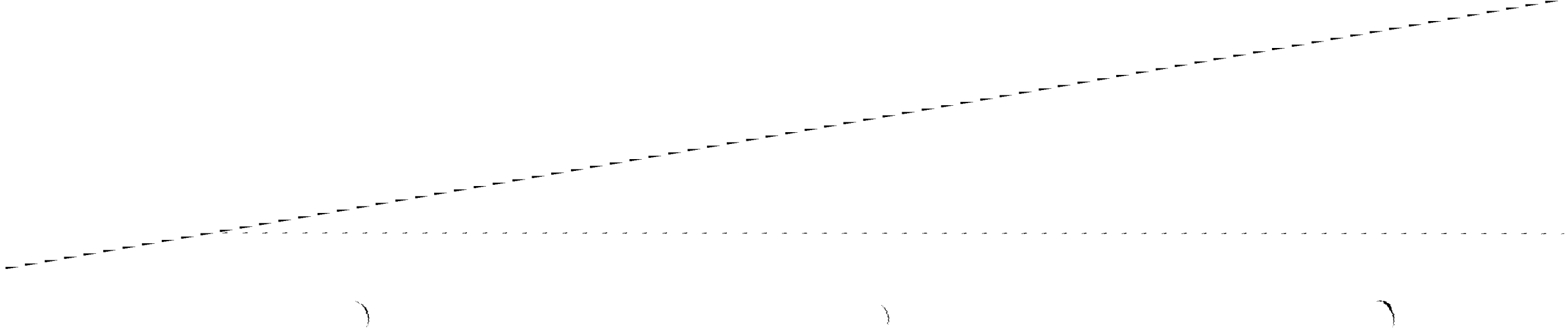
OPERATION AND MAINTENANCE INSTRUCTIONS
H337 SERIES
ENGINE TEST SET

THIS SERVICE MANUAL IS EFFECTIVE SERIAL NUMBER 400 AND SUBSEQUENT
AND PRIOR UNITS CONTAINING SOFTWARE H101-228 REV 4.01

HOWELL INSTRUMENTS, INC.
Fort Worth, Texas

15 SEPTEMBER 1988

Change 4: 7 NOVEMBER, 1994



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OPERATION AND MAINTENANCE INSTRUCTIONS

H337N SERIES

ENGINE TEST SET

Date of Original Issue: 15 September 1988

Instructions for updating manual: Remove old pages and replace with new pages having latest change number. Latest changes are indicated by change bars in the margins.

Page No.	Change No.	Date
A	1	10-16-90
iv	1	10-16-90
5-31	1	10-16-90
6-11	1	10-16-90
6-13	1	10-16-90
7-3 - 7-8A	1	10-16-90
7-9 - 7-12	1	10-16-90
7-15 - 7-16	1	10-16-90
7-19	1	10-16-90
7-21	1	10-16-90
7-24	1	10-16-90
7-26 - 7-28A	1	10-16-90
7-30	1	10-16-90
7-32 - 7-36A	1	10-16-90
7-38	1	10-16-90
7-41 - 7-43	1	10-16-90
7-46	1	10-16-90
7-48 - 7-50	1	10-16-90
7-54	1	10-16-90
7-56 - 7-61	1	10-16-90
Title	2	9-27-91
A	2	9-27-91
iv	2	9-27-91
1-1	2	9-27-91
3-1	2	9-27-91
4-12	2	9-27-91
8-1	2	9-27-91
Title	3	6-6-94
3-2	3	6-6-94
4-18	3	6-6-94

Page No.	Change No.	Date
Title	4	11-7-94
A	4	11-7-94
i	4	11-7-94
3-1 - 3-4	4	11-7-94
4-17 - 4-18B	4	11-7-94
7-4	4	11-7-94
7-6	4	11-7-94
7-15	4	11-7-94
7-38	4	11-7-94

TABLE OF CONTENTS

TABLE OF CONTENTS (Continued)

TABLE OF CONTENTS (Continued)

Section Page

V MAINTENANCE INSTRUCTIONS

TABLE OF CONTENTS (Continued)

THIS DOCUMENT IS SUBJECT TO THE LEGEND
RESTRICTIONS ON THE TITLE PAGE

Notice:

Howell Instruments, Inc. no longer releases assembly drawings, wiring schematics, Functional Descriptions, or illustrated parts lists, except to authorized repair stations.

For repair or replacement, please contact:

Howell Instruments, Inc.
8945 South Freeway
Fort Worth, TX 76140
817-336-7411

LIST OF ILLUSTRATIONS

LIST OF ILLUSTRATIONS (Continued)

LIST OF TABLES

SECTION I

INTRODUCTION AND GENERAL INFORMATION

1-1. INTRODUCTION.

1-2. GENERAL. This manual contains information pertaining to the H337N Series Engine Test Set manufactured by Howell Instruments, Inc., Fort Worth, Texas. The Engine Test Set (hereinafter referred to as the test set or the tester) is pictured in figure 1-1. Tester parts are illustrated and identified in the Illustrated Parts Breakdown, Section VII.

1-3. PURPOSE. The purpose of this manual is to provide sufficient information for the technician to understand, operate, calibrate, and maintain the tester.

1-4. SCOPE. In this manual are diagrams and the theory of operation of all tester circuitry, complete operation instructions showing cabling connections, a list of the calibration equipment and procedures necessary to maintain the accuracy of the tester, and troubleshooting and repair procedures.

1-5. ARRANGEMENT. This manual is arranged in the following sections:

Section	Title
I	Introduction and General Information
II	Special Tools and Test Equipment
III	Preparation for Use and Shipment
IV	Operation Instructions
V	Maintenance Instructions
VI	Diagrams
VII	Illustrated Parts Breakdown
VIII	Application Data
Appendix A	Descriptions of Integrated Circuits
Appendix B	Acceptance Test Procedure

1-6. ABBREVIATIONS AND SYMBOLS. Abbreviations and symbols used in this manual are explained in the following list:

Abbreviation/Symbol	Meaning
BIT	built-in test
CAL.	calibration
CALIB.	calibrated or calibration
CALIBR.	calibrated
CJ	cold junction
CK.	check

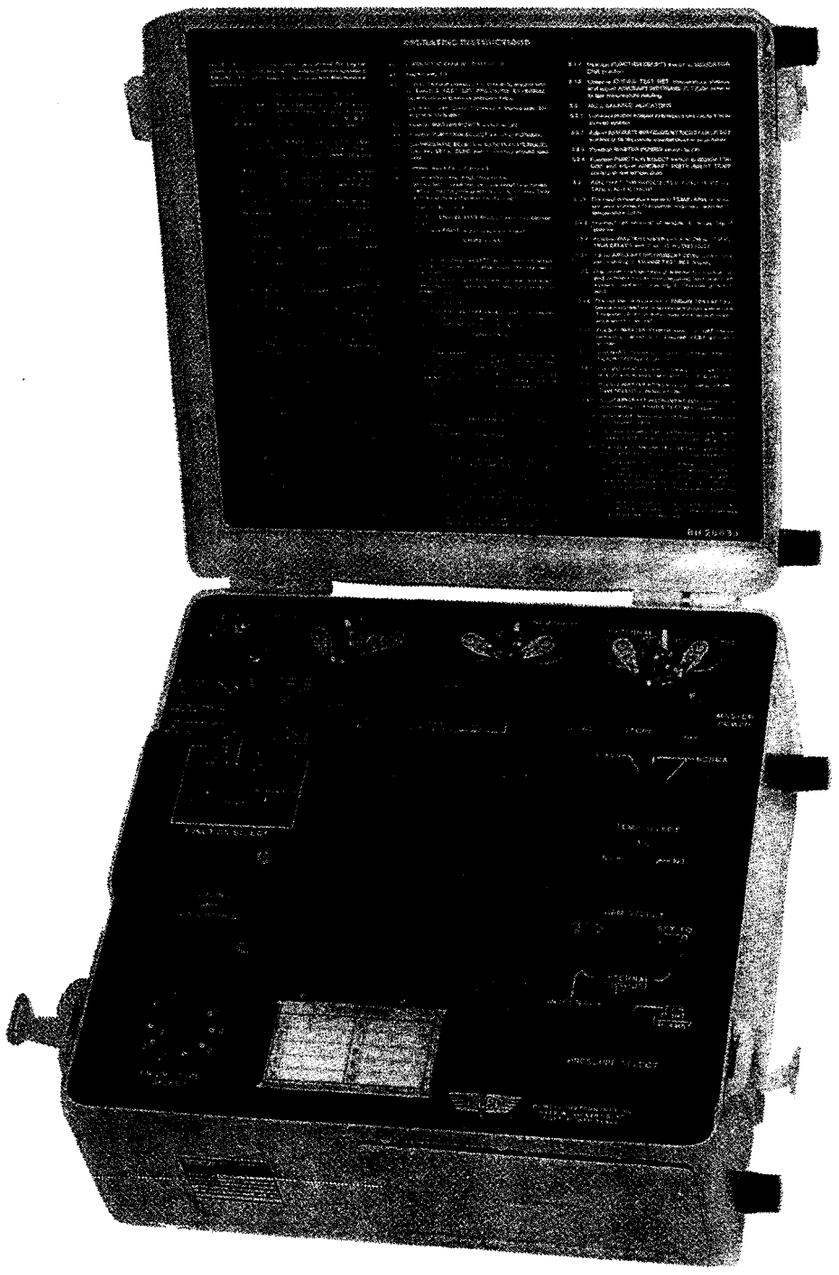

Figure 1-1. H337N Series Engine Test Set

1. Test aircraft temperature indicator.
2. Test resistance of aircraft temperature circuit.
3. Test insulation of aircraft temperature circuit.
4. Verify accuracy of aircraft rpm system.
5. Verify accuracy of aircraft temperature indicating system.
6. Monitor temperature during engine trimming.
7. Monitor rpm during engine trimming.
8. Monitor pressure during engine trimming.
9. Compute epr.
10. Measure engine torque.
11. Automatically correct temperature and rpm to standard day conditions.
12. Store and display or print up to 18 input data records (snapshots).
13. Store and display or print calibration and scaling data for up to 10 engine types.

1-9. SPECIFICATIONS. Specifications are listed in table 1-1.

Table 1-1. Specifications

Parameter	Range	Programmable Display Range	Accuracy (Note 1)
Engine Temperature (type K cr-al t/c)	0 to 1350°C (0 to 2462°F)	0 to 1350°C 0 to 2462°F	± 2° C ± 4° F
Engine Temperature (TF30 cr-al curve)	0 to 1360°C (0 to 2480°F)	0 to 1360°C 0 to 2480°F	± 2° C ± 4° F
Standard Day Temp	-60 to 100°C ambient	- - - - - - - - -	± 4° C @ 600° C
Ambient Temperature	-60 to 100°C (-76 to 212° F)	-60 to100°C -76 to 212°F	± 0.3° C ± 0.5° F
Frequency	10 to 30K Hz (note 2)	30,000 counts max (%RPM,RPM,PPH,HZ)	± 0.1 %
Standard Day Freq	-60 to 100°C ambient	- - - - - - - - - - -	± 0.2%RPM @ 70HZ = 100%
Internal Pressure Transducer	0 to 5vdc	0 to 101.8 IN.HG. ABS	± 0.25 IN.HG.

1-10. PHYSICAL DESCRIPTION. The tester is housed in a rugged, portable case. All cable and hose connections, switches, controls, and displays are located on the deck. The H337N Series part number assignment is as follows: H337N( )tester includes printer access without printer; H337NP-( ) tester includes printer.

Table 2-1. Special Tools and Test Equipment List (Continued)

TOOL/EQUIPMENT	NOMENCLATURE	USE AND APPLICATION
General Resistance DA763X	Resistance decade	Cold junction cal; insulation cal.
Electro Scientific DB62	Resistance decade	TAMB cal; tc res cal.
Anadex FS-600	Frequency synthesizer	RPM accy chk.
Tektronix 432	Oscilloscope	Troubleshooting.
Wallace & Tiernan 61A-1B-0100	Absolute pressure gage	Int press xdcr cal.
Triplett 630-NS	Volt-ohm-milliammeter	Operational checkout.
Fluke 8800A	Digital multimeter	Operational checkout.
- - - - -	Pressure source	Pressure cal.

SECTION III

PREPARATION FOR USE AND SHIPMENT

3-1. PREPARATION FOR USE.

3-2. UNPACKING. There are no special unpacking procedures. A list of items shipped is included in Section VIII. The tester is ready for use after unpacking. Operation instructions are contained in the instrument case lid as well as in Section IV of this manual.

3-3. ENGINE TEST SETUPS. Engine test setup diagrams, if included, are in Section VIII.

3-4. LOADING INTERNAL PRINTER PAPER (HOWELL PN C10717, MEMODYNE PN PT-20B1) IN PRINTER MAP-20SBCL (FIGURE 4-11, SHEET 6).

1. Loosen captive screws in PRINTER ACCESS door and lower door.

2. Depress both front panel slide latches (Figure 3-1) and pull printer mechanism out of housing until mechanism stops.

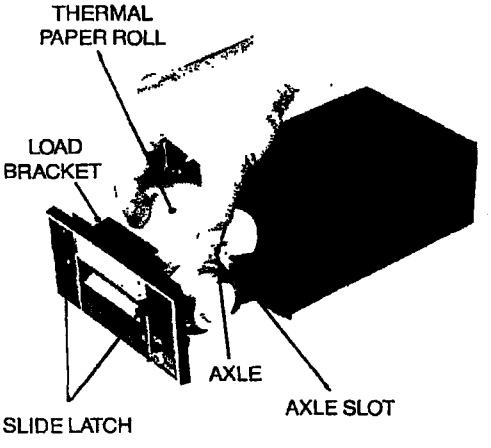

Figure 3-1. Loading Internal Printer Paper

3. Pull remaining paper out from under print head. Grasp empty paper roll and pull it straight along axle slot and out of printer assembly.

4. Slide paper roll axle out of used paper roll and insert axle into new paper roll (Howell pn C10717). DO NOT DISCARD AXLE!

5. Raise load bracket.

6. Slide axle (with new paper roll) into axle slot and seat the axle in bottom of slot. Be sure paper is fed from rear and passes over paper roll. Paper should be cut straight for easy insertion. Only outside paper surface is treated for printing.

7. Insert paper in slot formed by paper guide and print head until paper appears at front panel opening. Pull paper through front panel slot, close load bracket by pressing it downwards, and check that when power is on, EOP LED turns off. If not, paper is not in proper paper path. DTR light should be on when power is on.

8. Slide printer mechanism back into housing until both slide latches latch. Advance paper by momentarily setting switch to FEED. Place switch in center position for normal operation.

3-5. LOADING INTERNAL PRINTER PAPER (HOWELL PN C15055, MFE INSTRUMENT CORP. PN PT21B1) IN PRINTER MAP-21CBC (FIGURE 4-11, SHEET 6).

1. Loosen captive screws in PRINTER ACCESS door and lower door.

2. Rotate the paper advance knob (figure 4-11) downward to advance any remaining paper out of the printer. Lift up on the head release lever to raise the print head from the roller.

3. Lift up on both slide latches to release the slide assembly and pull the slide out of the housing until it stops. Lift the spent paper roll and axle from the notches in the slide assembly. Slide the axle out of the used paper roll. DO NOT DISCARD THE AXLE!

4. Break the seal on the new roll of paper. Tear off and discard the first layer of paper, including the glue or tape seal. Tear or cut cleanly for easy paper insertion. Slide the axle into the new paper roll and position the axle with the new roll above the notches in the slide assembly. Be sure the paper is fed from the top of the roll; only the outside surface of the paper is treated for printing.

5. Thread the paper into the paper slot and through the mechanism until it comes out the slot of the front panel. The PAPER light on the front panel changes from on to flashing.

6. Push down on the paper roll to seat the axle firmly into the bottom of the notches. Make sure the paper passes straight through the mechanism, then lower the head release lever. The PAPER light should turn off.

7. Push the slide back into the housing until the latches engage. Press the front-panel FEED button to check that the paper emerges smoothly from the mechanism. Press the ON LINE button to resume operation.

3-6. CABLE FOR OPTIONAL EXTERNAL PRINTER. If an external printer is to be used, prepare the interface cable as shown in figure 3-2 or 3-3. The printer used with the tester must be set to generate automatic linefeeds when sent carriage returns.

3-7. SETTING EXTERNAL PRINTER BAUD RATE.

1. Connect tester power cable to POWER INPUT receptacle and to appropriate power source.

2. Turn MASTER POWER switch on.

3. Set mode switch under SCALING AND CALIBRATION door to 11. Display will read:

(1)	(2)
SET BAUD	BAUD
EXTERNAL	RATE EQUAL
PRINTER	XXXX

where XXXX, the previously set baud rate or default value, is flashing.

4. Use CHANGE button to select desired baud rate. Choices are 110, 300, 600, 1200, 1800, 2000, 2400 and 3600.

5. After selecting desired baud rate, press ENTER button.

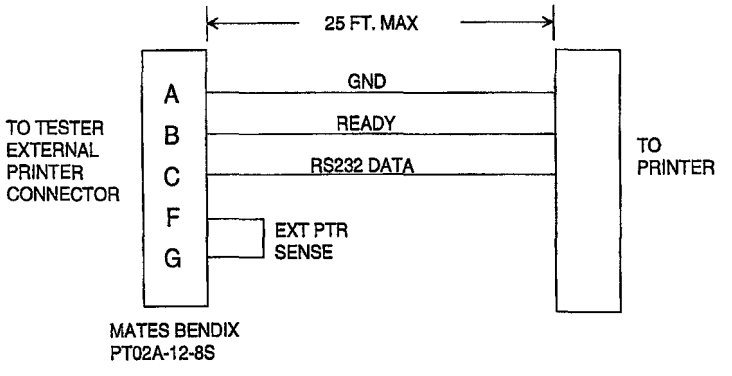

Figure 3-2. External Printer Cable for RS232 Interface

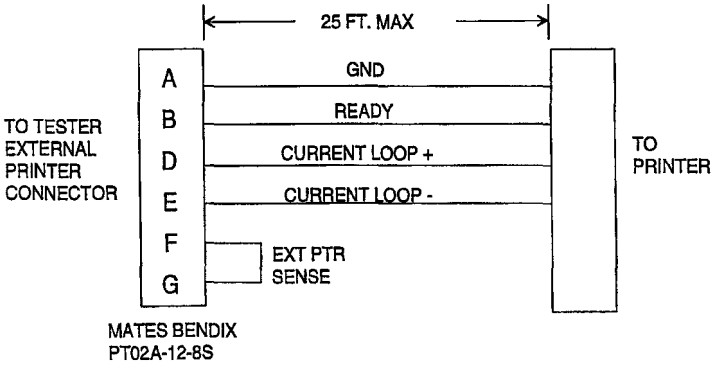

Figure 3-3. External Printer Cable for Current Loop Interface

NOTE

Current loop is driven by a 4.8 vdc source through a 56 ohm internal resistor. Maximum allowable source current is 25 ma at high logic level. Maximum available source current at low logic level is 0 ma (open collector).

3-8. PREPARATION FOR SHIPMENT.

3-9. The tester should be surrounded with two inches of rubberized hog hair when it is packed for shipment. Use the latest revision of specification MIL-P-116, method IIB, and JAN-P-100.

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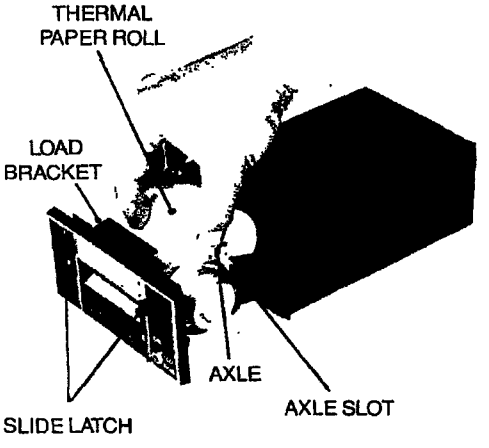

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where XXXX, the previously set baud rate or default value, is flashing.

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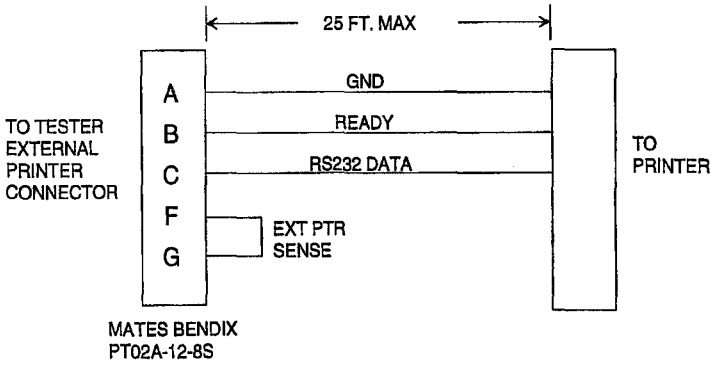

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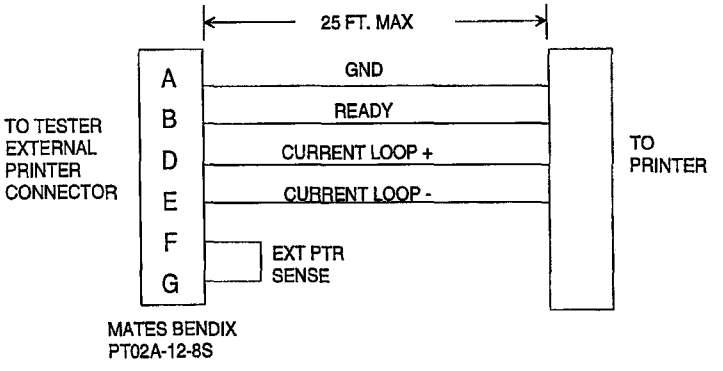

Figure 3-3. External Printer Cable for Current Loop Interface

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SECTION IV

OPERATION INSTRUCTIONS

4-1. THEORY OF OPERATION.

4-2. GENERAL. This section contains a brief discussion of the tester theory of operation as well as operation instructions. Included are a computer system block diagram, simplified schematics of the signal measuring circuits, and a power flow block diagram. Detailed descriptions of integrated circuits are included in Appendix A. Most circuitry is located on four printed circuit boards, namely the computer board, the analog board, the display board, and the power supply board.

4-3. COMPUTER SYSTEM. The tester is a combination digital voltmeter, millivolt source, and constant current source which is microprocessor controlled. Tester functions are managed by the central processing unit (CPU, U6, figure 4-1) and the stored program in the read-only memory (U1,U2). U6 is an 8-bit microprocessor which has the capability of addressing 65K bytes of memory with its 16-bit address lines. The 8-bit data bus is bi-directional as well as three-state. A 5-MHz clock oscillator provides the necessary timing. This clock is divided by 2 by CPU U6 and is further divided by counter/port/ram U11 to provide the built-in-test (BIT) frequencies for the frequency measuring circuits.

