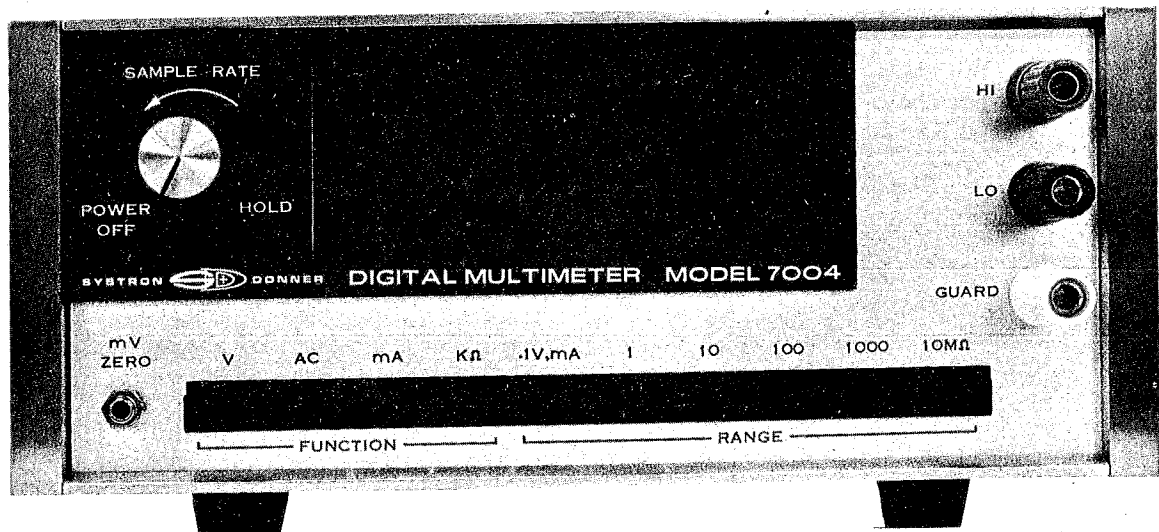


Concord Instrument Division

INSTRUCTION MANUAL



CONCORD INSTRUMENT
DIVISION
MODEL 7004
DIGITAL MULTIMETER

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SYSTRON  **DONNER**
CORPORATION

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Please specify both model and serial number in all correspondence concerning Systron-Donner instruments. Address all inquiries on operation or applications to your nearest sales representative or Sales Manager, Instruments, Systron-Donner Corporation, 888 Galindo Street, Concord, California.

CONCORD, CALIFORNIA

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CHAPTER 1 GENERAL INFORMATION

1.1 INTRODUCTION

The SD Model 7004 Digital Multimeter is a full four-digit precision instrument. It offers the five selectable functions of dc voltage, dc current, ac voltage, ac current and resistance. The instrument utilizes an advanced Dual-Slope Integration design with an extremely low-noise input amplifier and a fully guarded, isolated input circuit. These features combine to provide high accuracy and stability, plus exceptional immunity to the effects of both common mode and normal mode noise.

All function and range selection is made from front-panel push-button controls. The readout features a nonblinking display of four full digits plus overrange, auto-positioned decimal point, and an indicator for off-scale readings. Polarity indication for dc voltage and current is automatic with a minus indicator display.

Model 7004 is light-weight and completely portable. It consumes less than 8 watts while operating at line frequencies from 48 to 440 Hz and at voltages of 115/230 V or 100/200 V. The Multimeter may be fitted with an optional built-in battery pack with no increase in size. Optional DTL/TTL compatible digital outputs can also be included for remote printout, digital limit comparison, or other automatic data system requirements.

1.2 SPECIFICATIONS

DC VOLTS

| | |
|---------------------|--|
| Range: | ± 10000 V, ± 1000 V, ± 100.00 V, ± 10.000 V, ± 1000.0 V. |
| Resolution: | ± 10 μ V to ± 0.1 V in decade steps depending on range. |
| Overrange: | 30% on all ranges except on 1000 V range. Maximum readings are ± 13000 V, ± 1300 V, ± 130.00 V, ± 13.000 V and ± 1000.0 V at full accuracy. |
| Polarity Selection: | Automatic with minus indicator. |
| Input Impedance: | >1000 M Ω on 0.1 V, 1 V, and 10 V ranges. 10 M Ω on 100 V and 1000 V ranges. |

DC VOLTS (Cont'd)

| | |
|---|---|
| Accuracy: | All ranges except 0.1 V range (25±5°C); ±0.01% rdg. ±0.01% f.s. for 1 month. ±0.02% rdg. ±0.01% f.s. for 3 months. 0.1 V range (25±1°C); ±0.02% rdg. ±0.02% f.s. for 1 month. |
| Temperature Stability (0°C to 50°C): | All ranges except 0.1 V range; ±0.001% rdg. ±0.001% f.s./°C. 0.1 V range; ±0.005% rdg. ±0.01% f.s./°C. |
| Full-Scale Step Response: | 1 second to rated accuracy. |
| Normal Mode Noise Rejection: | >60 dB at 60 Hz. |
| Common Mode Noise Rejection: | >120 dB at dc; 100 dB from 49 Hz to 1 kHz with 1 kΩ source unbalance. |
| Maximum Input: | ±1000 volts on any range without damage. |

DC CURRENT

| | |
|---|--|
| Ranges: | ±.10000 mA, ±1.0000 mA, ±10.000 mA, ±100.00 mA, ±1000.0 mA. |
| Resolution: | ±10 nA to ±0.1 mA in decade steps depending on range. |
| Overrange: | 30% on all ranges. Maximum readings are ±.13000 mA, ±1.3000 mA, ±13.000 mA, ±130.00 mA and ±1300.0 mA at full accuracy. |
| Polarity Selection: | Automatic with minus indicator. |
| Configuration: | Shunts, internal to instrument. |
| Accuracy: | All ranges except 0.1 mA range (25±5°C): ±0.1% rdg. ±0.01% f.s. for 3 months. 0.1 mA range (25±1°C): ±0.1% rdg. ±0.04% f.s. for 3 months. |
| Temperature Stability (0°C to 50°C): | ±0.005% rdg. ±0.002% f.s./°C. |
| Full Scale Step Response: | 1 second to rated accuracy. |
| Normal Mode Noise Rejection: | >60 dB at 60 Hz. |

DC CURRENT (Cont'd)

Common Mode Noise Rejection: >120 dB at dc; 100 dB from 49 Hz to 1 kHz with 1 k Ω source unbalance.

Maximum Input: 100% above range selected without damage.

AC VOLTS

Ranges (rms value): .10000 V, 1.0000 V, 10.000 V, 100.00 V, 1000.0 V.

Resolution: 10 μ V to 0.1 V in decade steps depending on range.

Overrange: 30% on all ranges except 1000 V range. Maximum readings are .13000 V, 1.3000 V, 13.000 V, 130.00 V, and 500.00 V.

Input Impedance: 1 M Ω shunted by 100 pF.

Accuracy (50 Hz to 20 kHz, except 1000 V range is 50 Hz to 10 kHz.) All ranges except 0.1 V range (25 \pm 5 $^{\circ}$ C); \pm 0.2% rdg. \pm 0.02% f.s. for 3 months. 0.1 V range (25 \pm 1 $^{\circ}$ C); \pm 0.5% rdg. \pm 0.2% f.s. for 3 months.

Full-Scale Step Response: 3 seconds to rated accuracy.

Maximum Input: 500 volts rms on 10 V, 100 V, and 1000 V ranges. 150 volts rms on 0.1 V and 1 V ranges without damage.

AC CURRENT

Ranges: .10000 mA, 1.0000 mA, 10.000 mA, 100.00 mA, 1000.0 mA.

Resolution: 10 nA to 0.1 mA in decade steps depending on range.

Overrange: 30% on all ranges. Maximum readings are .13000 mA, 1.3000 mA, 13.000 mA, 130.00 mA, and 1300.0 mA.

Configuration: Shunts internal to instrument.

Accuracy (50 Hz to 20 kHz): All ranges except 0.1 mA range (25 \pm 5 $^{\circ}$ C); \pm 0.3% rdg. \pm 0.02% f.s. for 3 months. 0.1 mA range (25 \pm 1 $^{\circ}$ C); \pm 0.5% rdg. \pm 0.2% f.s. for 3 months.

AC CURRENT (Cont'd)

Full-Scale Step Response: 3 seconds to rated accuracy.
Maximum Input: 100% above range selected without damage.

RESISTANCE

| RANGE | CURRENT THRU RX | RESOLUTION | |
|-------------------|-----------------|-----------------|-----------|
| 1.0000 k Ω | 5 mA | 1 k Ω | 0.1 ohm |
| 10.000 k Ω | 500 μ A | 10 k Ω | 1 ohm |
| 100.00 k Ω | 50 μ A | 100 k Ω | 10 ohms |
| 1000.0 k Ω | 5 μ A | 1000 k Ω | 100 ohms |
| 10.000 M Ω | 0.5 μ A | 10 M Ω | 1000 ohms |

Overrange: 30% on all ranges. Maximum readings are 1.3000 k Ω , 13.000 k Ω , 130.00 k Ω , 1300.0 k Ω , and 13.000 M Ω at full accuracy.

Configuration: Two-wire measurement system.

Accuracy: All ranges (25 \pm 5 $^{\circ}$ C);
 \pm 0.1% rdg. \pm 0.01% f.s.

Full-Scale Step Response: Typical 1 second on all k Ω ranges;
3 seconds on 10 M Ω range.

Voltage Protection: 130 V rms without damage on any range.

GENERAL

Input Configuration: Fully floating and guarded in all functions.

Maximum Common Mode Voltage: \pm 500 V dc or peak V ac.

Range Selection: Manual by front-panel control.

Sample Rate: Continuously adjustable by front-panel control from 5 readings/second to 1 reading/10 seconds. Hold position enables external measurement command.

GENERAL (Cont'd)

Display: Full four-digits plus overrange digit (gas discharge tubes); automatic decimal point positioning for all functions and ranges; negative polarity indicator; display storage for non-blinking readout; offscale indication.

Operating Temperature: 0°C to +50°C.

Humidity Range: 0 to 80% Relative Humidity (0°C to +35°C).
0 to 70% Relative Humidity (+35°C to +50°C).

Dimensions: 3-1/2" H x 8-1/2" W x 13" D half-rack size portable package, including two side-carry handles.

Weight: 8 lb (3.6 kg) net; 13 lb (6 kg) shipping. Optional battery pack adds 4 pounds.

Power: 115/230 (±10%) V ac, or 100/200 (±10%) V ac, 48-440 Hz, 8 watts maximum.

1.3 OPTIONAL FEATURES

DIGITAL OUTPUTS (OPTION 05)

Non-isolated 8-4-2-1 BCD outputs and recorder control signals with DTL/TTL compatible logic levels. Low side of input signal and BCD common tied together through low internal impedance. Some degradation of common mode voltage and noise rejection should be anticipated when connected to unbuffered and/or non-isolated recording device. (*Outputs are not short-circuit-proof.*)

Outputs:

4 digits of BCD plus "1" (true) bit for overrange, minus polarity, and print command. Binary "1" (true) = +2.4 to +5 volts, 0.1 mA source. Binary "0" (false) = 0 to +0.5 volts, 1.8 mA sink.

DIGITAL OUTPUTS (Cont'd)

Inputs:

Single line (false-accepts ground true logic) for external READ-ON-DEMAND (single measurement per command), and RECORDER BUSY (inhibit).

INTERNAL BATTERY PACK (OPTION 09)

Provides 6 hours of continuous operation between charges; 14-hour recharge cycle through built-in charger. Charges from external power line with instrument in operation. Internal batteries do not increase size of instrument. Three-way battery power switch on rear panel:

- 1) BATTERY OFF - Operates from power and recharges batteries.
- 2) BATTERY ON - Operates from internal batteries or external floating +12 volt dc source which may be connected internally through rear-panel port. Instrument draws 0.7 ampere.
- 3) BATTERY TEST - Checks internal battery condition from front-panel display; also, verifies instrument performance.

CHAPTER 2 INSTALLATION

2.1 INTRODUCTION

The SD Model 7004 Digital Multimeter is shipped in an operational condition and is essentially ready for use as received. This chapter outlines the procedures for initial inspection and installation of the instrument. Instructions for reshipment are also included should the unit be returned to Systron-Donner Corporation for service or repair.

2.2 RECEIVING INSPECTION

Prior to accepting the meter from the shipper, inspect the condition of the shipping container for any indication of freight damage. Any sign of such damage must be noted by both the shipper and receiver and should be reported to the insurance investigator.

Immediately following removal of the instrument from the shipping carton, inspect for possible physical damage incurred during shipment. Check surfaces for scratches or dents and note condition of knobs and connectors. Should any damage be noted, notify your nearest Systron-Donner representative---DO NOT USE THE METER UNTIL INSTRUCTED TO DO SO BY THE REPRESENTATIVE.

