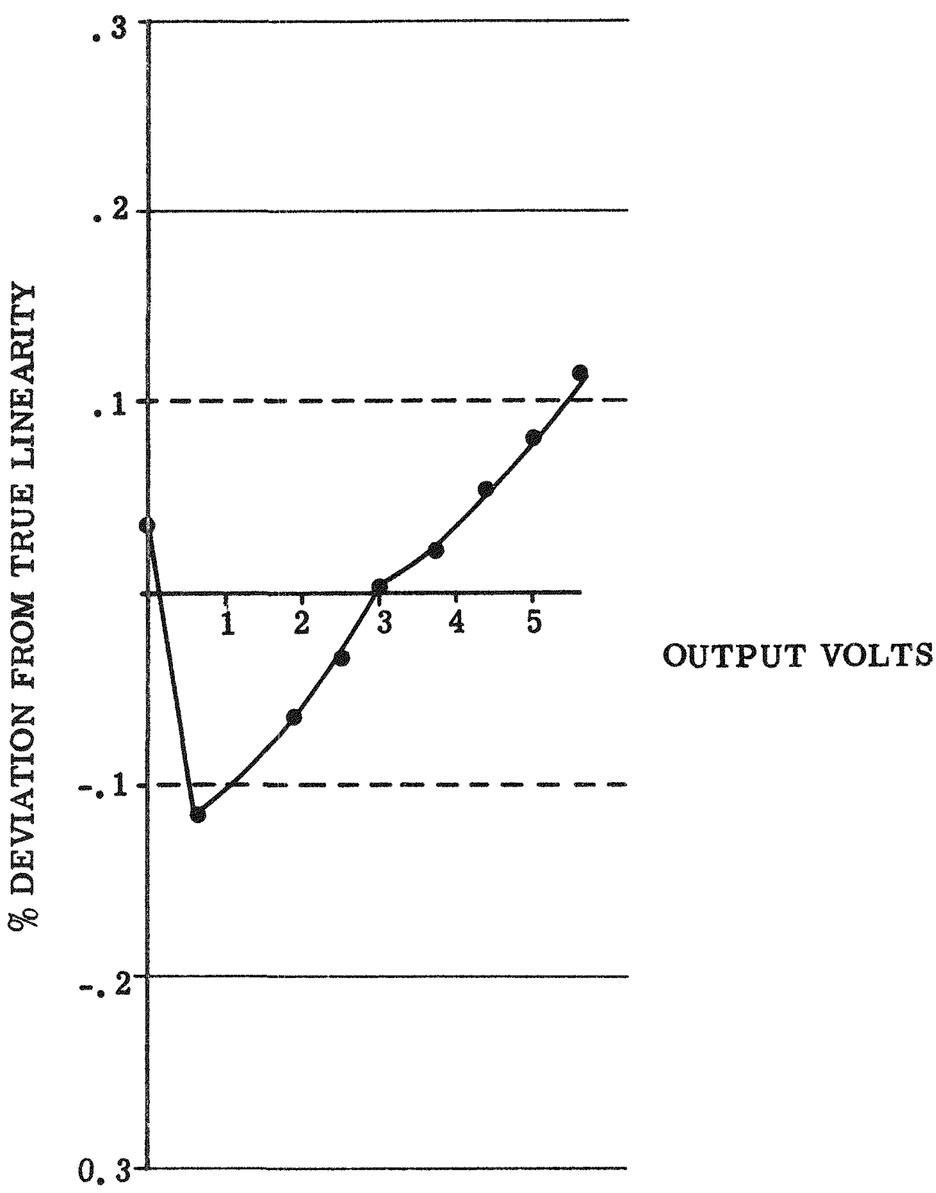


FIGURE 45 PSÁ, S/N 5 - LINEARITY DEVIATION AT +75° F.

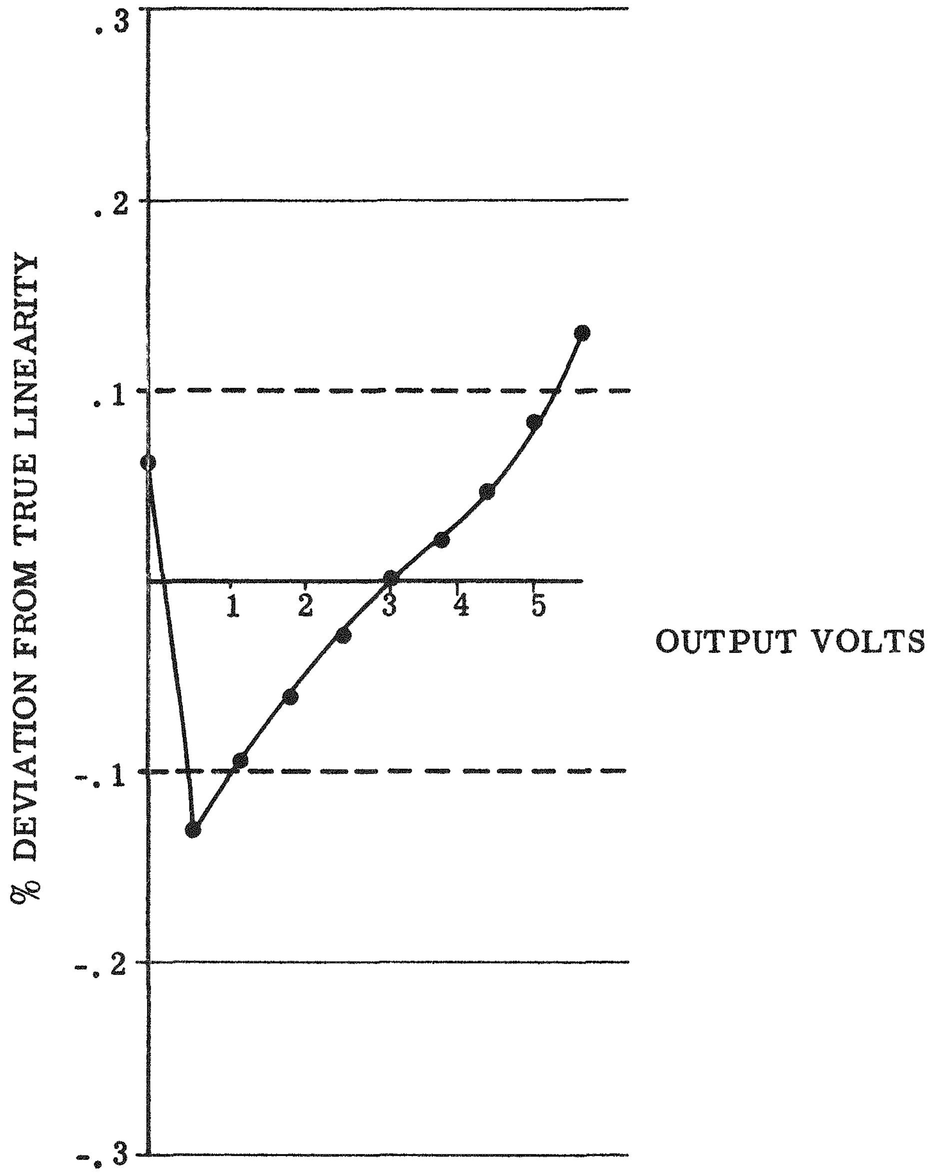


FIGURE 46 PSA, S/N 5 - LINEARITY DEVIATION AT +250° F.

6.2 PCA, S/N 5, PERFORMANCE DATA

The PCA, S/N 5, performance was measured at -260° F, +75° F, and +250° F. Test data for the three ambient temperatures are presented in Table XI and in Figures 47 and 48.

TABLE XI

PCA, P/N 2775019-2, STATIC CHARACTERISTICS

Ambient Temp.	-260°F			+75°F			+250°F		
Line Voltage Line Frequency	103 360	115 400	127 440	103 360	115 400	127 440	103 360	115 400	127 440
Input Null (millivolts)	-4.74	-4.76	-4.98	-0.72	-0.44	-0.26	-1.60	-1.49	-1.42
Zero Frequency Gain (volts/volt)	---	4730	3180	3200	3400	3360	1670	1810	1870
Rate Gain (.159 cps)(volts/sec./volt)	10	10	10	23	24	25	29	29	27
Proportional Gain (5cps)(volts/volt)	1.95	2.50	2.50	4.0	4.05	4.10	3.40	3.60	3.70
Saturation Level (volts)	14.5	16.1	17.9	11.6	13.2	14.5	10.6	11.8	13.1
Cut-Off Voltage (volts)	-1.06	-1.06	-1.07	-0.77	-0.78	-0.78	-0.62	-0.63	-0.63

PCA PERFORMANCE DATA

Output Ripple Voltage (Reflected to 10-ohm command source)	15 millivolts
Input Impedance	
Non-Operating	1600 ohms
Output Impedance	
Operating	10 ohms
Transfer Function	See Figure 47
Dynamic Linearity	See Figure 48
Power Consumption	
Null	3.0 watts
Saturation	5.25 watts
Weight	4.8 pounds