4-4. Switches in the deck switch matrix (figure 4-1) and jumper plug P104 determine which subroutines are run by the microprocessor. When P104 is removed, the tester goes into the internal calibration routine. The matrix switch having the highest priority for determining microprocessor action is the mode switch (figure 4-11, index 22) under the SCALING AND CALIBRATION access door. Switches with lesser priority in the order most-to-least are the FUNCTION SELECT switch and the TEMP SELECT switch.

4-5. Three counter/port/ram's (U11-U13) on the computer board (figure 4-1) provide the input-output (I/O) interface needed to read switch positions, to accumulate data from analog-to-digital and synchro converters, and to output data to printers. These circuits also contain timers which provide the frequency measurement capability. Each circuit contains 128 bytes of ram, two 16-bit programmable binary down-counters, and 19 programmable I/O bits arranged as three separate ports (port A - 8 bits, port B - 8 bits, and port C - 3 bits). Each bit is individually definable as an input or output. Port bits can be set or cleared individually and can be written or read in bytes. Following is a list of the circuits with their functions.

COUNTER/PORT/RAM	FUNCTIONS
U11 - port A (1PA bits)	Obtain data from ADC U17 and synchro converter U16, when used.
U11 - port B (1PB bits)	Control ADC and synchro converter functions. Sense tester switch closures.

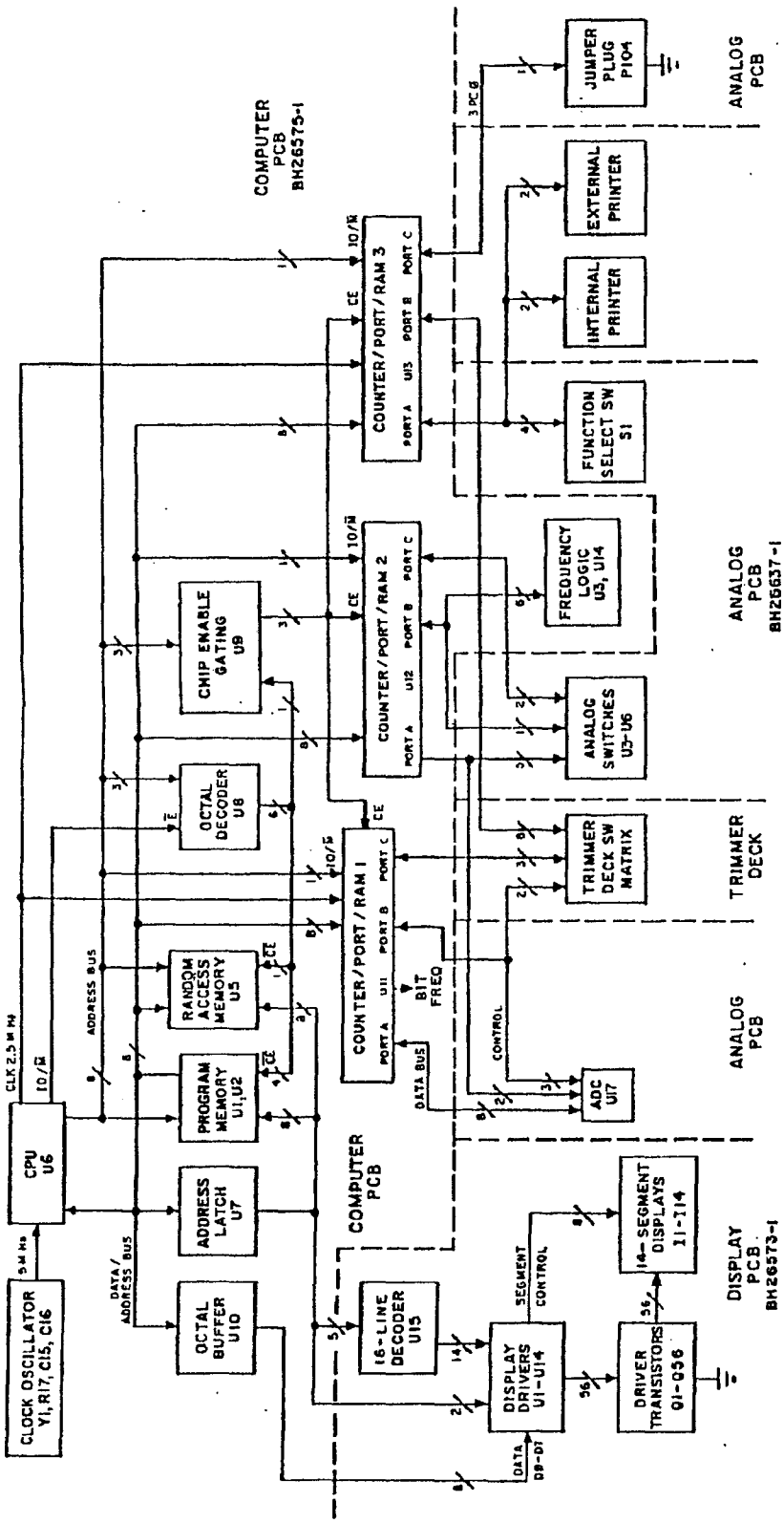


Figure 4-1. Computer System Block Diagram

COUNTER/PORT/RAM	FUNCTIONS
U11 - port C (1 PC bits)	Sense tester switch closures.
U12 - port A (2PA bits)	Multiplex inputs to amplifier U9. Select appropriate amplifier U9 offset circuit. Multiplex signals in ADC U17. Switch constant current source on and off when making resistance measurements.
U12 - port B (2PB bits)	Select appropriate amplifier U7 offset circuit for frequency measurements. Drive frequency timing logic.
U12 - port C (2PC bits)	Multiplex frequency signals to frequency amplifier U7.
U13 - port A (3PA bits)	Decode FUNCTION SELECT switch position. Control internal and external printer.
U13 - port B (3PB bits)	Sense tester switch positions.
U13 - port C (3PC bits)	Sense presence of jumper plug P104 for internal calibration mode.

4-6. ENGINE TEMPERATURE MEASURING CIRCUIT. The engine temperature signal from the engine thermocouples follows the path shown in figure 4-2. Switch positions required when measuring engine temperature are listed in the figure. The signal is amplified by U9 and offset by U2 on the analog board before being applied to adc converter U17. An input of 5 vdc will cause U17 to have a full-range (binary 4095) output. Analog switch U3, driven by port A bit 5 from counter/port/ram U11 on the computer board, controls the amount of offset voltage applied to U9 from U2. Port A bits 2 and 3 address one-of-four decoder U8 which drives analog switch U5 to route the thermocouple signal to U9.

4-7. To cancel any effect on the readings as a result of temperature variations in the junction between the tester's copper wiring and the thermocouple wires, a compensating junction (COMP JCT) is used in the negative lead of the input circuit. In close proximity to this junction is a thermistor (RT1) for junction temperature measurement. The microprocessor reads the thermistor signal and automatically references the thermocouple readings to 0°C.

4-8. AMBIENT TEMPERATURE MEASURING CIRCUIT. Figure 4-3 shows the circuit used to measure ambient temperature. An RTD probe, which has a resistance of approximately 108 ohms at 70°F, is connected to connector TAMB. U9 amplifies the signal before it is applied to ADC U17. Should the probe open, 5 vdc will charge filter capacitor C4 through resistors R43, R19, and R20, causing an upscale drift in the ambient temperature display.

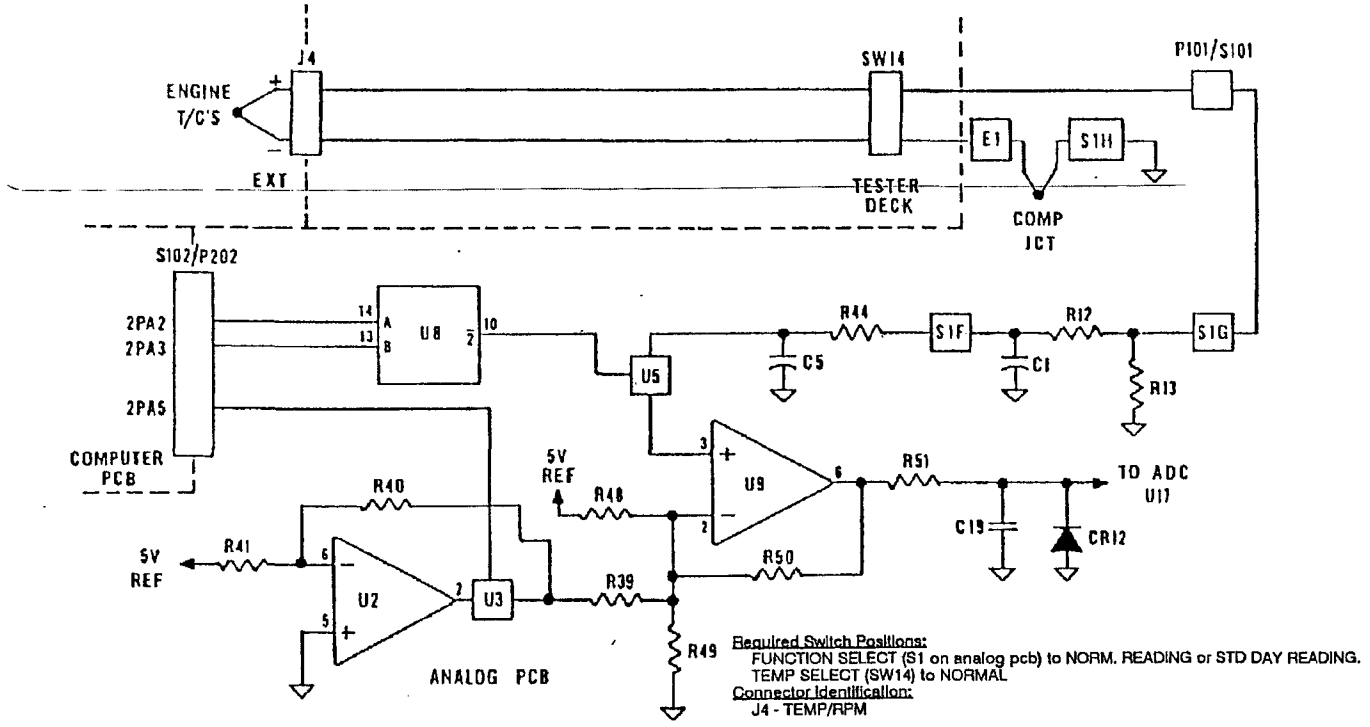


Figure 4-2. Engine Temperature Measuring Circuit, Simplified Schematic

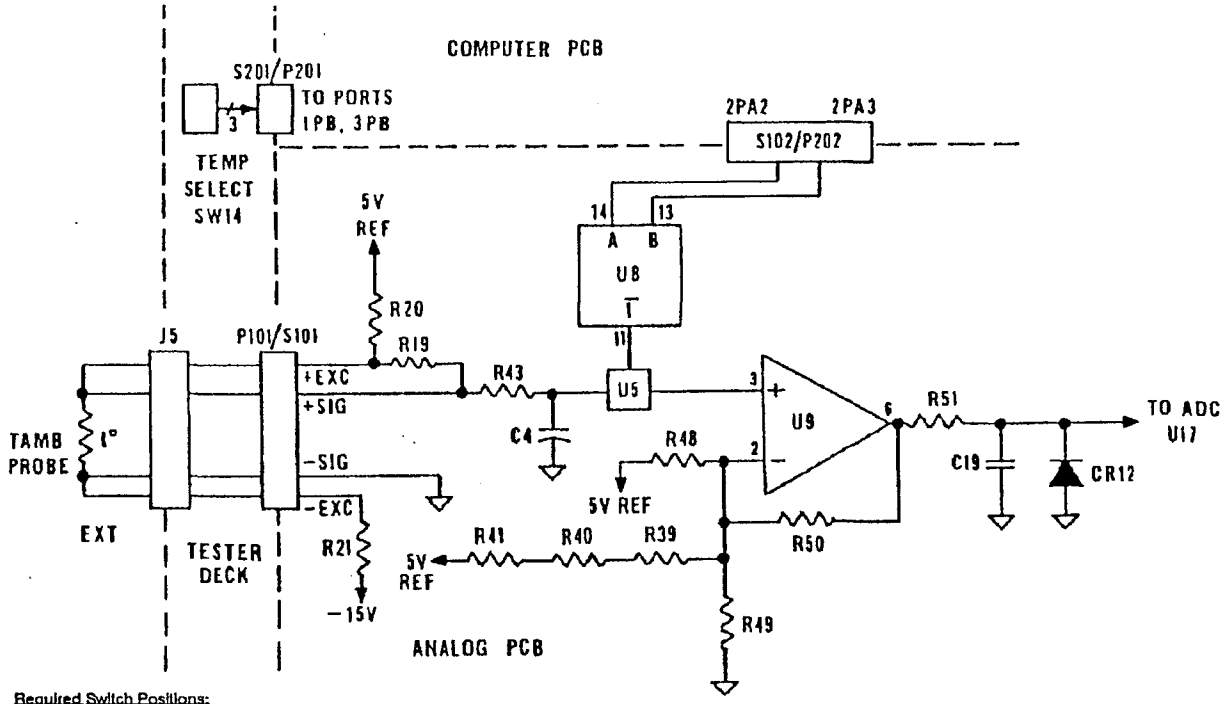


Figure 4-3. TAMB Measuring Circuit, Simplified Schematic

4-9. INSULATION RESISTANCE MEASURING CIRCUIT. A constant current, generated by the 5 vdc supply and the circuitry of U1 and Q1 (figure 4-4) flows through the unknown insulation resistance, R_X, of the aircraft engine temperature circuit. This current generates a voltage at the + input of buffer amplifier U2 on the analog board. The voltage is divided by resistors R14 and R15 before being applied to amplifier U9. The tester ZERO control adjusts the display to zero by adjusting the offset of U9 when R_X is jumpered. Thermocouple effects are canceled by measuring the circuit output with the current source turned off and subtracting this value from the output with the current source turned on. Switch Q1 turns the current source on and off.

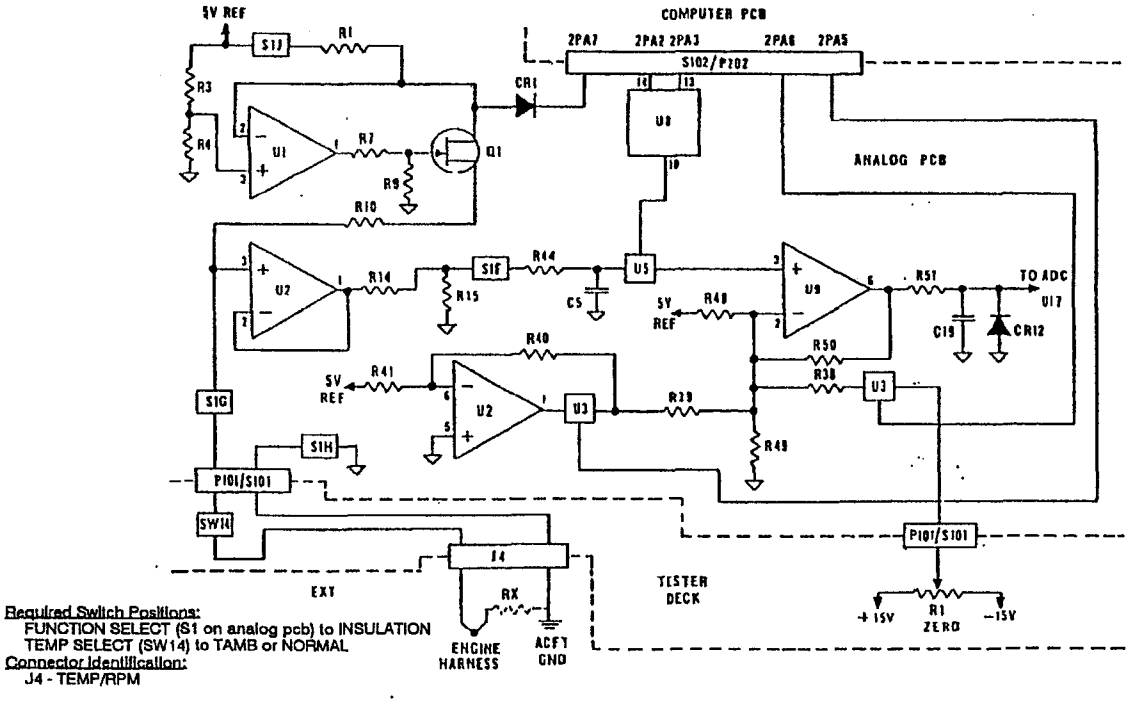


Figure 4-4. Insulation Resistance Measuring Circuit, Simplified Schematic

4-10. ENGINE TC RESISTANCE MEASURING CIRCUIT. A constant current, generated by the 5 vdc supply and the circuitry of U1and Q1 (figure 4-5) flows through the resistance spool and thermocouple wiring of the aircraft thermocouple circuit. The voltage thus generated is amplified by amplifier U9 on the analog board and applied to ADC U17. As in the insulation resistance measuring circuit, the tester ZERO control adjusts the offset of U9. This is done while jumpering the signal input pins at the aircraft to subtract the tester and test cable resistance from the tester readings. Thermocouple effects are canceled as explained in paragraph 4-9.

4-11. AIRCRAFT INSTRUMENT RESISTANCE SET CIRCUIT. When the aircraft instrument resistance is set prior to making the D'Arsonval temperature indicator test, the test cable leads are jumpered at the indicator (figure 4-6). The constant current generated by the 5 vdc supply and the circuitry of U1 and Q1 in the analog board flows through the AIRCRAFT INSTRUMENT RESISTANCE control (R3) and the wiring of the tester and test cable to ground. The generated voltage is amplified by U9 and applied to ADC U17. R3 is adjusted until the tester displays the resistance value specified on the aircraft indicator. Thermocouple effects are canceled as explained in paragraph 4-9.

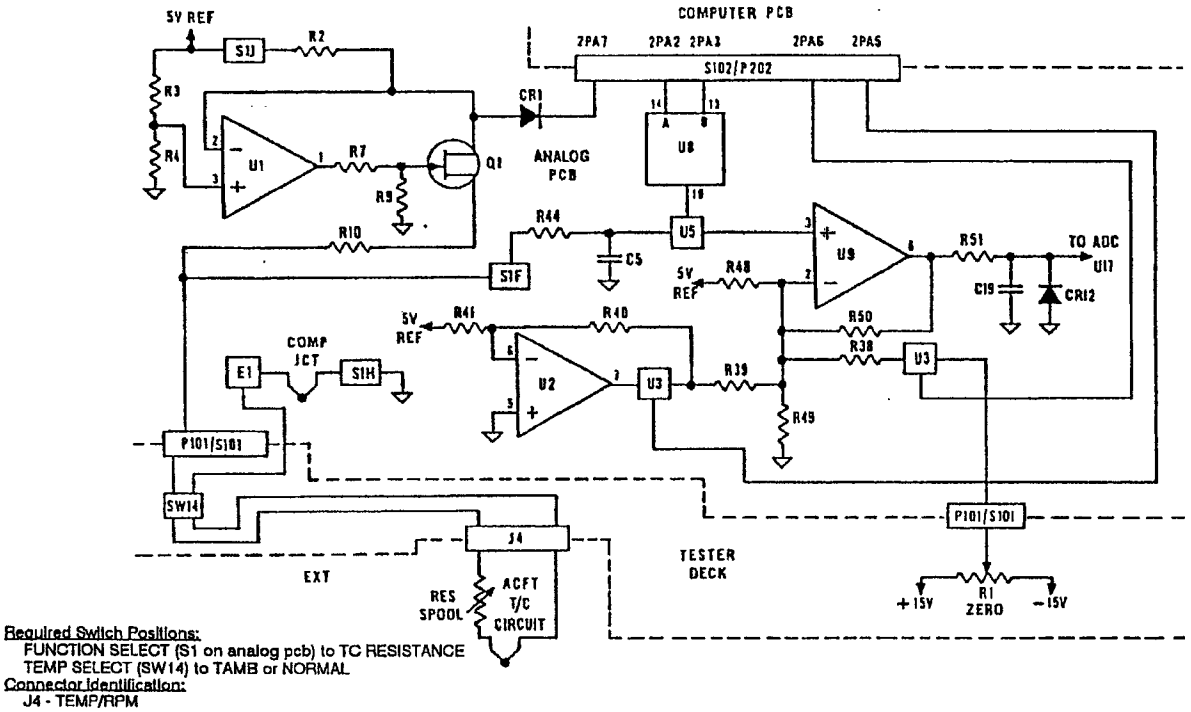
4-12. AIRCRAFT INDICATOR CHECK CIRCUIT. A negative voltage from the AIRCRAFT INSTRUMENT TEMP control (figure 4-7) is applied to the inverting input of amplifier U1, resulting in a positive test voltage. This voltage is applied through the AIRCRAFT INSTRUMENT RESISTANCE control to the aircraft indicator and simultaneously to amplifier U9 on the analog board for measurement.

4-13. RPM MEASURING CIRCUIT. Up to three rpm input signals (N1, N2, and N3) are applied to three isolation transformers (T1-T3) on the analog board (figure 4-8). The outputs of the transformers are diode-clamped and applied to analog switch U4 which multiplexes the signals to amplifier U7. The output of U7 clocks dual-D flip-flop U3 in the timer logic which consists of U3, NAND gate U14, port B bits of U12, and the timers in U12. RPM SELECT switch SW13 determines which signal is displayed.

4-14. PRESSURE MEASURING CIRCUIT. Twenty-eight vdc from the power supply excites the internal and external pressure transducers (figure 4-9). The external pressure or ratiometric input is applied through RC filter components to analog switch U6. U6 multiplexes the signal to amplifier U10. The internal pressure transducer signal is applied through jumper plug P104 to one of the analog inputs of ADC U17. PRESSURE SELECT switch SW10 determines which pressure parameter is displayed.

