FINAL REPORT

SYSTEM FOR MEASURING TURBINE BLADE TEMPERATURES

CONTRACT NAS8-28952

PERIOD OF PERFORMANCE

6/12/72 - 12/12/72

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ABSTRACT

This report presents the results and methods of tests performed at Kollsman Instrument Corporation in verifying the basic operational capabilities of the "System for Measuring the Turbine Blade Temperature."

This report fulfills the requirement of Exhibit "B" of the referenced contract.

Reference Documents:

1. Operating Manual for Turbine Blade Temperature System, dated 1 December 1972
2. Operating Instructions, Land Pyrometer Head

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Section I

INTRODUCTION

This report fulfills the requirements of Exhibit "B" of contract NAS8-28952 summarizing the results of the entire contract work.

Since the system was not specifically developed for this contract but is a system presently being produced, this report does not deal with the development aspects of the system but rather with the verification of the system performance and the test procedures used.

The theory of operation and system basic description is treated in the referenced documents in the Abstract of this report and is not a subject for this report.

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Section II

SYSTEM DESCRIPTION

The system consists of two components, the Amplifier DL83900-00-000, and the Pyrometer Head, PFQB/1. Both units are of the same type presently being produced for the Olympus engines in the Concorde and, in fact, have been taken off the production line for these components.

The amplifier, in addition to performing the function of amplification and linearization of the pyrometer head output, also provides two addition functions which are of no pertinence to this procurement but should be mentioned.

One function provides a signal for the Concorde engine control system that is not faulted by short term power interruptions. A separate amplifier terminal provides this output. It is connector terminal RP-23.

The other function is to provide means for inhibiting the pyrometer output signal during engine start-up when the pyrometer is grossly erroneous. This inhibit circuit is actuated by excitation to back connector terminals 14, 22 and 24.

The connector terminals pertinent to this procurement are shown in Figure 1. The schematic shows the terminals and interconnections between the pyrometer head of amplifier. Also shown are the indicator output terminals and the 400 Hz power input connections. A digital voltmeter, HP3460B, has been used to measure the output of the system.

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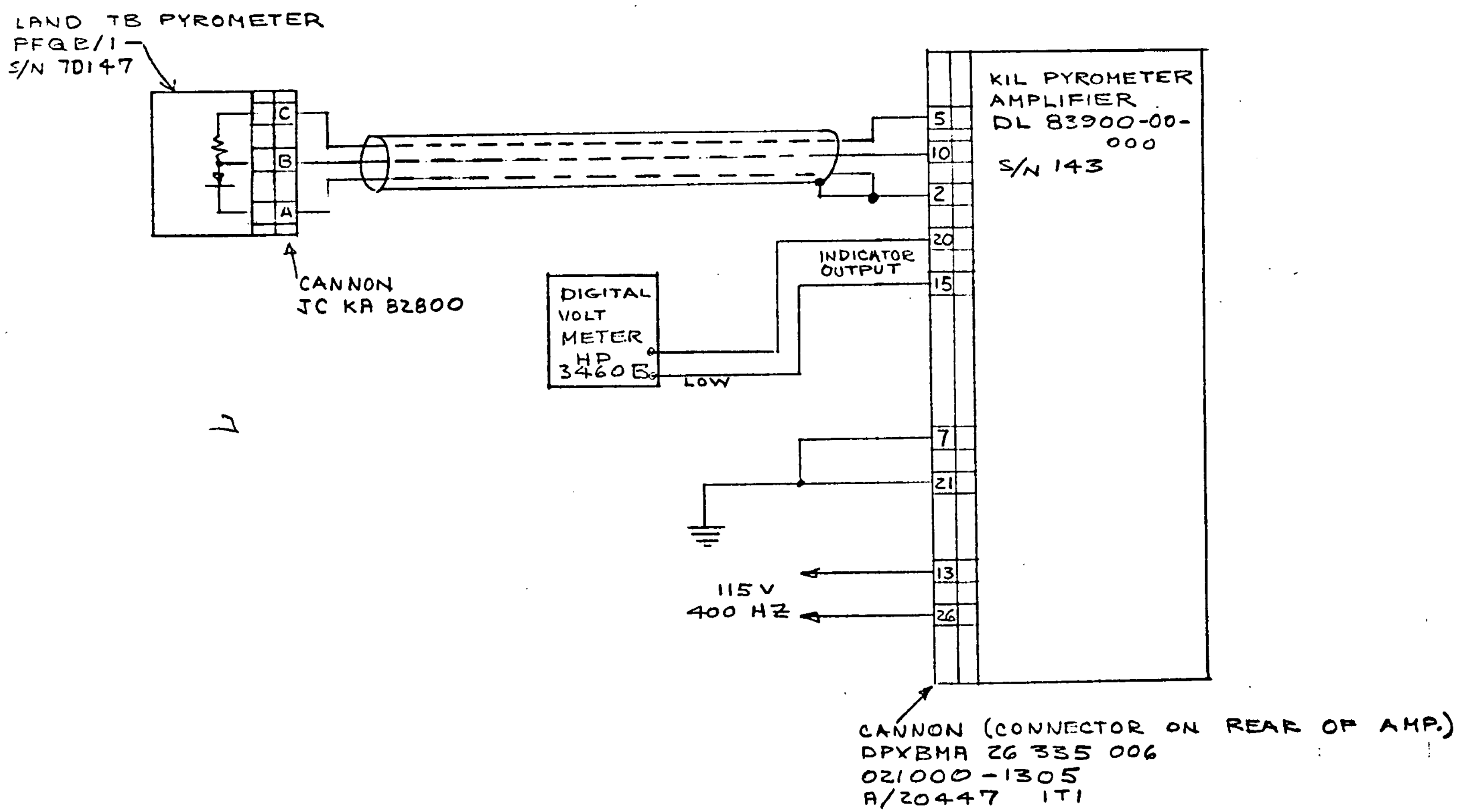