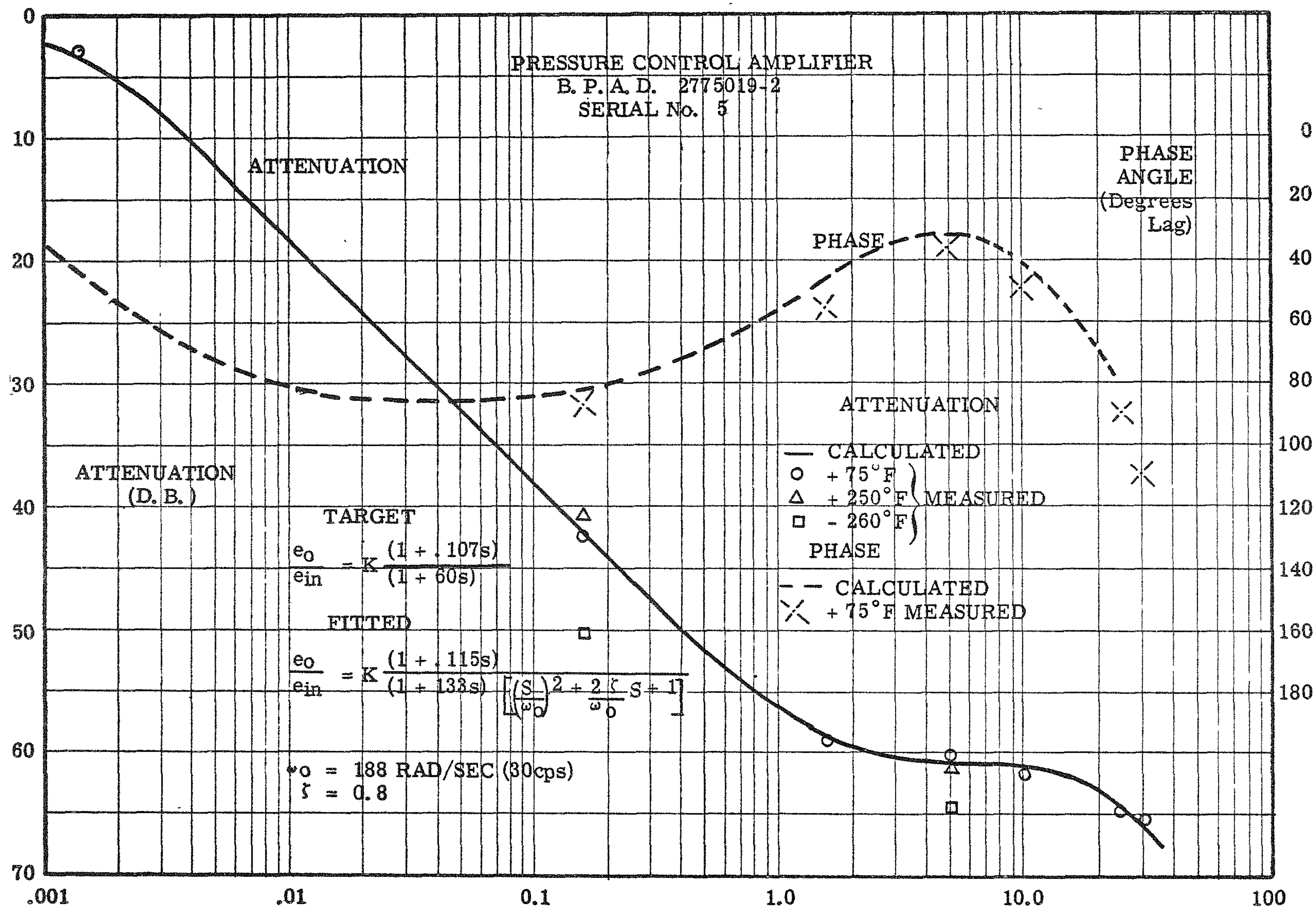


FIGURE 47 PCA, S/N 5 - FREQUENCY RESPONSE

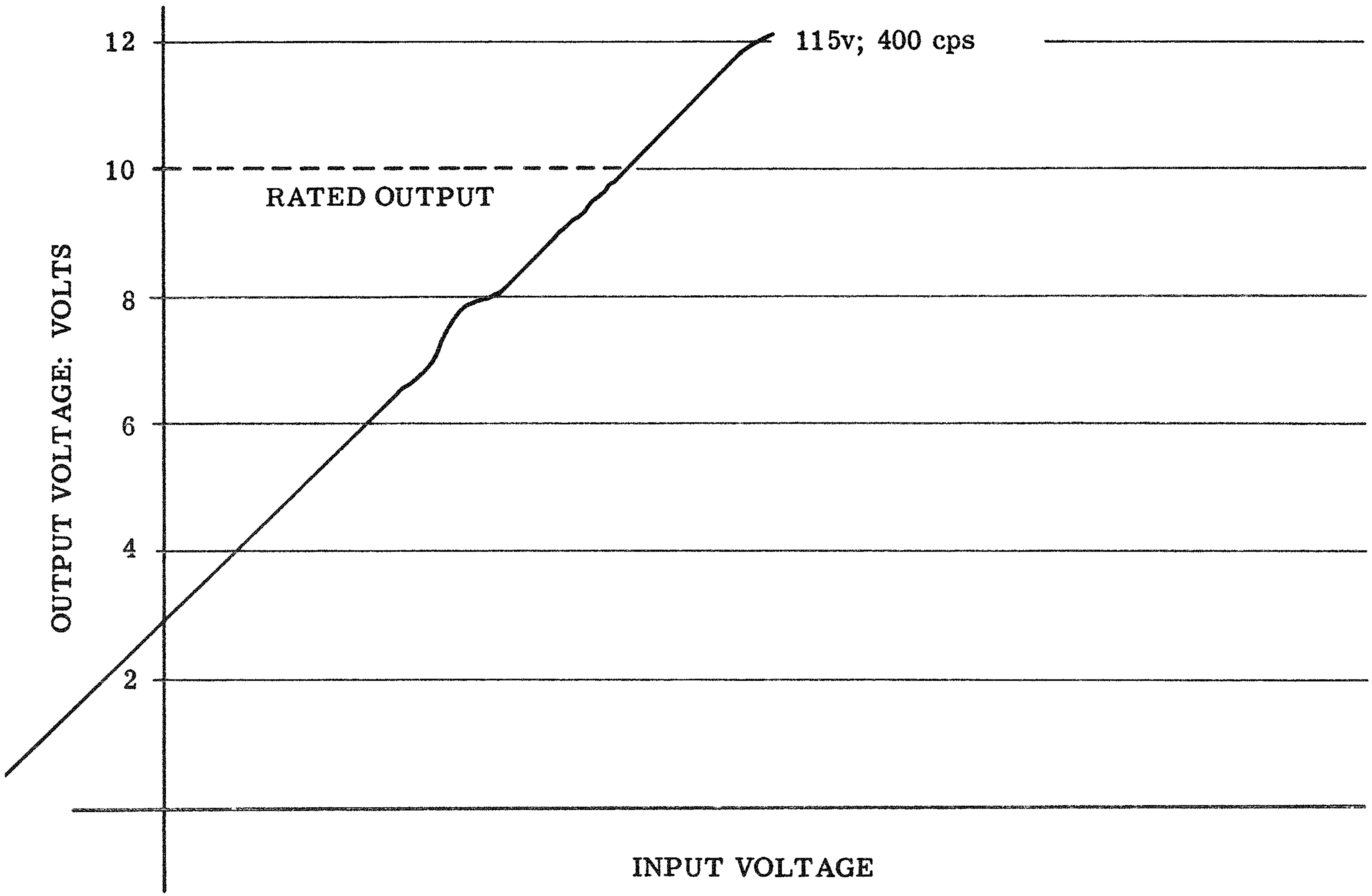


FIGURE 48 PCA, S/N 5 - DYNAMIC LINEARITY

6.3 TSA, S/N 5, PERFORMANCE DATA

The TSA, S/N 5, performance was measured at -260° F, +75° F and +250° F. The test results are given in Table XII and Figure 49 through 52.

TABLE XII

TSA, P/N 2775016-2, STATIC CHARACTERISTICS

Ambient Temp.	-260°F			+75°F			+250°F		
Line Voltage Line Frequency	103 360	115 400	127 440	103 360	115 400	127 440	103 360	115 400	127 440
Input Null (millivolts)	10.0	9.31	8.26	0.78	-0.31	0.16	-1.09	-2.29	-2.26
Gain (volts/volt) (@ 4.0 V output)	1.22	1.24	1.24	1.28	1.29	1.28	1.29	1.29	1.29
Linearity - % (@ 6.6 V output)	0.18	0.26	0.14	0.02	0.10	0.12	0.13	0.09	0.13
Saturation Level (volts)	13.1	11.0	13.4	9.0	11.8	12.4	8.8	10.2	11.8

TSA PERFORMANCE DATA

Output Ripple Voltage (Reflected to 10-ohm command source	5 millivolts
Input Impedance	
Operating	6200 ohms
Non-Operating	6200 ohms
Output Impedance	
Operating	2.36 ohms
Roll-Off Frequency	56 cps
Power Consumption	
Null	1.3 watts
Saturation	2.0 watts
Weight	4.1 pounds

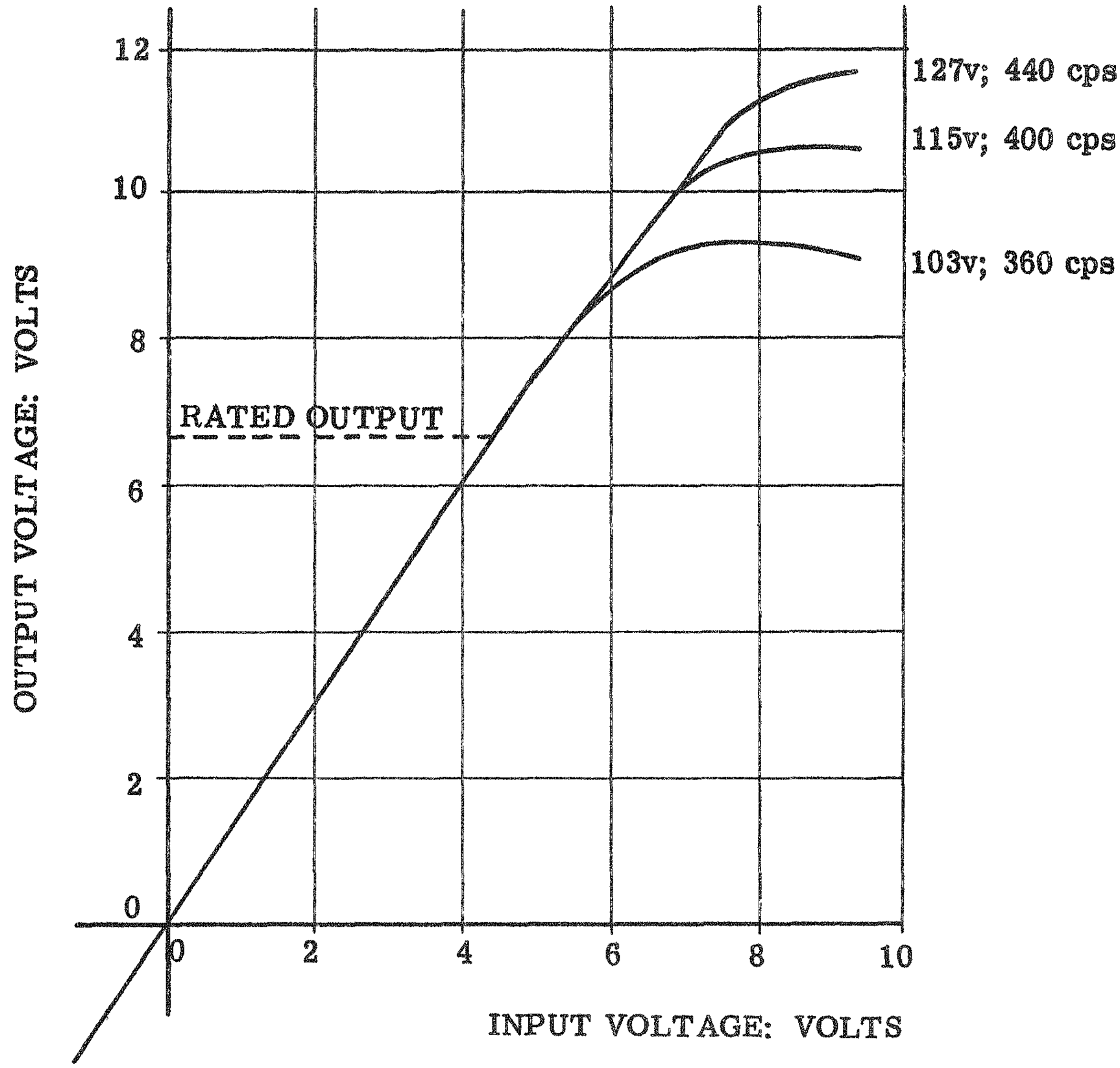


FIGURE 49 TSA, S/N 5 - LINEARITY AT +75° F.