2.3 RESHIPMENT

When the instrument is to be repackaged for shipment use the original packing materials. Your Systron-Donner field office can provide materials similar to those used for the original factory packaging, or repackage the instrument following these general instructions:

GENERAL PACKING INSTRUCTIONS

- 1) Attach a tag to the unit indicating the model number, serial number, name and address of the instrument owner, and a summary of the service or repairs required.
- 2) Wrap the instrument in heavy paper or plastic prior to placing it into the shipping container.
- 3) Select a strong carton or wooden box to house the instrument.
- 4) Use an adequate layer of shock-absorbing material on all sides of the instrument and protect the front panel with additional layers of cardboard. Be certain that there is no movement of the unit within the container.

GENERAL PACKING INSTRUCTIONS (Cont'd)

- 5) Seal the package with strong tape or metal bands.
- 6) Mark the shipping container "FRAGILE-DELICATE INSTRUMENT" to ensure careful handling.
- 7) Be certain that all correspondence refers to full instrument nomenclature (model and serial number).

2.4 POWER REQUIREMENTS

Model 7004 Digital Multimeter is equipped with a standard three-conductor power cord which, when plugged into an appropriate power receptacle, grounds the chassis to protect operating personnel from certain electrical hazards. Whenever the power cord is mated to a two-conductor outlet, a cord adapter-plug (properly installed) will provide the same protection.

The instrument operates from either 115 or 230 V at 48 to 440 Hz and consumes approximately 8 watts of power. A LINE switch on the rear panel adapts the unit for the local power line voltage. A 100/200 V tap on the primary of the power transformer is also provided to accommodate certain other power line requirements.

NOTE

The Model 7004 is shipped with a .25 ampere fuse (115 V operation). If 230 V operation is required, the .25 ampere fuse should be replaced with a .125 ampere fuse to adequately protect the meter.

2.5 ACCEPTANCE TEST PROCEDURE

The following procedure is performed to verify that no damage has occurred during transit and that the instrument is operative.

NOTE

Prior to performing the Acceptance Test Procedure it is recommended that the user become familiar with the instrument controls described in Section 3, OPERATION.

- 1) Check position of the LINE (115/230 V or 100/200 V) switch and connect ac power cord to an appropriate power source. If Internal Battery Pack (Option 09) is provided, turn BATTERY switch to the OFF position.
- 2) Turn POWER switch to the ON position; the display will illuminate.

ACCEPTANCE TEST PROCEDURE (Cont'd)

- 3) Select controls indicated in Table 2.1 and observe the display readings.

TABLE 2.1 ACCEPTANCE TEST PROCEDURE

| FUNCTION | RANGE | INPUT | DISPLAY |
|----------|-------|---------------------|---|
| V | 1000 | HI/LO/GUARD SHORTED | 0000.0±3 DIGITS |
| V & AC | 1000 | " " " | " " |
| mA | 1000 | " " " | " " |
| mA & AC | 1000 | " " " | " " |
| KΩ | 1000 | " " " | " " |
| KΩ | 1000 | HI/LO OPEN | OFFSCALE READING WITH OFFSCALE IN- DICATOR ENERGIZED. |

- 4) After completion of the Acceptance Test Procedure, refer to Section 3, OPERATION for additional operating information.

CHAPTER 3 OPERATION

3.1 INTRODUCTION

This chapter describes general operation of the Model 7004 Digital Multimeter. Front panel and rear panel functions are described in Tables 3.1 and 3.2. Operating procedures are given in Table 3.3. Also included is information concerning factors which affect measurement accuracy.

3.2 CONTROLS, CONNECTORS AND INDICATORS

3.2.1 Front Panel

Front Panel control functions for Model 7004 are described in this section (see Figure 3.1):

TABLE 3.1 FRONT PANEL FUNCTIONS

| INDEX | NAME | FUNCTION |
|-------|--|--|
| 1 | POWER-OFF (switch) | Applies power to the instrument when turned in the clockwise direction. |
| 2 | SAMPLE RATE and HOLD (Potentiometer and Switch) | Controls measurement sample-rate of 5 readings/second to 1 reading/10 seconds as knob is turned in clockwise direction. When in HOLD position, measurement cycle is interrupted until externally <u>com-</u> manded by remote programmer (Read). |
| 3 | HI/LO (Post Connectors) | Input terminals for all measurement functions. |
| 4 | GUARD (Post Connector) | Internal guard circuit may be left open (unconnected), or can be bused to the LO terminal. It may also be connected to an external guard potential. The guard circuit, when utilized, provides increased ac/dc common mode rejection of spurious or undesired signal currents. |

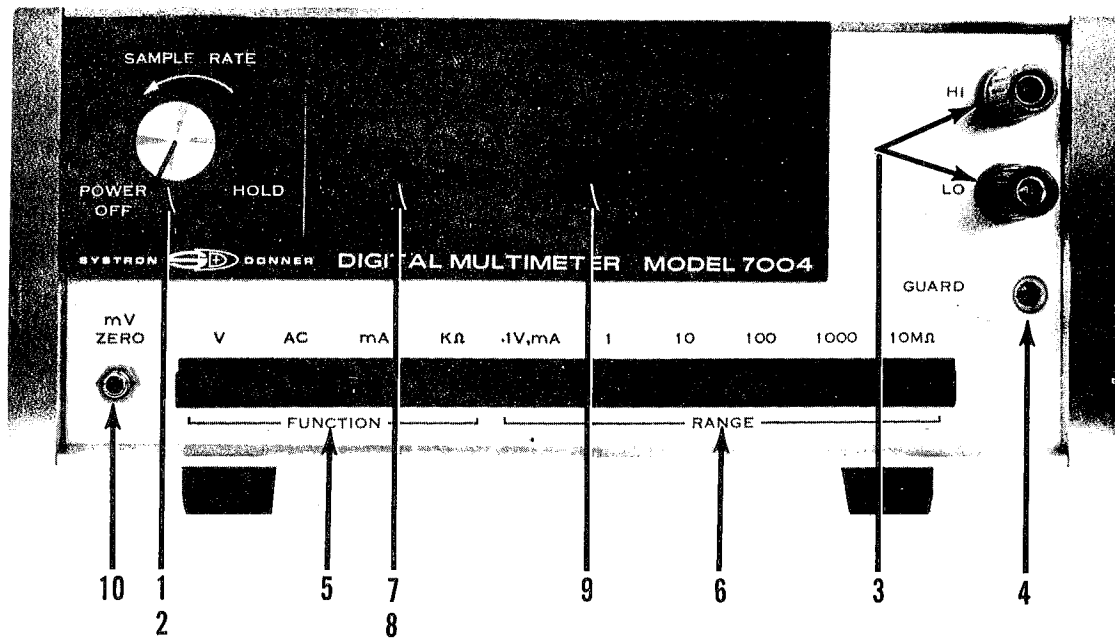


FIGURE 3.1 FRONT PANEL, MODEL 7004

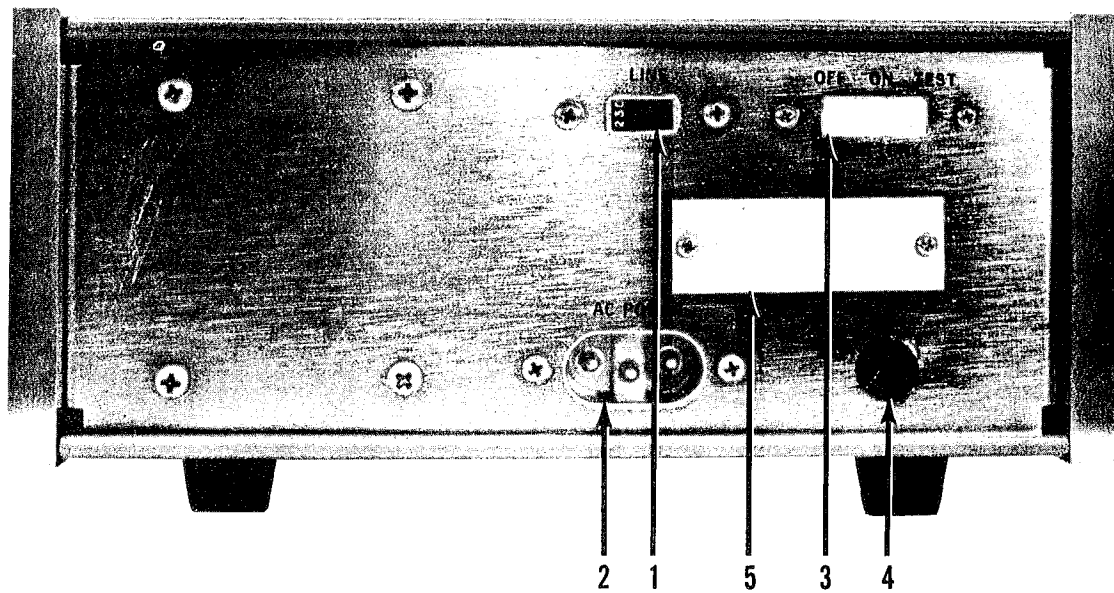


FIGURE 3.2 REAR PANEL, MODEL 7004

TABLE 3.1 FRONT PANEL FUNCTIONS (Cont'd)

| | | | | | |
|----|--|---|--------------------|------------------|--------------------------|
| 5 | FUNCTION (Pushbutton Switches) | Pushbutton switches initiate the following measurements: | | | |
| | | FUNCTION | PUSHBUTTON | | |
| | | dc voltage | depress V | | |
| | | dc current | depress mA | | |
| | | ac voltage | depress V & AC | | |
| | | ac current | depress mA & AC | | |
| | | resistance | depress K Ω | | |
| 6 | RANGE | Pushbutton switches select the following ranges: | | | |
| | | RANGE | AC/DC VOLTS | AC/DC CURRENT | K Ω RESISTANCE |
| | | .1V, mA | X | X | No |
| | | 1 | X | X | X |
| | | 10 | X | X | X |
| | | 100 | X | X | X |
| | | 1000 | X | X | X |
| | | 10 M Ω | No | No | X |
| 7 | Off-Scale Indicator | LED display, when lighted, indicates an off-scale condition. | | | |
| 8 | Polarity Indicator | Negative polarity dc measurements are indicated with a (-) sign. Positive polarity levels have no sign indication. | | | |
| 9 | Readout Tubes | Full four-digit display, with over-range (1), provides full scale readout and 30% overrange capability. Decimal point indication is determined by the range selected. | | | |
| 10 | mV ZERO (Screwdriver Adjustment) | Fine (screwdriver) adjustment for zeroing low-range mV readings when high-resolution accuracy is desired. | | | |

3.2.2 REAR PANEL

Rear Panel control functions for Model 7004 are described in this section (see Figure 3.2):

3.2.2 REAR PANEL (Cont'd)

TABLE 3.2 REAR PANEL FUNCTIONS

| INDEX | NAME | FUNCTION |
|-------|--|---|
| 1 | LINE (Switch) | Slide switch selects 115/230 ($\pm 10\%$) V ac, 48 to 440 Hz operation. Power transformer tap (modification) converts unit to 100/200 ($\pm 10\%$) V ac operation. |
| 2 | AC POWER (Three-conductor power receptacle) | Power receptacle mates with standard three-conductor power cord (supplied). |
| 3 | BATTERY (Switch) | Option 09, Internal Battery Pack - permits field operation of Model 7004. <i>OFF Position:</i> Instrument operates from ac power line while batteries are charging continuously. <i>ON Position:</i> Disconnects ac power line; instrument operates from internal battery pack. <i>TEST Position:</i> Internal battery voltage is indicated on front-panel readout. Instrument accuracy will be impaired if internal battery pack voltage drops below 11 V dc. |
| 4 | EXTERNAL BATTERY (Cable Port) | Provision included for connecting external 12 V dc (nominal) power supply into the instrument. <i>Do not exceed 13.5 V dc or damage may result.)</i> |
| 5 | BCD Output (Connector) | Option 05, Digital Outputs - provides non-isolated 8-4-2-1 BCD levels and DTL/TTL compatible recorder control logic levels. Mating connector is Amphenol #57-30240 (24 pins). |

TABLE 3.2 REAR PANEL FUNCTIONS (Cont'd)

| 5 | BCD Output (Cont'd) | BCD Connector Pin Assignments (J201) | | |
|---|---------------------|---|-----|--|
| | READOUT | BCD | PIN | |
| | 10 ³ | 1 | 7 | |
| | | 2 | 8 | |
| | | 4 | 19 | |
| | | 8 | 20 | |
| | 10 ² | 1 | 5 | |
| | | 2 | 6 | |
| | | 4 | 17 | |
| | | 8 | 18 | |
| | 10 ¹ | 1 | 3 | |
| | | 2 | 4 | |
| | | 4 | 15 | |
| | | 8 | 16 | |
| | 10 ⁰ | 1 | 1 | |
| | | 2 | 2 | |
| | | 4 | 13 | |
| | | 8 | 14 | |

Recorder Control
Pin Assignments (J201)

| FUNCTION | PIN |
|-------------------|-----|
| P.S. Common (Gnd) | 24 |
| Minus Polarity | 21 |
| Ovrange | 9 |
| Print Command | 23 |
| <u>Read</u> | 22 |
| Inhibit | 10 |

3.3 OPERATING PROCEDURES

The general method for operating Model 7004 is indicated in Table 3.3. All inputs are applied between HI/LO terminals; with the GUARD circuit connected to the LO terminal whenever possible.