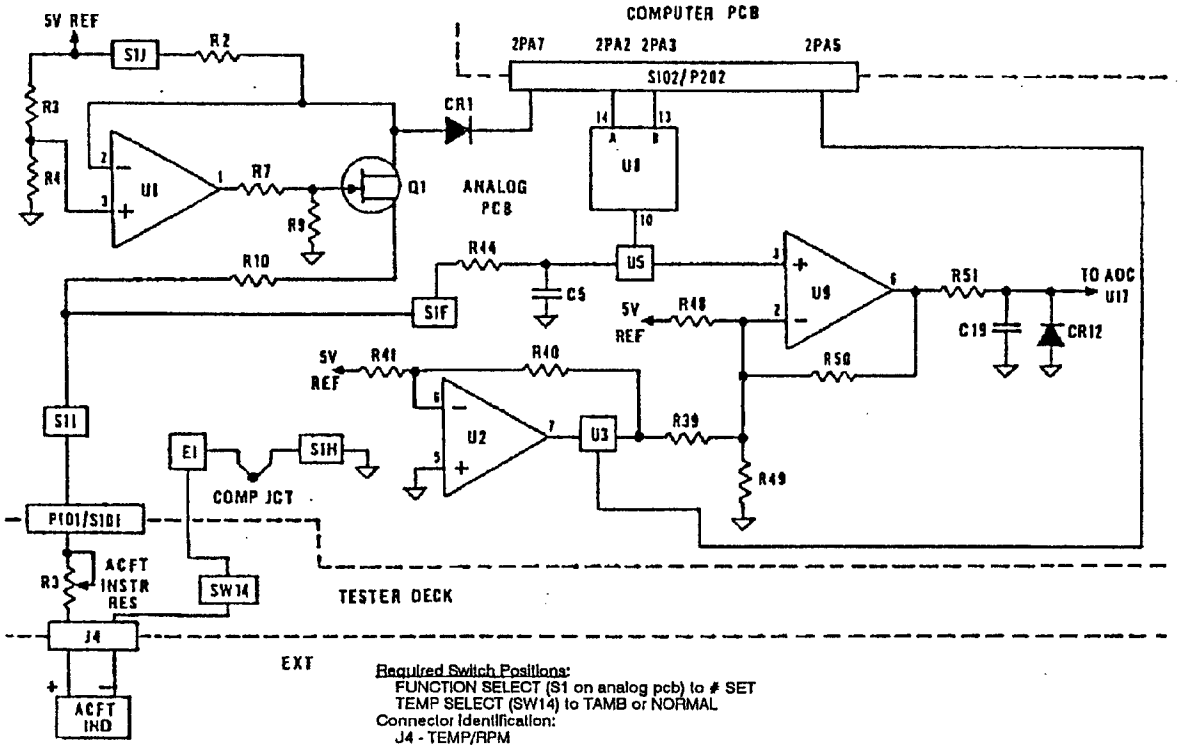
4-15. DISPLAY CIRCUIT. The display board (figure 4-1) presents 28 digits in 14 dual 14-segment light emitting diode (LED) displays (I1-I14). Eight digits are in the top row and 10 digits each are in the other two rows. Each dual display is driven by a display driver which can control individual segments and has its own memory. Eight bits of segment data at a time are presented on the data bus to the enabled display driver (enabled by 16-line decoder U15) and written into appropriate memory addressed by address lines A0 and A1. After display data is updated, internal oscillators in the display drivers sequentially present the data to output drivers which directly drive the LED displays. The drivers are active when the control pin labeled SOE is low, and the displays blank when this pin goes high. To correlate the output data with the proper segments, digit outputs (D1-D4) directly drive the bases of digit transistors Q1-Q56.

4-16. POWER SUPPLY. Primary power, 115vac or 230vac, 50-400 Hz; or 28vdc is applied to the POWER INPUT connector (figure 4-10). AC power is applied to power transformer T1. T1 has two primary windings which are connected in parallel when 115vac power is used and in series when 230vac power is used. Appropriate connections are made with jumpers in the power cable. The secondary winding is full-wave rectified to provide 28vdc to drive the power supply board and an optional internal printer. The power supply board contains an inverter and a 5-volt regulator circuit. Secondary voltages of inverter transformer T1 are rectified to provide 28vdc for pressure transducer excitation and ±15vdc for analog reference. The regulator provides 5vdc for display excitation and logic.



Required Switch Positions:
FUNCTION SELECT (S1 on analog pcb) to TC RESISTANCE
TEMP SELECT (SW14) to TAMB or NORMAL
Connector Identification:
J4 - TEMP/RPM

Figure 4-5. Thermocouple Resistance Measuring Circuit, Simplified Schematic



Required Switch Positions:
FUNCTION SELECT (S1 on analog pcb) to # SET
TEMP SELECT (SW14) to TAMB or NORMAL
Connector Identification:
J4 - TEMP/RPM

Figure 4-6. Aircraft Instrument Resistance Set Circuit, Simplified Schematic

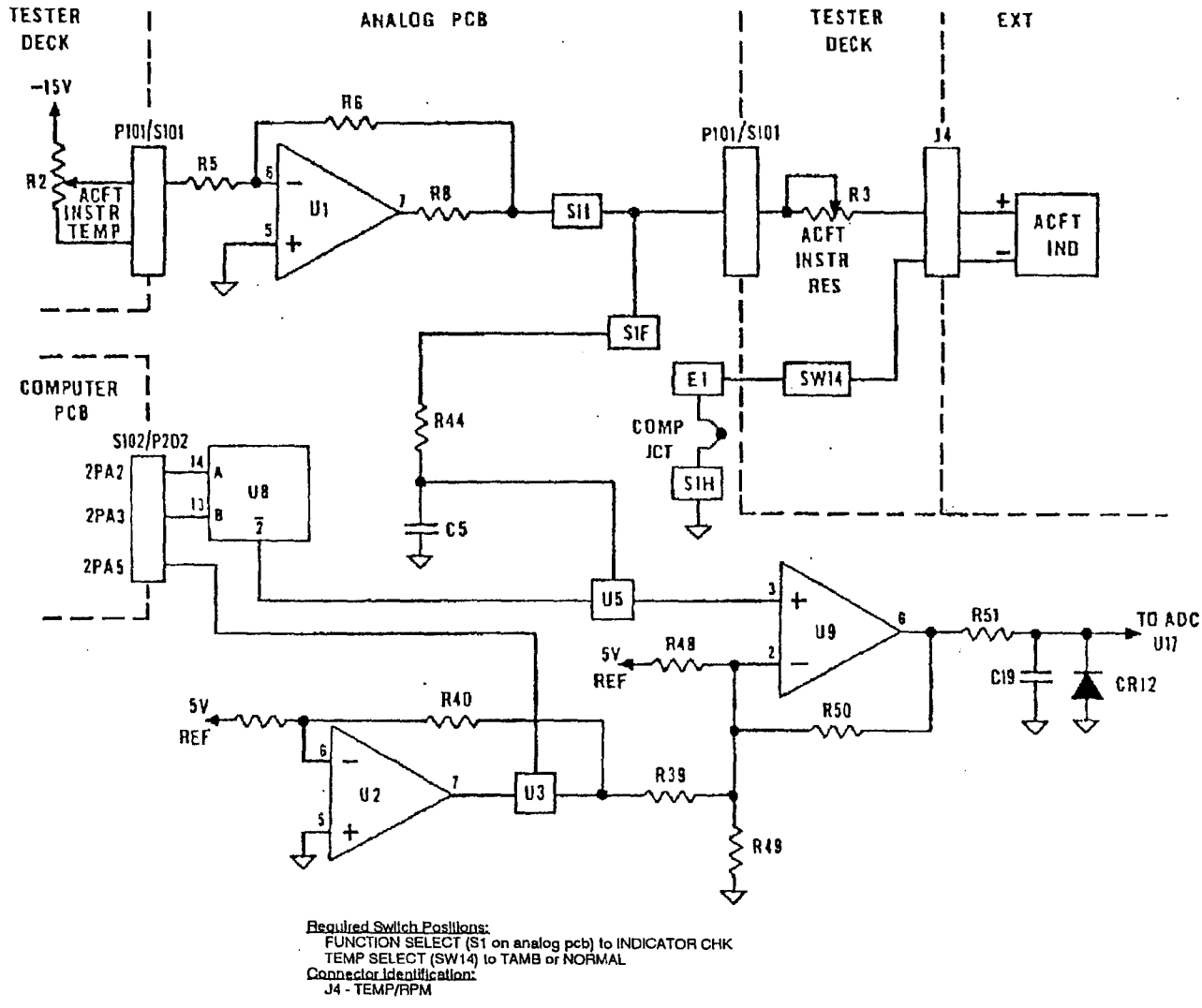
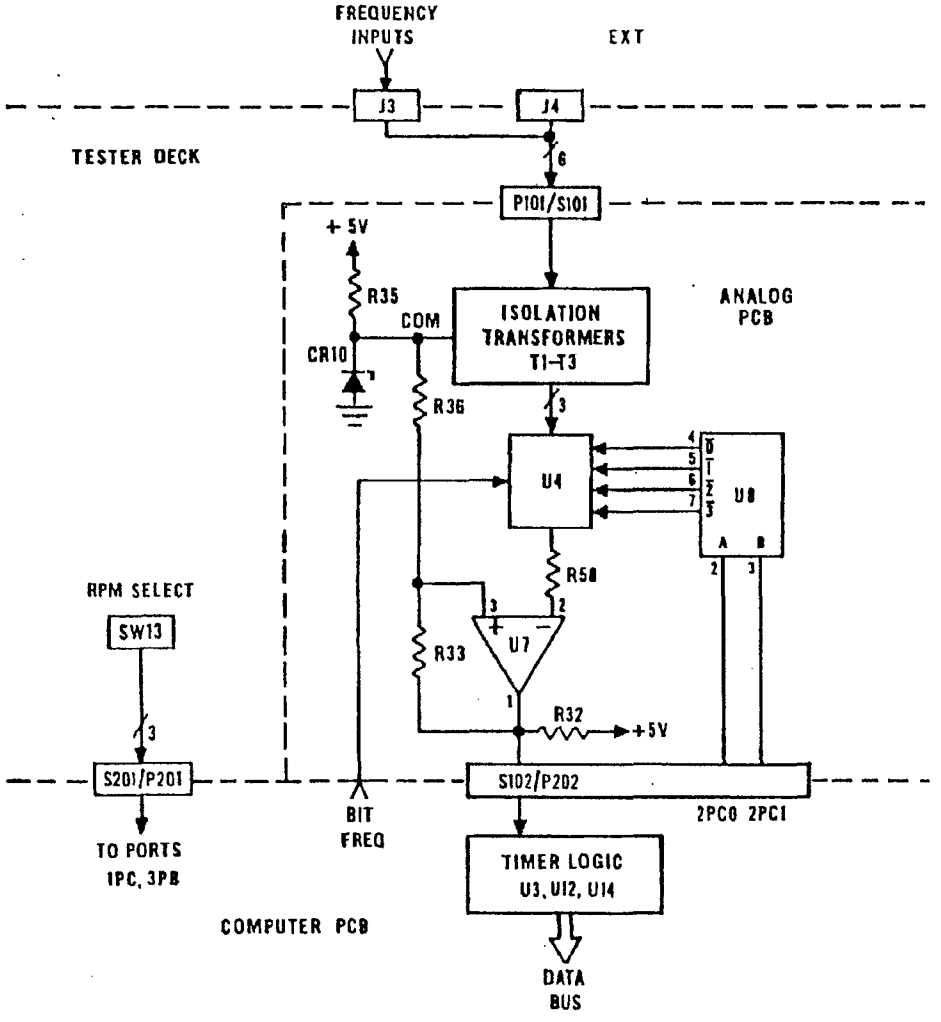
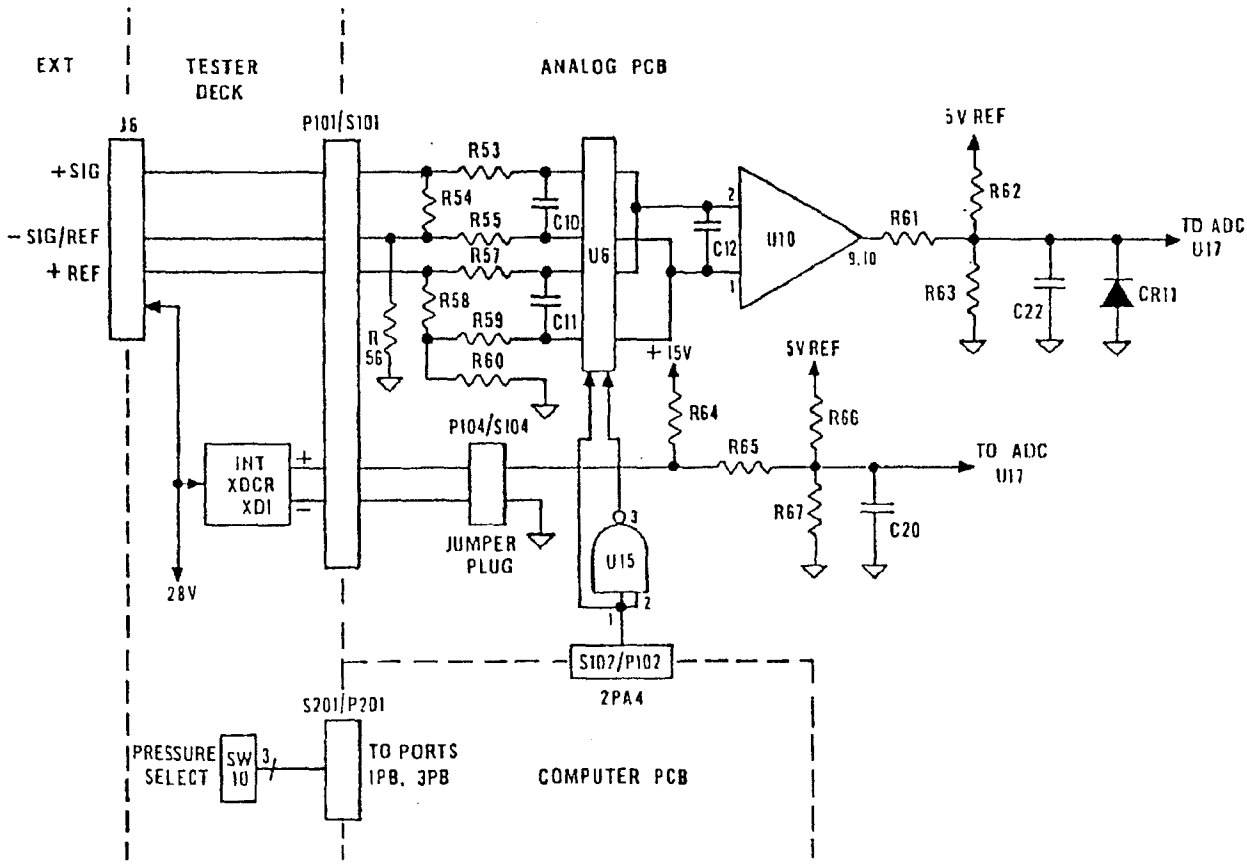


Figure 4-7. Aircraft Indicator Check Circuit, Simplified Schematic



Required Switch Positions:
FUNCTION SELECT (S1 on analog pcb) to NORM. READING, STD DAY READING, or AIRCRAFT INDICATOR ON.
TEMP SELECT (SW14) to TAMB or NORMAL.
RPM SELECT (SW13) to N1, N2, or N3.
Connector Identification:
J3 - RPM INPUT INSTR CABLE.
J4 - TEMP/RPM.

Figure 4-8. RPM Measuring Circuit, Simplified Schematic



Required Switch Positions:
FUNCTION SELECT (S1 on analog pcb) to NORM. READING, STD DAY READING, or AIRCRAFT INDICATOR ON.
TEMP SELECT (SW14) to TAMB or NORMAL.
PRESSURE SELECT (SW10) to INTERNAL, EXTERNAL, or EPR.

Figure 4-9. Pressure Measuring Circuit, Simplified Schematic

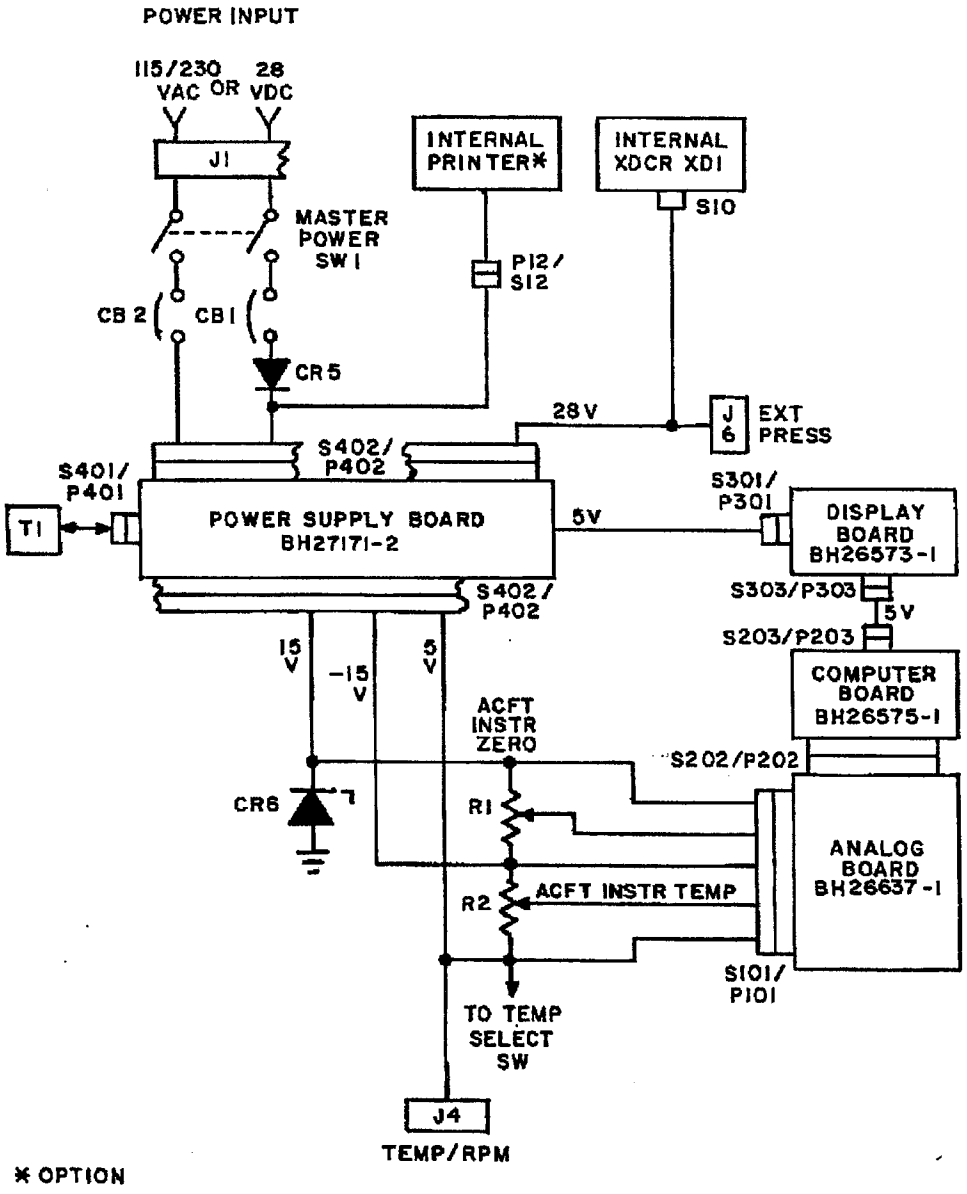


Figure 4-10. Power Flow Block Diagram

4-17. OPERATION INSTRUCTIONS.

4-18. INDICATORS AND CONTROLS. Tester indicators and controls are illustrated and listed with their functions in Figure 4-11. Test setups used with specific aircraft and engines are illustrated in Section VIII.

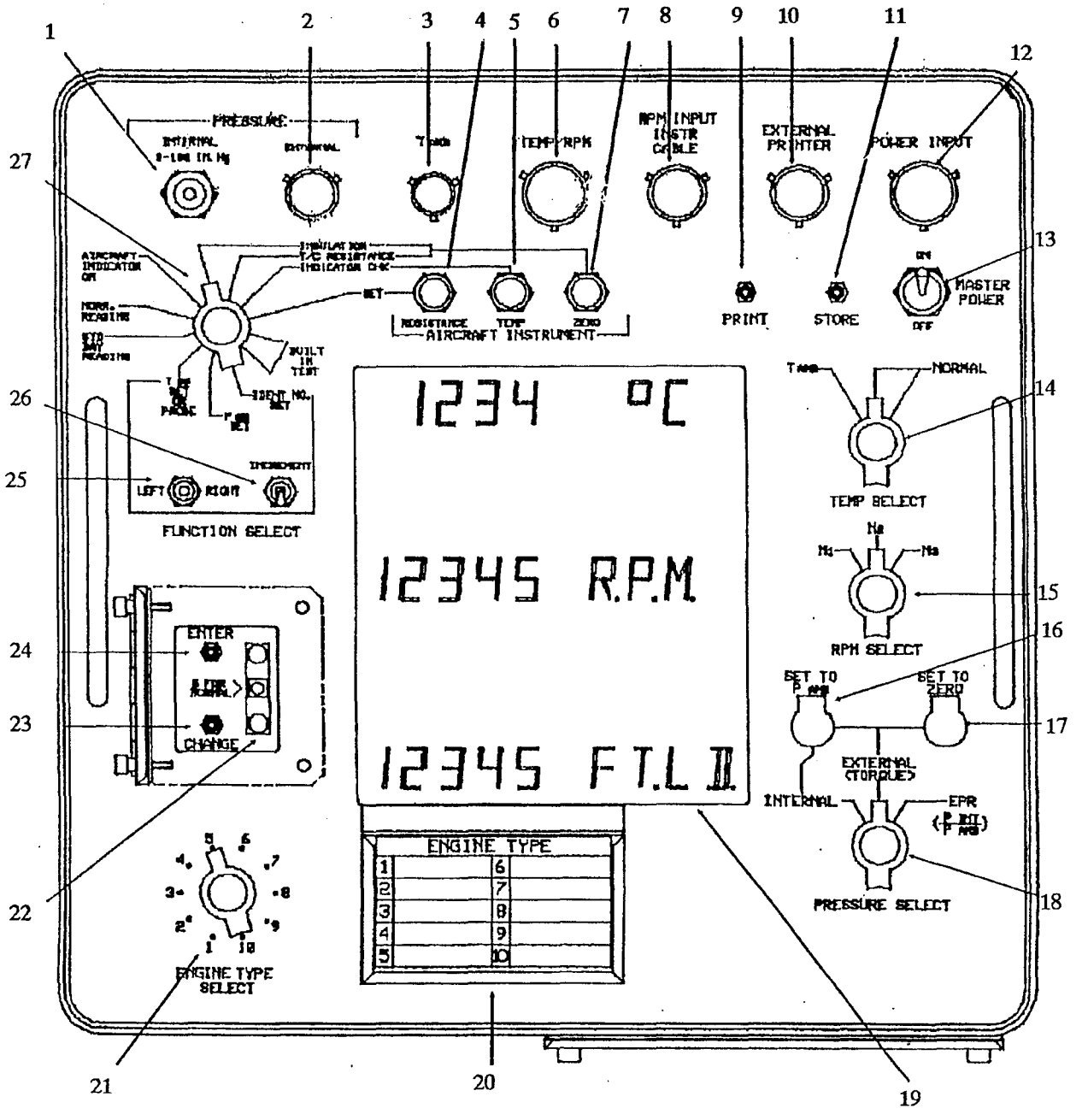


Figure 4-11. Tester Indicators and Controls. (Sheet 1 of 7)

INDEX NO.	INDICATOR OR CONTROL	FUNCTION
1	INTERNAL PRESSURE port	Allows either ambient pressure or some other pressure to be applied to the internal pressure transducer.
2	EXTERNAL PRESSURE connector	Makes excitation and signal connections to external pressure transducer cable.
3	TAMB connector	Makes excitation and signal connections to ambient temperature cable.
4	AIRCRAFT INSTRUMENT RESISTANCE adjust	Adjusts test circuit resistance to values required to test D'Arsonval temperature indicators.
5	AIRCRAFT INSTRUMENT TEMP adjust	Adjusts level of test signal when testing an aircraft temperature indicator.
6	TEMP/RPM connector	Connects engine temperature and rpm signals to tester and connects aircraft temperature indicator test signal to test cable.
7	INSULATION and TC RESISTANCE ZERO adjust	Zeros resistance display when measuring insulation resistance and when measuring resistance of aircraft temperature circuit.
8	RPM INPUT INSTR CABLE connector	Connects engine rpm signals to tester in single engine applications.
9	PRINT button	Initiates printout of input data stored with STORE button and printout of tester calibration and scaling data.
10	EXTERNAL PRINTER connector	Connects tester to external printer I/O interface cable.
11	STORE button	Stores date and identification number, trim target, ambient pressure setting, ambient temperature setting, and snapshots of input data.
12	POWER INPUT connector	Connects power to tester.