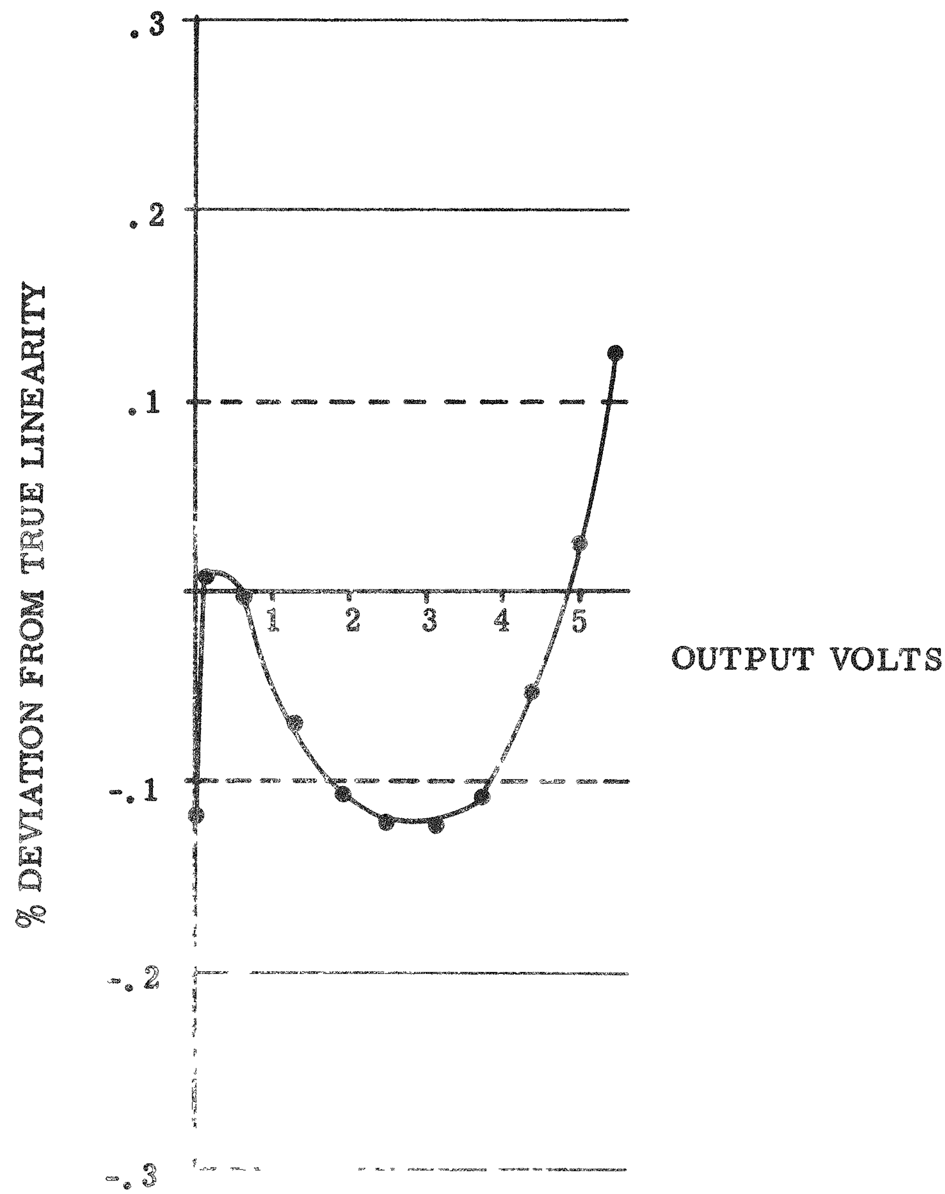


FIGURE 50 TSA, S/N 5 - LINEARITY DEVIATION AT -260° F.

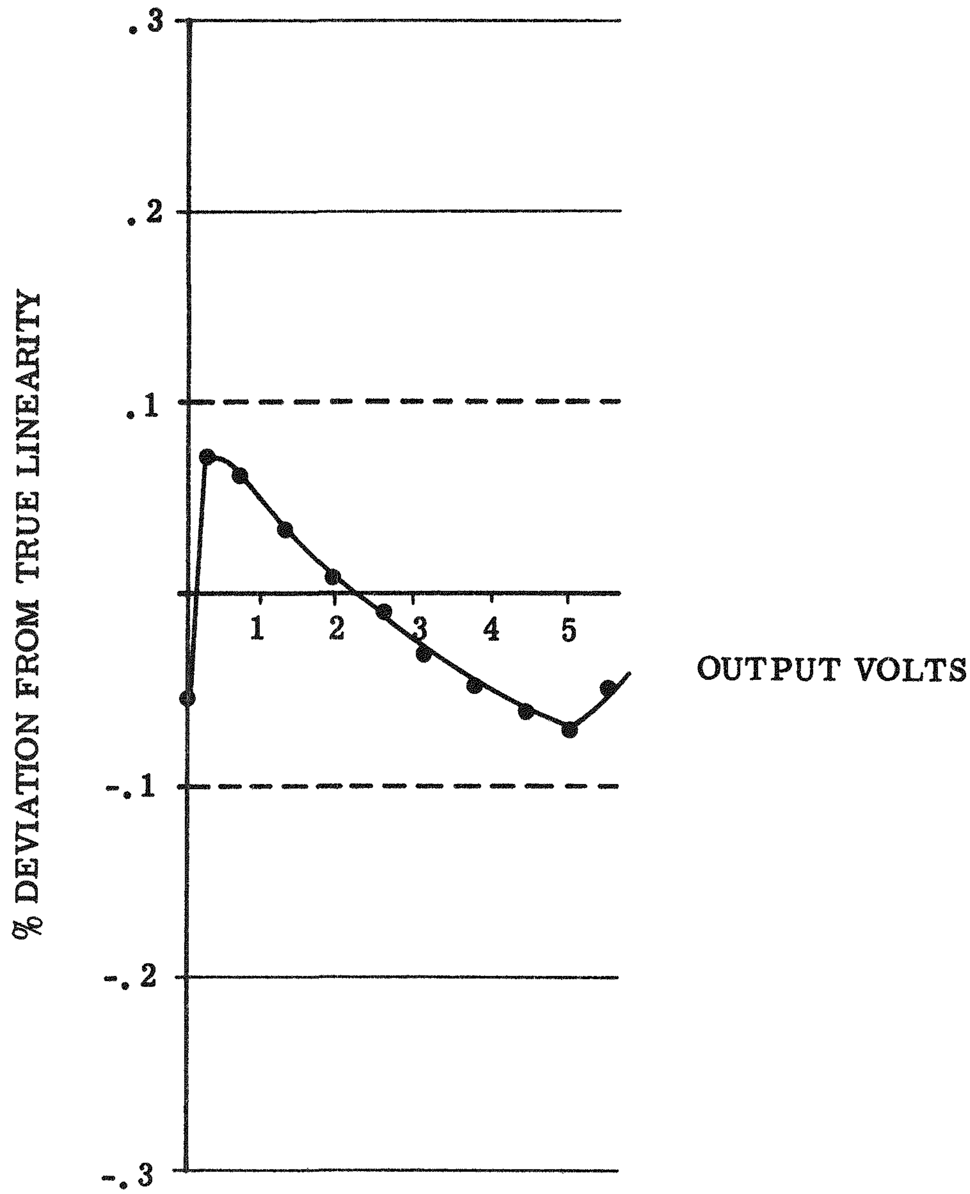


FIGURE 51 TSA, S/N 5 - LINEARITY DEVIATION AT +75° F.

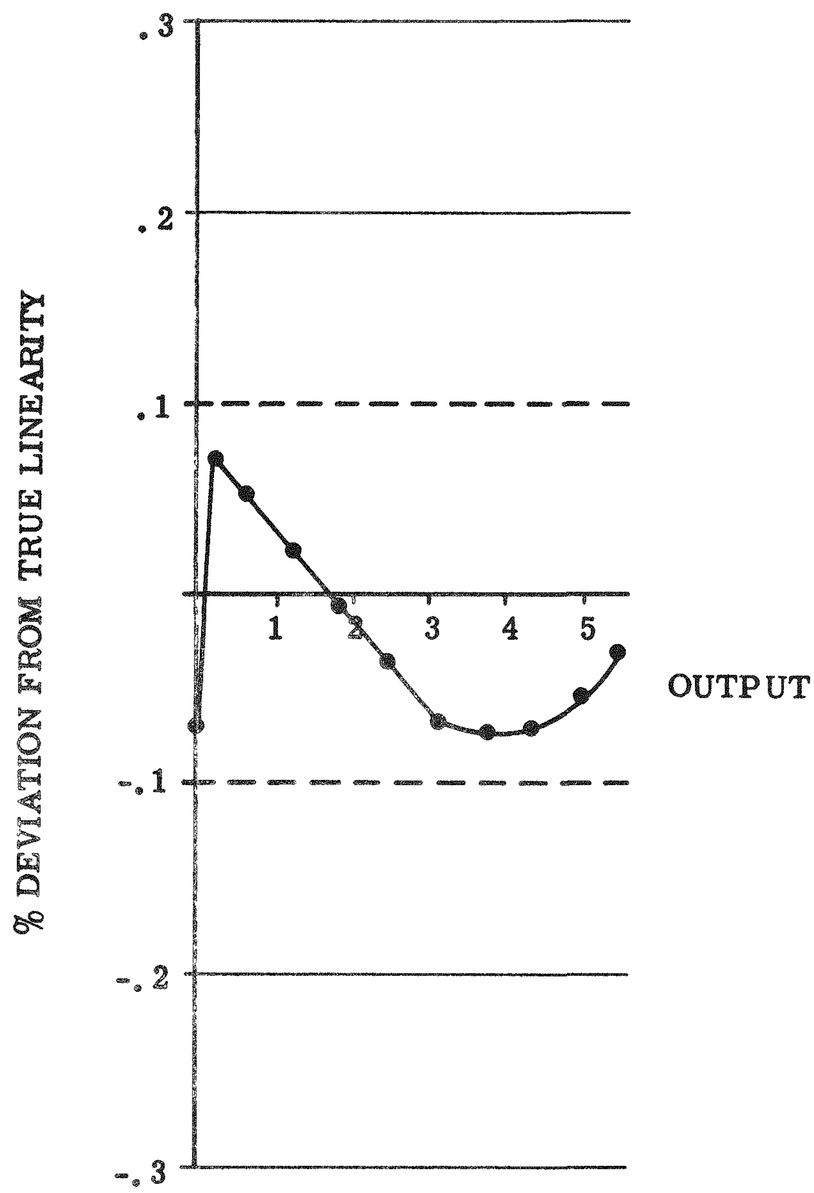


FIGURE 52 TSA, S/N 5 - LINEARITY DEVIATION AT +250° F.

6.4 TCA S/N 5 PERFORMANCE DATA

The TCA, S/N 5, performance data were taken at 260° F, +75° F, and +250° F. The data are given in Table XIII and in Figures 53 and 54.