3.3 OPERATING PROCEDURES (Cont'd)

TABLE 3.3 OPERATING PROCEDURES

| FUNCTION | OPERATION | DISPLAY |
|------------|--|--|
| DC VOLTS | Select V and desired RANGE 0.1, 1, 10, 100, or 1000. | Read display directly in dc volts. |
| DC CURRENT | Select mA and desired RANGE 0.1, 1, 10, 100, or 1000. | Read display directly in dc milliamperes. |
| AC VOLTS | Select V and AC with desired RANGE 0.1, 1, 10, 100, or 1000. | Read display directly in ac volts. |
| AC CURRENT | Select mA and AC with desired RANGE 0.1, 1, 10, 100, or 1000. | Read display directly in ac milliamperes. |
| RESISTANCE | Select $K\Omega$ and desired RANGE 1, 10, 100, 1000, or 10 $M\Omega$ | Read display directly in kilohms on the 1, 10, 100, 1000 ranges, and in megohms on the 10 $M\Omega$ range. |

3.3.1 Sample Rate and Hold Control

This control varies the measurement sample rate over the range of 5 readings/second to 1 reading/10 seconds. When set to the HOLD position, the last reading is displayed until the control is returned to the SAMPLE RATE position; or, a remote command is received on READ line (Pin 22) of connector J201.

3.3.2 Guard Terminal

The instrument contains two isolated inner chassis (top and bottom guard covers) connected to the GUARD terminal on the front panel. With the GUARD/LO terminals bused together, measurement errors due to ac or dc normal mode currents are reduced significantly. Although the GUARD terminal is usually bused to the LO terminal, in certain applications it may be advantageous to connect it to a separate Guard Voltage.

3.3.3 Overload Protection

Overload protection is provided on all ranges to the extent indicated below:

- 1) DC VOLTS - ± 1000 V (maximum allowable input) on all ranges.

3.3.3 Overload Protection (Cont'd)

- 2) AC VOLTS - 500 V rms on 10 V, 100 V, 1000 V ranges.
150 V rms on 0.1 V, 1 V ranges.
- 3) DC CURRENT - 100% above selected range, on all ranges.
- 4) AC CURRENT - 100% above selected range, on all ranges.
- 5) RESISTANCE - 130 V rms on all ranges.

3.3.4 mV Zero Adjustment

Located on the Model 7004 front panel is the mV ZERO adjustment. This control permits the user to accurately zero the instrument when low-level, high-resolution measurements are to be made on the 0.1 V range.

Before adjusting this control, allow the instrument to stabilize for at least 1/2 hour after turn-on. Connect a zero-ohm shorting bus across the HI/LO terminals and adjust the mV ZERO control until a reading of .00000 V \pm 2 counts is obtained.

CHAPTER 4 MAINTENANCE

4.1 INTRODUCTION

This section contains basic maintenance and calibration procedures for maintaining Model 7004 performance parameters. Information in this section includes: Factory Service, Routine Maintenance, Printed Circuit Board Repair, Test Equipment, and Calibration Procedures.

4.2 FACTORY SERVICE

Whenever a Systron-Donner instrument requires service, the nearest S-D representative should be contacted. He can provide field service, or arrange factory service when necessary. Address all inquiries concerning service, operation, or application to your nearest sales representative; or, to Sales Manager:

*SYSTRON-DONNER CORPORATION
CONCORD INSTRUMENT DIVISION
888 Galindo Street
Concord, California 94520
Phone: (415) 682-6161
TWX: 910-481-9479
Cable: SYSTRONDONNER*

4.3 ROUTINE MAINTENANCE

A regular program for maintenance and inspection every four to six months is recommended for this unit. As part of these regular procedures, the instrument should be checked in the following manner:

- 1) Disconnect ac power and remove the top and bottom covers.
- 2) Make a thorough visual inspection of all wiring and cables. Check for frayed, loose, or burned wires.
- 3) Check the physical integrity of all components. Look for burned or cracked components, loose solder connections, leakage of insulation compounds, and general physical damage. When a printed circuit board contains integrated-circuit packages, ensure that all packages are firmly mounted. Never unnecessarily remove and replace a package.
- 4) Check front panel switches and controls for loose or broken terminals, sticking shafts, etc.

4.3 ROUTINE MAINTENANCE (Cont'd)

- 5) If the internal panel surfaces and components have accumulated an excessive amount of dust, use a soft brush and low-pressure stream of air to remove the foreign material.

CAUTION

Do not clean P.C. boards or small internal components with a stiff brush or solvents, since damage to the circuits may result. A high-powered vacuum cleaner device should never be used on small internal components.

- 6) Wipe the external surfaces of the instrument with a soft, damp cloth to remove dirt, fingerprints, and other foreign materials.
- 7) Replace the top and bottom covers and reconnect ac power. Perform the operational test procedures given in Section 4.6. If performance does not match or exceed the specifications listed in Chapter 1 of this manual, corrective maintenance is in order.

4.4 PRINTED-CIRCUIT BOARD REPAIR

When replacing integrated circuits or other electronic components soldered to printed-circuit boards, the procedures indicated below must be followed or damage to the board may result:

- 1) Determine by troubleshooting techniques, which integrated circuit or discrete component(s) has failed.
- 2) Remove the defective component(s) from the board by cutting the pins or leads with a small diagonal clipping tool. (Always remove and replace the entire component.)
- 3) Apply heat (40-50 W soldering iron) sparingly to each of the cut pins or leads and remove from the board; clean the hole(s) with a toothpick or solder suction tool.
- 4) Form the tinned leads of the replacement part and insert in the printed circuit holes; solder, then trim leads to extend 1/16-inch beyond the back surface of the board. (Use only 63-37 solder with maximum 1/16-inch diameter.)

CAUTION

Always trim semiconductor leads only after soldered installation is complete. This procedure greatly lessens the possibility of component failure due to shock-wave damage caused by the trimming tool.

4.4 PRINTED CIRCUIT BOARD REPAIR (Cont'd)

- 5) When soldering semiconductor devices and all small components, be sure to use a heat sink tool or long-nosed plier connected to the component lead(s) while each is being soldered. Allow the soldered connection to cool before removing the heat sink.
- 6) Clean all dirt and solder-flux from the printed-circuit traces by liberal application of a freon-type solvent.

4.5 TEST EQUIPMENT

Listed in Table 4.1 is the inventory of test equipment required for maintenance and calibration of the Model 7004 Digital Multi-meter. In the event these specific items are not available, units of equal, or greater accuracy and capability may be used.

TABLE 4.1 TEST EQUIPMENT FOR MODEL 7004

| NOMENCALTURE | TYPE | USAGE |
|-------------------------------|--|----------------------------------|
| DC Voltage/Current Calibrator | Fluke Model 382A & 332B | dc voltage & current calibration |
| AC Voltage Calibrator | HP Model 745A (Use 0.1% resistors for ac current calibration) | ac voltage & current calibration |
| Resistance Standard | ESI Model RS925C | resistance calibration |
| Digital Voltmeter | Systron-Donner Model 7005A | calibration & troubleshooting |
| Oscilloscope | Tektronix Model 535 with Type D Plug-in | calibration & troubleshooting |

4.6 CALIBRATION PROCEDURES

This section contains step-by-step calibration procedures for the Model 7004. Perform these procedures in listed order since earlier steps may affect later ones.

Test and calibration tolerances listed in these procedures do not include specification variances of the test/calibration equipments listed in Table 4.1.

4.6 CALIBRATION PROCEDURES (Cont'd)

Unless otherwise indicated, all calibration procedures may be conducted while at room ambient temperature and at nominal power-line voltage and frequency.

For best results use high-quality test leads of 36-inch maximum length. Undesirable noise may be eliminated during the calibration procedures by grounding the LO/GUARD terminals to the test/calibration equipments.

4.6.1 Power Supply Voltages

- 1) Remove bottom instrument cover (rear end-trim; slide cover off), apply power, and check power supply voltages (bottom side, P.C. board) as follows:

TABLE 4.2 POWER SUPPLY VOLTAGES

| VOLTAGE | TEST POINT | ADJUSTMENT | TOLERANCE |
|----------|------------|------------|-----------|
| +17 V dc | Green | Fixed | Nominal |
| -18 V dc | Yellow | Fixed | Nominal |
| Ground | Red/Black | - | - |

- 2) Turn OFF power; replace instrument cover.

4.6.2 Calibration

- 1) Apply power to instrument and allow at least 1/2-hour warm-up.
- 2) Remove bottom instrument cover; set FUNCTION switch to V and RANGE switch to 0.1 V.
- 3) INPUT INTEGRATOR AMPLIFIER ZERO: Set front-panel mV ZERO control R2 (20-turn potentiometer) to approximately center-range (10 turns). With zero-ohm shorting bus across the inputs, monitor voltage output of Integrating Amplifier, TP-8, on the oscilloscope. Adjust DC OFFSET potentiometer R27 for minimum output amplitude on 5 mV/div. scale.
- 4) DETECTOR ZERO: Set RANGE switch to 10 V and adjust Detector Zero R71 for flashing (-) polarity sign.
- 5) INTEGRATOR ZERO: Remove short across the input, and apply +10 mV (10 counts) from the DC Voltage/Current Calibrator. Adjust Integrator Zero potentiometer R83 to read 10 counts. Now apply -10 mV input, the output should read -10 counts; if not, repeat steps 4) and 5) until both polarities read 10 counts.

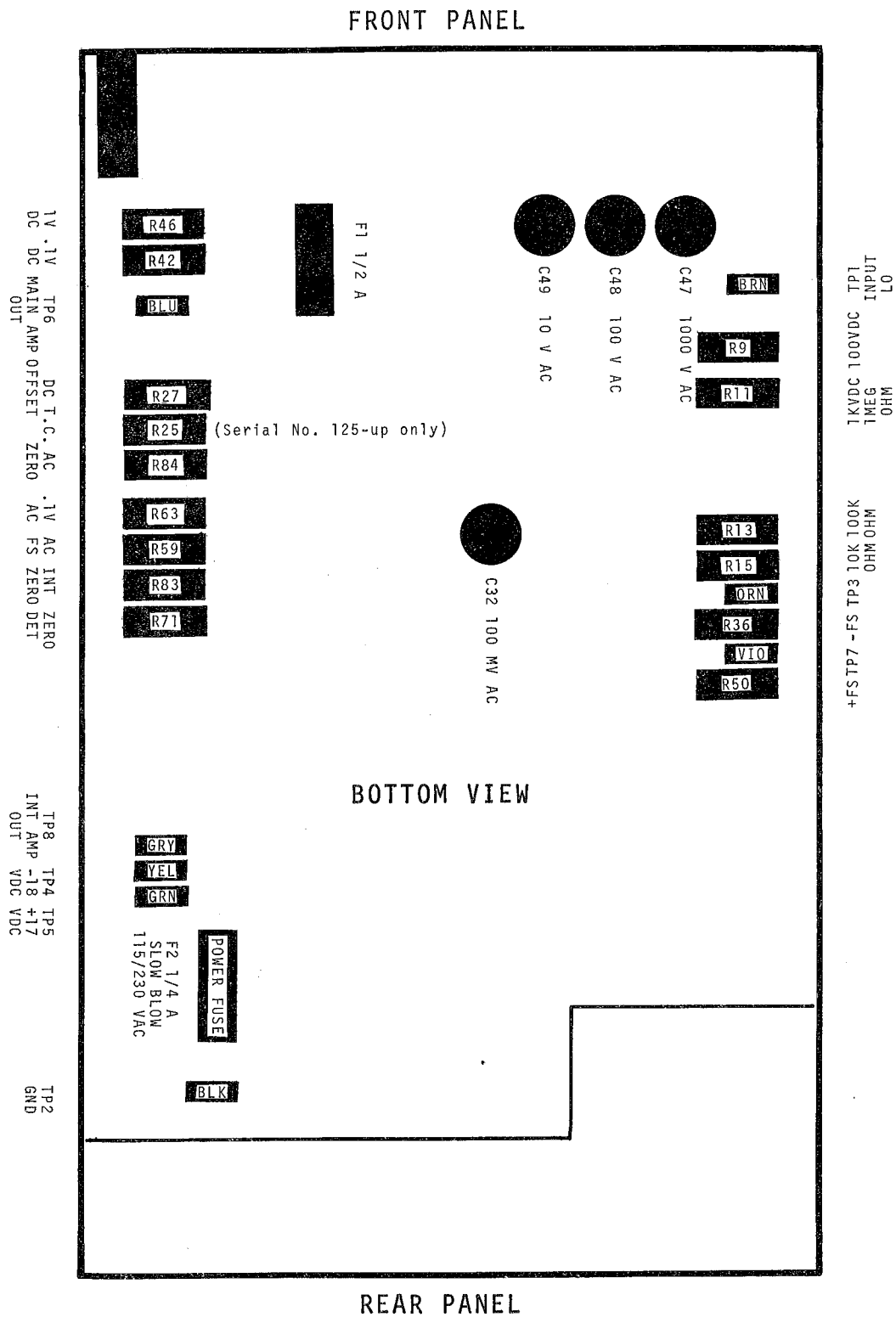


FIGURE 4.1 LOCATION, CALIBRATION CONTROLS

4.6.2 Calibration (Cont'd)

- 6) +FS (TP7-violet): Apply +10 V dc across the inputs and adjust +Full Scale potentiometer R50 to read 10.000 ± 1 count.
- 7) -FS (TP3-orange): Apply -10 V dc across the inputs and adjust -Full Scale potentiometer R36 to read -10.000 ± 1 count.
- 8) OHMS CALIBRATION: Set FUNCTION Switch to $K\Omega$ and select RANGE as indicated in Table 4.3:

TABLE 4.3 RESISTANCE CALIBRATION

| RANGE | CALIBRATOR INPUT | ADJUST | DISPLAY | (INITIAL) (ADJUSTMENT) | (FINAL) (CALIB) |
|--------------|---------------------|---------------|---------|---------------------------|--------------------|
| 1 | 1 $k\Omega$ | No adjustment | 1.0000 | ± 11 counts | ± 11 counts |
| 10 | 10 $k\Omega$ | R15 | 10.000 | ± 1 count | ± 11 counts |
| 100 | 100 $k\Omega$ | R13 | 100.00 | ± 1 count | ± 11 counts |
| 1000 | 1000 $k\Omega$ | R11 | 1000.0 | ± 1 count | ± 11 counts |
| 10 $M\Omega$ | 10 $M\Omega$ | No adjustment | 10.000 | ± 11 counts | ± 11 counts |

- 9) DC VOLTAGE CALIBRATION: Set FUNCTION switch to V and select RANGE as indicated in Table 4.4:

TABLE 4.4 DC VOLTAGE CALIBRATION

| RANGE | CALIBRATOR INPUT | ADJUST | DISPLAY |
|-------|---------------------|-----------------|-----------------------|
| .1 | ± 100 mV | R42 | .10000 ± 2 counts |
| 1 | ± 1 V | R46 | 1.0000 ± 1 count |
| 10 | ± 10 V | Same as 6) & 7) | 10.000 ± 1 count |
| 100 | ± 100 V | R9 | 100.00 ± 1 count |
| 1000 | ± 1000 V | R13 | 1000.0 ± 2 counts |

NOTE

If adjustment of R13 is necessary, the Resistance ranges may be slightly affected, but these will continue to be within specified tolerances. Also, do not attempt at this point, to readjust the Resistance ranges back to ± 1 count since the DC Voltage calibration will then be affected.

- 10) AC VOLTAGE CALIBRATION: (Perform DC VOLTAGE CALIBRATION first).

10) AC VOLTAGE CALIBRATION: (Cont'd)

- a) AC ZERO: Set FUNCTION switches to V and AC. Set RANGE switch to 0.1 V. Short the HI/LO input terminals with a bus jumper. (Do not use long test lead which will pick up noise.) Adjust AC Zero R84 so that display reads a minimum, but no higher than 15 counts.
- b) Apply a 0.1 V rms, 200 Hz input signal from the AC Voltage Calibrator across the HI/LO input terminals. Adjust R63 until the readout is $.10000 \pm 1$ count.
- c) Apply a 0.1 V rms, 20 kHz input signal across the HI/LO input terminals. Adjust frequency compensation capacitor C32 until the readout is $.10000 \pm 1$ count.
- d) Set the RANGE switch to the 1 V range. Apply a 1.0 V rms, 200 Hz input signal across the HI/LO input terminals. Adjust R59 until the readout is 0.9995 ± 2 counts.
- e) Set the RANGE switch to the 10 V range. Apply a 10 V rms, 200 Hz input signal across the HI/LO input terminals. Observe that the readout is 10.000 ± 22 counts.
- f) Apply a 10 V rms, 20 kHz input signal across the HI/LO input terminals. Adjust attenuator frequency compensation capacitor C49 for a reading of 09.990 ± 2 counts.
- g) Set the RANGE switch to the 100 V range. Apply a 100 V rms, 200 Hz input signal across the HI/LO input terminals. Observe that the readout is 100.00 ± 22 counts.
- h) Apply a 100 V rms, 20 kHz input signal across the HI/LO input terminals. Adjust attenuator frequency compensation capacitor C48 for a reading of 099.90 ± 2 counts.
- i) Set the RANGE switch to the 1000 V range. Apply a 500 V rms, 200 Hz input signal across the HI/LO input terminals. Observe that the readout is 500.0 ± 12 counts.
- j) Apply a 500 V rms, 10 kHz input signal across the HI/LO input terminals. Adjust attenuator frequency compensation capacitor C47 for a reading of 0499.5 ± 1 counts.
- k) In the event that an AC Voltage Calibrator with an output capability of 500 V rms is not available, the following procedure will provide adequate frequency compensation. Apply a 100 V rms, 200 Hz input signal across the HI/LO input terminals. Observe that the readout is 100.0 ± 4 counts.
- l) Apply a 100 V rms, 10 kHz input signal across the HI/LO input terminals. Adjust attenuator frequency compensation capacitor C47 to observe a reading of 99.8 ± 1 counts.

11) DC/AC CURRENT CALIBRATION

- a) DC CURRENT: Set FUNCTION switch to mA and RANGE switch as indicated below. Connect DC Current Calibrator output across the HI/LO input terminals. Observe display, no adjustment is required.

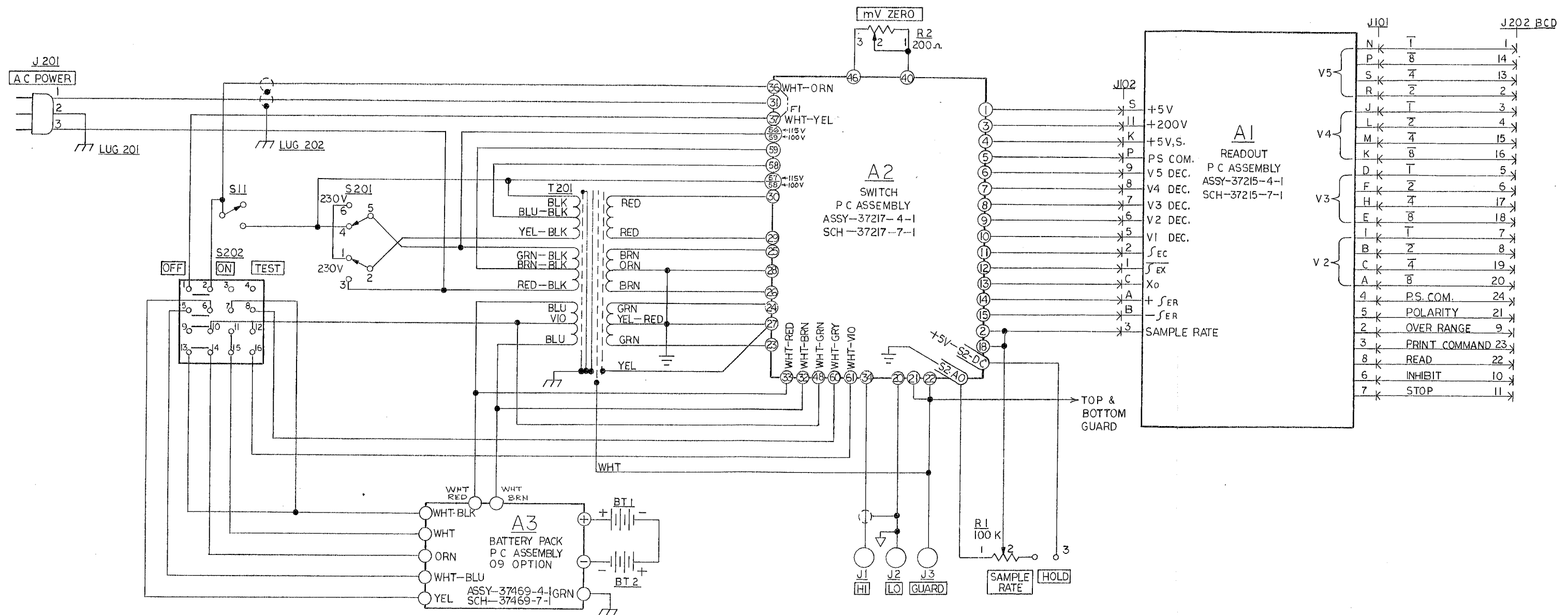
TABLE 4.5 DC CURRENT CALIBRATION

| RANGE | CALIBRATOR INPUT | DISPLAY | |
|-------|------------------|---------|------------|
| .1 | ±100 μ A | .10000 | ±14 counts |
| 1 | ±1 mA | 1.0000 | ±11 counts |
| 10 | ±10 mA | 10.000 | ±11 counts |
| 100 | ±100 mA | 100.00 | ±11 counts |
| 1000 | ±1000 mA | 1000.0 | ±11 counts |

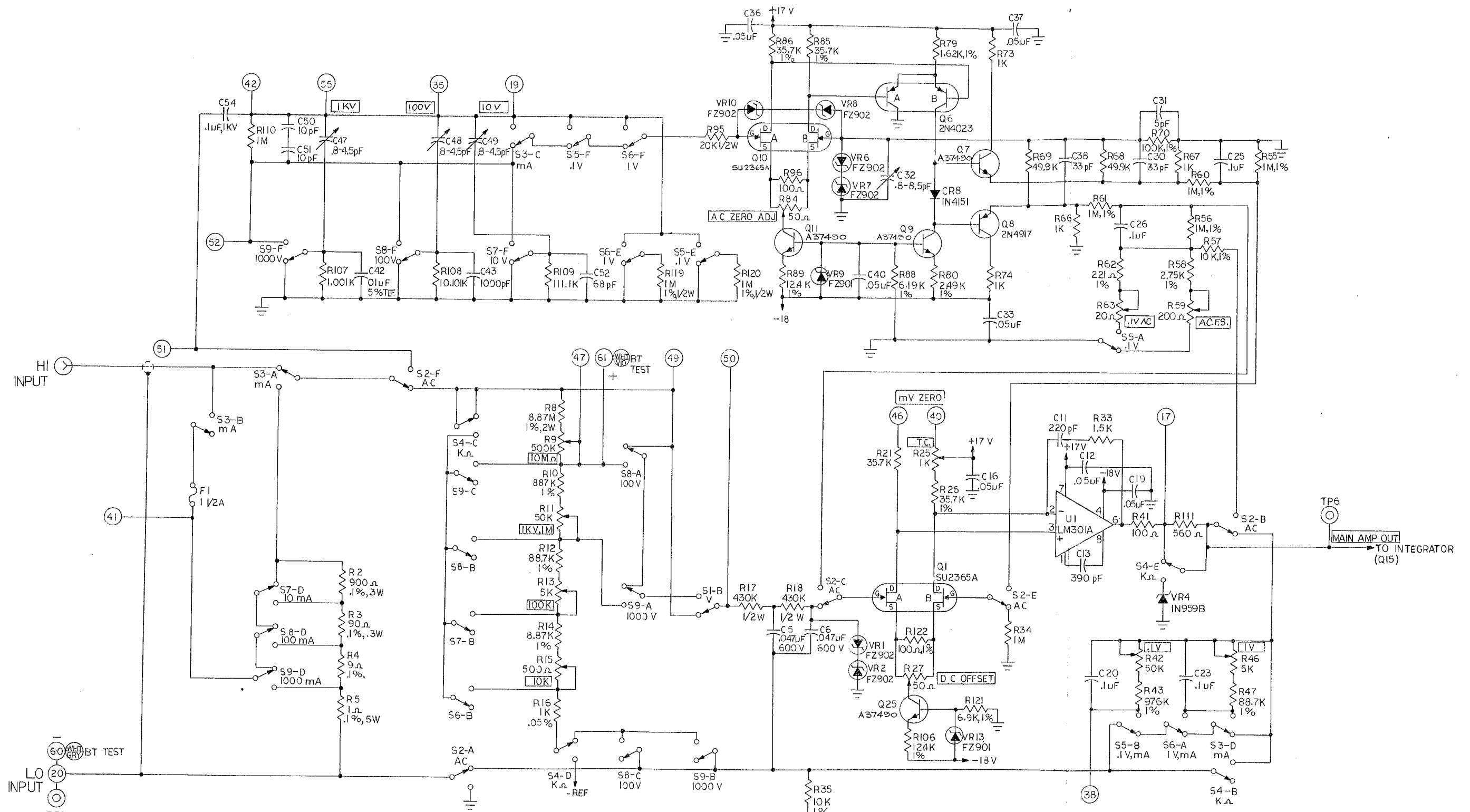
- b) AC CURRENT: Set FUNCTION switch to AC and mA; then, repeat Step 11a. Use AC Current Calibrator. If not available, apply ac voltage across precision resistors to obtain proper currents.