Figure 4-11. Tester Indicators and Controls (Sheet 2)

INDEX NO.	INDICATOR OR CONTROL	FUNCTION
13	MASTER POWER switch	Applies input power from POWER INPUT connector to tester.
14	TEMP SELECT switch	When mode switch (index no. 22) is to 0 and FUNCTION SELECT switch (index no. 27) is to STD DAY READING, NORM. READING, OR AIRCRAFT INDICATOR ON, programs tester to display ambient temperature reading or setting when in TAMB position and to display engine harness temperatures when in NORMAL positions.
15	RPM SELECT switch	Programs tester to display selected rpm input (N1, N2, or N3).
16	SET TO PAMB button	Is used to remove offset from internal and external absolute-type pressure transducer readings when transducer is vented to atmosphere.
17	SET TO ZERO button	Is used to remove offset from gauge/differential type external pressure transducer readings when transducer is vented to atmosphere.
18	PRESSURE SELECT switch	Depending on position of switch, it programs tester to display internal pressure transducer reading, external pressure transducer reading or PAMB setting, or epr if parameters (PINT and PAMB) are properly scaled.
19	Display	Displays parameter calibration/scaling data, parameter readings and data, indicator test signals, resistance readings, operator commands/messages, and built-in-test functions depending on position of mode switch (first priority), FUNCTION SELECT switch (second priority), and TEMP SELECT switch (third priority).
20	ENGINE TYPE card	Used by operator to record engine types selected with ENGINE TYPE SELECT switch.
21	ENGINE TYPE SELECT switch	Determines which set of parameter calibration and scaling data is used to generate engine parameter readings.

Figure 4-11. Tester Indicators and Controls (Sheet 3)

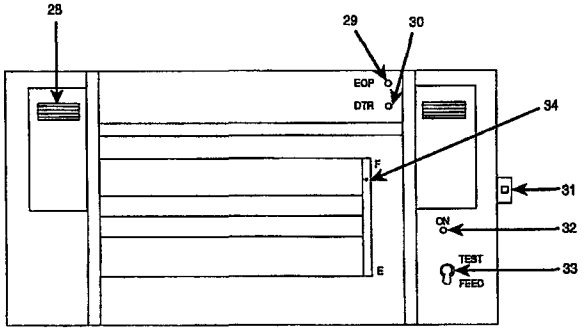
INDEX NO.	INDICATOR OR CONTROL	FUNCTION
22	Mode switch	Switch with highest priority in determining tester functions. Switch positions and functions follow. 0 - normal. Tester functions are determined by FUNCTION SELECT switch (second priority) and TEMP SELECT switch (third priority). 1 - read and print stored calibration and scaling data. 2 - engine temperature scaling. 3 - rpm scaling. 4 - external pressure transducer scaling. 5 - internal pressure transducer scaling. 6 - temperature calibration of engine temperature and TAMB probe. 7 - external pressure transducer calibration. 8 - internal pressure transducer calibration. 9 - insulation resistance calibration. 10 - thermocouple resistance calibration. 11 - set external printer baud rate.
23	CHANGE button	May be used to step through tester internal calibration displays. Is used to step through calibration and scaling data in mode 1. In calibration and scaling modes, is used to select temperature parameters, temperature calibration curves, engineering units, calibration input types, pressure types, scaling types, and to answer yes/no questions.
24	ENTER button	Causes the storing of selections made with the CHANGE button and of settings made with LEFT-RIGHT and INCREMENT switches.

Figure 4-11. Tester Indicators and Controls (Sheet 4)

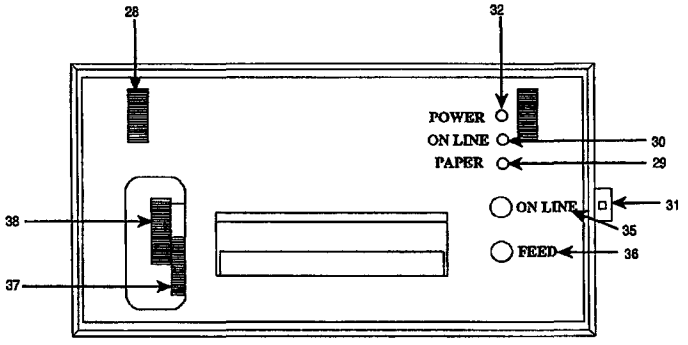
INDEX NO.	INDICATOR OR CONTROL	FUNCTION
25	LEFT-RIGHT switch	Selects digit/character to be incremented with INCREMENT switch. Steps display through stored data.
26	INCREMENT switch	Adjusts calibration and scaling values when in calibration and scaling modes. Adjusts identification number setting, trim target setting, PAMB setting, and TAMB setting when in normal mode.
27	FUNCTION SELECT switch	When tester is in normal mode (mode 0), switch has absolute control of tester function in the following positions. INSULATION - tester displays aircraft thermocouple harness insulation resistance. T/C RESISTANCE - tester displays aircraft thermocouple circuit resistance. INDICATOR CHK - tester displays setting of AIRCRAFT INSTRUMENT TEMP adjust. SET - tester displays setting of AIRCRAFT INSTRUMENT RESISTANCE adjust. BUILT IN TEST - one position tests display and CPU hardware (includes RAM, rpm circuit, and A/D converter). Other position tests printer. IDENT NO. SET - tester displays current identification number setting and allows operator to change setting. Then it displays current trim target setting and allows operator to change setting. PAMB SET - tester displays current PAMB setting and allows operator to change setting. TAMB SET OR PROBE - tester displays current TAMB reading if probe is connected or allows operator to set TAMB value if probe is not connected.

Figure 4-11. Tester Indicators and Controls (Sheet 5)

INDEX NO.	INDICATOR OR CONTROL	FUNCTION
		When TEMP SELECT switch is to NORMAL, tester functions corresponding to other FUNCTION SELECT positions are as follows: STD DAY READING - tester displays selected pressure and standard day corrected values of engine temperature and selected rpm. NORM. READING - Tester displays selected pressure and uncorrected values of engine temperature and selected rpm. AIRCRAFT INDICATOR ON - Engine temperature harness signal is applied to aircraft indicator. Tester displays selected pressure and uncorrected value of selected rpm. Temperature display reads A/C IND.



PRINTER MAP-20SBCL



PRINTER MAP-21CBC

28	Printer slide latch	Holds printer assembly in case.
29	EOP lamp or PAPER lamp	When lit, indicates printer is out-of-paper or paper is not in proper path. Printer is disabled when lamp is lit. PAPER lamp flashes when printer has paper but head release lever is in released position.

Figure 4-11. Tester Indicators and Controls (Sheet 6)

INDEX NO.	INDICATOR OR CONTROL	FUNCTION
30	DTR lamp or ON LINE lamp	Indicates when printer is ready to receive data. If ON LINE lamp is off, press ON LINE switch to light lamp and enable printer.
31	Power switch	Applies power to printer when PRINTER ACCESS door is open.
32	ON or POWER lamp	Indicates when power is applied to printer.
33	TEST-FEED switch	A three-position switch. Center position is used for normal operation. Momentarily putting switch in TEST position starts a 385-line test printout. Test may be ended by momentarily putting switch in FEED position. FEED position advances paper.
34	F-E indicator	Paper full-empty indicator indicates relative amount of paper remaining on roll.
35	ON LINE switch	Toggles printer between on-line and off-line status as shown by the ON LINE lamp. The printer will not go on-line if it is out-of-paper, the head release lever is in the up position, or if some other error condition exists. Switch is used with FEED switch to initiate a self-test.
36	FEED switch	If printer is off-line, pressing switch causes current line to be printed. Holding switch causes additional paper to be fed until the switch is released. Switch has no effect when printer Is on-line.
37	Head Release Lever	Raises print head from roller when installing new roll of paper.
38	Paper Advance Knob	Advances paper to provide blank space between printout and tear-off point. Advances any remaining paper out of printer when roll is nearly empty.

Figure 4-11. Tester Indicators and Controls (Sheet 7)

CAUTION

When not calibrating the tester, do not press ENTER button when one of the calibration modes (modes 6-11) is selected. Doing this will alter the calibration of the selected parameter.

It is recommended that a printout of calibration and scaling data be obtained prior to each use of the tester per instructions in paragraph 5-22.

NOTE

Calibration and scaling procedures of Section V shall have been accomplished prior to using the tester. Calibration and scaling values applicable to particular engines are included in Section VIII.

During normal operation, mode switch under SCALING AND CALIBRATION access door must be set to 00. Printer TEST-FEED switch must be set to center position.

With an open input condition, NORMAL TEMP SELECT display drifts downscale to approximately 60°C (140°F) and TAMB TEMP SELECT display indicates TAMB set value.

Assure that date/engine identification numbers are entered before starting engine.

4-19. POWER UP PROCEDURE.

1. Position MASTER POWER switch to OFF.

WARNING

To prevent electrical shock to personnel and possible damage to tester, always use a three-wire grounded power cable when powering the tester with ac power!

2. Connect power cable to POWER INPUT receptacle and to power source.

3. Turn MASTER POWER switch on and allow a 15 minute warmup.

4. Turn FUNCTION SELECT switch clockwise to first BUILT IN TEST position. As tester performs built-in tests, display sequence will be as follows:

(1)	(2)	(3)	(4)
DISPLAY TEST	⊠⊠⊠⊠⊠⊠⊠⊠⊠⊠⊠⊠	⊠⊠⊠⊠⊠⊠⊠⊠⊠⊠⊠⊠	⊠⊠⊠⊠⊠⊠⊠⊠⊠⊠⊠⊠

(5)	(6)	(7)
CPU HARDWARE TEST	CPU HARDWARE TEST	BUILT IN TEST COMPLETE

Display sequence repeats if FUNCTION SELECT switch is left in BUILT IN TEST position. Note that displays 2 through 4 test all segments of the display. If tester fails this test, refer to Section V.

NOTE

If a printer is not used, is disconnected, is not turned on, or is out-of-paper, then display will read as follows in the next step:

(1)	(2)
PRINTER TEST	NO PRINTER READY

5. Open PRINTER ACCESS door and turn FUNCTION SELECT switch to next BUILT IN TEST position. Display will continue to cycle through the following sequence as long as the switch is left in this position:

(1)	(2)	(3)	(4)
PRINTER TEST	H337N HOWELL INSTR. INC.	3479 WEST VICKERY	FT. WORTH TEXAS 76107

(5)	(6)
(817)	PRINTER
336-7411	TEST
	COMPLETE

While display goes through the above sequence, printer prints the following:

```
ABCDEFGHIJKLMNOPQRST
UVWXYZabcdefghijklmn
opqrstuvwxyz12345678
90/<>%

HOWELL INSTRUMENTS
3479 WEST VICKERY
FORT WORTH TEXAS
          76107
(817) 336-7411

PRINT TEST COMPLETE
```

4-20. SETTING IDENTIFICATION AND TRIM TARGET NUMBERS. Ten characters common to all positions of the ENGINE TYPE SELECT switch may be used to set the date and/or an identification number and an additional ten characters may be used to set a trim target. Once set, numbers appear in all subsequent engine data printouts until changed.

NOTE

Changing identification number causes subsequent snapshot (recording) numbers to start over with #001. Refer to paragraph 4-29 through 4-31.

1. Turn FUNCTION SELECT switch to IDENT NO. SET. Display will read as follows:

SET DATE
AND I.D.
(10 characters)

Set date and/or identification number using the 10 characters in the bottom row. First four left-hand characters may be set to 0-9 and remaining characters may be alphabetical or numerical. Press up on the INCREMENT switch to change value of flashing character. Hold INCREMENT switch in up position for continuous changes. Use LEFT-RIGHT switch to select other character positions.

2. After making setting, press STORE button. Display will read:

SET TRIM
TARGET
(10 characters)

3. Use LEFT-RIGHT and INCREMENT switches to make setting.

4. Press STORE button. Display of step 1 returns.

4-21. SETTING PAMB. This setting should be made if engine pressure ratio is to be measured and external pressure transducer is not being used to measure ambient pressure. Setting may also be used to remove offset from internal pressure transducer readings and external absolute-type pressure transducer readings. Set current uncorrected barometric pressure as follows:

1. Turn FUNCTION SELECT switch to PAMB SET. Display will read:

SET PAMB

XX.XX IN.HG.

2. Use LEFT-RIGHT and INCREMENT switches to set value and press STORE. Display will read:

(1)	(2)
OK	YES NO OFFSET INTERNAL (or EXTERNAL)

where selected answer to offset question (YES or NO) will be flashing and INTERNAL (or EXTERNAL) corresponds to position of PRESSURE SELECT switch.

3. If PAMB setting is not to be used to remove offset from internal and external pressure transducer readings, proceed at paragraph 4-22.

4. If PAMB setting is to be used to remove offset from internal and/or external pressure transducer readings, select desired transducer with PRESSURE SELECT switch and YES with CHANGE button under SCALING AND CALIBRATION access door. Press ENTER. Display will read:

(1)	(2)	(3)
PUSH SET TO PAMB	INTERNAL (or EXTERNAL) READING XX.XX IN.HG. (or P.S.I.)(or MBAR)	SET PAMB XX.XX IN.HG.

Press SET TO PAMB button before display (3) appears. If desired, remove offset from other transducer during this time by changing position of PRESSURE SELECT switch and pressing SET TO PAMB before display (3) appears.

4-22. SETTING TAMB. When a TAMB probe is not connected to the tester, ambient temperature must be set to the current value as follows:

1. Turn FUNCTION SELECT switch to TAMB SET. Display will read:

(1)	(2)
TAMB	SET TAMB
SET OR	READING
PROBE	+XXX.X °C

2. Use LEFT-RIGHT and INCREMENT switches to set value and press STORE.

4-23. AIRCRAFT TEMPERATURE INDICATOR CALIBRATION.

4-24. D'Arsonval Indicators.

1. Connect temperature cable to TEMP/RPM receptacle and D'Arsonval indicator adapter to cable.

2. Connect red (-) and blue (+) leads of adapter together.

3. Turn FUNCTION SELECT switch to SET and adjust AIRCRAFT INSTRUMENT RESISTANCE control until tester displays system resistance marked on aircraft indicator nameplate.

4. Turn FUNCTION SELECT switch to INDICATOR CHK.

5. Disconnect harness lead from indicator positive terminal and connect blue (+) lead of adapter to this terminal.

6. Connect red (-) adapter lead to indicator negative terminal.

7. Observe tester display and adjust AIRCRAFT INSTRUMENT TEMP control to desired test temperature.

8. Difference between tester reading and aircraft indicator reading is error of aircraft indicator and should not exceed technical manual tolerance.

4-25. Null Balance Indicators.

1. Connect temperature cable to TEMP/RPM receptacle and null balance indicator adapter to cable.

2. Disconnect aircraft harness from indicator and connect adapter to indicator.

3. Turn AIRCRAFT INSTRUMENT RESISTANCE control fully counterclockwise.

4. Turn FUNCTION SELECT switch to INDICATOR CHK.

5. Observe tester display and adjust AIRCRAFT INSTRUMENT TEMP control to desired test temperature.

6. Difference between tester reading and aircraft indicator reading is error of aircraft indicator and should not exceed technical manual tolerance.

4-26. AIRCRAFT CIRCUIT RESISTANCE ADJUSTMENT (D'ARSONVAL INDICATORS).

1. Connect temperature cable to TEMP/RPM receptacle and D'Arsonval indicator adapter to cable.

2. Connect red terminal of adapter to brass lug of adapter.

3. Turn FUNCTION SELECT switch to T/C RESISTANCE.

4. Adjust ZERO control for a zero reading on the tester.

5. Disconnect red terminal of adapter from brass lug and connect it to aircraft harness at negative indicator terminal.

6. Disconnect the positive harness lead from indicator and connect it to brass lug of adapter.

CAUTION

Check and clean all connections in aircraft thermocouple system before adjusting spool.

7. Resistance displayed on tester should be within technical manual tolerance. If it is not, adjust resistance spool in aircraft.

4-27. AIRCRAFT THERMOCOUPLE SYSTEM INSULATION RESISTANCE CHECK.

1. Connect temperature cable to TEMP/RPM receptacle and indicator adapter to cable.

2. Connect small insulation check ground lead to pin jack on temperature cable and clip it to brass lug on D'Arsonval adapter, or clip it to + (chromel) pin on input side of null balance adapter.

3. Turn FUNCTION SELECT switch to INSULATION.

4. Adjust tester ZERO control for a zero reading.

5. Remove both leads of aircraft harness from temperature indicator.

6. Disconnect clip lead from brass lug and connect it to aircraft ground.

7. Connect brass lug to one lead of aircraft harness.

8. Insulation resistance displayed on tester should be within technical manual tolerance.

9. Turn the MASTER POWER switch off and disconnect adapter leads from the aircraft harness.

4-28. ENGINE TRIM CHECK OPERATION.

CAUTION

To prevent damage to internal transducer, use to measure dry pressures only.

4-29. TURBOJET ENGINE TRIM CHECK.

1. Connect appropriate engine trim cables and adapters to TEMP/RPM and RPM INPUT INSTR CABLE receptacles on tester.

2. Connect the TAMB cable to TAMB receptacle on tester and connect TAMB probe to cable.

3. Connect the pressure hose to PRESSURE INTERNAL port and to appropriate engine fitting.

4. Turn ENGINE TYPE SELECT switch to required position.

5. Turn PRESSURE SELECT switch to INTERNAL.

6. Set identification number and trim target per paragraph 4-20.

7. Turn FUNCTION SELECT switch to NORM. READING, TEMP SELECT switch to NORMAL, and RPM SELECT switch to desired position.

NOTE

Monitor for hot start.

8. Start engine and trim to target value.

9. If internal pressure input has been designated PINT or PEXH per paragraph 5-18 and external pressure input has been designated PAMB per paragraph 5-17 or PAMB has been set as explained in paragraph 4-21, then engine pressure ratio can be read directly by turning PRESSURE SELECT switch to EPR.

10. If TAMB probe is connected or TAMB has been set per paragraph 4-22, then corrected temperature and rpm readings can be displayed by turning FUNCTION SELECT switch to STD DAY READING. Units of temperature and rpm will alternate with ST.D. to remind operator that these are standard day readings.

11. Up to 18 snapshots of engine trim data may be stored for future reading and/or printing. Press STORE button for each snapshot. Display reminds operator of snap number since last ID number change. Nineteenth press of STORE button overwrites oldest data. See paragraph 4-31 for displaying and printing data.

12. Turn MASTER POWER switch off before removing cables from tester and aircraft.

4-30. TURBOPROP ENGINE TRIM CHECK.

1. Connect appropriate engine trim cables and adapters to TEMP/RPM and RPM INPUT INSTR CABLE receptacles on tester.

2. Connect TAMB cable to TAMB receptacle on tester and connect TAMB probe to cable.

3. Connect torque pressure transducer to engine using appropriate adapters and to tester PRESSURE EXTERNAL receptacle using torque pressure cable.

4. Turn ENGINE TYPE SELECT switch to desired position.

NOTE

Do not do step 5 if a voltage ratio-type torque transducer is being used. Should the button be inadvertently pressed, it will be necessary to rescale the external transducer for the selected engine type per instructions in Section I.

5. Turn PRESSURE SELECT switch to EXTERNAL and depress SET TO ZERO button to zero torque transducer reading.

6. Set identification and trim target numbers per paragraph 4-20.

7. Turn FUNCTION SELECT switch to NORM. READING, TEMP SELECT switch to NORMAL, and RPM SELECT switch to desired position.

NOTE

Monitor for hot start.

8. Start engine and trim to target value.

9. If TAMB probe is connected or TAMB has been set per paragraph 4-22, then corrected temperature and rpm readings can be displayed by turning FUNCTION SELECT switch to STD DAY READING. Units of temperature and rpm will alternate with ST.D. to remind operator that these are standard day readings.

10. Up to 18 snapshots of engine trim data may be stored for future displaying and/or printing. Press STORE button for each snapshot. Display reminds operator of snap number since last ID number change. Nineteenth press of STORE button overwrites oldest data. See paragraph 4-31 for displaying and printing of data.

11. Turn MASTER POWER switch off before removing cables from tester and aircraft.

4-31. DISPLAYING AND PRINTING DATA. Stored data may be manually displayed or automatically printed beginning with most recent data. The order in which snapshot data is displayed and printed is as follows:

Engine type number
ID. number and snap number

Trim target
Internal pressure transducer reading
Engine pressure ratio
External pressure transducer reading
Engine temperature (uncorrected)
Engine rpm's (uncorrected)
Ambient temperature setting or reading
Ambient pressure setting (if a transducer is not designated PAMB)
Engine standard day temperature (if requested per paragraph 5-15)
Engine standard day rpm's (if requested)

Only active inputs are displayed and printed.

4-32. DISPLAYING DATA.

1. Press PRINT button. Display will read:

STORED
DATA

2. To slowly display all data beginning with the newest data, repeatedly press LEFT-RIGHT switch to either LEFT or RIGHT position to display each parameter. To advance quickly to data of interest, hold INCREMENT switch in up position until data of interest is displayed.

3. After stored data of interest has been displayed, leave manual display mode by pressing PRINT button.

4-33. PRINTING DATA.