TABLE XIII

TCA, P/N 2775018-2 STATIC CHARACTERISTICS

Ambient Temp	260°F			+75°F			+250°F		
Line Voltage Line Frequency	103 360	115 400	127 440	103 360	115 400	127 440	103 360	115 400	127 440
Input Null (millivolts)	70	140	218	60	-13	40	52	56	54
Zero Frequency Gain (volts/volt @ 8.0 V output)	11.3	11.6	12.1	26.7	27.3	28.2	23.4	26.3	26.1
Rate Gain (volt/sec/volt @ 0.159 cps)	0.03	0.04	0.04	0.31	0.33	0.34	0.57	0.60	0.61
Proportional Gain (volts/volt @ 5.0 cps)	0.73	0.75	0.73	1.33	1.33	1.27	1.54	1.54	1.54
Saturation Voltage (volts)	14.6	16.2	18.4	11.8	13.4	14.9	10.9	12.3	13.8
Cut-Off Voltage (volts)	-1.05	1.05	-1.05	0.75	0.75	0.76	-0.60	0.61	-0.61

TCA PERFORMANCE DATA

Output Ripple Voltage (Reflected to 10-ohm command source)	14 millivolts
Input Impedance	
Nor. Operating	1600 ohms
Output Impedance	
Operating	4 ohms
Transfer Function	See Figure 53
Dynamic Linearity	See Figure 54
Power Consumption	
Null	3.5 watts
Saturation	5.7 watts
Weight	6.1 pounds

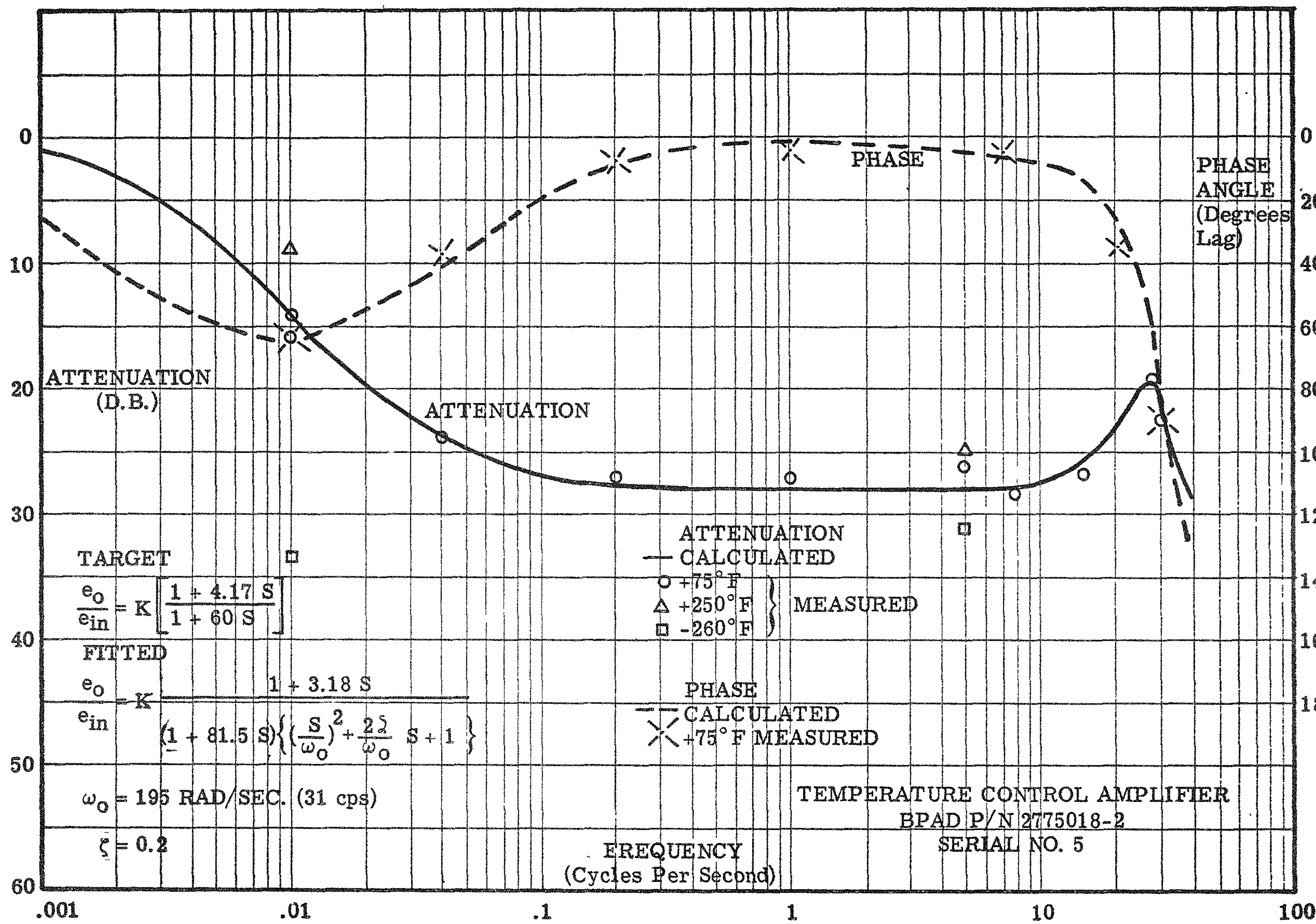


FIGURE 53 TCA, S/N 5 - FREQUENCY RESPONSE

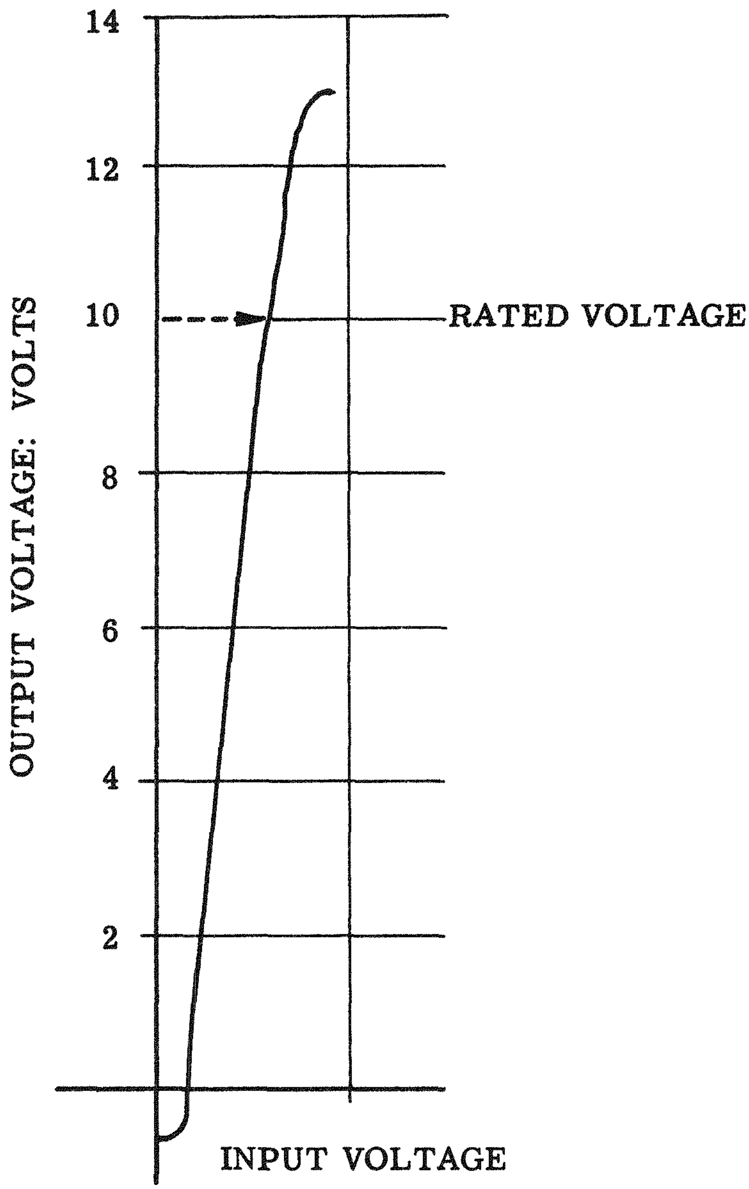


FIGURE 54 TCA, S/N 5 - DYNAMIC LINEARITY

SECTION 7

PERFORMANCE OF SYSTEM AMPLIFIER PACKAGE S/N 7

7.1 PSA, S/N 7, PERFORMANCE DATA

The PSA, S/N 7, performance was measured at -260° F, +75° F, and +260° F. The test results have been tabulated and presented in Table XIV and Figures 55 through 58.

TABLE XIV

PSA, P/N 2775017-3, STATIC CHARACTERISTICS

Ambient Temp.	-260°F			+75°F			+250°F		
Line Voltage Line Frequency	103 360	115 400	127 440	103 360	115 400	127 440	103 360	115 400	127 440
Input Null (millivolts)	4.13	3.66	1.22	0.69	-1.60	-4.16	0.31	-0.46	-3.26
Gain (volts/volt @ 4.0 V output)	1.31	1.31	1.32	1.31	1.32	1.32	1.31	1.31	1.32
Linearity - % (Ref: 5.75 volts)	0.13	0.14	0.15	0.17	0.18	0.22	0.19	0.15	0.19
Saturation Level (volts)	11.3	12.1	14.0	9.0	10.1	10.6	8.0	9.1	9.6

PSA PERFORMANCE DATA

Output Ripple Voltage (Reflected to 10-ohm command source)	6.25 millivolts
Input Impedance Non-Operating (Higher when operating)	12.2 K ohms (per channel)
Output Impedance Operating	8 ohms
Roll-Off Frequency (3 DB point)	18.6 cps
Power Consumption Null Saturation	 1.5 watts 2.5 watts
Weight	2.3 pounds

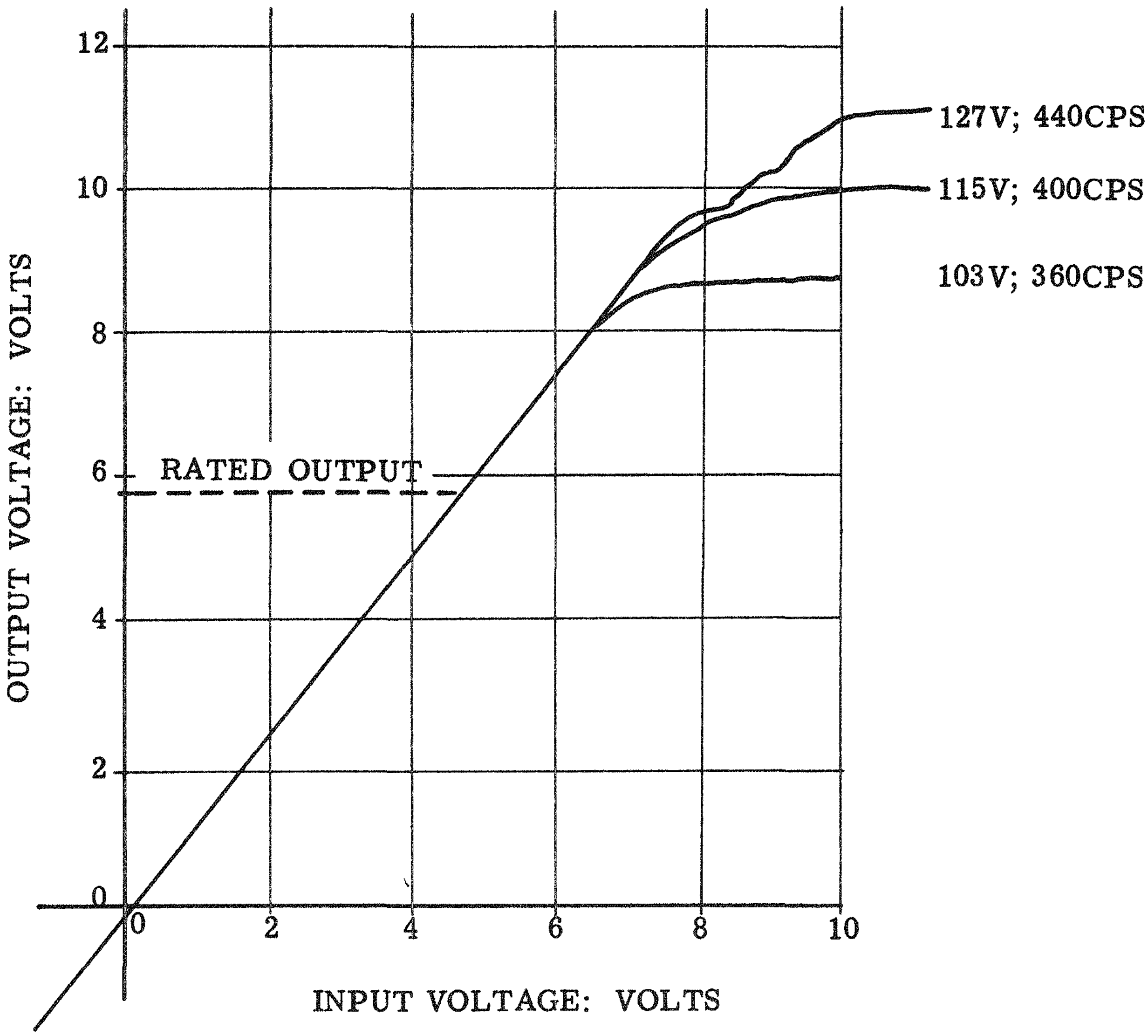


FIGURE 55 PSA, S/N 7 - LINEARITY AT +75° F.