TABLE 4.6 AC CURRENT CALIBRATION

| RANGE | CALIBRATOR INPUT | DISPLAY | |
|-------|------------------|---------|------------|
| .1 | 100 μ A | .10000 | ±52 counts |
| 1 | 1 mA | 1.0000 | ±32 counts |
| 10 | 10 mA | 10.000 | ±32 counts |
| 100 | 100 mA | 100.00 | ±32 counts |
| 1000 | 1000 mA | 1000.0 | ±32 counts |



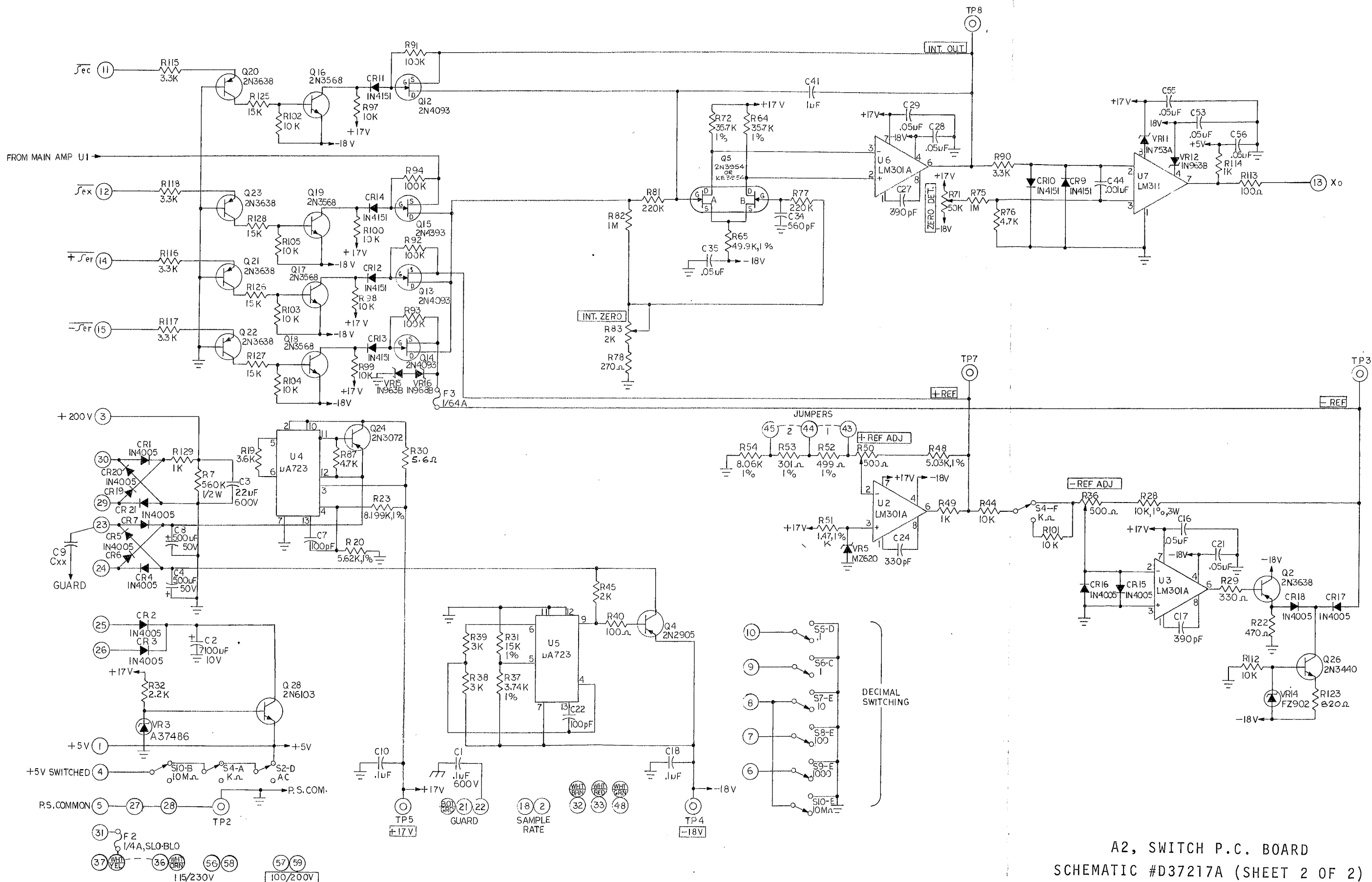
MODEL 7004
BLOCK DIAGRAM #D37190A



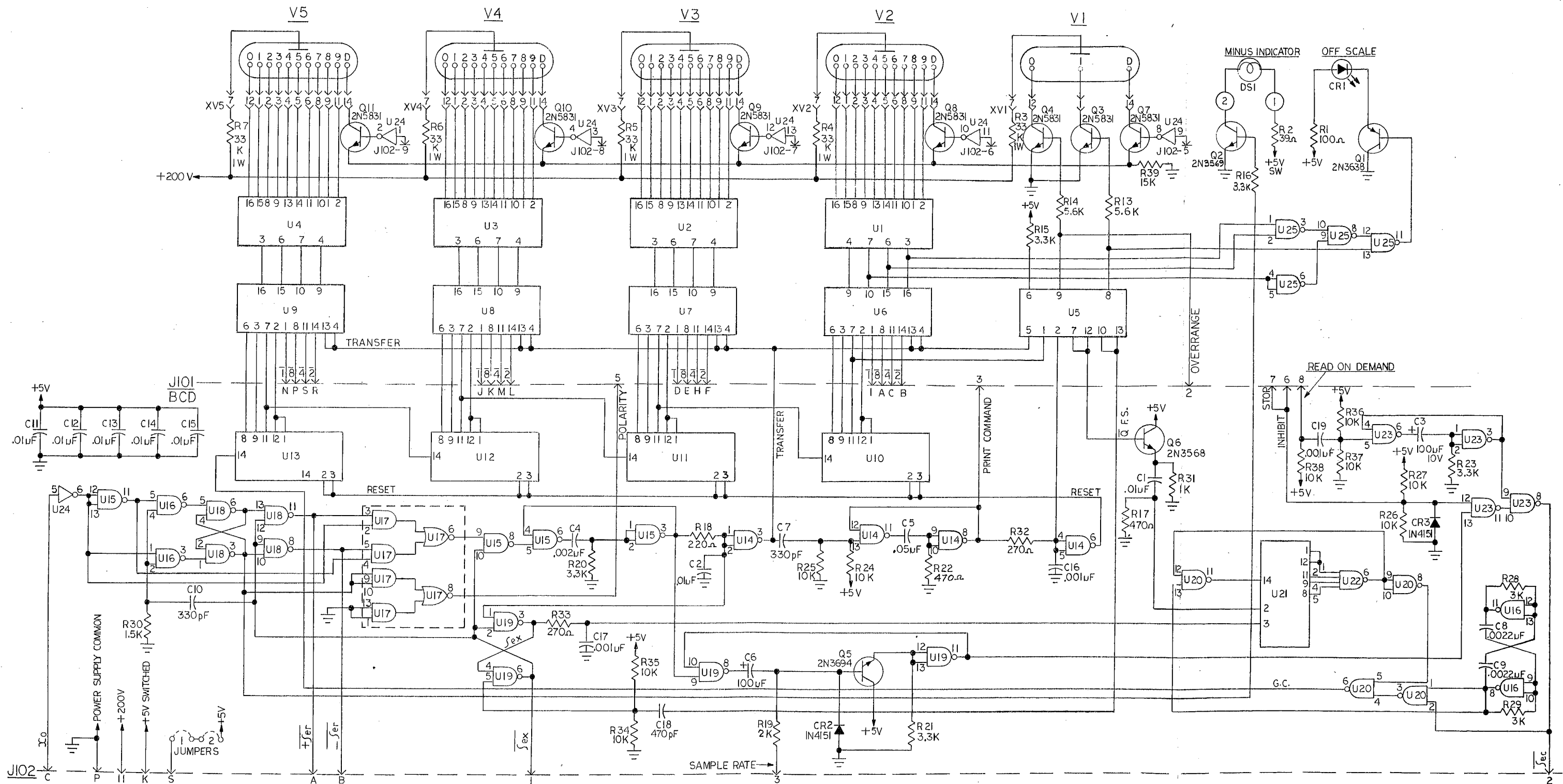
NOTE:
 1. UNLESS SPECIFIED RESISTORS ARE 5%, 1/4W.
 2. R107, R108 & R109 ARE MATCHED TO R110 WITHIN .05%.
 3. SWITCHES SHOWN IN 'OUT' POSITION.

- S 1 = V
- S 2 = AC
- S 3 = mA
- S 4 = K.Ω
- S 5 = .1V, mA
- S 6 = I
- S 7 = IO
- S 8 = IOO
- S 9 = IOOO
- S 10 = IO M.Ω

A2, SWITCH P.C. BOARD
 SCHEMATIC #D37217A (SHEET 1 OF 2)



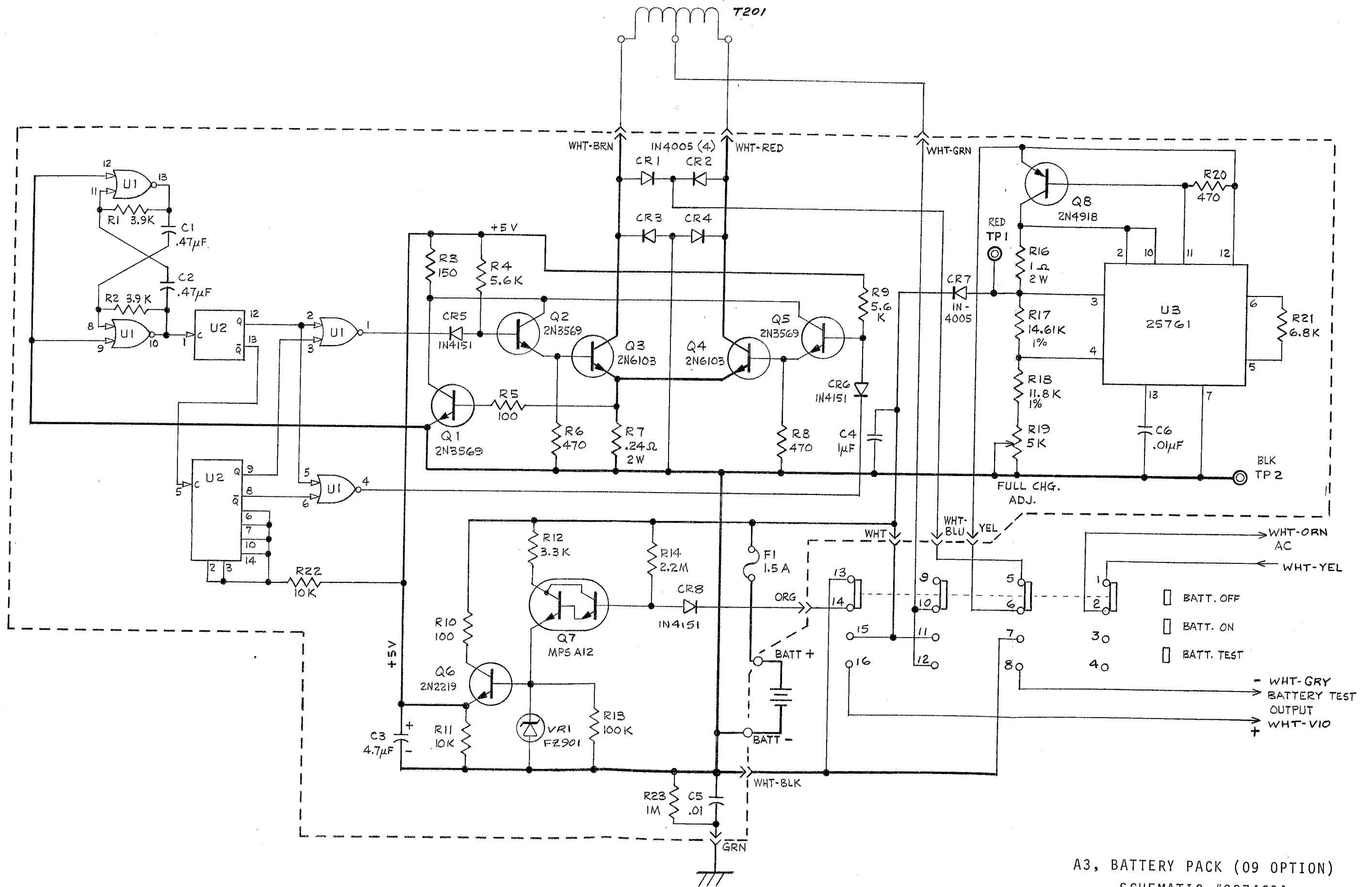
A2, SWITCH P.C. BOARD
 SCHEMATIC #D37217A (SHEET 2 OF 2)