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Figure 1. Wiring Diagram for Accuracy Evaluation

Section III

TEST DESCRIPTION

The following tests were conducted in a laboratory environment to ascertain the operational accuracies of the system. By design the system is capable of operating in an aircraft environment far exceeding the 150°F for the sensor called for in this procurement.

Figure 2 illustrates the test set-up used to determine the system operational accuracy. The schematic illustrates the test technique. An IR black body, Infrared Industries Model 463, was used as the target objective. A No. 8686 L and N Millivolt potentiometer was used to determine the black body thermocouple output with respect to a cold junction reference emersed in an ice bath. A platinum and platinum plus 10% Rhodium thermocouple was used. The spacing between the pyrometer and black body was approximately 5 inches. This distance is not critical if the black body target is adequate to fill the pyrometer field-of-view of 1/20 radian. This implies a target of at least 1/4 inch diameter normal to the line-of-sight.

Data was taken for discrete temperatures of 700 °C, 800 °C, 900 °C, and 1000 °C. These temperatures were set by reference to the IR Black Body thermocouple output as read on the potentiometer. At each temperature setting the digital voltmeter was read. Immediately after a voltmeter reading was made at a discrete temperature, the press-to-test switch on the front panel of the amplifier was switched on and the amplifier output under this condition was recorded.

Actuation of the switch injects a signal into the front end of the amplifier producing in effect a signal corresponding to a temperature of approximately 900 °C. This test serves as a check on the performance of the amplifier. If the signal obtained falls between -1,975 -2,025 millivolts, the amplifier is performing properly.