1. Open printer door.

2. Press PRINT button. Display will read:

STORED
DATA

3. Press PRINT button again. Printer proceeds to print snapshots, beginning with the newest data, and tester displays data as it is being printed.

4. After data of interest has been printed, press PRINT button again. Printout will cease and indicate point of termination by "PRINT TERMINATED". Figure 4-12 on the following page is a sample printout.

```
                STORED DATA


          ENGINE TYPE   3
       ID:  241086 300 001
       TRIM TGT: 2.010 EPR
        PINT  29.38 IN. HG.
       PINT/PAMB      0.999
        PEXT   17.18 P.S.I.
       TEMP   1360   DEG.C
       N1      0.0    PCNT.
       N2       0    R.P.M.
       N3       0    P.P.H.
        TAMB   43.1  DEG.C
        PAMB   29.40 IN.HG.
           STANDARD DAY
             READINGS
        TEMP   1215  DEG.C
       N1      0.0    PCNT.
       N2       0    R.P.M.
       N3       0    P.P.H.


         PRINTOUT FINISHED
```

Figure 4-12. Sample Printout of Stored Data

SECTION V

MAINTENANCE INSTRUCTIONS

5-1. GENERAL.

5-2. An annual accuracy check should be performed to ensure that the test set is operating within the accuracy tolerances listed. This check should also be performed following replacement of any electronic components associated with the measurement circuitry. Calibration of any function that is out of tolerance is required to return the test set to specification. Follow calibration procedures in the order listed. Recommended test equipment is listed in table 5-1. Equivalent equipment will suffice.

Table 5-1. Test Equipment

NOMENCLATURE	PART NUMBER OR MODEL	APPLICATION	RANGE	ACCURACY
Ice Bath Junction	Howell Instruments BH14106	Temperature cal	- - - -	±0.25°C
or Cold Junction Compensator	Omega Engrg CJ-K			
Resistor	Howell Instruments BH2435	Operational checkout	8 ohm, 0.4w	±0.1%
Resistor	Howell Instruments BH2436	Operational checkout	22 ohm, 0.4w	±0.1%
Resistor	Ultronix C3971	Operational checkout	1K, 3w	±1%
Voltage Standard	General Resistance DAS-46AX	Temperature cal; internal voltage cal; pressure voltage cal	0 to 10 vdc	±0.0025% +5 uv
Resistance Decade 2	General Resistance DA763X	Insulation cal; cold junction cal	0 to 11.1111 megohm	±0.01% +0.010 ohm /decade

Table 5-1. Test Equipment (Continued)

NOMENCLATURE	PART NUMBER OR MODEL	APPLICATION	RANGE	ACCURACY
Resistance Decade 1	Electro Scientific DB62	TAMB cal; tc res cal	0 to 11,111.1 ohms	±0.01% +0.0005 ohm/decade
Frequency Synthesizer	Anadex FS-600	RPM accy chk	100 mHz to 1199.99 KHz	±0.001%
Oscilloscope	Tektronix 432	Trouble-shooting	Vert: 1mv to 10v/div Horiz: 0.2us to 5s/div	±3% ±3%
Absolute Pressure Gage	Wallace & Tiernan 61A-1B-0100	Int press transducer cal	0 to 100 in Hga	±0.066% fsc
Volt-Ohm-Milliammeter	Triplett 630-NS	Operational checkout; trouble-shooting	0 to 60 vdc	±1.5%
Digital Multimeter	Fluke 8800A	Operational checkout; trouble-shooting	±200mv ± 20v	±0.008% input ±0.0025% rng ±0.005% input ±0.001% rng
Pressure Source	- - - -	Pressure cal	Depends on xdcr	- - - -

5-3. CALIBRATION INSTRUCTIONS.

5-4. EXTERNAL CALIBRATION.

5-5. Temperature Calibration.

1. Connect power cable to POWER INPUT connector and to appropriate power source.
2. Turn MASTER POWER switch on.

3. Set mode switch under SCALING AND CALIBRATION access door to 6. Display will read:

NOTE

To continue when "SEE SERVICE MANUAL" appears, press ENTER. If "ENTER ACCESS I.D." appears, use LEFT-RIGHT and INCREMENT switches to set access identification to H337N and then press ENTER. Display 2 appears only if tester has been turned off since the last time access identification was set.

(1)	(2)	(3)	(4)
SEE SERVICE MANUAL	ENTER ACCESS I.D. --------	TEMP CALIBRATE	CAL. T/C OR R.T.D.

Selected input, T/C (engine temp) or R.T.D. (TAMB) will be flashing. Use CHANGE button under SCALING AND CALIBRATION access door to select R.T.D.

4. Press ENTER. Display will read:

(1)	(2)	(3)
R.T.D. PROBE CALIBRATE	PLACE RESISTOR J5 A/B-C/D	R.T.D.-60°C PUT76.33 OHM RD.XXX.X°C

NOTE

Pressing CHANGE button when a low calibration point is displayed in mode 6 causes high calibration point to be displayed.

Use four leads of equal length in the following calibration setup.

5. Connect two leads to one terminal of resistance decade 1 (Table 5-1) and to pins A and B of TAMB connector. Connect two other leads to other terminal and to pins C and D.

6. Set resistance decade to 76.33 ohms.

7. Press ENTER. Reading will become -60.0°C and then display will read:

R.T.D. 100°C PUT138.5OHM RD. -60.0°C	or	R.T.D 85°C* PUT132.8OHM* RD. -60.0°C	*Serial number 339 and subsequent.

NOTE

Pressing CHANGE button when a high calibration point is displayed in mode 6 causes display to momentarily read CALIBR NOT COMPLETE and then to return to initial displays of mode.

8. Set resistance decade to 138.50 or 132.80 ohms as applicable.

9. Press ENTER. Reading will become 100.0°C or 85.0°C and then display will read:

(1)	(2)	(3)	(4)
CAL. COMPLETE	SEE SERVICE MANUAL	TEMP CALIBRATE	CAL. T/C OR R.T.D.

10. Disconnect resistance decade from tester.

11. Make calibration setup of figure 5-1.

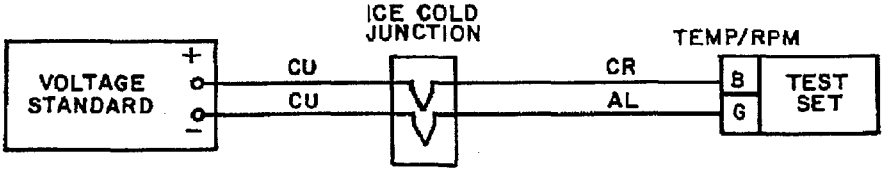


Figure 5-1. Thermocouple Input Calibration Setup

12. Use CHANGE button to select T/C and press ENTER. Display will read:

(1)	(2)	(3)	(4)
T/C CALIBRATE	PUT IN NORM. READ POSITION	PUT TEMP SW IN NORMAL	PUT 32 °F = 0 MV RD. XXXX°F

NOTE

Display 2 appears only if FUNCTION SELECT switch is not in NORM. READING position and display 3 appears only if TEMP SELECT switch is not in NORMAL position.

13. Turn FUNCTION SELECT switch to NORM. READING and TEMP SELECT switch to NORMAL.

14. Set voltage standard to 0.000 mvdc.

15. Press ENTER. Reading will become 32°F and then display will read:

PUT 1832
°F = 41.269MV.
RD. 32°F

16. Set voltage standard to 41.269 mvdc.

17. Press ENTER. Reading will become 1832°F and then display will read:

(1)	(2)
CAL. COMPLETE	SEE SERVICE MANUAL

18. Set mode switch to 0.

19. Set voltage standard to 20.640 mvdc. Temperature display shall read 932 ±4°F. If not, perform cold junction calibration of paragraph 5-11 and then repeat steps 1-19.

20. This completes the temperature calibration.

5-6. External Pressure Transducer Calibration.

1. Connect external pressure transducer cable and transducer to EXTERNAL PRESSURE connector if pressure will be the signal source.

2. Set mode switch to 7. Display will read:

NOTE

To continue when "SEE SERVICE MANUAL" appears, press ENTER. If "ENTER ACCESS I.D." appears, use LEFT-RIGHT and INCREMENT switches to set access identification to H337N and then press ENTER. Display 2 appears only if tester has been turned off since the last time access identification was set.

(1)	(2)	(3)	(4)
SEE SERVICE MANUAL	ENTER ACCESS I.D. -------	EXTERNAL TRANSDUCER CALIB.	SELECT ENG. TYPE XX

where XX is the position of the ENGINE TYPE SELECT switch.

3. Turn ENGINE TYPE SELECT switch to desired position.

4. Press ENTER. Display will read:

VOLTAGE
PRESSURE
CALIBRATE

where selected calibration source (VOLTAGE or PRESSURE) will be flashing. Select desired calibration source with CHANGE button. Proceed at step 5 if VOLTAGE was selected and at step 10 if PRESSURE was selected.

5. Press ENTER. Display will read:

SPAN
EQUALS
XXXX.XX (IN.HG. or P.S.I.)

Selected engineering units (IN.HG. or P.S.I.) will be flashing. Select desired units with CHANGE button.

6. Press ENTER. One digit of span value will begin to flash. Set span value using LEFT-RIGHT and INCREMENT switches.

7. Press ENTER. Display will read:

SPAN
EQUALS
X.XXX VOLTS

and one digit of span voltage will be flashing. Set span voltage (taken from calibration sheet) using LEFT-RIGHT and INCREMENT switches.

8. Press ENTER. Display will read:

(1)	(2)	(3)
SET PAMB	TO	SEE
OR ZERO IN	COMPLETE	SERVICE
MODE 0	CALIBR.	MANUAL

9. Scale transducer per paragraph 5-17.

10. Press ENTER. Display will read:

FULL
SCALE EQU.
XXXX.XX (IN. HG. or P.S.I.)

Selected engineering units (IN.HG. or P.S.I.) will be flashing. Select desired units with CHANGE button.

11. Press ENTER. Display will read:

FULL
SCALE EQU.
XXXX.XX (IN.HG. or P.S.I.)

and one digit of full-scale value will be flashing. Set full-scale value using LEFT-RIGHT and INCREMENT switches.

12. Press ENTER. Display will read:

SELECT
ABSOLUTE
GAUGE/DIFF.

and selected pressure type (ABSOLUTE or GAUGE/DIFF.) will be flashing. Select desired pressure type. If ABSOLUTE is selected, proceed at step 13. If GAUGE/DIFF. is selected, proceed at step 20.

13. Press ENTER. Display will read:

VENT
TRANSDUCER
XX.XX (IN.HG. or P.S.I.)

and one digit of current reading will be flashing. Set reading to current barometric pressure using LEFT-RIGHT and INCREMENT switches.

14. Press ENTER. Display will read:

APPLY
XX.XX (IN.HG. or P.S.I.)

where one digit of full-scale value (XX.XX), set in step 11, will be flashing.

15. Apply a full-scale pressure near the value of XX.XX to the transducer and use the LEFT-RIGHT and INCREMENT switches to change display until it is equal to the applied pressure.

16. Press ENTER. Display will read:

(1)	(2)	(3)	(4)
SPAN	READING	CAL	SEE
EQUALS	NOW	COMPLETE	SERVICE
X.XXX VOLTS	XX.XX (IN.HG. or P.S.I.)		MANUAL

where (1) is the newly calculated span value and (2) is the current external pressure transducer reading. Span value of display (1) should equal (high cal pressure) - (low cal pressure) / full-scale pressure x 5.000 volts ±0.2%.

17. Scale transducer per paragraph 5-17.

18. Set mode switch to 0, turn PRESSURE SELECT switch to EXTERNAL and apply a known pressure to the transducer. Pressure display shall read desired pressure ±0.2%. If it does, this completes the calibration and scaling of the external pressure transducer. Proceed at step 3 to calibrate external pressure transducers of other engine types. If it doesn't read desired pressure ±0.2%, make the external pressure test setup of figure 5-2.

NOTE

Check that excitation voltage across the 1K resistor in the test setup is from 24 to 32 vdc.

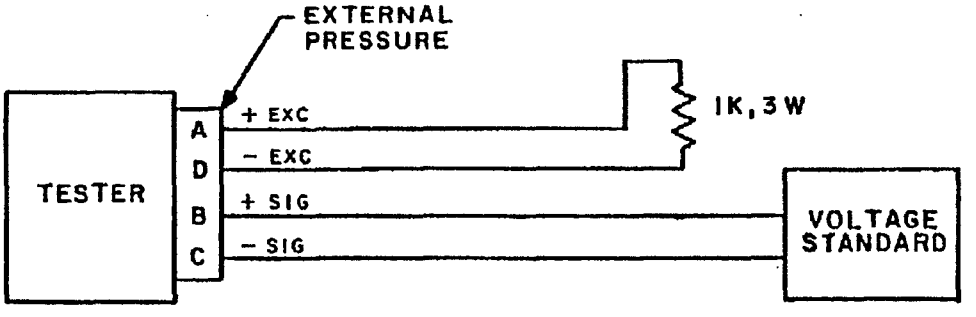


Figure 5-2. External Pressure Test Setup

19. Apply transducer span voltage to tester. Pressure display shall read desired pressure ±0.1%. If it does, replace external pressure transducer and repeat this paragraph.

If it doesn't, perform external transducer voltage calibration of paragraph 5-12 and then repeat this paragraph.

20. Press ENTER. Display will read:

VENT
TRANSDUCER
PUSH ENTER

Vent transducer port to atmospheric pressure.

21. Press ENTER. Display will read:

APPLY
XX.XX (IN.HG. or P.S.I.)

where one digit of full-scale value (XX.XX), set in step 11, will be flashing.

22. Apply a full-scale pressure near the value of XX.XX to the transducer and use LEFT-RIGHT and INCREMENT switches to change display until it is equal to applied pressure.

23. Press ENTER. Display will read:

(1)	(2)	(3)	(4)
SPAN	READING	CAL	SEE
EQUALS	NOW	COMPLETE	SERVICE
X.XXX VOLTS	XX.XX(IN.HG. or P.S.I.)		MANUAL

where (1) is the newly calculated span value and (2) is the current external pressure transducer reading. Span value of display (1) should equal (high cal pressure) - (low cal pressure) / full-scale pressure x 5.000 volts ±0.2%.

24. Perform steps 17 through 19 as required.

5-7. INTERNAL PRESSURE TRANSDUCER CALIBRATION.

1. Set mode switch to 8. Display will read:

NOTE

To continue when "SEE SERVICE MANUAL" appears, press ENTER. If "ENTER ACCESS I.D." appears, use LEFT-RIGHT and INCREMENT switches to set access identification to H337N and then press ENTER. Display 2 appears only if tester has been turned off since the last time access identification was set.

(1)	(2)	(2)	(3)
SEE	ENTER	INTERNAL	VOLTAGE
SERVICE	ACCESS I.D.	TRANSDUCER	PRESSURE
MANUAL	- - - - -	CALIB	CALIBRATE

A calibration source (VOLTAGE or PRESSURE) will be flashing. Select desired source with CHANGE button. Proceed at step 2 if VOLTAGE was selected and at step 8 if PRESSURE was selected.

2. Press ENTER. Display will read:

FULL
SCALE EQU.
(101.80 IN.HG. or 50.00 P.S.I.)

Bottom line will be flashing. Select desired units (IN.HG. or P.S.I.) with CHANGE button.

3. Press ENTER. Display will read:

SPAN
EQUALS
X.XXX VOLTS

and one digit of VOLTS will be flashing.

4. Set span voltage (taken from a calibration sheet) using LEFT-RIGHT and INCREMENT switches.

5. Press ENTER. Display will read:

(1)	(2)	(3)
SET TO	TO	SEE
PAMB IN	COMPLETE	SERVICE
MODE 0	CALIB.	MANUAL

6. Scale transducer per paragraph 5-18.

7. Set mode switch to 0 and PRESSURE SELECT switch to INTERNAL and remove any error in ambient pressure reading per paragraph 4-21. Then apply a known pressure to the internal transducer. Pressure display shall read desired reading ± 0.25 IN.HG. (± 0.12 P.S.I.). If reading is in-tolerance, this completes the calibration and scaling of the transducer. If reading is out-of-tolerance, perform internal transducer voltage calibration of paragraph 5-13 and then repeat applicable steps of this paragraph. If reading is still out-of-tolerance, replace internal transducer and repeat applicable steps of this paragraph.

8. Press ENTER. Display will read:

FULL
SCALE EQU.
(101.80 IN.HG. or 50.00 P.S.I.)

Bottom line will be flashing. Select desired units (IN.HG. or P.S.I.) with CHANGE button.

9. Omitted.

10. Press ENTER. Display will read:

VENT
TRANSDUCER
XX.XX (IN.HG. or P.S.I.)

and one digit of current reading will be flashing. Uncap internal transducer port and set reading to current barometric pressure using LEFT-RIGHT and INCREMENT switches.

11. Press ENTER. Display will read:

APPLY
XX.XX (IN.HG. or P.S.I.)

where one digit of full-scale value (XX.XX), selected in step 8, will be flashing.

12. Apply a full-scale pressure near the value of XX.XX to the transducer and use the LEFT-RIGHT and INCREMENT switches to change display until it is equal to the applied pressure.

13. Press ENTER. Display will read:

(1)	(2)	(3)	(4)
SPAN	READING	CAL	SEE
EQUALS	NOW	COMPLETE	SERVICE
X.XXX VOLTS	XX.XX (IN.HG. or P.S.I.)		MANUAL

where (1) is the newly calculated span value and (2) is the current internal pressure transducer reading. Span value of display (1) should equal (high cal pressure) - (low cal pressure)/full-scale pressure x 5.000 volts ±0.25%.

14. Scale transducer per paragraph 5-18.

15. Perform step 7.

Left Blank Intentionally

Left Blank Intentionally

5-8. Insulation Resistance Calibration.

1. Set mode switch to 9. Display will read:

NOTE

To continue when "SEE SERVICE MANUAL" appears, press ENTER. If "ENTER ACCESS I.D." appears, use LEFT-RIGHT and INCREMENT switches to set access identification to H337N and then press ENTER. Display 2 appears only if tester has been turned off since the last time access identification was set.

(1)	(2)	(3)	(4)
SEE SERVICE MANUAL	ENTER ACCESS I.D. -----	CAL INSULATION RESISTANCE	PUT IN INSULATION POSITION

Display (2) appears only if FUNCTION SELECT switch is not in INSULATION position.

2. Turn FUNCTION SELECT switch to INSULATION. Display will read:

PUT 0 K
J4 A TO B
RD. XXXX K

NOTE: J4 is TEMP/RPM connector.

3. Connect resistance decade 2 (table 5-1) to pins A and B of TEMP/RPM connector and set resistance to 0 ohms.

4. Press ENTER . RD. will change to 0 K and then display will read:

PUT 200 K
J4 A TO B
RD. 0.0 K

5. Set resistance to 200K.

6. Press ENTER. RD. will change to 200 K and then display will read:

(1)	(2)
CAL COMPLETE	SEE SERVICE MANUAL

7. Disconnect resistance decade from tester. This completes the calibration of the insulation resistance circuit.

5-9. T/C Resistance Calibration.

1. Set mode switch to 10. Display will read:

NOTE

To continue when "SEE SERVICE MANUAL" appears, press ENTER. If "ENTER ACCESS I.D." appears, use LEFT-RIGHT and INCREMENT switches to set access identification to H337N and then press ENTER. Display 2 appears only if tester has been turned off since the last time access identification was set.

(1)	(2)	(3)	(4)
SEE	ENTER	CAL	PUT IN
SERVICE	ACCESS I.D.	T/C	T/C RESIS.
MANUAL	- - - - -	RESISTANCE	POSITION

Display 4 appears only if the FUNCTION SELECT switch is not in T/C RESISTANCE position.

2. Turn FUNCTION SELECT switch to T/C RESISTANCE. Display will read:

PUT 0 OHM
J4 B TO G
RD. XXXX

NOTE: J4 is TEMP/RPM connector.

3. Connect resistance decade 1 (table 5-1) to pins B and G of TEMP/RPM connector and set resistance to 0 ohms.

4. Press ENTER. RD. will change to 00.00 and then display will read:

PUT 35.OHM
J4 B TO G
RD. 00.00

5. Set resistance to 35.00 ohms and press ENTER. RD. will change to 35.00 and then display will read:

(1)	(2)
CAL	SEE
COMPLETE	SERVICE
	MANUAL

6. Disconnect resistance decade from tester. This completes the calibration of the T/C resistance circuit.

5-10. INTERNAL CALIBRATION.

NOTE

Do not perform the procedures of paragraphs 5-11 through 5-13 unless instructed while performing the calibration procedures of paragraphs 5-4 through 5-9.

5-11. COLD JUNCTION CALIBRATION.

1. Disconnect cables from tester.

2. Remove 12 screws from around edge of tester deck and lift deck assembly from case assembly.

3. Remove jumper plug P104 from socket S104 on the analog board (figure 5-3).

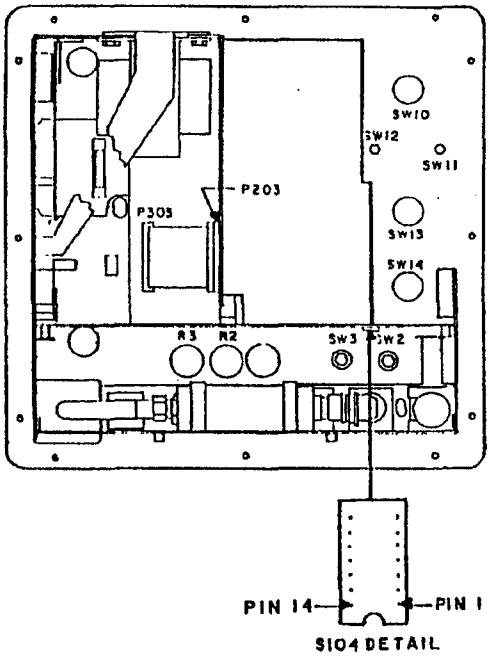


Figure 5-3. Socket S104 Pin Identification

4. Connect power cable to tester and to power source.

5. Turn MASTER POWER switch on. Display will read:

(1)	(2)
COLD	CJ -40°F
JUNCTION	6-8 186.8K
S104 6-8	RD. XXX.X°F

6. Using resistance decade 2 (table 5-1), apply 186.8K ohms to connector S104, pins 6 and 8.

7. Press ENTER button under SCALING AND CALIBRATION access door. Reading (RD.) will become -40.0°F and display will change to:

CJ 160°
6-8 4.662K
RD. -40.0°F

8. Set resistance decade to 4.662K ohms.

9. Press ENTER. Reading will become 160.0°F and then display will read:

(1)	(2)
INTERNAL	PUT 0.00 V.
TRANSDUCER	13(-) 12(+)
VOLT CALIB.	RD. X.XXX V.