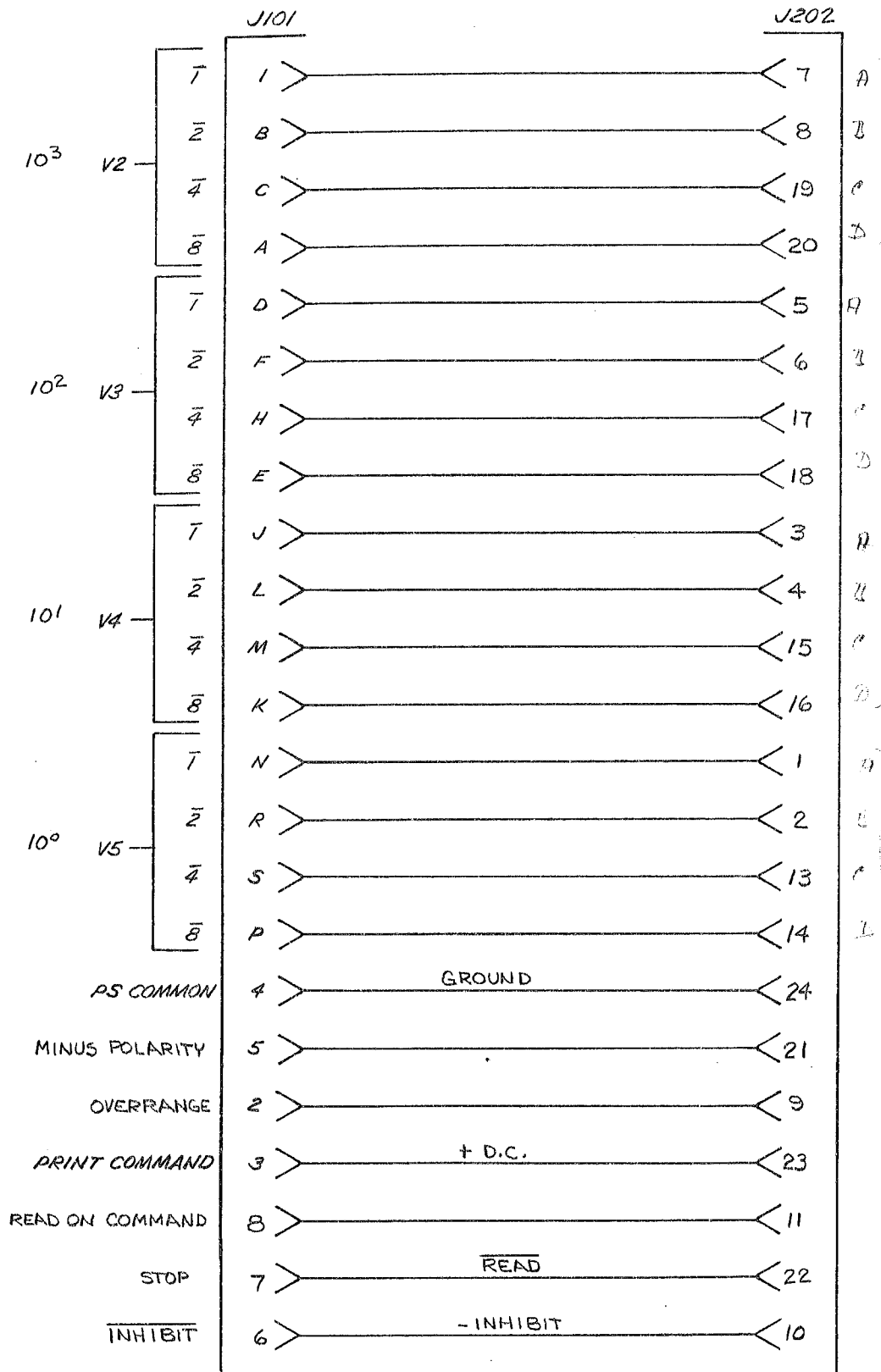
NOTE:
1. ALL RESISTORS 1/4 W UNLESS OTHERWISE SPECIFIED.

| U | TYPE | GND PIN | +5V PIN |
|----------------------|----------|--------------|---------|
| 1,2,3,4 | SN7441AN | 12 | 5 |
| 5 | SN74L73N | 11 | 3,4,14 |
| 6,7,8,9 | SN74L75N | 12 | 5 |
| 10,11,12,13 | SN74L90N | 6,7,10 | 5 |
| 14 | SN7400N | 7 | 14 |
| 15,16,18,19,20,23,25 | SN74L00N | 7 | 14 |
| 17 | SN74L51N | 1,7,13 | 14 |
| 21 | SN7493N | 10 | 5 |
| 22 | SN74L20N | 7,9,10,12,13 | 14 |
| 24 | SN74L04N | 7 | 14 |

A1, COUNT CHAIN & READOUT P.C. BOARD
SCHEMATIC #D37215A



A3, BATTERY PACK (09 OPTION)
SCHEMATIC #C37469A



AMPHENOL
57-40240

BCD (05 OPTION) SCHEMATIC #C37218A

CHAPTER 6

7004 FINAL ASSEMBLY PARTS LIST

| Ref. | Description | SD Part No. |
|------|---------------------------------|----------------|
| | 7004 Final Assembly | 37190-4-1 |
| | 7004 Schematic | 37190-7-1 |
| | Test Assembly | 37197-4-1 |
| | Bottom Cover Assembly | 45065-3 |
| | End Trim | 39033 |
| | Top Trim | 39859-3 |
| | Handle | 33570-3 |
| | Front Trim | 37230-6-1 |
| | Readout Window | 37202-1-1 |
| | Trim Strip | 37203-1-1 |
| | Foil Cal. Trim Strip | 37203-6-1 |
| | Label | 23456 |
| | Line Cord | 50303270 |
| | Cover Mtg. Bracket | 39857 |
| | Cover Top | 33567-3 |
| | 100 V Assembly | 37473-4-1 |
| | BCD Option 05 Assembly | 37218-4-1 |
| | Battery Pack Option 09 Assembly | 37219-4-1 |
| | Front Cover Assembly | 37229-4-1 |
| | Test Probe Ket | 37232-4-1 |
| | Rack Mount Kit Single | 45410-3 |
| | Rack Mount Kit Dual | |

AI COUNT CHAIN & READOUT P.C. ASSEMBLY PARTS LIST

| Ref. | Description | SD Part No. |
|------|--|--------------------------|
| A1 | Count Chain & Readout P.C. Assembly Count Chain & Readout Schematic | D37215-4-1 D37215-7-1 |
| C1 | Capacitor, 01 μ F, Disc | C0556 |
| C2 | Capacitor, 01 μ F, Disc | C0556 |
| C3 | Capacitor, 100 μ F, 10 V, Electro | C0660 |
| C4 | Capacitor, .002 μ F, 500 V | C0328 |
| C5 | Capacitor, .05 μ F, 100 V | C0708 |
| C6 | Capacitor, 100 μ F, 25 V | C0832 |
| C7 | Capacitor, 330 pF, 500 V | C0898 |
| C8 | Capacitor, .0022 μ F, 200 V | C0687 |
| C9 | Capacitor, .0022 μ F, 200 V | C0687 |
| C10 | Capacitor, 330 pF, 500 V | C0898 |
| C11 | Capacitor, 01 μ F, Disc | C0556 |
| C12 | Capacitor, 01 μ F, Disc | C0556 |
| C13 | Capacitor, 01 μ F, Disc | C0556 |
| C14 | Capacitor, 01 μ F, Disc | C0556 |
| C15 | Capacitor, 01 μ F, Disc | C0556 |
| C16 | Capacitor, .001 μ F, 500 V | C0424 |
| C17 | Capacitor, .001 μ F, 500 V | C0424 |
| C18 | Capacitor, 470 pF, 300 V | C0542 |
| C19 | Capacitor, .001 μ F, 500 V | C0424 |
| CR1 | Diode, Light Emitting | CR0367 |
| CR2 | Diode, 1N4151 | CR0150 |
| CR3 | Diode, 1N4151 | CR0150 |
| Q1 | Transistor, 2N3638 | Q0181 |
| Q2 | Transistor, 2N3569 | Q0318 |
| Q3 | Transistor, 2N5831 | 26004021 |
| Q4 | Transistor, 2N5831 | 26004021 |
| Q5 | Transistor, 2N3694 | 26012660 |
| Q6 | Transistor, 2N3568 | Q0180 |
| Q7 | Transistor, 2N5831 | 26004021 |
| Q8 | Transistor, 2N5831 | 26004021 |
| Q9 | Transistor, 2N5831 | 26004021 |
| Q10 | Transistor, 2N5831 | 26004021 |
| Q11 | Transistor, 2N5831 | 26004021 |
| R1 | Resistor, 470 Ω , 1/4, 5% | R1044 |
| R2 | Resistor, 39 Ω , 1/4 W, 5% | R1552 |
| R3 | Resistor, 33 k, 1 W, 5% | R1263 |
| R4 | Resistor, 33 k, 1 W, 5% | R1263 |
| R5 | Resistor, 33 k, 1 W, 5% | R1263 |

A1 COUNT CHAIN & READOUT P.C. ASSEMBLY PARTS LIST (Cont'd)

| Ref. | Description | SD Part No. |
|------|------------------------------------|----------------|
| R6 | Resistor, 33 k, 1 W, 5% | R1263 |
| R7 | Resistor, 33 k, 1 W, 5% | R1263 |
| R8 | Not Used | |
| R9 | Not Used | |
| R10 | Not Used | |
| R11 | Not Used | |
| R12 | Not Used | |
| R13 | Resistor, 5.6 k, 1/4 W, 5% | R0821 |
| R14 | Resistor, 5.6 k, 1/4 W, 5% | R0821 |
| R15 | Resistor, 3.3 k, 1/4 W, 5% | R0742 |
| R16 | Resistor, 820 Ω , 1/4 W, 5% | R0762 |
| R17 | Resistor, 470 Ω , 1/4 W, 5% | R1044 |
| R18 | Resistor, 220 Ω , 1/4 W, 5% | R0760 |
| R19 | Resistor, 2 k, 1/4 W, 5% | R0734 |
| R20 | Resistor, 3.3 k, 1/4 W, 5% | R0742 |
| R21 | Resistor, 3.3 k, 1/4 W, 5% | R0742 |
| R22 | Resistor, 470 Ω , 1/4 W, 5% | R1044 |
| R23 | Resistor, 3.3 k, 1/4 W, 5% | R0742 |
| R24 | Resistor, 10 k, 1/4 W, 5% | R0766 |
| R25 | Resistor, 10 k, 1/4 W, 5% | R0766 |
| R26 | Resistor, 10 k, 1/4 W, 5% | R0766 |
| R27 | Resistor, 10 k, 1/4 W, 5% | R0766 |
| R28 | Resistor, 3 k, 1/4 W, 5% | R0711 |
| R29 | Resistor, 3 k, 1/4 W, 5% | R0711 |
| R30 | Resistor, 1.5 k, 1/4 W, 5% | R0783 |
| R31 | Resistor, 1 k, 1/4 W, 5% | R0765 |
| R32 | Resistor, 270 Ω , 1/4 W, 5% | R0694 |
| R33 | Resistor, 270 Ω , 1/4 W, 5% | R0694 |
| R34 | Resistor, 10 k, 1/4 W, 5% | R0766 |
| R35 | Resistor, 10 k, 1/4 W, 5% | R0766 |
| R36 | Resistor, 10 k, 1/4 W, 5% | R0766 |
| R37 | Resistor, 10 k, 1/4 W, 5% | R0766 |
| R38 | Resistor, 10 k, 1/4 W, 5% | R0766 |
| R39 | Resistor, 15 k, 1/4 W, 5% | R0728 |
| U1 | Integrated Circuit, SN7441AN | 019707 |
| U2 | Integrated Circuit, SN7441AN | 019707 |
| U3 | Integrated Circuit, SN7441AN | 019707 |
| U4 | Integrated Circuit, SN7441AN | 019707 |
| U5 | Integrated Circuit, SN74L73N | 045200 |
| U6 | Integrated Circuit, SN74L75N | 045201 |
| U7 | Integrated Circuit, SN74L75N | 045201 |

A1 COUNT CHAIN & READOUT P.C. ASSEMBLY PARTS LIST (Cont'd)

| Ref. | Description | SD Part No. |
|------|---|-------------|
| U8 | Integrated Circuit, SN74L75N | 045201 |
| U9 | Integrated Circuit, SN74L75N | 045201 |
| U10 | Integrated Circuit, SN74L90N | 045202 |
| U11 | Integrated Circuit, SN74L90N | 045202 |
| U12 | Integrated Circuit, SN74L90N | 045202 |
| U13 | Integrated Circuit, SN74L90N | 045202 |
| U14 | Integrated Circuit, SN7400N | 019705 |
| U15 | Integrated Circuit, SN74L00N | 025796 |
| U16 | Integrated Circuit, SN74L00N | 025796 |
| U17 | Integrated Circuit, SN74L51N | 025799 |
| U18 | Integrated Circuit, SN74L00N | 025796 |
| U19 | Integrated Circuit, SN74L00N | 025796 |
| U20 | Integrated Circuit, SN74L00N | 025796 |
| U21 | Integrated Circuit, SN7493N | 25715 |
| U22 | Integrated Circuit, SN74L20N | 025798 |
| U23 | Integrated Circuit, SN74L00N | 025796 |
| U24 | Integrated Circuit, SN74L04N | 045204 |
| U25 | Integrated Circuit, SN74L04N | 045204 |
| V1 | Tube, Readout <i>NL-5750-S National Electronics</i> | V0132 |
| V2 | Tube, Readout | V0132 |
| V3 | Tube, Readout | V0132 |
| V4 | Tube, Readout | V0132 |
| V5 | Tube, Readout | V0132 |
| XV1 | Socket Readout Tube | X0179 |
| XV2 | Socket Readout Tube | X0179 |
| XV3 | Socket Readout Tube | X0179 |
| XV4 | Socket Readout Tube | X0179 |
| XV5 | Socket Readout Tube | X0179 |
| XU1 | IC Sockets | X0185 |
| XU2 | IC Sockets | X0185 |
| XU3 | IC Sockets | X0185 |
| XU4 | IC Sockets | X0185 |
| DS1 | Lamp | 10050 |