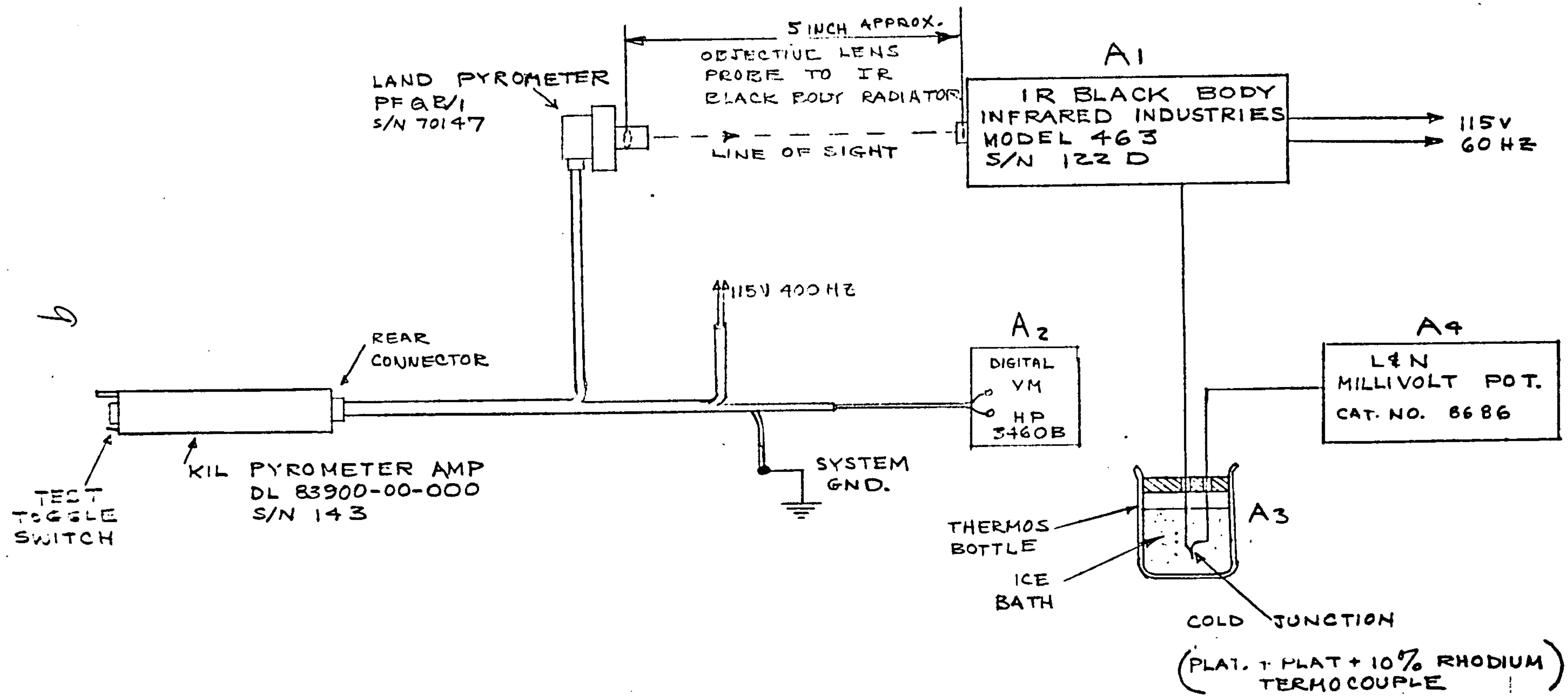

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Figure 2. Test Setup for Pyrometer Accuracy Evaluation

Section IV

TEST RESULTS

The result of the calibration tests are tabulated in Table 1. Column 2 of this table records the range of output voltage to be expected from the system. Column 3 records the output of the system at each test point as measured on the digital voltmeter A2. Column 4 is the difference between the reading obtained and nearest point within the calibration range. In this case the point falls on the lower limit of the range. Column 5 expresses the results of column 4 in degrees C. Column 6 is the reading resulting after the press to test switch was actuated.

The results show calibration errors within the range expected for the test equipment used.

The stability of the system was observed over a period of 20 hours. During this period the temperature calibration repeated within 2 MV (0.4 C). The press to test switch showed repeatability of the amplifier within 1/2 MV (0.1 C).

The stability capability of the system is from our production experience in excess of that required to meet the 3% over 200 hours specification of this procurement and thus no sustained 200 hour stability test was deemed necessary.

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PERFORMANCE DATA

Subject	SYSTEM TEST DATA	Date	10-1-72
Type No.	SYSTEM FOR MEASURING TURBINE	Job No.	310113
Remarks	BLADE TEMPERATURE		

System Sensitivity = $\frac{250MV}{50°C}$ = $\frac{5MV}{°C}$

TABLE 1

Signature

[1] A1 Black Body Target	[2] System Calibration Range	[3] A2 System Output	[4] Neasrest Point in Calibration Range - System Output	[5] System Error	[6] Press To Test Read A2
T°C	Millivolts	Millivolts	Millivolts	°C	Millivolts
700	-375/-1025	-929	-975 + 925 = -46	-9	2.013
800	-1490/-1510	-1459	-1490 + 1459 = -31	-6	2.013
900	-1995/-2005	-1967	-1995 + 1967 = -25	-5	2.013
1000	-2495/-2505	-2484	-2495 + 2484 = -11	-2	2.013

Section V

SYSTEM TESTER EVALUATION

The system tester was arranged with respect to the system as shown in Figure 3. Table 2 indicates the position of the test selection switch and the results necessary to default or pass the system. The system tested satisfactory at all test points.