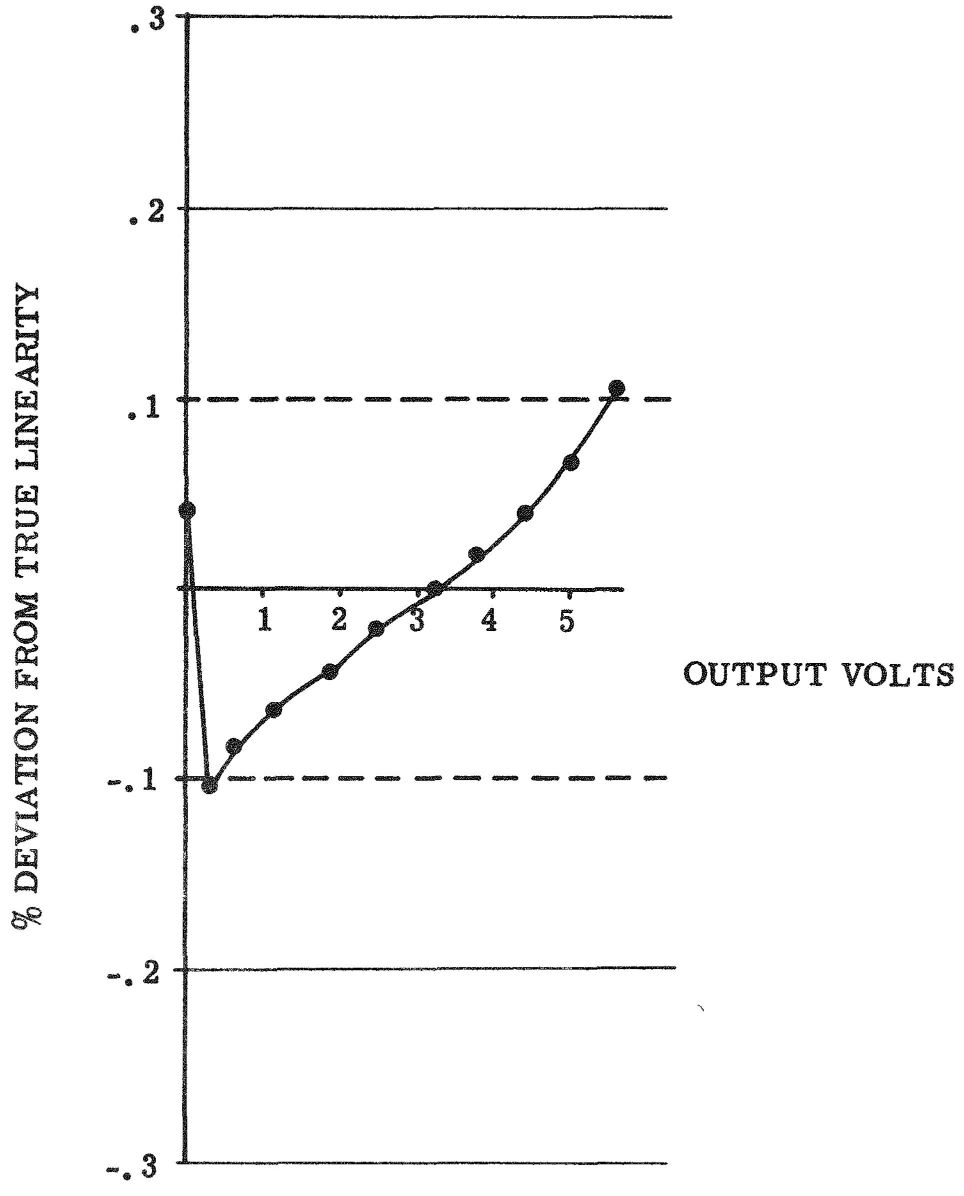


FIGURE 56 PSA, S/N 7 - LINEARITY DEVIATION AT -260° F.

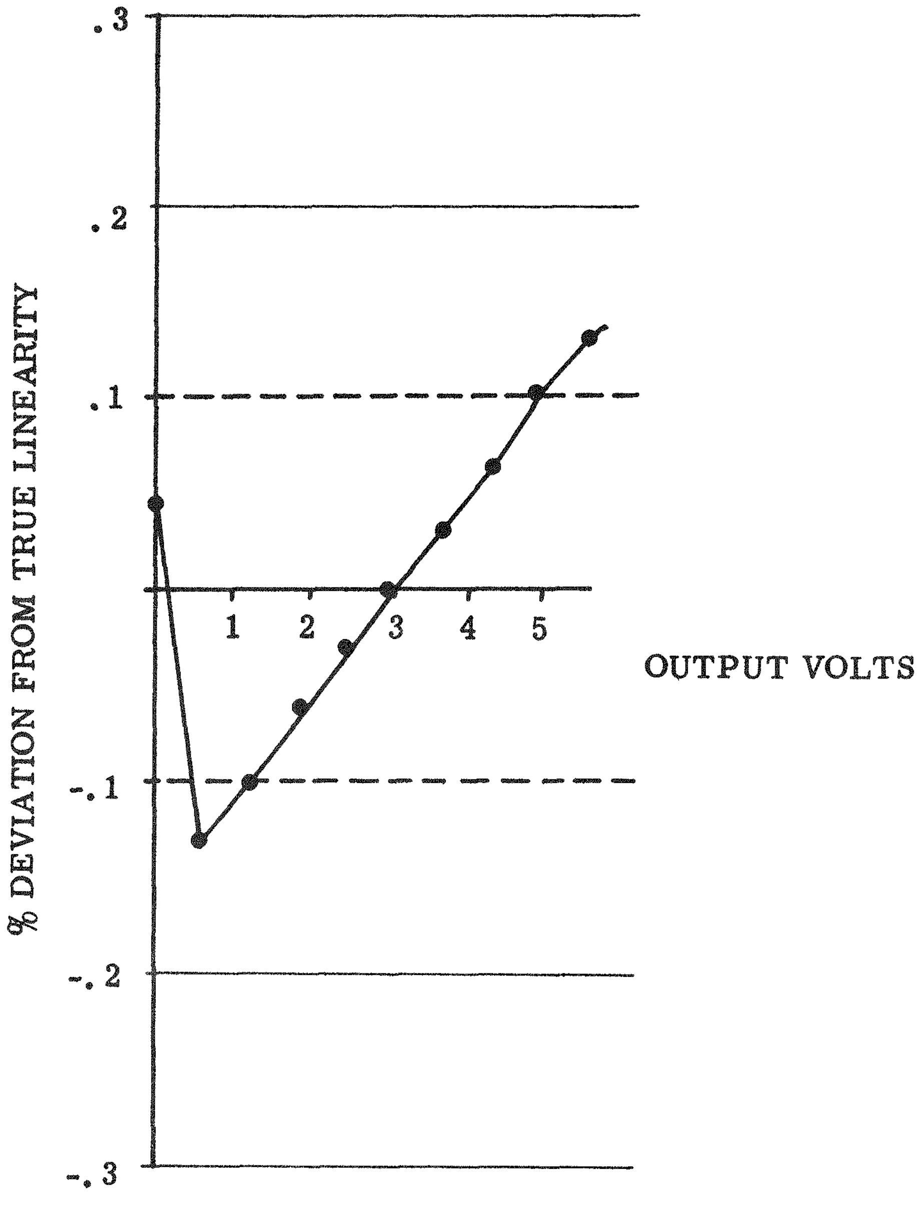


FIGURE 57 PSA, S/N 7 - LINEARITY DEVIATION AT +75° F.

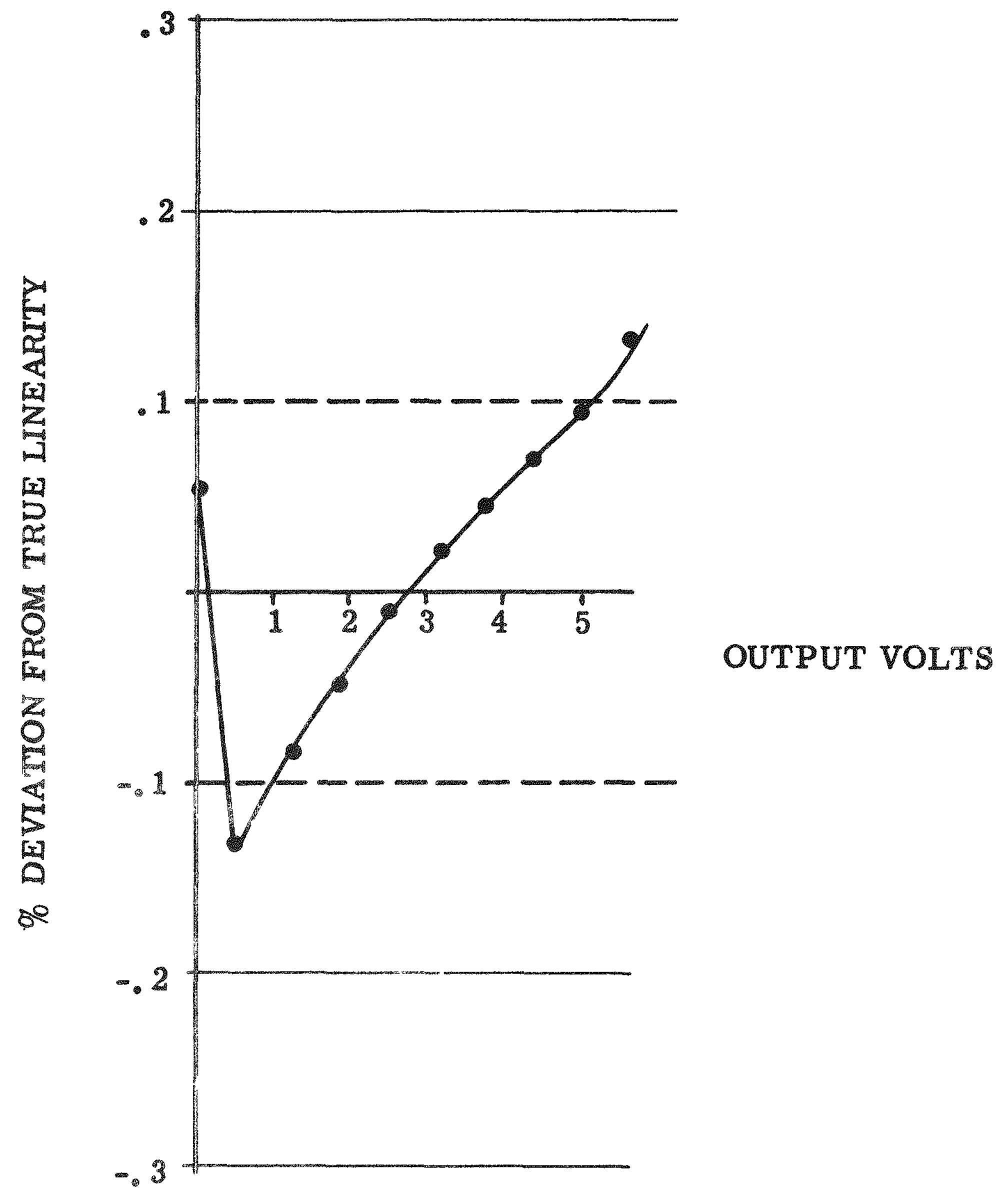


FIGURE 58 PSA, S/N 7 - LINEARITY DEVIATION AT +250° F.