A2 SWITCH P.C. ASSEMBLY PARTS LIST

| Ref. | Description | SD Part No. |
|------|---|--------------------------|
| A2 | Switch P.C. Board Assembly Switch P.C. Schematic | D37217-4-1 D37217-7-1 |
| C1 | Capacitor, .1 μ F, 600 V | 03285090 |
| C2 | Capacitor, 7100 μ F, 10 V | C1188 |
| C3 | Capacitor, .22 μ F, 600 V | 03286700 |
| C4 | Capacitor, 500 μ F, 50 V | C1243 |
| C5 | Capacitor, .047 μ F, 600 V | C0793 |
| C6 | Capacitor, .047 μ F, 600 V | C0793 |
| C7 | Capacitor, 100 pF, 500 V | C0536 |
| C8 | Capacitor, 500 μ F, 50 V | C1243 |
| C9 | Capacitor, Factory Selected | Cxxx |
| C10 | Capacitor, .1 μ F, 50 V | C0881 |
| C11 | Capacitor, 200 μ F, 500 V | C0538 |
| C12 | Capacitor, .05 μ F, 100 V | C0708 |
| C13 | Capacitor, 390 pF, 500 V | C0871 |
| C14 | Capacitor, .05 μ F, 100 V | C0708 |
| C15 | Not Used | |
| C16 | Capacitor, .05 μ F, 100 V | C0708 |
| C17 | Capacitor, 390 pF, 500 V | C0871 |
| C18 | Capacitor, .1 μ F, 50 V | C0881 |
| C19 | Capacitor, .05 μ F, 100 V | C0708 |
| C20 | Capacitor, .1 μ F, 200 V, Met. Myl | C0382 |
| C21 | Capacitor, .05 μ F, 100 V | C0708 |
| C22 | Capacitor, 100 pF, 500 V | C0536 |
| C23 | Capacitor, .1 μ F, 200 V Met. Myl. | C0382 |
| C24 | Capacitor, 390 pF, 500 V | C0871 |
| C25 | Capacitor, .1 μ F, 200 V, Met. Myl. | C0382 |
| C26 | Capacitor, .1 μ F, 200 V, Met. Myl. | C0382 |
| C27 | Capacitor, 390 pF, 500 V | C0871 |
| C28 | Capacitor, .05 μ F, 100 V | C0708 |
| C29 | Capacitor, .05 μ F, 100 V | C0708 |
| C30 | Capacitor, 33 pF, 500 V | C0531 |
| C31 | Capacitor, 5 pF, 500 V | C1071 |
| C32 | Capacitor, .8-8.5 pF, Trimmer | C1291 |
| C33 | Capacitor, .05 μ F, 100 V | C0708 |
| C34 | Capacitor, 560 pF, 300 V | C0644 |
| C35 | Capacitor, .05 μ F, 100 V | C0708 |
| C36 | Capacitor, .05 μ F, 100 V | C0708 |
| C37 | Capacitor, .05 μ F, 100 V | C0708 |
| C38 | Capacitor, 33 pF, 500 V | C0531 |
| C39 | Not Used | |

A2, SWITCH P.C. ASSEMBLY PARTS LIST (Cont'd)

| Ref. | Description | SD Part No. |
|------|-----------------------------------|-------------|
| C40 | Capacitor, .05 μ F, 100 V | C0708 |
| C41 | Capacitor, 1 μ F, 50 V | C1272 |
| C42 | Capacitor, .01 μ F, 100 V, 5% | C1295 |
| C43 | Capacitor, 1000 pF, 300 V | C1144 |
| C44 | Capacitor, .001 μ F, 1 KV | C0235 |
| C45 | Not Used | |
| C46 | Not Used | |
| C47 | Capacitor, .8-4.5 pF, Trimmer | 03270200 |
| C48 | Capacitor, .8-4.5 pF, Trimmer | 03270200 |
| C49 | Capacitor, .8-4.5 pF, Trimmer | 03270200 |
| C50 | Capacitor, 10 pF, 500 V | C0527 |
| C51 | Capacitor, 10 pF, 500 V | C0527 |
| C52 | Capacitor, 68 pF, 500 V | C0635 |
| C53 | Capacitor, .05 μ F, 100 V | C0708 |
| C54 | Capacitor, .1 μ F, 1.2 KV | 03286130 |
| C55 | Capacitor, .05 μ F, 100 V | C0708 |
| C56 | Capacitor, .05 μ F, 100 V | C0708 |
| CR1 | Diode, IN4005 | CR0284 |
| CR2 | Diode, IN4005 | CR0284 |
| CR3 | Diode, IN4005 | CR0284 |
| CR4 | Diode, IN4005 | CR0284 |
| CR5 | Diode, IN4005 | CR0284 |
| CR6 | Diode, IN4005 | CR0284 |
| CR7 | Diode, IN4005 | CR0284 |
| CR8 | Diode, IN4151 | CR0150 |
| CR9 | Diode, IN4151 | CR0150 |
| CR10 | Diode, IN4151 | CR0150 |
| CR11 | Diode, IN4151 | CR0150 |
| CR12 | Diode, IN4151 | CR0150 |
| CR12 | Diode, IN4151 | CR0150 |
| CR13 | Diode, IN4151 | CR0150 |
| CR14 | Diode, IN4151 | CR0150 |
| CR15 | Diode, IN4005 | CR0284 |
| CR16 | Diode, IN4005 | CR0284 |
| CR17 | Diode, IN4005 | CR0284 |
| CR18 | Diode, IN4005 | CR0284 |
| CR19 | Diode, IN4005 | CR0284 |
| CR20 | Diode, IN4005 | CR0284 |
| CR21 | Diode, IN4005 | CR0284 |
| VR1 | Diode, Zener, FZ902 | 26015850 |

A2 SWITCH P.C. ASSEMBLY PARTS LIST (Cont'd)

| Ref. | Description | SD Part No. |
|------|----------------------------------|----------------|
| VR2 | Diode, Zener, FZ902 | 26015850 |
| VR3 | Diode, Zener, 2N3640, Selected | 37486 |
| VR4 | Diode, Zener, 1N959B | CR0346 |
| VR5 | Diode, Zener, MZ620 | CR0371 |
| VR6 | Diode, Zener, FZ902 | 26015850 |
| VR7 | Diode, Zener, FZ902 | 26015850 |
| VR8 | Diode, Zener, FZ902 | 26015850 |
| VR9 | Diode, Zener, FZ901 | 26015340 |
| VR10 | Diode, Zener, FZ902 | 26015850 |
| VR11 | Diode, Zener, 1N753A | 26014210 |
| VR12 | Diode, Zener, 1N963B | CR0174 |
| VR13 | Diode, Zener, FZ901 | 26015340 |
| VR14 | Diode, Zener, FZ902 | 26015850 |
| VR15 | Diode, Zener, 1N963B | CR0174 |
| VR16 | Diode, Zener, 1N968B | CR0265 |
| Q1 | Transistor, S _u 2365A | Q0302 |
| Q2 | Transistor, 2N3638 | Q0181 |
| Q3 | Not Used | |
| Q4 | Transistor, 2N2905 | Q0259 |
| Q5 | Transistor, SN3954 | 26013160 |
| Q6 | Transistor, 2N4023 | 26013950 |
| Q7 | Transistor, 2N3693, Selected | 37490 |
| Q8 | Transistor, 2N4917 | 26014620 |
| Q9 | Transistor, 2N3693, Selected | 37490 |
| Q10 | Transistor, S _u 2365A | Q0302 |
| Q11 | Transistor, 2N3693, Selected | 37490 |
| Q12 | Transistor, 2N4093 | Q0301 |
| Q13 | Transistor, 2N4093 | Q0301 |
| Q14 | Transistor, 2N4093 | Q0301 |
| Q15 | Transistor, 2N4393 | Q0316 |
| Q16 | Transistor, 2N3568 | Q0180 |
| Q17 | Transistor, 2N3568 | Q0180 |
| Q18 | Transistor, 2N3568 | Q0180 |
| Q19 | Transistor, 2N3568 | Q0180 |
| Q20 | Transistor, 2N3638 | Q0181 |
| Q21 | Transistor, 2N3638 | Q0181 |
| Q22 | Transistor, 2N3638 | Q0181 |
| Q23 | Transistor, 2N3638 | Q0181 |
| Q24 | Transistor, 2N3072 | 26008560 |
| Q25 | Transistor, 2N3693, Selected | 37490 |
| Q26 | Transistor, 2N3440 | Q0319 |
| Q27 | Not Used | |

A2 SWITCH P.C. ASSEMBLY PARTS LIST (Cont'd)

| Ref. | Description | SD Part No. |
|------|--|-------------|
| Q28 | Transistor, 2N6103 | Q0317 |
| R1 | Not Used | |
| R2 | Resistor, 900 Ω , .1%, 3 W | R2807 |
| R3 | Resistor, 90 Ω , .1%, 3 W | R2808 |
| R4 | Resistor, 9 Ω , .1%, 3 W | R2809 |
| R5 | Resistor, 1 Ω , 1%, 3 W | R2810 |
| R6 | Not Used | |
| R7 | Resistor, 560 k, 5%, 1/2 W | 02031140 |
| R8 | Resistor, 8.87 M, 1%, 2 W | R2851 |
| R9 | Resistor, 500 k, Potentiometer | R2847 |
| R10 | Resistor, 887 k, 1%, 1/4 W | R2848 |
| R11 | Resistor, 50 k, Potentiometer | R2783 |
| R12 | Resistor, 88.7 k, 1%, 1/4 W | R2845 |
| R13 | Resistor, 5 k, Potentiometer | 01111360 |
| R14 | Resistor, 8.87 k, 1%, 1/4 W | R2840 |
| R15 | Resistor, 500 Ω , Potentiometer | R2821 |
| R16 | Resistor, 1 k, .05%, 1/4 W | R2832 |
| R17 | Resistor, 430 k, 5%, 1/2 W | R0276 |
| R18 | Resistor, 430 k, 5%, 1/2 W | R0276 |
| R19 | Resistor, 3.6 k, 5%, 1/4 W | R0938 |
| R20 | Resistor, 5.62 k, 1%, 1/8 W | R2837 |
| R21 | Resistor, 35.7 k, 1%, 1/4 W | R2853 |
| R22 | Resistor, 470 Ω , 5%, 1/4 W | R1044 |
| R23 | Resistor, 8.199 k, 1%, 1/4 W | R2839 |
| R24 | Not Used | |
| R25 | Resistor, 1 k, Potentiometer | R2816 |
| R26 | Resistor, 35.7 k, 1%, 1/4 W | R2853 |
| R27 | Resistor, 50 Ω , Potentiometer | R2822 |
| R28 | Resistor, 10 k, 1%, 3 W | 02421000 |
| R29 | Resistor, 330 Ω , 5%, 1/4 W | R0662 |
| R30 | Resistor, 5.6 Ω , 5%, 1/4 W | R2498 |
| R31 | Resistor, 15 k, 1%, 1/4 W | R2073 |
| R32 | Resistor, 2.2 k, 5%, 1/4 W | R0749 |
| R33 | Resistor, 1.5 k, 5%, 1/4 W | R0783 |
| R34 | Resistor, 1 M, 5%, 1/4 W | R0962 |
| R35 | Resistor, 10 k, 1%, 1/4 W | R2455 |
| R36 | Resistor, 500 Ω , Potentiometer | R2821 |
| R37 | Resistor, 3.74 k, 1%, 1/4 W | R2824 |
| R38 | Resistor, 3 k, 5%, 1/4 W | R0711 |
| R39 | Resistor, 3 k, 5%, 1/4 W | R0711 |
| R40 | Resistor, 100 Ω , 5%, 1/4 W | R0966 |