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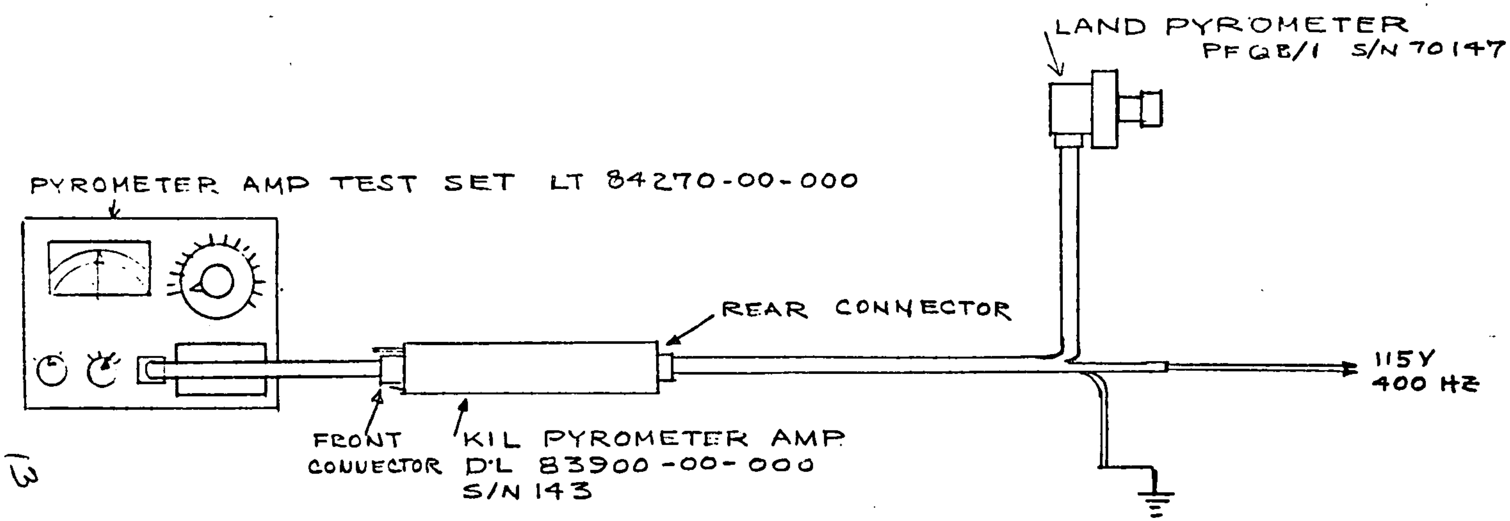

Figure 3. Test Setup for Pyrometer, Amplifier Test Using Pyrometer Test Set

PERFORMANCE DATA

Subject	Date
Type No. SYSTEM TESTER CHECKS	Job No.
Remarks	
TABLE 2	Signature

Test Point	Title		K Ohms Setting	Meter Reading	Default Condition
1	20K Self Test		x10	20±2K	Tester Faulty
2	REF Self Test			White Sector	Tester Faulty
3	Ios Self Test			White Sector	Tester Faulty
4	Vos Self Test			White Sector	Tester Faulty
5	Rp	NOT APPLICABLE			
6	Rt Head Res.		x10orx100	10K-200K	(Head or
7	Head Insulation			White	Inter-
8	AMP Insulation			Sector	CONNECTION Failure)
9	VOS AMP INPUT			White Sector	Amp Faulty
10	Ios AMP INPUT			White Sector	Amp Faulty
11	600C	100MV		White Sector	Amp Faulty
12	600I	FSD		White Sector	Amp Faulty
13	750C	50MV		White Sector	Amp Faulty
14	750I	FSD		White Sector	Amp Faulty
15	820C	20MV		White Sector	Amp Faulty
16	820I	FSD		White Sector	Amp Faulty
17	870C			White Sector	Amp Faulty
18	870I			White Sector	Amp Faulty
19	900C	10MV		White Sector	Amp Faulty
20	900I	FSD		White Sector	Amp Faulty
21	920C			White Sector	Amp Faulty
22	920I			White Sector	Amp Faulty
23	940C			White Sector	Amp Faulty
24	940I			White Sector	Amp Faulty
25	970C			White Sector	Amp Faulty
26	970I			White Sector	Amp Faulty
27	1020C	20MV		White Sector	Amp Faulty
28	1020I	FSD		" "	" "
29	1100C			" "	" "
30	1100I			" "	" "