7.2 PCA S/N 7 [illegible]

The [illegible] performance [illegible] -260°F, +75°F, and 250°F. Test data for the three ambient temperatures are presented in Table XI and [illegible] 59 and 60.

TABLE XI

PCA P/N 2775019-3, STATIC CHARACTERISTICS

Ambient Temp.	-260°F			+75°F			250°F		
Voltage	105	115	127	105	115	127	105	115	127
Frequency	360	400	440	360	400	440	360	400	440
Input Null (millivolts)	0.93	0.95	1.32	1.67	0.13	-0.51	-0.33	-1.05	1.81
Zero Frequency Gain (volts/volt)	10300	7200	7090	2640	2730	2610	1600	1720	1650
Rate Gain (.159 cps)(volts sec/volt)	9.0	10	10	25	25	22	25	25	27
Proportional Gain (5 cps)(volts/volt)	2.6	2.5	2.4	3.5	3.3	3.5	3.5	3.5	3.5
Saturation Level (volts)	13.7	15.4	15.1	11.1	13.3	14.0	10.2	11.7	12.6
Cut Off Voltage (volts)	0.98	0.99	-0.99	0.76	0.77	0.78	-0.59	-0.60	-0.61

PCA PERFORMANCE DATA

Output Ripple Voltage (Reflected to 10-Ohm command source)	11 millivolts
Input Impedance Non Operating	1600 ohms
Output Impedance Operating	5 ohms
Transfer Function	See Figure 59
Dynamic Linearity	See Figure 60
Power Consumption Null Saturation	 3.25 watts 5.0 watts
Weight	4.8 pounds

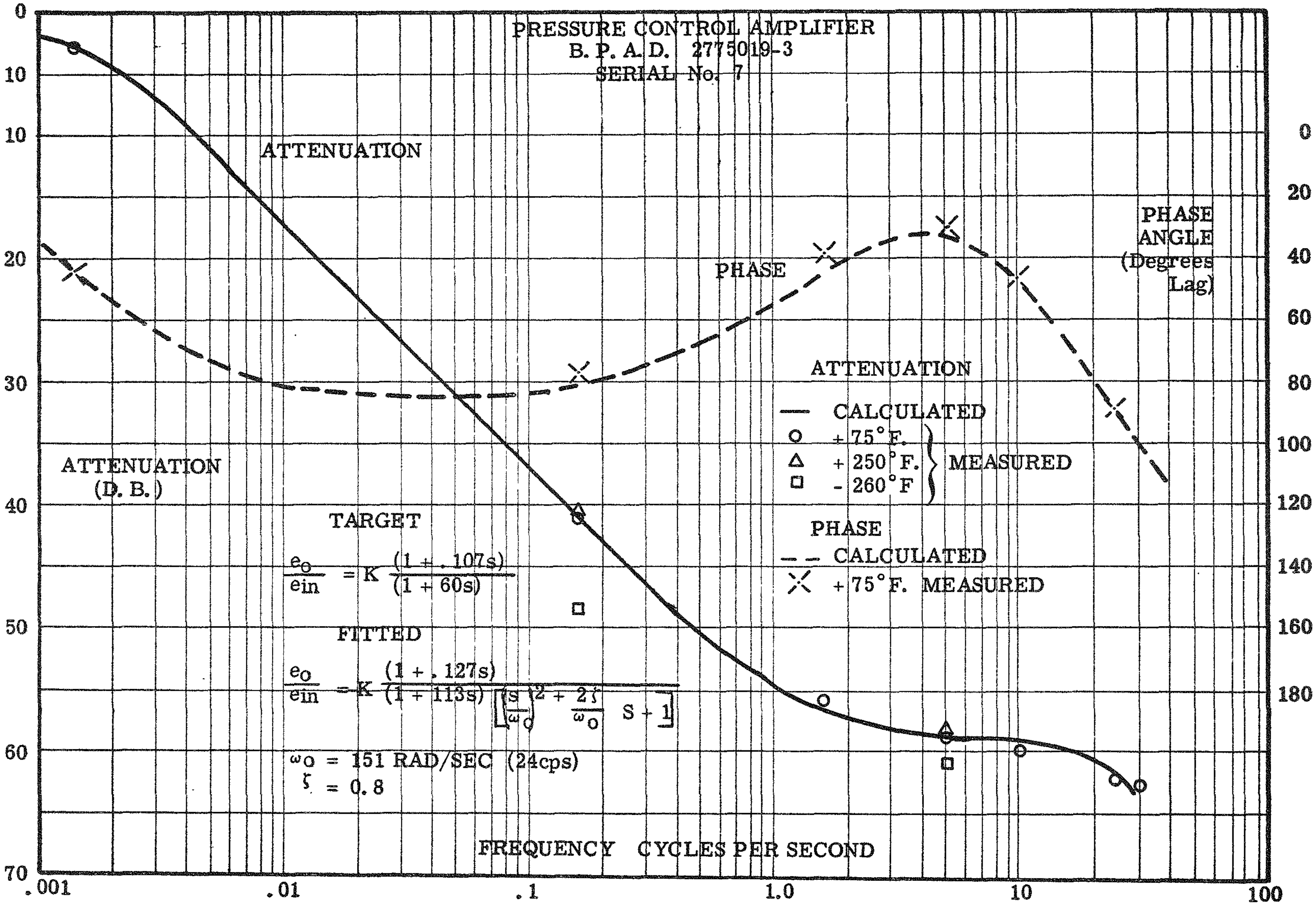


FIGURE 59 PCA, S/N 7 - FREQUENCY RESPONSE

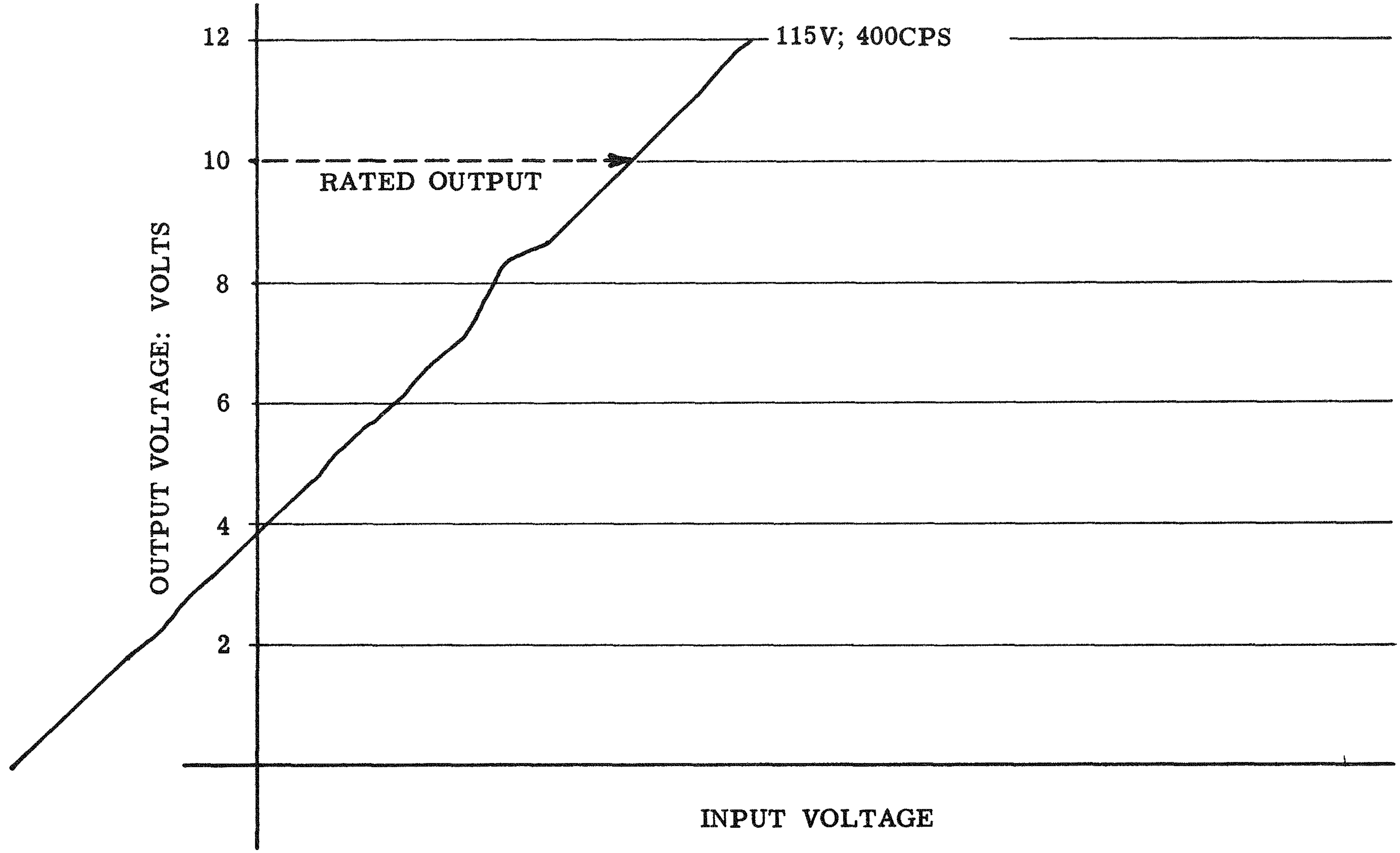


FIGURE 60 PCA, S/N 7 - Dynamic Linearity

7.3 TSA, S/N 7, PERFORMANCE DATA

The TSA, S/N 7, performance was measured at -260° F, +75° F, and +250° F. The tests results are given in Table XVI and Figures 61 through 64.