A2, SWITCH P.C. ASSEMBLY PARTS LIST (Cont'd)

| Ref. | Description | SD Part No. |
|------|--|----------------|
| R41 | Resistor, 100 Ω , 5%, 1/4 W | R0966 |
| R42 | Resistor, 50 k, Potentiometer | R2783 |
| R43 | Resistor, 976 k, 1%, 1/4 W | R2849 |
| R44 | Resistor, 10 k, 1%, 1/4 W | R2455 |
| R45 | Resistor, 2 k, 5%, 1/4 W | R0734 |
| R46 | Resistor, 5 k, Potentiometer | 01111360 |
| R47 | Resistor, 88.7 k, 1%, 1/4 W | R2845 |
| R48 | Resistor, 5.03 k, 1%, 1/4 W | R2530 |
| R49 | Resistor, 1 k, 5%, 1/4 W | R0765 |
| R50 | Resistor, 500 Ω , Potentiometer | R2821 |
| R51 | Resistor, 1.47 k, 1%, 1/4 W | R2833 |
| R52 | Resistor, 499 Ω , 1%, 1/4 W | R2831 |
| R53 | Resistor, 301 Ω , 1%, 1/4 W | R2830 |
| R54 | Resistor, 8.06 k, 1%, 1/4 W | R2570 |
| R55 | Resistor, 1 M, 1%, 1/4 W | 02394780 |
| R56 | Resistor, 1 M, 1%, 1/4 W | 02394780 |
| R57 | Resistor, 10 k, 1%, 1/4 W | R2455 |
| R58 | Resistor, 2.74 k, 1%, 1/4 W | R1981 |
| R59 | Resistor, 200 Ω , Potentiometer | R2722 |
| R60 | Resistor, 1 M, 1%, 1/4 W | 02394780 |
| R61 | Resistor, 1 M, 1%, 1/4 W | 02394780 |
| R62 | Resistor, 221 Ω , 1%, 1/4 W | R2829 |
| R63 | Resistor, 20 Ω , Potentiometer | R2784 |
| R64 | Resistor, 35.7 k, 1%, 1/4 W | R2853 |
| R65 | Resistor, 49.9 k, 1%, 1/4 W | R2844 |
| R66 | Resistor, 1 k, 5%, 1/4 W | R0765 |
| R67 | Resistor, 1 k, 5%, 1/4 W | R0765 |
| R68 | Resistor, 49.9 k, 1%, 1/4 W | R2844 |
| R69 | Resistor, 49.9 k, 1%, 1/4 W | R2844 |
| R70 | Resistor, 100 k, 1%, 1/4 W | R2846 |
| R71 | Resistor, 50 k, Potentiometer | R2783 |
| R72 | Resistor, 35.7 k, 1%, 1/4 W | R2853 |
| R73 | Resistor, 1 k, 5%, 1/4 W | R0765 |
| R74 | Resistor, 1 k, 5%, 1/4 W | R0765 |
| R75 | Resistor, 1 M, 5%, 1/4 W | R0962 |
| R76 | Resistor, 4.7 k, 5%, 1/4 W | R0892 |
| R77 | Resistor, 220 k, 5%, 1/4 W | R0967 |
| R78 | Resistor, 270 Ω , 5%, 1/4 W | R0694 |
| R79 | Resistor, 1.62 k, 1%, 1/4 W | R2834 |
| R80 | Resistor, 2.49 k, 1%, 1/4 W | R2835 |
| R81 | Resistor, 220 k, 5%, 1/4 W | R0967 |

A2, SWITCH P.C. ASSEMBLY PARTS LIST (Cont'd)

| Ref. | Description | SD Part No. |
|------|---------------------------------------|----------------|
| R82 | Resistor, 1 M, 5%, 1/4 W | R0962 |
| R83 | Resistor, 2 k, Potentiometer | R2721 |
| R84 | Resistor, 50 Ω , Potentiometer | R2822 |
| R85 | Resistor, 35.7 k, 1%, 1/4 W | R2853 |
| R86 | Resistor, 35.7 k, 1%, 1/4 W | R2853 |
| R87 | Resistor, 4.7 k, 5%, 1/4 W | R0892 |
| R88 | Resistor, 6.19 k, 1%, 1/4 W | R2838 |
| R89 | Resistor, 12.4 k, 1%, 1/4 W | R2841 |
| R90 | Resistor, 3.3 k, 5%, 1/4 W | R0742 |
| R91 | Resistor, 100 k, 5%, 1/4 W | R0741 |
| R92 | Resistor, 100 k, 5%, 1/4 W | R0741 |
| R93 | Resistor, 100 k, 5%, 1/4 W | R0741 |
| R94 | Resistor, 100 k, 5%, 1/4 W | R0741 |
| R95 | Resistor, 20 k, 1%, 1/2 W | 02379680 |
| R96 | Resistor, 100 Ω , 1%, 1/4 W | R2620 |
| R97 | Resistor, 10 k, 5%, 1/4 W | R0766 |
| R98 | Resistor, 10 k, 5%, 1/4 W | R0766 |
| R99 | Resistor, 10 k, 5%, 1/4 W | R0766 |
| R100 | Resistor, 10 k, 5%, 1/4 W | R0766 |
| R101 | Resistor, 10 k, 5%, 1/4 W | R0766 |
| R102 | Resistor, 10 k, 5%, 1/4 W | R0766 |
| R103 | Resistor, 10 k, 5%, 1/4 W | R0766 |
| R104 | Resistor, 10 k, 5%, 1/4 W | R0766 |
| R105 | Resistor, 10 k, 5%, 1/4 W | R0766 |
| R106 | Resistor, 12.4 k, 1%, 1/4 W | R2841 |
| R107 | Resistor, 1.0010 k, Part of Set | 37225-6-1 |
| R108 | Resistor, 10.101 k, Part of Set | 37225-6-1 |
| R109 | Resistor, 111.11 k, Part of Set | 37225-6-1 |
| R110 | Resistor, 1 M, Part of Set | 37225-6-1 |
| R111 | Resistor, 560 Ω , 5%, 1/4 W | R0819 |
| R112 | Resistor, 10 k, 5%, 1/4 W | R0766 |
| R113 | Resistor, 100 Ω , 5%, 1/4 W | R0966 |
| R114 | Resistor, 1 k, 5%, 1/4 W | R0765 |
| R115 | Resistor, 3.3 k, 5%, 1/4 W | R0742 |
| R116 | Resistor, 3.3 k, 5%, 1/4 W | R0742 |
| R117 | Resistor, 3.3 k, 5%, 1/4 W | R0742 |
| R118 | Resistor, 3.3 k, 5%, 1/4 W | R0742 |
| R119 | Resistor, 1 M, 1%, 1/2 W | 02381310 |
| R120 | Resistor, 1 M, 1%, 1/2 W | 02381310 |
| R121 | Resistor, 6,19 k, 1%, 1/4 W | R2838 |
| R122 | Resistor, 100 Ω , 1%, 1/4 W | R2620 |

A2, SWITCH P.C. ASSEMBLY PARTS LIST (Cont'd)

| Ref. | Description | SD Part No. |
|------|------------------------------------|-------------|
| R123 | Resistor, 820 Ω , 5%, 1/4 W | R0762 |
| R124 | Resistor, 1 Ω , 5%, 2 W | R2855 |
| R125 | Resistor, 15 k, 5%, 1/4 W | R0728 |
| R126 | Resistor, 15 k, 5%, 1/4 W | R0728 |
| R127 | Resistor, 15 k, 5%, 1/4 W | R0728 |
| R128 | Resistor, 15 k, 5%, 1/4 W | R0728 |
| R129 | Resistor, 1 k, 5%, 1/4 W | R0765 |
| U1 | Integrated Circuit, LM301A | 25745 |
| U2 | Integrated Circuit, LM301A | 25745 |
| U3 | Integrated Circuit, LM301A | 25745 |
| U4 | Integrated Circuit, μ A723 | 25761 |
| U5 | Integrated Circuit, μ A723 | 25761 |
| U6 | Integrated Circuit, LM301A | 25745 |
| U7 | Integrated Circuit, LM311 | 25792 |
| TP1 | Test Point, Brown | E0235 |
| TP2 | Test Point, Black | E0234 |
| TP3 | Test Point, Orange | E0237 |
| TP4 | Test Point, Yellow | E0238 |
| TP5 | Test Point, Green | E0239 |
| TP6 | Test Point, Blue | E0240 |
| TP7 | Test Point, Violet | E0241 |
| TP8 | Test Point, Grey | E0242 |
| F1 | Fuse, 1 1/2 A | F0046 |
| F2 | Fuse, 1/4 A Slo Blo | F0067 |
| F3 | Fuse, 1/64 A Pigtail | F0069 |
| S1 | Switch, 10 Positive Pushbutton | S0411 |
| S2 | Switch, 10 Positive Pushbutton | S0411 |
| S3 | Switch, 10 Positive Pushbutton | S0411 |
| S4 | Switch, 10 Positive Pushbutton | S0411 |
| S5 | Switch, 10 Positive Pushbutton | S0411 |
| S6 | Switch, 10 Positive Pushbutton | S0411 |
| S7 | Switch, 10 Positive Pushbutton | S0411 |
| S8 | Switch, 10 Positive Pushbutton | S0411 |
| S9 | Switch, 10 Positive Pushbutton | S0411 |
| S10 | Switch, 10 Positive Pushbutton | S0411 |

05 OPTION BCD ASSEMBLY PARTS LIST

| Ref. | Description | SD Part No. |
|------|-------------------------|----------------|
| | 05 Option BCD Assembly | 37218-4-1 |
| | 05 Option BCD Schematic | 37218-7-1 |
| J101 | Connector, 30 Pin | J0504 |
| J202 | Connector, 24 Pin | J0298 |
| P201 | Mating Connector | J0244 |

09 OPTION BATTERY PACK ASSEMBLY PARTS LIST

| Ref. | Description | SD Part No. |
|------|----------------------------------|----------------|
| | 09 Option Battery Pack Assembly | 37219-4-1 |
| BT1 | Battery, 6 V, 4.5 A. Hr. | BT0005 |
| BT2 | Battery, 6 V, 4.5 A. Hr. | BT0005 |
| S202 | Switch, 4P3T Slide | S0415 |
| | Battery Switch Assembly | 37228-4-1 |
| | Battery Pack P.C. Board Assembly | 37469-4-1 |

BATTERY PACK P.C. BOARD PARTS LIST

| Ref. | Description | SD Part No. |
|------|--------------------------------------|----------------|
| | Battery Pack P.C. Board Assembly | 37469-4-1 |
| | Battery Pack P.C. Board Schematic | 37469-7-1 |
| C1 | Capacitor, .47 μ F, 200 V | 03284010 |
| C2 | Capacitor, .47 μ F, 200 V | 03284010 |
| C3 | Capacitor, 4.7 μ F, 25 V | 03287820 |
| C4 | Capacitor, 1 μ F, 25 V | C0879 |
| C5 | Capacitor, .01 μ F, 500 V, Disc. | C0423 |
| C6 | Capacitor, .01 μ F, 100 V, Disc. | C0556 |
| CR1 | Diode, 1N4005 | CR0284 |
| CR2 | Diode, 1N4005 | CR0284 |
| CR3 | Diode, 1N4005 | CR0284 |
| CR4 | Diode, 1N4005 | CR0284 |
| CR5 | Diode, 1N4151 | CR0150 |
| CR6 | Diode, 1N4151 | CR0150 |
| CR7 | Diode, 1N4005 | CR0284 |
| CR8 | Diode, 1N752A, 5.6 V, Zener | CR0064 |
| CR9 | Diode, 1N4151 | CR0150 |
| F3 | Fuse, 1.5 A, F Blo, 8AG | F0046 |
| Q1 | Transistor, 2N3569 | Q0318 |
| Q2 | Transistor, 2N3569 | Q0318 |
| Q3 | Transistor, 2N6103 | Q0317 |
| Q4 | Transistor, 2N6103 | Q0317 |
| Q5 | Transistor, 2N3569 | Q0318 |
| Q6 | Transistor, 2N2219 | Q0246 |
| Q7 | Transistor, MPS A12 | Q0286 |
| Q8 | Transistor, 2N4918 | Q0268 |
| R1 | Resistor, 3.9 k, 5%, 1/4 W | R0939 |
| R2 | Resistor, 3.9 k, 5%, 1/4 W | R0939 |
| R3 | Resistor, 150 Ω , 5%, 1/4 W | R0983 |
| R4 | Resistor, 5.6 k, 5%, 1/4 W | R0821 |
| R5 | Resistor, 100 Ω , 5%, 1/4 W | R0966 |
| R6 | Resistor, 470 Ω , 5%, 1/4 W | R1044 |
| R7 | Resistor, .24 Ω , 5%, 2 W | 02394000 |
| R8 | Resistor, 470 Ω , 5%, 1/4 W | R1044 |
| R9 | Resistor, 5.6 k, 5%, 1/4 W | R0821 |
| R10 | Resistor, 100 Ω , 5%, 1/4 W | R0966 |
| R11 | Resistor, 10 k, 5%, 1/4 W | R0766 |
| R12 | Resistor, 3.3 k, 5%, 1/4 W | R0742 |
| R13 | Resistor, 100 k, 5%, 1/4 W | R0741 |

BATTERY PACK P.C. BOARD PARTS LIST (Cont'd)

| Ref. | Description | SD Part No. |
|------|------------------------------------|----------------|
| R14 | Resistor, 2.2 M, 5%, 1/4 W | R1014 |
| R15 | Not Used | |
| R16 | Resistor, .68 Ω , 5%, 2 W | R2291 |
| R17 | Resistor, 14.61 k, 1%, 1/4 W | R0859 |
| R18 | Resistor, 11.8 k, 1%, 1/4 W | R1003 |
| R19 | Resistor, 5 k, Potentiometer | R2697 |
| R20 | Resistor, 470 Ω , 5%, 1/4 W | R1044 |
| R21 | Resistor, 6.8 k, 5%, 1/4 W | R0696 |
| R22 | Resistor, 10 k, 5%, 1/4 W | R0766 |
| R23 | Resistor, 1 M, 5%, 1/4 W | R0962 |
| TP1 | Test Point, Red | E0279 |
| TP2 | Test Point, Black | E0280 |
| U1 | Integrated Circuit, SN74L02N | 25797 |
| U2 | Integrated Circuit, SN74L73N | 45200 |
| U3 | Integrated Circuit, μ 723 | 25761 |
| | Heat Sink, (Q8) | H1956 |