10. Turn MASTER POWER switch off.

11. Disconnect resistance decade from tester, reconnect jumper plug P104, and reinstall deck assembly in case.

5-12. External Transducer Voltage Calibration.

1. Perform steps 1-5 of paragraph 5-11.

2. Use CHANGE button under SCALING AND CALIBRATION access door to step to the following displays:

(1)	(2)
EXTERNAL	PUT 0.00 V.
TRANSDUCER	J6C(-) B(+)
VOLT CALIB.	RD. X.XXX V.

3. Connect voltage standard (table 5-1) to pins B(+) and C(-) of EXTERNAL PRESSURE connector.

4. Set voltage standard to 0.000 vdc.

5. Press ENTER. Reading will become 0.000 V. and then display will read:

PUT 6.00 V.
J6C(-) B(+)
RD. 0.000 V.

6. Set voltage standard to 6.000 vdc.

7. Press ENTER. Reading will become 6.000 V. and then display will read:

(1)	(2)
RATIO	PUT 0.00V.
VOLTS	J6C(-) F(+)
VOLT CALIB.	RD. X.XXX V.

8. Set voltage standard to 0.000 vdc.

9. Press ENTER. Reading will become 0.000 V. and then display will read:

PUT 6.00 V.
J6C(-) F(+)
RD. X.XXX V.

10. Set voltage standard to 6.000 vdc.

11. Press ENTER. Reading will become 6.000 V. and then display will read:

(1)	(2)
COLD	CJ -40°F
JUNCTION	6-8 186.8K
S104 6-8	RD. XXX.X°F

This completes the external transducer voltage calibration.

12. Turn MASTER POWER switch off.

13. Disconnect voltage standard from tester, reconnect jumper plug P104, and reinstall deck assembly in case.

5-13. Internal Transducer Voltage Calibration.

1. Perform steps 1-5 of paragraph 5-11.

2. Use CHANGE button under SCALING AND CALIBRATION access door to step to the following displays:

(1)	(2)
INTERNAL	PUT 0.00 V.
TRANSDUCER	13(-) 12(+)
VOLT CALIB.	RD. X.XXX V.

3. Connect voltage standard (table 5-1) to pins 12(+) and 13(-) of S104 (figure 5-3).

4. Set voltage standard to 0.000 vdc.

5. Press ENTER. Reading will become 0.000 V. and then display will read:

PUT 5.00 V.
13(-) 12(+)
RD. 0.000 V.

6. Set voltage standard to 5.000 vdc.

7. Press ENTER. Reading will become 5.000 V. and then display will read:

(1)	(2)
EXTERNAL	PUT 0.00 V.
TRANSDUCER	J6C(-) B(+)
VOLT CALIB.	R.D. X.XXX V.

This completes the internal transducer voltage calibration.

8. Turn MASTER POWER switch off.

9. Disconnect voltage standard from tester, reconnect jumper plug P104, and reinstall deck assembly in case.

5-14. SCALING INSTRUCTIONS.

5-15. TEMPERATURE SCALING. Temperature scaling is used to select the engineering units (°C or °F) of ambient temperature and engine temperature and the engine temperature calibration curve (chromel-alumel or TF30) for each engine type tested.

1. Turn mode switch to 2. Display will read:

(1)	(2)
TEMP	SELECT
SCALING	ENG. TYPE XX

where XX is the position of the ENGINE TYPE SELECT switch.

2. Turn ENGINE TYPE SELECT switch to desired position.

3. Press ENTER. Display will read:

TAMB
READING
IN °C °F

and selected units (°C or °F) will be flashing. Select desired units with CHANGE button.

4. Press ENTER. Display will read:

T/C
READING
IN °C °F

and selected units (°C or °F) will be flashing. Select desired units with CHANGE button.

5. Press ENTER. Display will read:

T/C
CAL. CURVE
CR/AL TF30

and selected calibration curve (CR/AL or TF30) will be flashing. Select desired curve with CHANGE button.

6. Press ENTER. Display will read:

STANDARD
DAY PRINT
YES OR NO

At this point, decide if standard day readings are desired in data printouts. Select desired answer with CHANGE button.

7. Press ENTER. Display will read:

(1)	(2)	(3)
SCALING	TEMP	SELECT
COMPLETED	SCALING	ENG. TYPE XX

8. Repeat steps 2 through 7 for other engine types.

5-16. RPM SCALING. For up to three parameters (N1, N2, and N3) on each engine type, the operator may set full-scale (in Hz) and select the desired engineering units (PCNT., R.P.M., HZ., OR P.P.H.).

1. Turn mode switch to 3. Display will read:

(1)	(2)
RPM	SELECT
SCALING	ENG. TYPE XX
	N1 N2 N3

where XX, the position of the ENGINE TYPE SELECT switch, is flashing as well as N1, N2, or N3, the position of the RPM SELECT switch.

2. Turn ENGINE TYPE SELECT switch to desired position.

3. Turn RPM SELECT switch to desired position.

4. Press ENTER. Display will read:

SELECT
PCNT. R.P.M.
HZ. P.P.H.

and selected engineering units will be flashing. Select desired units with CHANGE button.

5. Press ENTER. Display will read:

SELECT
FULL SCALE
XXXXX.XX HZ.

where XXXXX.XX equals previous full-scale setting. Full-scale range is 40.00 to 30,000 Hz. Set full-scale value using LEFT-RIGHT and INCREMENT switches.

6. Press ENTER. Display will read:

XXXX HZ.
EQUAL
YYYY units

where XXXX is full-scale value set in step 5 and units are those selected in step 4.

NOTE

If units selected in step 4 were Hz, then YYYY will equal XXXX in the above display.

If selected units are other than Hz, then set full-scale units value using LEFT-RIGHT and INCREMENT switches.

7. Press ENTER. Display will read:

(1)	(2)	(3)
SCALING COMPLETED	RPM SCALING	SELECT ENG. TYPE XX N1 N2 N3

Repeat steps 2 through 7 for other parameters and other engine types.

5-17. EXTERNAL PRESSURE TRANSDUCER SCALING. External pressure transducer scaling allows the operator to scale external pressure readings in FT.LB., IN.HG., PCNT., P.S.I. or MBAR.

1. Turn mode switch to 4. Display will read:

(1)	(2)
EXTERNAL TRANSDUCER SCALING	SELECT ENG. TYPE XX

where XX is the position of the ENGINE TYPE SELECT switch.

2. Turn ENGINE TYPE SELECT switch to desired position.

3. Press ENTER. Display will read:

PRINT
DESIGNATOR
(PAMB, PEXH, PEXT, or TRQ)

Use CHANGE button to select the designator of external pressure that will appear in data printouts.

NOTE

Since internal and external transducers measure different parameters, tester will not allow same print designator to be assigned to both the internal and external transducer.

4. Press ENTER. Display will read:

VOLTAGE
PRESSURE
SCALING

where selected scaling (VOLTAGE or PRESSURE) will be flashing. Select desired scaling with CHANGE button. If VOLTAGE is selected, proceed at step 5. If PRESSURE is selected, proceed at step 13.

5. Press ENTER. Display will read:

LINEAR
RATIO
VOLT SCALE

NOTE

Ratio must be selected when scaling external pressure signals for PWA 100 Series turboprop engines. See RPM and Torque Scaling for PWA 100 Series Engines in Section VIII, Difference Data.

Use CHANGE button to select the transducer type (linear or voltage ratio) that is to be scaled.

6. Press ENTER. Display will read:

X.XXX V.
EQUALS
YYYYY units

where X.XXX V. is the default or previously set voltage and YYYY units is the default or previously stored display value and units. Units will be flashing.

7. Use CHANGE button to select desired display units (FT.LB., IN.HG., PCNT., MBAR, or P.S.I.)

NOTE

If print designator PAMB was selected in step 3 for external pressure, then tester will only allow operator to select IN.HG., MBAR, or P.S.I. in this step.

8. Press ENTER. One digit of display value (YYYY) will begin to flash.

9. Set display value using LEFT-RIGHT and INCREMENT switches.

10. Press ENTER. One digit of voltage value (X.XXX) will begin to flash.

11. Set voltage value that corresponds to display value using LEFT-RIGHT and INCREMENT switches.

12. Press ENTER. Display will read:

(1)	(2)	(3)
SCALING COMPLETED	EXTERNAL TRANSDUCER SCALING	SELECT ENG. TYPE XX

Proceed at step 2 to scale additional external pressure transducers used with other engine types.

13. Press ENTER. Display will read:

(1)	(2)
CAL. FOR ENG. TYPE XX IS	YES NO XXXX (IN.HG. or P.S.I.) Y.YYY VOLTS

where XX is the current position of the ENGINE TYPE SELECT switch and XXXX is the previously stored full-scale pressure and Y.YYY is the previously stored span voltage

resulting from the calibration. Tester is waiting for operator to answer YES or NO to the correctness of the calibration. Use CHANGE button to select desired answer. If answer is YES, proceed at step 14. If answer is NO, proceed at step 22. Answering NO allows the operator to select a transducer used with some other engine type.

14. Press ENTER. Display will read:

(1)	(2)
SCALING	SCALING
FOR ENGINE	XXXX (IN.HG. or P.S.I.) =
TYPE XX	YYYY units

where XX is the current position of the ENGINE TYPE SELECT switch, XXXX is the full-scale pressure stored during calibration, and YYYY units is the default or previously stored display value and units. Units will be flashing.

15. Use CHANGE button to select desired display units (IN.HG., P.S.I., FT.LB., MBAR, or PCNT.)

NOTE

If print designator PAMB was selected in step 3 for external pressure, then tester will only allow operator to select IN.HG., P.S.I. or MBAR in this step.

16. Press ENTER. One digit of display value will begin to flash.

17. Set display value using LEFT-RIGHT and INCREMENT switches.

NOTE

If display units are IN.HG., MBAR, or P.S.I., proceed at step 21 and observe that calibration value becomes equal to display value after ENTER is pressed.

18. Press ENTER. Scaling units (XXXX units) will begin to flash. Use CHANGE button to select desired scaling units (IN.HG. or P.S.I.).

19. Press ENTER. One digit of scaling value will begin to flash.

20. Set scaling value using LEFT-RIGHT and INCREMENT switches.

21. Press ENTER. Display will read:

(1)	(2)	(3)
SCALING	EXTERNAL	SELECT
COMPLETED	TRANSDUCER	ENG. TYPE XX
	SCALING	

Proceed at step 2 to scale additional external pressure transducers used with other engine types.

22. Press ENTER. Display will read:

YES NO
SAME CAL
AS ANOTHER

If desired external pressure transducer calibration is the same as that used with another engine type, answer YES and proceed at step 23. If not, answer NO and proceed at step 24. Select answer with CHANGE button.

23. Press ENTER. Display will read:

TYPE XX
XXXX (IN.HG. or P.S.I.)
Y.YYY VOLTS

where XX is the first engine type for which an external pressure transducer calibration has been stored. Use CHANGE button to step through external pressure transducer calibrations. If a calibration appears which satisfies the requirements of the selected engine type, proceed at step 14. If all external transducer calibrations are stepped through twice and one is not selected, then display will read:

DO EXT.
TRANSDUCER
CAL POS 7

Complete paragraph 5-6 for the selected engine type and return to step 1.

24. Press ENTER. Display will read:

DO EXT.
TRANSDUCER
CAL POS 7

Complete paragraph 5-6 for selected engine type and return to step 1.

5-18. INTERNAL PRESSURE TRANSDUCER SCALING. Internal pressure transducer scaling allows the operator to scale the internal transducer readings in IN.HG.., P.S.I. or MBAR.

1. Turn mode switch to 5. Display will read:

(1)	(2)
INTERNAL TRANSDUCER SCALING	SELECT ENG. TYPE XX

2. Turn ENGINE TYPE SELECT switch to desired position.

NOTE

PINT or PEXH must be selected in the next step if tester is to display EPR for engine type.

3. Press ENTER. Display will read:

PRINT
DESIGNATOR
(PAMB, PINT, or PEXH)

Use CHANGE button to select the designator of internal pressure that will appear in data printouts. If PAMB is selected, then "NOT SCALED" will be displayed when PRESSURE SELECT switch is turned to EPR.

NOTE

Tester will not allow same print designator to be assigned to both internal and external transducers.

4. Press ENTER. Display will read:

INTERNAL
RANGE
(101.80 IN.HG., 50.00 P.S.I., 3447 MBAR or NOT SCALED)

where units or scaling message selected during previous scaling will be flashing.

5. Use CHANGE button to select desired caption.

6. Press ENTER. Display will read:

(1)	(2)	(3)
SCALING COMPLETED	INTERNAL TRANSDUCER SCALING	SELECT ENG. TYPE XX

Proceed at step 2 to scale the internal transducer for other engine types.

5-19. DISPLAYING AND PRINTING STORED CALIBRATION AND SCALING DATA.

5-20. Mode 1 allows the operator to display and/or print the calibration and scaling data of all parameters of all engine types. No changes can be made in this mode.

5-21. DISPLAYING STORED CALIBRATION AND SCALING DATA.

1. Set mode switch beneath SCALING AND CALIBRATION access door to 1. Display will read:

STORED
SCALING/
CALIB.

2. Turn ENGINE TYPE SELECT switch to desired position. Display will read:

STORED
SCALING/
CALIB.

3. Press CHANGE button to obtain each of the following displays:

(1)
ENG. T. XX
T/C IN (°C or °F)
CURV (CR/AL or TF30)

where XX is the position of the ENGINE TYPE SELECT switch.

(2)
TAMB IN (°C or °F)

NOTE

If full-scale input or reading is set to zero when scaling an rpm parameter, then the two scaling displays of the parameter will be replaced with the following single display.

RPM - NX
NOT SCALED

(3)
RPM N1
F.S. XXXX HZ

(4)
XXXX HZ
EQUALS
YYYY (HZ, R.P.M., PCNT., or P.P.H.)

(5)
RPM - N2
F.S. XXXX HZ

(6)
XXXX HZ
EQUALS
YYYY (HZ, R.P.M., PCNT., or P.P.H.)

(7)
RPM - N3
F.S. XXXX HZ

(8)
XXXX HZ
EQUALS
YYYY (HZ, R.P.M., PCNT., or P.P.H.)

NOTE

If span voltage or pressure was set to zero during an external pressure transducer calibration, then display 9 will be replaced with the following display and display 10 will not appear.

EXTERNAL
TRANSDUCER
NOT CALIB.

(9)
EXT. XDCR.
SPAN = X.XXX V.
= XXXX (IN.HG. or P.S.I.)

(10)
SCALING
XXXX (IN.HG. or P.S.I.) =
YYYY (IN.HG., P.S.I., FT.LB., MBAR, or PCNT.)

NOTE

If pressure or full-scale reading was set to zero during an external pressure transducer scaling, then display 10 will be replaced with the following display.

EXTERNAL
TRANSDUCER
NOT SCALED

NOTE

If span voltage or pressure was set to zero during an internal pressure transducer calibration, then display 11 will be replaced with the following display and display 12 will not appear.

INTERNAL
TRANSDUCER
NOT CALIB.

(11)
INT.XDCR.
SPAN = X.XXX V.
= XX.XX (IN.HG. or P.S.I.)

(12)
SCALING
(101.80 IN.HG., 50.00 P.S.I., or 3447 MBAR)

NOTE

If pressure or full-scale reading was set to zero or "NOT SCALED" was selected during an internal pressure transducer scaling, then display 12 will be replaced with the following display.

INTERNAL
TRANSDUCER
NOT SCALED

(13)
STANDARD
DAY PRINT
(YES or NO)

(14)
PRINT
DESIGNATOR
INT = (PINT, PEXH, or PAMB)

(15)
PRINT
DESIGNATOR
EXT = (PEXT, PEXH, PAMB, or TRQ)

(16)
EXTERNAL
SCALED
(LINEAR OR RATIO)

(17)
END OF
STORED
DATA

STORED
SCALING/
CALIB.

Repeat steps 2 and 3 as desired for other engine types.

5-22. PRINTING STORED CALIBRATION AND SCALING DATA.

1. Set mode switch beneath SCALING AND CALIBRATION access door to 1.

2. Turn ENGINE TYPE SELECT switch to desired position.

3. Press PRINT button.

4. Repeat steps 2 and 3 for printouts of additional calibration and scaling data. Figure 5-4 is a sample printout.

5-23. INSPECTION AND PREVENTIVE MAINTENANCE.

5-24. Other than calibrating the tester every 12 months, there is no scheduled inspection or preventive maintenance.

```
STORED
SCALING AND
CALIBRATION
CONSTANTS

ENGINE TYPE 2
T/C  IN DEG.  F
CURVE TYPE CR/AL

TAMB IN DEG.  F

R.P.M.  N1
FULL SCALE
70.00 HZ.
EQUALS
100.0PCNT.

R.P.M.  N2
FULL SCALE
70.00 HZ.
EQUALS
10000 R.P.M.

R.P.M.  N3
FULL SCALE
10000  HZ.
EQUALS
30000  P.P.H.

EXTERNAL TRANSDUCER
SPAN
5.000 VOLTS
EQUALS
100.00 P.S.I.

SCALED TO
100.00 P.S.I.
EQUALS
100.00 P.S.I.

INTERNAL TRANSDUCER
SPAN
5.000 VOLTS
EQUALS
101.80 IN.HG.

SCALED TO
101.80 IN.HG.

STANDARD DAY
PRINT    YES

PRINT DESIGNATORS

INTERNAL =PINT

EXTERNAL =PEXT

EXTERNAL IS LINEAR P
```

Figure 5-4. Sample Printout of Calibration and Scaling Data

5-25. TROUBLESHOOTING.

5-26. GENERAL TROUBLESHOOTING PROCEDURES. Note from parts lists in the Illustrated Parts Breakdown (Section VII) that a circuit board assembly may contain several integrated circuits having the same part number. Swapping locations of identical integrated circuits may provide a clue to a malfunction. Care should be exercised when swapping gates to note which circuits are affected by the gates.

CAUTION

Integrated circuit leads are fragile. Exercise care when removing or installing integrated circuits.

Always remove power from the tester when removing or installing a circuit component. The numbering of integrated circuit pins is explained in paragraph A-1 of Appendix A.

5-27. TROUBLESHOOTING THE TESTER. If the tester will successfully complete the display test, built-in-test, and the printer test of paragraph 4-19, then it is operationally ready. If the display proves faulty during the display test, then refer to figure 5-5 and table 5-2. If an error message is displayed during a built-in test, refer to table 5-3 for the possible cause and replace applicable integrated circuits until the malfunction is corrected.

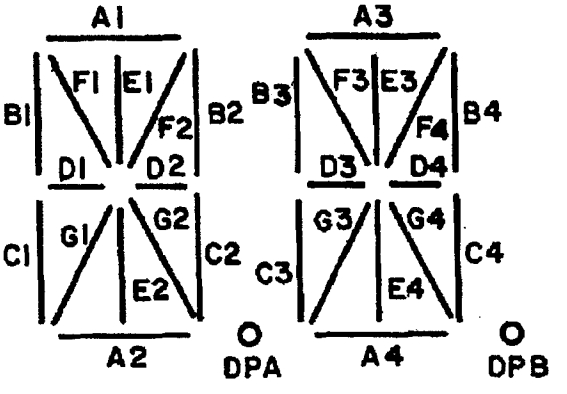


Figure 5-5. Dual 14-Segment Display

Table 5-2. Display Test Troubleshooting Table

TROUBLE	PROBABLE CAUSE	REMEDY
All 1" segments of a display (fig 5-5) do not light.	Applicable display driver (U1-U14); driver transistor (Q1, Q5, Q9, etc.); or display (I1-I14) on display board (26, fig 7-3).	Replace defective component.
All 2" segments of a display (fig 5-5) do not light.	Applicable display driver (U1-U14); driver transistor (Q2, Q6, Q10, etc.); or display (I1-I14) on display board (26, fig 7-3).	Replace defective component.
All 3" segments of a display (fig 5-5) do not light.	Applicable display driver (U1-U14); driver transistor (Q3, Q7, Q11, etc.); or display (I1-I14) on display board (26, fig 7-3).	Replace defective component.
All 4" segments of a display (fig 5-5) do not light.	Applicable display driver (U1-U14); driver transistor (Q4, Q8, Q12, etc.); or display (I1-I14) on display board (26, fig 7-3).	Replace defective component.
A display does not light.	Decoder U15 on display board (19, fig 7-6).	Replace defective component.
All common-lettered segments (i.e. A-segments, B-segments, etc.) of a display do not light.	Applicable display driver (U1-U14) (6, fig 7-6); resistor network (RN1-RN14) (1); or display (I1-I14) (4) on display board.	Replace defective component.
All digits display abnormal test pattern.	Octal buffer U10 (37, fig 7-4) on computer board.	Replace.

Table 5-3. Built-In Test Error Messages

ERROR MESSAGE	POSSIBLE CAUSE	CIRCUIT LOCATION
TACH TEST FAILED	U4 on analog board.	3, fig 7-5.
	U7 on analog board.	16, fig 7-5.
	U3 on computer board.	9, fig 7-4.
	U12 on computer board.	7, fig 7-4.
	U14 on computer board.	11, fig 7-4.
I/O RAM FAILED	U11-U13 on computer board.	7, fig 7-4.
2K RAM FAILED	U5 on computer board.	28, fig 7-4.
ANALOG CIRCUIT FAILED	U9 on analog board.	52, fig 7-5.
	Q1, U1, U3, U4, U5, or U6 on analog board.	3, fig 7-5.
	U17 on analog board.	60, fig 7-5.

5-28. REPAIR.

5-29. GENERAL REPAIR PROCEDURES. Use a minimum amount of heat when unsoldering and resoldering components. Resolder components using 60-40 tin-lead rosin-core solder with a maximum diameter of 1/16 inch. Isopropyl alcohol may be used to remove excess flux.

5-30. OPENING AND CLOSING TESTER ASSEMBLY.

1. Disconnect cables from tester.

2. Remove screws (2, figure 7-2) around edge of tester deck and lift deck assembly from case.

3. When closing tester assembly, inspect deck gasket (26, 27, figure 7-2) for breaks and deterioration and replace if necessary to ensure a watertight seal. When replacing deck gasket, apply 847 Rubber and Gasket Adhesive manufactured by 3M Company, St. Paul, Minnesota, or an equivalent, to the underneath side of the gasket to hold it in place and for sealing. Inspect bead of sealant around the flange of the case for breaks or voids and replace as necessary with RTV 3140 Adhesive/Sealant manufactured by Dow Corning® corporation, Midland, Michigan, or an equivalent for a watertight seal.

5-31. REPLACEMENT OF INTERNAL PRESSURE TRANSDUCER.