TABLE XVI

TSA, P/N 2775016-3, STATIC CHARACTERISTICS

Ambient Temp.	-260°F			+75°F			+250°F		
Line Voltage Line Frequency	103 360	115 400	127 440	103 360	115 400	127 440	103 360	115 400	127 440
Input Null (millivolts)	-7.14	-6.00	-6.40	0.08	0.14	0.17	2.12	2.00	1.35
Gain (volts/volt) @ 4.0 V output)	1.25	1.25	1.25	1.29	1.29	1.29	1.30	1.30	1.30
Linearity - % (@6.6 V output)	0.29	0.17	0.10	0.08	0.10	0.12	0.08	0.11	0.13
Saturation Level (volts)	9.9	11.3	12.5	8.9	10.2	11.4	8.8	10.0	10.8

TSA PERFORMANCE DATA

Output Ripple Voltage (Reflected to 10-ohm command source)	5.5 millivolts
Input Impedance	
Operating	6200 ohms
Non-Operating	6200 ohms
Output Impedance	
Operating	3.0 ohms
Roll-Off Frequency	47 cps
Power Consumption	
Null	1.4 watts
Saturation	2.1 watts
Weight	4.1 pounds

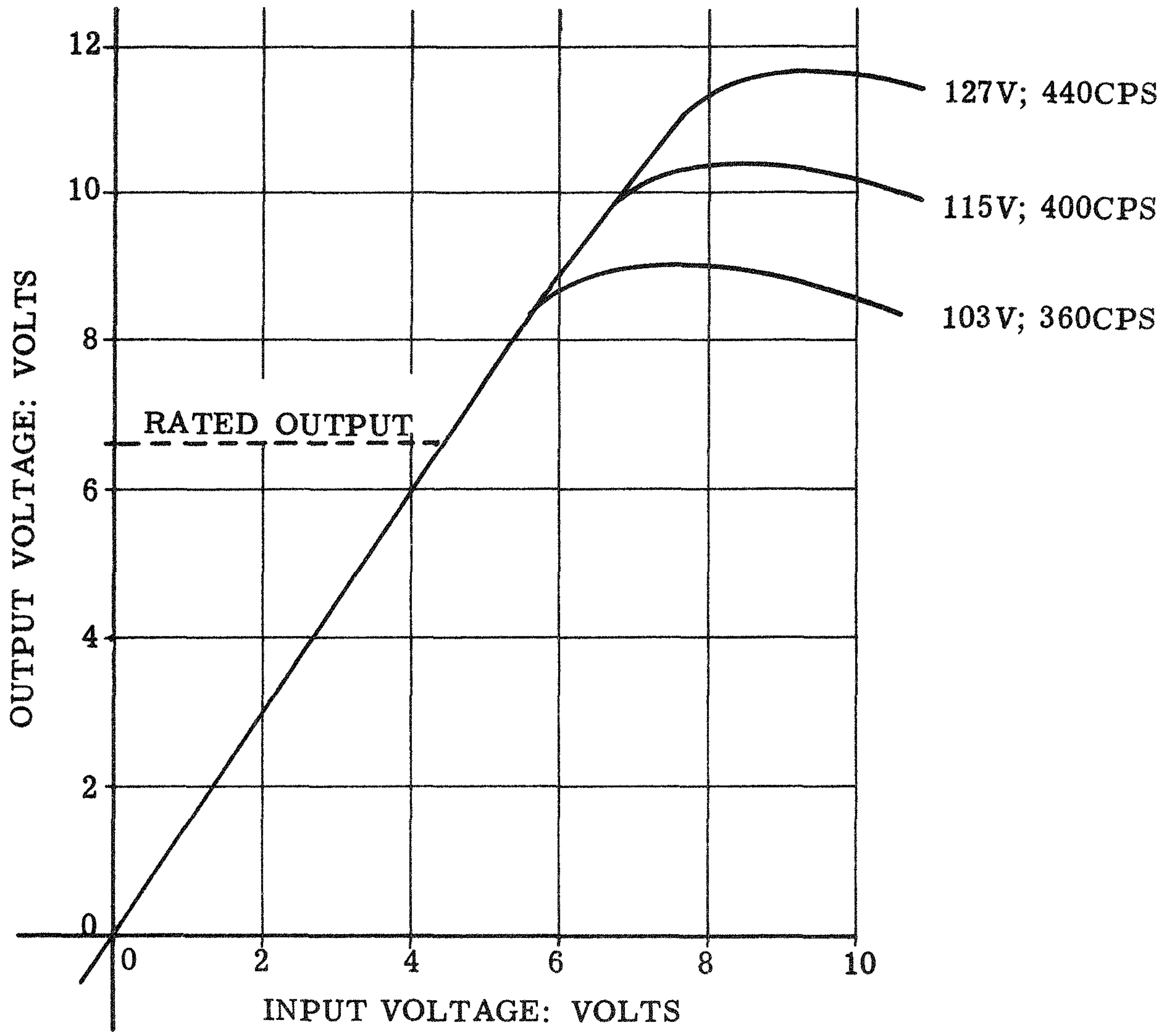


FIGURE 61 TSA, S/N 7 - LINEARITY AT +75° F.

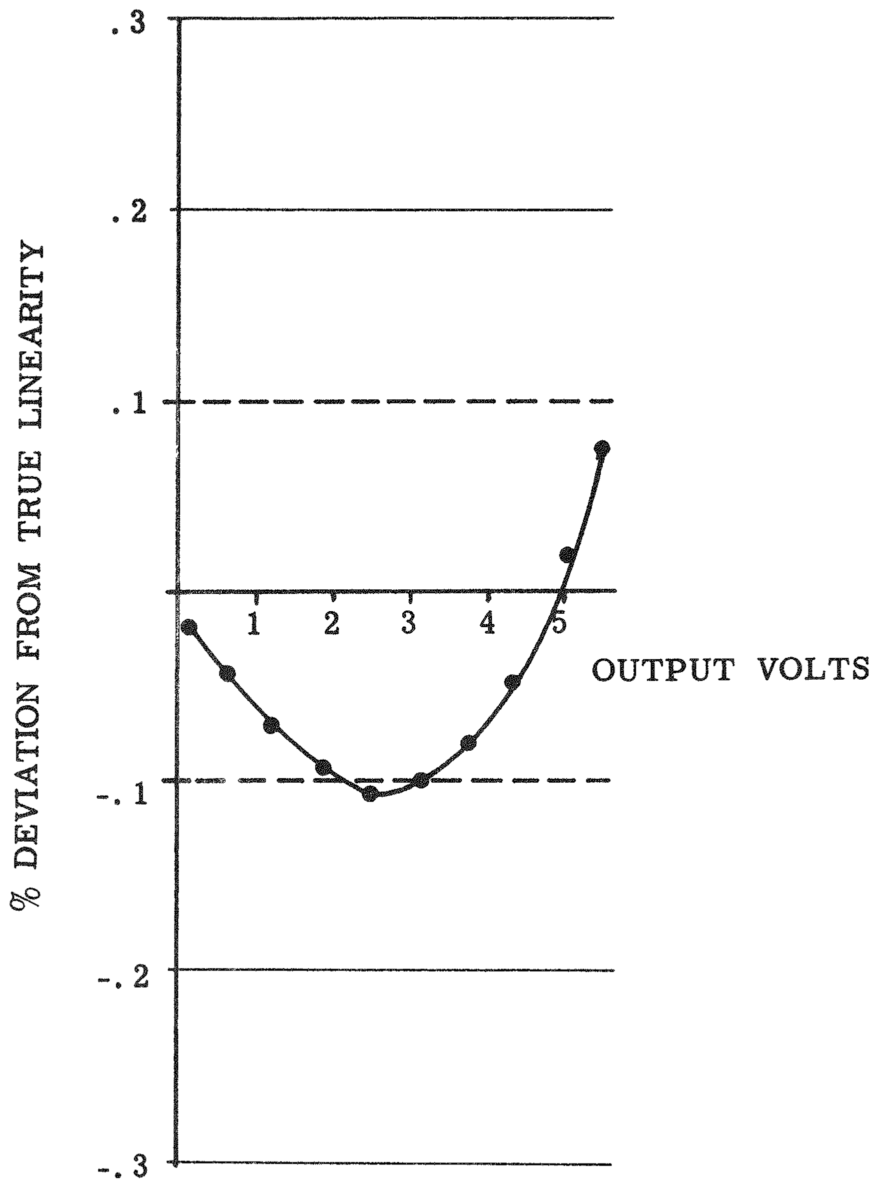


FIGURE 62 TSA, S/N 7 - LINEARITY DEVIATION AT -260° F.

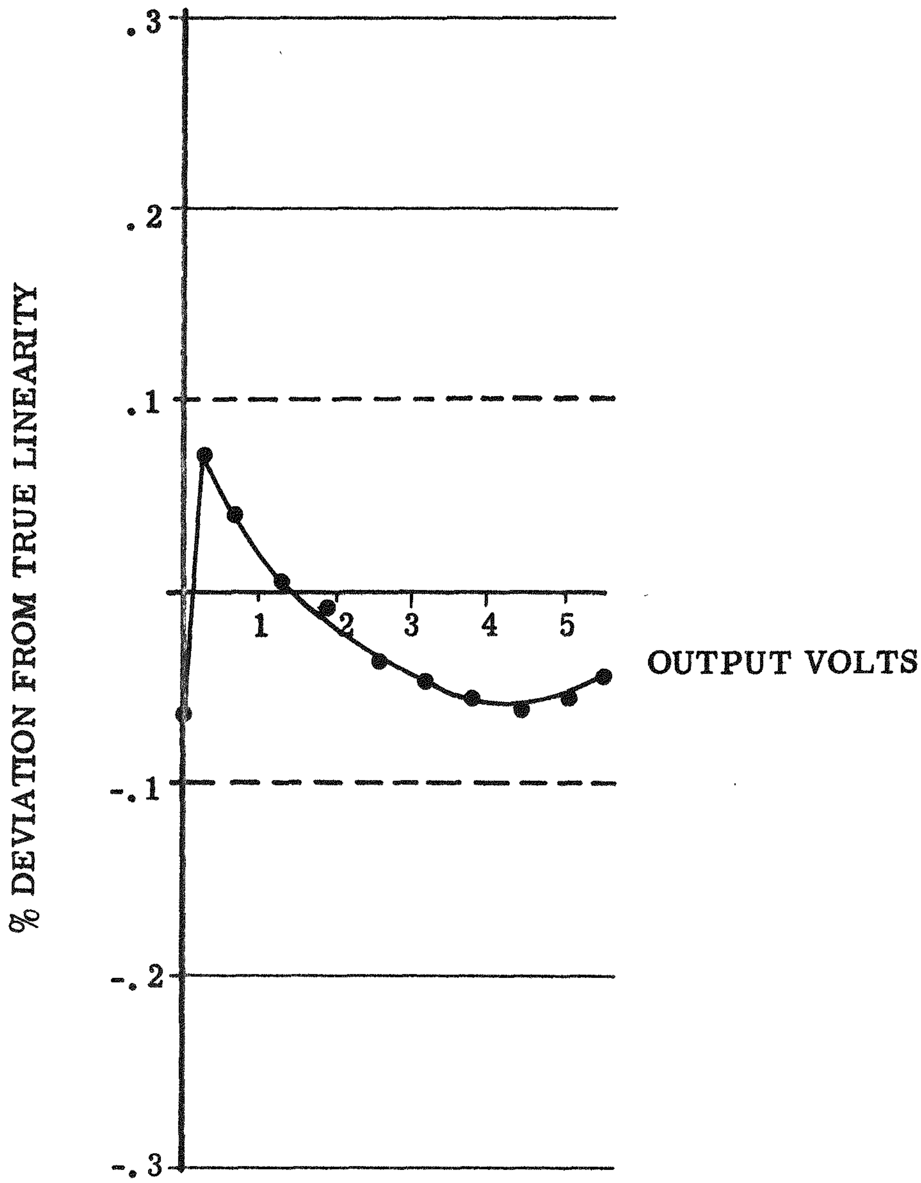


FIGURE 63 TSA, S/N 7 - LINEARITY DEVIATION AT +75° F.