1. Open tester assembly per paragraph 5-30 to gain access to the transducer bracket assembly (2, figure 7-3).

2. Disconnect connector S10 from transducer.

3. Remove two screws (2, figure 7-8) holding transducer and clamps to bracket.

4. Remove hose and clamps from transducer (1).

5. Install clamps on new transducer.

6. Attach hose to transducer.

7. Attach clamps to transducer bracket.

8. Connect connector S10 to transducer.

9. Close tester assembly per paragraph 5-30.

10. Calibrate and scale internal pressure transducer per paragraphs 5-7 and 5-18.

5-32. REPLACEMENT OF INTERNAL PRINTER.

1. Open tester assembly per paragraph 5-30.

2. Disconnect connector S11 from printer.

3. Mark and disconnect wires at printer terminal strip.

4. Remove four screws (4, figure 7-2) and two mounting bars (8) and remove printer.

5. Attach new printer to tester case using four screws (4) and two mounting bars (8).

6. Reconnect wires to printer terminal strip.

7. Reconnect connector S11 to printer.

8. Load paper into printer per paragraph 3-3.

9. Apply power to tester, turn FUNCTION SELECT switch clockwise to second BUILT IN TEST position and test printer per paragraph 4-19, step 6.

10. Close tester assembly per paragraph 5-30.

5-33. REPLACEMENT OF DISPLAY BOARD COMPONENTS.

1. Open tester assembly per paragraph 5-30 to gain access to the display board (26, figure 7-3).

2. Determine if component to be replaced can be accessed without removing board.

3. If board must be removed, then first disconnect connector S201 from computer board and P303 from display board.

4. Remove four screws (9) and six washers (10) and disconnect computer board (8) from analog board (12).

5. Remove two screws (27) and two screws (28) and remove display board.

6. To reinstall display board, attach board to deck assembly with two screws (27) and two screws (28).

7. Reinstall computer board (8) using four screws (9) and six washers (10).

8. Reconnect connectors S201 and P303.

9. Close tester assembly per paragraph 5-30.

5-34. REPLACEMENT OF PUSHBUTTON SWITCHES. When installing PRINT, STORE, SET TO PAMB, SET TO ZERO, CHANGE or ENTER switch, do not tighten nut more than 2 to 3 inch-pounds to prevent damage to switch.

5-35. TEST.

5-36. The following procedures provide a complete acceptance test of the tester after repair:

1. Turn ENGINE TYPE SELECT switch to 8 and calibrate the tester per paragraphs 5-3 through 5-9.

2. Scale temperature for engine type 8 in °C using the chromel-alumel curve per paragraph 5-15.

3. Scale temperature for engine type 9 in °F using the chromel-alumel curve per paragraph 5-15.

4. Scale temperature for engine type 10 in °C using the TF30 curve per paragraph 5-15.

5. Scale N1 for engine type 8 such that 70.00 Hz equals 100.0 PCNT per paragraph 5-16.

6. Scale N2 for engine type 8 such that 10,000 Hz equals 10,000 R.P.M. per paragraph 5-16.

7. Scale N3 for engine type 8 such that 10,000 Hz equals 30,000 P.P.H. per paragraph 5-16.

8. Scale external pressure transducer for engine type 8 such that linear voltage of 5V equals 100 P.S.I. per paragraph 5-17.

9. Scale external pressure transducer for engine type 9 such that voltage ratio of 5V equals 100.0 PCNT.

10. Select print designator of PINT for internal pressure transducer and select 101.80 IN.HG. for the scaling per paragraph 5-18.

11. Perform acceptance test procedure of Appendix B.

THIS DOCUMENT IS SUBJECT TO THE LEGEND
RESTRICTIONS ON THE TITLE PAGE

Notice:

Howell Instruments, Inc. no longer releases assembly drawings, wiring schematics, Functional Descriptions, or illustrated parts lists, except to authorized repair stations.

For repair or replacement, please contact:

Howell Instruments, Inc.
8945 South Freeway
Fort Worth, TX 76140
817-336-7411

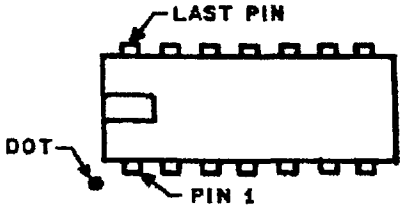
APPENDIX A

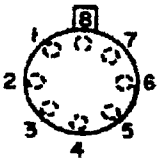
Descriptions of Integrated Circuits

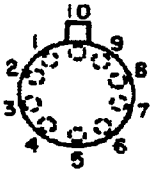
A-1. GENERAL. This appendix defines integrated circuits used in the tester. The definitions are in Howell part number (C-number) order. The tester uses standard positive logic. A logic 0 = a low voltage = false. A logic 1 = a high voltage = true. Signal names on schematic diagrams identify the logic 1 level. The following table defines the logic levels.

CIRCUITRY	LOGIC 0 INPUT	LOGIC 0 OUTPUT	LOGIC 1 INPUT	LOGIC 1 OUTPUT
TTL	$\leq$0.8vdc	$\leq$0.4vdc	$\geq$2.0vdc	$\geq$2.4vdc
CMOS	$\leq$30%V_{DD}	$\leq$0.05vdc	$\geq$70%V_{DD}	$\geq V_{DD}$-0.05vdc

The following top views of integrated circuits identify pin locations:







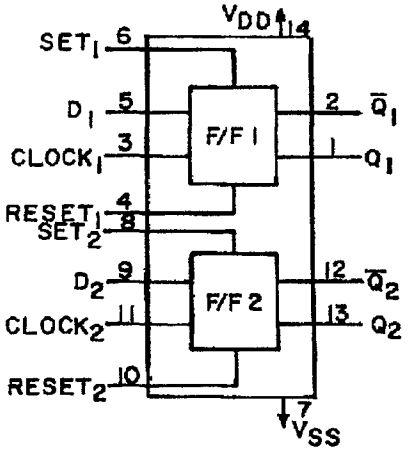
Following is a list of the part numbers of circuits defined in this appendix:

C5617	C10238	C10354	C10712	C10819
C6157	C10239	C10708	C10814	C11270
C8108	C10271	C10709	C10815	C11310
	C10272	C10710	C10816	

C5617

DUAL D-TYPE EDGE-TRIGGERED FLIP-FLOP

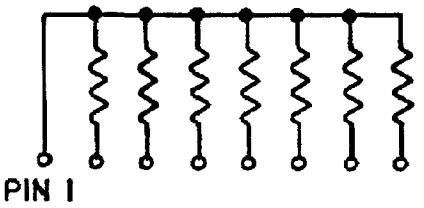
Each flip-flop has independent data, set, reset, and clock inputs, and Q and $\overline{Q}$ outputs. The logic level present at the D-input is transferred to the Q-output during the positive-going transition of the clock pulse. Setting or resetting is independent of the clock and is accomplished by a high level on the set or reset line respectively.



C6157 (CTS 750-81-R4.7K)

RESISTOR NETWORK

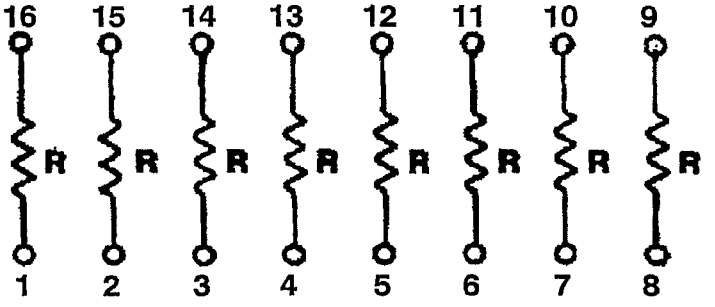
This package consists of seven 4.7K ohm resistors connected as shown in the following schematic:



C8108

RESISTOR NETWORK

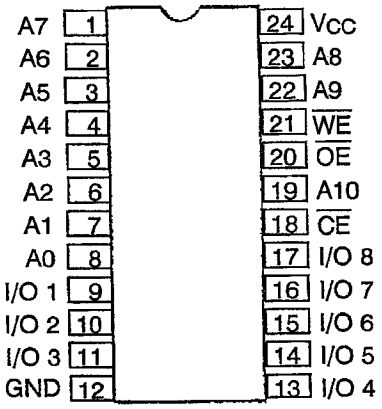
This network contains eight, 22-ohm 1/4-watt resistors arranged as shown in the schematic.



C10238

2048-WORD X 8-BIT HIGH SPEED STATIC CMOS RAM

PIN ARRANGEMENT



TOP VIEW

PIN NAMES

A_0 - A_{10}	ADDRESS INPUTS
I/O_1 - I/O_8	DATA INPUTS/OUTPUTS
$\overline{CE}$	CHIP ENABLE
$\overline{OE}$	OUTPUT ENABLE
$\overline{WE}$	WRITE ENABLE
V_{CC}	+ 5V
GND	GROUND
NC	NO CONNECT

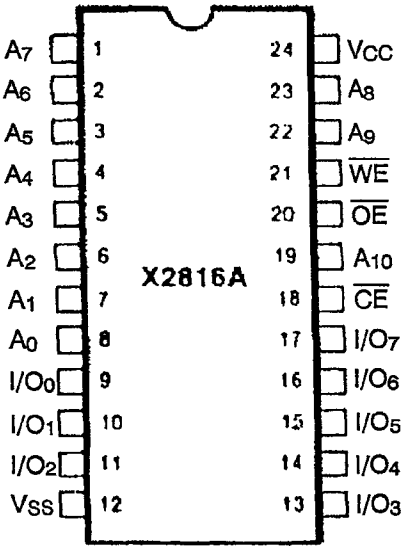
MODE SELECTION

$\overline{CS}$	$\overline{OE}$	$\overline{WE}$	Mode	I/O Pin
H	X	X	Not Selected	High Z
L	L	H	Read	Dout
L	H	L	Write	Din
L	L	L	Write	Din

C10239

2K X 8 BIT ELECTRICALLY ERASABLE PROM (E^2 PROM)

This electrically erasable, programmable, read-only memory is capable of storing 16,384 bits of data. The data can be modified under program control.



PIN NAMES

A_0 - A_{10}	ADDRESS INPUTS
I/O_0 - I/O_7	DATA INPUTS/OUTPUTS
$\overline{CE}$	CHIP ENABLE
$\overline{OE}$	OUTPUT ENABLE
$\overline{WE}$	WRITE ENABLE
V_{CC}	+ 5V
V_{SS}	GROUND
NC	NO CONNECT

MODE SELECTION

$\overline{CE}$	$\overline{OE}$	$\overline{WE}$	MODE	I/O	POWER
H	X	X	Standby	High Z	Standby
L	L	H	Read	D_{OUT}	Active
L	H	L	Byte Write	D_{IN}	Active
L	H	H	Read and Write Inhibit	High Z	Active

MICROPROCESSOR

This is an 8-bit microprocessor that functions as the central processing unit (CPU) in National Semiconductor's NSC800 micro-computer family. Many system functions are incorporated on the device, such as vectored priority interrupts, refresh control, power-save feature, and interrupt acknowledge. The microprocessor is fully compatible with the Zilog Z80™ instruction set. It is housed in a 40-pin dual-in-line package.

Dedicated memories (NSC810 RAM-I/O-TIMER and NSC830 ROM-I/O) have on-chip logic for direct interface to the NSC800.

Following are the functions of all input/output pins. Some of these descriptions reference internal circuits:

INPUT SIGNALS

Reset Input ($\overline{\text{RESET IN}}$): Active low. Sets A (8-15) and AD (0-7) to TRI-STATE® (high impedance). Clears the contents of PC, I and R registers, disables interrupts, and causes a reset output to be activated.

Bus Request ($\overline{\text{BREQ}}$): Active low. Used when another device is requesting the system bus. $\overline{\text{BREQ}}$ is recognized at the end of the current machine cycle, then A (8-15), AD (0-7). IO/M, RD, and WR are set to the high impedance mode and the request is acknowledged via the BACK output signal.

Non-Maskable Interrupt ($\overline{\text{NMI}}$): Active low. The non-maskable interrupt, generated by the peripheral device(s), is the highest priority interrupt request line. Input is only recognized at the end of the current instruction. Its execution is independent of the interrupt enable flip-flop. NMI execution involves saving the PC on the stack and automatic branching to restart address X'0066 in memory.

Restart Interrupts A, B, C ($\overline{\text{RSTA}}$, $\overline{\text{RSTB}}$, $\overline{\text{RSTC}}$): Active low. Restarts generated by the peripherals are recognized at the end of the current instruction if their respective interrupt enable bits (and IFF1/IFF2) are set. Execution is identical to NMI except interrupts are enabled for the following restart addresses:

NAME	RESTART ADDRESS (X')
$\overline{\text{RSTA}}$	003C
$\overline{\text{RSTB}}$	0034
$\overline{\text{RSTC}}$	002C

The order of priority is fixed (highest first) as follows:

1) $\overline{\text{RSTA}}$, 2) $\overline{\text{RSTB}}$, 3) $\overline{\text{RSTC}}$

Interrupt Request ($\overline{INTR}$): Active low. An interrupt request input generated by a peripheral device is recognized at the end of the current instruction provided that the interrupt enable and master interrupt enable bits are set. INTR is the lowest priority interrupt request input. Under program control, INTR can be executed in three distinct modes in conjunction with the INTA output.

Wait ($\overline{WAIT}$): Active low. When set low during $\overline{RD}$ or $\overline{WR}$, the CPU extends its machine cycle in increments of t (wait) states. The wait machine cycle continues until the WAIT input returns high.

Power Save ($\overline{PS}$): Active low. $\overline{PS}$ is sampled at the end of the current instruction cycle. When PS is low, the CPU stops executing at the end of current instruction and keeps itself in the low-power mode. Normal operation resumes when PS is returned high.

OUTPUT SIGNALS

Bus Acknowledge ($\overline{BACK}$): Active low. $\overline{BACK}$ indicates to the bus requesting device that the CPU bus and its control signals are in the TRI-STATE mode. The requesting device may then take control of the bus and its control signals.

Address Bits 8-15 [A (8-15)]: Active high. These are the most significant 8 bits of the memory address bus, or of the input /output address. During a BREQ/BACK cycle, the A(8-15) bus is in the TRI-STATE mode.

Reset Out (RESET OUT): Active high. When RESET OUT is high, it indicates the CPU is being reset. The signal is normally used to reset the peripheral devices.

Input/Output/Memory (IO/$\overline{M}$): An active high on the IO/$\overline{M}$ output signifies that the current machine cycle is relative to an input/output device. An active low on the IO/M output signifies that the current machine cycle is relative to memory. It is TRI-STATE during BREQ/BACK cycles.

Refresh ($\overline{RFSH}$): Active low. The refresh output indicates that the dynamic RAM refresh cycle is in progress. RFSH goes low during T3 and T4 states of all M1 cycles.

Address Latch Enable (ALE): ALE is active only during the T1 state of M cycles and T3 state of M1 cycles. The high-to-low transition of ALE indicates that a valid memory/I-O/refresh address is available on the AD (0-7) lines.

Read Strobe ($\overline{RD}$): Active low. On the trailing edge of the $\overline{RD}$ strobe, data are input to the CPU via the AD (0-7) lines. The RD line is in the TRI-STATE mode during BREQ/BACK cycles.

Write Strobe ($\overline{WR}$): While the $\overline{WR}$ line is low, valid data are output by the CPU on the AD (0-7) lines. The WR line is in the TRI-STATE mode during BREQ/BACK cycles.

Clock (CLK): CLK is an output provided for use as a system clock. The CLK output is a square wave at one half the input frequency.

Interrupt Acknowledge ($\overline{\text{INTA}}$): Active low. The interrupt acknowledge output is activated in the M1 cycle (S) immediately following the t state in which the INTR input is recognized (Output is normally used to gate the interrupt response vector from the peripheral controller onto the AD (0-7) lines). It is used in two of the three interrupt modes. In mode 0, an instruction is gated onto the AD (0-7) line during INTA. In mode 2, a single interrupt response vector is gated onto the data bus.

Status (S0, S1): Bus status outputs indicate encoded information regarding the ensuing M cycle as follows:

S1	S0	STATE
0	0	HALT
0	1	WRITE
1	0	READ
1	1	(OPCODE) FETCH

INPUT/OUTPUT SIGNALS

Power (V_{CC}): +5-volt supply.

Ground (GND): 0-volt reference.

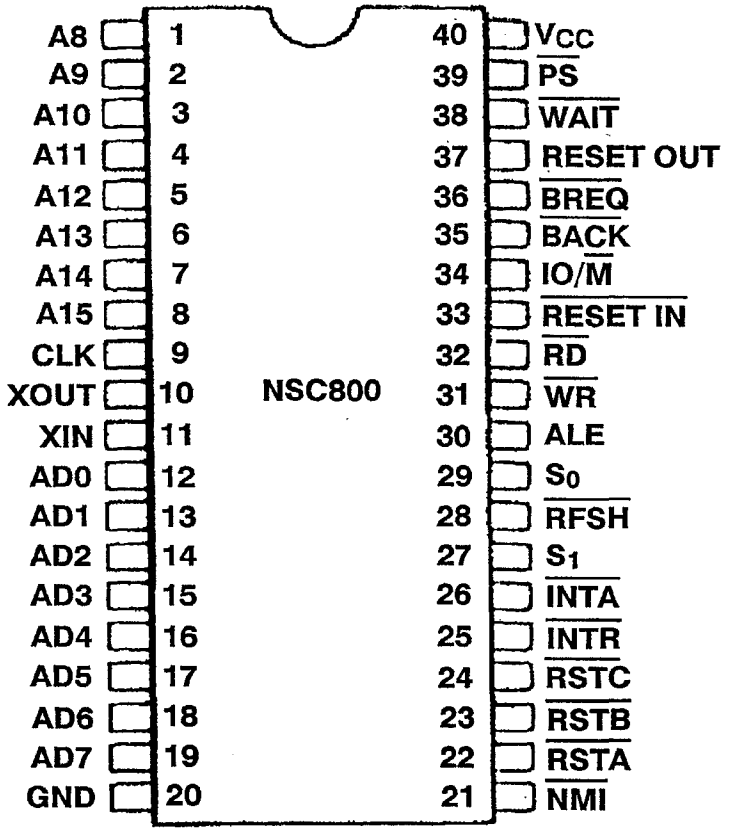
Crystal or R-C (XIN, XOUT): XIN may be used as an external clock input.

Multiplexed Address/Data (AD 0-7): Active high.

At $\overline{\text{RD}}$ Time:	Input data to CPU.
At $\overline{\text{WR}}$ Time:	Output data from CPU.
At Falling Edge of ALE Time:	Least significant byte of address during memory reference cycle. 8-bit port address during I/O reference cycle.
During $\overline{\text{BREQ}}$/$\overline{\text{BACK}}$ cycle:	High Impedance.

INPUT PROTECTION

All inputs are protected from static charge with diode clamps to both V_{CC} and GND. Normal precautions taken with MOS devices are recommended.



C 10272

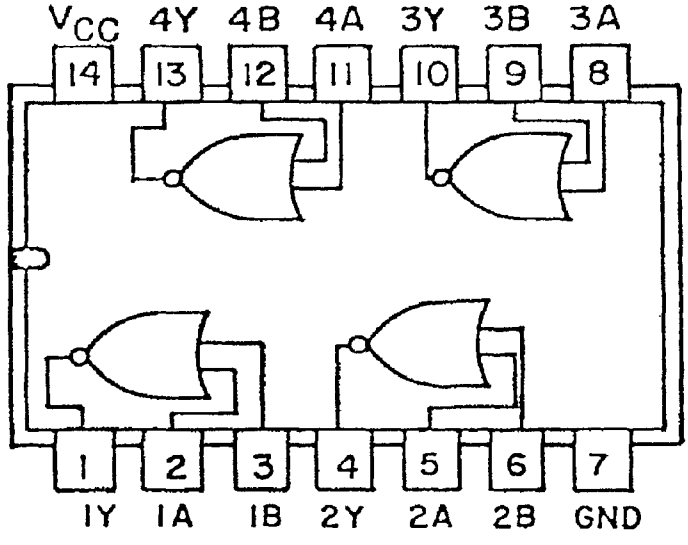
RAM-I/O-TIMER

The NSC8l0 is a RAM-I/O-TIMER device contained in a standard 40-pin, dual-in-line package. This chip functions as a memory, an input/output peripheral interface, and a timing device. The memory is comprised of 1024 bits of static RAM organized as 128 x 8. The I/O portion consists of 22 programmable input/output bits arranged as three separate ports, with each bit individually definable as an input or output. Port bits can be set or cleared individually and can be written or read in bytes. Several types of strobed mode operations are available through Port A. The timer portion of the device consists of two programmable 16-bit binary down-counters, each capable of operation in any one of six modes. Timer counts are extendable by one of the available prescale values.

C10354

QUADRUPLE 2-INPUT POSITIVE-NOR GATES

If one or both inputs of a single gate go to the 1 logic level, the output will go to the 0 logic level. If both inputs go to the 0 level, the output will go to the 1 level. By definition, $Y = A + B$. Circuit operation is summarized in the truth table.



Truth Table

A	B	Y
0	0	1
0	1	0
1	0	0
1	1	0

4-DIGIT EXPANDABLE SEGMENT DISPLAY CONTROLLER

This display controller is an interface element with memory that drives a 4-digit, 8-segment LED display. It allows individual control of any segment in the 4-digit display. The number of segments per digit can be expanded without any external components. For example, two controllers can be cascaded to drive a 16-segment alphanumeric display.

The display controllers receive data information through 8 data lines a, b . . . DP, and digit information through 2 address inputs K1 and K2. The input data is written into the register selected by the address information when Chip Enable (CE) and Write Enable (WE) are low, and is latched when either CE or WE return high. Data hold time is not required.

A self-contained internal oscillator sequentially presents the stored data to high drive TRI-STATABLE output drivers which directly drive the LED display. The drivers are active when the control pin labeled SOE is low and go into TRI-STATE® when SOE is high. This feature allows for duty cycle brightness control, or for disabling the output drive for power conservation.

The digit outputs directly drive the base of the digit transistors when the control pin labeled DIO is low. When DIO is high, the digit lines turn into inputs and the internal scanning multiplexer is disabled.

When any digit line is forced high by an external device, usually another controller, the data information for that digit is presented to the output. In this manner, 16-segment alphanumeric displays, 24 or 32-segment displays, or an array of discreet LED's can be controlled by the simple cascading of expandable segment display controllers. All inputs except digit inputs are TTL compatible and do not clamp input voltages above V_{CC}.

The digit outputs directly drive the base of a grounded emitter digit transistor without the need of a Darlington configuration. If a controller is driving a digit transistor and also supplying digit information to a cascaded controller, base resistors are needed in the digit transistors to provide an adequate high level to the digit inputs of the cascaded controller.

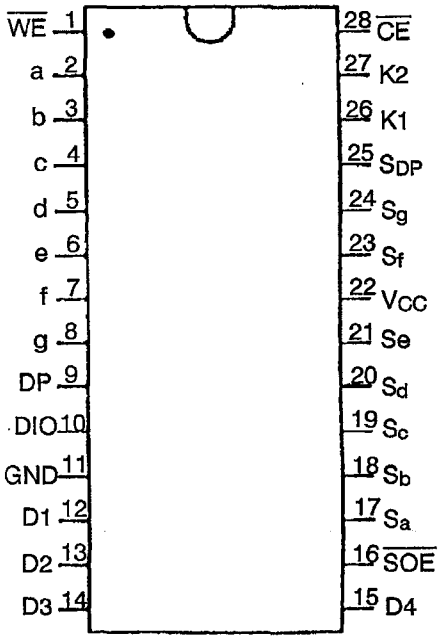
These display controllers contain four 8-bit registers; any one may be randomly written into. In normal operation, the internal multiplexer scans the registers and refreshes the display. In cascaded operation, one controller serves as a master refresh device and cascaded controllers are slaved to it through digit lines operating as inputs.

The controller appears to a microprocessor as memory and to the user as a self-scan display. Since every segment is under microprocessor control, great versatility is obtained.

Low power standby operation occurs with both $\overline{SOE}$ and $\overline{DIO}$ inputs high.

Connection Diagram

Dual-In-Line Package



Truth Tables

Input Control

$\overline{CE}$	DIGIT ADDRESS		$\overline{WE}$	OPERATION
	K2	K1		
0	0	0	0	Write digit 1
0	0	0	1	Latch digit 1
0	0	1	0	Write digit 2
0	0	1	1	Latch digit 2
0	1	0	0	Write digit 3
0	1	0	1	Latch digit 3
0	1	1	0	Write digit 4
0	1	1	1	Latch digit 4
1	x	x	x	Disable writing

Output Control

$\overline{DIO}$	$\overline{SOE}$	DIGIT LINES				OPERATION
		D4	D3	D2	D1	
0	0	R	R	R	R	Refresh display
0	1	R	R	R	R	Disable segment outputs
1	0	0	0	0	0	Digits are now inputs
1	0	0	0	0	1	Display digit 1
1	0	0	0	1	0	Display digit 2
1	0	0	1	0	0	Display digit 3
1	0	1	0	0	0	Display digit 4

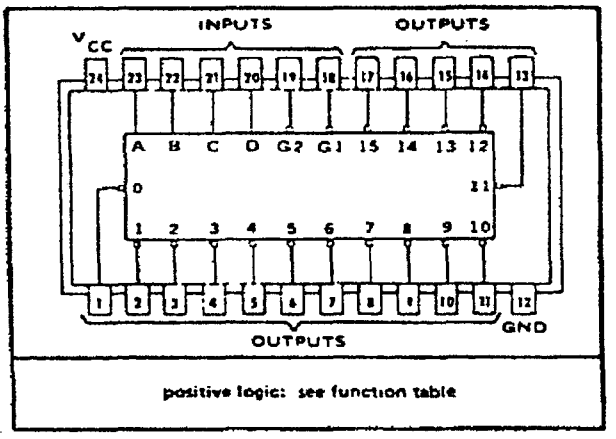
R = refresh (digit lines sequentially pulsed).

X = don't care.

C10709

4-LINE-TO-16LINE DECODERS/DEMULTIPLEXERS

These circuits decode four binary-coded inputs into one of sixteen mutually exclusive outputs when both the strobe inputs, G1 and G2, are low. The demultiplexing function is performed by using the 4 input lines to address the output line, passing data from one of the strobe inputs with the other strobe input low. When either strobe input is high, all outputs are high. Circuit operation is summarized in the function table.



FUNCTION TABLE

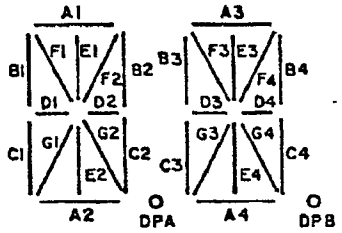
INPUTS						OUTPUTS															
G1	G2	D	C	B	A	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
L	L	L	L	L	L	L	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H
L	L	L	L	L	H	H	L	H	H	H	H	H	H	H	H	H	H	H	H	H	H
L	L	L	L	H	L	H	H	L	H	H	H	H	H	H	H	H	H	H	H	H	H
L	L	L	L	H	H	H	H	H	L	H	H	H	H	H	H	H	H	H	H	H	H
L	L	L	H	L	L	H	H	H	H	L	H	H	H	H	H	H	H	H	H	H	H
L	L	L	H	L	H	H	H	H	H	H	L	H	H	H	H	H	H	H	H	H	H
L	L	L	H	H	L	H	H	H	H	H	H	L	H	H	H	H	H	H	H	H	H
L	L	L	H	H	H	H	H	H	H	H	H	H	L	H	H	H	H	H	H	H	H
L	L	H	L	L	L	H	H	H	H	H	H	H	H	L	H	H	H	H	H	H	H
L	L	H	L	L	H	H	H	H	H	H	H	H	H	H	L	H	H	H	H	H	H
L	L	H	L	H	L	H	H	H	H	H	H	H	H	H	H	L	H	H	H	H	H
L	L	H	L	H	H	H	H	H	H	H	H	H	H	H	H	H	L	H	H	H	H
L	L	H	H	L	L	H	H	H	H	H	H	H	H	H	H	H	H	L	H	H	H
L	L	H	H	L	H	H	H	H	H	H	H	H	H	H	H	H	H	H	L	H	H
L	L	H	H	H	L	H	H	H	H	H	H	H	H	H	H	H	H	H	H	L	H
L	L	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	L
L	H	X	X	X	X	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H
H	L	X	X	X	X	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H
H	H	X	X	X	X	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H	H

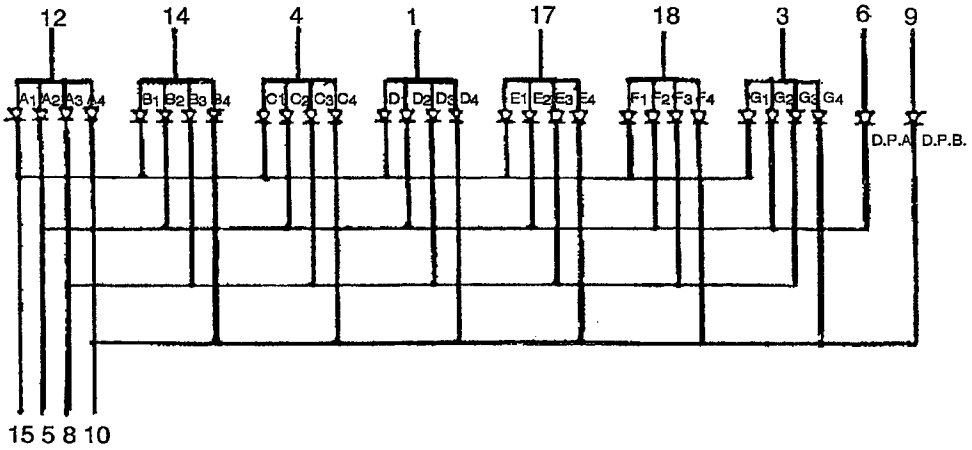
H = high level, L = low level, X = irrelevant

C10710

DUAL DIGIT NUMERIC DISPLAYS

These are orange, 14-segment, common cathode displays in 2-character packages. Characters are .54" high with right-hand decimal point.





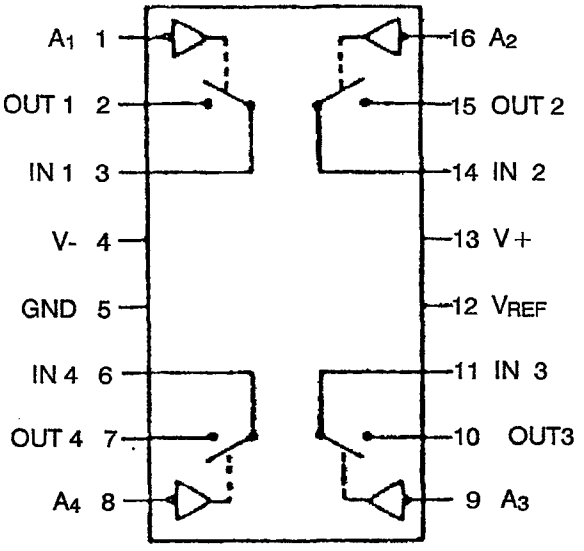
PIN NO.	FUNCTION
1	Anode D
2	No Connection
3	Anode G
4	Anode C
5	Cathode 2 Includes D.P.A.
6	Anode D.P.-Display A
7	No Connection
8	Cathode 3
9	Anode D.P.-Display B
10	Cathode 4 Includes D.P.B.
11	No Connection
12	Anode A
13	No Connection
14	Anode B
15	Cathode 1
16	No Connection
17	Anode E
18	Anode F

C10712

QUAD SPST CMOS ANALOG SWITCH

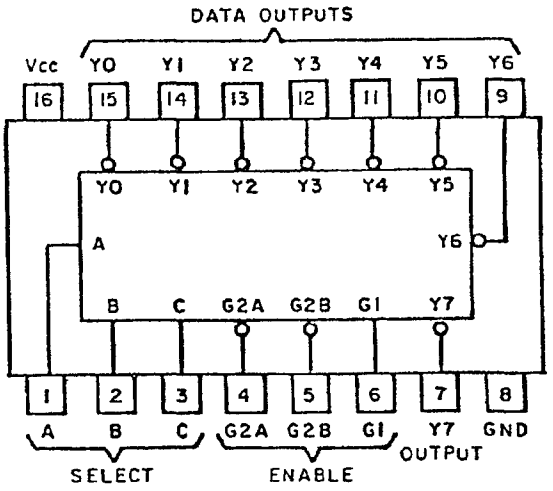
This device contains four independently selectable SPST switches which feature fast switching speeds (185 ns) combined with low power dissipation. Each switch provides low "ON" resistance operation for input signal voltages up to the supply rails and for signal currents up to 80 ma. All switches provide break-before-make switching. A logic 0 on a control line turns a switch on.

Top View



3-TO-8 LINE DECODERS/DEMULTIPLEXERS

These Schottky-clamped TTL MSI circuits are designed for use in high-performance memory-decoding or data-routing applications. These circuits decode one-of-eight lines dependent on the conditions at the three binary select inputs and three enable inputs. Two active-low and one active-high enable inputs reduce the need for external gates or inverters when expanding. An enable input can be used as a data input for demultiplexing applications. Circuit operation is summarized in the function table.



FUNCTION TABLE

INPUTS					OUTPUTS							
ENABLE		SELECT										
G1	G2*	C	B	A	Y0	Y1	Y2	Y3	Y4	Y5	Y6	Y7
X	H	X	X	X	H	H	H	H	H	H	H	H
L	X	X	X	X	H	H	H	H	H	H	H	H
H	L	L	L	L	L	H	H	H	H	H	H	H
H	L	L	L	H	H	L	H	H	H	H	H	H
H	L	L	H	L	H	H	L	H	H	H	H	H
H	L	L	H	H	H	H	H	L	H	H	H	H
H	L	H	L	L	H	H	H	H	L	H	H	H
H	L	H	L	H	H	H	H	H	H	L	H	H
H	L	H	H	L	H	H	H	H	H	H	L	H
H	L	H	H	H	H	H	H	H	H	H	H	L

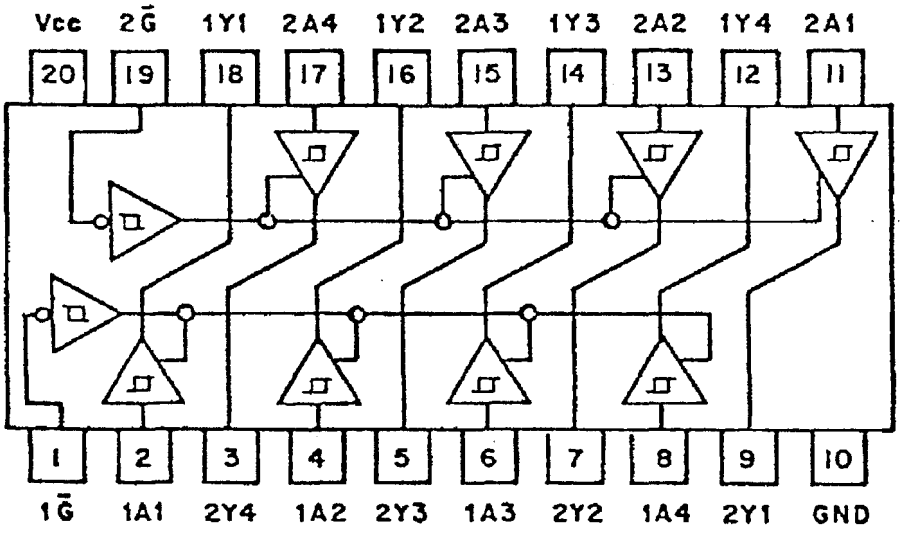
* G2 = G2A + G2B

H = HIGH LEVEL, L = LOW LEVEL, X = IRRELEVANT

C10815

OCTAL BUFFERS AND LINE DRIVERS WITH 3-STATE OUTPUTS

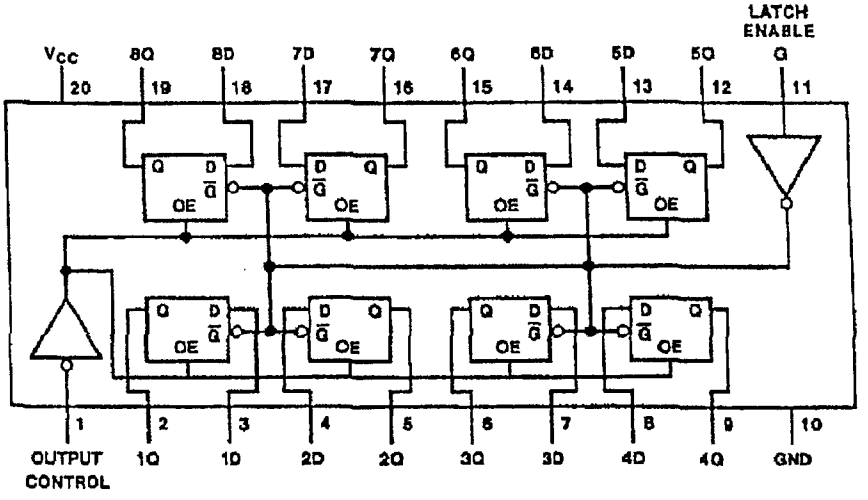
These octal buffers and line drivers are designed specifically to improve both the performance and density of three-state memory address drivers, clock drivers, and bus-oriented receivers and transmitters. These circuits provide noninverted 3-state outputs.



C10816

OCTAL D-TYPE TRANSPARENT LATCHES

These 8-bit registers feature totem-pole three-state outputs designed specifically for driving highly-capacitive or relatively low-impedance loads. The high-impedance third state and increased high-logic-level drive provide these registers with the capability of being connected directly to and driving the bus lines in a bus-organized system without need for interface or pull-up components. The eight latches are transparent D-type latches, meaning that while the enable (G) is high, the Q outputs will follow the data (D) inputs. When the enable is taken low, the output will be latched at the level of the data that was set up. Circuit operation is summarized in the function table.



Function Table

OUTPUT CONTROL	ENABLE G	D	OUTPUT
L	H	H	H
L	H	L	L
L	L	X	Q_0
H	X	X	Z

H = high level (steady state).

L = low level (steady state).

Q_0 = level of Q before the indicated steady state input conditions were established.

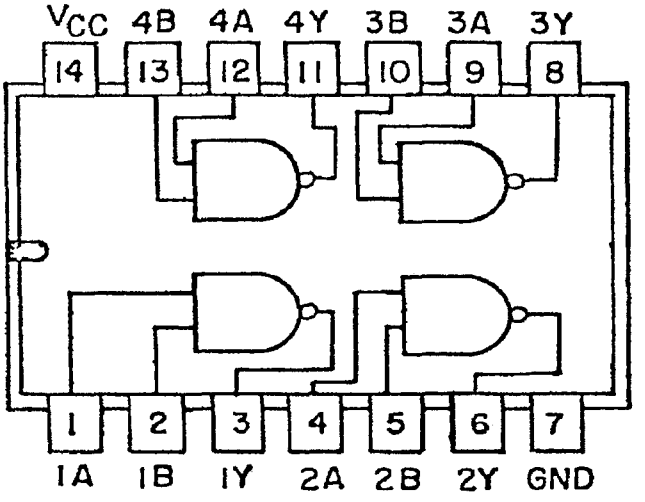
X = irrelevant (any input, including transitions).

Z = off (high-impedance) state of a 3-state output.

C10819

QUADRUPLE 2-INPUT POSITIVE-NAND GATES

If all inputs of a single gate go to the 1 logic level, the output will go to the 0 level. If one or more inputs go to the 0 level, the output will go to the 1 level. By definition, $Y = \overline{AB}$. Circuit operation is summarized in the truth table.



Truth Table

A	B	Y
0	0	1
0	1	1
1	0	1
1	1	0

C11270

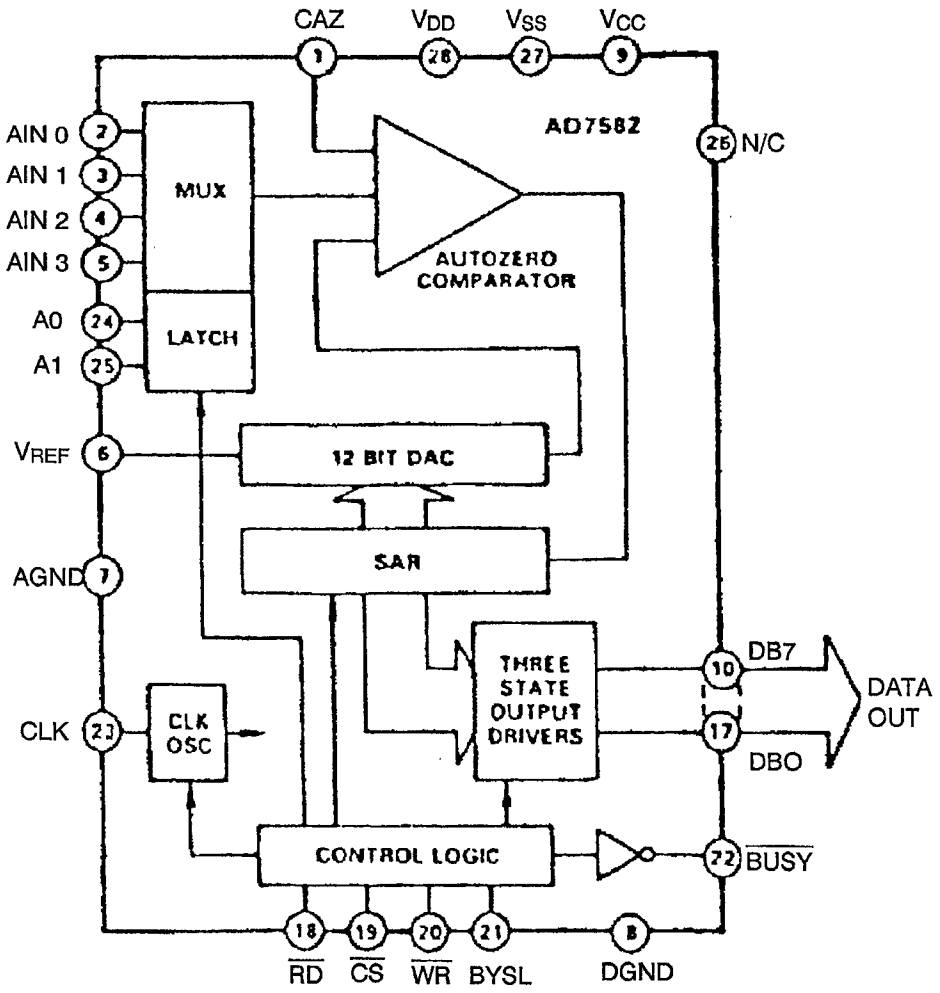
12-BIT ANALOG-TO-DIGITAL CONVERTER

This is a medium speed, 4-channel, 12-bit CMOS A/D converter which uses the successive approximation technique to provide a conversion time of 100 us per channel. An auto-zero cycle occurs at the start of each conversion, resulting in very low system offset voltages, typically less than 100 uv. The device uses standard microprocessor interface control signals: CS (decoded device address); READ ; and WRITE. The 4-channel input multiplexer is controlled via address inputs A0 and A1.

Conversion results are available in two bytes (8 LSB's and 4 MSB's) over an 8-bit three state output bus. Either byte can be read first. Two converter busy flags are available to facilitate polling of the converter's status.

The analog input voltage range is 0 to +5V when using a reference voltage of +5V.

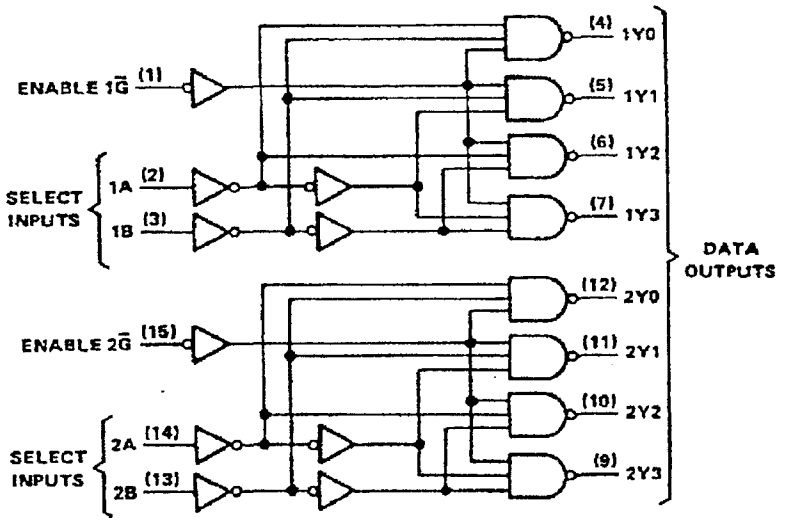
Following is a functional diagram:



C11310

DUAL 2-LINE TO 4-LINE DECODERS/DEMULTIPLEXERS

This circuit is designed to be used in high-performance memory-decoding or data-routing applications requiring very short propagation delay times. The device is comprised of two individual two-line to four-line decoders in a single package. The active-low enable input can be used as a data line in demultiplexing applications. Following is a logic diagram and a function table.



FUNCTION TABLE

INPUTS			OUTPUTS			
ENABLE	SELECT					
$\overline{G}$	B	A	Y0	Y1	Y2	Y3
H	X	X	H	H	H	H
L	L	L	L	H	H	H
L	L	H	H	L	H	H
L	H	L	H	H	L	H
L	H	H	H	H	H	L