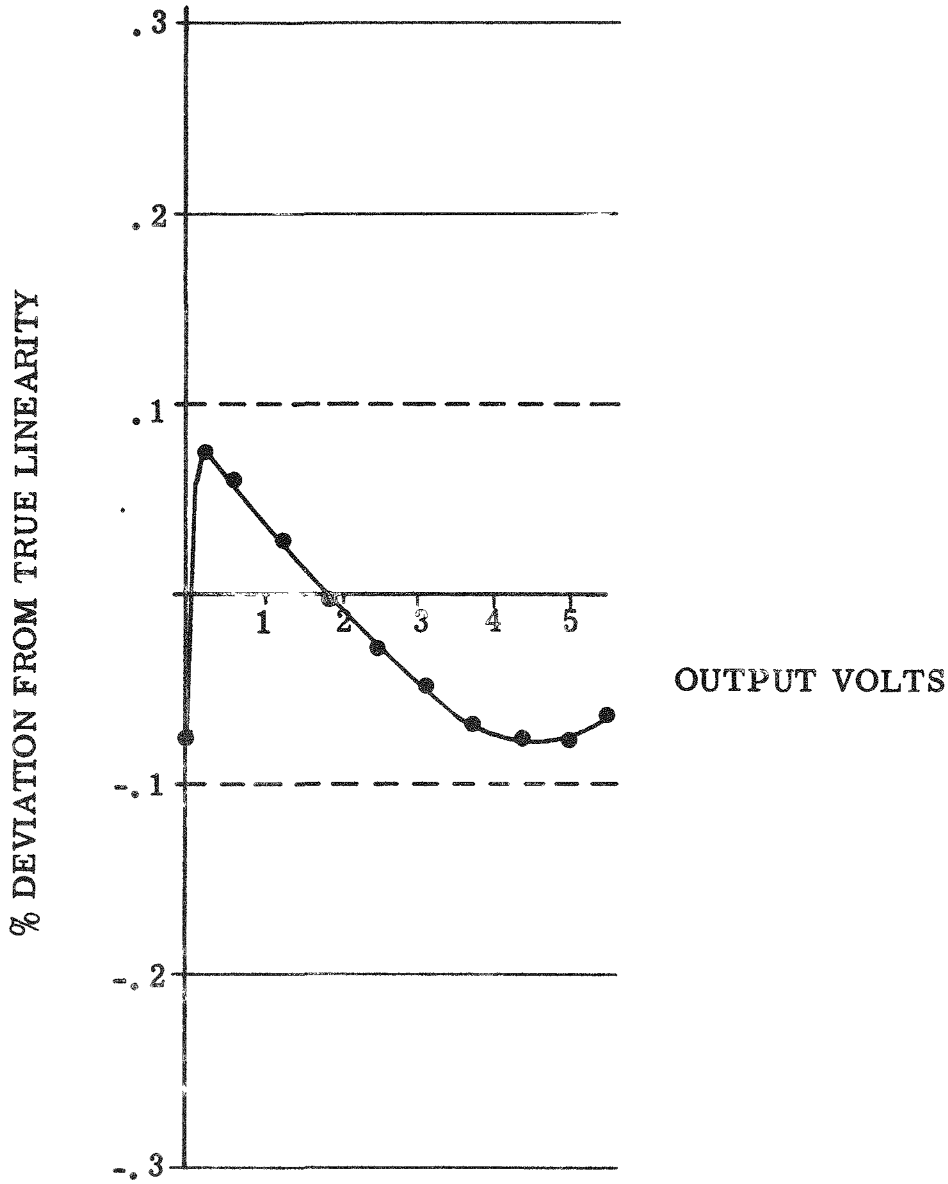


FIGURE 64 TSA, S/N 7 - LINEARITY DEVIATION AT +250° F.

7.4 TCA, S/N 7, PERFORMANCE DATA

The TCA, S/N 7, performance data were taken at -260° F, +75° F, and +250° F. The data are given in Table XVII and in Figures 65 and 66.

TABLE XVII

TCA, P/N 2775018-3, STATIC CHARACTERISTICS

Ambient Temp.	-260°F			+75°F			+250°F		
Line Voltage Line Frequency	103 360	115 400	127 440	103 360	115 400	127 440	103 360	115 400	127 440
Input Null (millivolts)	-220	-55	-138	-98	-11	+110	-195	67	162
Zero Frequency Gain (volts/volt @ 8.0 V output)	8.00	9.14	7.86	18.1	19.4	21.6	13.1	19.6	20.1
Rate Gain (volt/sec/volt @ 0.159 cps)	0.04	0.04	0.04	0.23	0.23	0.22	0.36	0.36	0.34
Proportional Gain (volts/volt 5.0 cps)	0.38	0.35	0.35	0.94	0.91	0.87	1.09	1.09	1.03
Saturation Voltage (volts)	14.6	6.9	18.4	12.2	13.9	15.4	11.3	12.7	14.2
Cut-Off Voltage (volts)	-1.3	-1.3	-1.3	-0.77	-0.77	-0.78	-0.61	-0.62	-0.63

TCA PERFORMANCE DATA

Output Ripple Voltage (Reflected to 10-ohm command source)	20 millivolts
Input Impedance Non-Operating	 1600 ohms
Output Impedance Operating	 3.3 ohms
Transfer Function	See Figure 65
Dynamic Linearity	See Figure 66
Power Consumption Null Saturation	 3.8 watts 5.2 watts
Weight	6.1 pounds

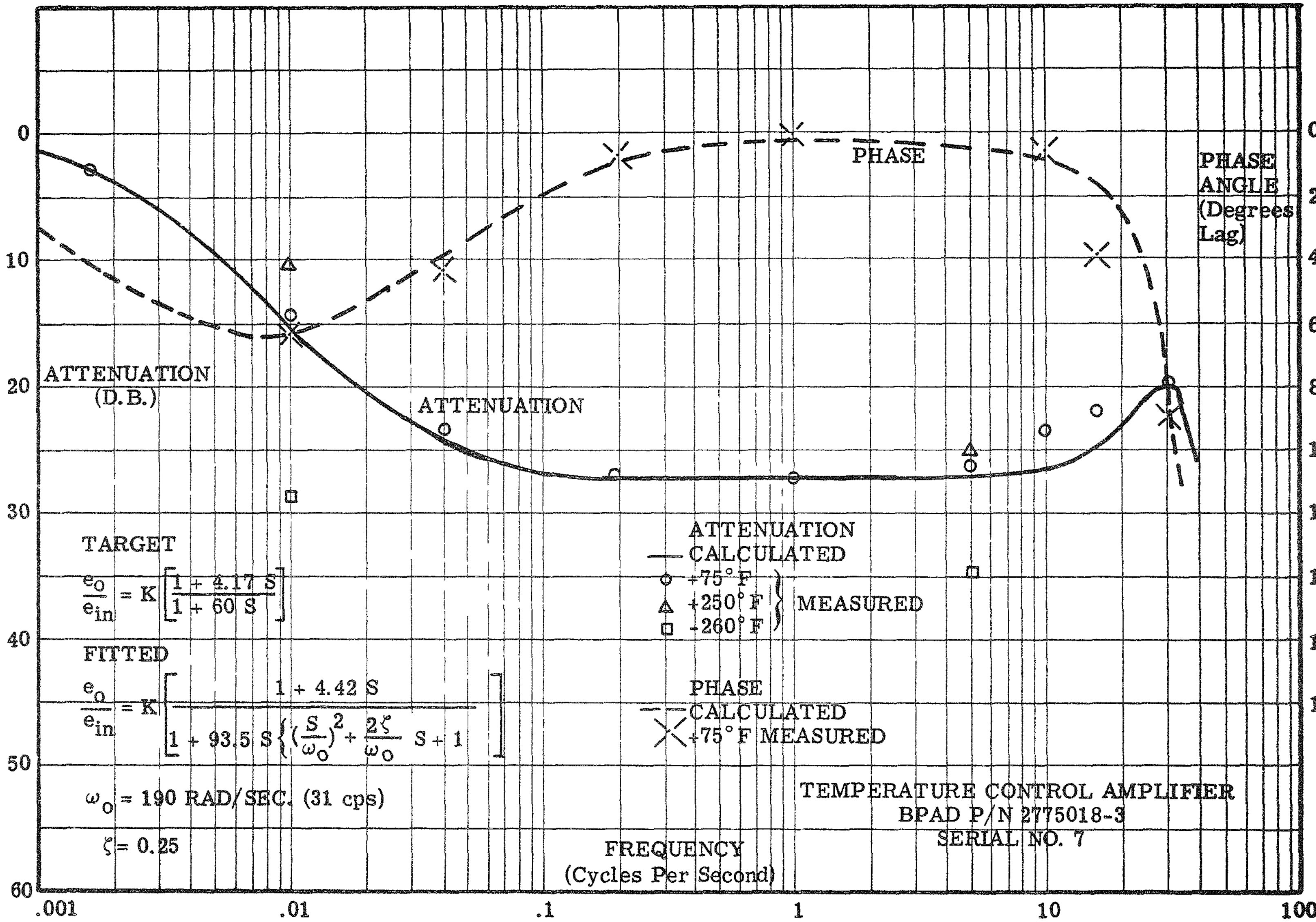


FIGURE 65 TCA, S/N 7 - FREQUENCY RESPONSE

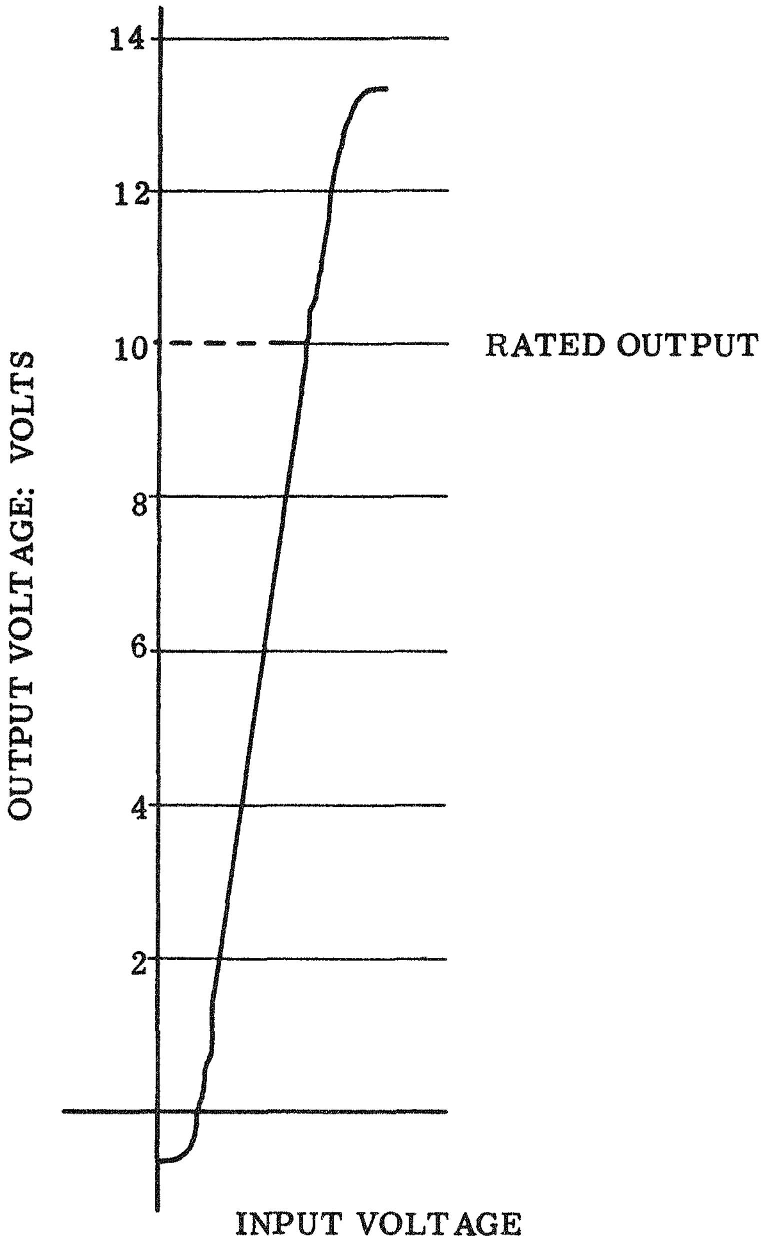


FIGURE 66 TCA, S/N 7 - DYNAMIC LINEARITY